United States Patent

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[54] **AREA SECURITY CABLE COMPRISING STRAIN AND HEAT-RESPONSIVE NETWORK**
6 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **174/115,**
174/110 PM, 174/124 G, 340/227 C
[51] **Int. Cl.** **H01b 7/32**
[50] **Field of Search** ..... 340/227 C,
276, 285, 280; 337/414, 415; 73/154, 159; 338/26;
174/115, 113, 117.2, 102, 107, 105, 117

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ABSTRACT: An area security cable having a network of conductors such as a tamperproof wire screen or a tamperproof cable braid for use with an associated detection circuit. The screen can be part of an enclosure, and can comprise insulated wires connected to form one or more trigger circuits. The cable may comprise a signal carrying core jacketed by one or more braids of insulated wires which are connected with each other to form one or more trigger circuits. Some of the screen or braid wires are resistance wires and at least one is metal of low melting point. The cable also has an unbraided and untwisted wire of high tensile strength, and the screen or cable can have an additional wire not included in the trigger circuit and adapted to constitute the bulb of a resistance thermometer. The trigger circuits can be connected to an energized detector circuit such as an instrument movement and a bridge, whereby any breaking or shorting of one or more of the wires of the cable or screen will result in a response by the instrument movement. The resistance bulb wire can be connected to a temperature bridge so that cable or screen temperature can be read.

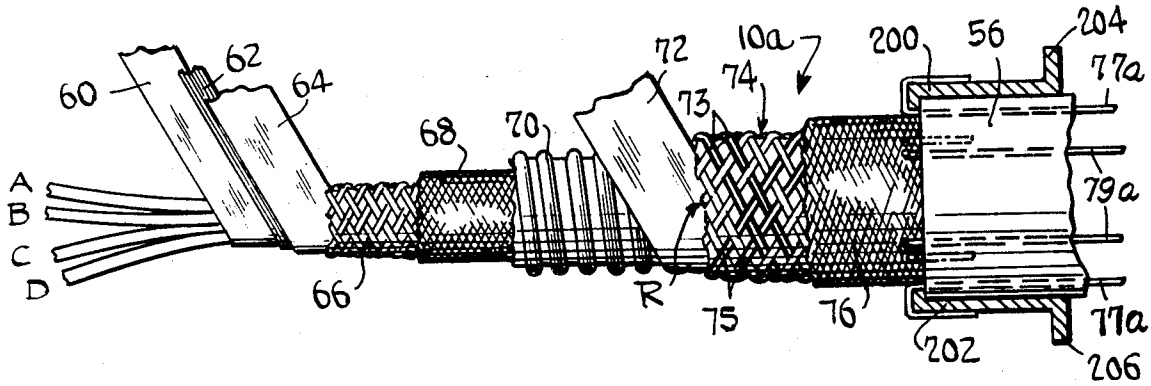


Fig. 1

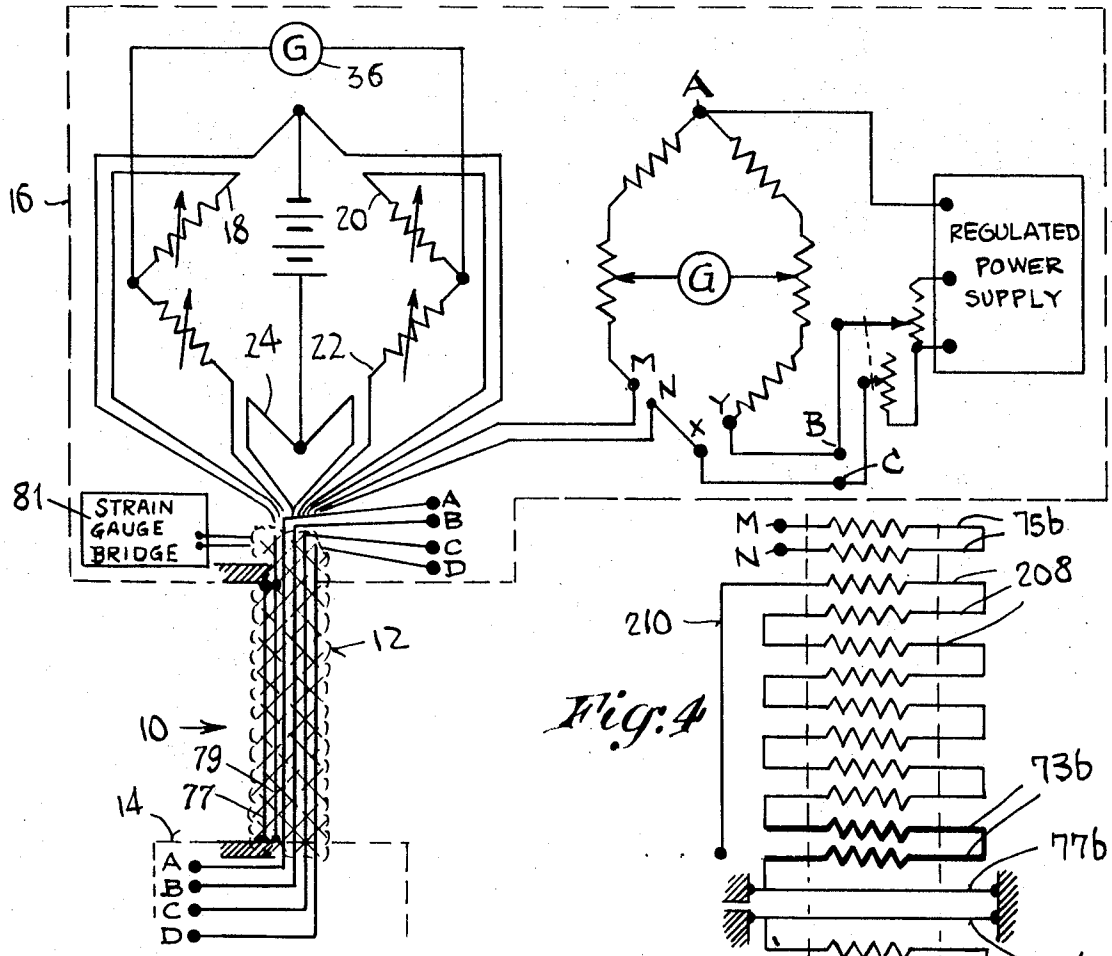


Fig. 4

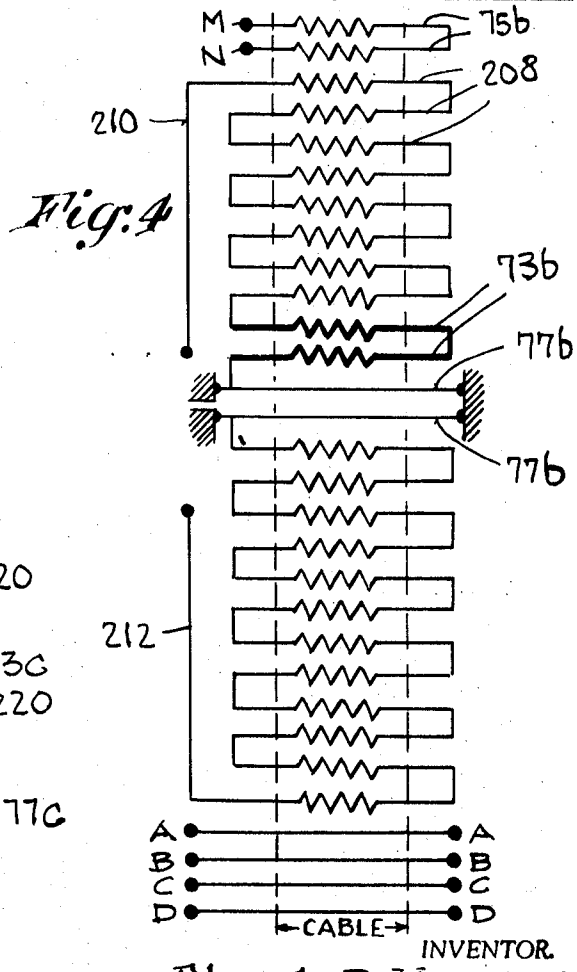


Fig. 5

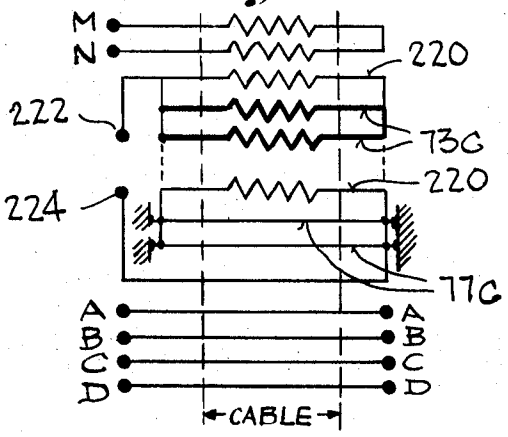
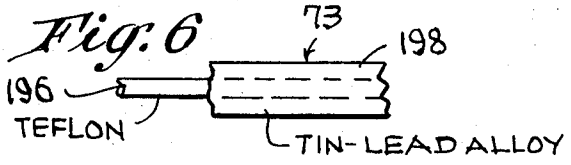
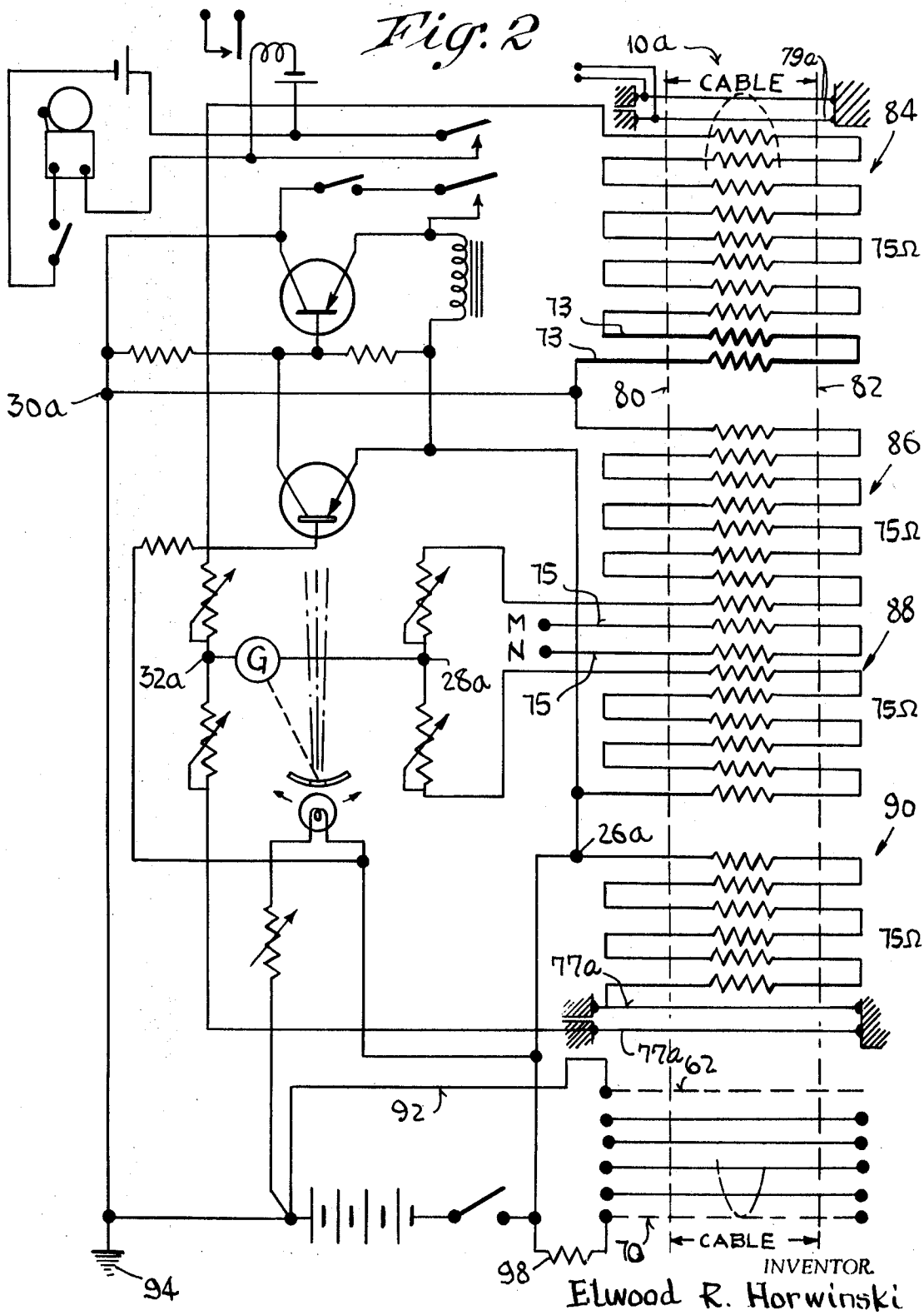


Fig. 6



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Fig. 2



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Fig. 3

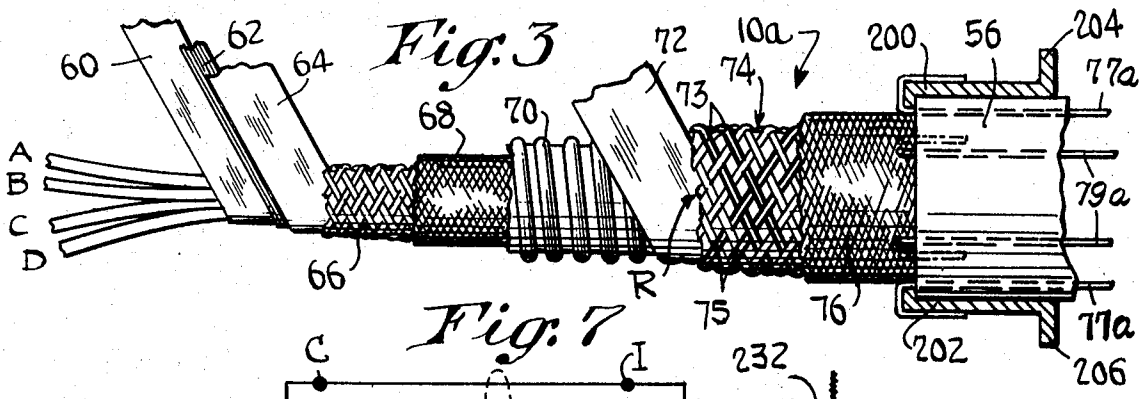


Fig. 7

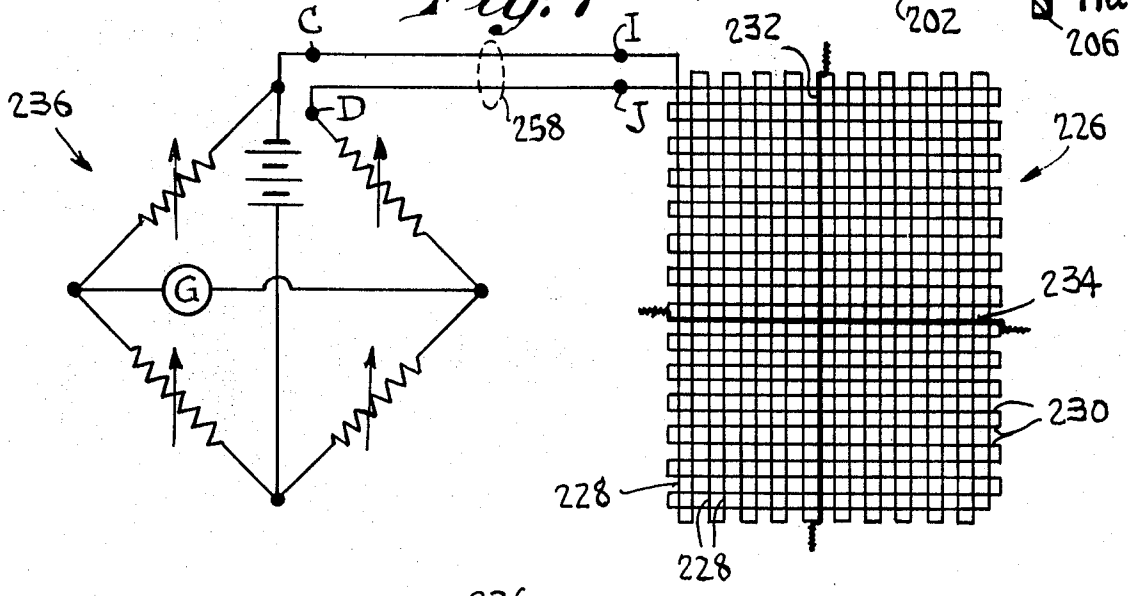


Fig. 8

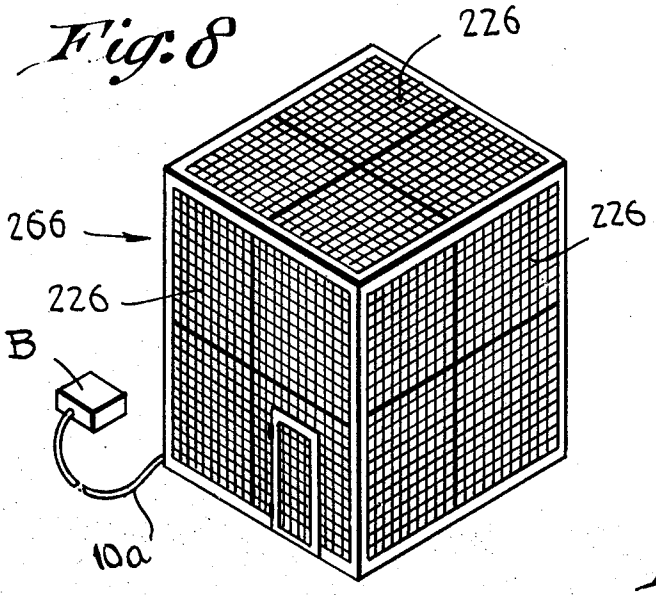
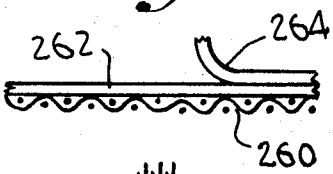


Fig. 9



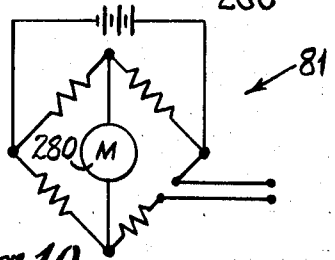


Fig. 10

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AREA SECURITY CABLE COMPRISING STRAIN AND HEAT-RESPONSIVE NETWORK

CROSS REFERENCES TO RELATED APPLICATIONS

Copending application of Conrad S. Ham and Elwood R. Horwinski, Ser. No. 780,931 filed Oct. 28,1968, entitled "-Printed-Circuit Type Security Apparatus For Protecting Areas," allowed on Jan. 5,1971 and having common ownership with the present application.

BACKGROUND

This invention relates to area security devices such as those which use screens or cables, whereby any tapping of or tampering with the screen or cable, or abnormal conditions of the same will be made known.

Heretofore various systems such as light or infrared beams, electric eyes, high or lethal voltage guards, cable armoring and the like have been utilized to safeguard restricted areas where unauthorized personnel were not desired or to safeguard cable wires. These systems have proved to be satisfactory in a number of instances, but drawbacks still existed. The high-voltage installations constituted a hazard and danger to workers and other authorized personnel in the area. Some prior systems were vulnerable to power failure, others could be defeated too easily by the use of more or less sophisticated equipment in the hands of an unscrupulous person, and most systems were restricted to certain specific conditions whereby other conditions were not covered.

SUMMARY

The above disadvantages, drawbacks and limitations of prior devices intended to guard restricted areas, protect cable wires and the like are obviated by the present invention, and one object is to provide an improved area or space security network and cable protection means for guarding both cables and restricted areas, which network and means are especially effective and resistant to efforts intended to defeat their purposes, including not only direct actions of unauthorized people but also actions involving fire, excessive stresses and the like. This is accomplished by the provision of a conductor network which may be in the form of wire braid in a cable, or in the form of a close-woven wire mesh constituted of crossing insulated wires, or in the form of a printed circuit grid, the wires or conductors being connected so as to form at least one continuous trigger circuit or preferably a plurality of such circuits, said circuit or circuits being capable of connection to an electrical detection device which will indicate any alteration of the circuit characteristics. The conductors are preferably of appreciable electrical resistance, and include at least one wire or conductor of low melting point, or a conductor of low ductility and high tensile strength, or both. There can also be included an isolated circuit comprising a conductor constituting the bulb of a resistance thermometer. The network comprising wire mesh, grid or braid is arranged to enclose the space being protected or guarded, as by applying it to walls, ceiling and floor surfaces and the like, or incorporating it in wall and other construction panelling, or in a cable as the case may be. For wall purposes, the wire mesh is fabricated to be essentially flat or planar. Other configurations such as the braid in the cable may be utilized, however, to suit particular situations. Excessive heat melts the conductor of low melting point. Excessive stress breaks the conductor of low ductility. Thus these conditions disrupt the trigger circuit, setting off an indication of abnormal conditions. Temperature readings are had by use of the conductor constituting the resistance bulb.

Other objects and advantages reside in an improved area security apparatus as above which lends itself well to existing cable fabricating processes, and to new constructions of buildings, rooms, vaults, safe boxes and the like; a security apparatus as above which is relatively simple and inexpensive, reliable and foolproof in operation, easily serviced, not subject to malfunctioning because of commercial power failure, wholly safe from the standpoint of fire and explosion hazard,

damage to its environment or danger to personnel; and a highly effective security apparatus which is especially flexible in being adapted to a large variety of conditions and applications.

Other features and advantages will hereinafter appear. In the drawings:

FIG. 1 REVEALS A DIAGRAMMATIC REPRESENTATION OF ONE FORM OF SECURITY CABLE AS PROVIDED BY THE INVENTION.

FIG. 2 reveals a diagrammatic showing of a cable constituting another form of the invention.

FIG. 3 is a detail of an end portion of a guard-type cable as provided by the invention.

FIG. 4 reveals a diagrammatic showing of a simplified cable circuit as provided by the invention.

FIG. 5 is a diagrammatic representation of another form of cable braid circuit according to the invention.

FIG. 6 is a detail of a low melting point wire according to the invention.

FIG. 7 reveals a diagrammatic representation of another embodiment of the invention.

FIG. 8 is a perspective view of an installation which is guarded by the network of the invention.

FIG. 9 is a fragmentary edge view of a guard-type wallpaper made in accordance with the invention.

FIG. 10 reveals a well-known strain gauge bridge for use with the tamperproof cable of FIG. 3, to measure the strain in the cable. Referring first to the simplified schematic circuit of FIG. 1 and to FIG. 3, there is illustrated a representation of a tamperproof cable 10 or 10*a* made in accordance with the invention, said cable having a core consisting of four electrical conductors or signal wires labeled respectively A, B, C and D and which are provided with the usual insulating jackets or sleeving. Surrounding the core wires A, B, C and D is a woven braid 12 of resistance wires, each resistance wire being insulated from the others by sleeving or insulating coatings.

One end of the cable 10 is shown as terminating at a source of signals, indicated schematically by the broken outline 14. The remaining end of the cable 10 is brought into a sensing or working station designated generally by the broken outline 16, said station including in addition to equipment (not shown) connected to the terminations of the signal wires A, B, C and D an alarm or indicator system described as to its operation and construction in U.S. Pat. No. 2,761,052 issued to Knud J. Knudsen on Aug. 28, 1956 and entitled "Electric Temperature Control," and in the above identified allowed application of Conrad S. Ham and Elwood R. Horwinski.

The legs 18, 20, 22 and 24 of the bridge respectively include adjustable resistors and further include four independent sets of the resistance wires constituting trigger circuits and making up the braid 12.

At the termination end of the cable 10 are four independent sets of resistance wires making up the trigger circuits of the braid 12. It will be understood that each such independent set of resistance wires may include a plurality of strands connected in series with each other to constitute one continuous trigger circuit, said strands having their terminal ends connected to appropriate equipment (not shown).

It will be understood that, to effect series connections of the resistance wires of the braid 12, suitable end connections of the braid wires are made at the signal source 14 as well as at the other cable end comprising the working station.

With the above organization there is had a complete bridge circuit which includes the resistance wires of the braid 12. Such bridge circuit may be balanced by suitable adjustment of the bridge, in conjunction with a proper selection of resistance values for the wires making up the braid 12. Once the bridge is balanced, the galvanometer or responsive instrument 36 will indicate a null or zero setting, signifying that there is no breakage of any resistance wire in the cable 10, nor any short circuiting of one resistance wire to another, or short circuiting of resistance wires to the signal wires or to ground, etc. However, if any tampering with the cable 10 occurs, which will

cause breakage of one or several of the resistance wires, or shorting of such resistance wires to each other or to the signal wires of the core, the balance of the bridge circuit would be upset, and the indicating instrument **36** will be deflected or otherwise disturbed to give notice that the cable **10** is no longer intact. The use of the bridge and sets of resistance wires results in an extremely sensitive response to even slight disturbances in such wires.

In accordance with the present invention the cable **10** (or **10***a*) and preferably the braid and outer portions thereof are constituted in a unique manner whereby it will respond to conditions of elevated temperature by causing an indication to be given, and whereby measurements of the temperature of the cable can also be made. The cable **10** or **10***a* also has low ductility wires in the outer portion, which constitute a trigger circuit and respond to conditions of elevated stress by breaking, for the purpose of providing indications and has other low ductility wires for the purpose of providing indications of the strain or tensile stress of the cable. In FIG. **1** the cable **10** is shown as having low ductility, high tensile strength strain wires **77** for connection in the bridge circuit, which wires are adapted to break in response to excessive strain. Also, the cable **10** has additional low ductility, high tensile strength wires **79** for connection in a strain gauge bridge circuit **81** for the purpose of indicating or reading the cable strain. Other improvements are more clearly shown in FIGS. **2** and **3** wherein details of a unique tamperproof cable **10***a* are revealed, together with a somewhat more comprehensive indicating or control bridge circuit described as to its construction and operate in the above-identified allowed application of Conrad S. Ham and Elwood R. Horwinski.

The tamperproof cable **10***a* has an outermost jacket **56** and an innermost signal-carrying core **58**, the latter being constituted of four insulated signal wires A, B, C and D, said core being spiral wrapped with a Mylar or other suitable plastic web **60** over which there is applied a conducting shield constituted of a spiral wrap of bare conducting wires **62**. Over the shield **62** there is a second spiral wrap **64** of Mylar, after which there is applied a conductive, trigger network comprising an open weave braid of insulated resistance wires **66**, preferably **24** in number. Around the braid **66** of resistance wires there is woven a fiberglass insulating braid **68**, which is then enclosed in a flexible metal conduit **70**. Surrounding the flexible metal conduit **70** there is a spiral wrap **72** of Mylar strip, and then a second open weave braid **74** of insulated wires. The braid **74** may comprise, for example, **20** insulated resistance wires indicated generally by the letter R, a pair of insulated wires **73** of low melting point, and a second pair of insulated wires **75** of platinum or other suitable metal adapted to constitute the bulb portion of a resistance thermometer. Surrounding the braid **74** is a closely woven fiberglass braid **76**, and finally the outer protective solid tubular jacket **56** which is advantageously of polyvinyl chloride.

In FIG. **2**, the cable **10***a* is indicated as extending between two broken lines **80**, **82** and the two open weave braids of insulated wire **66**, **74**, comprising a total of **48** wires, are represented as grouped in four series-connected sets **84**, **86**, **88** and **90**, each set being indicated as having a nominal resistance of 75 ohms. The set **84** may comprise 10 wires, the set **86** may comprise eight wires, the set **88** may comprise six wires, and the set **90** may comprise eight wires. This gives a total of 32 wires, and the remaining 16 wires are left unconnected and serve no purpose except in physically forming the open basket weave or braid construction.

The set of wires **84** may contain the wires **73** of low melting point. The resistance bulb wires **75** are shown electrically isolated, for connection to the resistance thermometer bridge.

The invention further provides straight or unbraided fine insulated wires **77***a* and **79***a* of low ductility and high tensile strength (for example, piano wire) in the cables **10** and **10***a*, having their ends suitably anchored to the cable ends whereby cable strain can be indicated by means of the wires **79***a* and whereby any undue pulling forces on the cable can rupture the wires **77***a* and result in an indication being given. In FIG. **2** the wires **77***a* are shown as included in the set **90**, and the wires **79***a* are brought to terminals for connection to the bridge **81**.

Referring to FIG. **2**, the spiral wrap shield **62** is shown as connected by a wire **92** to a ground **94**. A 100 ohm resistor **98** is connected to the flexible metal conduit **70**. The independent sections of resistance wires **84**, **86**, **88** and **90** are included in the four legs of a bridge having junctures **26***a*, **28***a*, **30***a* and **32***a*.

As shown in FIG. **3**, the resistance bulb wires **75** may be incorporated in the braid **74**, as well as the wires **73** of low melting point.

FIG. **6** shows one form of low melting point wire, wherein a Teflon (tetrafluorethylene) core **196** is provided with a metallic jacket **198** comprising a tin-lead alloy. The metal jacket **198** is coated with an insulating enamel of any suitable type used for insulating wires.

The unbraided or straight conductors **77***a* and **79***a*, FIG. **3**, may be disposed between the insulating braid **76** and the insulating jacket **56**, with the ends folded over and welded to separate, partially circular metal shells **200**, **202** provided with connector lugs **204**, **206** respectively. The shells **200**, **202** (and other similar shells not shown) are insulatedly secured to each other in any suitable manner. At the other cable end, the wires **77***a* may both be secured to a single metal ring whereby they are electrically connected, and the wires **79***a* similarly secured independently of the wires **77***a*.

Another form of the invention is illustrated in FIG. **4**. Here, the core of the cable **10***b* comprising the conducting wires A, B, C, and D is surrounded by a woven braid of insulated resistance wires **208** which are so connected that they are all in series. The cable **10** includes insulated low ductility wires **77***b* and low melting point wires **73***b*, as well as resistance bulb wires **75***b*. The terminations **210**, **212** of the wires **208** can be connected to suitable equipment (not shown).

In FIG. **5** another form of the invention is illustrated, wherein the cable signal wires A, B, C and D are enclosed is a resistance and heat-sensitive wire braid comprising wires **220** and **73***c* shown as being connected in parallel with each other and with low ductility wires **77***c*. The terminations **222**, **224** of the parallel connected wires can be brought to an indicator device (not shown), such device will be disturbed when any of the wires is broken, melted or else shorted to another wire.

Whereas the foregoing protective wire network has been illustrated as being in the form of a braid in a cable, it could as well have a flat configuration such as wire screening, printed circuit grids and the like. In FIG. **7** there is illustrated a flat configuration **226** which may comprise printed circuit conductors **228** on one side of an insulating sheet and printed circuit conductors **230** on the other side of the insulating sheet. The conductors **228**, **230** preferably are disposed to be perpendicular to each other. The conductors **228** may further include a conductor **232** of low melting point, and the conductors **230** may include a conductor **234** of low melting point.

As shown, all of the conductors are connected in series, with their ends brought out to terminals I and J.

In FIG. **7**, there is shown a bridge **236** described as to its construction and operation in the above-identified allowed application of Conrad S. Ham and Elwood R. Horwinski.

The braid **66**, **74** of FIG. **3** may be replaced by a planar network configuration like that of FIG. **7**, at **226**. Such planar configuration could represent part of an enclosure, and such configuration or the network **226** of FIG. **7** may be in the nature of window screening or fly screening or mesh, shown in cross section in FIG. **9**. The mesh configuration may be incorporated in wall panels. For example, in FIG. **9** a mesh configuration **260** is shown as applied to heavy wallpaper **262** having a backing sheet **264** adapted to be peeled off to expose a pressure sensitive adhesive. The makeup of the mesh and wallpaper shown in FIG. **9** may thus be similar to the configuration **226** in FIG. **7**.

A use of the planar mesh or network configuration is illustrated in FIG. **8**, which depicts a walk-in vault **266** having all

of its sides provided with network configurations **226**. The network configurations are connected to constitute trigger circuits which may be connected with the cable **10***a* and a detection bridge "B".

The strain gauge bridge **81** shown in a representative manner in FIG. **10**.

It will now be seen from the foregoing that I have provided a novel and improved tamperproof area protective construction which is extremely effective and foolproof in preventing undetected and unauthorized tampering with a cable or an enclosure, and in responding to elevated conditions of temperature and strain. Although it might be possible ultimately with the use of sophisticated equipment over a period of time, to tamper with the present improved security system, such possibility is extremely unlikely and not only requires the highest kind of skills but also the use of complicated electronic equipment, employed over an appreciable time.

The improved security apparatus is seen to be relatively simple, of straight-forward design, and to be reliable and foolproof in its operation.

Considering the cable or planar network per se, it will be understood that the severing or melting of any one of the wires making up the trigger circuit, or the shorting of such wires with other wires of the circuit or to ground, will result in the indicator being made operative to either give a signal or else actuate a control for a desired purpose, as for example to shut off power to the wires A, B, C and D. Thus the cable is useful in explosive atmospheres, boiler rooms etc. where the environment is of a nature that could cause cable damage. By quickly disconnecting the power, the likelihood of dangerous sparking is minimized.

Variations and modifications are possible, and portions of the improvement may be used without others.

I claim:

1. A tamperproof cable comprising, in combination:
a. a signal-conducting core,
b. a braid construction constituted of resistance wires surrounding said core, and
c. means insulating the resistance wires of the braid from each other and from the signal-conducting core,
d. said braid construction including at least one wire having a low melting point substantially under that of copper wire.

2. A tamperproof cable comprising, in combination:
a. signal-conducting core,
b. a wrapping construction constituted of resistance wires surrounding said bore, and
c. means insulating the resistance wires of the braid from each other and from the signal-conducting core,
d. said braid including at least one wire constituting a circuit separate and apart from the remaining wires of the braid.

3. A cable as in claim 2, wherein:
a. said braid further includes at least one wire having a low melting point substantially below that of copper wire.

4. A tamperproof cable comprising, in combination:
a. a signal-conducting core,
b. a wrapping construction constituted of resistance wires surrounding said core, and
c. means insulating the resistance wires of the wrapping construction from each other and from the signal-conducting core,
d. said cable comprising one unbraided and untwisted wire of low ductility and high tensile strength, insulated from said braid wires, and
e. means anchoring said high tensile strength wire to end portions of said cable.

5. A cable as in claim 4, wherein:
a. said braid further includes at least one wire having a low melting point appreciably less than that of copper wire.

6. A cable as in claim 4, wherein:
a. the means anchoring the high tensile strength wire comprises bushings carried by the cable,
b. said cable including an outer insulating jacket to which the bushings are secured.