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METHOD AND APPARATUS FOR MONITORING THE TEETH OF
A COMB PLATE FOR A PASSENGER CONVEYOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to passenger conveyors and, more particularly, to a safety device for passenger conveyors.

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2. Description of the Related Art

A passenger conveyor, such as an escalator or a moving walk, is typically formed of a plurality of tread plates propelled between stationary pieces, i.e., landings, where passengers get on and off the conveyor. To prevent foreign objects from getting jammed at the gap or interface between the landing and the tread plates, a comb plate is attached to each landing for deflecting or pushing foreign objects away from that interface. The comb plate has a plurality of teeth shaped to mesh with longitudinal grooves in the tread plates.

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During the course of operation of the passenger conveyor, the teeth of the comb plate may break off or otherwise become damaged so that objects such as the pointed heel of a shoe, miscellaneous refuse, or, more dangerously, a body part of a passenger, may become lodged or entrapped between a tread plate and the comb plate. The comb plate teeth may be damaged due to cyclic stresses during use or impact loads by, for example, pebbles or screws wedged in the grooves of moving tread plates. A typical mode of failure is that one or more comb plate teeth break off thereby exposing the gap between the landing and a tread plate.

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Consequently, the comb plate becomes less effective in deflecting objects from the gap. If the

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drive mechanism is not immediately stopped, the passenger may suffer substantial injury or the conveyor drive mechanism may sustain substantial damage.

Typically, comb plate teeth are visually inspected by building or service personnel. This dependency on human observation and intervention has sometimes led to
5 damaged comb teeth remaining in service for extended periods of time, and thus exposed passengers to unnecessary risks.

U.S. Patent No. 5,718,319 discloses a safety device for detecting objects stuck in an escalator or a moving walk. The device includes a high-strength flexible wire extending transversely through a series of holes formed in the teeth of a comb plate. The wire is
10 connected to an actuator, which shuts off the motor operating the escalator when the wire is stretched or elongated. This device, however, cannot detect cracked or missing teeth as it is possible that a tooth can be broken off without causing the wire to stretch. Furthermore, this device requires increased maintenance as the wire traps and accumulates small foreign objects, which would have been deflected by the comb plate teeth.

15 German reference DE 2 135 864 discloses a further safety device for escalators including an electrical conductor arranged in the comb teeth for establishing an electronic signal path through the comb tooth assembly. Similarly, International Publication No. WO 91/06501 discloses an escalator safety device in which the teeth comprise an electric conductor molded therein which is part of an electrical circuit. These safety devices are difficult to
20 manufacture and therefore are expensive to manufacture.

Yet another safety device is disclosed in Japanese Abstract No. JP 4-153195 in which optical means 24, 25, 26 are used to detect deformation or breaks in the comb teeth. Similarly, German reference DE 680 847 discloses a safety device for an escalator in which a light beam is projected through holes in the comb teeth and detected by a photoelectric device
5 positioned on the side of the escalator. The manufacture of the optical means is also complex. Furthermore, dirt or other foreign objects may occlude the light path and produce a false signal.

Accordingly, there is a need for a reliable method and apparatus for automatically detecting damaged comb plate teeth.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and an apparatus for detecting damage to comb plate teeth of a passenger conveyor.

According to an aspect of the invention, a missing or broken comb tooth can be
5 detected by monitoring the continuity of an electrical or fluid circuit passing through or along each of the comb plate teeth, the circuit comprising part of a mechanism embedded in the comb plate. Thus, a break in the continuity of the circuit indicates a comb tooth has been damaged.

In one embodiment, a signal line is arranged on a circuit board to extend along or through each of the comb plate teeth to form a series circuit so that when a comb tooth is
10 damaged, the flow of electrical current through the series circuit is interrupted. If the conductor supplies power to a relay of a safety circuit of the passenger conveyor, a damaged comb tooth will result in a loss of power to the relay, causing the passenger conveyor to immediately stop so as to prevent further injury to the passenger or damage to the conveyor drive mechanism. Alternatively, the signal line forms a parallel circuit such that damage to a comb tooth results in a
15 change or stoppage of electrical current through the circuit. A monitoring device detects the change in the electrical current and actuates a warning device and/or shuts off the conveyor's drive mechanism. Using Kirchoff's law, the number of broken comb teeth can be determined by measuring or monitoring changes in the equivalent resistance of the parallel circuit or the signal strength of the entire parallel circuit. Depending on the damage severity, the monitoring device
20 may shut down the passenger conveyor or issue a warning signal indicating the comb plate has sustained damage.

In another embodiment, the comb plate includes a continuous fluid channel formed in each of the comb plate teeth. The fluid chamber may be filled with an electrically conductive fluid such as, for example, a conductive gas or antifreeze liquid connected to a voltage source to form a circuit so that when a comb tooth breaks, the fluid leaks out thereby opening the circuit.

5 Upon sensing an open circuit a detector informs a controller then actuates a warning device to indicate that a comb plate tooth has been damaged.

Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of
10 illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. It should be further understood that the drawings are not necessarily drawn to scale and that, unless otherwise indicated, they are merely intended to conceptually illustrate the structures and procedures described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference characters denote similar elements throughout the several views:

Fig. 1 depicts a prior art passenger escalator having a comb plate;

5 Fig. 2 is a cross-sectional view of a comb plate and a tread plate;

Fig. 3 is a plan view of two sections of a comb plate according to an embodiment of the present invention;

Fig. 4 is a cross sectional view of a comb plate according to an embodiment of the present invention;

10 Fig. 5 is a plan view as in Fig. 3 showing another embodiment of the present invention;

Fig. 6 is a schematic view of yet another embodiment of the present invention;

Fig. 7 is a schematic view of another embodiment of the invention incorporating a fluid chamber; and

15 Fig. 8 schematically illustrates another embodiment of the invention having a pressure sensor disposed inside a fluid chamber.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Fig. 1 illustrates a prior art escalator 10 including a treadway 12 formed by a plurality of tread plates 14 and risers 16. The tread plates 14 have longitudinally spaced tread grooves 18 formed on their top surfaces and are guided to slide beneath a comb plate 20 attached to a landing 22. Typically, the comb plate 20 is constructed of a plurality of sections arranged side by side and has teeth 24 shaped to project into the tread grooves 18. So arranged, the comb plate teeth 24 prevent debris deposited in the tread grooves 18 or a passenger's shoe or garment from becoming lodged at the gap between the landing 22 and a tread plate 14 by deflecting it away from the gap.

Fig. 2 depicts a cross-sectional view of an assembly of a landing 22, a comb plate 20, and a tread plate 14. As can readily be seen, the comb plate tooth 24 extends into a groove 18 of the tread plate 14 and is dimensioned to maintain a minimum clearance between the bottom surface 26 of the tooth 24 and the bottom wall 28 of the groove 18. Typically, the comb plate tooth 24 has a sloping top surface extending from near the bottom wall 28 of the groove 18 to a distance above the tread plate 14 and shaped to deflect objects away from the interface 30 between the landing 22 and the tread plate 14. However, a comb plate tooth 24 can become damaged or broken due to fatigue or from collision with debris entrenched in the groove 18 of a tread plate 14. Without the sloping surface, the broken or damaged comb plate tooth 24 loses the ability to deflect debris trapped in the groove 18 of a tread plate 14 thereby increasing the likelihood that the debris becomes lodged under the landing.

In accordance with the present invention, each of the comb plate teeth 24 can be monitored using an electrical and/or fluid mechanism embedded in the comb plate. Advantageously, the mechanism establishes a detectable physical variable such as, for example, the strength of an electrical signal or a level of fluid pressure for each of the comb plate teeth 24 so that when a tooth of the comb plate 20 becomes damaged, the value of the detectable physical variable changes. A detector senses the changed value of the detectable physical variable and generates a signal, preferably when the changed value varies from a predetermined threshold. A controller receives the signal from the detector and causes the passenger conveyor 10 to shut down and/or issues a warning to the passenger(s) or operator(s) of the conveyor 10.

Figs. 3 and 4 schematically illustrate an embodiment of an apparatus for detecting a damaged tooth of a comb plate 20 comprising two comb plate sections 44, 46 using a serial continuity check. Each comb plate section 44, 46 comprises a circuit board 31 comprising teeth 33 corresponding to the teeth 24 of the comb plate 20. A signal line 32 is arranged on the circuit board 31 using known circuit board printing technology and extends along and/or through each of the teeth 33 of the circuit board 31. The comb plate 20 is overmolded around the circuit board 31.

As shown in Fig. 3, the signal line 32 may be connected to a signal generator 34 for generating a signal through the signal line 32 such that a damaged tooth 24 will disrupt or otherwise vary the signal transmitted through the signal line 32. The signal line 32 may, for example, be a conductive signal path formed on the one-sided circuit board injection overmolded with an engineering plastic to form the comb plate 20 and comb plate teeth 24.

The circuit board 31 may be formed of high temperature composite material such as, for example, polyimide, which has a higher processing temperature than the overmold material; in which case, the circuit board 31 and the overmold material form separate layers. Alternatively, the circuit board 31 and the overmold material are the same; in which case, the circuit board 31 fuses with the overmold material. In any event, the conductive signal lines 32 are embedded in each of the comb plate teeth 24.

A detector 36 connected to the signal line senses the signal disruption or variation and sends a warning message indicating the presence of a damaged tooth to a controller 38. In response to the message from the detector 36, the controller 38 may actuate a warning device or shut down the passenger conveyor 10. To avoid false readings, the detector 36 is preferably configured to transmit the warning message only when the signal strength is below a predetermined threshold. Alternatively, as depicted in Fig. 5, the detector 36 includes a relay 40 energized by a voltage source 42 connected to the signal line 32 so that when a comb plate tooth 24 is broken, the relay 40 loses power and opens a safety circuit (not shown) of the conveyor 10 thereby shutting down the conveyor 10 or actuates a warning-signaling device to issue a warning to the passengers or an operator of the conveyor 10.

Although only two comb plate sections 44, 46 are shown in Figs. 3 and 5, it is contemplated that one or more sections can be used to construct a comb plate 20 of a desired width for these embodiments and the embodiments described below. To connect the signal lines 32 of adjacent sections, a suitable connecting device such as for example spring contacts 48 disposed at corresponding locations of the adjacent sections may be used.

Fig. 6 schematically depicts a comb plate 20 in which the circuit board 31 comprises a parallel circuit wherein a resistive element 60 is formed at each of the comb plate teeth 24 such that damage to one or more comb teeth 24 results in a change of electrical current through the circuit. The detector 36 senses the change in electrical current and causes the controller 38 to actuate a warning device and/or shut off the conveyor drive mechanism. Additionally, using Kirchoff's law, the number of broken comb teeth may be determined by measuring or monitoring changes in the equivalent resistance of the parallel circuit or the signal strength of the entire parallel circuit. Depending on the damage severity, the detector 36 may shut down the passenger conveyor 10 or issue a warning signal indicating the comb plate 20 has sustained damage.

Fig. 7 schematically illustrates a comb plate 20 incorporating a fluid chamber 62 having a plurality of channels 64 extending into the comb plate teeth 24. The fluid chamber 62 and channels 64 may be filled with a fluid (e.g., air, antifreeze liquid, etc.) and pressurized to a predetermined pressure by a pressure regulator 66 so that when a comb plate tooth 24 is broken, fluid is lost and a pressure sensor 68 for sensing pressure in the fluid chamber sends a signal to the controller 38. The controller 38 responds to the signal from the pressure sensor 66 and causes a warning device to issue a warning to an operator of the passenger conveyor 10, and/or sends a control signal to a safety circuit to shut down the passenger conveyor 10. Alternatively, the fluid in the fluid chamber 62 and channels 64 may comprise an electrical conductive fluid. In this alternative embodiment, the circuit of Figs. 3 and 5 may be connected to the ends of the fluid

chamber 62 for conducting an electric signal through the fluid. When one of the comb fingers 24 breaks, the fluid drains from the comb plate section of that finger 24 and disrupts the signal.

Optionally, as depicted in Fig. 8, a negative pressure may be created in the fluid chamber 62 so that when a comb plate tooth 24 is broken, the fluid chamber 62 loses the negative pressure. A pressure sensor 68 (e.g., a micro pressure switch) disposed in the fluid chamber 62 then responds to the loss of negative pressure and sends a signal to the controller 38. Upon receiving the signal from the pressure sensor 68, the controller 38 may shut down the passenger conveyor 10 (by, for example, opening a safety circuit) and/or actuate a warning device.

The embodiments of Figs. 7 and 8 may be formed using gas-assisted injection molding technology. According to this method, gas is injected into the plastic as the comb plate is being molded so as to form the fluid chamber 62.

Thus, while there have shown and described and pointed out fundamental novel features of the invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Moreover, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment of the invention may be incorporated in any other disclosed or described or suggested form or embodiment as a general

matter of design choice. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

CLAIMS

We claim:

1 1. An apparatus for detecting one or more damaged teeth of a comb plate of a
2 passenger conveyor, comprising:
3 a comb plate having a plurality of teeth;
4 a mechanism arranged in the comb plate having a detectable physical variable with
5 a value which varies when one of the plurality of teeth of the comb plate becomes damaged, said
6 mechanism extending along each of the plural teeth and comprising one of a circuit board
7 embedded in the comb plate having a signal line printed thereon and a fluid arranged in a fluid
8 chamber defined within the comb plate and including a plurality of channels extending through the
9 plurality of teeth of the comb plate; and
10 a detector operatively connected to said mechanism for sensing the value of the
11 detectable physical variable and generating a signal when the value passes a predetermined
12 threshold.

1 2. The apparatus of claim 1, wherein said mechanism comprises said circuit
2 board and the signal line is connectable to a voltage source for supplying a reference voltage as
3 the detectable physical variable.

1 3. The apparatus of claim 2, wherein the detector includes a relay connected
2 to the signal line such that a damaged tooth results in an open circuit and a loss of power to the
3 relay.

1 4. The apparatus of claim 1, further comprising a controller responsive to the
2 signal from the detector for one of shutting down the passenger conveyor and causing a warning
3 to issue.

1 5. The apparatus of claim 2, wherein the signal line forms a series circuit
2 such that a damaged tooth results in a loss of signal through the signal line.

1 6. The apparatus of claim 2, wherein the signal line forms a parallel circuit
2 including a resistive element disposed at each of the comb plate teeth such that a damaged tooth
3 results in a change in an equivalent resistance of the parallel circuit.

1 7. The apparatus of claim 1, wherein said mechanism comprises the fluid in
2 the fluid chamber and the fluid chamber includes a pressure different from atmospheric pressure
3 such that a damaged tooth results in a change of the pressure, the detectable physical variable
4 being the pressure of the fluid chamber.

1 8. The apparatus of claim 7, wherein the pressure is above atmospheric
2 pressure.

1 9. The apparatus of claim 7, wherein the pressure is below atmospheric
2 pressure.

1 10. The apparatus of claim 7, wherein the detector includes a pressure sensor
2 that outputs a signal in response to the change of pressure in the fluid chamber.

1 11. The apparatus of claim 10, wherein the detector is disposed inside the fluid
2 chamber.

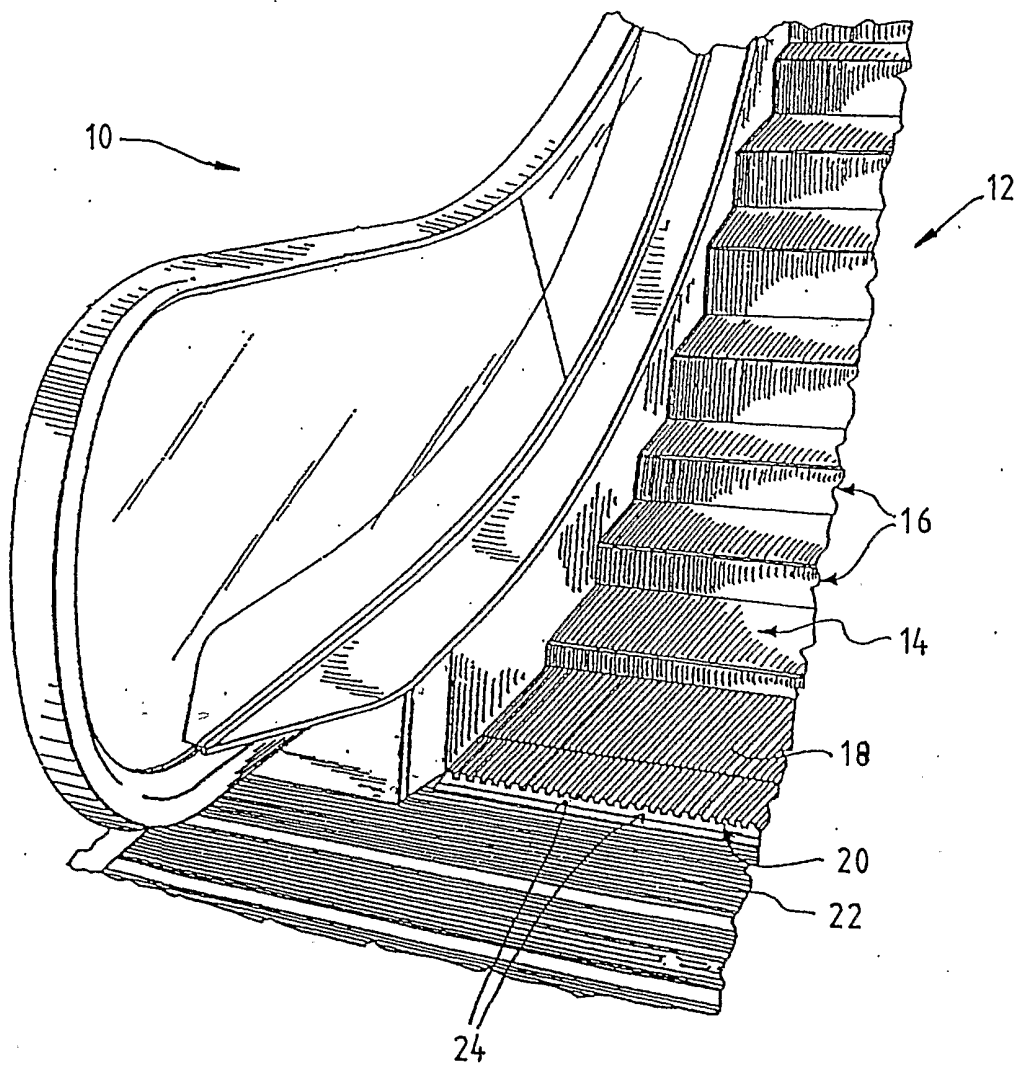
1 12. The apparatus of claim 7, wherein the fluid in the fluid chamber is
2 electrically conductive so as to form a signal path therethrough and an electrical signal source is
3 connected to the fluid chamber for supplying an electrical signal to the fluid such that a damaged
4 tooth results in a loss of the fluid and thus an open circuit, the detector being responsive to a
5 change in the electrical signal.

1 13. The apparatus of claim 12, wherein the fluid includes a gas.

1 14. The apparatus of claim 12, wherein the fluid includes a liquid.

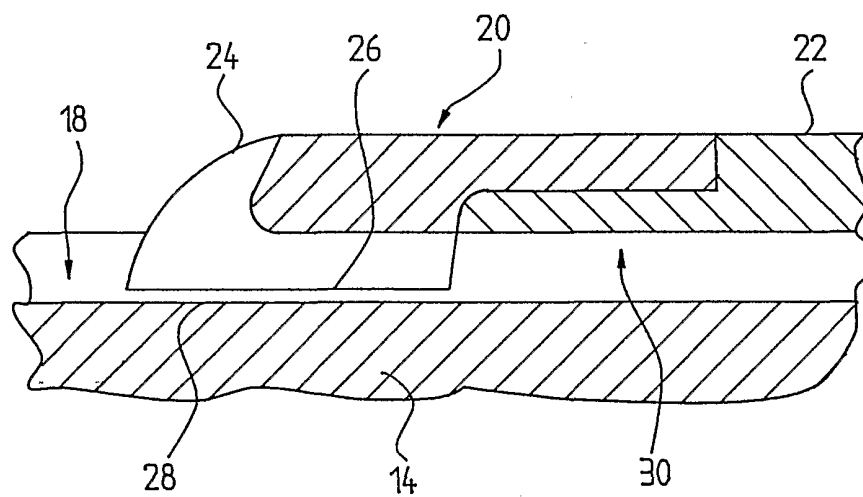
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Fig. 1



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Fig. 2



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Fig. 3

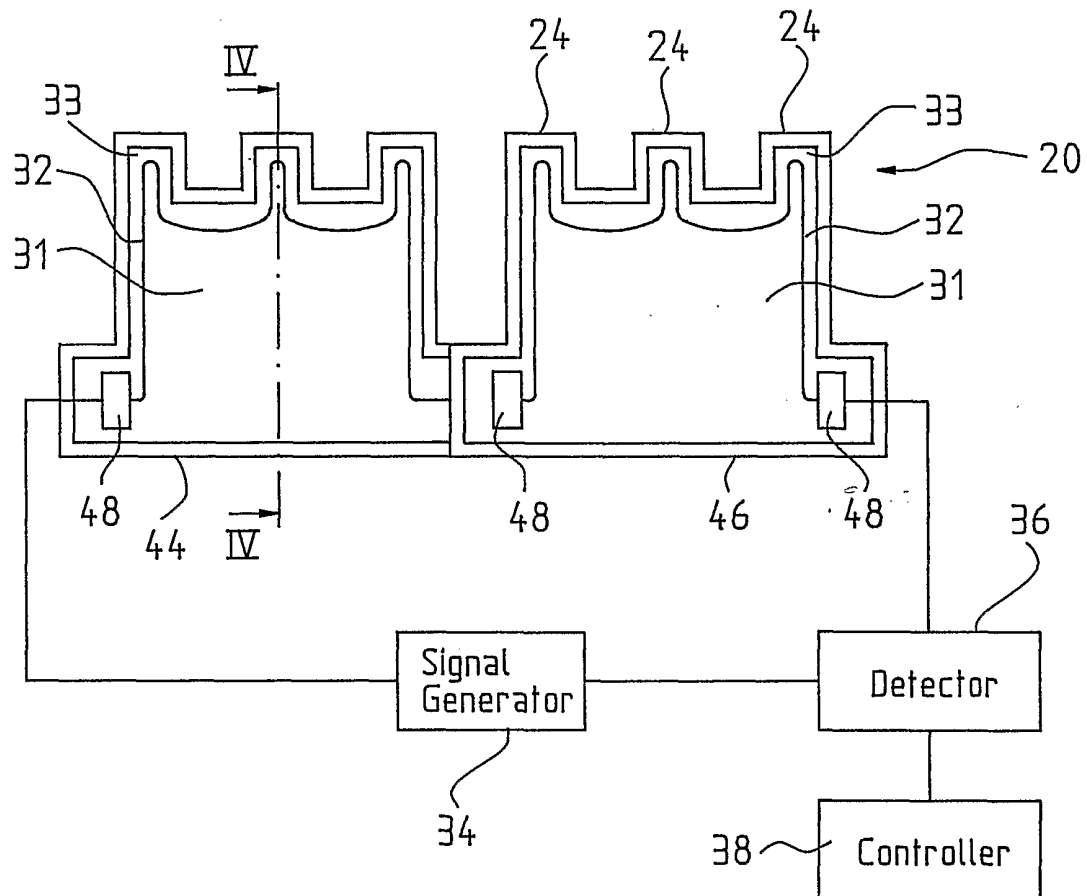
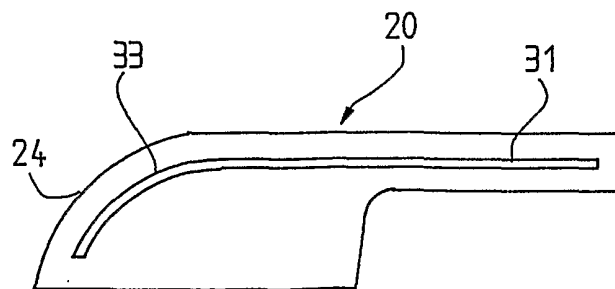


Fig. 4



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Fig. 5

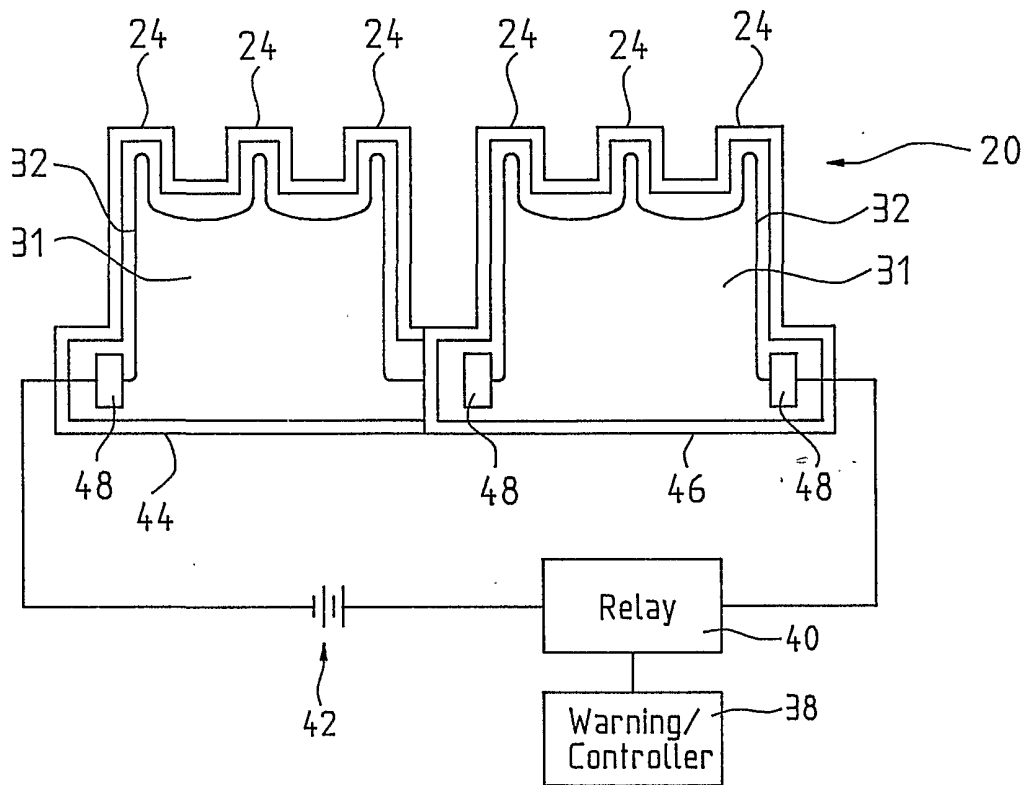
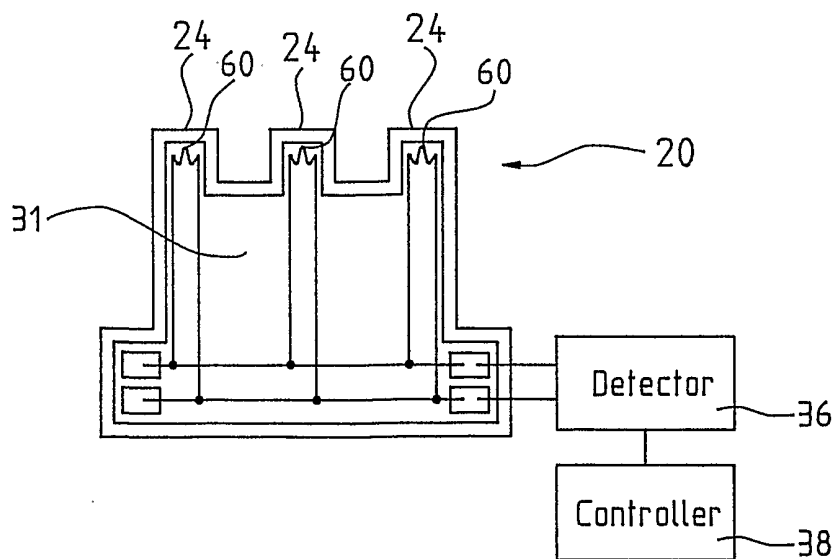


Fig. 6



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Fig. 7

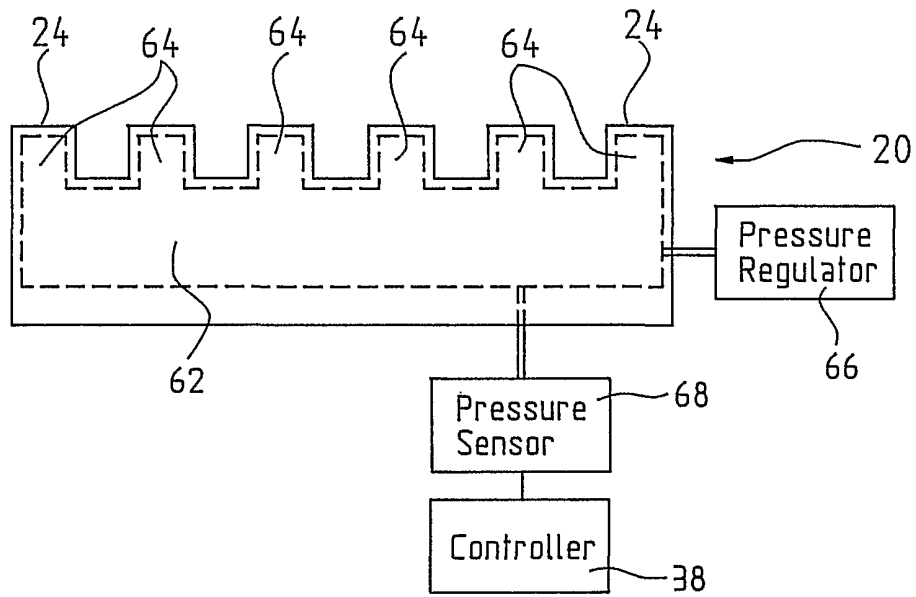
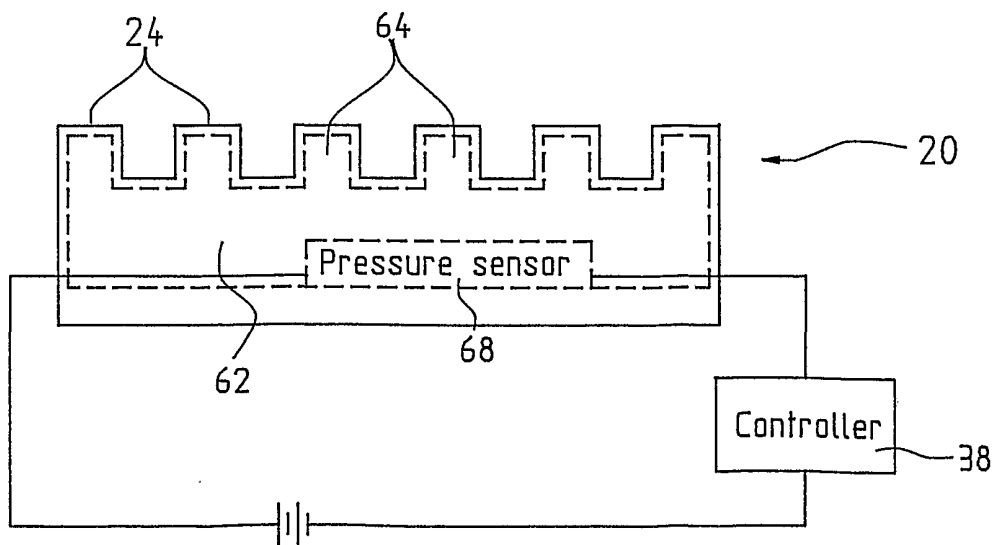


Fig. 8



INTERNATIONAL SEARCH REPORT

In **national** Application No

PCT/CH 01/00497

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B66B29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 233 717 A (HITACHI LTD.) 8 February 1966 (1966-02-08) column 2, line 70 - line 71; figure 4 column 3, line 1 - line 2 ---	1-3
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) -& JP 07 025575 A (MITSUBISHI DENKI BILL TECHNO SERVICE KK), 27 January 1995 (1995-01-27) abstract; figure 2 ---	1,2,5
A	US 4 088 219 A (BINNS KEITH) 9 May 1978 (1978-05-09) abstract; figure 1 column 1, line 29 - line 34 -----	1,7



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

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L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CH 01/00497

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