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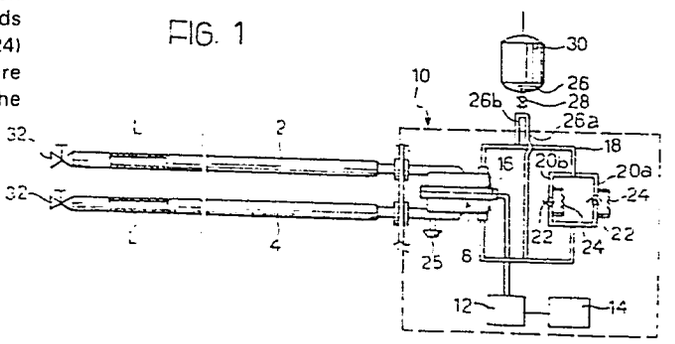
(54) **Improved apparatus for indicating the passage of an intruder across the boundary of a predetermined region.**

(57) The alarm apparatus for indicating the passage of an intruder across the boundery of a predetermined region comprises at least one pair of yieldable fluid-filled tubes (2, 4) for burying side by side along the boundary of the region, a diaphragm-type, two-directional differential pressure transducer (8) connected to one end of each tube and arranged to output an electrical signal as a result of the deformation of the diaphragm means (16a, 16b) caused by a difference between the pressures in the two tubes, valve means (22) mounted in at least one bypass duct (18) of the transducer and arranged to put the two tubes suddenly into fluid communication when the difference between the pressures in the two tubes exceeds a predetermined threshold value, and capillary means (24) which put the two tubes into fluid communication and are interposed in the bypass duct hydraulically in parallel with the valve means.

FIG. 1



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Improved apparatus for indicating the passage of an intruder æross the boundary of a predetermined region.

The present invention relates to alarm apparatus for signalling the passage of an intruder across the boundary of a predetermined region.

More particularly, the invention relates to apparatus of the type including at least one pair of yieldable tubes which are intended to be filled with fluid and buried along the boundary of the region and which can transmit an energy pulse in response to pressure applied to the exterior of a tube, and transducer means for converting the energy pulse into an alarm signal.

Apparatus of the aforesaid type is known from US patent No. 3,438,021, in which each tube is yieldable and is connected at one end to a respective diaphragm-type transducer device. This apparatus has the disadvantage of requiring accurate electrical balancing between the respective transducer devices and this is particularly difficult in view of the extreme sensitivity of the transducer devices themselves which may be influenced by variations of temperature and of the nature of the ground in which the apparatus is buried, and variations in the resistance of the materials, for example, as a result of ageing.

In a subsequent improvement described in UK patent no. 1,272,908, the two yieldable tubes are connected to a single two-directional, differential diaphragm-type pressure transducer which reduces the disadvantages of the apparatus of the aforesaid US patent.

Further improvements described in the operating manual of the "Periguard" (registered trade mark) device, made in accordance with the teachings of the US and UK

patents mentioned above, and also mentioned in the UK patent no. 2,029,062, include the use of capillary means which are associated with the free end of each tube and put the two tubes into fluid communication to cause a slow balancing of the pressure in the two tubes, while allowing pressure differences between the liquids on opposite sides of the diaphragm to be established in transitory operating conditions to cause the actuation of the alarm signal. More particularly, the capillary means serve to balance the pressure in the two tubes when a disturbance, which should not however be signalled as an intrusion, comes to affect the two tubes permanently in a different manner.

In view of the state of the art examined, the object of the present invention is to provide an improved apparatus which is highly reliable and provides a constant response signal over the working life of the apparatus, and which requires minimum maintenance.

This object is achieved by means of apparatus comprising:

- at least one pair of yieldable fluid-filled tubes intended for burying side by side along the boundary of the region,
- a two-directional differential pressure transducer including diaphragm means associated with pressure sensor means, connected to one end of each tube and arranged to output an electrical signal as a result of a deformation of the diaphragm means caused by a difference between the pressures existing in the two tubes, and
- capillary means which put the two tubes into fluid communication,

characterised in that it further includes:

- valve means mounted in at least one bypass duct of

the transducer and arranged to put the two tubes suddenly into communication when the difference between the pressures in the two tubes exceeds a predetermined threshold, and in that

- the capillary means are interposed in the bypass duct hydraulically in parallel with the valve means.

Other preferred characteristics of the apparatus according to the invention are defined in the dependent claims 2 to 9.

These characteristics and further advantages will be explained in detail with reference to the appended drawings provided purely by way of non-limiting example, in which:

Figure 1 is a diagrammatic view illustrating the arrangement of the apparatus;

Figure 2 is a partially-sectioned view illustrating a detail of one embodiment of the apparatus,

Figures 3 and 4 are sectional views of enlarged details of Figure 2.

With reference to the drawings, Figure 1 illustrates diagrammatically apparatus according to the invention intended to be buried along the boundary of a predetermined region to detect the passage of an intruder across this boundary.

Essentially, the apparatus comprises a pair of yieldable tubes 2 and 4 which are intended to be filled with pressurised liquid L and buried at a typical depth

of about 40-60cms, substantially parallel to each other and about 1-1.5m apart. The tubes 2 and 4 are made of a yieldable material, such as rubber, and the liquid is typically water with possible additives for lowering its freezing point.

The two yieldable tubes are connected at one end to a pressure transducer device 8 of the two-directional differential type, including diaphragm means, indicated 16, and pressure sensor means 42 (Figure 3), which will be described in more detail below and which can output an electrical signal in response to a variation between the pressures in the two tubes. A processing circuit 12 is associated with the transducer and is arranged to output an electrical signal which is converted into an alarm signal by an alarm device 14 when the signal output by the transducer exceeds a predetermined threshold.

A bypass duct 18 is connected at its ends to the transducer device on opposite sides of the diaphragm means 16. The bypass duct includes two branches 20a and 20b which are hydraulically connected in parallel and in which are mounted two one-way on-off valves 22 that are hydraulically in antiparallel to each other. These valves 22 are arranged to put the two tubes 2 and 4 suddenly into liquid communication when the difference between the pressures in the two tubes exceeds a predetermined threshold. Capillary means 24 are interposed in the bypass duct, preferably hydraulically in parallel with each valve 22.

According to a preferred characteristic, a pressure switch device 25 is connected to at least one of the two tubes, or is in liquid communication with therewith, for

providing an alarm signal when the pressure in the tube with which it is associated falls below a threshold.

In Figure 1 a duct for supplying liquid from a source 30 is indicated 26; the duct 26 communicates by means of two branches 26a and 26b with the bypass duct 18. Preferably, a differential valve 28 is connected in the supply duct and can enable the supply of pressurised liquid to the tubes 2 and 4 should the pressure in the two tubes fall below an operative value for the apparatus.

The other ends of each tube 2 and 4 are not interconnected and are each provided with a respective vent valve 32 for venting air from the two tubes during the refilling of the tubes with pressurised liquid supplied through the duct 26.

Details of one embodiment of the apparatus are illustrated in greater detail in Figures 2, 3 and 4. Elements corresponding to elements of Figure 1 are illustrated in Figures 2, 3 and 4 with the same reference numerals.

Figure 2 illustrates a housing 10 made, for example, by die-casting and constituted by a number of sectional parts. The housing 10 defines an internal chamber 34 communicating through respective ducts 36, 38 and connector members 40 with the two tubes 2 and 4. The transducer device 8 is mounted in the chamber 34 between the two connectors 36, 38.

Preferably, the transducer 8 includes first and second diaphragms 16a, 16b fixed to the walls of the chamber 34 with a liquid-tight seal. Each diaphragm is operatively

associated with a respective pressure sensor 42, preferably of piezoelectric type. The two diaphragms 16a and 16b are mounted with their respective opposing sensors preferably facing each other and are connected together by the interposition of a waterproof glue 44. The surface of each diaphragm facing the liquid may optionally be covered with a layer of waterproofing material.

Figure 4 illustrates in detail a one-way flow valve 22 connected in the bypass duct 18. Each valve 22 has a tubular body 46 inserted in a chamber 48 defined by the housing 10 and communicating with the respective branch 20a or 20b of the bypass duct through apertures 50 and 52. The tubular body 46 defines an axial duct 47 with an inlet opening 49 and has an internally-threaded end 56 mounted in the body 10 and another internally-threaded end 60. The tubular body 46 has a radial capillary duct 64 which constitutes the capillary communication means which enable the pressure in the two tubes to balance slowly. The tubular body 46 has two or more radial ducts 62 adjacent to a surface 66 which acts as a valve seat and cooperates with a spherical obturator member 68 which is held in a closed position under the action of resilient means 70 inserted in the tubular body 46 and interacting axially between the obturator and an internally-hexagonal screw 62 inserted in the end 60. A sudden pressure drop in one of the tubes 2 and 4 causes the one-way flow valve to open, allowing rapid passage of liquid through the bypass duct to equalise the pressure in the two tubes again. This sharp pressure drop may be caused, for example, by failure of the material or damage to the tubes caused, for example by a rodent. In view of the use of these valves, the pressure in the tubes is

balanced immediately and damage to the transducer device is thus avoided. The capillary means constituted by the duct 64, however, enable slow balancing of the pressures in the two tubes while allowing a pressure difference to be established between the two tubes in transitory conditions in order to activate the alarm signal.

According to a further preferred characteristic, the apparatus according to the invention includes a test device (not illustrated) for indicating that the transducer is operational. This test device is preferably constituted by means for supplying one or other of the sensors independently with an electrical signal which can cause the deformation of the sensor and the diaphragm associated therewith. The deformation of the diaphragm in its turn causes the deformation of the other diaphragm rigidly connected thereto and of the respective sensor, causing a response signal which is processed by the processing circuit 12. This test system allows the functioning of the transducer to be checked extremely simply.

The processing circuit 12 and its alarm device are preferably located within the housing 10. The processing circuit 12 may conveniently be arranged to differentiate the direction in which the intruder crosses the boundary of the region defined by the yieldable tubes on the basis of the signal provided by the transducer. Correspondingly, the alarm device 14 is provided with separate optical or audible signalling devices which are activated by the processing circuit to signal whether the crossing or approach to the boundary has occurred in one direction or the other, or to provide an indication of the type of intrusion

occurring.

According to a further preferred characteristic, the housing 10 has a plurality of pairs of connectors of the type indicated 40 with respective pairs of ducts communicating with the chamber 34 on opposite sides of the transducer. These auxiliary connector members enable a plurality of pairs of yieldable tubes to be connected to the transducer to extend the range of detection of the apparatus itself. The connectors are arranged to receive respective obturators when the supplementary pairs of yieldable tubes are not used.

Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to that described and illustrated, without thereby departing from the scope of the present invention.

CLAIMS

1. Apparatus for indicating the passage of an intruder across the boundary of a predetermined region, comprising:

- at least one pair of fluid-filled yieldable tubes (2, 4) intended for burying side by side along the boundary of the region,
- a two-directional differential pressure transducer (8) including diaphragm means (16a, 16b) associated with pressure sensor means (42), connected to one end of each tube and arranged to output an electrical signal as a result of a deformation of the diaphragm means caused by a difference between the pressures existing in the two tubes, and
- capillary means (24) which put the two tubes into fluid communication,

characterised in that it further includes:

- valve means (22) mounted in at least one bypass duct (18) of the transducer and arranged to put the two tubes suddenly into communication when the difference between the pressures in the two tubes exceeds a predetermined threshold, and in that
- the capillary means (24, 64) are interposed in the bypass duct hydraulically in parallel with the valve means.

2. Apparatus according to Claim 1, characterised in that the valve means include two one-way on-off valves mounted in hydraulically-parallel branches of the bypass duct and connected hydraulically in antiparallel.

3. Apparatus according to Claim 2, characterised in each of the on-off valves comprises:

- a tubular body (46) having an inlet opening (49)

and an outlet opening (62),

- an obturator member (68) cooperating with a valve seat (66) carried by the tubular body adjacent the outlet opening (62) and held in its closing position by resilient means (70), the tubular body having a capillary duct (64) constituting the capillary means.

4. Apparatus according to any one of Claims 1 and 3, characterised in that the transducer comprises:

- a housing (10) defining an internal chamber (34) having at least one pair of apertures each connectible to a respective yieldable tube of the said pair,

- first and second diaphragms (16a, 16b) each carrying a respective pressure sensor member (42) on one face, the first and second diaphragms being fixed with a liquid-tight seal in the chamber in a position intermediate the apertures, with the respective sensors preferably facing each other and being rigidly interconnected by the interposition of a waterproofing glue material (44).

5. Apparatus according to Claim 4, including a test device for indicating that the transducer is operational, characterised in that the test device comprises means for supplying one or other of the sensors independently with an electrical signal which can cause its deformation.

6. Apparatus according to any one of Claims 1 to 5, including means for supplying liquid to the tubes and vent valve means for venting the gases in the tubes, characterised in that the means for supplying liquid comprise a duct (26) connected to the bypass duct of the transducer, and a differential valve (28) for allowing

the supply of liquid to the bypass duct when the liquid pressure falls below a predetermined operational value, and in that the vent valve means (32) are mounted at the other free end of each tube.

7. Apparatus according to any one of Claims 1 and 6, characterised in that it further includes at least one pressure switch device (25) communicating with one of the tubes and able to output an electrical signal when the liquid pressure in the tube associated therewith falls below a predetermined minimum value.

8. Apparatus according to any one of Claims 1 to 7, characterised in that the housing (10) has a plurality of pairs of connector members (40) for connecting pairs of yieldable tubes in liquid communication with the transducer, the connector members of each pair being located on opposite sides of the diaphragm means and each of the connector members being arranged to receive a respective obturator member.

9. Apparatus according to any one of Claims 1 to 8, including, in known manner, a processing circuit (12) associated with the transducer and arranged to provide an electrical signal which is converted into an alarm signal by an alarm device (14) when the signal output by the transducer exceeds a predetermined threshold, characterised in that the processing circuit is arranged to differentiate the direction in which the intruder crosses the boundary of the region defined by the yieldable tubes, and in that the alarm device includes separate optical and audible signalling means for activation by the processing circuit to indicate whether the crossing or approach has occurred in one direction or the other, or to provide an indication of the act.

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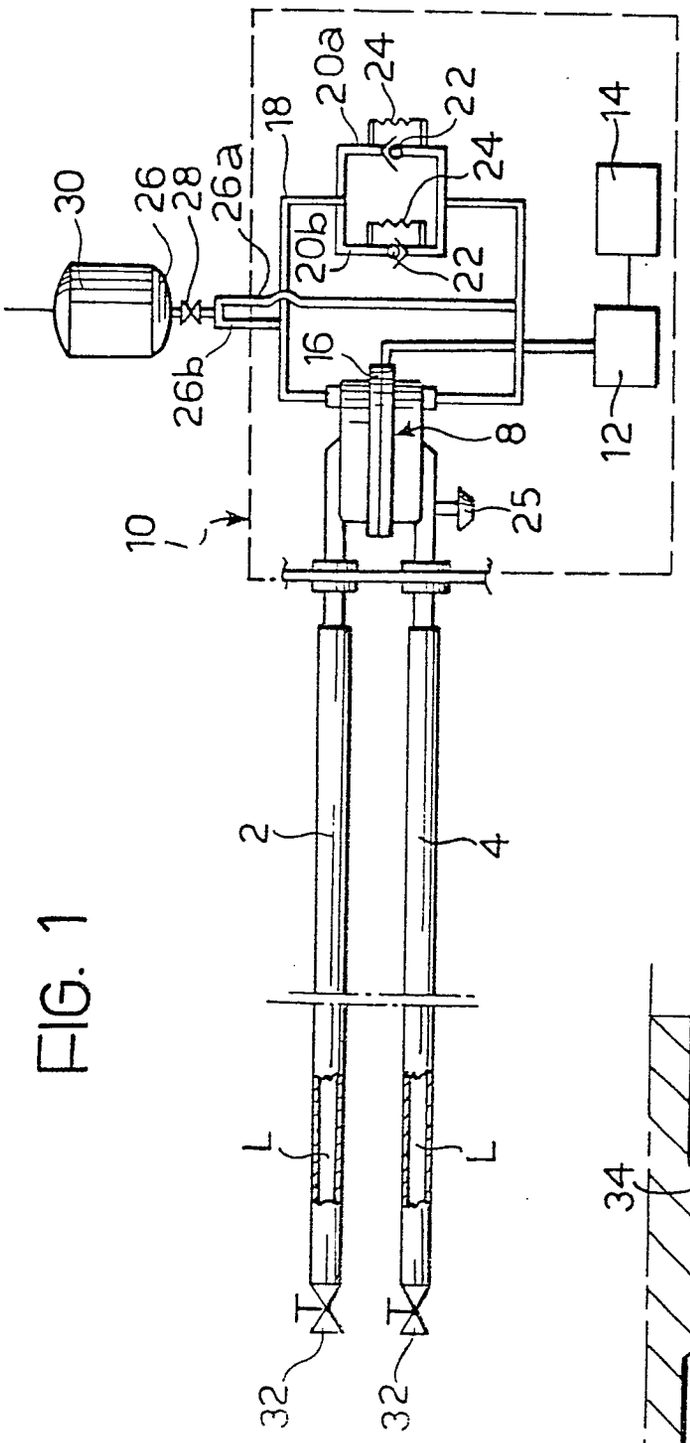

FIG. 1

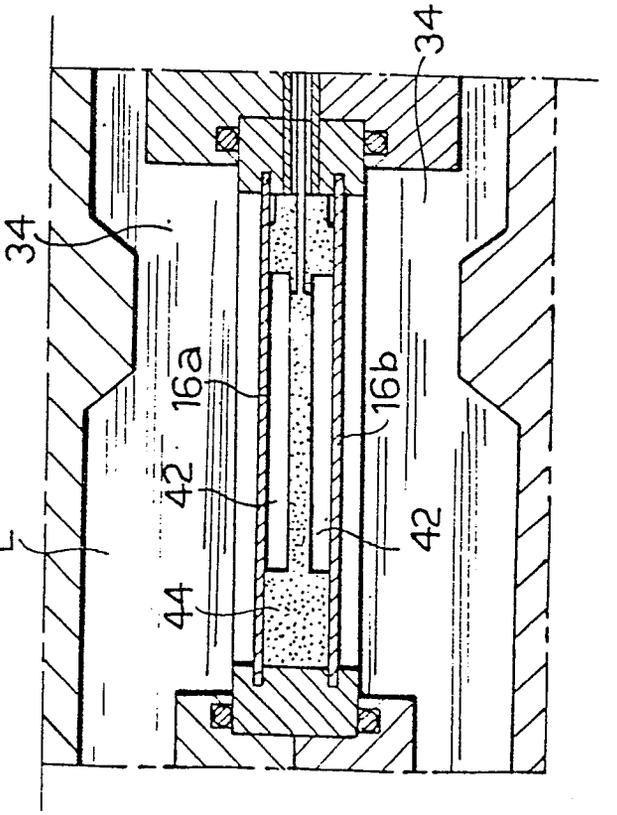

FIG. 3

FIG. 4

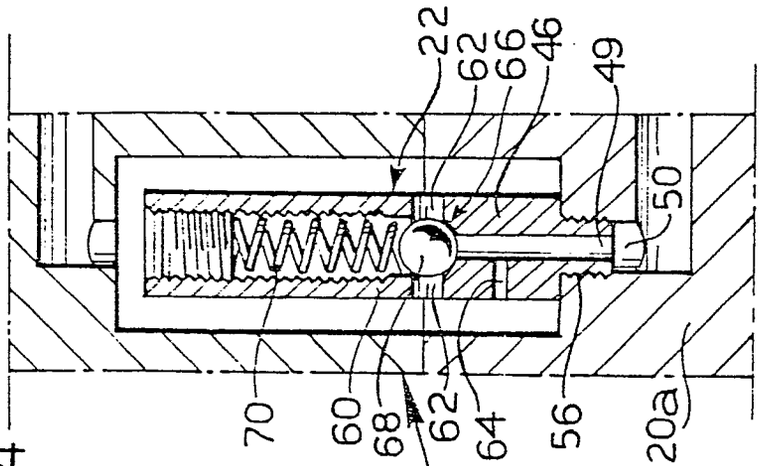
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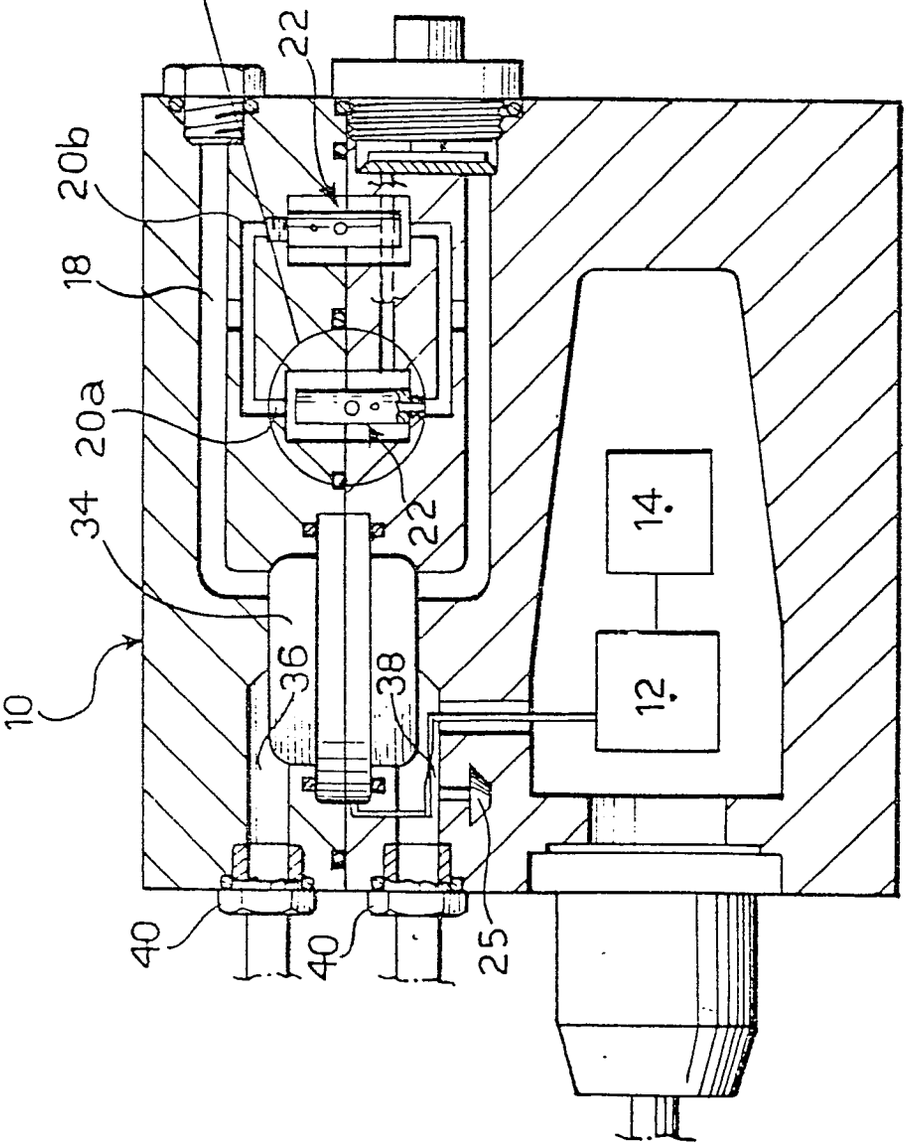
FIG. 2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