

616183

FORM 1
REGULATION 9

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-1973

APPLICATION FOR A PATENT

I/We RAYCHEM CORPORATION

of 300 Constitution Drive, Menlo Park, CALIFORNIA 94025, U.S.A.

hereby apply for the grant of a Patent for an invention entitled:

BRANCHED SENSOR SYSTEM

which is described in the accompanying complete specification. This Application is a Convention Application and is based on the Application(s) numbered: 057,459 for a Patent or similar protection made in U.S.A. on 3 June 1987.

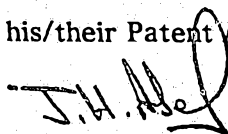
My/Our address for service is:

GRIFFITH HASSEL & FRAZER
71 YORK STREET
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DATED this 2nd day of June, 1988.

RAYCHEM CORPORATION

By his/their Patent Attorneys



GRIFFITH HASSEL & FRAZER

TO: THE COMMISSIONER OF PATENTS
COMMONWEALTH OF AUSTRALIA
4665A:rk

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02/06/88

COMMONWEALTH OF AUSTRALIA
Patents Act 1952-1962

DECLARATION IN SUPPORT OF A CONVENTION OR NON-CONVENTION
APPLICATION FOR A PATENT OR PATENT OF ADDITION

In Support of the Application No.

made by RAYCHEM CORPORATION a company organised according to the laws of
the State of Delaware of 300 Constitution Drive, Menlo Park,
California 94025, U.S.A.

for a PATENT/~~PATENT OF ADDITION~~ for an invention entitled

BRANCHED SENSOR SYSTEM

I, HERBERT G. BURKARD of 256 Prior Lane, Atherton, California 94025,
U.S.A., do solemnly and sincerely declare as follows:

~~1. We are the applicants for the patent/patent of addition.~~

1. I am authorised by the above mentioned applicant for the
patent/~~patent of addition~~ to make the declaration on its behalf.

2. The basic application(s) as defined by Section 141 of the Act
was/were made in the following country or countries on the following
date(s) by the following applicant(s) namely:

IN THE NAME OF COUNTRY

DATED

Heinrich Koppitsch U.S.A.
and Francis Sparling

03 June 1987

~~3. I am/We are the actual inventor(s) of the invention.~~

Heinrich Koppitsch, 380 Conil Way, Menlo Park, CA 94025

Francis Sparling, 1076 Rockefeller, Sunnyvale, CA 94087

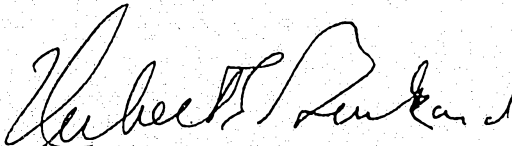
is/are the actual inventor(s) of the invention and the facts upon which
the applicant(s) is/are entitled to make the application as follows: —
as regards entitlement under Section 34 of the Act:- BY AN ASSIGNMENT
FROM THE INVENTORS TO THE APPLICANTS

—as regards entitlement under Part XVI of the Act:- BY AN ASSIGNMENT
FROM THE INVENTORS TO THE APPLICANTS

4. The basic application(s) referred to in paragraph 2 of the
Declaration was/were the first applications made in a convention country
in respect of the invention the subject of the application.

Declared at MENLO PARK this 20 day of May 1988.

TO: The Commissioner of Patents
Commonwealth of Australia


HERBERT G BURKARD
Assistant Secretary

(12) PATENT ABRIDGMENT (11) Document No. AU-B-17316/88
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- (56) Prior Art Documents
AU 41043/85 G01D 1/00
AU 41044/85 G01D 5/16
AU 30002/84 G01D 5/16
- (57) Claim

1. A sensor cable for use in detecting and obtaining information about an event, the cable comprising

- (A) a trunk line cable which follows an elongate trunk path having a near end and a far end; and
- (B) at least one branch line cable which extends from the trunk line cable at an intermediate point along the trunk path and follows an elongate branch path from the intermediate point to a distant point;

wherein

the trunk line cable comprises first, second, third, and fourth elongate electrically conductive members,

each of the first and second members running along the whole length of the trunk path but being discontinuous at each intermediate point to provide an incoming end nearer to the near end of the trunk path and an outgoing end nearer to the far end of the trunk path,

each of the third and fourth members running

continuously along the whole length of the trunk path,

the first and third members being electrically connected to each other at the far end of the trunk cable, and

the second and fourth members being electrically connected to each other at the far end of the trunk cable;

the branch line cable comprises fifth, sixth, seventh, and eighth elongate electrically conductive members, each of which runs continuously along the whole length of the branch path and has a first end at the intermediate point and a second end at the distant point;

each of the first ends of the fifth, sixth, seventh and eighth members is respectively connected to one of the incoming and outgoing ends of the first and second members, and each of the second ends of the fifth and sixth members is respectively connected to each of the second ends of the seventh and eighth members, so that the incoming and outgoing ends of the first member are electrically connected to each other through the branch line and the incoming and outgoing ends of the second member are electrically connected to each other through the branch line;

the first and second members are, in the absence of an event, insulated from each other and from other components of the cable along the length of the cable except for said connections at each intermediate point and at the far end of the trunk cable;

the third and fourth members are, both in the absence of an event and upon occurrence of an event, electrically insulated from each other and from other components of the cable, along the length of the cable, except for said connections at the far end of the trunk cable;

the fifth and sixth members (a) are, in the absence of an event, insulated from each other and from other components of the cable except for said connections at each intermediate point and distant point, and (b) become, upon occurrence of an event at a point along the branch path, electrically connected to each other at that point; and

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the seventh and eighth members are, both in the absence of an event and upon occurrence of an event, electrically insulated from each other and from other components of the cable except for said connections at each intermediate point and distant point.

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COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

Form 10

COMPLETE SPECIFICATION

FOR OFFICE USE

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Related Art:

TO BE COMPLETED BY APPLICANT

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Complete Specification for the invention entitled:

BRANCHED SENSOR SYSTEM

The following statement is a full description of this invention,
including the best method of performing it known to me/us:-

4665A:rk

This invention relates to methods and apparatus for detecting and locating changes in variables.

European Patent Publications Nos. 133,748, 160,440, 144,211, 164,838, 160,441, 191,547, 222,012, and 242,029 disclose methods and apparatus for detecting and obtaining information about (particularly locating) changes in variables. Such changes are referred to in that application, and likewise in this application, by the generic term "event". In a preferred embodiment of such methods, and in other methods, there is used a sensor cable comprising two insulated wires and two "non-insulated" wires which are not connected to each other in the absence of an event but which become electrically connected to each other upon occurrence of an event. The non-insulated wires can for example comprise a metal core surrounded by a conductive polymer jacket, so that the wires become electrically connected if there is a water leak. The possibility of connection can for example exist at all points along an elongate path or over selected stretches or at discrete locations of an elongate path; for example the non-insulated wires can be wires which are insulated except at spaced locations and which can become connected at one or more of those locations through a switch which is switched on by occurrence of an event at the location of that switch.

When such a four-wire sensor cable is used to detect events along a path comprising one or more branch paths extending from a main (or trunk) path, the cable can simply be routed along the branch path to the end of the branch path and then straight back to the trunk path. However, this can lead to misleading results, since an event taking

place along the branch can cause connection of the non-insulated wires in both the outgoing branch cable and the incoming branch cable. This problem can be overcome by running the sensor cable from the junction of the trunk and branch paths to the end of the branch path only, and using four insulated "jumper" wires to make the appropriate connections from the end of the branch back to the trunk; but this is an expensive and inconvenient solution, especially when space is limited, eg. in a double containment system.

We have now recognized that in a branched system using a four-wire sensor cable, the two insulated wires are not needed in the branch line to perform the functions for which they are needed when the four wire sensor cable is part of a trunk line, and that these insulated wires can, therefore, be used (a) as insulated jumper wires to connect the non-insulated wires between the junction of a branch and the end of a branch, or (b) can be connected to each other at the end of a branch and to incoming and outgoing ends of one of the insulated wires at the junction of a branch, thus providing a loop around the branch for continuity checking purposes.

In a first embodiment of the invention, the insulated wires of the trunk cable are simply connected to each other across the junction; the non-insulated wires of the branch are connected (a) at the junction, to the non-insulated wires coming into (or going out of) the junction along the trunk path, and (b) at the end of the branch, to the insulated wires of the branch; and the insulated wires of the branch are connected at the junction to the non-insulated wires

going out of (or coming into) the junction along the trunk path. In this way the errors which can occur with a simple loop system are substantially reduced or eliminated, as is the expense of the return leg of the four-wire sensor cable, or the inconvenience and expense of using separate jumper wires. Furthermore, the connections which have to be made at the end of the branch line can be the same as those made at the end of the trunk line, so that the same termination apparatus can be used.

Accordingly, in one aspect, the present invention provides a sensor cable for use in detecting and obtaining information about an event, the cable comprising

- (A) a trunk line cable which follows an elongate trunk path having a near end and a far end; and
- (B) at least one branch line cable which extends from the trunk line cable at an intermediate point along the trunk path and follows an elongate branch path from the intermediate point to a distant point;

wherein

the trunk line cable comprises first, second, third, and fourth elongate electrically conductive members,

each of the first and second members running along the whole length of the trunk path but being discontinuous at each intermediate point to provide an incoming end nearer to the near end of the trunk path and an outgoing end nearer to the far end of the trunk path,

each of the third and fourth members running continuously along the whole length of the trunk path,

the first and third members being electrically connected to each other at the far end of the trunk cable, and



the second and fourth members being electrically connected to each other at the far end of the trunk cable;

- 5 the branch line cable comprises fifth, sixth, seventh, and eighth elongate electrically conductive members, each of which runs continuously along the whole length of the branch path and has a first end at the intermediate point and a second end at the distant point;
- 10 each of the first ends of the fifth, sixth, seventh and eighth members is respectively connected to one of the incoming and outgoing ends of the first and second members, and each of the second ends of the fifth and sixth members is respectively connected to each of the second ends of the seventh and eighth members, so that the incoming and outgoing ends of the first
- 15 member are electrically connected to each other through the branch line and the incoming and outgoing ends of the second member are electrically connected to each other through the branch line;

- the first and second members are, in the absence of an event, insulated
- 20 from each other and from other components of the cable along the length of the cable except for said connections at each intermediate point and at the far end of the trunk cable;

- the third and fourth members are, both in the absence of an event and upon
- 25 occurrence of an event, electrically insulated from each other and from other components of the cable, along the length of the cable, except for said connections at the far end of the trunk cable;

- the fifth and sixth members (a) are, in the absence of an event, insulated
- 30 from each other and from other components of the cable except for said connections at each intermediate point and distant point, and (b) become, upon occurrence of an event at a point along the branch path, electrically connected to each other at that point; and



the seventh and eighth members are, both in the absence of an event and upon occurrence of an event, electrically insulated from each other and from other components of the cable except for said connections at each intermediate point and distant point.

5

In one embodiment of the invention, as illustrated for example in Figure 2, at least one of the branch line cables comprises at least one zone cable which extends from the branch line cable at a sub-intermediate point and follows an elongate zone path from the sub-intermediate point to a zone distant point, the zone cable comprising ninth, tenth, eleventh, and twelfth elongate electrically conductive members, each of which runs continuously along the whole length of the zone path and has a first end at the sub-intermediate point and a second end at the zone distant point;

10

each of the fifth and sixth members runs continuously along the whole length of the branch path, one of the seventh and eighth members runs along the whole length of the branch path, and the other of the seventh and eighth members runs along the whole length of the branch path but is discontinuous at each sub-intermediate point to provide an incoming end nearer to the intermediate point and an outgoing end nearer to distant point;

20

the first ends of the ninth and tenth members are connected to the fifth and sixth members respectively at the sub-intermediate point;

25

the ninth and tenth members (a) are, in the absence of an event, insulated from each other and from other components of the cable except for said connections at the sub intermediate point, and (b) become, upon occurrence of an event at a point along the zone path, electrically connected to each other at that point;

30

the near ends of the eleventh and twelfth members are respectively connected to the incoming and outgoing ends of the seventh or eighth members at the sub-intermediate point, and the far ends of the eleventh and twelfth members are connected to each other at the zone distant point;

35



the eleventh and twelfth members are insulated from each other and from other components of the cable, except for said connections at the sub-intermediate point and at the zone distant point, both in the absence of an event and upon occurrence of an event; and

the cable includes, adjacent to each sub-intermediate point, two identical resistors, one forming part of the fifth member before the sub-intermediate point and the other forming part of the sixth member after the sub-intermediate point.

This embodiment provides for location of the zone along which the event has occurred, but not for identifying the point along the zone path at which the event occurred.

The novel sensor cables of the invention preferably form part of an apparatus for detecting and locating an event which comprises

- (1) a sensor cable as defined above;
- (2) a power source; and
- (3) a voltage measuring device.

The apparatus is preferably such that, upon occurrence of an event at a location along the cable, an electrical connection is made at that location either between the first and second members, or between the fifth and sixth members, or between the ninth and tenth members; and the making of said connection results in a system in which

- (i) the first member is electrically connection (a) at the near end of the trunk path, to the power source and to the voltage-measuring device, and (b) at the far end of the trunk path, to the third member;



(ii) the third member is electrically connected (a) at the near end of the trunk path, to the voltage-measuring device, and (b) at the far end of the trunk bath, to the first member;

5 (iii) the fourth member is electrically connected (a) at the near end of the trunk path, to the power source, and (b) at the far end of the trunk path, to the second member;

10 (iv) there is a test circuit in which a current of known size flows and which comprises

(a) those parts of the second, sixth and seventh members which lie between the connection point and the far end of the trunk path,

15 (b) the connection;

(c) those parts of the first, fifth and eighth members which lie between the connection point and the near end of the trunk path,

20 (d) the fourth member of the trunk cable, and

25 (e) the power source,

and

(v) there is a reference circuit which comprises

30 (a) the first, fifth and eighth members,

(b) the third member, and

35 (c) the voltage-measuring device;

whereby the voltage measured by the voltage-measuring device can be used to determine the location of the connection point.



In preferred apparatus of this kind, at all points on the sensor cable at which occurrence of an event can cause connection between the first and second members or the fifth and sixth members, the sum of (a) the resistances of the first, fifth and eighth members and any resistors in series therewith, between the near end and the connection point, and (b) the resistances of the second, sixth and seventh members and any resistors in series therewith, between the connection point and the far end, is substantially independent of the location of the connection point.

In order to achieve this result, it is preferred that

- (i) the incoming ends of the first and second members at each intermediate point are connected to the first ends of the fifth and sixth members respectively, or to the first ends of the seventh and eighth members respectively;
- (ii) the outgoing ends of the first and second members at each intermediate point are connected to the first ends of the eighth and seventh members respectively, or to the first ends of the fifth and sixth members respectively,
- (iii) the second ends of the fifth and eighth members are connected at each distant point; and
- (iv) the second ends of the sixth and seventh members being connected at each distant point.

The trunk line cable comprises first, second, third and fourth elongate electrically conductive members. For any segments of the trunk line along which detection of an event



is not required, the cable can simply comprise four insulated wires which are of low resistance. For any extended segments along which detection of an event is required, the trunk cable can comprise two low resistance insulated wires and two high resistance conductive-polymer-coated wires which become electrically connected to each other if an event occurs, eg. a leak of water or another electrolyte, or a leak of a hydrocarbon or other organic fluid which causes swelling of a component in the cable, thus effecting electrical connection; the high resistance wires are preferably identical and have a resistance per unit length which is substantially invariable under the operating conditions. The trunk cable can also comprise spaced-apart locations at which connection between the source and locating members takes place upon occurrence of an event, eg. through the operation of switch. One form of switch is a pair of conductive-polymer-coated wires which extend from the trunk cable; one wire is connected to the source member and the other to the locating member. The pair of wires can be part of a zone cable which extends from the trunk cable and which comprises in addition two insulated low resistance wires which are connected as a loop to form part of the return member and thus enable the continuity of the system to be checked. Other possible features of the branch line cable are described in the European patent applications referred to above.

The branch line cable can have the same characteristics as are described above for the trunk line cable, except that at least part of the branch line comprises members which, upon occurrence of an event, become electrically connected. However, the invention is particularly useful when the



branch line cable comprises two low resistance insulated wires (which may be the same or different) and two conductive-polymer-coated wires (which are preferably the same), particularly when at least part of the trunk cable has substantially the same physical construction as the branch line cable. Particularly under such circumstances, it is preferred to put resistors in the connections between the conductive-polymer-coated wires; this results in discontinuities in the possible readings of the voltage-measuring device, so that despite a small error in the reading, the location of the event can be identified as being in the trunk line or branch line, as the case may be.

A very useful attribute of the apparatus of the present invention is that it can be assembled at an installation site from pre-terminated cables and preassembled connection and termination units which can be manufactured in a factory, thus eliminated the need to carry out in situ wiring, with the attendant risk of error. The various connection and termination units can be assembled (and if desired sealed) as flexible harnesses or in boxes.

Referring now to the drawing, each of the Figures is a current diagram of an apparatus of the invention which comprises

- (A) a constant current power supply (100);
- (B) a high impedance voltmeter (200);
- (C) a trunk line cable which has a near end (300) and a far end (400), and which is made up of a plurality of segments, each segment comprising a first member



(11, 12, 13 etc.), a second member (21, 22, 23 etc.), a third member (31, 32, 33 etc.) and a fourth member (41, 42, 43 etc.); and

- (D) at least one branch line cable which extends from an intermediate point (500) along the trunk path to a distant point (600) and which is made up of one or more segments, each segment comprising a fifth member (51, 52, 53 etc.), a sixth member (61, 62, 63 etc.), a seventh member (71, 72, 73 etc.) and an eighth member (81, 82, 83 etc.).

In each of the Figures, the phantom lines enclose components which can conveniently be preassembled in a manufacturing facility (eg. as a box or a flexible harness), with appropriate connecting means for the cables which make up the rest of the apparatus. The pre-assembled parts and the cables can then be assembled at the site of the installation.

Referring now to Figure 1, this comprises a trunk cable having two identical branch cables connected thereto in accordance with the first embodiment of the invention. The segment of the trunk cable closest to the near end 300 comprises four low resistance insulated wires 11, 21, 31 and 41 and extends along a path along which detection of an event is not required. The second, third and fourth segments of trunk cable comprise two low resistance insulated wires 32, 33 and 34, and 42, 43 and 44, and two identical high resistance conductive-polymer-coated wires 12, 13 and 14, and 22, 23 and 24 which become connected to each other if an event occurs, eg. a leak of water or a hydrocarbon. At each intermediate point 500, the trunk



cable and the branch cable are connected to a preassembled T-connector 501 which will not detect occurrence of an event, which makes the connections shown, and which includes four identical resistors 1, 2, 3 and 4. The branch cable has a single segment which runs from the intermediate point 500 to the distant point 600 and which has the same physical construction as the second segment of the trunk cable and comprises two low resistance insulated wires 71 and 81 and two identical high resistance conductive-polymer-coated wires 51 and 61 which become connected to each other if an event occurs. At the distant point 600, the branch cable is connected to a preassembled terminator 601 which makes the connections shown. The final segment of the trunk cable is connected to a preassembled terminator 602 which makes the connections shown and which can be identical to terminator 601.

The wires 11, 12, 51 and 13, the resistors 1 and 2, and the connections between them together form a locating member. The wires 21, 22, 61 and 23, the resistors 3 and 4, and the connections between them together form a source member.

When the occurrence of an event causes a connection to be made at a single point along the trunk or branch cables (ie. between members 12 and 22, or members 51 and 61, or members 13 and 23), the voltage measured by the voltmeter depends upon the resistance of the locating member between the near end 300 and the connection point. Through knowledge of the resistance per unit length of the various components, or through prior mapping of the system, the measured voltage indicates the location of the event. The



resistors 1, 2, 3 and 4 ensure that, despite a small error in the voltage measurement, an operator can distinguish between an event at an end of the trunk cable close to a T-connector and an event at the end of a branch cable close to a T-connector or at the end of a branch cable close to a terminator 601.

In Figure 1, the connections in the T-connector are between members 51 and 12, 61 and 22, 71 and 23, and 81 and 13. However, since the members 71 and 81 have much lower resistance than the members 51 and 61, results which are substantially the same could be obtained by making the connections between 51 and 12 (as before), 81 and 13 (as before), 61 and 23, and 71 and 22; and results which are equally accurate, or substantially as accurate, but in which locations on the branch line were measured from the distant point instead of the intermediate point, could be obtained by making the connections between 12 and 71, 22 and 81, 51 and 23, and 61 and 13 (equally accurate) or between 12 and 71, 22 and 51, 81 and 23, and 61 and 13 (substantially as accurate).

Figure 1 shows two branch lines, but there could be any number of branch lines.

Referring now to Figure 2, this shows a system in accordance with the second embodiment of the invention which will detect the occurrence of an event in one of a plurality of zones, but not elsewhere, and will identify the zone in which the event took place, but will not identify the location of the event in the zone. Between the zones, both the trunk cable and the branch cable comprise four insulated low resistance wires. In each zone, a first conductive-



polymer-coated wire extends from the locating member, and a second conductive-polymer-coated wire extends from the source member, close to but not touching the first wire; upon occurrence of an event anywhere in the zone, the first and second wires are brought into electrical contact, thus connecting the source and locating members. Resistors are placed in the locating member so that the voltage measured by the voltmeter identifies the zone in which an event has taken place, and balancing resistors are placed in the source member.

The segment of the trunk cable closest to the near end 300 comprises four low resistance wires 11, 21, 31 and 41. At the intermediate point 500, the trunk cable and the branch cable are connected to a pre-assembled T-connector 501 which makes the connections shown. The first segment of the branch cable has the same physical construction as the trunk cable and contains four low resistance insulated wires, and is connected to a T-zone connector 701, which makes the connections shown between a zone cable and the first and second segments of the branch cable, and which contains resistors 5 and 6. The zone cable has the same physical construction as the branch cable of Figure 1, and contains two low resistance insulated wires 171 and 181 and two conductive-polymer-coated wires 151 and 161. It is, however, connected differently both at the T-zone connector 701 and at the zone terminator 801; the wires 171 and 181 are connected as a loop between insulated wires 81 and 82 so that it is possible to make a continuity check of the zone cable. The second segment of the branch cable likewise contains four insulated wires 52, 62, 72 and 82. The second segment is connected to another T-zone connector 702 which



is the same as 701 and to which is connected a second zone cable comprising insulated wires 271 and 281 and conductive-polymer-coated wires 251 and 261 and terminating in zone terminator 802. Terminator 603, which can be the same as terminator 601 used in Figure 1 makes the appropriate connections at the end of the branch line.

The second segment of the trunk cable, comprising four insulated wires 12, 22, 32 and 42, is connected via an end zone connector 901 to a zone cable which is like that in the other zones, which comprises two insulated wires 371 and 381 and two conductive-polymer-coated wires 351 and 361, and which is connected to zone terminator 803.



The claims defining the invention are as follows:

1. A sensor cable for use in detecting and obtaining information about an event, the cable comprising

- (A) a trunk line cable which follows an elongate trunk path having a near end and a far end; and
- (B) at least one branch line cable which extends from the trunk line cable at an intermediate point along the trunk path and follows an elongate branch path from the intermediate point to a distant point;

wherein

the trunk line cable comprises first, second, third, and fourth elongate electrically conductive members,

each of the first and second members running along the whole length of the trunk path but being discontinuous at each intermediate point to provide an incoming end nearer to the near end of the trunk path and an outgoing end nearer to the far end of the trunk path,

each of the third and fourth members running continuously along the whole length of the trunk path,

the first and third members being electrically connected to each other at the far end of the trunk cable, and

the second and fourth members being electrically connected to each other at the far end of the trunk cable;

the branch line cable comprises fifth, sixth, seventh, and eighth elongate electrically conductive members, each of which runs continuously along the whole length of the branch path and has a first end at the intermediate point and a second end at the distant point;



each of the first ends of the fifth, sixth, seventh and eighth members is respectively connected to one of the incoming and outgoing ends of the first and second members, and each of the second ends of the fifth and sixth members is respectively connected to each of the second ends of the seventh and eighth members, so that the incoming and outgoing ends of the first member are electrically connected to each other through the branch line and the incoming and outgoing ends of the second member are electrically connected to each other through the branch line;

the first and second members are, in the absence of an event, insulated from each other and from other components of the cable along the length of the cable except for said connections at each intermediate point and at the far end of the trunk cable;

the third and fourth members are, both in the absence of an event and upon occurrence of an event, electrically insulated from each other and from other components of the cable, along the length of the cable, except for said connections at the far end of the trunk cable;

the fifth and sixth members (a) are, in the absence of an event, insulated from each other and from other components of the cable except for said connections at each intermediate point and distant point, and (b) become, upon occurrence of an event at a point along the branch path, electrically connected to each other at that point; and

the seventh and eighth members are, both in the absence of an event and upon occurrence of an event, electrically insulated from each other and from other components of the cable except for said connections at each intermediate point and distant point.



2. A cable according to Claim 1 wherein

- (i) the incoming ends of the first and second members at each intermediate point are connected to the first ends of the fifth and sixth members respectively, or to the first ends of the seventh and eighth members respectively;
- (ii) the outgoing ends of the first and second members at each intermediate point are connected to the first ends of the eighth and seventh members respectively, or to the first ends of the fifth and sixth members respectively;
- (iii) the second ends of the fifth and eighth members are connected at each distant point; and
- (iv) the second ends of the sixth and seventh members are connected at each distant point.

3. A cable according to Claim 1 or 2 wherein the physical construction of at least a part of the trunk cable is identical to the physical construction of at least a part of the branch cable.

4. A cable according to any one of the preceding claims wherein at least a part of each of the fifth and sixth members comprises a metallic wire which is electrically surrounded by a conductive polymer.

5. A cable according to any one of the preceding claims which includes four substantially identical resistors adjacent to each intermediate point, each resistor providing one of said connections between the first ends of the fifth, sixth, seventh and eighth members and the incoming and outgoing ends of the first and second members respectively.



6. A cable according to any one of the preceding claims wherein the trunk cable comprises a plurality of preterminated lengths of cable, each length comprising a part of the first, second, third and fourth members; each branch cable comprises a preterminated length of cable which comprises the fifth, sixth, seventh and eighth members; at each intermediate point, the preterminated lengths and the trunk cable and the branch cables are terminated by substantially identical termination units which are such that the elongate members can only be connected in an electrically correct arrangement; and the trunk cable and the branch cables are terminated by substantially identical termination units which are such that the elongate members can only be connected in an electrically correct arrangement.

7. A cable according to any one of claims 1 to 4 wherein

at least one of the branch line cables comprises at least one zone cable which extends from the branch line cable at a sub-intermediate point and follows an elongate zone path from the sub-intermediate point to a zone distant point, the zone cable comprising ninth, tenth, eleventh, and twelfth elongate electrically conductive members, each of which runs continuously along the whole length of the zone path and has a first end at the sub-intermediate point and a second end at the zone distant point;

each of the fifth and sixth members runs continuously along the whole length of the branch path, one of the seventh and eighth members runs along the whole length of the branch path, and the other of the seventh and eighth members runs along the whole length of the branch path but is discontinuous at each sub-intermediate point to provide an incoming end nearer to the intermediate point and an outgoing end nearer to distant point;

the first ends of the ninth and tenth members are connected to the fifth and sixth members respectively at the sub-intermediate point;

the ninth and tenth members (a) are, in the absence of an event, insulated from each other and from other components of the cable except for said connections at the sub-intermediate point, and (b)



become, upon occurrence of an event at a point along the zone path, electrically connected to each other at that point;

the near ends of the eleventh and twelfth members are respectively connected to the incoming and outgoing ends of the seventh or eighth members at the sub-intermediate point, and the far ends of the eleventh and twelfth members are connected to each other at the zone distant point;

the eleventh and twelfth members are insulated from each other and from other components of the cable, except for said connections at the sub-intermediate point and at the zone distant point, both in the absence of an event and upon occurrence of an event; and

the cable includes, adjacent to each sub-intermediate point, two identical resistors, one forming part of the fifth member before the sub-intermediate point and the other forming part of the sixth member after the sub-intermediate point.

8. A cable according to Claim 1 substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

9 Apparatus suitable for use in detecting and locating an event, the apparatus comprising:

- (1) a sensor cable as claimed in any one of the preceding claims;
- (2) a power source; and
- (3) a voltage measuring device;

10. Apparatus according to Claim 9 wherein upon occurrence of an event at a location along the cable, an electrical connection is made at that location either between the first and second members, or between the fifth and sixth members, or between the ninth and tenth



members; and the making of said connection results in a system in which

- (i) the first member is electrically connected, at the near end of the trunk path, to the power source and to the voltage-measuring device;
- (ii) the third member is electrically connected, at the near end of the trunk path, to the voltage-measuring device;
- (iii) the fourth member is electrically connected, at the near end of the trunk path, to the power source;
- (iv) there is a test circuit in which a current of known size flows and which comprises
 - (a) those parts of the second, sixth and seventh members which lie between the connection point and the far end of the trunk path,
 - (b) the connection;
 - (c) those parts of the first, fifth and eighth members which lie between the connection point and the near end of the trunk path,
 - (d) the fourth member of the trunk cable, and
 - (e) the power source,

and

- (v) there is a reference circuit which comprises
 - (a) the first, fifth and eighth members,
 - (b) the third member, and



(c) the voltage-measuring device;

whereby the voltage measured by the voltage-measuring device can be used to determine the location of the connection point.

11. Apparatus according to Claim 10 wherein, at all points on the sensor cable at which occurrence of an event can cause connection between the first and second members or the fifth and sixth members or the ninth and tenth members, the sum of (a) the resistances of the first, fifth and eighth members and any resistors in series therewith, between the near end and the connection point, and (b) the resistances of the second, sixth and seventh members and any resistors in series therewith, between the connection point and the far end, is substantially independent of the location of the connection point.

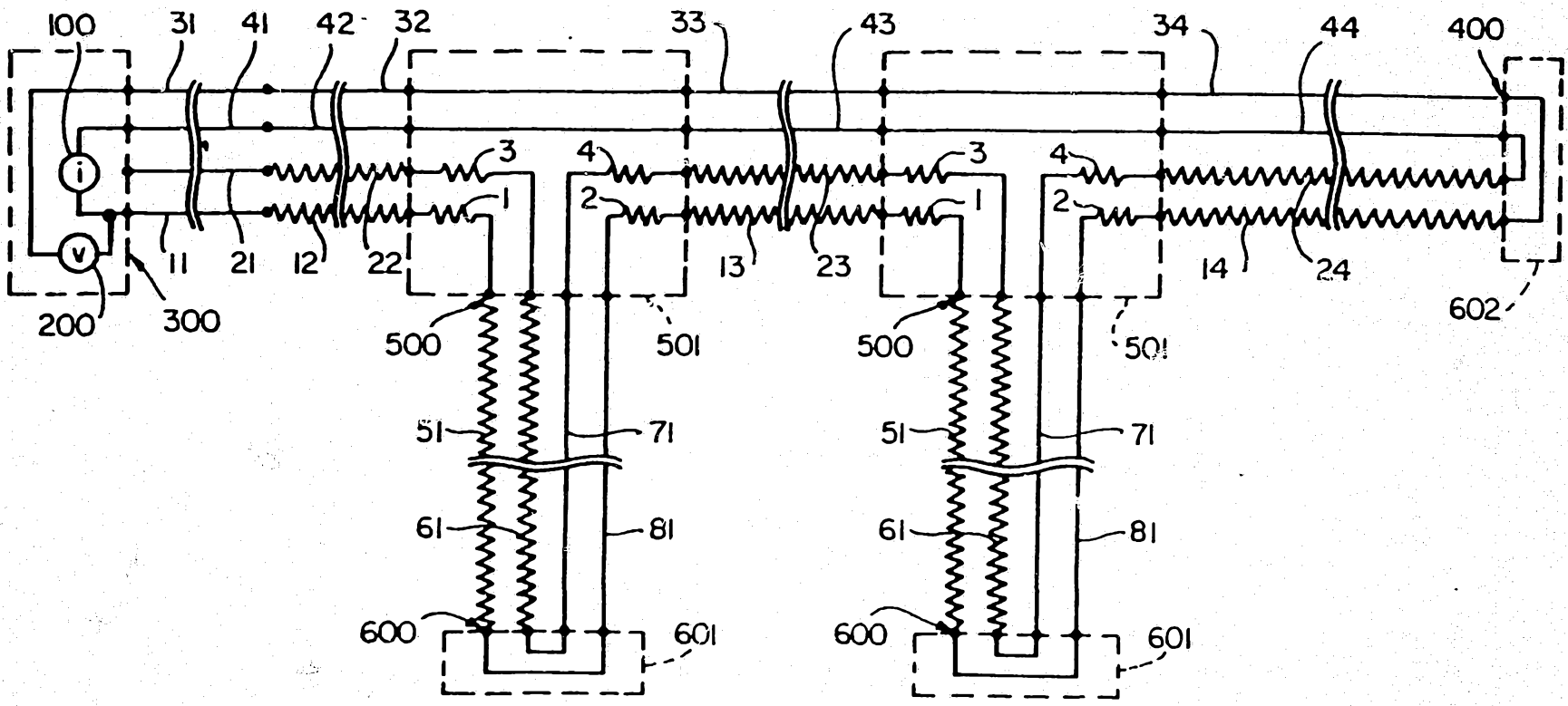
DATED this 6th day of August 1991

RAYCHEM CORPORATION

By their Patent Attorneys

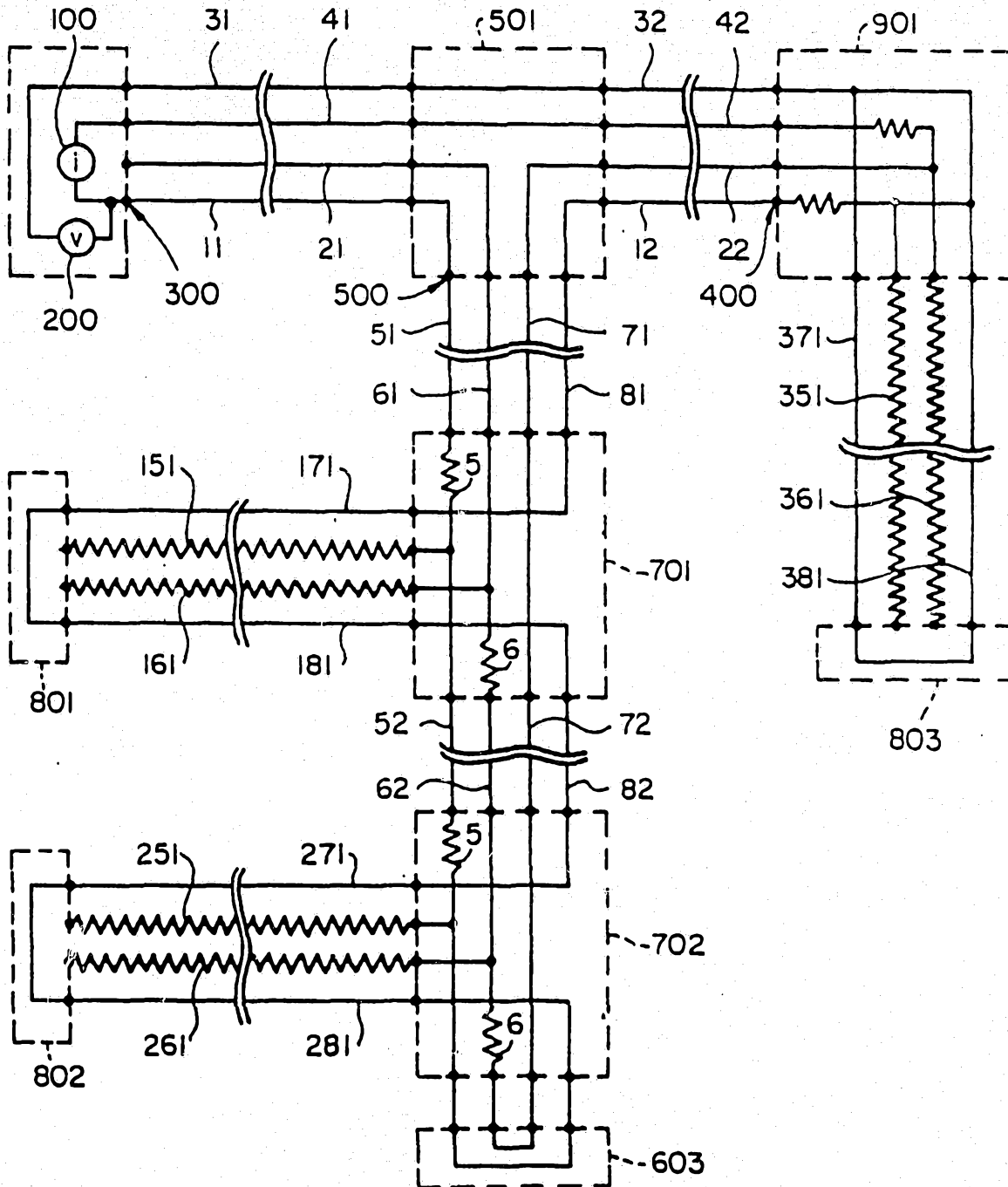
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FIG_1

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FIG_2