

12 **EUROPEAN PATENT APPLICATION**

21 Application number: 79302781.4

51 Int. Cl.<sup>3</sup>: G 08 B 13/14

22 Date of filing: 04.12.79

30 Priority: 08.12.78 GB 4772478  
22.08.79 GB 7929297

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43 Date of publication of application:  
23.07.80 Bulletin 80/15

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84 Designated Contracting States:  
BE DE FR IT NL SE

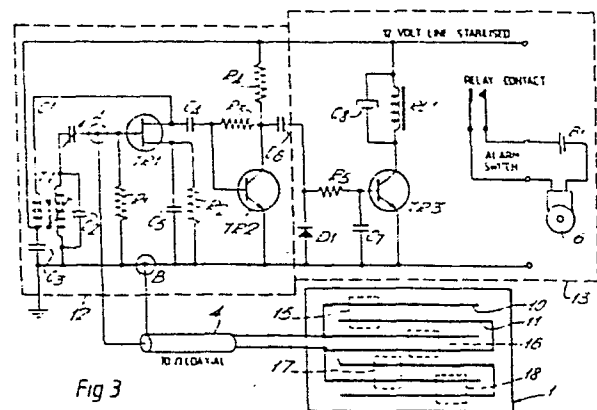
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54 Alarm system and method for detecting the movement of an object away from a predetermined position.

57 Alarm system and method for detecting the movement of an object away from a predetermined position, such an object being typically an item on display in a shop or a door in a closed position.

The alarm system comprises a sensing circuit (12) which includes two electrical conductors (10, 11) spaced from but adjacent each other and adjacent to the predetermined position to be occupied by at least one item (15 - 18) when in use. The sensing circuit (12) includes a signal generator responsive to the capacitance present between the two conductors (10, 11) to provide a first output condition indicative of a substantially constant capacitance value present between the electrodes due to the undisturbed presence of the item (15 - 18) and to provide a second output condition indicative of a change in capacitance value due to the disturbance of the item or items (15 - 18) present. The output of the sensing circuit (12) is received by an alarm actuating circuit (13) which causes actuation of an alarm element (6) when the output condition from the sensing circuit (12) changes significantly to cause the actuating circuit (13) to trigger due to the movement of the item (15 - 18) from its predetermined position.



# TITLE MODIFIED

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The invention relates to an alarm system capable of detecting when an article is removed from a predetermined position.

In known alarm systems used to deter or detect shop-lifters for example, each article on an open display has been interconnected in a loop by means of a wire coupled to an alarm. Such a system is obtrusive and tends to detract from the display. Adding or removing articles with such a display requires disconnecting the interconnected wires in the loop which can become tedious.

An alternative known system makes use of pressure pads which are connected to an alarm and removal of an article triggers this alarm. In such a system it is necessary to have a pressure pad for each article on display if removal of one is to be detected and thus changes in the number of articles displayed requires addition or removal of one or more pads and changes in the system connections. Thus such a system does not lend itself to frequent changes in the display.

It has also been proposed to use the capacitive effect of displayed articles to trigger an alarm by a system which uses a metal sheet as a conductor connected to an alarm system and each displayed article is placed on this sheet which overlies a shelf. In such a system effectively it was necessary to measure the

capacitance of the articles between this electrode and earth and such a system has been shown to be unreliable due to stray capacitance effects and such a system could instigate an alarm condition merely by a customer being in the vicinity of the display which proves to be an embarrassment to both the customer and the shop-keeper.

The present invention is concerned with a system which overcomes the above drawbacks to provide a reliable, flexible and typically unobtrusive system which can cope with a number of articles together if required.

According to the invention there is provided an alarm system for indicating the removal of an article from a predetermined position comprising:

a) sensing circuit means including

(i) two electrical conductors spaced from but adjacent each other and for positioning adjacent to the predetermined position to be occupied by at least one article when in use, and (ii) signal generating means responsive to the capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and to provide a second output condition indicative of a change in capacitance value present due to the disturbance of said at least one article, and

b) alarm actuator means responsive to the output of

said sensing circuit means to provide an alarm indication as a result of a change in the output condition of said sensing circuit means whenever a change in capacitance due to the removal of an article occurs.

According to a further aspect of the invention there is provided a method of detecting and indicating when an article has been removed from a predetermined position comprising:

providing two electrical conductors spaced from but adjacent each other and adjacent the predetermined position to be occupied by at least one said article,

sensing the capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and to provide a second output condition when a change in capacitance value due to the disturbance of said at least one article occurs,

and actuating an alarm indicator whenever a change in the output condition occurs as a result of the removal of said article.

According to a third aspect of the invention there is provided an alarm system for indicating the removal of an article from a predetermined position comprising:

sensing circuit means including

(i) two electrical conductors spaced from but adjacent each other and for positioning adjacent to the predetermined position to be occupied by at least one article when in use, and

(ii) signal generating means responsive to the capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and to provide a second output condition indicative of the rate of change in capacitance value present due to the disturbance of said at least one article, and

alarm actuator means responsive to the output of said sensing circuit means to provide an alarm indication as a result of a change in the output condition of said sensing circuit means whenever a rapid change in capacitance due to the removal of an article occurs.

According to a fourth aspect of the invention there is provided a method of detecting and indicating when an article has been removed from a predetermined position comprising:

providing two electrical conductors spaced from but adjacent each other and adjacent the predetermined position to be occupied by at least one said article,

sensing the rate of change in capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and providing a second output condition when a rapid change in capacitance value due to the disturbance of said at least one article occurs,

and actuating an alarm indicator whenever a change in the output condition occurs as a result of the removal of said article.

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

FIGURE 1 shows a block diagram of the system of the invention,

FIGURE 2 shows one configuration for arranging the electrodes adjacent to an object to be protected by the alarm,

FIGURE 3 shows one embodiment for realising the system of Figure 1,

FIGURE 4 shows an alternative arrangement to Figure 1 which detects rate of change in capacitance,

FIGURE 5 shows an embodiment for realising the system of Figure 4, and

FIGURE 6 shows in more detail a suitable configuration for providing the elements of the Figure 5 arrangement.

In the basic system of Figure 1, the item or items to be displayed will be positioned such that they will overlies the electrodes 10, 11 which will typically be provided on top of a display stand but not necessarily in the straight configuration indicated. The effective capacitance of the items so placed is indicated by capacitor c. The electrodes 10 and 11 are connected to the sensor 12 which produces an output level indicative of the change in the capacitance c. Any object removed

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from across the electrodes 10 and 11 will cause a rapid change in capacitance and thus the sensor 12 will detect this change and the output thereof will rise. The output of sensor 12 is received by alarm block 13 which compares the sensor level with a predetermined threshold and effects an alarm condition when the threshold is exceeded.

The way in which the electrodes can be arranged is shown in Figure 2.

The shelf 1 is provided on its upper face with two metallic electrode strips 10, 11 which are arranged typically in an interleaved pattern so that, irrespective of the position of placing an article 15 on the shelf, the base of the article will overlie the two electrodes 10 and 11. The article is assumed to be metallic, or to incorporate metal at or near its base, or to carry a sticker or tag 5 which is made of or incorporates metal.

The strips are advantageously self-adhesive, and may be for example  $\frac{3}{4}$  inch apart, and one-eighth to three-eighths of an inch in width. Thin wire could also be used. The sticker could be a small disc of silver paper, for use in the case of glass, china etc. When the disc is placed over the strips, there is an increase of capacitative bridging of the strips 10 and 11.

The two electrode strips in this example are connected by the inner and outer portions of a coaxial cable 4 to the sensor arrangement.

Although the electrodes 10 and 11 are shown on the upper surface of the shelf in contact with the article 15 (or metallic sticker 5), it would also be possible to disguise the electrodes by covering these with a thin dry material (e.g. cloth), and placing the article on the cloth. Alternatively if the shelf were thin it may be possible to provide the electrodes on its lower surface, although in these latter configurations the sensitivity of the system would be somewhat reduced.

An arrangement for realising the system of Figure 1 is shown in Figure 3. The electrodes 10 and 11 are shown interleaved by way of example and suitable positions for a number of articles 15 - 18 are shown thereon. The electrodes are connected via cable 4 to points A and B. The sensor 12 consists of a high impedance oscillator employing a field effect transistor (FET) TR1 (e.g. 2N3819). Components associated with the oscillator include inductance  $T_1$ , capacitors  $C_1$ ,  $C_2$ ,  $C_3$  and  $C_5$  and resistors  $R_1$  and  $R_2$ . The circuit is arranged to go into, and out of, oscillation by the change of capacity occurring between the strips.

The setting of the oscillator is controlled by the variable capacitor  $C_1$  in the gate circuit of the FET, and which is affected by the loading of the shelf; when the shelf is loaded with articles, the capacitor  $C_1$

is adjusted so that the oscillator is just not oscillating, When an article is removed from the shelf, the capacity at the shelf decreases, and allows the oscillator to start working.

The output of the oscillator is typically selected to be at R.F. frequency, e.g. 450-470 Kcs., and this output is passed via capacitor  $C_4$  to the amplifier comprised of transistor TR2 with associated resistors  $R_3$  and  $R_4$ . The output from this transistor passes via capacitor  $C_6$  and is rectified by the diode D1, and the DC content is fed to the driving circuit comprising power transistor TR3 and associated resistor  $R_5$  and capacitor  $C_7$  which circuit actuates the relay circuit ( $RL_1$  and  $C_8$ ) when this DC level exceeds a predetermined threshold. The contacts of the relay are used to switch on any convenient alarm system shown here as a bell 6 powered by battery  $B_1$ .

The oscillator radiates only micro-watts, and only does so when an article is removed. The oscillator is not in a state of oscillation, when everything is normal at the shelf. When in this normal state, the supply current used by the equipment is very low. The maximum current is used when an article is removed from the shelf, and this current mainly consists of that which is consumed by the power transistor and the relay used.

It will be appreciated that the oscillator circuit and the relay could be miniaturised and encapsulated.

The relay although shown as an electro-mechanical device, this could alternatively comprise a solid state switch.

By use of a display device coupled to respective relays for each of a plurality of shelves, there may be obtained an indication of which shelf, amongst many, is subject to the removal of an article.

When the alarm or indicator means installed at a point remote from the shelf, e.g. at a supervisory post or assistant's location in a shop, the device provides an automatic safeguard against unobserved removal of articles, and moreover dependent on the type of alarm (i.e. visual or audible) can give notification of an alarm condition without giving any indication of that fact to the person removing the article.

The placing of the electrodes as a pair in close proximity to each other and over which the article is placed so as to bridge the electrodes, ensures that stray capacitance effects due to customers or assistants moving in the vicinity of the display are minimised and thus reduce the possibility of false alarm conditions.

Although the system has been described generally for use with an 'article' comprising an object for display, the system is also capable of detecting the movement of other 'articles' away from a predetermined position for example such as in opening of a door or window, a face of which could be provided with a metallic strip for example in the vicinity of the electrodes and any movement thereof causing actuation of the alarm.

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In the alternative and preferred arrangement of Figure 4 a system is shown which rather than sensor 12 detecting a change in capacitance per se, detects the rate of change in capacitance, so that a relatively large rate of change in capacitance as a result of removal of of an article causes an alarm condition but a small rate of change, caused by slight stray capacitance or circuit drift for example will not cause false alarm conditions to be instigated.

This rate of change function will now be described with reference to the embodiment of Figure 5. Although not shown, electrodes 10 and 11 could again be coupled via coaxial cable to the sensor 12.

Oscillator 20 is a free running oscillator (typically 200 kHz). The oscillator output is received by buffer 22 to prevent loading of the oscillator. A filter 21 is provided to remove any r.f. present. The buffered oscillator output passes via pulse shaper 24 to a phase locked loop configuration provided by blocks 26 - 29 inclusive. The shaped pulses are received by the first comparator 26 which produces an error voltage which passes via low pass filter 27 to control the oscillator 28. The output of the voltage controlled oscillator (VCO) is used as the other input to comparator 26 so as to allow this comparator to determine the error and adjust the error voltage. Similarly comparator 29 receives the pulses from shaper 24 and the output from VCO 28,

so as to again produce an error voltage. This error voltage passes via driver 30 to an integrator 31 where it is integrated. The integrator output is received by alarm trip unit 13 which instigates an alarm condition when this output exceeds a predetermined level.

The low pass filter 27 effectively determines the rate at which a change in capacitance  $c$  affecting oscillator 20 will cause the VCO to come out of lock and so cause the error voltage at the output of comparator 29 to continuously change as the VCO is searching for a locked situation. Thus this comparator output on integration will effectively cause the alarm to actuate. Thus the low pass filter 27 and integrator 31 provide the facility for determining the rate of change rather than change per se in capacitance  $c$ .

An arrangement for realising the system of Figure 5 is shown in Figure 6. The oscillator 20 comprises coil  $L_1$  (e.g. a standard I.F. coil), resistors  $R_1$ - $R_3$ , capacitors  $C_1$ ,  $C_2$  and integrated circuit element 40.  $C_8$  is a decoupling capacitor. Filter 21 comprises  $R_4$  and  $C_3$ . Buffer 22 comprises  $C_4$ ,  $R_5$  and element 41. Pulse shaper 24 comprises  $R_{12}$  and element 46. Driver 30 comprises elements 47, 50, 51 and resistor  $R_9$ . Integrator 31 comprises element 52,  $R_{10}$ ,  $R_{11}$ ,  $C_7$  and diode  $D_1$ . The phase locked loop 26 - 29 comprises integrated circuit chip 44 and associated components  $R_6$ - $R_8$ ,  $C_5$ ,  $C_6$  and relay contact  $A_1$ . The alarm trip 13 comprises elements 42,

43, 48, 49, resistors R13, R14, diodes D<sub>2</sub>, D<sub>3</sub>, light emitting diode 56, relay A and loudspeaker 55 (e.g. Piezo transducer U35R). Elements 42 and 43 operate in parallel to provide the necessary current handling capability due to the relatively low value of R13.

Elements 40 - 43 can conveniently comprise 4 dual input Nand gates on a single chip (e.g. type 4011). The inputs of each of these elements 40 - 43 are strapped together so that each functions as an inverter. Chip 44 is a phase locked loop chip (e.g. type 4046).

Elements 46 - 49 can typically comprise 4 Schmitt triggers on a single chip (e.g. type 4093).

Elements 50 - 52 can conveniently comprise 3 out of 4 of the Nand gates of an I.C. chip (e.g. type 4011), each with inputs strapped to function as inverters. It is convenient to use NANDs since these are also used elsewhere although a normal inverter chip could be used.

In the system of Figure 3 the output from the integrator is normally low. When a rapid capacitance change occurs, then C<sub>7</sub> charges up and the elements 42, 43 go low (when C<sub>7</sub> reaches about 1/2 rail voltage). The Schmitts 48, 49 positively select the alarm condition causing the transducer 55 to operate.

The relay A is also energised and contact A<sub>1</sub> closes and thus R<sub>8</sub> is placed in parallel with R<sub>7</sub> to relock the phase locked loop more quickly, (R<sub>7</sub> and C<sub>6</sub> forming the low pass filter). C<sub>5</sub> and R<sub>6</sub> define the center frequency

of the VCO.

On relocking of the VCO the integrator output will fall and the alarm condition will cease thus de-energising relay A, opening its contact  $A_1$  and disconnecting  $R_8$  thus returning the sensitivity back to the normal condition to again await changes caused by any disturbance of capacitance  $c$ .

Thus in this embodiment the oscillator is free running whether or not an alarm condition is occurring. Any slight changes in capacitance will cause the oscillator frequency to vary but this variation can be followed by the phase locked loop system. A rapid capacitance change however will cause the loop error to become large and thus on integration cause an alarm condition to be instigated. The system will automatically relock into a standby condition on de-energisation of relay A. This locking into a standby condition will also occur automatically a short time after articles have been placed on the electrodes when making up the display and thus typically no manual adjustment or setting up of the system is required, other than initially arranging the electrodes in a suitable configuration.

Although in this embodiment the system has been generally described as for use with an article comprising an object for display, this system can also be used with 'articles' such as doors or windows which typically could be provided on one face with a metallic strip in the

vicinity of the electrodes to allow any movement of the door or window by opening to be detected and an alarm condition actuated.

## CLAIMS:

1. An alarm system for indicating the removal of an article from a predetermined position comprising:

(a) sensing circuit means including

(i) two electrical conductors spaced from but adjacent each other and for positioning adjacent to the predetermined position to be occupied by at least one article when in use, and

(ii) signal generating means responsive to the capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and to provide a second output condition indicative of a change in capacitance value present due to the disturbance of said at least one article, and

(b) alarm actuator means responsive to the output of said sensing circuit means to provide an alarm indication as a result of a change in the output condition of said sensing circuit means whenever a change in capacitance due to the removal of an article occurs.

2. A system as claimed in claim 1, wherein the signal generating means comprises an oscillator capable of providing a first output condition in which

no oscillation occurs during normal operation and a second output condition in which oscillation occurs on movement of an object due to a change in capacitance in the oscillator circuit as sensed between the two conductors, and

adjustment means are provided for selecting the first output condition to compensate for the type and number of articles present, when in use.

3. A system as claimed in claim 2, wherein the alarm actuator means includes a driver circuit for rectifying the oscillator output and actuating an alarm element when the rectified oscillator output exceeds a predetermined level.

4. A system as claimed in claim 1, 2 or 3, wherein the two electrical conductors of the sensing circuit means comprise a substantially parallel adjacent pair of metallic electrodes.

5. A method of detecting and indicating when an article has been removed from a predetermined position comprising:

providing two electrical conductors spaced from but adjacent each other and adjacent the predetermined position to be occupied by at least one said article,

sensing the capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and to provide a second output condition when a change in capacitance value due to the disturbance of said at least one article occurs, and

actuating an alarm indicator whenever a change in the output condition occurs as a result of the removal of said article.

6. An alarm system for indicating the removal of an article from a predetermined position comprising:

(a) sensing circuit means including

(i) two electrical conductors spaced from but adjacent each other and for positioning adjacent to the predetermined position to be occupied by at least one article when in use, and

(ii) signal generating means responsive to the capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and to provide a second output condition indicative of the rate of change in capacitance value present due to the disturbance of said at least one article, and

(b) alarm actuator means responsive to the output of said sensing circuit means to provide an alarm indication as a result of a change in the output condition of said sensing circuit means whenever a rapid change in capacitance due to the removal of an article occurs.

7. A system as claimed in claim 6 wherein said signal generating means comprises an oscillator capable of providing an oscillation frequency dependent on the value of capacitance present between the

conductors and integration means for integrating a signal dependent on the output of said oscillator to provide an output to said alarm actuator means dependent on the rate of change of the capacitance value.

8. A system as claimed in claim 7, wherein the signal generating means includes a phase locked loop arrangement for providing an error voltage dependent on the frequency variation due to a change in capacitance between the conductors so as to compensate for any small variation in the capacitance value present to prevent an alarm condition occurring due to stray capacitance variation, but to provide on integration by said integration means a sufficient voltage to allow operation of said actuator means whenever a relatively large change in capacitance occurs due to removal of one or more of said articles.

9. A system as claimed in claim 8, wherein the phase locked loop arrangement includes comparator means, a voltage controlled oscillator for providing an output signal dependent on the output of said comparator means, which comparator means compares the voltage controlled oscillator output with the signal derived from the oscillator of said signal generating means to provide an error voltage dependent on any detected change in frequency.

10. A system as claimed in claim 9, wherein said comparator means comprise a first comparator for providing an output for said voltage controlled oscillator and a second comparator for providing an output for said integrating means.

11. A method of detecting and indicating when an article has been removed from a predetermined position comprising:

providing two electrical conductors spaced from but adjacent each other and adjacent the predetermined position to be occupied by at least one said article,

sensing the rate of change in capacitance present between these conductors to provide a first output condition indicative of substantially constant capacitance value present between the electrodes due to the undisturbed presence of said at least one article and providing a second output condition when a rapid change in capacitance value due to the disturbance of said at least one article occurs, and

actuating an alarm indicator whenever a change in the output condition occurs as a result of the removal of said article.

12. An alarm system substantially as described herein with reference to Figures 1 to 3 or Figures 4 to 6 of the accompanying drawings.

13. A method of detecting and indicating when an article has been removed from a predetermined position substantially as claimed in claim 5 or 11.

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Fig. 1.

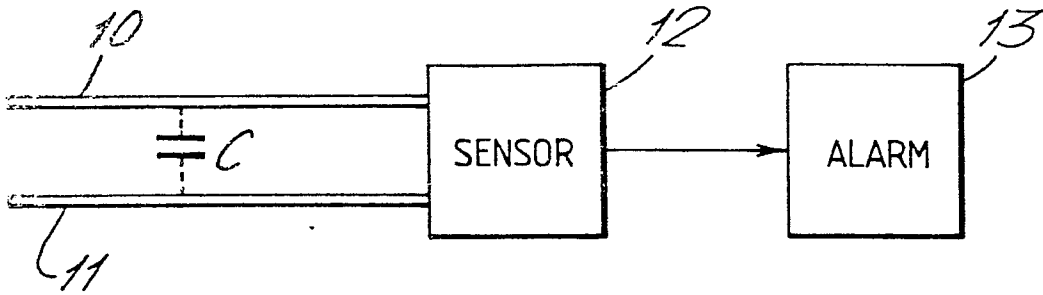
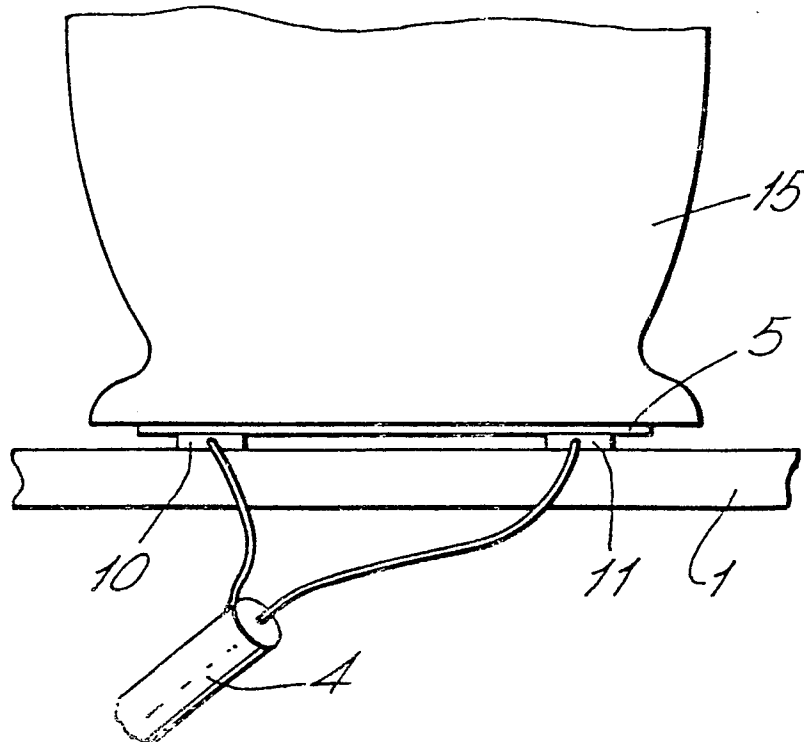


Fig. 2.



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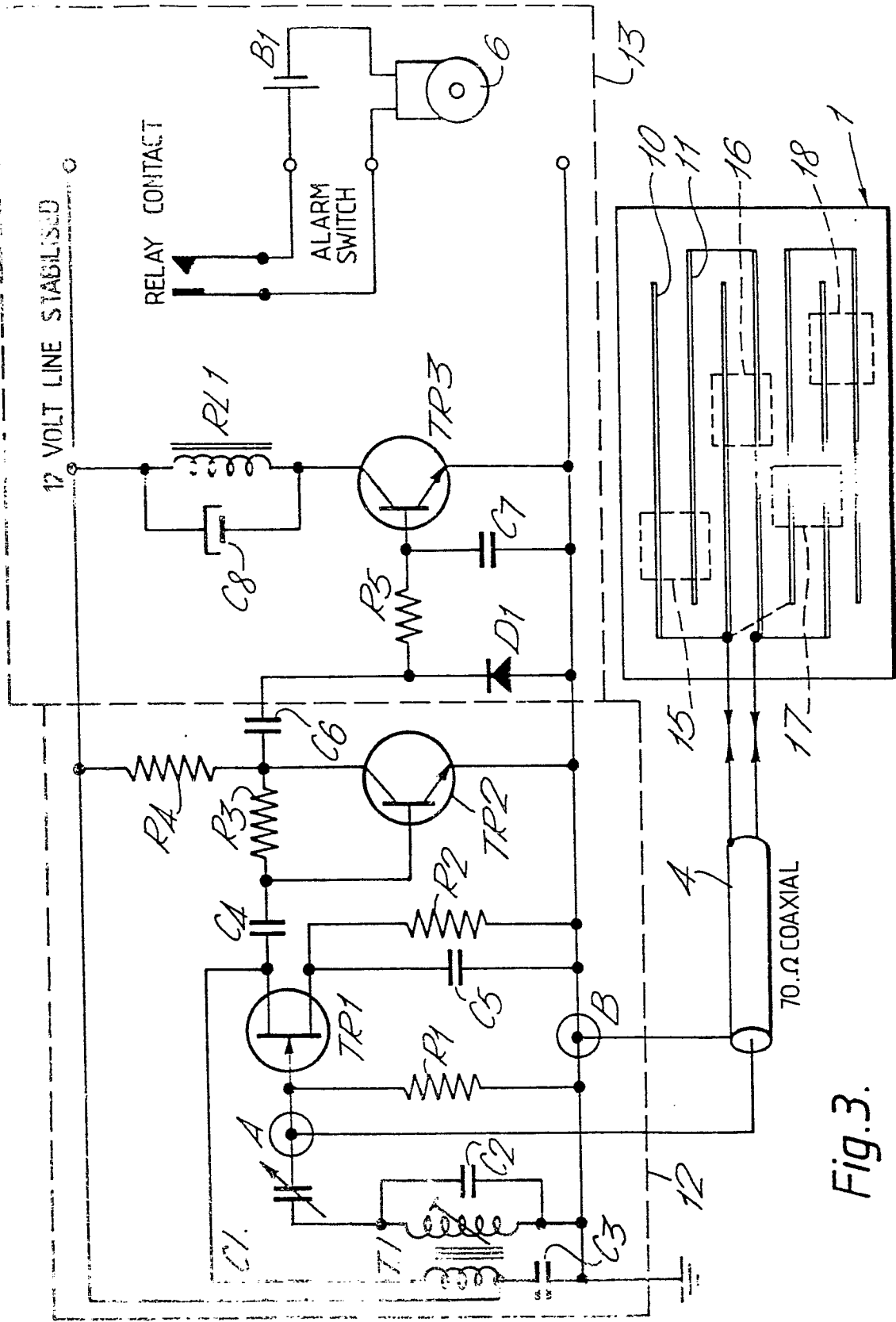


Fig. 3.



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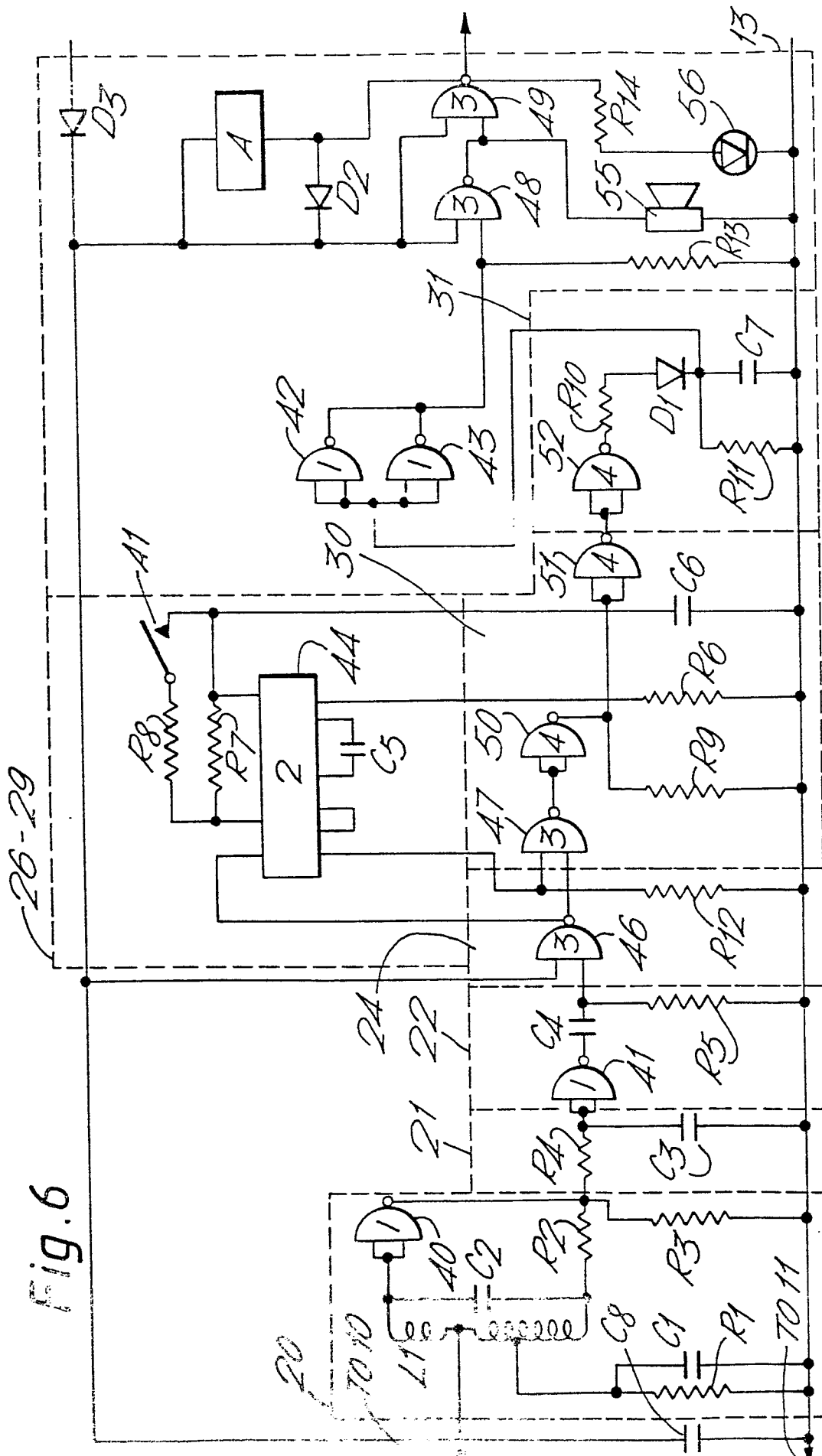


Fig. 6



DOCUMENTS CONSIDERED TO BE RELEVANT		CLASSIFICATION OF THE APPLICATION (Int. Cl.)	
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<p>DE - B - 1 121 507 (SIEMENS &amp; HALSKE AG) * complete document *</p> <p>--</p> <p>DE - U - 1 808 250 (TELEFONBAU UND NORMALZEIT GMBH) * complete document *</p> <p>--</p> <p>A US - A - 3 919 705 (J.L. STENDIG et al.) * fig. 7 *</p> <p>--</p> <p>DE - A - 2 323 065 (W. CORDES) * claims; fig. 1 *</p> <p>--</p> <p>US - A - 4 091 371 (ST. I. MASON JR. et al.) * claims, column 3, line 28 to column 6, line 39; fig. 4 *</p> <p>----</p>	<p>1, 4-6, 11</p> <p>1,5, 6</p> <p>1-3, 6,7</p>	<p>G 08 B 13/14</p> <p>TECHNICAL FIELDS SEARCHED (Int. Cl.)</p> <p>G 08 B 13/00</p> <p>CATEGORY OF CITED DOCUMENTS</p> <p>X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons</p> <p>&amp;: member of the same patent family, corresponding document</p>
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
Berlin	12-03-1980	BEYER	