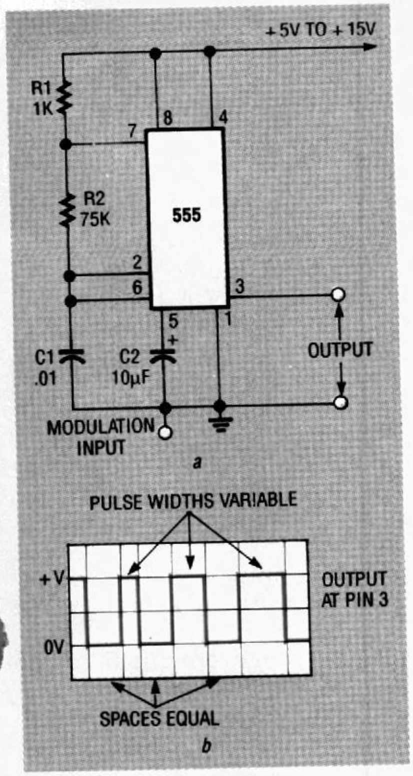

FIG. 16—CIRCUIT FOR APPLYING AC-COUPLED FM or PPM to a 555 configured as an oscillator, a, and waveforms at output of pin 3, *b*.

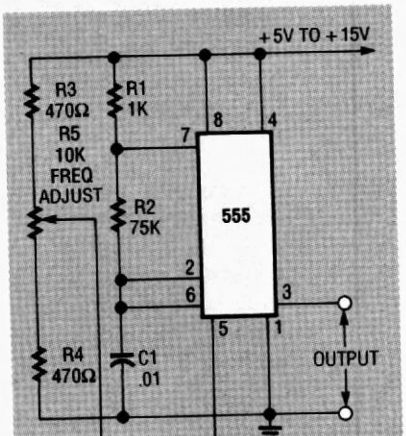

FIG. 17—CIRCUIT FOR APPLYING A DC-COUPLED FM or PPM to a 555 configured as an oscillator.

RESET pins.

In Fig. 11-b, the precise circuit waveforms at OUTPUT pin 3 and across C1 are shown. It can be seen that the duration of the first half-cycle of oscillation is considerably longer than the succeeding half cycles because of the time for C1 to charge to two-thirds of the supply voltage. Also, note that when the astable mode is turned off, the C1 voltage decays slowly to zero; the output at OUTPUT pin 3 is zero volts in the OFF condition. The waveform characteristics of Fig. 12-a are similar as shown in Fig. 12-b.

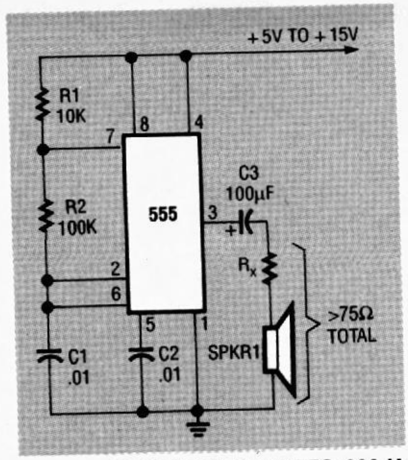

FIG. 18—CIRCUIT GENERATES 800-Hz MONOTONE ALARM that operates from 750-milliwatts.

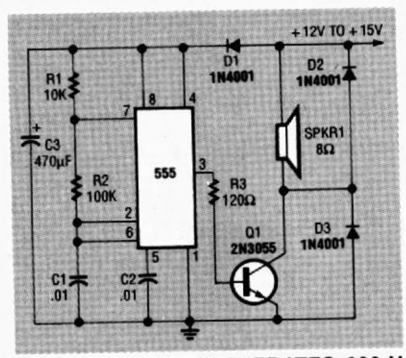

FIG. 19—CIRCUIT GENERATES 800-Hz MONOSTABLE ALARM.

Figure 13-a shows an alternative method for triggering the 555 in the astable mode. Here transistor Q1 is normally biased ON by R1, so it acts like a closed switch, which pulls the junction of C1 and R4 close to zero volts through R2 preventing oscillation. When pushbutton switch S1 is closed, Q1 is biased off, and the astable circuit is free to oscillate normally.

Refer to Fig. 13-b for the waveforms of the circuit in Fig. 13-a. When the astable response is triggered on, the first half cycle is again considerably longer than in succeeding half cycles, and that the voltage on C1 decays rapidly to nearly zero volts when the trigger is off. Also notice that OUTPUT pin 3 is high in the OFF state.

Figure 14 shows how the circuit in Fig. 13-a can be modified to give *press-to-turn-off* oscillation simply by replacing Q1 with a pushbutton switch. A digital signal can trigger this circuit if a diode is connected as shown in the diagram and the pushbutton S1 is deleted. With S1 removed, the circuit will be turned off when the input signal voltage is reduced below one-third of the supply voltage. The waveform is shown in Fig. 14-b.

Finally, to complete this look at triggering techniques, Fig.

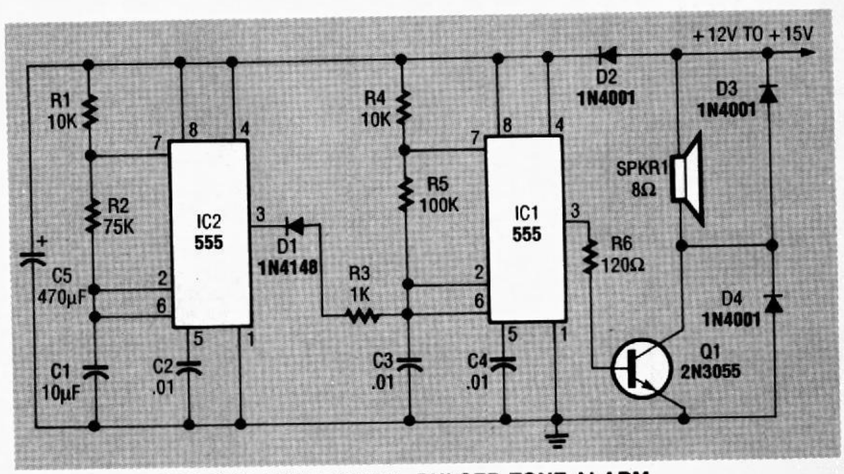

FIG. 20—CIRCUIT GENERATES 800-Hz PULSED-TONE ALARM.

15-a shows how the Fig. 13-a circuit can be modified so that the duration of its first half-cycle is almost equal to that of all succeeding half-cycles, thus giving precision operation. In the Fig. 15-a circuit, when pushbutton switch S1 is open, Q1 is saturated, so the voltage divider made up of R2 and R3 pulls the junction of R5 and C1 to slightly below one-third of the supply

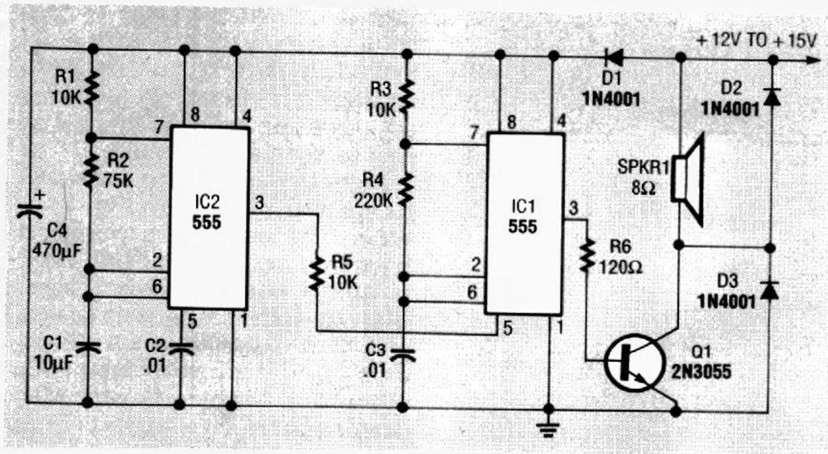

FIG. 21—CIRCUIT GENERATES WARBLE ALARM of European emergency vehicles.

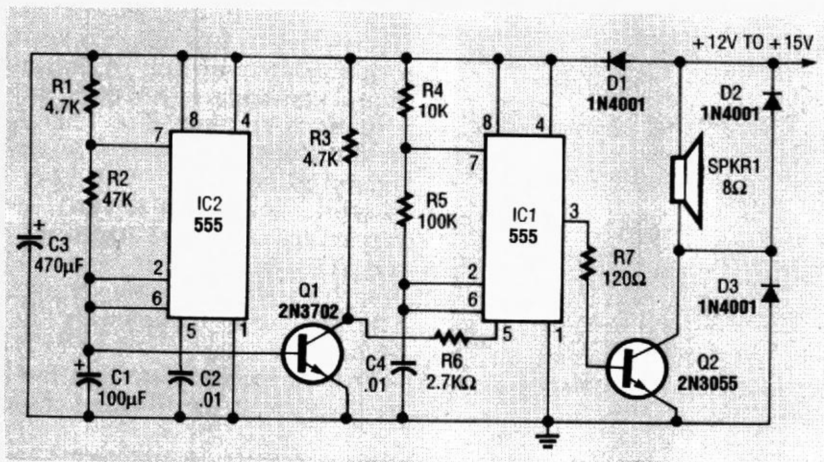

FIG. 22—CIRCUIT GENERATES SIREN WAIL of police cars.

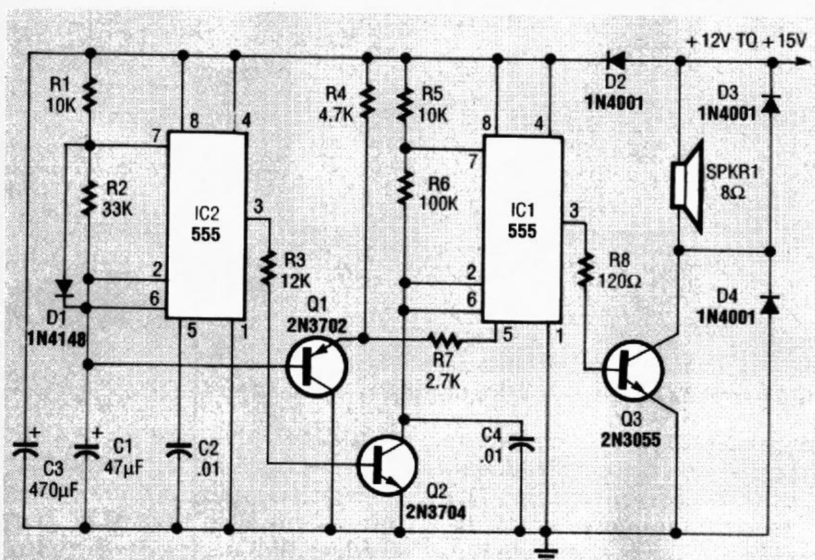

FIG. 23.—CIRCUIT GENERATES PENETRATING ALARM of Star Trek spaceship.

voltage through diode D1, thus turning the circuit off. When S1 is closed, Q1 turns off, D1 is reverse biased through R2, and the circuit is then free to oscillate normally.

Notice in Fig. 15-b that when S1 is first closed, C1 starts to charge from an initial value of almost a third of the supply voltage rather than from zero volts. Therefore, the duration of the initial half cycle is similar to that of all the succeeding half cycles.

Modulation techniques

All of the 555 astable circuits reviewed so far can be frequency or pulse-position modulated (FM or PPM) by feeding a suitable modulation signal to CONTROL VOLTAGE pin 5, which is connected to part of the internal voltage divider chain of the 555. The AC modulation signal is fed to pin 5 through a blocking capacitor, as in Fig. 16-a, or the DC modulation signal can be fed directly to pin 5, as shown in Fig. 17.

The voltage on pin 5 of the Fig. 15-a circuit alters the width of the pulses in each timing cycle of the 555, but it has almost no effect on the space duration. The signal at pin 5 changes the PPM pulse width position, affecting the total cycle period so it also influences the output frequency, as shown in Fig. 16-b. In so doing, pin 3 provides a frequency-modulated signal. Those characteristics of the 555 are useful for generating special waveforms.

Alarms and sirens

Some of the most popular applications for the 555 organized as an astable multivibrator are as waveform generators for loudspeakers. They can produce alarm and siren sounds. Figures 18 to 23 show different ways to create those sounds. All of the circuits in those figures are triggered by making or breaking their supply-voltage connections.

Figure 18 shows an 800-Hz monotone alarm-call generator circuit, which can be powered by any 5- to 15-volt DC supply. The speaker SPKR1 can have any impedance value. Note, however, that R_X must be wired in series with any speaker whose total impedances is less than 75 ohms. Select a resistor to give a total series resistance with the speaker of 75 ohms.

continued on page 94

Refer to Fig. 3-b. Pulse width (or time to charge capacitor C1 is:

$t_1 = 0.7\,C1\,(R1 + R2)$

Space length or time to discharge capacitor C1 is:

$t_2 = 0.7\,C1R2$

The total cycle time is:

$T = t_1 + t_2$

The ratio of pulse width to the total cycle time is the *duty cycle*. In a 555-based oscillator, the duty cycle is defined by the relative values of the two timing resistors R1 and R2:

Duty cycle = R2/(R1 + 2R2)

Frequency in hertz (Hz) is the reciprocal of total cycle time: F = 1/T.

The circuit in Fig. 3-a can be modified in many different ways. Figure 5, for example, shows how it can be made into a variable-frequency square-wave generator by replacing R2 with a fixed resistor and potentiometer in series. The frequency can be varied over a range of about 650 Hz to 7.2 kHz with the values of the resistor and potentiometer R3 shown. If required, the frequency span can be further increased by switch-selecting alternative values of C1.

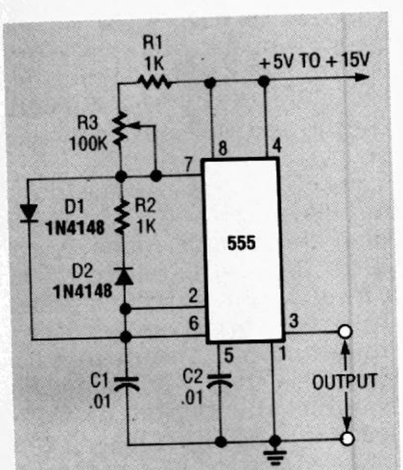

FIG. 8—A 1.2 kHz OSCILLATOR with a duty cycle variable from 1 to 99%.

Width-space control

The circuit in Fig. 3-a can generate a fixed-frequency output waveform with any desired pulse width-to-space length ratio by selecting the appropriate values for R1 and R2. In each operating cycle, C1 alternately charges through R1 and R2, and discharges only through R2. For example, if R1 and R2 have equal values, the circuit will generate a 2:1 width-to-space ratio.

The width-to-space periods can be independently controlled with either the Figs. 6 or 7. In Fig. 6, C1 alternately charges through R1, diode D1, and potentiometer R3, and it discharges through potentiometer R4, diode D2, and R2. In Fig. 7, C1 alternately charges through R1, potentiometer R3, and diode D1, and it discharges through potentiometer R4, diode D2, and R2. In both Fig. 6 and 7 circuits, R2 protects the 555 if potentiometer R4 is shorted.

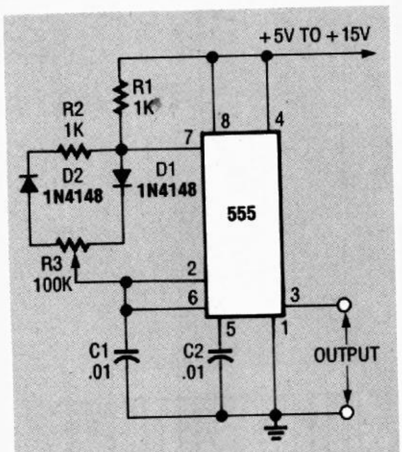

FIG. 9—AN ALTERNATE VERSION OF OSCILLATOR shown in Fig. 8.

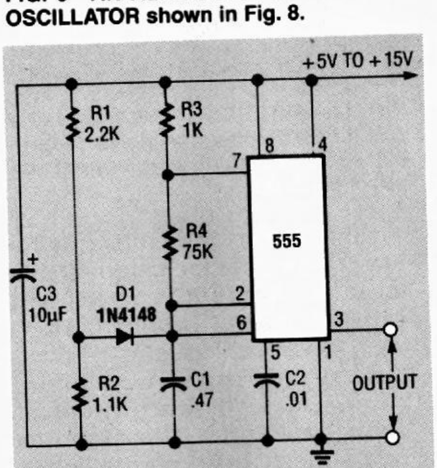

FIG. 10—A PRECISION LOW-FREQUENCY OSCILLATOR with a frequency of about 20 Hz.

In the circuits of Figs. 6 and 7, the width-to-space periods can be independently varied over about a 100:1 range, enabling the width-to-space ratio to be varied from 100:1 to 1:100. The oscillation frequency varies as the ratio is altered.

Figures 8 and 9 show alternate ways of connecting the 555 in the astable mode so that the width-to-space ratio can be varied without altering the oscillating frequency. In those circuits, the pulse width period automatically increases as the space length period decreases, and vice versa. Therefore, the total period of each operating cycle is constant. In those circuits, the feature of interest is the duty cycle. In Figs. 8 and 9, the duty cycle can be varied from 1% to 99% with potentiometer R3.

In the circuit of Fig. 8, C1 alternately charges through R1, the upper half of R3, and D1, and it discharges through D2, R2, and the lower half of potentiometer R3. In Fig. 9, C1 alternately charges through R1 and D1 and the right-hand half of potentiometer R3, and it discharges through the left-hand half potentiometer R3, D2, and

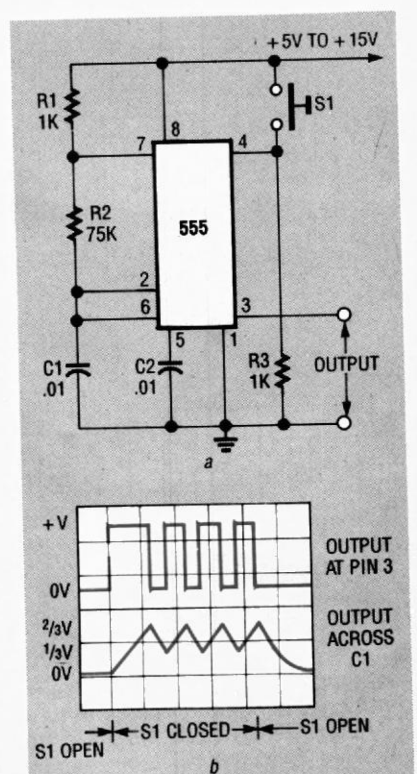

FIG. 11—GATED 1-kHz OSCILLATOR offering "press-to-turn-on" operation, *a*, CFHB and waveforms at output of pin 3 and across C1, *b*.

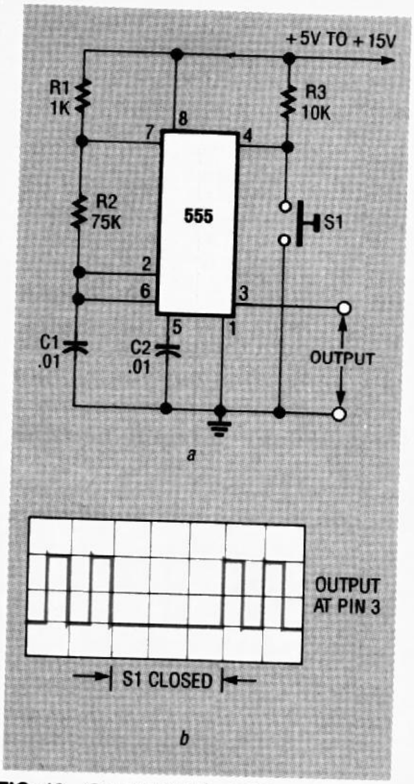

FIG. 12—GATED 1-kHz OSCILLATOR offering "press-to-turn-off" operation, *a*, and waveforms at output of pin 3 and across C1, *b*.

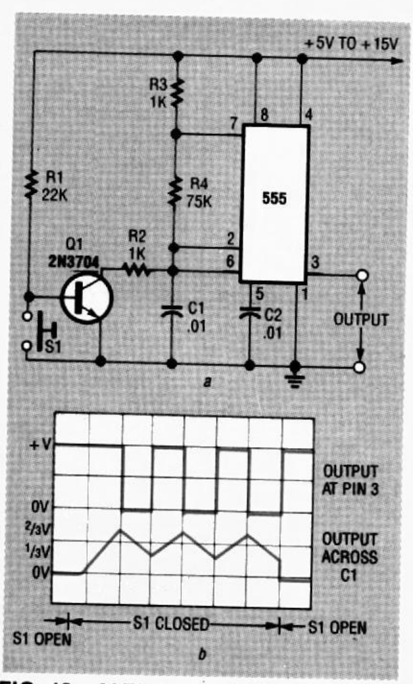

FIG. 13—ALTERNATIVE GATED 1-kHz OSCILLATOR offering "press-to-turn-on" operation, *a*, and waveforms at output of pin 3 and across C1, *b*.

R2. Both circuits oscillate at about 1.2 kHz with the value of C1 shown.

Precision astable circuit

In the description of astable multivibrator operation given earlier in this article, it was stated that in the first half cycle of oscillation timing capacitor C1 charges from zero volts to two-thirds of the supply voltage, but in all subsequent half-cycles it either discharges from two-thirds to one-third of the supply voltage or charges from one-third to two-thirds of that voltage. Consequently, the first half cycle of oscillation has a far longer period than all subsequent half cycles.

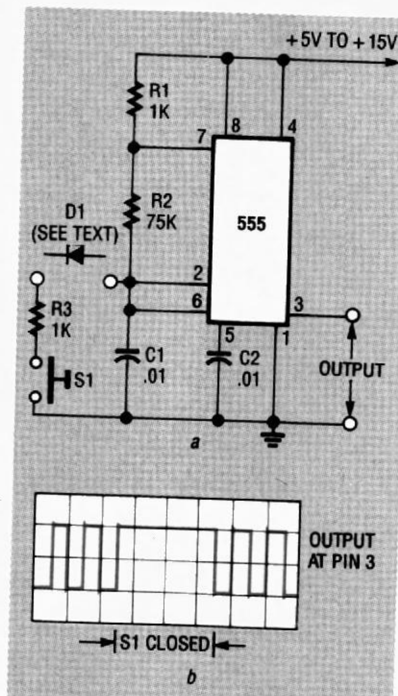

FIG. 14—ALTERNATIVE GATED 1-kHz OSCILLATOR offering "press-to-turn-off" operation, 1a and waveforms at output of pin 3, *b*.

In applications calling for a low-frequency clock signal, this large differential in period can cause a timing problem. However, this problem can be averted by adding an external voltage divider and diode as shown in Fig. 10. Those components bias C1 to a point slightly below one-third of the supply voltage (rather than zero volts) at the moment of switch-on. Here, R1 rapidly charges C1 to one-third of the supply voltage through D1 at switch-on, and all of the C1 charge is subsequently controlled by R3 and/or R4 only.

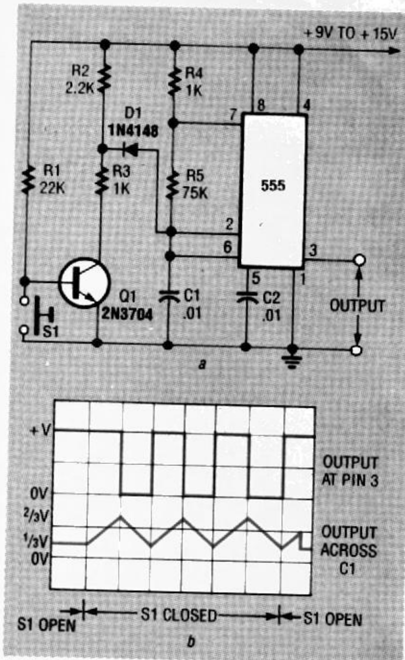

FIG. 15—PRECISION VERSION OF THE OSCILLATOR in Fig. 13, *a*, and waveforms at output of pin 3 and across C1, *b*.

Astable gating

The 555 in the astable multivibrator mode can be triggered ON and OFF in many different ways with either an electromechanical switch or an electronic signal. The most popular way to trigger the 555 is through RESET pin 4. Figures 11-a and 12-a show alternative ways of triggering the 555 with this pin and pushbutton switch S1.

The 555 is organized so that if pin 4 is biased above about 0.7 volts, the astable mode is enabled. But if it is biased below 0.7 volts by a current greater than 0.1 milliampere (by grounding pin 4 with a resistance less than 7 kilohms, for example) the astable mode is disabled, and the 555's output is biased low.

For example, the circuit in Fig. 11-a is normally turned off by R3, but it can be turned on by closing pushbutton switch S1, which biases pin 4 high. Figure 12-a shows an astable circuit that is normally on, but it can be turned off by closing pushbutton switch S1, which shorts pin 4 to ground. The circuits in Figs. 11 and 12 can also be triggered by applying suitable electronic signals directly to their