

United States Patent

[11] **3,609,739**

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**[54] ALARM AND DETECTION SYSTEMS
COMPRISING ELECTRICAL CONDUCTIVE
COATING
3 Claims, 4 Drawing Figs.**

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340/276, 340/285 |
| [51] | Int. Cl..... | G08b 13/00,
G08b 13/04 |
| [50] | Field of Search..... | 340/273,
274, 276, 285; 338/308, 309; 117/201, 211;
118/10 |

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ABSTRACT: An alarm system for protection against unauthorized intrusion which comprises a closed electric circuit and an alarm responsive to a break in said closed circuit and further comprising a four-leg bridge circuit wherein each leg of the bridge comprises a different resistive portion of said closed circuit or comprises a nonresistive value to balance any part or all of an unused leg of said bridge. A plurality of high gain amplifiers are each associated with a different pair of legs of said bridge circuit and each amplifier is attached to detect a change in the resistive value of said leg pairs and to produce a current in response to said change, which current actuates said alarm. This alarm system makes virtually impossible the compromising of the alarm system by shunting any terminals of any switch, actuator, connecting leads, or entrance or exit terminals of any surface to be protected.

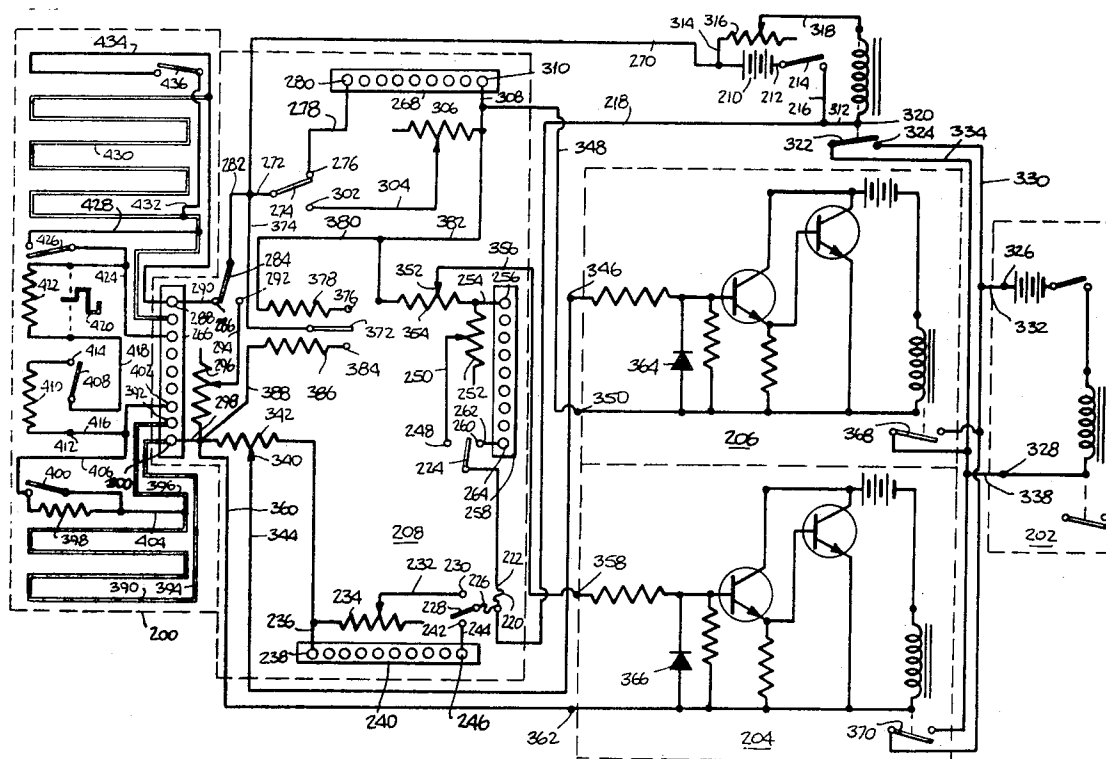


Fig. 1.

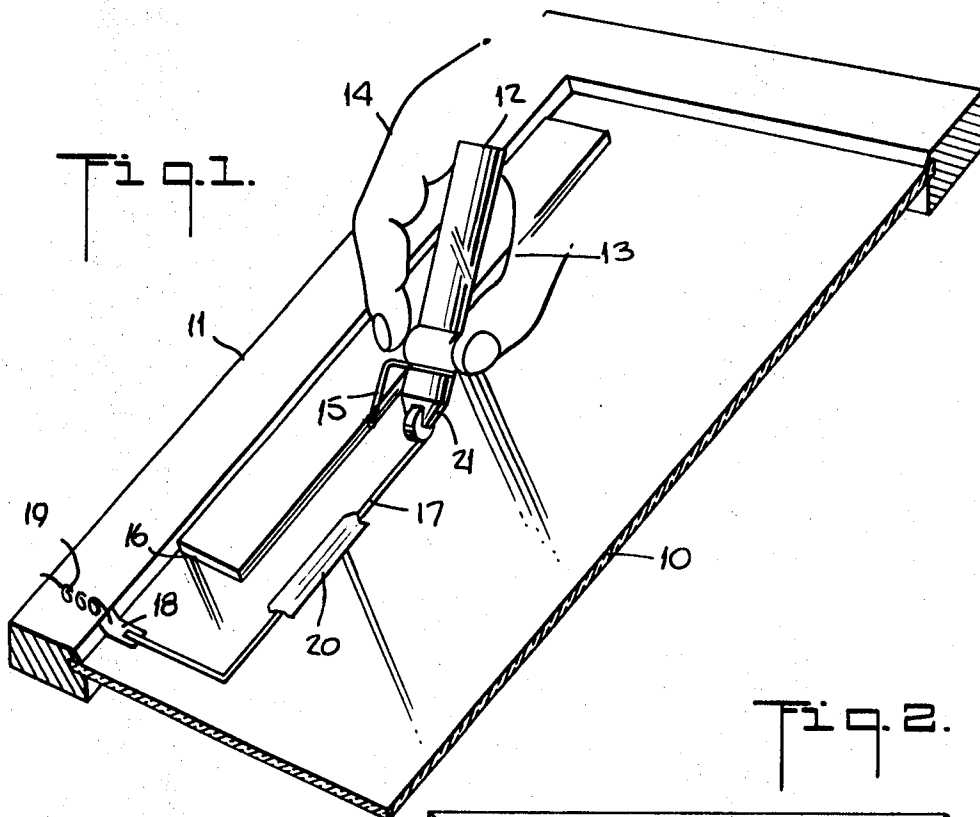
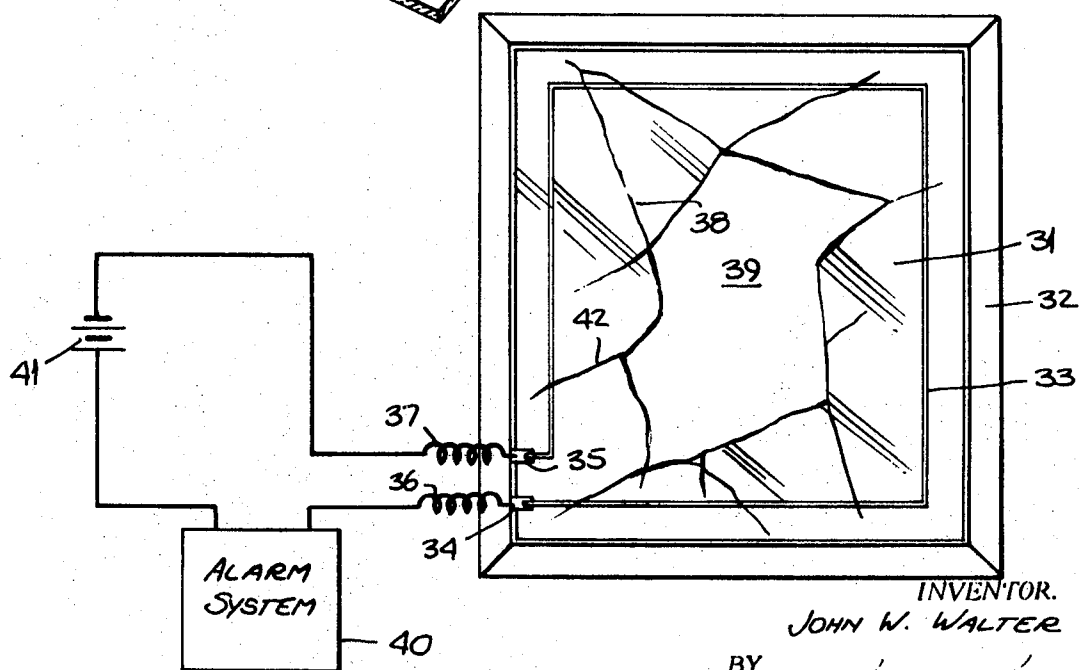


Fig. 2.



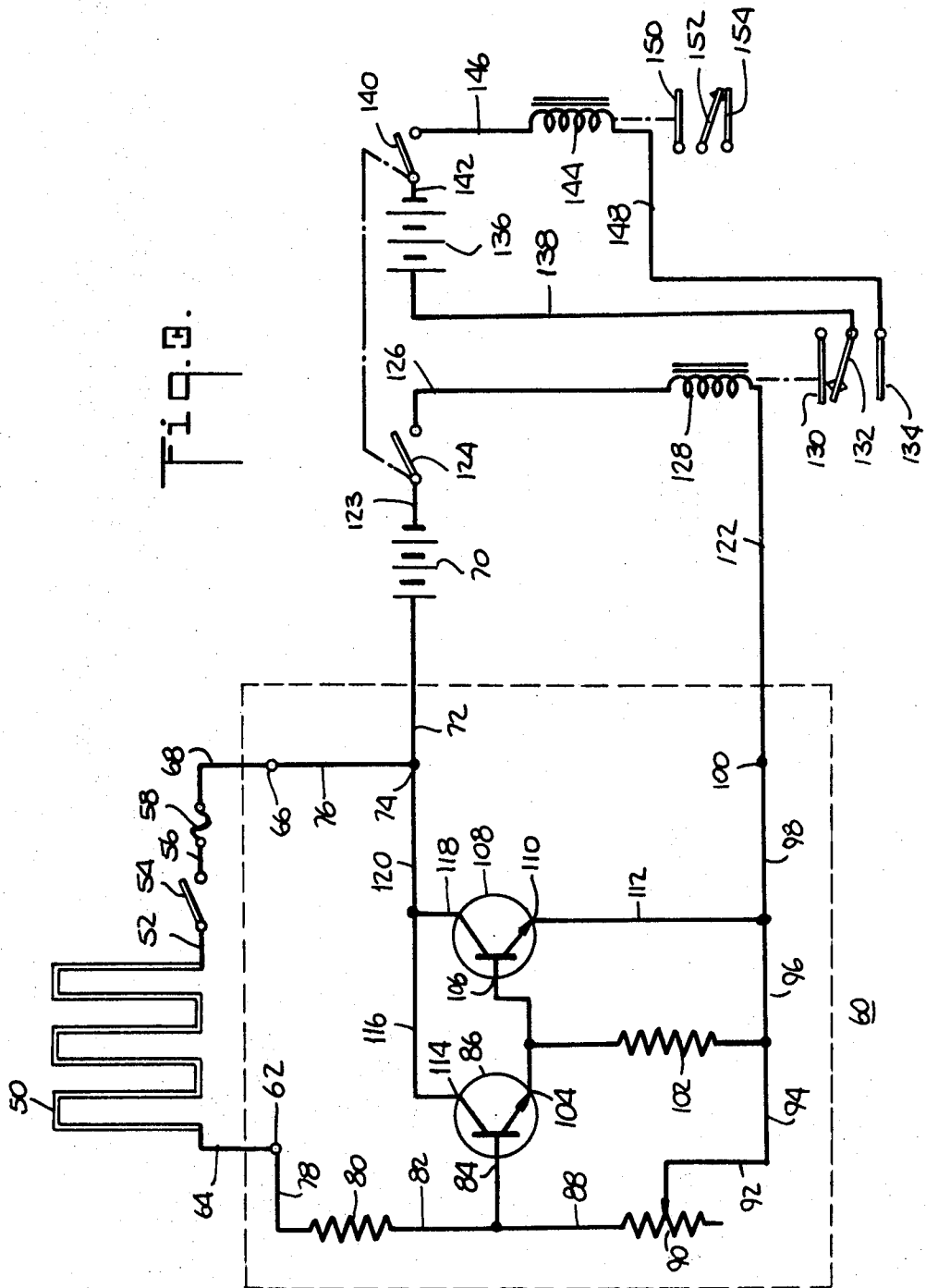
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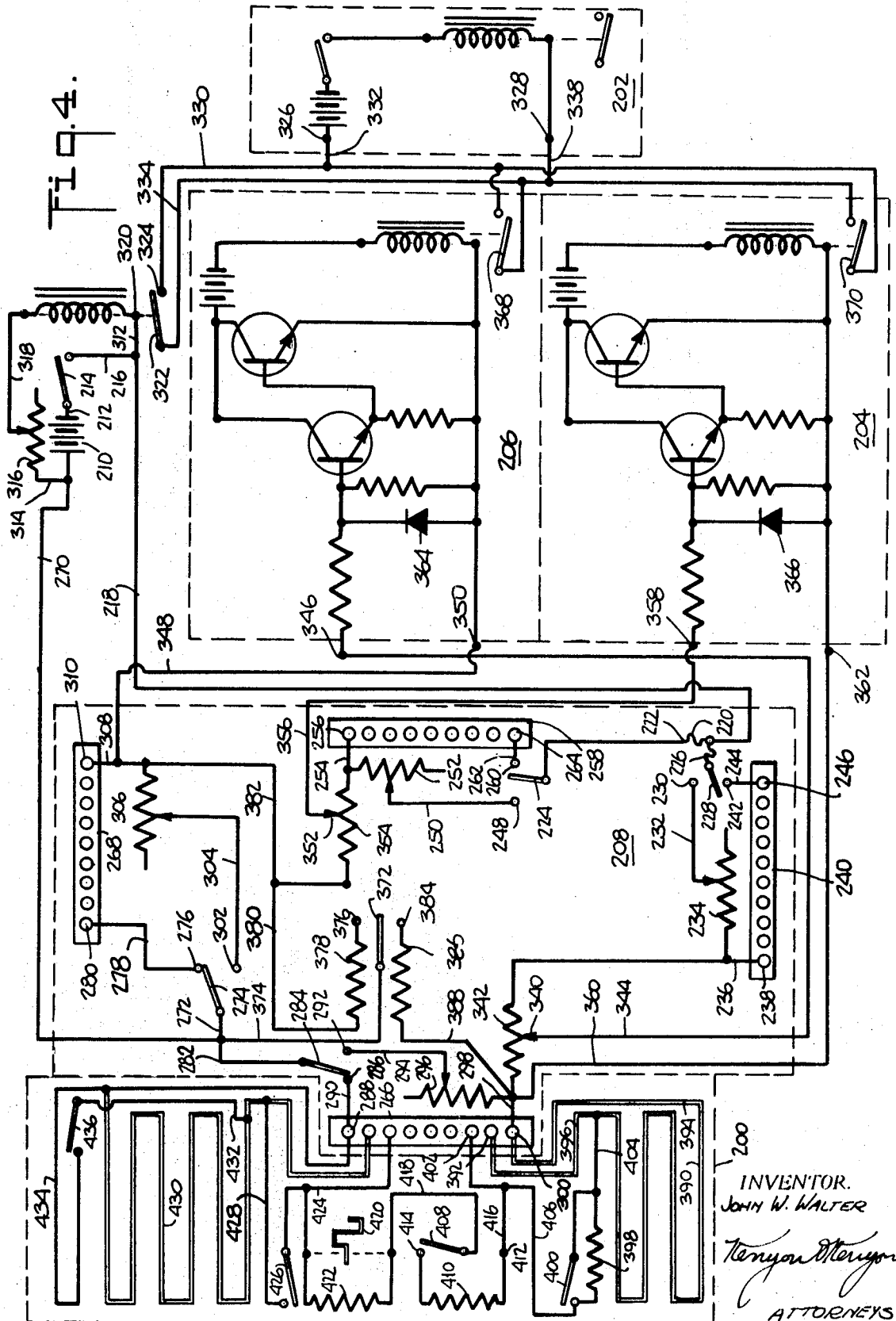
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ALARM AND DETECTION SYSTEMS COMPRISING ELECTRICAL CONDUCTIVE COATING

FIELD OF THE INVENTION

This invention relates to an improved method and system for the protection of glass and other surfaces by detecting breakage and/or intrusion by unauthorized means that is substantially tamper- and defeatproof, as well as easier to apply and less obtrusive.

DESCRIPTION OF THE PRIOR ART

In prior systems, the process for protection of window and wall areas was complex and time-consuming, and was as follows: For protection of window and other types of transparent and translucent areas, guide lines must be made with tailor chalk or similar marking material on the surface, near the outside borders, to insure an even line of appearance. Then a coat of clear varnish, or similar material, is applied to the surface along the guide lines as a bonding agent. The varnish is allowed to dry about 15-30 minutes until it becomes tacky. Lead foil, usually three-eighths inch wide and no less than 0.0015 inch thick with a negligible electrical resistance is then pressed against the varnish, carefully following the guide lines made previously. Another thickness of foil is folded back about 2 inches at all places where electrical connections are to be made to the foil to prevent the solder from melting through the foil. After all the foil has been applied, the excess varnish must be wiped from the surface with a clean rag saturated with turpentine or similar solvent; usually after waiting at least 20 minutes for the foil to first become more adherent to the surface. Finally, a final coat of clear varnish or similar material is applied over the foil, extending about one-eighth inch to ¼ inch past the outside edges of the foil to complete the bond to the surface and provide some protection to the foil from accidental damage by window cleaners, etc. For protection of nontransparent, translucent areas the process is basically similar, except guide lines and care in cleaning off the excess varnish generally is not necessary since a final coat of regular pigmented paint or wood or other type of panelling is normally applied over the foil.

In these types of prior art systems, it was possible for skilled, unauthorized personnel to cut a hole in the glass and either enter through the hole if the pane of glass is large enough, or if not, by attaching jumperwires, with alligator or similar fasteners to the foil and/or the wires connecting to the foil, and enter by shunting out the foil and then widening the hole. Because of the relative thickness (minimum 0.0015 inch) of the foil, fractures and small cracks in the glass do not cause the foil to break; but it takes an actual shift in the position of the glass itself, in addition to the fracture, to split the lead foil and thereby set off the alarm. In those areas where the building code requires special shatterproof glass, the problem that there must be an actual shifting of the glass to cause the foil to break is especially acute. Also, the relatively large width of the foil (approximately three-eighths inch wide) makes this prior art type of protection quite objectionable and unsightly when applied to windows, especially those of the colonial and double hung type, in residential systems. Also, the thickness of the foil presents a sufficient enough profile on the window glass to tend to catch fingernails and window cleaning utensils while in the process of cleaning the window, creating the possibility of ripping, tearing, or otherwise unconsciously damaging the foil.

The prior art common practice then, in the burglar alarm industry, as described above, is a lengthy process of applying relatively thick, wide, unsightly, strips of lead foil to the surfaces to be protected which are unfortunately able to be shorted out by those experienced in such matters, thereby rendering the system to which it is connected useless.

Heretofore, the prior art processes used to coat glass surfaces, with electrically conductive coatings in other industries, were involved with the use of the coating for heating purposes in order to melt ice and snow for windshields, as disclosed in Letters Pat. Nos. 2,710,900; 2,877,329 and 3,063,881 and

again, for coating electronic tubes as disclosed in Letters Pat. No. 2,280,135, all of which involve substantial heating and baking of the glass, which, when used for windows, would require the glass to be removed from the window frame. Another method used involves repeatedly impacting the surface with the conductive material in the form of pellets, as disclosed in U.S. Letters Pat. No. 2,817,603, which also involves removing the glass from the frame.

SUMMARY OF THE INVENTION

In my invention, I provide an elongated strip of electrical conductive coating composition adherently applied to a pane of glass or other body. Said strip is comprised in a closed circuit of an alarm system which includes means for actuating an alarm responsive to a break in said closed circuit. Further said strip (a), substantially reduces the time and effort required to apply; (b), is somewhat decorative instead of unsightly; (c), is extremely sensitive to even minute cracks, thereby making it very difficult to cut around; and (d), capable of having a prearranged detectable resistance which renders compromising the system by unauthorized means virtually impossible.

It is therefore an object of my invention to provide a novel method of application of electrically conductive material, capable of containing prearranged resistances, if desired, by varying the width, thickness and/or relative conductivity of the coating to ordinary window glass, which will be easy to apply without the necessity of removing the glass from the frame, which will be extremely thin, very narrow and unobtrusive, thereby making it extremely sensitive to hairline cracks in the glass, and thus making it very difficult to cut around without first cracking the glass.

It is another object of my invention to provide a novel method of application of an electrically conductive material to translucent and opaque nonconductive surfaces without the necessity of removing the surface from its housing, which will be very susceptible to fracture of the base surface, be easy to apply, and be capable of containing prearranged resistances, if desired.

It is further an object of my invention to provide apparatus, for inclusion in an electrical circuit, which is capable of detecting and amplifying an electrical signal which has passed through this electrically conductive painted striping to sufficient amplitude so as to be able to operate the standard type of commercially available supervisory type alarm systems and/or capable of controlling any other type of electrically controllable system and/or device.

It is another object of my invention to provide apparatus for inclusion in an electrical circuit, which is capable of detecting and amplifying minute changes in the resistance of the electrically conductive painted striping to sufficient amplitude so as to be able to operate the standard type of commercially available supervisory type alarm system or any other electrically controllable system or device, which eliminates the possibility of an attempt to defeat or otherwise tamper with the striping by means of a shunt.

These and other objects and advantages of my invention will become apparent from a reading and consideration of the description hereinbelow in connection with the drawings, in which:

FIG. 1 is a fragmentary perspective view showing the process of applying the electrically conductive coating;

FIG. 2 shows partially schematically, and partially pictorially, a view of a typical glass window which has been coated with the electrically conductive paint which is connected to an alarm or detection system;

FIG. 3 is a schematic drawing of a security alarm system utilizing my apparatus for detection of an electrical signal after it has passed through the electrically conductive coating; and

FIG. 4 is a schematic drawing of a security alarm system utilizing my apparatus for detection of minute changes in the resistance of the electrically conductive coating.

DETAILED DESCRIPTION

The electrically conductive material, which is used in my invention, consists of finely ground particles of silver suspended with a bonding agent in an acetone solvent used as a carrier to form a silver lacquer. The silver can be replaced with any other good electrically conductive material such as copper, aluminum, nickel, gold, etc., which is capable of being ground to a fine enough state for easy application. In addition, various partial conductors, such as carbon, may be added to the solution to increase its electrical resistance. The color of the lacquer, after drying normally, resembles the color of the original metal used, i.e., a silver base will be silver in color. Although the color and opaqueness of the dried lacquer is considered a feature in that it will be noticed by a would-be intruder and have the effect as a warning and deterrent, the lacquer may be made more transparent by using organic conductive materials, metallic oxides and clear epoxy resins, to partially or completely replace the silver in the solution. Other solvents, such as turpentine, benzine, alcohol, water, etc., may be substituted for the acetone as a carrier depending upon the characteristics of the conductive material and bonding agent. The final result then is to obtain an electrically conducting lacquer type solution for use as a paint with a viscosity, application, and drying time approximating that of ordinary fingernail polish and also being able to add as impurities partial and/or nonconducting materials to the solution to increase, if necessary, its electrical resistance. Some of the commercially available lacquers which can be used in my invention are those made for use in repairing printed circuits. For example, such a lacquer is a silver suspension in a liquid coating solution composition which is manufactured by General Cement Manufacturing Company, Rockford, Ill. under the trade name Silver Print. Other lacquers which can be used in my invention are those made for use as conductive bonding agents. For example, such a lacquer is a silver suspension in a liquid coating composition comprising an organic resin base and a volatile solvent manufactured by Emerson & Cuming, Inc., Canton, Mass. under the trade name Eccocoat CC-2.

Referring now to the drawings, there is shown in FIG. 1 a cutaway perspective view of an ordinary pane of window glass 10 mounted in a wooden frame 11 as is usually found in windows and doors. A paint striping tool 12 is shown half filled with the electrically conductive lacquer 13 and held by the hand 14. A guide arm 15 is placed along a ruler or straightedge 16 which is used to guide the striping tool along in a straight line. The striping tool is placed on the glass and moved along with a slight pressure against the glass and the straightedge, thus producing a thin strip 17, approximately one-sixteenth inch wide, of the electrically conductive material. The strip 17 is applied to the glass 10 in a continuous line and at the termination of both ends it is directed off the pane of glass 10 by cementing a small piece of tinned copper or lead foil 18 to the wooden frame 11 and onto the glass 10, extending a minimum of three-fourths inch and then painting the strip 17 directly overlapping the lead foil 18 a distance of one-fourth inch. The strip 17 is then widened and thickened to a minimum width of one-fourth inch with a small paint brush all along the edge of the lead foil on the edge where the painted strip connects to the foil; this insures the best possible electrical connection between the strip 17 and the foil 18. The circuit is completed by soldering a separate insulated wire 19 to the foil at both terminations and connecting it to the alarm system as described in FIGS. 2, 3 and 4. Although using the striping tool 12, described above, is the fastest and most accurate way of applying a straight thin regulated line, an artist's fine paint brush may be used instead, for hard to reach places or over abnormally rough surfaces, such as pebble glass or fluted glass. A spray of aerosol may also be used by masking off the areas not to be painted; likewise, a paint roller, cut down to a small width, may also be substituted for the striping tool 12. After applying the electrically conductive strip 17 to the glass any excess and/or overlaps in making corners may be easily trimmed off with a razor blade so that the end result is a

neat looking thin strip with square or mitered corners. The method suggested above for connecting a wire 19 to the strip 17 may be varied by soldering the insulated wire 19 directly onto the piece of lead foil 18 which has been cemented on the glass 10 only without running the foil onto the wooden frame. This is especially useful when the frame 11 is made of metal instead of wood where the foil 18 would have to be insulated from the metal frame. If the window, which has been striped, will be subject to high humidity or frequent cleaning a protective coat of commercially available clear varnish 20 may be applied over the electrically conductive strip 17 and its foil connections 18 for a distance of approximately one-eighth inch on either side and completely covering the strip 17. This clear coating 20 will seal out moisture and form a hard protective coat over the strip 17 which will protect it from minor scratches from sharp objects. The normally preferred width of the electrically conductive strip 17 is one-sixteenth inch; however, this can be varied by changing the knurled wheel applicator 21 on the striping tool 12 to produce widths from one thirty-second inch to one-fourth inch. By doubling up a second strip directly alongside and touching the first strip, larger widths are possible. The normal preferred thickness of the electrically conductive strip when applied with the normal viscosity, as mentioned above, is 0.0003 inch (3 millionths of an inch thick). At this thickness even small hairline cracks will rupture the strip. The thickness of the strip may be changed by adding more solvent to the solution, thereby making a thinner mix. The electrical resistance of the normal electrically conductive strip, made from a pure silver lacquer with the viscosity or ordinary nail polish, which is applied on a glass surface in the method described above which has a width of one-sixteenth inch and a thickness of 0.0003 inch is 2.0 ohms per lineal inch. This resistance can be easily increased or decreased as desired by changing the width and thickness of the strip and/or adding semi- or nonconductive impurities into the solution, as described above.

FIG. 2 shows a plan view of a typical window 32 in which the glass 31 has been broken with the glass missing in the center 39. The electrically conductive strip 33 has been applied and connections to an alarm system 40, shown schematically, have been made through wires 36 and 37 connected to the lead foil connectors 34 and 35 in the manner described in FIG. 1. Power to the system furnished by battery 41.

The electrically conductive lacquer 33 is applied in the manner described in FIG. 1 to all glass and/or other nonconductive fractureable surfaces which are to be protected against unauthorized intrusion. The circuit is connected with wires 36 and 37 in series (continuous loop) as will be further described in FIGS. 3 and 4 to the alarm system 40. If any of the fractureable surfaces are tampered with, first a tiny hairline crack 42 will form and run to the nearest outside edge of the base surface. When this crack passes through the electrically conductive strip 33 the subsequent minute separation of the fractureable surface will cause the extremely thin (0.0003 inch) strip 33 to split. In prior art systems where, instead, relatively thick (0.0015 inch) lead foil is cemented to the fractureable surface a hairline crack would not split the foil because of its larger tensile strength. Actually a regular complete crack in the surface in the majority of cases will not split the prior art foil; it is only when the position of the glass is changed under the foil, after the crack is made as when the glass falls away from the foil under its own weight, that the foil is torn. Thus in the situation where a building code or other circumstance require the use of shatterproof glass, my invention might be the only method of unauthorized entrance detection. In my invention then, the thin electrically conductive strip 33 has a very low tensile strength and is split easily when the surface to which it is applied is fractured in any way; whereas, in prior art systems the foil must be actually torn or sheared by the fracture to be effective. In prior art systems, because of the requirement that the foil be torn or sheared, it was possible for those skilled in the art to carefully remove sections of the glass that were cracked but did not touch the foil and to enter through the

hole 39 (if large enough) or to short out the foil by connecting a single wire shunt connecting the two foil connectors 34 and 35, thus compromising the system and then breaking out the rest of the glass 31 and entering through the enlarged hole.

Referring now to FIG. 3 the electrically conductive painted strip 50 schematically represents all such strips on all the protected areas in the system, connected in the series. One end of the continuous strip 50 is connected by wire 52 to switch 54. Switch 54 represents all such switches throughout the system, connected in series. Switch 54 is connected by wire 56 to fusible thermolink 58. Fusible thermolink 58 represents all such thermolinks throughout the system connected in series. This series circuit just outlined is typical of the components which are used as sensing devices in the system. These sensing devices control and drive a high gain amplifier 60 which is schematically shown within the dashed box. One end of the electrically conductive strip 50 is connected to terminal 62 of the high gain amplifier 60 by wire 64 and one end of the fusible thermolink 58 is connected to terminal 66 of the high gain amplifier 60 by wire 68. Thus, in this manner, the sensing devices of the system are connected together in series and are connected to the high gain amplifier 60.

The series circuit just outlined between terminals 62 and 66 represents all the components which are used as sensing devices and which control and drive the amplifier 60 by placing a positive potential, from the positive terminal of battery 70 via wire 72, to terminal 74, via wire 76 to terminal 66 through the aforementioned series circuit terminating at terminal 62, via wire 78, through resistor 80, via wire 82, to the base 84 of transistor 86; via wire 88 through variable resistor 90; via wires 92, 94, 96 and 98 to terminal 100.

Resistor 102 is connected from the junction of wires 94 and 96 to the emitter 104 of transistor 86 and also to the base 106 of transistor 108. The emitter 110 of transistor 108 is connected by wire 112 to the junction between wires 96 and 98. The collector 114 of transistor 86 is connected by wire 116 to the collector 118 of transistor 108 and also by wire 120 to terminal 74 and by wire 72 to battery 70.

The high gain amplifier 60, which is capable of detecting small signal levels passing through the electrically conductive strip 50, is connected to a standard alarm system through terminals 74 and 100. The standard alarm system consists of a source of power shown as the battery 70 which is connected at its negative terminal to an on/off switch 124 by wire 123. The on/off switch 124 is connected by wire 126 to one terminal of a sensitive trouble relay 128. The other terminal of the relay 128 is connected by wire 122 to terminal 100 of the amplifier 60.

When a sufficient current flows through trouble relay 128, contact 130 is energized. When contact 130 is energized, movable contact 132 is constrained into electrical connection with contact 130. When no current flows through trouble relay 128, contact 130 is not energized. When contact 130 is not energized, movable contact 132 is to be constrained in the normal position in electrical connection with contact 134. When movable contact 132 is in electrical connection with contact 134, a closed alarm circuit is formed. This used alarm circuit comprises a power source shown as battery 136 which has its positive terminal connected to movable contact 132 by wire 138 and which has its negative terminal connected to an on/off switch 140 by wire 142. The on/off switch 140 is connected to an alarm relay 144 by wire 146 and the alarm relay is connected to contact 134 by wire 148. When the alarm circuit thus described is closed, i.e. when movable contact 132 is in electrical connection with contact 134, and on/off switch 140 is in the closed position, an electric current will flow through the alarm relay 144. When a current flows through the alarm relay 144, contact 150 will be energized and thus contact 152 will be constrained in electrical connection with contact 150. When no current flows through alarm relay 144, the movable contact 152 will be in its normal position in electrical connection with contact 154. When current flows through alarm relay 144 and thus movable contact 152 is in

electrical connection with contact 150, a circuit (not shown) will be closed which will cause a bell, buzzer or other alarm mechanism to actuate.

In connection with the preceding detailed description of FIG. 3, the operation of the alarm system depicted therein will now be described. Before turning on the system, all the switches in the system (represented by switch 54) will be in a closed position, i.e. all windows, doors, etc. with switches must be closed and furthermore the strip 50 must be unbroken. The system is then turned on by closing switches 124 and 140. These switches are shown connected by a dashed line to illustrate that they may be connected together. The positive terminal of battery 70 is connected by wire 72 to terminal 74, via wire 76, to terminal 66, via wire 68 through fusible link 58, via wire 56, through switch 54, via wire 52, to the conductive strip 50. At this point the electrical resistance contained in the aforementioned components is quite negligible, possibly amounting to a maximum of about 1,000 ohms depending on the lengths of the wires and the number of switches; therefore a significant amount of current of the battery 70 appears at the junction of wire 52 and strip 50. However, as the current passes through the thin strip 50 its value begins to fall because of the inherent resistance of the strip 50 which normally amounts to approximately 2 ohms per lineal inch of strip for a strip one-sixteenth inch wide and 0.0003 inch thick made from a pure silver lacquer. As the total length of the strip in a normal alarm system usually amounts to more than 2,000 lineal inches, this would amount to a total resistance of more than 4,000 ohms and this resistance would not permit enough current to flow through the circuit to energize contact 130 by trouble relay 128 if connected to it by running a wire from terminal 62 directly to the trouble relay 128 as is the normal case in prior art system which use strips of lead foil of minimal electrical resistance instead of the electrically conductive strip used in my invention.

It is therefore necessary to use an amplifier/detector 60 which is capable of amplifying the reduced signal after it has passed through the strip 50. Continuing the circuit then; this diminished signal from strip 50 appears via wire 64, at terminal 62, via wire 78, through current limiting resistor 80, (which protects transistor 86 from being overdriven on small series loop systems which have a total resistance which is too small, then via wire 82 to forward bias the base terminal 84 of transistor 86. An adjustable reverse negative bias of the base 84 is provided via wire 88, through variable resistor 90, via wires 92, 94, 96, 98 to terminal 100, via wire 122 through trouble relay 128 via wire 126 to switch 124, via wire 123 to the negative terminal of battery 70. This high resistance adjustable bias controls the sensitivity of the amplifier 60 and by decreasing the resistance of the variable resistor 90, the transistor 86 will become less forward biased and will therefore conduct less current and by increasing the resistance of the variable resistor 90 the transistor 86 will become more forward biased and will therefore conduct more current. Thus, the amount of current flow through trouble relay 128 can be accurately set. The current and forward bias at the base 84 of transistor 86 will turn on the transistor 86 and allow current to flow via wires 96 and through resistor 102 to the emitter terminal 104 of transistor 86, then through the emitter 104 and to the positive potential appearing at the collector 114 of transistor 86. This current flow which appears at emitter terminal 104 of transistor 86, also appears at base terminal 106 of transistor 108. This current flow is directly proportional to and of higher value than the current appearing at base terminal 84 of transistor 86. This increased current flow at the base 106 of transistor 108 causes the transistor 108 to fully turn on and creates a current flow starting from the negative terminal of battery 70 via wire 123 through switch 124, via wire 126, through trouble relay 128, via wire 122 to terminal 100, via wires 98 and 112, to emitter terminal 110 of transistor 108, through transistor 108 to collector terminal 118 of transistor 108, via wire 120 to terminal 74, via wire 72 to the positive terminal of battery 70. This current flow is of suffi-

cient quantity to energize contact 130 by trouble relay 128 and thereby keep contacts 132 and 134 open. Whenever there is a break, momentary or permanent, in any of the components of the closed circuit loop between terminals 62 and 66, the positive potential will no longer appear at base terminal 84 of transistor 86 and instead a negative potential will appear at the base 84 by way of the bias resistor 90 which will reverse bias the transistor 86 to cutoff thus stopping the current flow through trouble relay 128 so that contact 130 will no longer be energized to keep contacts 132 and 134 open and thus an alarm condition is caused. Relay 128, which is shown located outside the amplifier 60 for remote operation, may instead be located between the junction of wires 116 and 120 and the collector terminal 118 of transistor 108. This will result in a slightly higher gain of the amplifier 60. Furthermore, in systems where the total resistance of the series loop is less than 0.2 megohms, transistor 108 and its associated wiring and resistor 102 are not needed since transistor 86 will produce enough current gain to energize contact 130 by relay 128.

FIG. 4 illustrates a further embodiment of FIG. 3 which adds a measure of sophistication to the amplifier/detection process and makes the compromising of the continuous series loop system described in FIG. 3, by using an ordinary wire to shunt any of the electrically conductive strip 50 and/or closed circuit switch 54, virtually impossible. This is achieved by creating prearranged electrical resistances at each window and door switch and by using the inherent resistance which can be developed in the electrically conductive strip by varying the width and chemical composition of the conductive lacquer. It is the inherent resistance and the ability to add additional resistance to the electrically conductive coating that makes possible this sophisticated tamperproof system. Prior art systems comprising lead foil glass protection have no provision for such variable resistance, therefore making it impossible to prevent unauthorized shunting of the foil by intruders. It may be seen by a reading of the following description that when my system is properly installed and balanced there will be no possible way to shunt the terminals of any switch, actuator, connecting wire, and/or entrance and exit terminals of any surface on which the electrically conductive strip has been applied.

FIG. 4 schematically illustrates a typical continuous loop series circuit with prearranged resistances enclosed in a dashed box and designated generally at 200. The continuous loop series circuit 200 represents the sensing portion of the alarm system. An alarm annunciator means is enclosed in a dashed box and is designated at 202. The alarm means 202 is the same as was fully described in connection with the alarm means shown in FIG. 3. Two amplifier detection units are enclosed in dashed boxes and are designated generally at 204 and 206. A terminal block is enclosed in a dashed box and is designated generally at 208. The terminal block 208 is a modified Wheatstone bridge circuit. The power supply for the terminal block 208 comprises a battery 210 which has its negative terminal connected via wire 212 to on-off switch 214, via wires 216 and 218 to fuse 220, via wire 222 to zone switch 224 and simultaneously via fuse 226 to zone switch 228. The two zone switches 224 and 228 are not necessary for the proper operation of the system but are a further embodiment which allows the operator of the alarm system to disconnect a complete leg of the Wheatstone bridge terminal block 208, for example, by closing switch 228 into electrical connection with contact 230 thus transferring the power via fuse 226 via wire 232 to variable resistor 234 via wire 236 to terminal 238 of terminal strip 240. Terminal strip 240 represents a patch board to which are connected the switches and resistances which will make up one leg of the Wheatstone bridge terminal block 208. This bypasses the normal situation where the power is connected via fuse 226 to switch 228 to contact 242, via wire 244 to terminal 246 of terminal strip 240. Similarly, the other leg of Wheatstone bridge terminal block 208 may be disconnected by closing switch 224 into electrical connection with contact

248 transferring the power via wire 250 to variable resistor 252, via wire 254 to terminal 256 of terminal strip 258. Terminal strip 258 represents a second leg of the Wheatstone bridge terminal block 208. This bypasses the normal situation where the power from lead 222 is connected via zone switch 224 to contact 260, via wire 262 to terminal 264 of terminal strip 258.

The terminating wires of series loop circuit 200 (not shown) are connected to terminals 246 and 238 on bridge leg terminal strip 240 and to terminals 264 and 256 on bridge leg terminal strip 258. The extra terminals on the bridge terminal strips 240, 258, 266 and 268 are used for ease in running wires to the alarm contact switches and conductive strips, as will be described in the description of the loop circuit 200.

The positive terminal battery 210 supplies power via wires 270 and 272 to zone switch 274. Zone switch 274 can connect to contact 276 (as shown) transferring the power via wire 278 to terminal 280 on terminal strip 268. Similarly, power is also supplied via wires 270 and 282 to zone switch 284. Zone switch 284 can come into electrical connection with contact 286 (as shown), transferring the power via wire 290 to terminal 288 on terminal strip 266. Zone switch 284 can also transfer the power from wire 282 to contact 292, via wire 294 to variable resistor 296, via wire 298 to terminal 300 of terminal strip 266; further, zone switch 274 can also transfer the power from wire 272 to contact 302, via wire 304 to variable resistor 306, via wire 308 to terminal 310 of terminal strip 268. The two zone switches 274 and 284 serve the same functions as zone switches 224 and 228 described above.

The condition of the battery 210 is constantly supervised by relay 310 via wires 312 and 216 to switch 214, via wire 212 to battery 210, via wire 314 to variable resistor 316 and finally via wire 318 returning to relay 310. The variable resistor 316 is adjusted so that the current flow through relay 310 will be just enough to energize contact 320 and thus keep movable contact 322 from coming into electrical connection with contact 324. When the battery 210 begins to lose power the current flow through relay 310 will not be enough to energize contact 320 and movable contact 216 will come into electrical connection with contact 324, thus completing the connection between alarm terminals 326 and 328 via wires 330, 332, 334 and 338, and thus creating an alarm condition of battery weakness.

Current to drive the amplifier/detector 206 is obtained from the center terminal 340 on variable resistor 342, via wire 344 to terminal 346 of amplifier 206. Negative bias for the amplifier/detector 206 is obtained from terminal 310 on terminal strip 268, via wires 308 and 348 to terminal 350 of amplifier 206. Variable resistor 342 connects terminal 238 on terminal strip 240 with terminal 300 on terminal strip 266.

Similarly, current to drive amplifier/detector 204 is obtained from the center terminal 352 of variable resistor 354 via wire 356 to terminal 358 of amplifier 204. Negative bias for the amplifier/detector 204 is obtained from terminal 300 on terminal strip 266, via wires 298 and 360 to terminal 362 of amplifier 204. Variable resistor 354 connects terminal 256 on terminal strip 258 with terminal 310 on terminal strip 268.

The amplifiers 206 and 204 are exactly the same as the amplifier 60 shown in FIG. 3 and described supra, except for the addition of diodes 364 and 366, and the reversal of trouble relay contacts 368 and 370 from contact 132 of FIG. 3. The diodes 364 and 366 are inserted to drain off any excess or surge in current entering the amplifier/detectors 206 and 204. Since the amplifier/detectors 206 and 204 will normally be in a static position as will be explained infra, the relay contacts 368 and 370 are set oppositely from relay contact 132 shown in FIG. 3 so that they switch current only when the amplifier/detector is activated.

A battery test switch 372 is connected via wires 374 and 270 to the positive terminal of battery 210. The switch 372 is a spring return center switch. When switch 372 comes into electrical connection with contact 376 positive voltage is conducted through resistor 378 via wires 380, 382 and 308 to ter-

terminal 310 on terminal strip 268. By closing switch 372 in this manner when the alarm loop circuit 202 has been set, a high resistance shunt is connected across the two terminals 280 and 310 of Wheatstone bridge leg terminal strip 268 which therefore connects resistor 378 in parallel with the alarm loop circuit (not shown). The resistor 378 is calculated to be just low enough to cause a sufficient imbalance in the right side of the bridge circuit to operate amplifier/detector 204 because of the lower resistance in the leg of the Wheatstone bridge represented by terminal strip 268. This lower resistance is caused by the high resistance shunt connected in parallel with said leg. This then will test power supply circuit which contains battery 210 as well as the battery shown in amplifier/detector 204 by imparting the smallest possible signal upon the amplifier 204 under optimum battery conditions which will be just enough to cause an alarm condition. Similarly when battery test switch 372 is connected to contact 384 a positive voltage is placed through resistor 386, via wires 388 and 298 to terminal 300 on terminal strip 266. This high resistance shunt creates the same imbalance condition on the left side of the bridge circuit as explained supra in regard to the right side of the bridge circuit and will cause an alarm condition via amplifier/detector 206 when switch 372 connects with contact 384 if the batteries are at acceptable strength. As either battery falls below its calculated minimum acceptable strength, the signal produced will not be great enough to cause an alarm condition when the switch 372 connects with either contact 376 or 384, thus indicating the time to change the battery (ies). However, even under this low battery condition a low resistance wire shunt made by an unauthorized intruder will cause a greater imbalance in the bridge circuit and will cause an alarm condition.

The closed circuit series loop designated generally at 200 is illustrative of one of many possible configurations of the conductive strips, resistances and switches which may be found in the system. A schematic representation of the electrically conductive strips with added resistance, shown at 390, is connected between terminals 300 and 392 on terminal strip 266 by wires 394 and 396; resistor 398 is connected in parallel with normally closed switch 400. Switch 400 is connected between terminals 392 and 402 by wires 396, 404 and 406. Terminals 392 and 402 are used for patch board purposes only and for ease in connecting the circuits and for testing purposes and are not necessary to the operation of the system. Switch contact 408 is part of a single pole double throw switch with resistor 410 concealed inside the switch and connected between contacts 412 and 414. Wire 416 is connected to normally closed contact 412 and wire 418 is connected to common movable contact 408. Temperature sensing switch 420 is normally open and resistor 422 is connected in parallel and concealed inside said switch and is connected to the circuit by leads 418 and 424. Switch contact 426 is normally an open switch which can be held in the closed position and connected to the circuit by leads 424 and 428. A schematic representation of an electrically conductive resistive strip 430 is connected by wires 432 and 434 in parallel with normally closed switch contact 436 which can be held in the open position (as shown) and which connects via wire 434 to terminal 288 on terminal strip 266. The above then comprises a complete electrical path connected in series with specified resistances added to the circuit and switches which when released will either break the circuit, as in switch 426, or will shunt out a resistance in the circuit, as in switches 400, 420 and 436. Switch 408 will first break the circuit and then shunt out resistor 410 for a double effect.

Describing further the representative series loop 200: When the resistors are concealed in the switches it prevents a would-be intruder from knowing that the circuit is a resistance type circuit, however, the resistors will be just as effective electrically if they are not concealed but are connected to the switch terminals on the outside of the switch. In either case a shunt across the terminals with a wire or another resistor will effectively change the resistance of the circuit enough to cause an

alarm condition. Single pole-double throw switches with resistors connected in the manner of switch 408 are the most effective for confusing an intruder because it acts as a closed circuit switch with a resistance in series with it, yet when shunted out across the terminal it acts as a switch with a resistance in parallel, and when the switch is activated it first breaks the circuit and then shunts out the resistor 410. The electrically conductive strip can be mixed and applied with a large enough resistance to cause an alarm condition when as little as 5 lineal inches is shunted out by unauthorized persons. The electrically conductive strip can have enough resistance in itself to be used in place of the resistors used in conjunction with the switches.

The systems of FIG. 4 is turned on by closing switch 214 which supplies power from the negative terminal of battery 210 to the Wheatstone bridge shown generally as 208 via wire 212, 216 and 218 to fuse 220, via wire 222 to switch 224 and simultaneously via fuse 226 to switch 228; the positive terminal of battery 210 completes the circuit via wires 270, 272 to switch 274 and simultaneously via wire 282 to switch 284. The power is applied to the bridge circuit 208 by closing zone switches 224, 228, 274 and 284. This delivers the power to the series loop circuit 200; via terminal 246 on terminal strip 240, via wire 244 and contact 242; via terminal 264 on terminal strip 258 via wire 262 and contact 260; via terminal 280 on terminal strip 268 via wire 278 and contact 276; and via terminal 288 on terminal strip 266 via wire 290 and contact 286. This then comprises the input to the bridge circuit 208. The output of the bridge circuit 208 is obtained from the center terminals 340 and 352 respectively of variable resistors 342 and 354 respectively via wires 344 and 356 respectively to terminals 346 and 358 respectively of amplifiers 206 and 204 respectively; and also from bridge terminals 310 and 300 respectively, via wires 308 and 298 respectively, via wires 348 and 360 respectively to terminals 350 and 362 respectively of amplifiers 206 and 204 respectively.

In order to keep the initial bridge circuit in balance each terminal strip bridge leg: 240, 258, 266 and 268 must be wired so that each series loop to which they are connected will have a total impedance which is as close as possible to each of the others. This is easily accomplished by adding a resistor to each leg of the bridge to make it equal the leg with the highest impedance. The final balancing of the system is done as follows: Two microammeters (not shown) are connected into the amplifier circuits; one in amplifier 206, and one in amplifier 204, connecting the battery to the relay winding. Variable resistors 342 and 354 are adjusted so that each meter measures a current with a level such that the input transistors of each amplifier will be slightly forward biased; not enough to turn on the transistor, but close to the threshold of doing so. This makes the amplifier extremely sensitive to any further increase in current flow in the bridge circuit; yet this level of current is a small enough drain on the amplifier batteries that it approximates their shelf life. Obviously the amplifiers may be made more or less sensitive to any change in impedance in the bridge circuit by adjusting the variable resistors 342 and 354—a higher reading on microammeter for more sensitivity or a lower reading for a lower sensitivity. When the meters in each amplifier read an equal amount of current usage, the bridge is in perfect balance and the meters are disconnected from the circuit and the system is ready for operation. Since each amplifier reacts only to a forward bias of its base as explained in the description of the amplifier 60 shown in FIG. 3, two amplifiers 206 and 204 are required to react to each opposite half of the bridge. If for any reason the impedance of any component part of any series loop changes (by a switch opening or closing; by the electrically conductive strip being ruptured, or by an intruder shunting out any component part of the loop including the lead wires); the Wheatstone bridge terminal block 208 will be in a state of imbalance and a forward bias will appear at the input terminals of one amplifier and a negative bias at the input terminals of the other. The amplifier with the negative bias will remain in a cutoff state; how-

ever, the other amplifier with the now increased forward bias condition will turn on and create an alarm condition. The lesser number of components per loop and the higher resistance per component, the more sensitive the bridge will be to a change in impedance. If necessary, additional bridge circuits may be added to the system to accommodate more total components for added sensitivity. Fuses 220 and 226 are sensitive low current fuses that will cause a break in the circuit whenever any component in the bridge is shunted to a high potential or ground, causing a bridge imbalance and thus an alarm condition. With the system just described herein in FIG. 4, it is quite feasible to construct a system so sensitive that an intruder who just touches any two exposed component terminals, lead-ins or electrically conductive striping takeoff terminal connections with his bare hands, thereby causing a high resistance shunt which will create enough impedance imbalance in the system to cause an alarm condition, therefore making it virtually impossible to tamper with the system.

I claim:

1. An alarm system for protection against unauthorized in-

trusion which comprises a closed electric circuit and an alarm responsive to a break in said circuit, further comprising:

a pair of two-leg resistance bridge circuits wherein a different resistive portion of said closed electric circuit is comprised in one or more legs of said resistance bridge circuits so that initially each leg of said resistance bridge circuits is of equal resistance, and

a plurality of high gain amplifiers each associated with a different pair of legs of said resistance bridge circuits; to detect a change in the resistive value of said leg pairs and to produce a current in response to said change which current actuates said alarm.

2. An alarm system according to claim 1 wherein at least one resistive portion of said closed circuit comprises a resistor which is hidden across the terminals of a switch and wherein said switch is adapted when opened to shunt out said resistor.

3. An alarm system according to claim 2 wherein said switch is adapted when opened first to break said closed electrical circuit and then to shunt out said resistor.

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