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CAPACITY OPERATED APPARATUS

2,929,969

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2 Sheets-Sheet 1

FIG. 1.

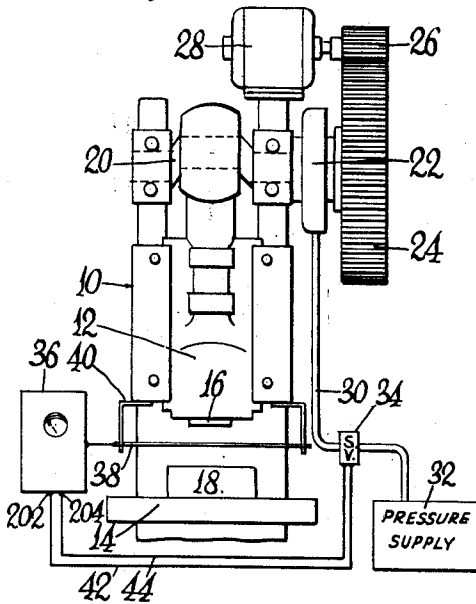


FIG. 2.

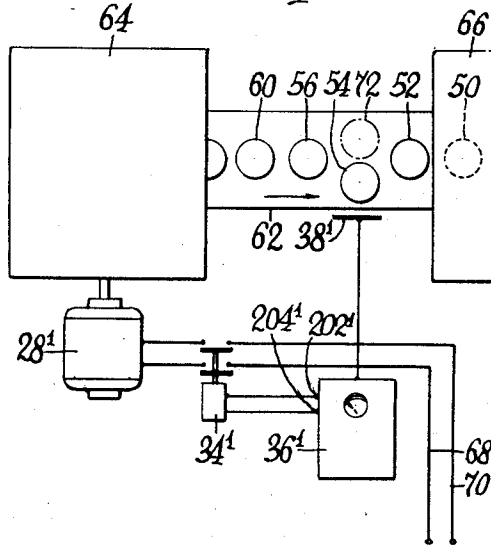
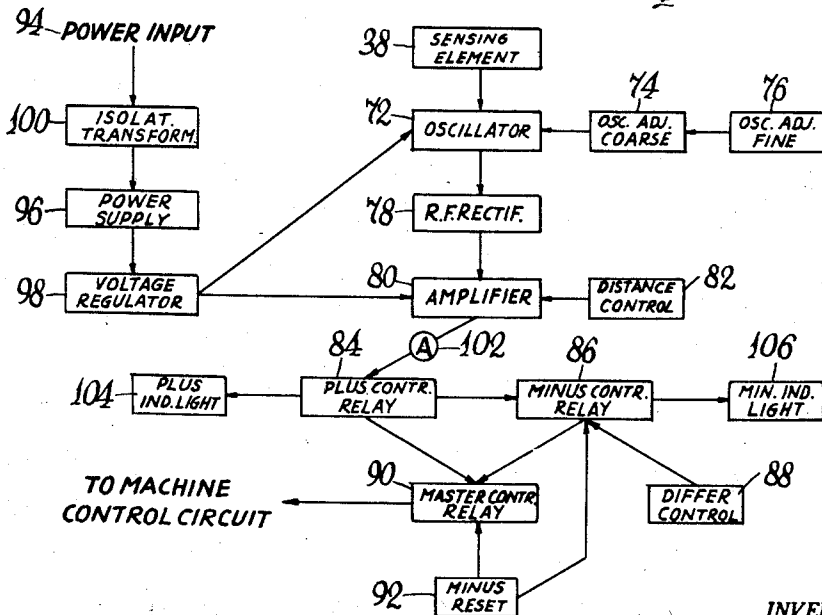


FIG. 3.



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CAPACITY OPERATED APPARATUS

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10 Claims. (Cl. 317-146)

This invention relates to capacity operated apparatus and more particularly to improved apparatus having sensitivity to a change in a capacitative field such as may be caused by the presence or absence, position, or size of an object in that field.

There have been many proposals in the prior art pertaining to various kinds of guard arrangements, such as for a work forming press or the like, wherein the increase of capacity of an antenna to ground upon the introduction of a body, such as a workman's hand, into the field between the antenna and ground is used to alter the operation of an oscillator to which the antenna is connected so as to sound an alarm, stop the machine, or the like. It has been a general criticism of devices of such proposals that they are not sufficiently sensitive under all operating conditions, such as where the background capacity of the surrounding area is subject to change, or that they are overly sensitive to effects of dirt, atmospheric factors, and other variables thereby resulting in false alarm or machine stopping operations, or that they are so complex as to be expensive to manufacture and maintain and to be subject to unreliability arising out of their complexity. Accordingly, although the broad concept of operating a control by sensitivity to capacity of an antenna thereof to ground is old in the art, the practical utilization of such devices has been retarded by the foregoing characteristic difficulties.

In accordance with the present invention, improved capacity operated apparatus is provided which is sensitive not only to an increase of capacity to ground but also to a decrease thereof with an adjustable tolerance or range of capacities which is accepted as normal by the apparatus without actuation thereof, which range is precisely regulatable as to absolute value as well as to width or ratio of its maximum to minimum values for any particular adjustment. It is especially important that the apparatus of the invention combines the aforesaid high degree of flexibility and adjustability with unusual simplicity, thereby resulting in decreased cost of manufacture and maintenance and increased reliability.

On account of the high degree of adjustability characteristic of devices manufactured in accordance with the present invention, the invention may be embodied in many forms of apparatus, wherever the presence, absence, position or size of an object in a field within or adjacent to the apparatus is a condition upon which some action is desired to be predicated. For example the invention finds utility as a control in machinery where facilities of the invention will operate to stop the machinery upon the occurrence of an abnormal condition such as the entrance of a part of a workman's body into a danger area, in automatic process devices where it is required to sense the presence or condition of product pieces or the like for process control in accordance with automation techniques, and the like.

Accordingly, a major object of the invention is to provide an improved capacity operated apparatus.

Another object of the invention is to provide an ap-

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paratus as aforesaid which is sensitive to both increases and decreases in capacities detected while being of simple and reliable construction.

Still another object of the invention is to provide an improved apparatus as aforesaid having a high degree of adjustability and adaptability so as to be capable of employment in a wide variety of applications including operating situations subject to changes in requirements or in background conditions in the field to which the apparatus is sensitive.

Other objects of the invention will be apparent from the foregoing general discussion and the following description and claims, and from the drawings wherein:

Fig. 1 is a schematic diagram illustrating one typical employment of apparatus in accordance with the invention;

Fig. 2 is a schematic diagram of another typical employment of apparatus in accordance with the invention;

Fig. 3 is a block diagram of a capacity sensitive control device in accordance with the invention, such as illustrated in Figs. 1 and 2; and

Fig. 4 is a wiring diagram of a preferred actual circuit in accordance with the block diagram of Fig. 3.

Referring more particularly to Fig. 1 of the drawing, there is illustrated therein a typical work forming press 10 which is shown to include a ram 12 arranged to cooperate with an anvil 14 to open and close complementary dies 16, 18 in a conventional manner, thereby giving rise to a potentially dangerous situation wherein a workman might be injured by entrance into the area between the dies, or the machine or dies might be damaged should a piece of material other than an intended workpiece gain entrance therebetween. The machine is further shown to include a typical drive for the ram 12 such as an eccentric 20 operable through a combination clutch and brake 22 by a flywheel 24, gear driven at 26 by an electric motor 28. As is well known in the art, any of many control devices may be employed to commence and halt operation of the ram 12, and the control device 22 shown herein may, for example, be of the general kind shown in U.S. Patent 2,428,337 wherein the control device is operated by pneumatic pressure such as may be supplied by a line 30 from a pressure source 32 under the control of a normally closed solenoid valve 34. In such an arrangement, when the valve is open pressure will be admitted to the control device 22 and the ram will be operated by the continuous drive 28, 26, 24, and when the valve 34 is closed the clutch of the control device 22 will be opened and its brake will be set whereby operation of the ram will be brought to a halt, the pressure beyond the valve being, of course, bled off in any suitable manner after the valve is de-energized, such as through a normally open auxiliary port in the valve leading to the atmosphere for that purpose.

In accordance with the present invention a capacity operated device 36 as hereinafter described may be incorporated in the aforescribed work forming apparatus, the control device 36 including an antenna 38 which may be a rod shaped element mounted by insulators as shown at 40 about the danger area of the machine and so that the device 36 will be operable through wires 42, 44 to close the valve 34 upon departure of the capacity sensed by the antenna 38 from a specified range of values, as when the normal or background capacity is decreased by the absence of an object normally present in the field sensed by the antenna 38 or when the capacity sensed is increased by the presence of an object normally absent in that field.

In Fig. 2 of the drawing, another typical apparatus embodying the invention is illustrated diagrammatically, in which the invention is employed to carry out so-called "automation" techniques. In that figure a process is il-

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illustrated wherein a plurality of objects such as "tin" cans 50, 52, 54, 56, 60 are placed on a conveyor 62, having a driving motor 28', by a device indicated at 64 comprising one station of the apparatus. The cans are to be carried by the conveyor, as indicated by the arrow, to another station of the apparatus indicated at 66 where some operation, such as the filling of the cans or the like, is to be undertaken, which operation requires that the cans be properly aligned on the conveyor 62. As shown, one of the cans 54 is not in such proper alignment on the conveyor 62, which non-alignment is a condition to be detected. Accordingly, the apparatus includes an antenna or sensing probe 38', which in this case may conveniently be plate shaped, of a capacity operated control 36' in accordance with the invention. Thus the device 36' will be actuated by the improper proximity of the misaligned can 54 to its probe 38' to de-energize a relay, in this case a normally open electrical relay 34' to open the power supply line 68, 70 of the conveyor motor 28' so as to bring the conveyor to a halt until the misalignment is corrected. Alternatively, it will be understood that the signal supplied by the control device 36' may be utilized to initiate any other corrective procedure, such as for example the operation of a device (not shown) for correcting the misalignment automatically. Since the capacity operated control device of the invention is sensitive to an abnormal decrease in capacity as well as an increase thereof, the device 36' would be equally operative in the situation where a can is misaligned in a direction which places it abnormally distant from the probe 38', as indicated by the dotted showing at 72, as well as where the object is abnormally proximate to the probe as aforescribed.

Referring now to Fig. 3, a preferred embodiment of the capacity operated control 36 or 36' of the invention comprises the sensing element 38 (or 38') which is connected to control the R.F. output of an oscillator 72, the oscillator being provided with coarse and fine adjustments 74, 76 for use in set-up operations to adjust the influence of the sensing element on the oscillator in accordance with such factors as the size and shape of the sensing element utilized. The R.F. output of the oscillator is fed to an R.F. rectifier 78 which in turn supplies a rectified signal, corresponding to the level of the R.F. signal from the oscillator, to a two stage amplifier 80 having an amplification adjustment 82 which it will be seen in effect governs the minimum distance to which an object to be detected can approach the sensing element 38 without tripping, in this case de-energizing, the final output of the control.

The output of the amplifier 80 is connected to energize a pair of relays, named herein the "plus control relay" 84 and the "minus control relay" 86, these relays being a pair of electromagnetic relay devices connected in series and operable upon different levels of output of the amplifier 80, the plus control relay 84 being normally energized by the output of the amplifier 80 but being de-energized when the output of the amplifier drops in accordance with the drop of the R.F. output of the oscillator 72 when the capacity sensed by the probe 38 is abnormally high, and the minus control relay 86 being normally de-energized but being energized by a reverse sequence of events when the capacity sensed by the probe 38 is abnormally low. For adjusting the range of capacities which will be accepted by the apparatus without affecting the final output of the control 36, a difference control 88 is provided which adjusts the threshold of operation of the normally de-energized minus control relay device 86.

The final output of the device is under the control of a master control relay 90 which is connected to the plus and minus relays 84, 86 so as to be energized only when the plus relay 84 is energized and the minus relay 86 is simultaneously de-energized. The output circuit of the master control relay 90 may then be utilized to de-

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energize the circuit of the solenoid valve 34 of Fig. 1 or of the relay 34' of Fig. 2 or the like to effect a control function whenever the capacity sensed by the probe 38 is abnormally high or abnormally low.

Since in most applications the sensing of an abnormally low capacity is indicative of a situation calling for an adjustment or other specific attention, the minus control relay 86 is provided with a holding circuit which will maintain it in energized condition until the device is reset by a control indicated at 92. For example, if the background capacity sensed by the probe 38 in the work forming press of Fig. 1 is reduced such as by removal of a mass of metal from the probe area which was present when the device was set up, the fact that the minus control relay has a holding circuit which can be broken only by operation of the minus reset 92 will insure that the apparatus is reset before continued operation of the machine is attempted. Therefore accidental operation of the machine cannot be effected by restoration of a just normal amount of capacity as sensed by the probe 38, such as might be effected by the entrance of a workman's hand or the like which might just offset the previous abnormal decrease in sensed capacity. So that the minus reset control 92 cannot be used in an unauthorized manner to negative this safety feature, it is preferred that the reset control have a connection to disable the master control relay during the reset operation, as indicated in the drawing.

Also as shown in Fig. 3, the apparatus includes the usual features of a power input 94, a power supply or rectifier 96, and a voltage regulator 98 for supplying power to various components of the apparatus as indicated, it being preferred that an isolating transformer 100 be employed in the power input circuit. Also, the apparatus may include an ammeter 102 to indicate the output of the amplifier 80 as an inverse measure of the capacity sensed by the probe 38, and indicator lights 104, 106 to indicate the operating condition of the plus and minus control relays 84, 86.

Referring now to Fig. 4 of the drawings, the circuit outlined in the block diagram of Fig. 3 may include a power supply comprising the isolating transformer 100 connected to deliver power from A.C. line terminals 94-94 by lines 107, 108 to the power supply transformer 109, across the primary of which a network comprising resistors 110, 112 and condensers 114, 116 is connected to establish a ground at 118 for the isolated incoming A.C. circuit. The power supply transformer has the usual filament supply secondaries 120 and 122, one of the secondaries 120 providing filament energization for a full wave rectifier tube 124, the plate elements of which are connected to opposite sides of a condenser 126 and to opposite ends of the main secondary winding of the power supply transformer 109 as shown. The rectified output of the power supply is passed through a ripple filter comprising a resistor 128 and condensers 130, 132 to a first voltage regulator tube 134 in series with a second voltage regulator tube 136 for supplying various controlled voltages for operation of the several vacuum tubes of the apparatus to be enumerated.

The sensing element or antenna 38, which may be an elongate rod as indicated in Fig. 1 or a small plate (38') as represented in Fig. 2 is connected through an isolating condenser 138 to the control grid 140 of an oscillator tube 142 so as to load the feedback circuit of the oscillator to a variable degree in accordance with the capacity to ground sensed by the antenna or probe 38. This feedback and the tank circuit of the oscillator comprise an inductance 143, the upper half of which as shown comprises the tank coil of the oscillator while the lower half thereof comprises the feedback source therefor, and a tank condenser 144. The tank circuit is coupled to the oscillator grid by coupling condensers 74, 146 one of which 74, is variable to provide coarse tuning of the oscillator. Another variable condenser 76 is connected in

parallel with the sensing element 38 to ground as shown to provide fine tuning of the sensitivity of the oscillator to the capacity detected by the probe. Also as shown, the oscillator circuit includes a grid bias resistor 152 and a plate supply including a choke coil 154 and a voltage dropping resistor 156 providing a D.C. voltage from a point between the two voltage regulator tubes 134, 136. A pair of condensers 158, 160 bypass the R.F. from the oscillator plate to ground.

The useful output of the oscillator is taken from its cathode to the cathode of an R.F. rectifier tube 162 connected to operate as a diode as shown and providing a rectified signal at its grid which is passed through a filter comprising a resistor 166 and condensers 168, 170 arranged to bleed R.F. to ground, the D.C. output being delivered to a potentiometer arrangement provided by resistors 82, 172, the variable tap one of which 82 comprises the distance control of the apparatus, in effect controlling the output of the amplifier (80) to which it is connected. In the circuit of Fig. 4 the amplifier comprises a first amplifier tube 174 the grid of which is connected to the potentiometer 82, this tube being connected in cascade arrangement with another tube 176 as shown, the output of the first stage of amplification being taken from the plate of the amplifier tube 174 and delivered to the control grid of a second amplifier tube 178. The tube 176 receives plate voltage through a resistor 180 and acts as a load for the first amplifier tube 174, operating to cut off if the common filament of the tubes 174, 176 should fail, a high resistance 182 being connected to provide bias for this purpose. Also, a cathode bias resistance 184 is provided for the tube 176 to limit the current through the cascade combination. As shown, the second stage amplifier tube 178 is provided with a screen grid voltage dropping resistor 186, and the output at the plate of the second stage amplifier and the screen grid of that tube are provided with bypass condensers 188, 190 to ground.

The current of the amplified output is measurable by the ammeter 192 connected in that circuit, which also includes the operating coil of the plus control relay 84 and normally includes the operating coil of the minus relay 86 in parallel with the difference control 88 comprising a variable resistor as shown in series with a fixed resistor 192. The parallel combination of the minus relay 86 coil and the shunt circuit of the differential control 88 thereacross is connected through a ripple filter arrangement comprising a condenser 194 and a resistor 196 to the power supply at the rectifier tube 124 as shown.

Since it is desired that the normally energized plus relay 84 have a low threshold of operation, a small relay device is used for this purpose having but a single normally open contactor 198 which controls an A.C. operable relay 200, the operating coil of which is connected in series with the contactor 198 across the A.C. supply provided by the secondary of the isolating transformer 100 as shown. Accordingly, insofar as the schematic block diagram of Fig. 3 is concerned, the A.C. relay 200 forms an auxiliary part of the plus relay 84.

From the foregoing it will be seen that with the coarse and fine adjustments 74, 76 properly set for giving the sensing probe 38 a control action over the level of oscillation of the oscillator tube 142, an amplified D.C. signal corresponding to the level of oscillation as modified by the setting of the distance control potentiometer 82 will be fed through the plus and minus control relays 84, 86, and when the background capacity sensed by the probe 38 is that to which the device has been set up, the aforesaid signal from the amplifier will be operable to maintain the plus relay 84 energized while it will be insufficient to energize the minus relay 86. In defining the upper limit of capacity which will be tolerated at

the probe 38 while maintaining the plus and minus relays in the aforesaid normally energized and de-energized condition, the distance control 82 is employed, which correlates the capacity sensed by the probe 38 with the current passing through the coil of the plus control relay 84 so that this current can be reduced or increased, as the case may be, to the threshold of operation of the plus relay 84 in the presence of the maximum capacity to be tolerated. So also, it will be seen that the shunt circuit of the differential control variable resistor 88 provided across the energizing coil of the minus relay 86 is operable to determine the part of the current of that parallel circuit which passes through the coil of the minus relay 86 so as to adjust the effective threshold of effective energization of the minus relay device so that the value of the current delivered to this parallel combination which is necessary for energization of the minus control relay 86 may be varied at will to provide an adjustable difference between the amplifier current necessary to energize the plus relay 84 and the higher amplifier current necessary for energization of the minus relay 86.

The contacts of the master control relay 90 are connected in series between the output terminals 202, 204 of the control device and the secondary of the isolating transformer 100 as shown to energize the controlled apparatus as at terminals 202, 204 in Fig. 1 or 202', 204' in Fig. 2 when the normally open relay 90 is energized. Accordingly, in the illustrated embodiment of the invention, the contacts of the master relay 90 are shown to be normally open, although it will be understood that this relay could equally well be a normally closed type where required by the circuit to be controlled. As shown the coil of this relay 90 is connected across the secondary of the isolating transformer 100 by a controlled circuit consisting of wire 206, through a normally closed contact 208 of the minus relay 86, through a line 210 and a normally closed contact 212 of the minus reset push button 92, through a line 214 and a normally open contact 216 of the auxiliary plus relay 200 to a line 218. Thus it will be seen that when the minus relay 86 is de-energized and the plus relay 84 is energized so as to energize the auxiliary plus relay 200, the master relay 90 will be energized.

On the other hand, if the plus relay 84 is de-energized, the contact 198 thereof will be opened and the foregoing circuit will be broken at the contact 216 of the relay 200, and if the minus relay 86 is energized, the foregoing circuit will be broken at its normally closed contact 208. When the minus control relay 86 is energized, another contact 220 of this relay is connected to close a holding circuit for the relay 86 through a resistor 222, through which circuit the coil of the relay 86 is connected between the voltage supply and ground as shown. Accordingly, once the minus control relay 86 is energized the device cannot be returned to normal condition until the reset push button 92 is actuated, disconnecting the coil of the minus relay 86 from the circuit at a normally closed contact 224 of the push button, and connecting a resistor 226 in place thereof through a normally open contact 228 of the push button. Since the circuit of the master control relay 90 is in series with a normally closed contact 212 of the push button as aforesaid, the push button cannot be used to negative the effect of operation of the minus relay 86 for unauthorized operation of the apparatus at a time when the capacity sensed by the probe 38 is low, under which condition the minus relay 86 would be energized were not its circuit broken by the push button.

In addition to the ammeter 102, a further aid to determining the capacitive condition sensed by the apparatus both in set up operations and also where an actuation of the apparatus is a signal of a particular condition in the capacitive field, the plus and minus indicator lights 104, 106 are provided as shown, these lamps being normally connected through corresponding resistors 230, 232

across the filament winding 122 of the power transformer 109 whereby they draw insufficient current to glow brightly. For operation of the lamps, the current limiting resistors 232, 230 are connected to be shorted out through a normally closed contact 234 of the minus control relay 86 and a normally open contact 236 of the auxiliary plus control relay 200, as by a line 238 and a line 240, respectively, and a common line 242. Also, as shown in the drawing, extra contacts are provided on relays 86 and 200 for effecting such additional control operations as may be desired.

Typical components of the circuit of Fig. 4 may be as follows:

Part No.:

222	47K ohms/1 w. carbon resistor, 10%
182	10 megohms/½ w. carbon resistor, 10%
184	240 ohms/1 w. wire wound resistor, 10%
88	50K ohms/½ w. carbon potentiometer, 5%
192	10K ohms/½ w. carbon resistor, 10%
180	27K ohms/1 w. carbon resistor, 10%
226	9K ohms/10 w. wire wound resistor, 10%
82	250K ohms/2 w. carbon potentiometer, 10%
172	100K ohms/½ w. carbon resistor, 5%
186	33K ohms/1 w. carbon resistor, 10%
166	470K ohms/½ w. carbon resistor, 10%
156	4.7K ohms/1 w. carbon resistor, 5%
196	240 ohms/1 w. wire wound resistor, 10%
128	2K ohms/10 w. wire wound resistor, 10%
152	100K ohms/½ w. carbon resistor, 5%
230	82 ohms/1 w. wire wound resistor, 10%
232	82 ohms/1 w. wire wound resistor, 10%
110	220K ohms/½ w. carbon resistor, 10%
112	220K ohms/½ w. carbon resistor, 10%
168	.022 mf./600 v. D.C. paper condenser
188	.022 mf./1000 v. D.C. paper condenser
190	.005 mf./600 v. D.C. disc condenser
170	.022 mf./600 v. D.C. paper condenser
194	20 mf./450 v. D.C. electrolytic condenser
130	20 mf./450 v. D.C. electrolytic condenser
132	40 mf./450 v. D.C. electrolytic condenser
160	.005 mf./600 v. D.C. disc condenser
158	.005 mf./600 v. D.C. disc condenser
138	560 mmf./500 v. D.C. ceramic condenser neg. temp. coef.
146	50 mmf./500 v. D.C. ceramic condenser zero temp. coef.
74	250 mmf./variable condenser
76	25 mmf./variable condenser
144	100 mmf./500 v. D.C. ceramic condenser zero temp. coef.
126	1 mf./660 v. A.C. oil-filled condenser
114	.022 mf./1000 v. D.C. paper condenser
116	.022 mf./1000 v. D.C. paper condenser
154	.5 mH./50 ma. choke coil
143	50 wind. CT oscillator coil
124	5Y3 GT power rectifier tube
134	OA2 voltage regulator tube
136	OB2 voltage regulator tube
142	12AY7 R.F. oscillator and R.F. rectifier tube
162	
174	5814-A amplifier tube
176	
178	5654 amplifier tube
200	115 v. A.C./3 PDT auxil. plus relay
84	7200 ohms/SPST plus relay
86	7600 ohms/3 PDT minus relay
109	Pri. 100-130 v./60 cy. Sola constant voltage transformer
	Sec. 600 v. CT/6.3 v. CT/5 v.

From the foregoing it is believed that the operation of the apparatus described will be clear. The oscillator adjustments 74, 76 will ordinarily be used only in adapting the apparatus to relatively fixed parameters, such as the size and shape of the probe 38 used and the conditions

of background capacity determined by the environment of the probe. However, should that background capacity increase or decrease substantially, as by addition or removal of a conductive mass from the environment which was present when the oscillator was tuned, the plus or minus control relay, respectively, will react, and the oscillator will have to be tuned to new environment. In normal use, with an unchanging environment, the distance control 82 will be used to adjust the sensitivity to increases in capacity, as may be caused by approach of an object to be detected, and the difference control 83 will be used to determine the extent of the tolerance to downward change in capacity, as by recession of such an object.

While only two arrangements embodying the invention have been shown and described in detail, it will be understood that the invention is not limited thereto but may otherwise be embodied within the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value higher than that of a second of said relay means, and master relay means connected in circuit with the outputs of said first and second relay means to be operatively energized only when said first relay means is operatively deenergized and said second relay means is operatively energized.

2. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value higher than that of a second of said relay means, and master relay means connected in circuit with the outputs of said first and second relay means to be operatively energized only when said first relay means is operatively de-energized and said second relay means is operatively energized, said first relay means including holding circuit means connected to maintain the same operatively energized once so energized.

3. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value different from that of a second of said relay means, and master relay means connected in circuit with the outputs of said first and second relay means to be operatively energized only when one of said relay means is operatively energized and the other of said relay means is operatively de-energized.

4. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, a pair of relay means having inputs connected in series in circuit to be operable in accordance with an output of said oscillator, the

threshold of operative energization of a first of said relay means being a value different from that of a second of said relay means, and output circuit means connected in circuit with the outputs of said first and second relay means to be operative when one of said relay means is operatively energized and the other of said relay means is operatively de-energized, one of said relay means including locking means connected to prevent reversal of the operating condition thereof after it has passed between operatively energized condition and operatively de-energized condition once.

5. In a capacity operated control device, a capacity field sensitive antenna, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value different from that of a second of said relay means, and master relay means connected in circuit with the outputs of said first and second relay means to be operatively energized only when one of said relay means is operatively energized and the other of said relay means is operatively de-energized.

6. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, a pair of relay means having inputs connected in series in circuit to be operable in accordance with an output of said oscillator, the threshold of operative energization of a first of said relay means being a value different from that of a second of said relay means, and output circuit means connected in circuit with the outputs of said first and second relay means to be operative when one of said relay means is operatively energized and the other of said relay means is operatively de-energized, one of said relay means including locking means connected to prevent reversal of the operating condition thereof after it has passed between operatively energized condition and operatively de-energized condition once, and reset means adapted to release said locking means and to disable said output circuit means simultaneously.

7. In combination with an apparatus having a danger area, a capacity field sensitive antenna arranged to guard said area, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value higher than that of a second of said relay means, and master relay means connected in circuit with the outputs of said first and second relay means to be operatively energized only when said first relay means is operatively de-energized and said second

relay means is operatively energized, said first relay means including holding circuit means connected to maintain the same operatively energized once so energized.

8. In combination with an apparatus having a danger area, a capacity field sensitive antenna arranged to guard said area, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value higher than that of a second of said relay means, and master relay means connected in circuit with the outputs of said first and second relay means to be operatively energized only when said first relay means is operatively de-energized and said second relay means is operatively energized, said first relay means including holding circuit means connected to maintain the same operatively energized once so energized, and holding circuit release means connected to disable said holding circuit and said master relay means simultaneously.

9. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, variable gain amplifier means connected in circuit with an output of said oscillator, a pair of relay means having inputs connected in series with an output of said amplifier means, the threshold of operative energization of a first of said relay means being adjustable to a value different from that of a second of said relay means, and output circuit means connected in circuit with the outputs of said first and second relay means to be operative when one of said relay means is operatively energized and the other of said relay means is operatively de-energized.

10. In an apparatus having an operating condition to be detected characterized by a change in configuration of one side of a capacitative field, an antenna defining the other side of said field, an oscillator connected to said antenna to be controlled thereby, a pair of relay means having inputs connected in circuit to be operable in accordance with an output of said oscillator, the threshold of operative energization of a first of said relay means being a value different from that of a second of said relay means, and output circuit means connected in circuit with the outputs of said first and second relay means to be operative when one of said relay means is operatively energized and the other of said relay means is operatively de-energized.

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