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Lawlor et al.

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(45) **Date of Patent: Apr. 24, 2007**

(54) **REARVIEW MIRROR ASSEMBLY FOR A VEHICLE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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Related U.S. Application Data

(63) Continuation of application No. 10/512,206, filed as application No. PCT/IE03/00059 on Apr. 25, 2003, now Pat. No. 7,110,156.

(30) **Foreign Application Priority Data**

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Jul. 1, 2002 (IE) S2002/0545

(51) **Int. Cl.**
G02F 1/15 (2006.01)
G02F 1/153 (2006.01)
G02B 5/08 (2006.01)
G02B 7/182 (2006.01)
B60Q 1/26 (2006.01)

(52) **U.S. Cl.** **359/265**; 359/267; 359/601; 359/604; 359/843; 359/871; 359/872; 362/492; 362/494; 340/815.4; 340/461; 307/10.1

(58) **Field of Classification Search** 359/265, 359/267, 271–273, 601–604, 607, 608, 841–844, 359/871–873; 362/235, 464, 492, 494; 340/425.5, 340/461, 525, 815.4, 988; 307/10.1
See application file for complete search history.

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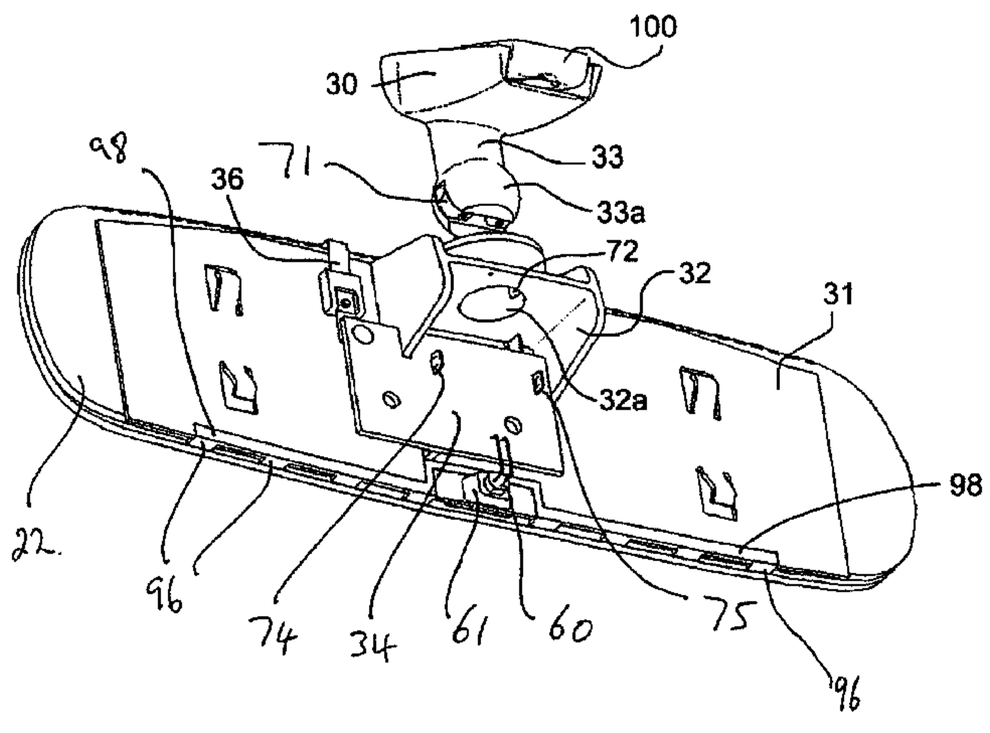
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Primary Examiner—Loha Ben
(74) *Attorney, Agent, or Firm*—Van Dyke, Gardner, Linn & Burkhart, LLP

(57) **ABSTRACT**

A rearview mirror assembly for a vehicle comprises an electro-optic mirror unit whose reflectivity is variable in response to an electrical voltage applied thereto. At least one light sensor is included and an electrical circuit controls operation of the mirror unit in response to the at least one light sensor. The mirror unit is mounted on one side of a backplate that comprises an electrically non-conductive material comprising a conductive lead frame.

19 Claims, 20 Drawing Sheets



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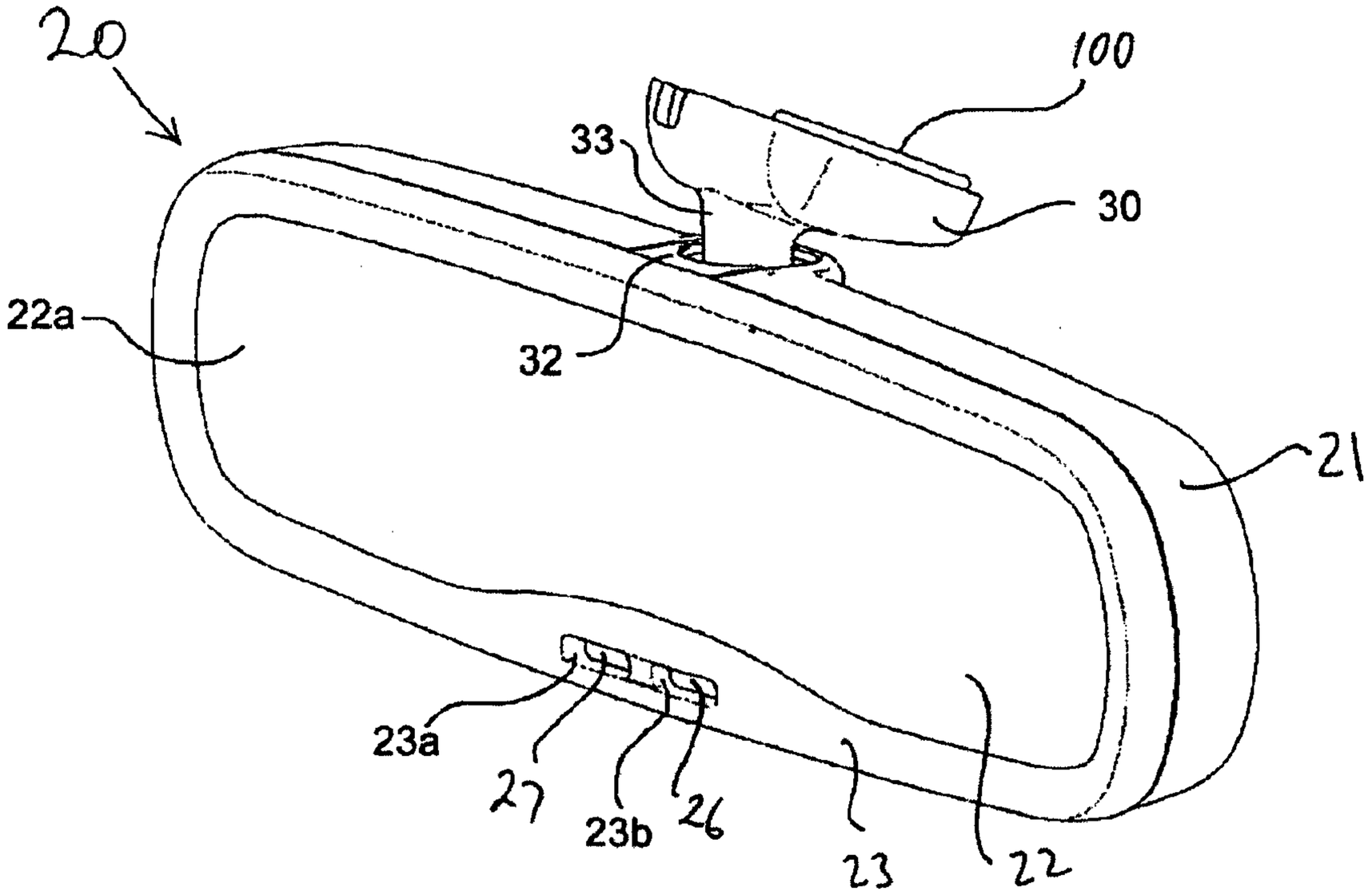


Fig. 1

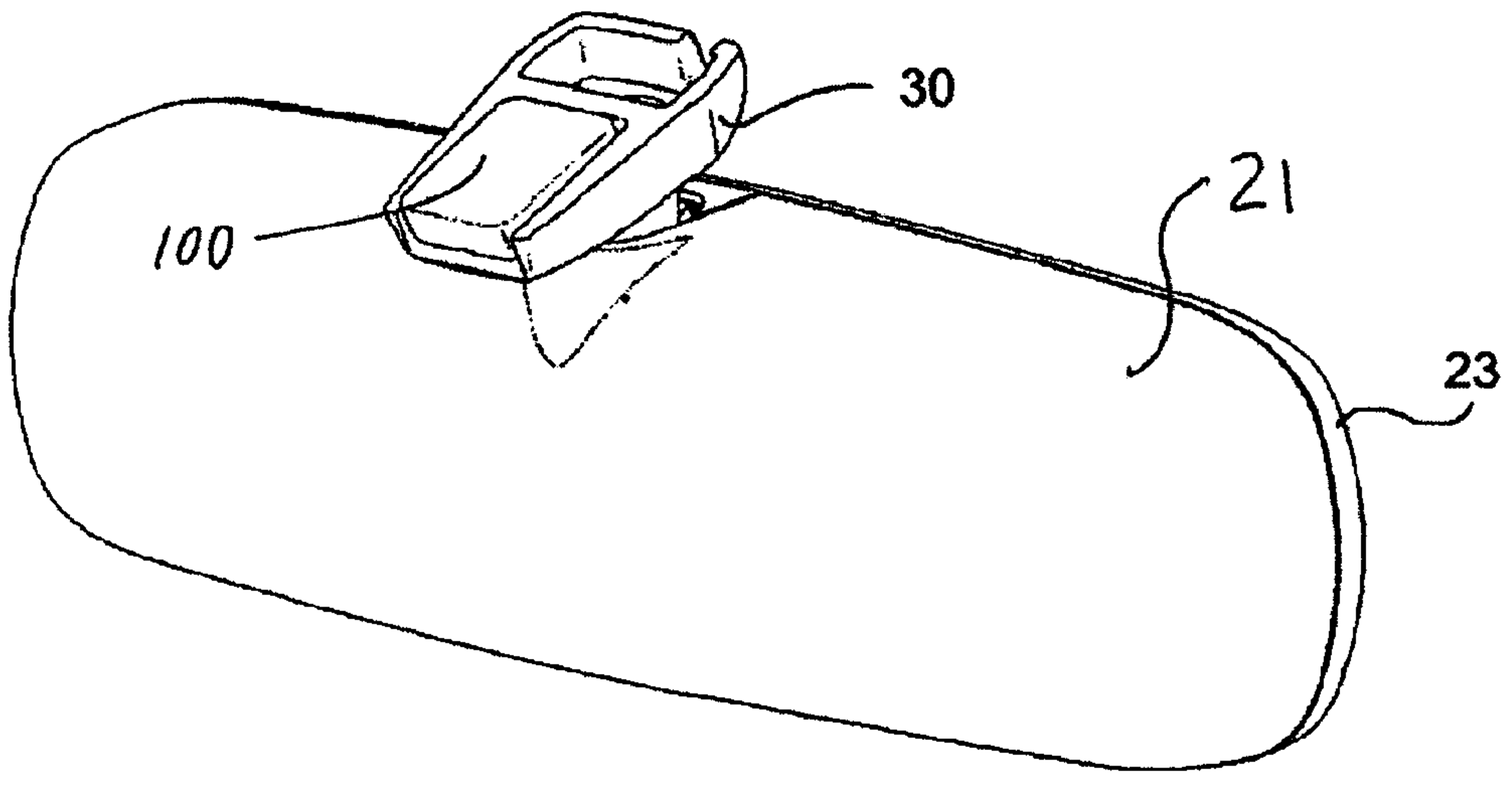


Fig. 2

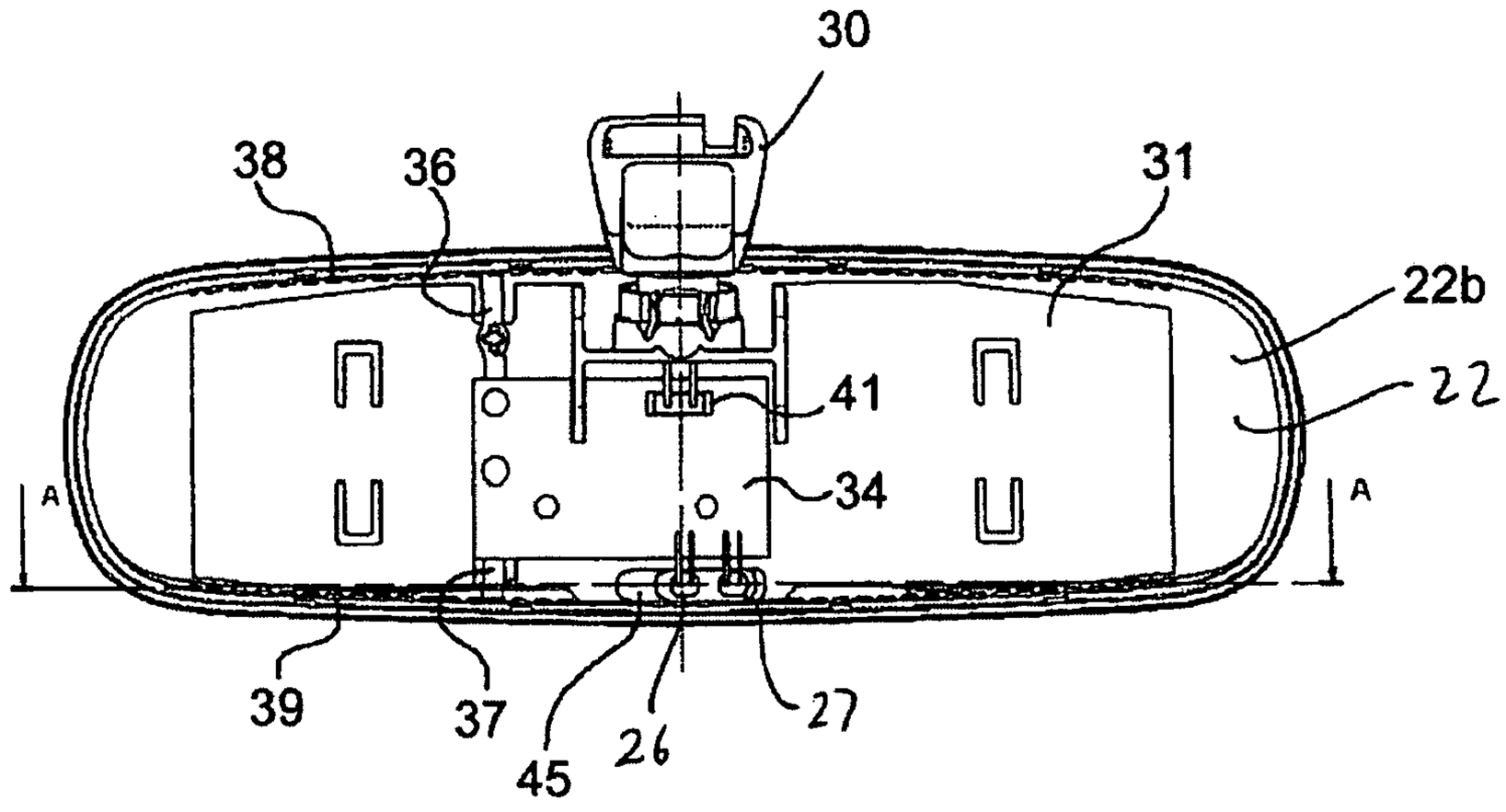

30
38
36
31
22b
22
41
34
A
A
39
37
45
26
27

Fig. 3

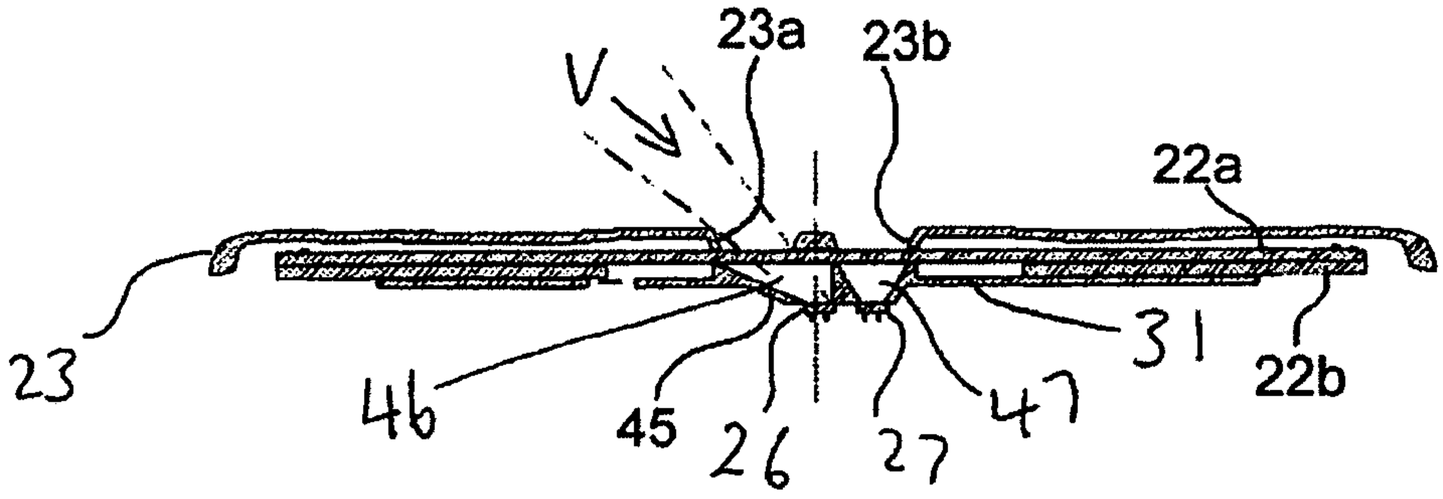

V
23a
23b
22a
23
46
45
26
27
47
31
22b

Fig. 4

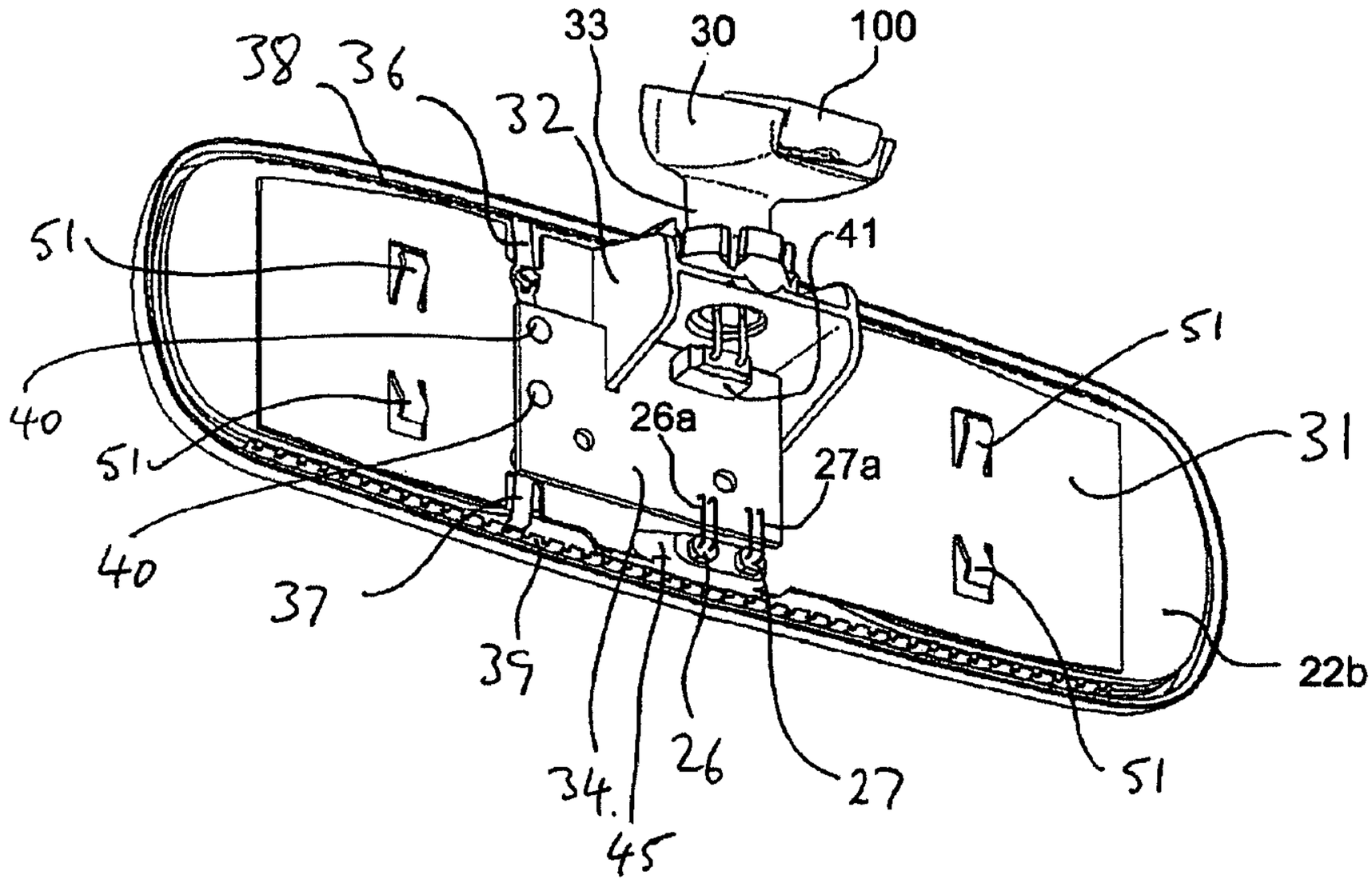


Fig. 5

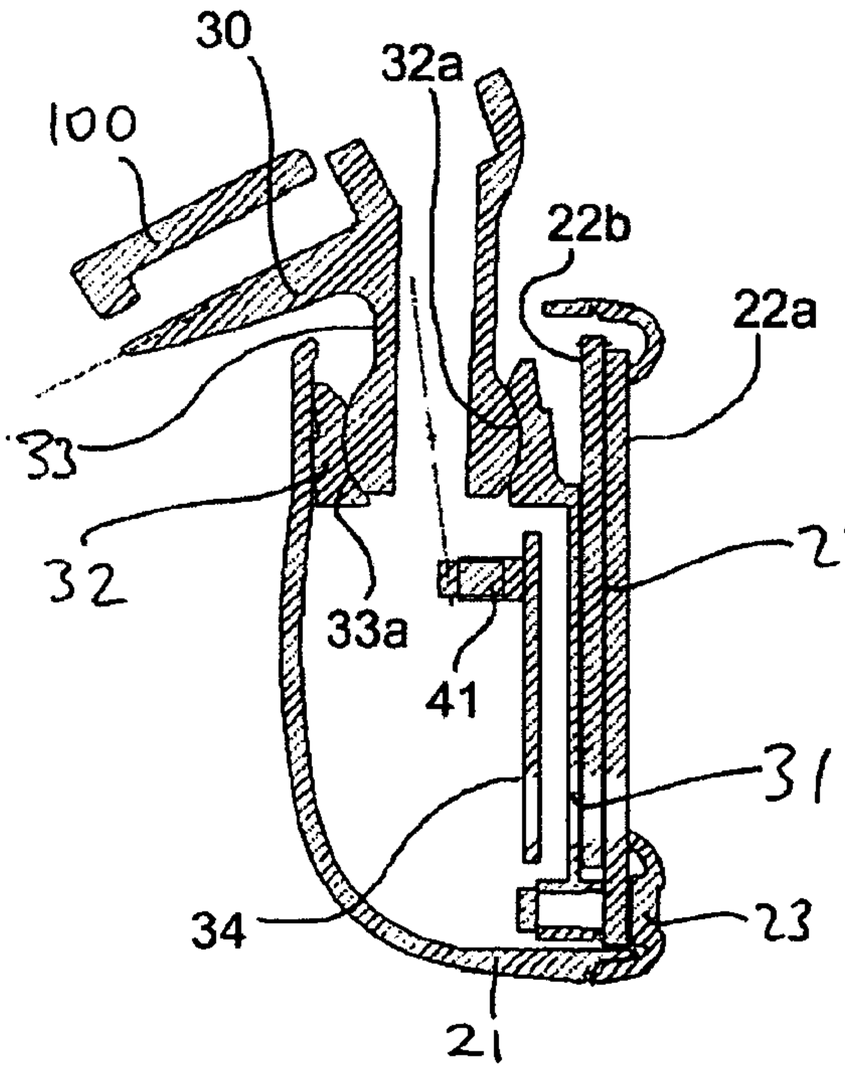


Fig. 6

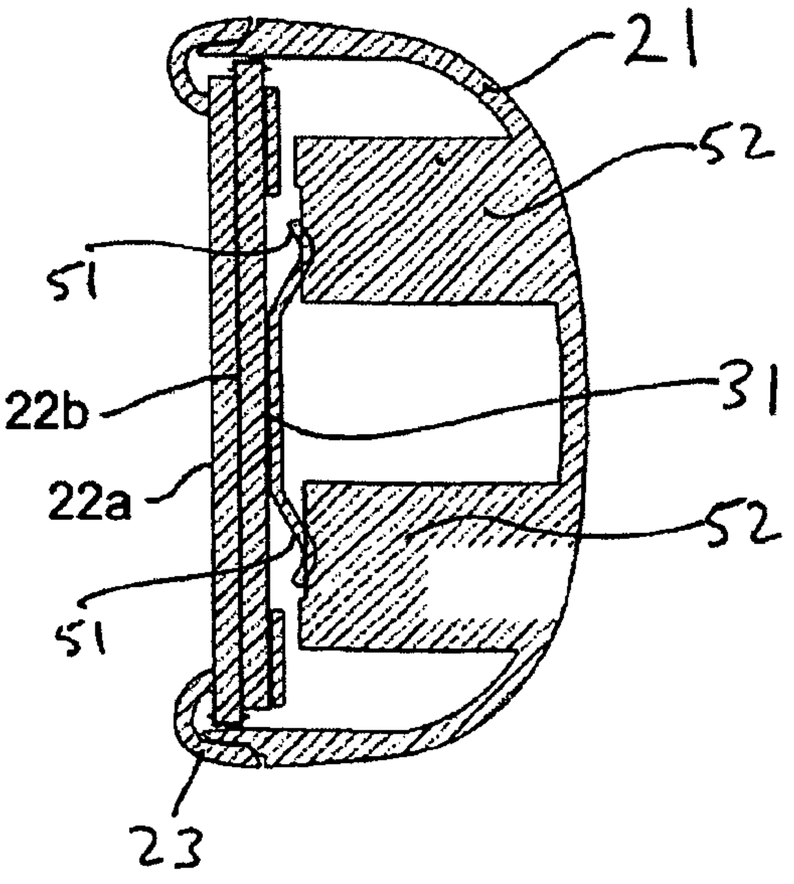


Fig. 7

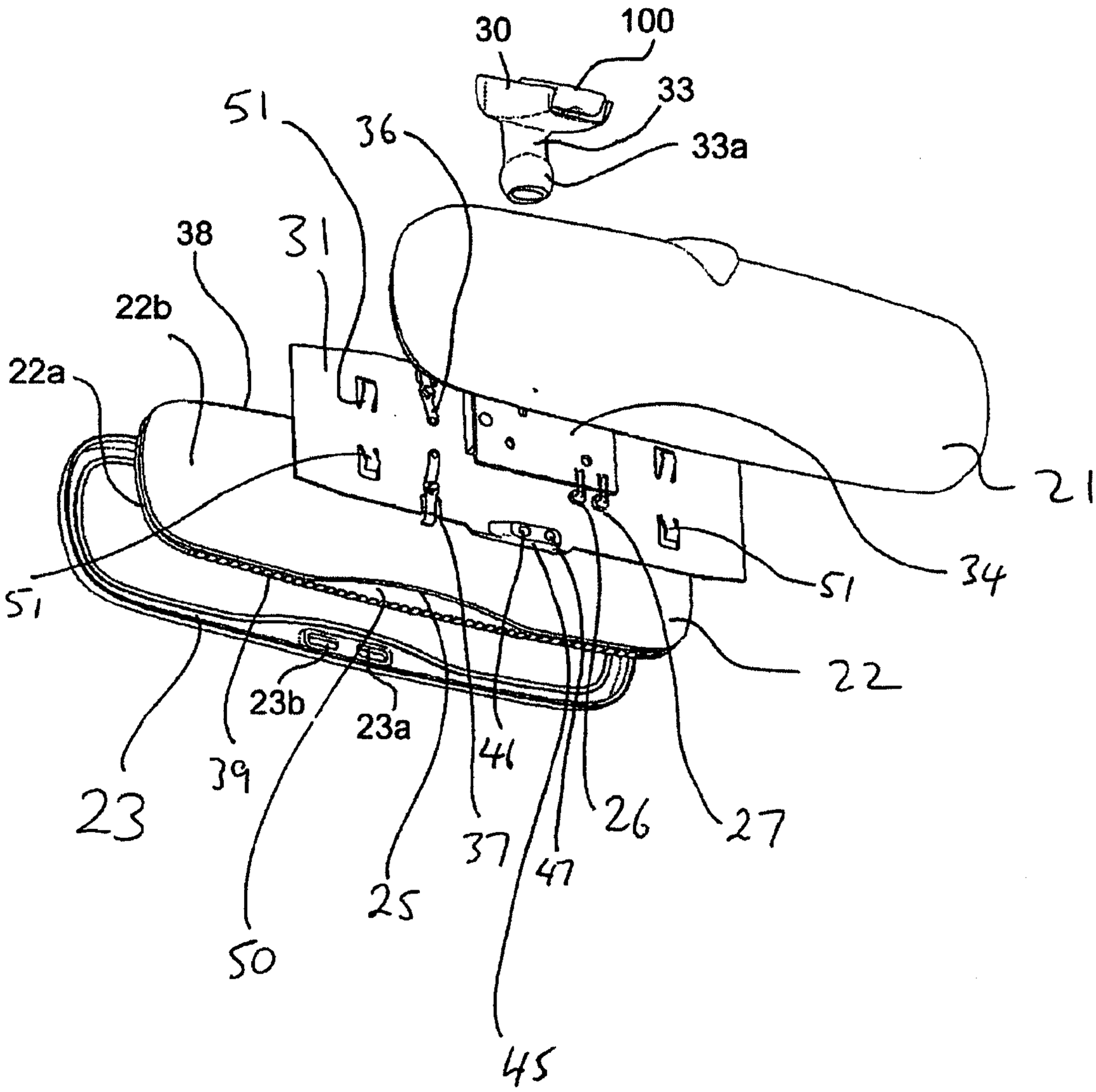

30
100
33
33a
51
36
38
31
22b
22a
21
34
51
51
22
23b
23a
23
39
41
37
25
26
47
27
50
45

Fig. 7a

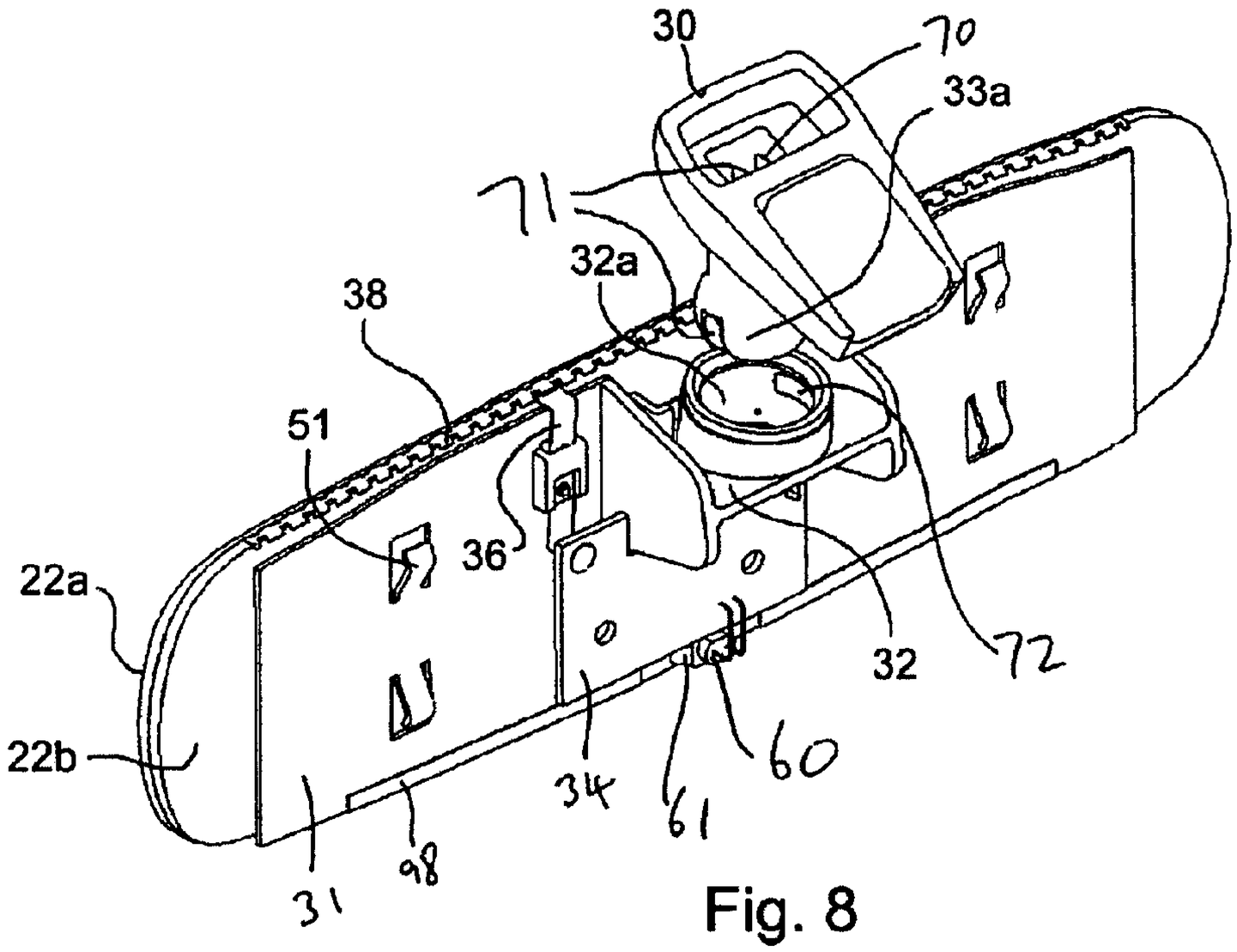

30
70
33a
71
32a
38
51
36
22a
22b
34
61
60
32
72
31
98

Fig. 8

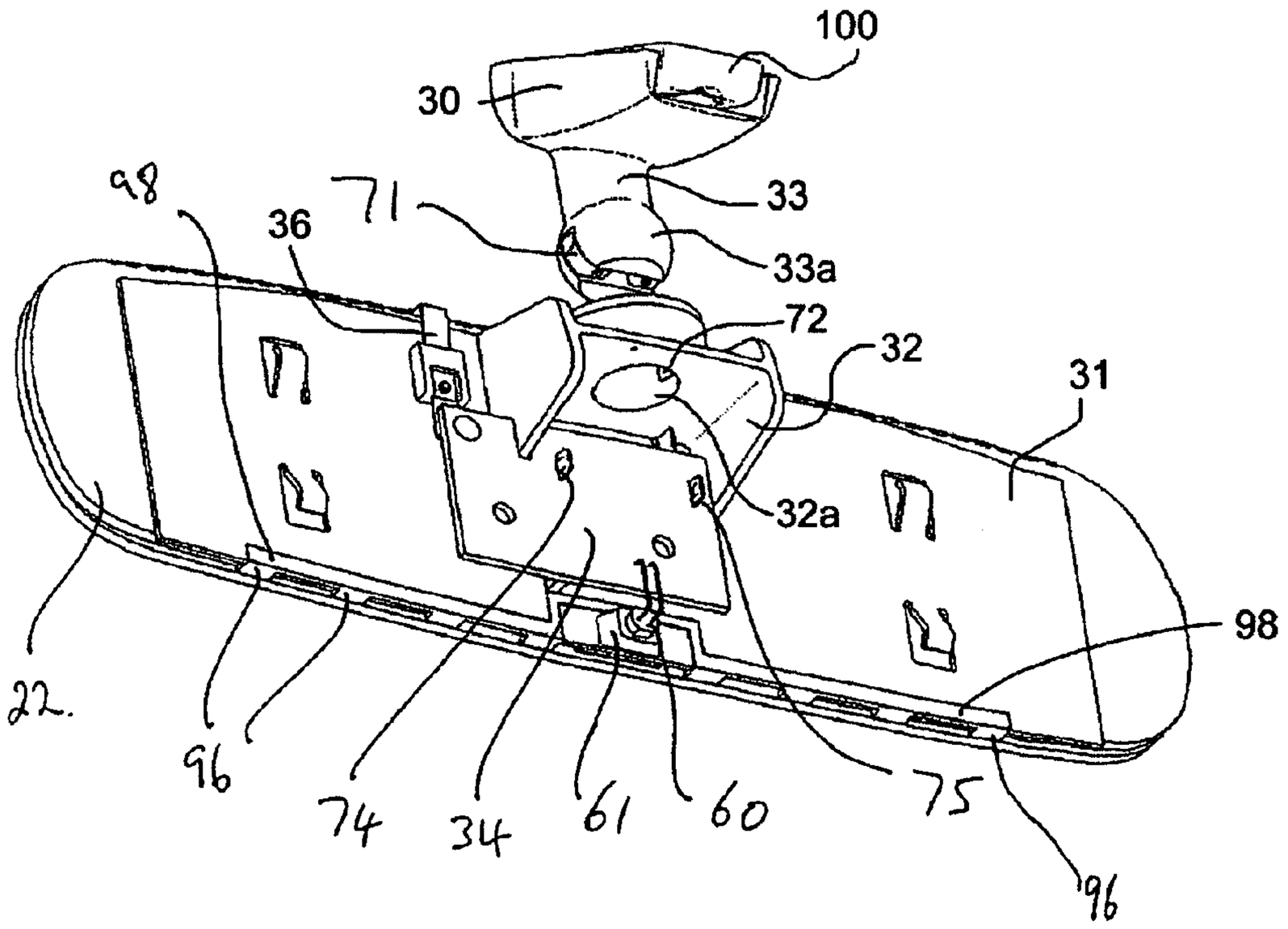

100
30
98
71
33
36
33a
72
32
31
32a
98
22.
96
74
34
61
60
75
96

Fig. 9

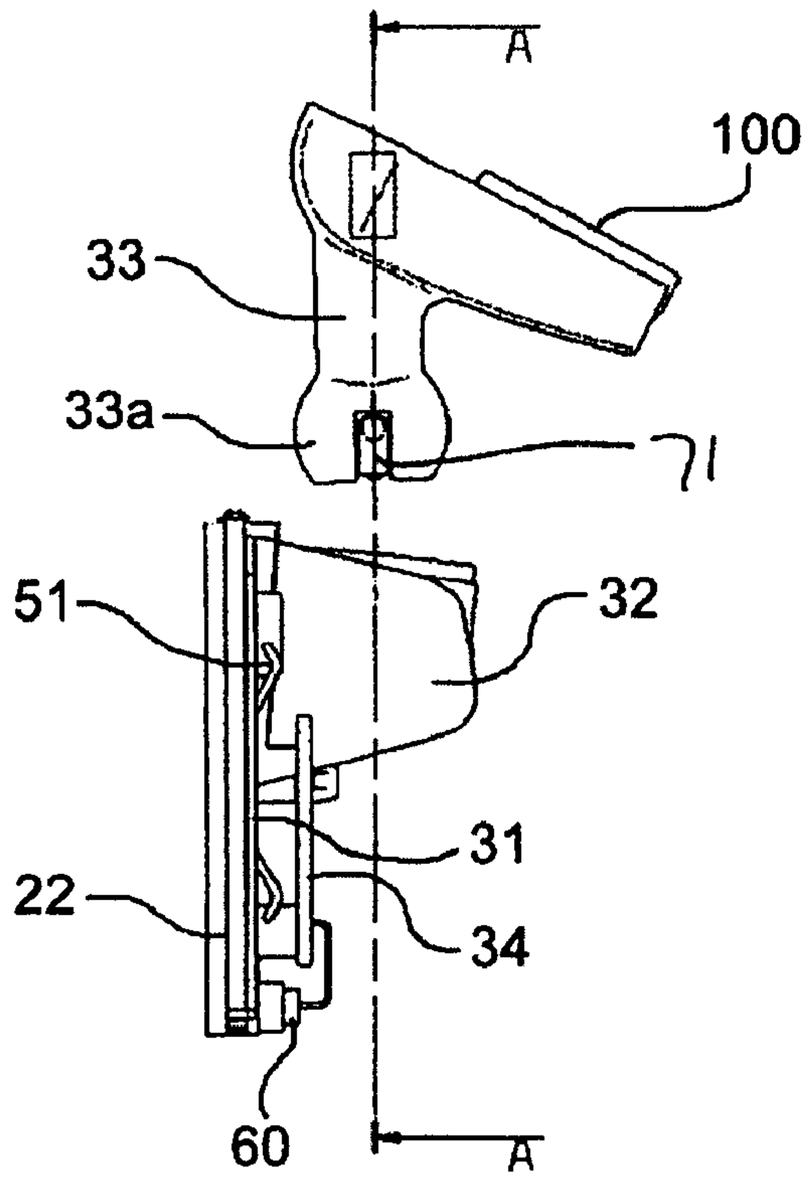

A
100
33
33a
71
51
32
31
22
34
60
A

Fig. 10

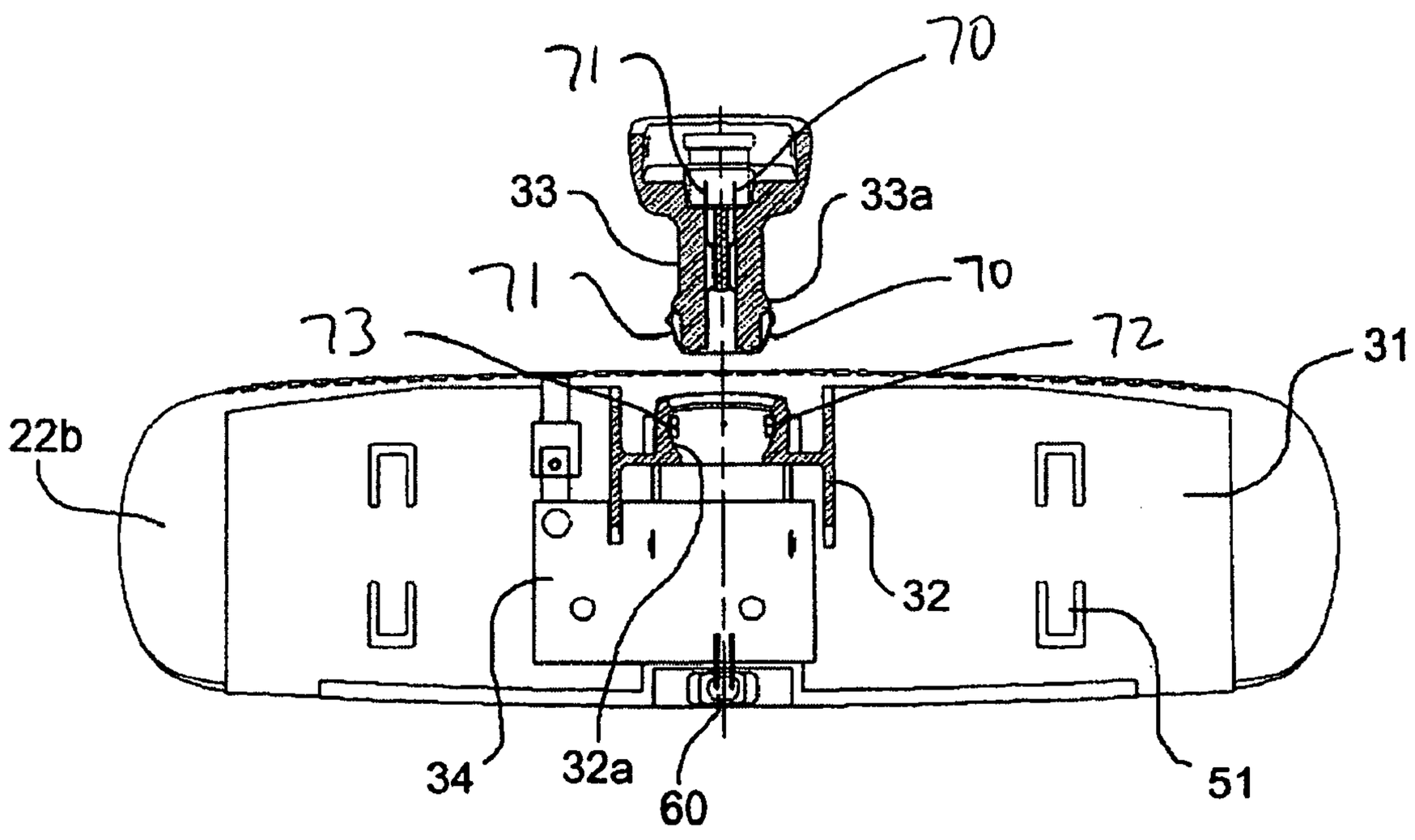

71
70
33
33a
71
70
73
72
31
22b
32
34
32a
60
51

Fig. 11

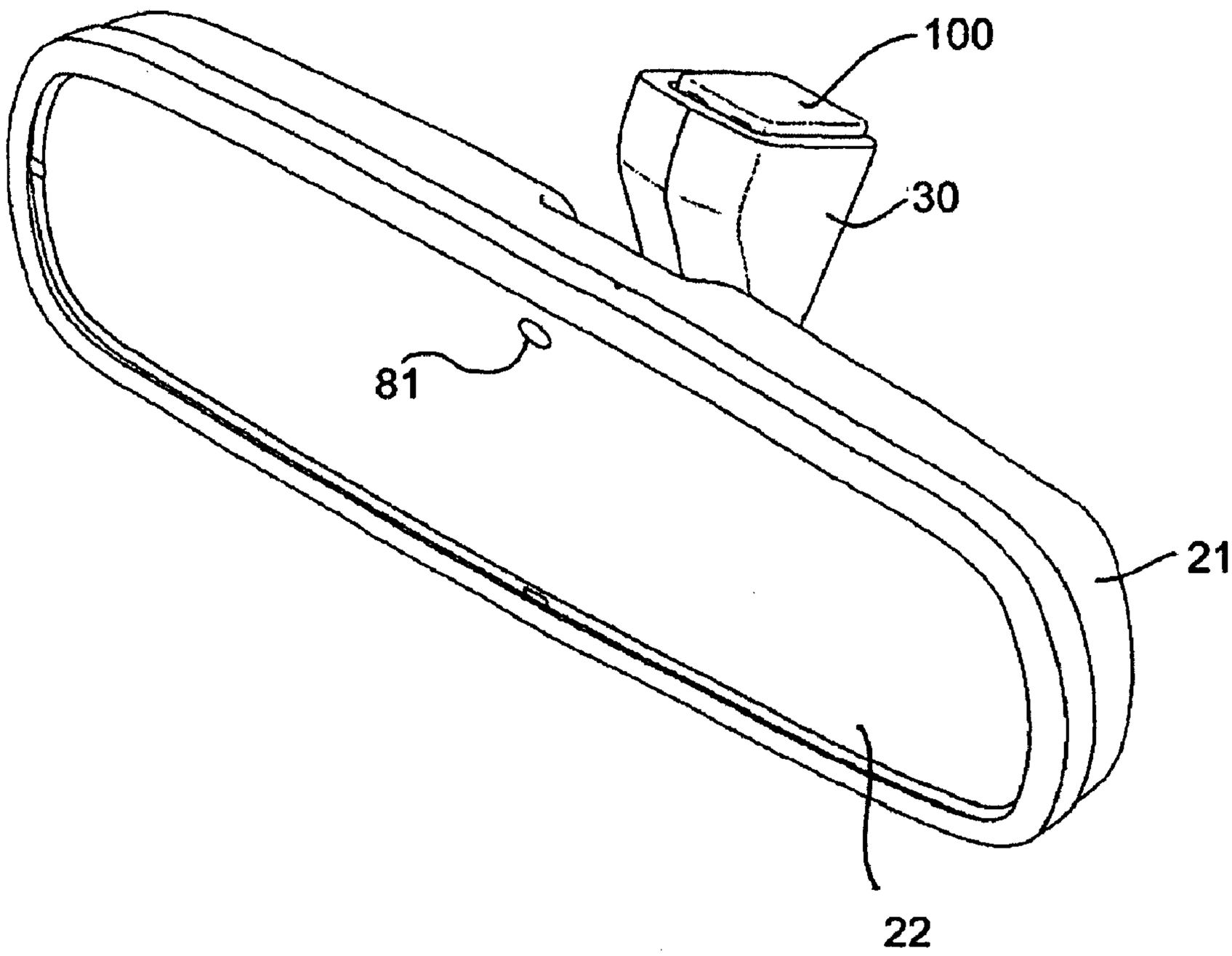


Fig. 12

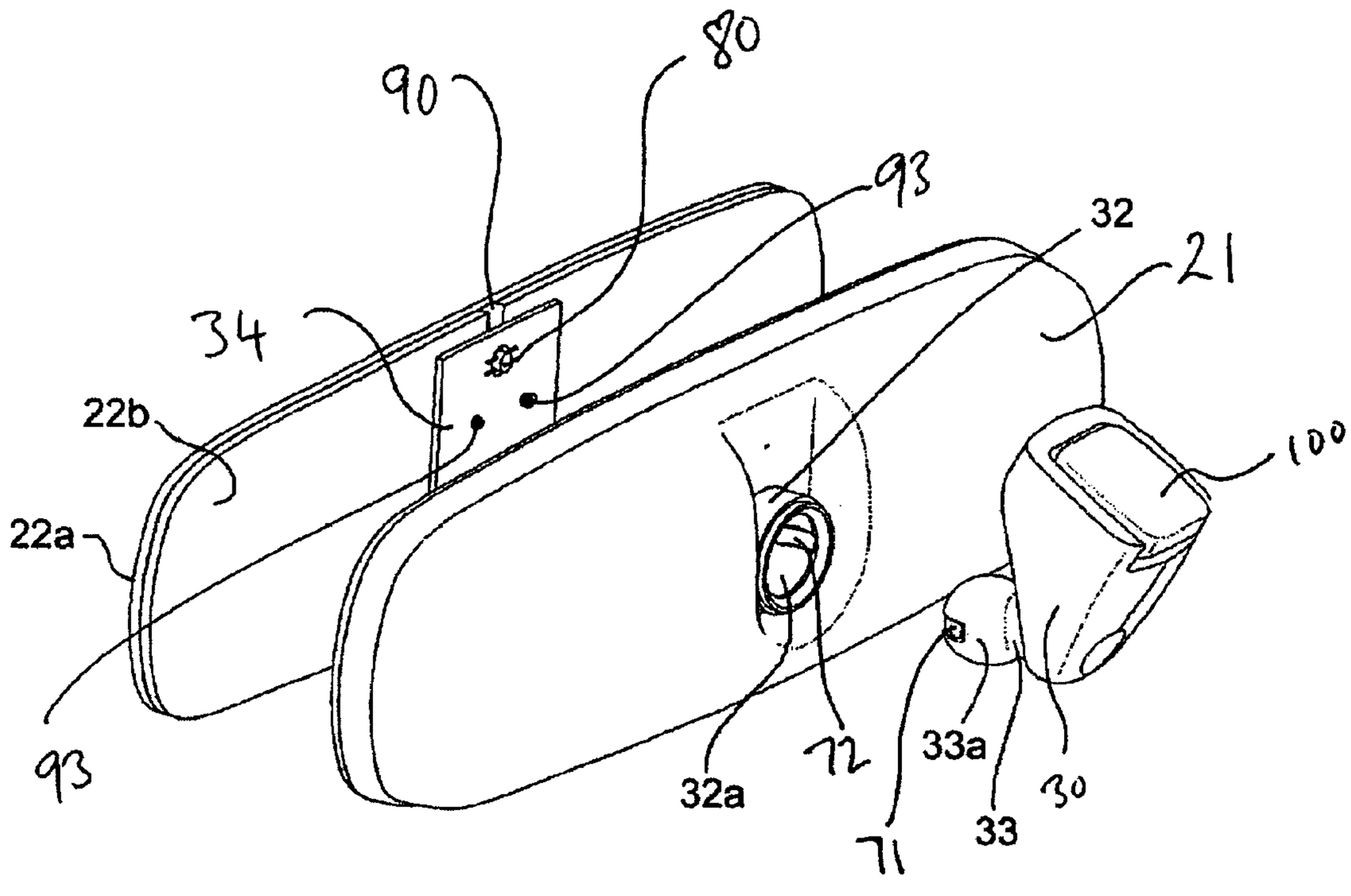


Fig. 13

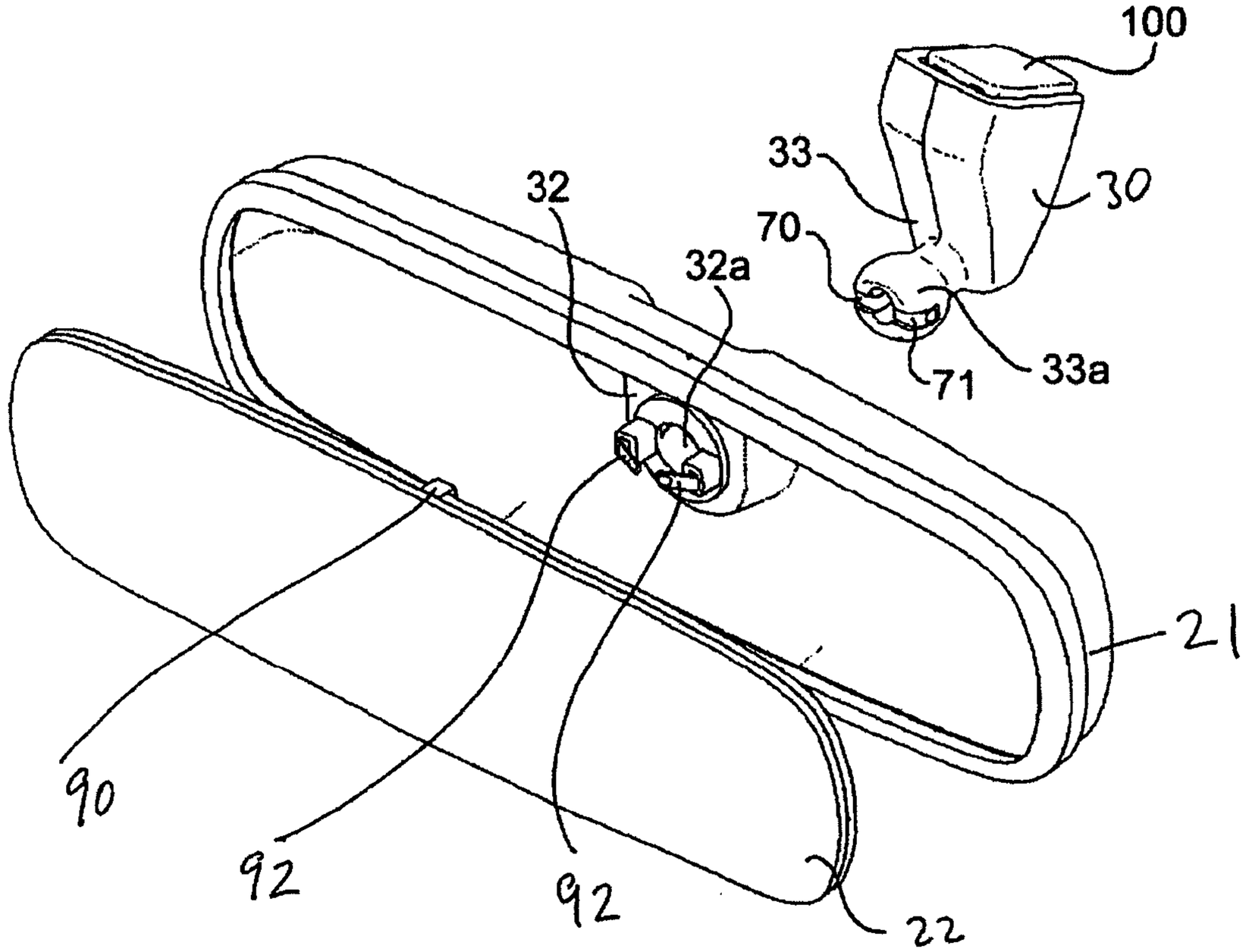


Fig. 14

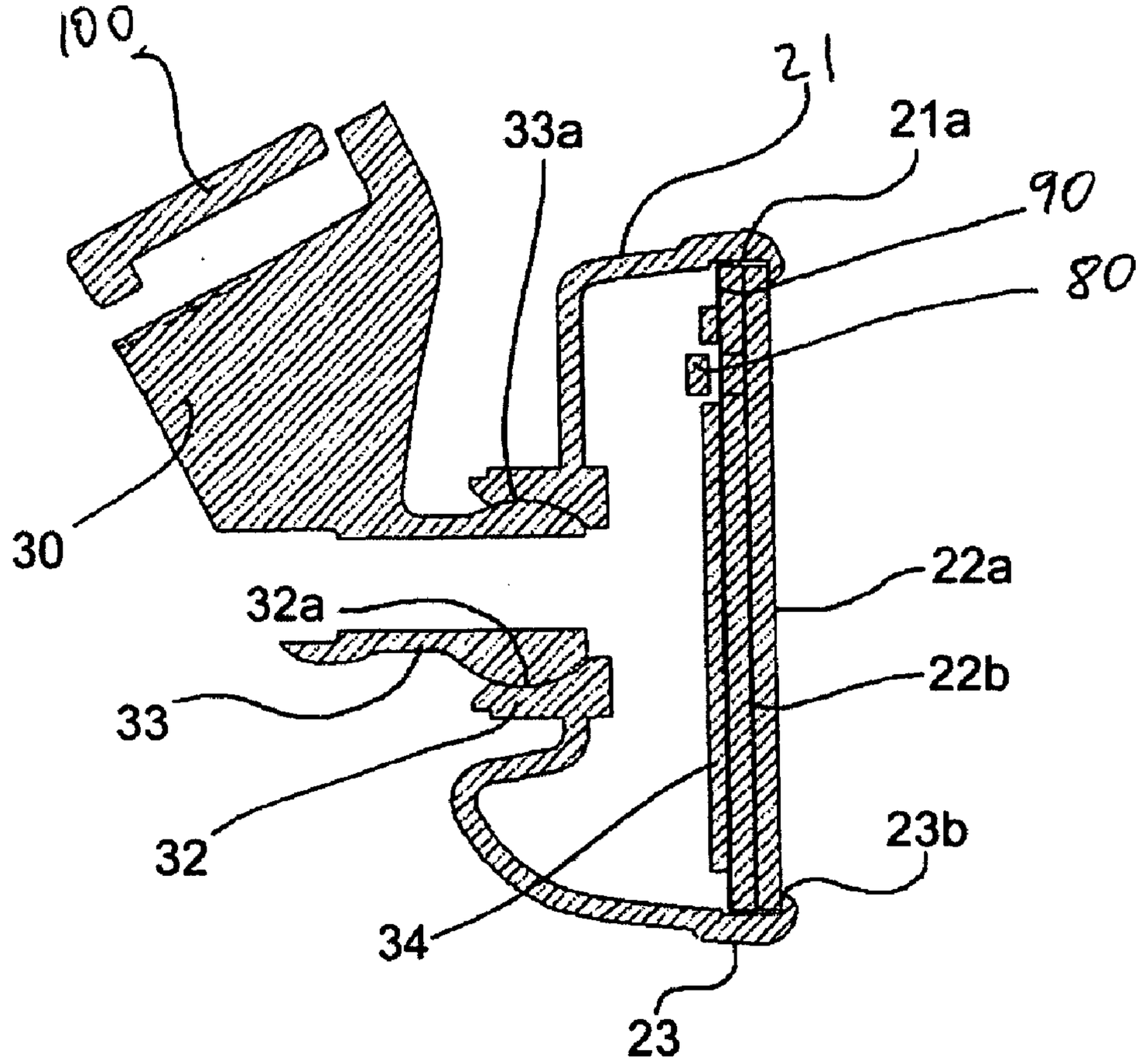


Fig. 15

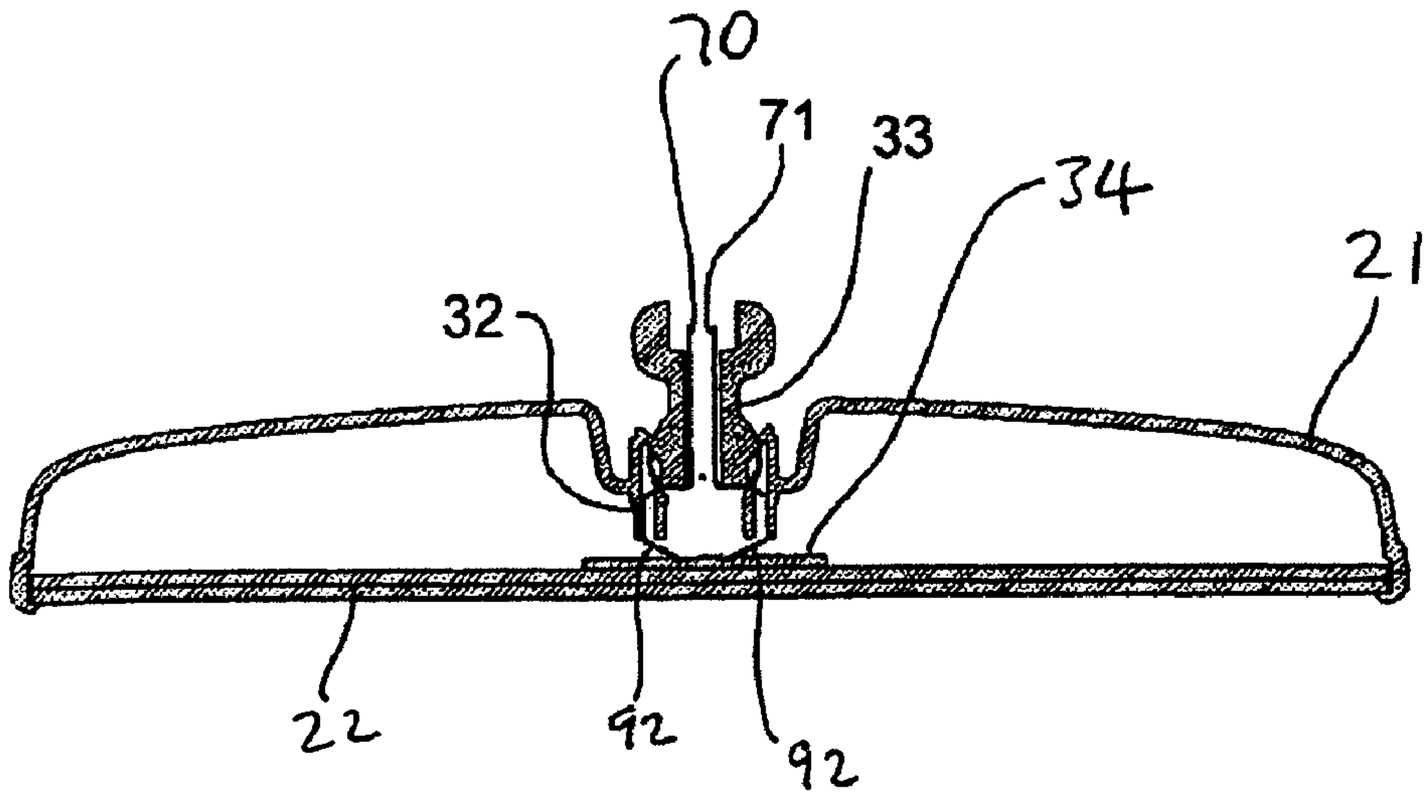


Fig. 16

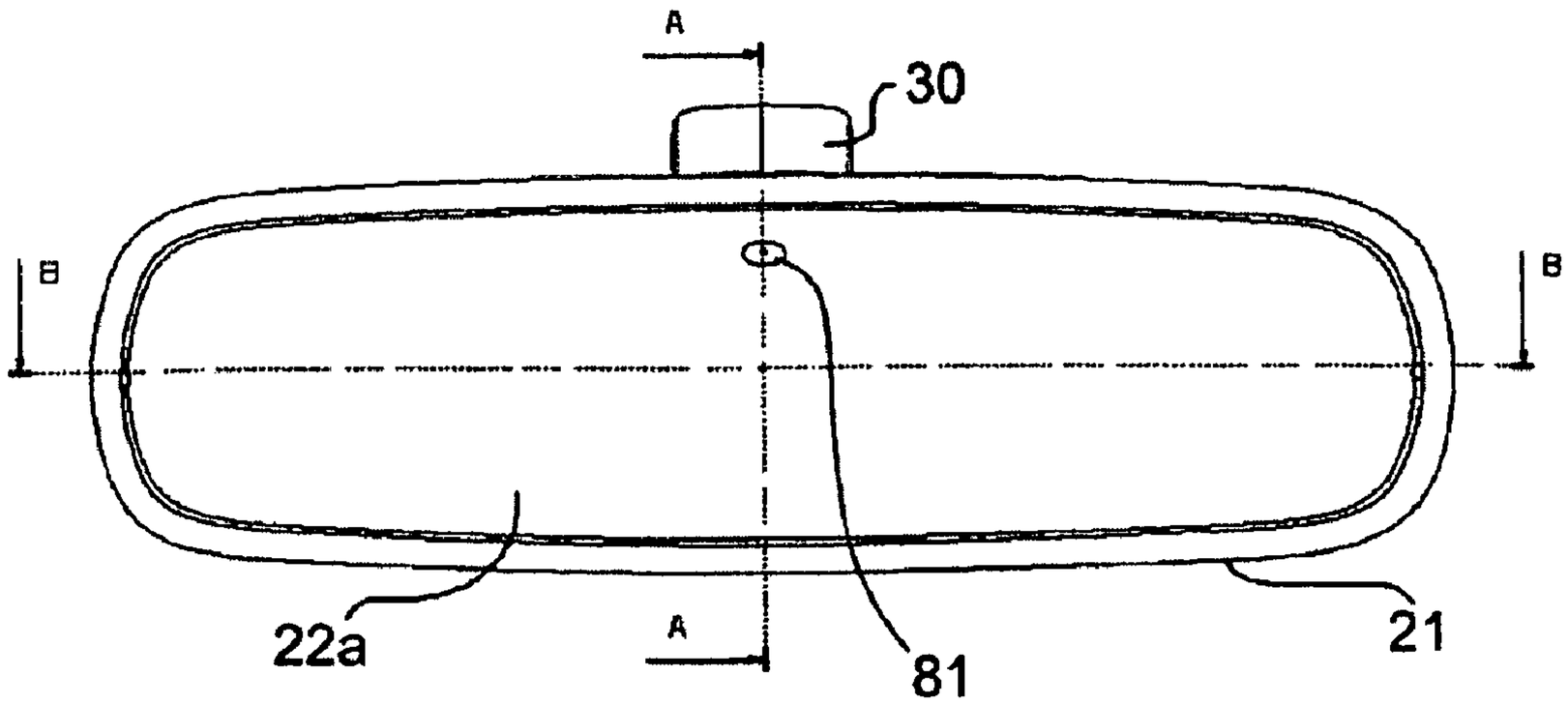


Fig. 16a

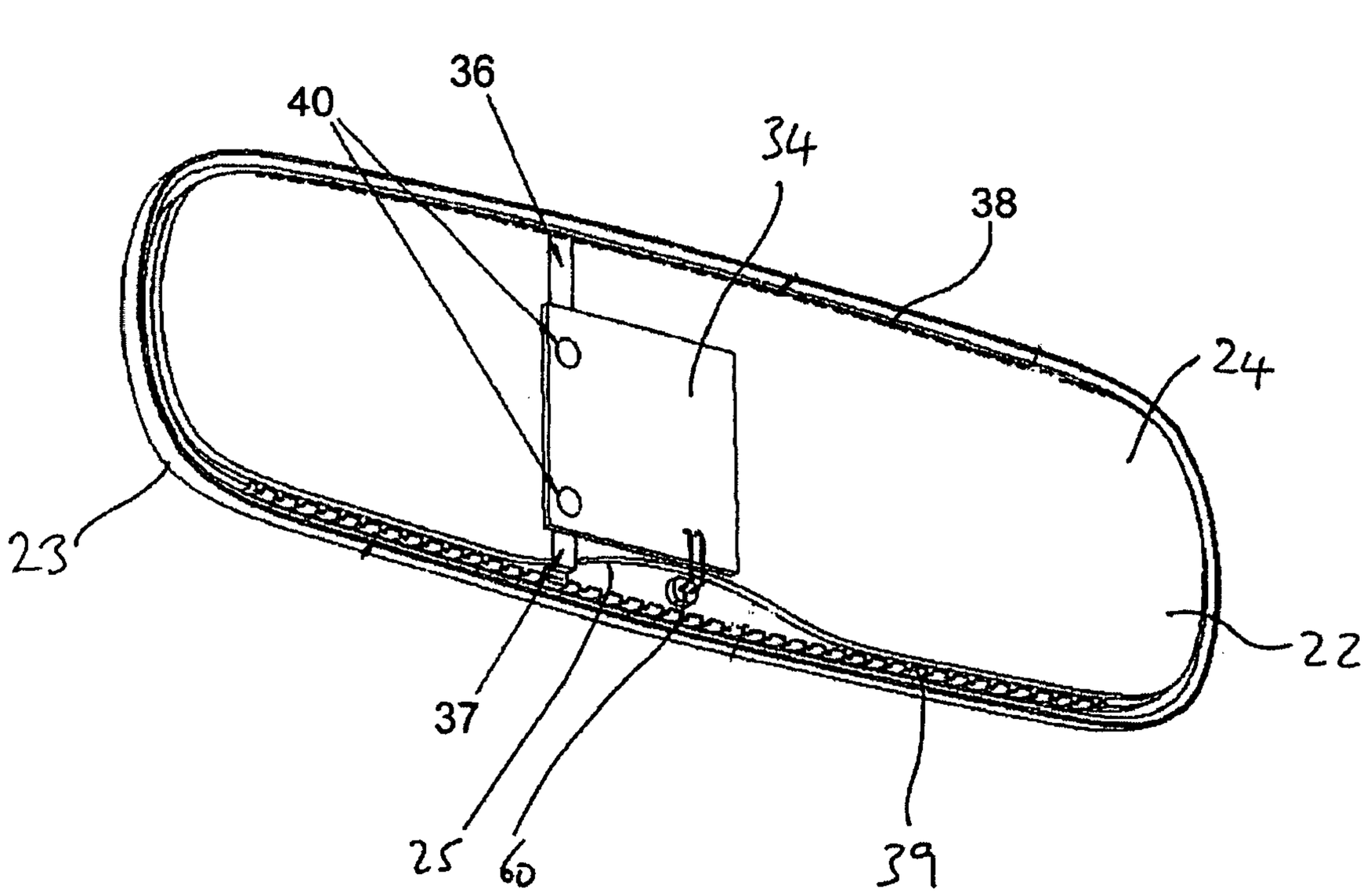


Fig. 17

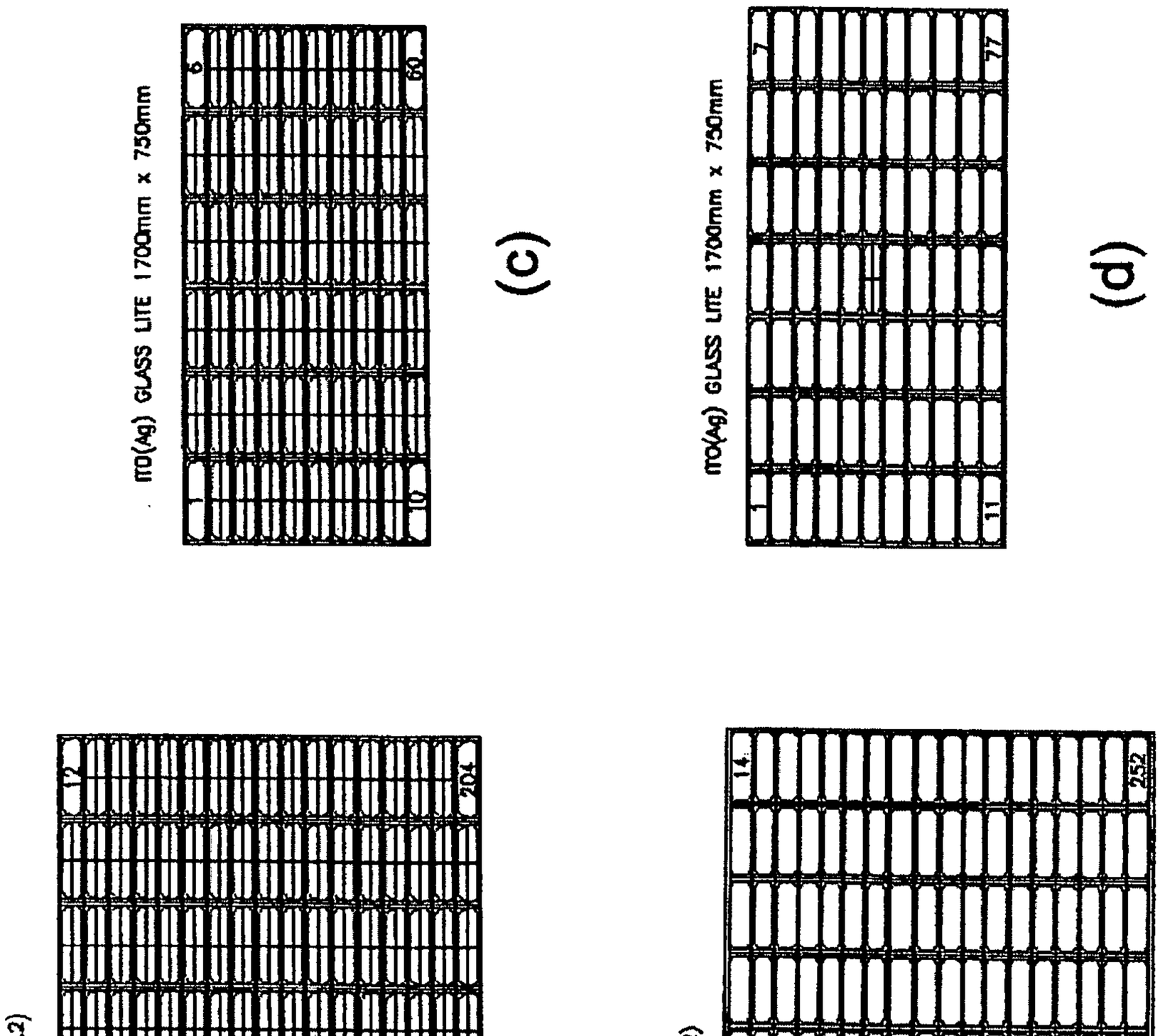

TEC GLASS LITE 132"x48" (3352.8 x 1219.2)
6
102
204
(a)
TEC GLASS LITE 132"x48" (3352.8 x 1219.2)
7
126
252
(b)
ITO(Ag) GLASS LITE 1700mm x 750mm
6
60
(c)
ITO(Ag) GLASS LITE 1700mm x 750mm
7
77
(d)

Figure 18

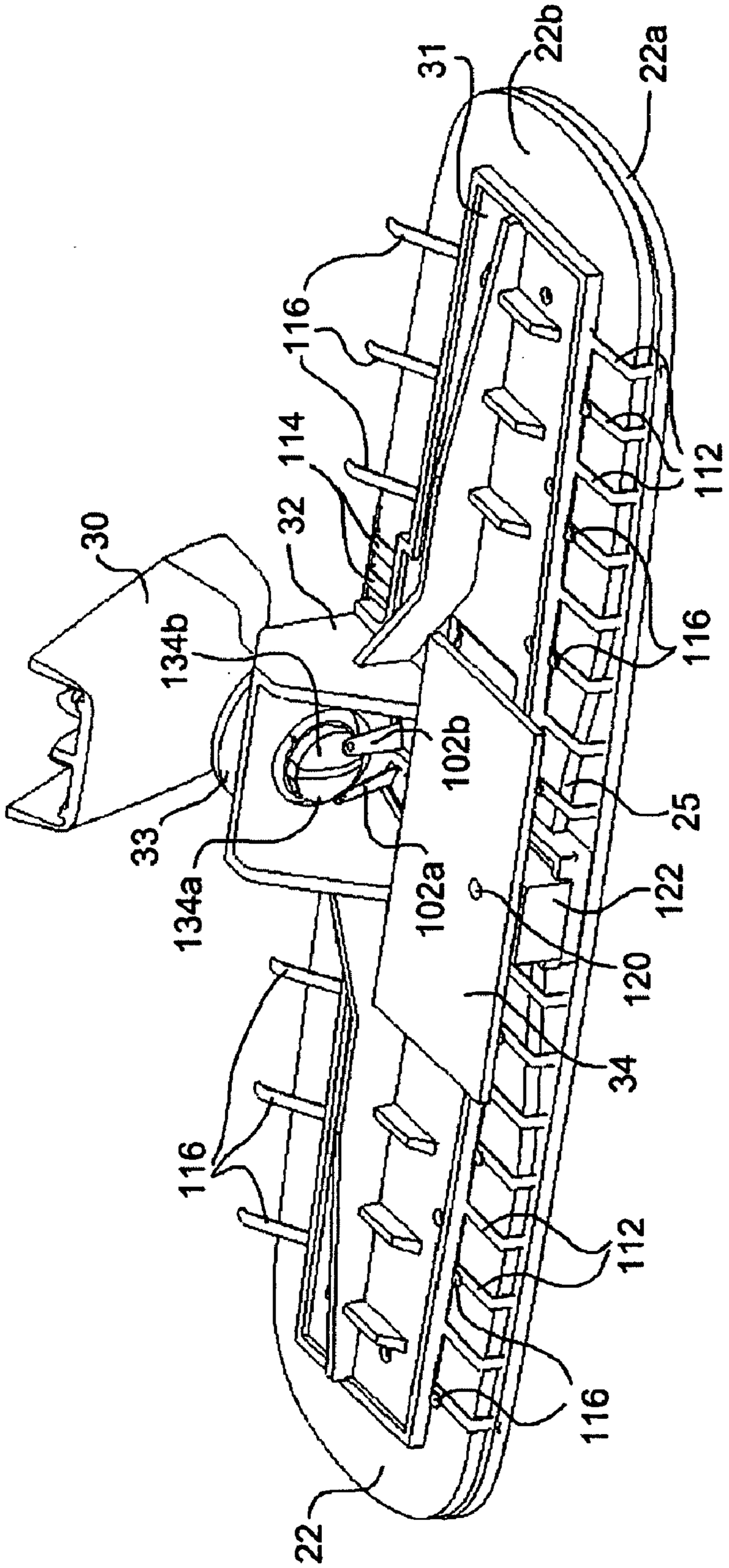

31
22b
22a
116
114
32
30
134b
33
134a
102b
102a
112
116
25
122
120
34
116
112
116
22

Fig. 19

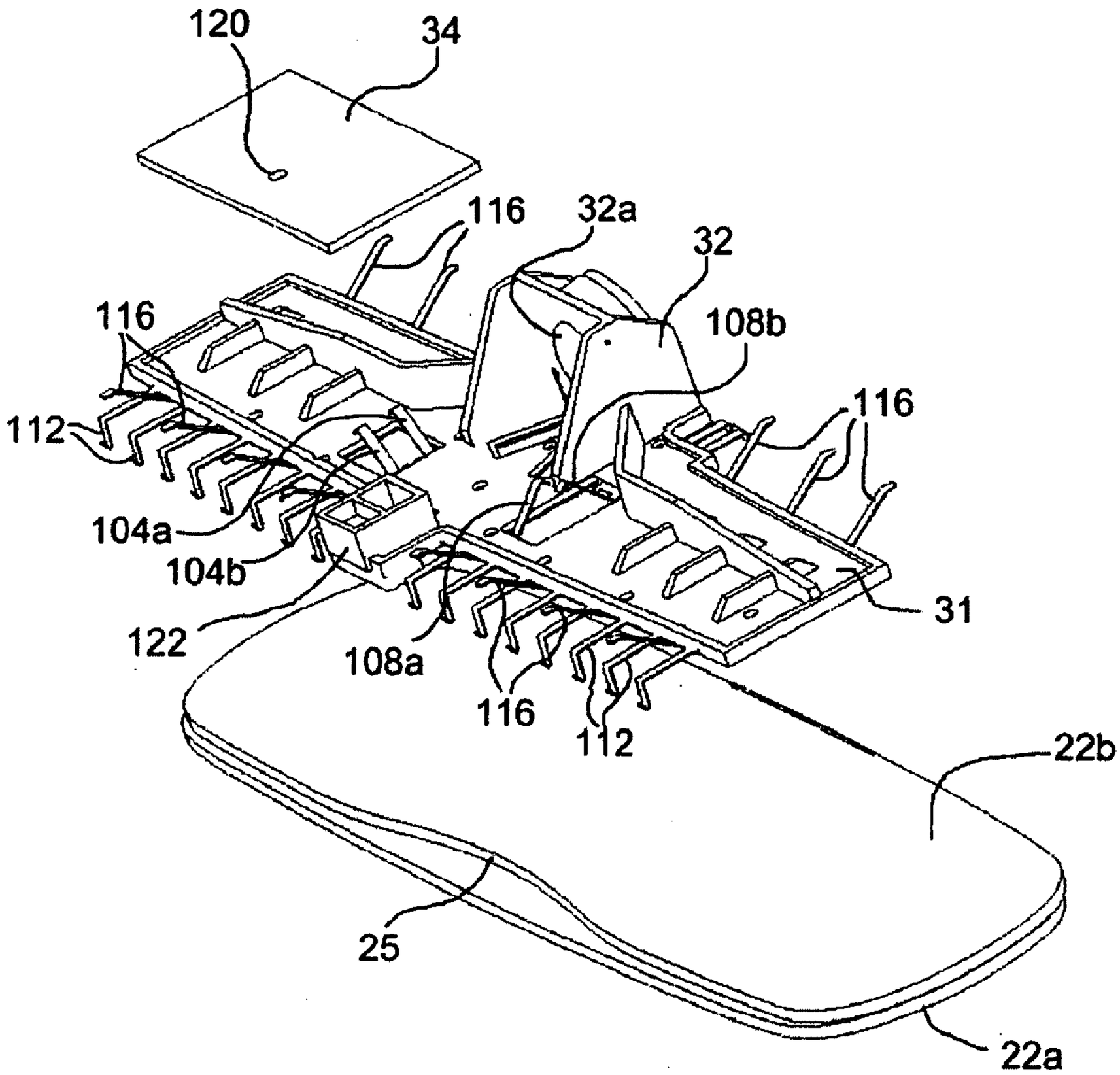

120
34
116
32a
32
116
108b
116
112
104a
104b
122
108a
116
112
31
22b
25
22a

Fig. 20

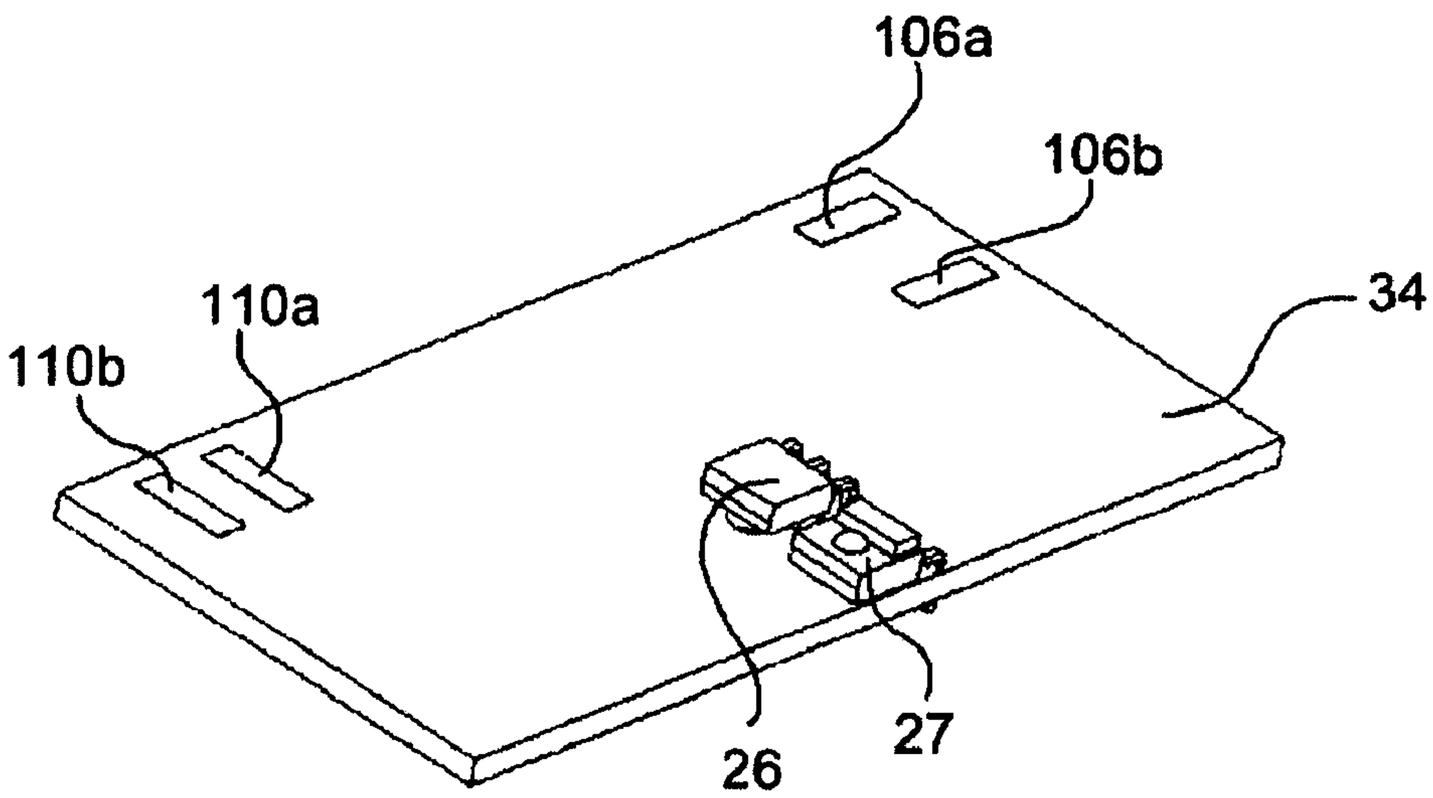
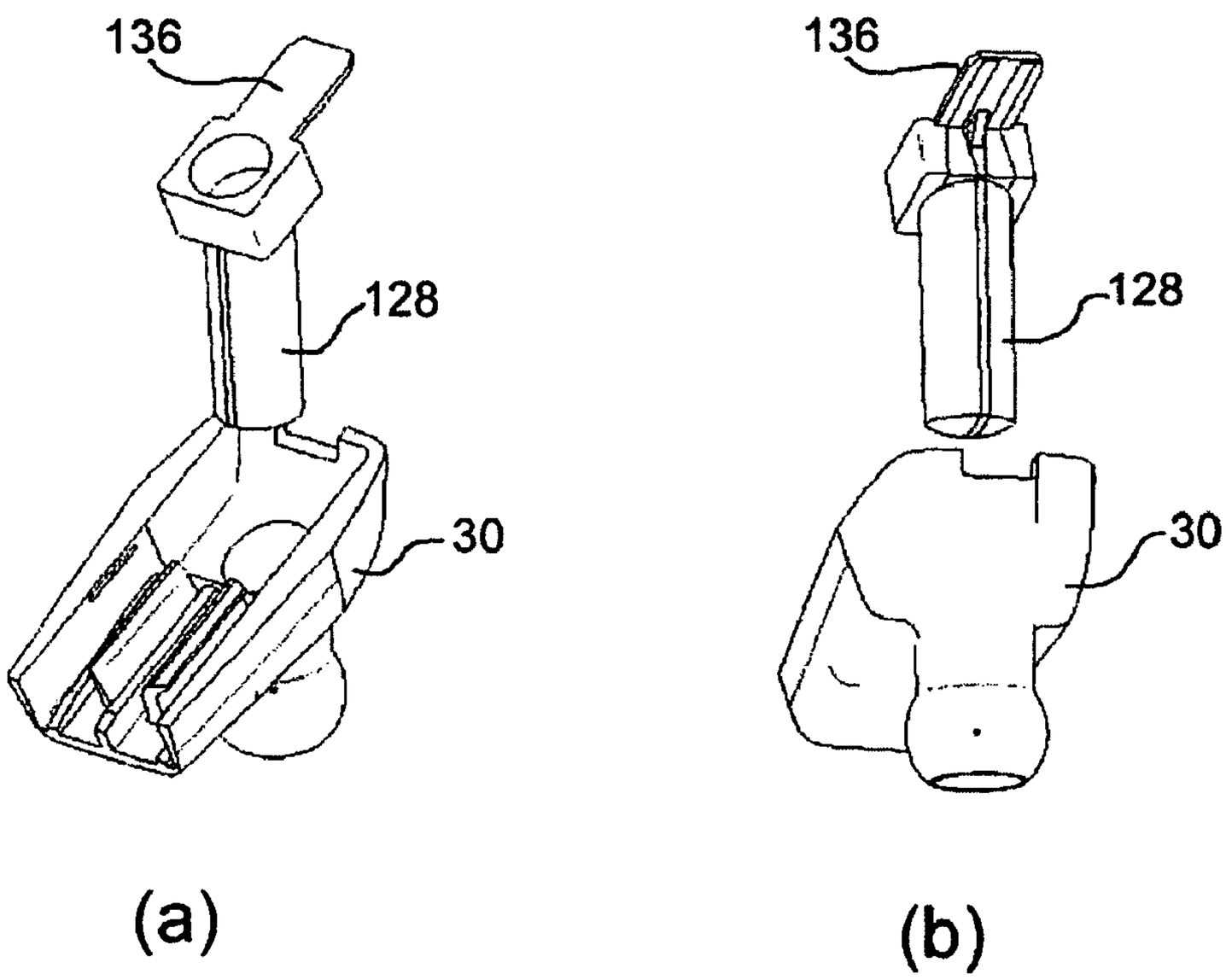


Fig. 21



(a) (b)

Fig. 25

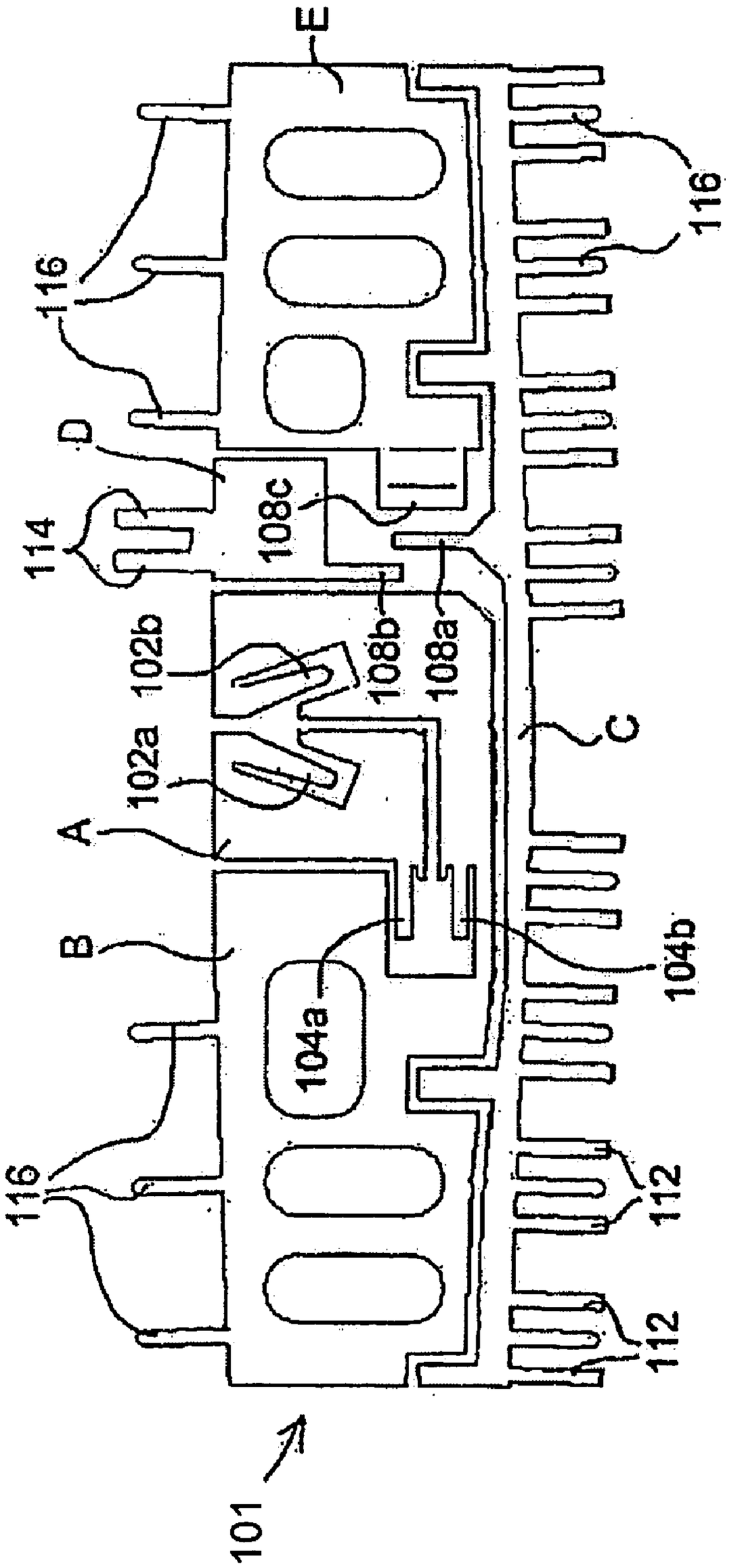

E
116
116
D
114
108c
102b
108b
108a
102a
A
B
C
104b
104a
112
112
116
101

Fig. 22

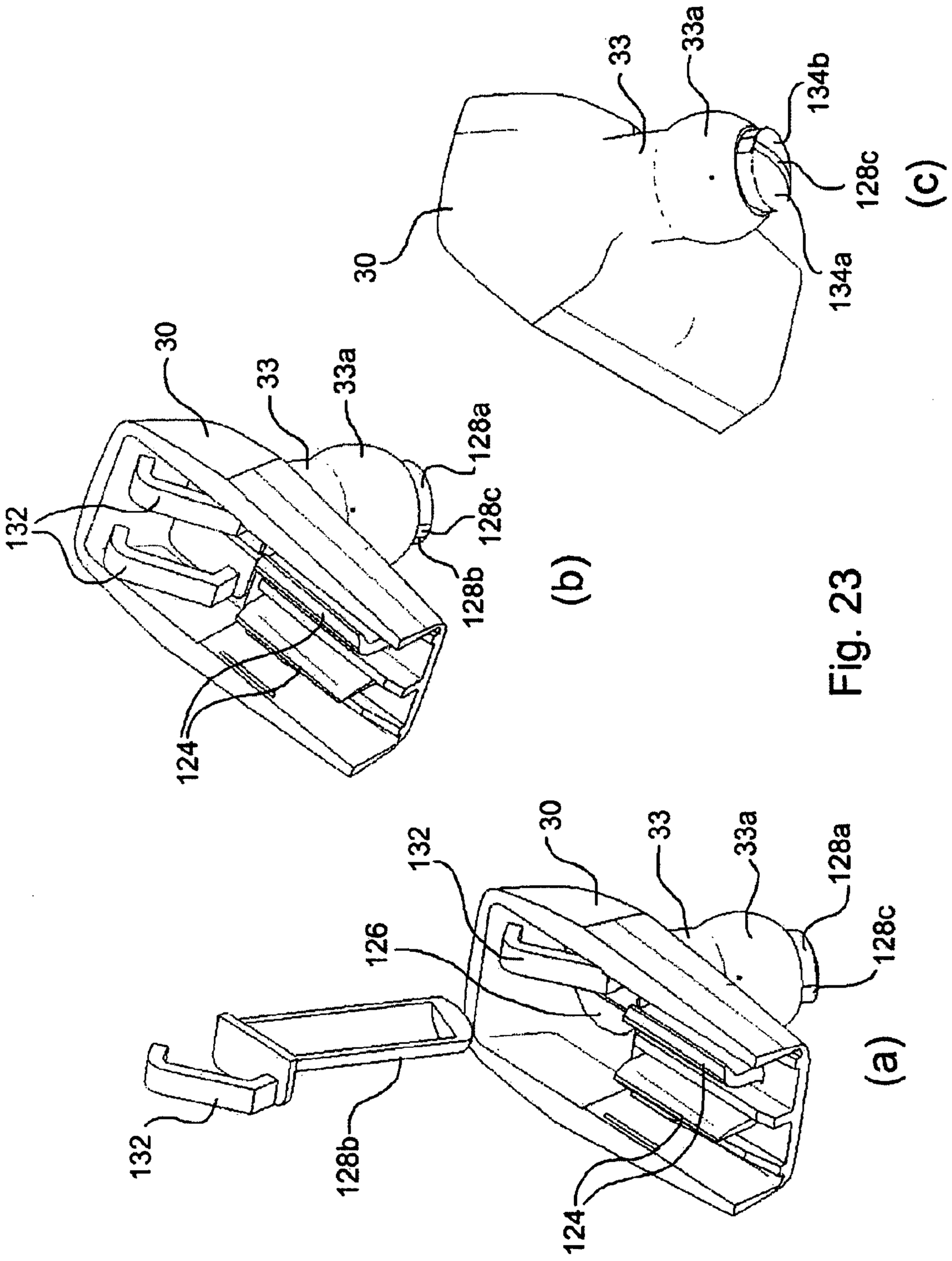

30
33
33a
134b
128c
134a
(c)
132
30
33
33a
128a
128c
128b
124
(b)
132
30
33
33a
128a
126
128c
132
128b
124
(a)

Fig. 23

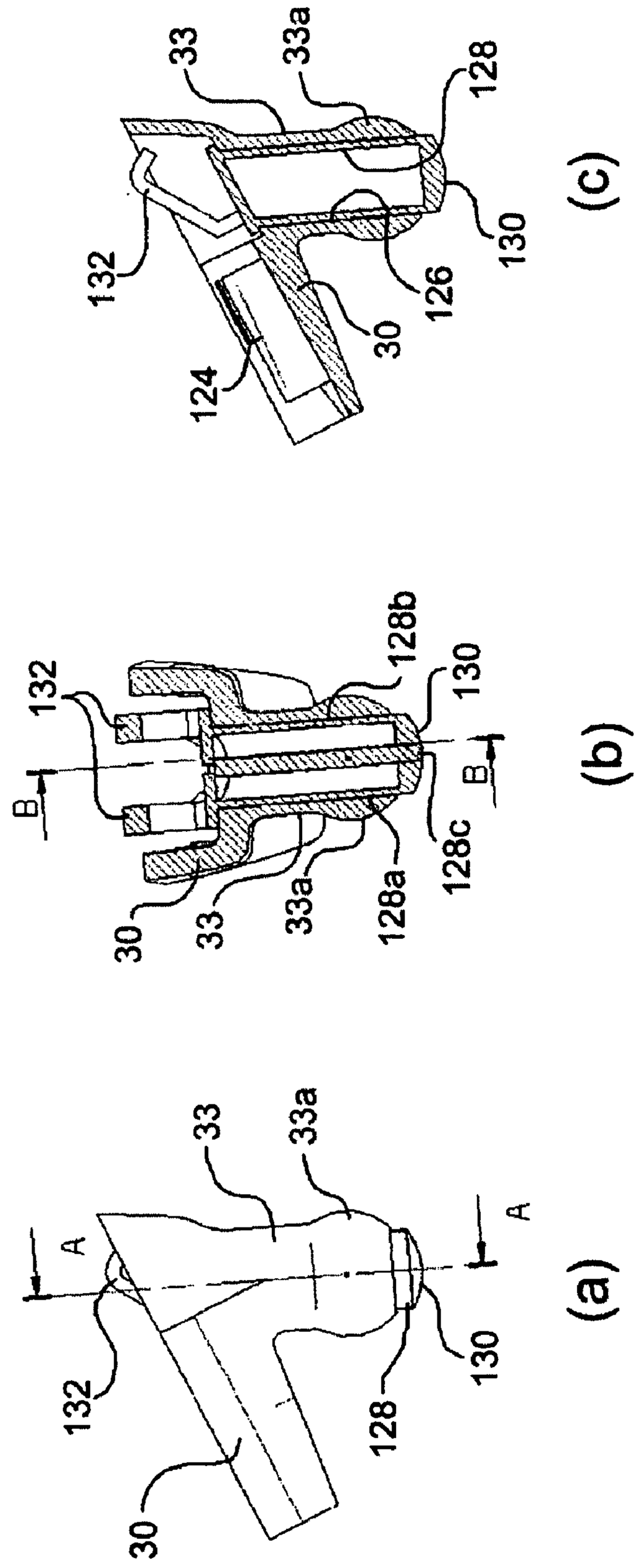

33
33a
128
132
130
126
30
124
(c)
132
B
30
33
33a
128a
128c
B
128b
130
(b)
33
33a
A
132
30
128
130
A
(a)

Fig. 24

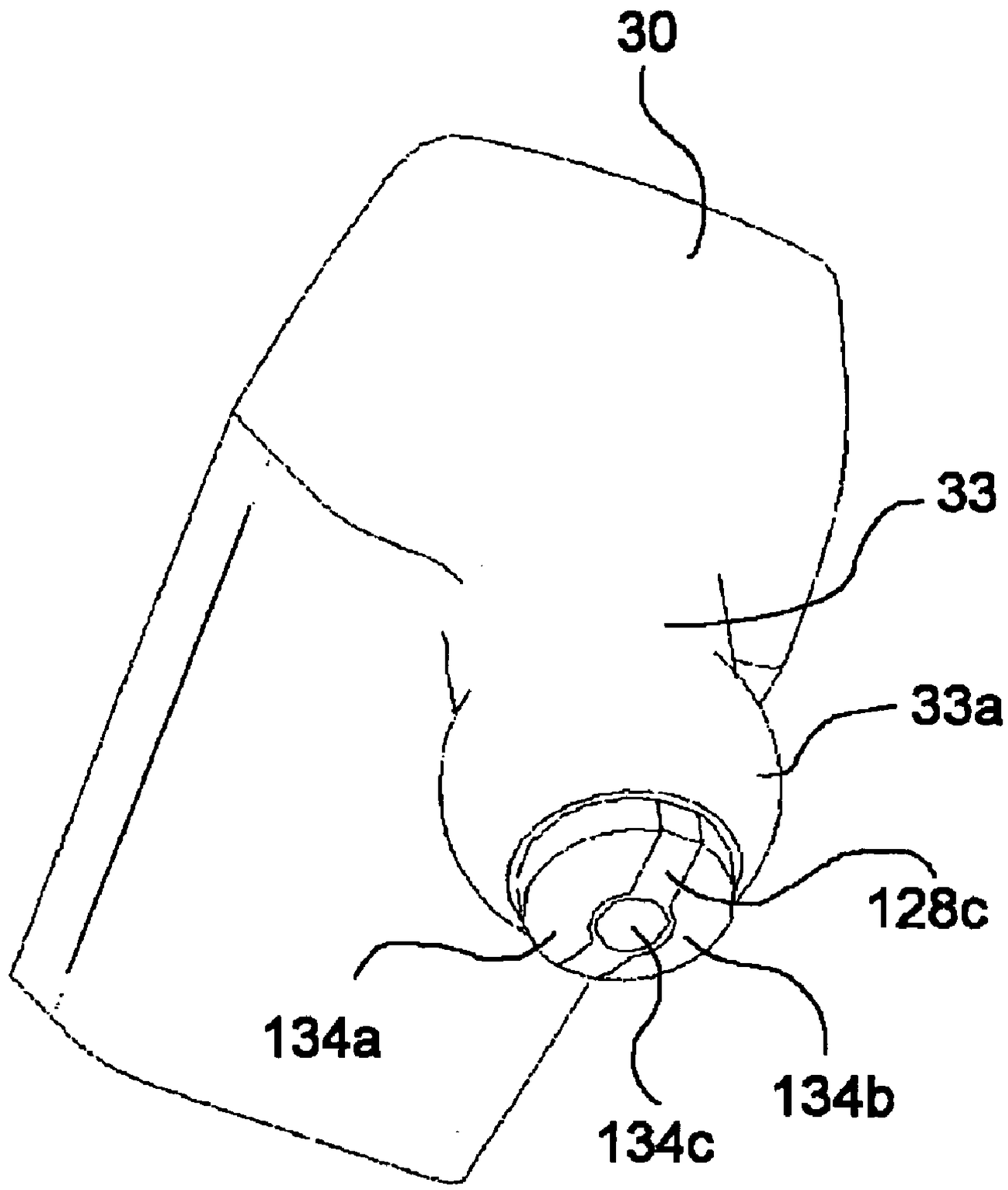


Fig. 26

REARVIEW MIRROR ASSEMBLY FOR A VEHICLE

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation of U.S. patent application Ser. No. 10/512,206, filed Oct. 22, 2004, entitled REARVIEW MIRROR ASSEMBLIES, by Patrick J. Lawlor, Niall R. Lynam, John P. Desmond, and Patrick J. Dowling, now U.S. Pat. No. 7,110,156, which corresponds to PCT/IE03/00059, the disclosure of which is hereby incorporated by reference herein.

The present invention relates to rearview mirror assemblies, for example electro-optic rearview mirror assemblies in which two glass plates sandwich an electro-optic medium.

Electro-optic rearview mirrors are well known in the art; see for example U.S. Pat. Nos. 5,140,455, 5,151,816 and 5,659,423 and the following paper: N. R. Lynam, "Electrochromic Automotive Day/Night Mirrors", SAE Technical Paper Series, (870636) (1987).

Brackets for supporting rearview mirrors are well known in the art; see for example U.S. Pat. Nos. 4,936,533, 5,058,851, 4,524,941 and 4,012,022. Rearview mirrors in many instances are mounted to the brackets by means of a ball and socket connection.

Electro-optic and in particular electro-chromic (EC) mirrors are now in general usage in vehicles at the upper end of the market. The EC mirrors are relatively expensive and their cost can make them prohibitive for motor vehicles at the medium and lower end of the market. Such EC mirrors however confer considerable advantages over known prismatic mirrors and it is therefore desirable to reduce the cost of production of electro-optic mirrors so that they can be used in a broad range of vehicle types.

There is therefore a need for a rearview mirror that is economical to produce but which meets the expectations of the automobile market in terms of functional performance such as vibration, safety regulations, ease of assembly at an auto company in terms of bracket mounting, electrical connections and reliability.

These objects are achieved by the inventions claimed in one or more of the appended claims.

Embodiments of the invention will now be described, by way of examples with reference to the accompanying drawings, in which:

FIG. **1** is a front perspective view of a rearview mirror assembly according to one embodiment of the invention.

FIG. **2** is a rear perspective view of the mirror assembly of FIG. **1**.

FIG. **3** is a rear view of the interior of the mirror of FIG. **1**.

FIG. **4** is a cross sectional view of the mirror of FIG. **3** taken along the line A—A.

FIG. **5** is a rear perspective view of the mirror of FIG. **1** with the housing removed.

FIGS. **6** and **7** are cross sectional views of the mirror of FIG. **1**.

FIG. **7***a* is an exploded rear perspective view of the mirror of FIG. **1**.

FIGS. **8** and **9** are rear perspective views of another embodiment of the invention, omitting the mirror housing.

FIG. **10** is a side view of the mirror unit and bracket of FIGS. **8** and **9**.

FIG. **11** is a cross sectional view of the mirror unit and bracket of FIGS. **8** and **9** taken on the line A—A of FIG. **10**.

FIG. **12** is a front perspective view of another embodiment of rearview mirror assembly according to the invention.

FIG. **13** is a exploded rear view of the rearview mirror assembly of FIG. **12**.

FIG. **14** is a exploded front view of the rearview mirror assembly of FIG. **12**.

FIG. **15** is a cross-sectional view of the mirror unit and support arm of the assembly of FIG. **12** taken on the line A—A of FIG. **16***a*.

FIG. **16** is a cross-sectional view of the mirror assembly of FIG. **12** taken on the line B—B of FIG. **16***a*.

FIG. **16***a* is a front view of the rearview mirror assembly of FIG. **12**.

FIG. **17** is a rear perspective view of part of another embodiment of the invention.

FIGS. **18**(*a*)–(*d*) are schematic diagrams illustrating large area sheets of glass from which individual front and rear glass plates used in electro-optical mirror units are cut.

FIG. **19** is a rear perspective view of a still further embodiment of the invention, omitting the housing and bezel.

FIG. **20** is an exploded view of the embodiment of FIG. **19**, omitting the bracket.

FIG. **21** shows the rear side (i.e. the side facing the backplate) of the PCB of FIGS. **19** and **20**, omitting all the circuitry except the light sensors and contact strips.

FIG. **22** is a plan view of a phosphor bronze lead frame embedded in the backplate of the embodiment of FIGS. **19** and **20**.

FIGS. **23**(*a*) to **23**(*c*) are various perspective views of the support bracket of the embodiment of FIGS. **19** and **20**.

FIG. **24**(*a*) is a side view of the bracket of FIG. **23**.

FIG. **24**(*b*) is a cross-section of the bracket of FIG. **23** taken on the line A—A of FIG. **24**(*a*).

FIG. **24**(*c*) is a cross-section of the bracket of FIG. **23** taken on the line B—B of FIG. **24**(*b*).

FIGS. **25**(*a*) and **25**(*b*) are perspective views of a further embodiment of bracket which could be used in the embodiment of FIGS. **19** and **20**.

FIG. **26** is a perspective views of a still further embodiment of bracket which could be used in the embodiment of FIGS. **19** and **20**.

As will be described in more detail, electro-optic mirror units comprise front and rear glass plates with an electro-optic medium sandwiched between them. The glass used in these units is highly specialised and expensive, and since the front and rear glass plates of an electro-optic mirror unit constitute a significant proportion of the costs of the overall mirror assembly it is very important to try to minimise wastage of glass from the plate glass from which the mirror glass profiles are cut. However, the problem is complicated by the fact that the transparent front TEC glass is provided in sheets of a different width from the sheets of the reflective rear ITO(Ag) glass, TEC and ITO(Ag) glasses being commercially available types of glass used in electro-optic mirror construction.

Referring initially to FIG. **18**, FIG. **18**(*a*) shows the number (204) of front glass plates conventionally cut from a standard sheet of TEC glass measuring 3352.8 mm×1219.2 mm, each glass plate being 249.5 mm wide by 65.7 mm high. By contrast, FIG. **18**(*b*) shows the number (252) of front glass plates which may be produced from the same standard size sheet when each front glass plate is 219.4 mm wide and 61.5 mm high. This represents a 23% increase in the number of front glass plates available from the standard TEC glass sheet. Similarly, FIG. **18**(*c*) shows that only 60

standard sized 249.5 mm wide by 65.7 mm high rear glass plates can be cut from a standard 1700 mm by 750 mm sheet of ITO(Ag) glass, whereas FIG. **18**(*d*) shows that 77 rear glass plates of size 219.4 mm wide and 61.5 mm high can be cut from the same ITO(Ag) glass sheet. This represents a 28% increase in the number of rear glass plates available from the standard ITO(Ag) glass sheet.

It has therefore been discovered that optimum usage of both the front and rear glass sheets is obtained by using front and rear mirror glass plates of size 219.4 mm by 61.5 mm. These are therefore the sizes of front and rear glass plates used in the various embodiments, except where otherwise noted. This minimises wastage and leads to optimum cost efficiency. In determining these sizes it has also been determined that in terms of a low cost electro-optic mirror the size of the mirror face is in fact larger than the average size of a prismatic type mirror face. Thus, the invention not only provides optimum efficiency in terms of glass usage and thus cost reduction by minimising wastage, but it also provides, a larger more effective mirror than the prismatic type mirror which it will replace.

Referring now to FIGS. **1** to **7** and **7***a*, a rear view mirror assembly **20** comprises a housing **21** containing an electro-optic mirror unit **22**, a bezel **23** which retains the mirror unit **22** in the housing, the mirror unit **22** being located just behind the bezel **23** and being viewable through the opening in the bezel, and a support bracket **30** for attaching the assembly to the interior cabin of a vehicle, for example to the top of the windscreen or the header. In the present embodiment the upper end of the bracket **30** is adapted for sliding engagement with a mirror mount **100**, often referred to as a "button", which is adhesively attached to the interior surface of the windscreen in known manner.

Electro-optic mirror units are well-known in the art and typically comprise front and rear glass plates **22***a*, **22***b* respectively (FIG. **7**) with a layer of an electro-optic medium (not shown) sandwiched between them. The front plate **22***a* is transparent and the rear plate **22***b* has a layer of silver or other reflective material on its inside surface. The unit **22** is positioned in the housing **21** with the front plate **22***a* exposed through the bezel opening so that the reflective layer on the rear plate **22***b* is viewed through the front plate and the layer of electro-optic medium. The inside surface of each plate bears an electrically conductive electrode layer, the electrode layer on the front plate being transparent and the electrode layer on the rear plate also being transparent, at least if it is in front of the reflective layer (alternatively the reflective layer may also constitute the electrode layer for the rear plate so avoiding the need for a separate electrode layer on the rear plate). The light transmissivity of the electro-optic medium, and hence the reflectivity of the mirror unit, can be varied by the application of a variable control voltage across the electro-optic medium, i.e. across the conductive electrode layers on the inside surfaces of the plates. The electro-optic medium may comprise any material, for example electro-chromic or liquid crystal, which has the desired electro-optic properties.

The electro-optic mirror unit **22** is preferably an electrochromic (EC) cell either of the solid state type or electrochemichromic type, but may be any desired form of cell. In the present embodiments the mirror unit **22** is an EC cell whose front plate **22***a* comprises TEC glass and whose rear plate **22***b* comprises ITO(Ag) glass. The electro-optic medium sandwiched between the plates **22***a*, **22***b* is a self-supporting solid polymer matrix (SPM). The construction of EC cells is well known in the art and is described for example in the prior art documents noted above or in U.S. Pat. No. 5,572,354 the contents of which are incorporated herein by reference. However, this and following embodiments are not limited to the use of any particular types of glass, any particular type of electro-optic medium or any particular type of electro-optic mirror unit.

The front and rear plates **22***a*, **22***b* are the same size (except for a recess **25**, FIG. **7***a*, provided in the bottom edge of the rear plate **22***b* for a purpose to be described) but have a small vertical offset, so that the upper edge of the rear plate **22***b* projects slightly above the upper edge of the front plate **22***a*, and correspondingly the lower edge of the front plate **22***a* projects slightly below the lower edge of the rear plate **22***b*. This offset is clearly seen in FIGS. **6** and **7**. The reason for the offset is to expose a narrow strip of the conductive electrode layer on the inside surface of the rear plate **22***b* at the top of the mirror unit and a corresponding narrow strip of the conductive electrode layer on the inside surface of the front plate **22***a* at the bottom of the mirror unit. These exposed strips are electrically connected to conductive electrode contacts **38** and **39** respectively which are essentially elongated toothed clips having a generally U-shaped cross section and which clip over the exposed edges of the rear and front plates respectively.

The EC cell **22** is securely fixed by adhesive, clips or other suitable means to a non-conductive backplate **31** moulded, for example, for glass-filled polypropylene (PP) or nylon. A socket member **32** is mounted on the opposite side of the backplate **31** to the cell **22**, i.e. on the rear side of the backplate, and is preferably formed integrally with the backplate. A dependent portion **33** of the bracket **30** forms a corresponding ball member. The ball and socket members **33**, **32** interengage to form a pivot assembly, FIG. **6**, such that a part-spherical external surface **33***a* of the ball member **33** is rotatable within a complementary part-spherical internal surface **32***a* of the socket member to allow a range of angular movement of the mirror unit relative to the bracket **30**. The bracket **30** is preferably moulded from a different material to the backplate **31**. For example, the bracket **30** can be moulded of nylon and the backplate of PP, or vice versa.

A printed circuit board (PCB) **34** includes an electrical circuit for controlling the operation of the EC cell **22**, in particular by varying its reflectivity in response to the signals from a pair of light sensors **26** and **27** (e.g. photodiodes or phototransistors) which are mounted on, but dependent via pairs of rigid conductors **26***a* and **27***a* from, the PCB. The PCB **34** is fixed by adhesive, clips or other suitable means to the rear side of the backplate **31**, the electrical circuit being on the side of the PCB facing the backplate and therefore not visible in the drawings.

The backplate **31** has electrical contacts **36**, **37** electrically connected to the electrode contacts **38**, **39** of the EC cell. Contact pads **40** (FIG. **5**) on the PCB **34** are connected to respective ones of the contacts **36**, **37** and the electrical circuit on the PCB **34** supplies the variable control voltage across the EC cell **22** via the pads **40**. A wire harness **41** provides a power supply to the PCB **34** from the vehicle power supply. The arrangement of the contact pads **40** and contacts **36**, **37** eliminates the need for soldering, making the product easier to assemble. The preferred sizes of the front TEC glass and rear ITO(Ag) glass plates as referred to above results in a reduced size requirement for the electrodes **38**, **39** of around 15% with consequent cost savings.

The backplate **31** has a boss **45** incorporating flared apertures **46**, **47** (FIG. **4**) for accommodating the light sensors **26**, **27** respectively. The location of the sensors **26**, **27** in the boss **45** provides very significant mechanical protection for the sensors and since the surface **50** of the

front glass plate **22***a* is conductive an electrical path is available for discharge of electrostatic and other non-desirable electrical charges. Since the sensors **26**, **27** are disposed rearwardly of the silvered rear glass plate **22***b* the bottom edge of the latter has a recess **25** relative to the front glass plate and the boss **45** is located in register with the recess **25**. Thus the sensors **26**, **27** are able to receive light through the front transparent glass plate **22***a* unobstructed by the rear glass plate **22***b*. The sensors **26**, **27** face in the same direction in the boss **45**, i.e. normal to the mirror unit **22** and generally facing the rear of the vehicle when the mirror assembly is mounted in the vehicle cabin for rearview viewing.

The bezel **23** has respective apertures **23***a*, **23***b* in front of the flared apertures **46**, **47** in the boss **45**. The bezel aperture **23***b* is located directly in front of the flared aperture **47** and sensor **27** so that the latter detects light directed along an axis generally normal to the EC cell **22**. However, the bezel aperture **23***a* is laterally offset relative to the sensor **26** which, together with the skewed aspect of the flared aperture **46** seen in FIG. **4**, ensures that the sensor **26** detects light directed laterally from one side of the axis normal to the cell, i.e. from the direction V, despite facing in the same direction as the sensor **27**.

In use, when the mirror assembly is mounted for rearward viewing in the interior cabin of a vehicle, the sensor **27** senses light from the rear of the vehicle generally along a longitudinal axis of the vehicle while the sensor **26** senses light from the rear of the vehicle but obliquely to the right or to the left of the longitudinal vehicle axis. In particular, the sensor **26** senses light from a passenger or driver side window of the vehicle. Thus the sensor **27** acts as a glare sensor, since it is responsive to, for example, the glare from following headlamps, while the sensor **26** acts as an ambient sensor, since it is responsive to the general level of illumination outside the vehicle.

With both ambient and glare sensors facing rearwardly in the bezel **23** the housing **21** does not need to have an aperture for the ambient sensor **26**, which conventionally faces forwardly.

The backplate **31** is also provided with resilient members **51** which abut and engage flanges **52** on the inside of the housing **21** and provide rigidity and assist in vibration minimization. This construction eliminates further components while maintaining a support function.

The direct connection between the bracket **30** and the backplate **31**, which itself is directly fixed to the EC cell **22**, improves the stiffness of the assembly that leads to an improvement in the vibration performance of the mirror and thus allows for the use of an all-plastic bracket support **30** which is a major reduction in the cost of the product. This also means that the mirror housing **21** is not required as a structural component and principally serves as a cosmetic shroud around the mirror unit. This allows a low cost plastic such as PP to be used. As stated, the PCB **34** clips onto the back plate **31** and has the glare sensor **27** and the ambient sensor **26** located together on the PCB **34**. Thus the ambient sensor **26** does not need to extend through the rear of the mirror housing **21** and allows for the PCB **34** to be reduced in size and hence enables a cost reduction in the PCB. Since the backplate contains a support boss **45** for the sensors, this eliminates the need for other sensor supports and hence a reduction in the component count is achieved.

One of the advantages of the above embodiment is that the glare and ambient light sensors are configured so as to view via apertures in the bezel portion of the mirror assembly. This is particularly useful when additional accessories (such as are disclosed in U.S. Pat. Nos. 6,124,886, 6,245,262 and 6,222,460, the entire disclosures of which are hereby incorporated by reference herein) are included in the cavity of the mirror housing. By configuring both sensors to view via bezel-located apertures/view-ports, additional accessories/structures can be accommodated within the mirror housing cavity without concern for occluding a field of view of either sensor.

Rather than having a recess **25**, the rear glass plate **22***b* may have a portion of its reflective coating removed to enable positioning of the light sensors and the bezel in register with the area of reflective coating which is absent. Alternatively, the rear glass plate can have a transflective portion such as is disclosed in U.S. Pat. No. 5,910,854, the entire disclosure of which is hereby incorporated by reference herein.

Furthermore, microlouvers or angle-of-incidence-transmission-dependent films such as are available from 3M could enable the sensor **26** to receive ambient light that is incident at an angle to the vehicle's longitudinal axis despite the sensor **26** facing in the same direction as the glare sensor **27**. Alternatively, off-axis ambient light can be directed to the sensor **26** via a light pipe.

The above mirror assembly can be provided as an assembled kit but without the housing **21** (i.e. essentially as seen in FIG. **5**). Such kit would comprise an EC cell, a PCB (including EC cell drive circuitry), a backplate, first and second light sensors, a bracket, and a bezel with first and second apertures therein, with the second aperture that corresponds to the second or ambient light sensor being so located when the kit is married to a mirror housing during assembly of the complete interior mirror assembly, the second photo sensor views sideways from the mirror assembly when it is mounted in the vehicle cabin, i.e. towards a driver-side or passenger-side front side window. This facilitates assembly of such kits in a central manufacturing location, and then their shipment to remote mirror assembly plants located, for example, overseas, where the assembled kit is married with a locally-made mirror housing, any additional accessories and an (optionally) locally-made mirror mount to form a complete interior rearview mirror assembly. Alternatively, the kit need not be assembled prior to shipment, and the entire assembly from the component parts could take place at the final mirror assembly site.

FIGS. **8** to **11** show another embodiment of the invention. In this embodiment similar numerals have been used for like parts as in the previous embodiment and only the differences between this embodiment and the embodiment of FIG. **1** will be described. In FIGS. **8** to **11** the housing **21** and bezel **23** are not shown.

In this embodiment only one light sensor **60** is used which integrates both the glare and ambient functions and this single sensor **60** is located in a boss **61** on the backplate **31** and will look through a single aperture (not shown) in the bezel **31**.

In this embodiment electrical contacts **70**, **71** are moulded into the ball member **33** and electrical contacts **72**, **73** are moulded into the socket member **32**. A portion of each of the contacts **70**, **71** is exposed on the part-spherical external surface **33***a* of the ball member **33** and a portion of each of the contacts **72**, **73** is exposed on the part-spherical internal surface **32***a* of the socket member **32**. The orientation and positions of the portions of the electrical contacts **70**–**73** disposed on the part-spherical surfaces **32***a* and **33***a* is such that over a range of angular movement of the mirror unit **22** the contact **70** is in sliding engagement with the contact **72** and the contact **71** is in sliding engagement with the contact **73**.

The contacts **70**, **71** extend upwardly in the ball member **33** to the upper end of the bracket **30** for making electrical contact with the vehicle electrical supply. The contacts **72** and **73** in the socket member are electrically connected, by connectors not shown, to the PCB **34** at contacts **74**, **75** respectively. The sliding engagement of the contacts **72**, **73** with the contacts **70**, **71** respectively, and the connection of the contacts **72**, **73** with the PCB contacts **74**, **75**, supplies electrical power from the vehicle power supply to the PCB **34**. This arrangement eliminates the need for a separate wire harness which reduces costs and enables the mirror to be assembled more easily.

In this embodiment the backplate **31** incorporates plastic tabs **96** which are coated with a conductive material, the conductive coating extending in a strip **98** along the bottom edge of the backplate **31** and being electrically connected to the PCB **34** in the region of the boss **61**. The conductive tabs **96** resiliently press against the conductive surface of the front glass plate **22***a* to provide an electrical connection from the PCB **34** to the front glass plate **22***a* of the electrochromic cell **22**. This design eliminates one electrode strip **39** off the EC cell **22** and results in a saving of around 54% of the cost of the electrode **39**.

FIGS. **12** to **16** and **16***a* show a further embodiment of the invention. In this construction, the backplate **31** of the previous embodiment is not used and the PCB **34** is fixed by adhesive, clips or other suitable means directly to the rear plate **22***b* of the EC cell **22**. Furthermore, only a single light sensor **80** is provided, in this embodiment near the top of the EC cell, a small area **81** of the reflective layer on the rear glass plate **22***b* being removed in register with the sensor **80** to allow the sensor to view through the transparent front glass plate **22***a*. Alternatively, the top edge of the rear glass plate **22***b* could be recessed, in a similar manner to that previously described for the recess **25** in the bottom edge, and the sensor **80** aligned with the recess. The PCB **34** is electrically connected to the top edge of the conductive electrode layer on one of the glass plates **22***a*, **22***b* of the EC cell **22** by an electrical contact **90**.

In the case where the edge of the cell **22** has a conductive material it is sufficient for the contact **90** to abut the edge of the cell. In the case where the edge of the cell does not have a conductive material it is necessary for the contact **90** to be engaged or partly located between the front and rear glass sheets so as to make electrical connection with the relevant conductive electrode layer. The contact **90** is located in place during manufacture of the cell, and it is noted in this embodiment that the contact **90** may be a conductive tape foil or layer. A similar arrangement (not shown) is used at the bottom of the cell to make electrical contact with the conductive electrode layer on the other of the glass plates of the EC cell **22**.

In this embodiment, due to the absence of the backplate **31**, the socket **32** is moulded into the rear of the housing **21**, but the same arrangement of slidably engaging electrical contacts **70**, **71** and **72**, **73** are provided on the ball member **33** and the socket member **31** respectively as previously described. At the inner surface of the socket **32** resilient electrical contacts **92**, connected to the contacts **72**, **73** respectively, engage respective electrical contacts **93** on the PCB **34** to provide an electrical connection between the power supply contacts **70**, **71** and the PCB **34**.

It will be noted from FIG. **15** that in this embodiment the front and rear glass plates **22***a*, **22***b* of the EC cell **22** are positioned in strict register with no vertical offset as is seen, for example, in FIGS. **6** and **7**. This means that the height of the mirror can be greater than that in the previous embodiments leading to an even better product. In the embodiment of FIGS. **1** to **7** the height of the glass sheets is 61.5 mm and the visible height of the mirror glass to the vehicle driver is 53 mm. In the present embodiment the height of the glass is 59 mm and because there is no offset in the front and rear glass plates the height of the visible mirror is again 53 mm. Thus, less glass is used in this construction because of the lack of offset in the front and rear glass plates of the EC cell **22**. In this case the number of TEC glass plates is increased by 25% and the number of ITO(Ag) glass plates is increased by 40% as compared with existing mirrors. Alternatively, if the height of the glass is maintained at 61.5 mm, the visible height of the mirror would be 2.5 mm greater at 55.5 mm leading to an even better product. In this embodiment therefore, the cost can be reduced further or the size of the product can be increased because of the absence of overlapping glass sheets. Also the cost of providing the electrodes **38**, **39** used in the previous embodiments is eliminated.

It will be seen from FIGS. **15** and **16** that the housing **21** has no separate bezel **23**, but rather the bezel **23** is integral with the main body of the housing **21**. The integral bezel **23** defines a mirror viewing opening **23***b* which is slightly smaller than the lateral dimensions of the EC cell **22**, as seen in FIG. **15**. Therefore, in order to insert the EC cell **22** into the housing **21** the latter is warmed sufficiently to the resiliently soften the housing polymeric material (e.g. PP or nylon) but not sufficiently for the housing to lose its structural integrity. Then the EC cell **22** is inserted behind the bezel **23** while the housing **21** is still warm so that the edge of the EC cell is located in and gripped by a shallow recess **21***a* of the housing just behind the bezel. Thereafter the housing is allowed to cool and become rigid. This method of assembly has the advantage that a separate bezel is not required and the number of parts is reduced.

However, due to the need to get the EC cell **22** through the front opening in the housing **21**, the lateral dimensions of the opening are only slightly less than the lateral dimensions of the EC cell. This means that in the assembled mirror the bezel overlaps the edges of the EC cell by only a small amount, typically 1.5 mm. This exposes the black epoxy lacquer seal which is conventionally coated around the edges of the glass plates and which extends partially onto the front surface of the front glass panel as a narrow strip several mm wide adjacent the edge. The exposed part of this seal, i.e. the part of the strip not covered by the bezel, will provide a cosmetic effect which can appear to the driver as part of the bezel itself.

FIG. **17** shows part of another embodiment of the invention in which the electrical contact **36**, **37** are in the form of a conductive adhesive tape or coating for electrical connection to electrical contacts **40** on the PCB **34**. This embodiment is a kind of hybrid of the embodiments of FIGS. **8**–**11** and **12**–**16**, since it has a single sensor **60** like the embodiment of FIGS. **8**–**11** but the PCB **34** is mounted directly on the rear of the EC cell **22** like the embodiment of FIGS. **12**–**16**. Alternatively there may be two light sensors as shown in relation to FIGS. **1**–**7**. It wall be appreciated that the embodiment of FIG. **17** will have a housing **21** similar to that of FIGS. **12**–**16**, i.e. the socket member **32** will be moulded to the rear of the housing.

FIGS. **19** to **24** show another embodiment of the invention. In this embodiment similar numerals have been used for like parts as in the previous embodiment. In FIGS. **19** to **24** the housing **21** and bezel **23** are not shown, but may be fitted as described for the embodiment of FIGS. **1** to **7**.

As in the first embodiment, in the present embodiment the EC cell **22** is securely fixed by adhesive, clips or other suitable means to a non-conductive backplate **31** moulded, for example, from glass-filled polypropylene (PP) or nylon. A socket member **32** is mounted on the opposite side of the backplate **31** to the cell **22**, i.e. on the rear side of the backplate, and is preferably formed integrally with the backplate. The socket member **32** engages with the ball member **33** of a support bracket **30** to allow angular adjustment of the EC cell **22**. The PCB **34** is fixed by adhesive, clips or other suitable means to the rear side of the backplate **31**, the electrical circuit being on the side of the PCB facing the backplate and therefore not being visible in FIGS. **19** and **20**.

An electrically conductive lead frame **101**, FIG. **22**, is embedded in the backplate **31**. The lead frame **101** is stamped from a flat phosphor bronze sheet and is embedded into the backplate **31** by moulding the latter around it, leaving certain contact and biasing fingers free of the moulded material as will be described. The lead frame comprises five electrically isolated portions A, B C, D and E (in actual fact, for ease of handling the four portions are initially joined by narrow bridges of phosphor bronze in the initial stamping but these are severed during or after the moulding process to isolate the four portions). The electrical functions of the five portions of the lead frame are:

Portion A: Power supply +12v

Portion B: Ground

Portion C: EC cell anode (+ve)

Portion D: EC cell cathode.

Portion E: Heat Sink.

The EC cell cathode can be −ve or ground, and in the latter case the lead frame portions B and D can remain connected within the lead frame to provide one large ground plane providing substantial EMC protection.

The lead frame fingers which are left free of and thus extend out of the moulded material of the backplate **31** are as follows (see also FIGS. **19**–**21**):

- Spring contacts **102***a*, **102***b* which are bent upwardly out of the plane of the lead frame to bear resiliently against respective electrical contacts **134***a*, **134***b* on the ball member **33**. These connect respectively to power (+12v) and ground of the vehicle electrical supply via the bracket **30** as will be described.
- Spring contacts **104***a*, **104***b* which are bent upwardly out of the plane of the lead frame to bear resiliently against respective electrical contacts strips **106***a*, **106***b* (FIG. **21**) on the side of the PCB **34** facing the backplate **31**. These transfer the power and ground of the vehicle electrical supply to the PCB **34** via the lead frame portions A and B.
- Spring contacts **108***a*, **108***b* which are bent upwardly out of the plane of the lead frame to bear resiliently against respective electrical contacts strips **110***a*, **110***b* (FIG. **21**) on the side of the PCB **34** facing the backplate **31**. These receive the EC cell anode and cathode voltages from the PCB **34** for control of the EC cell reflectivity.
- A spring contact **108***c* which is bent upwardly out of the plane of the lead frame to make large area contact with the PCB **34** to dissipate heat from copper tracks and heat generating components on the "hottest" area of the PCB. The portion E thereby constitutes an efficient heat sink.
- A plurality of contact fingers **112** (the outer pair of each group of three seen at the bottom of FIG. **22**) which are bent through 90 degrees at their outer ends to engage the conductive electrode layer on the inside surface of the front glass plate **22***a* (the front and rear glass plates **22***a*, **22***b* are slightly offset as in the first embodiment). These apply the EC cell anode voltage from the contact **108***a* via the lead frame portion C.
- A pair of contact fingers **114** which are bent through 90 degrees at their outer ends to engage the conductive electrode layer on the inside surface of the rear glass plate **22***b*. These apply the EC cell cathode voltage from the contact **108***b* via the lead frame portion D.
- A plurality of spring fingers **116** which are bent out of the plane of the lead frame from the portions B, C and D to bear resiliently against the interior of the mirror housing **21** (not shown) to stabilise the EC cell **22** within the housing (at the bottom of the lead frame the spring fingers **116** are the centre fingers of each group of three).

This embodiment again uses ambient and glare light sensors **26**, **27** although in this case they are surface mounted on the PCB **34** rather than depending from it. As before, the glare sensor **27** faces rearwardly of the vehicle when the mirror is mounted in the vehicle cabin and views through the transparent front glass plate **22***a* of the EC cell via a recess **25** in the edge of the rear glass plate **22***b*. However, the ambient sensor **26** in this case faces forwardly (relative to the vehicle) and views forwardly of the vehicle through an aperture **120** in the PCB **34** and a corresponding aperture (not shown) in the mirror housing. When the PCB **34** is mounted on the backplate **31** the sensors **26** and **27** sit in respective apertures in a housing **122** moulded to the backplate **31**, the housing both mechanically protecting the sensors and shielding them from extraneous light. Alternatively, a single light sensor may be positioned so that it is shrouded from stray light by a feature of the backplate, receives glare light though an aperture in the bezel and through the recess in the rear glass and receives ambient light from the opposite direction through a hole in the PCB and an aperture in the mirror housing. This one sensor can monitor both ambient and glare light levels. Where two sensors are used, mounting them close together on the PCB **34** reduces adverse EMC effects by eliminating long conductive lines between the sensors.

The bracket **30**, FIGS. **23** and **24**, is (except as noted below) moulded from glass-filled polypropylene (PP) or nylon. It has an upper end with internal rails **124** for sliding engagement with a "button"-type mirror mount **100** for attachment of the bracket to the interior surface of a vehicle windscreen in conventional manner. The bracket **30** further includes a ball member **33** which depends from the upper end of the bracket and has a part-spherical external surface **33***a* rotatable within a complementary part-spherical internal surface **32***a* (FIG. **20**) of the socket member **32** to allow a range of angular movement of the EC mirror unit **22** relative to the bracket **30**.

The ball member **33** comprises a central cylindrical bore **126** and a cylindrical body **128** of electrically insulating material extending fully through the bore **126** from the upper end of the bracket and terminating in an exposed convex surface **130** below the lower end of the bore. The body **128** comprises three parts: two outer generally semi-cylindrical parts **128***a*, **128***b* separated by a central planar part **128***c*. At the upper end of the bracket the parts **128***a*, **128***b* have

respective integral spring arms **132**, and at the lower and of the body **128** all three parts collectively define the convex surface **130**.

The outer surfaces of the semi-cylindrical parts **128***a*, **128***b* are plated with an electrically coating, the coating on each part extending onto the convex surface **130** to form respective electrical contacts **134***a*, **134***b* and from there each coating extends continuously along the length of the part **128***a* or **128***b* to the upper end of the bracket and onto the top surface of the respective spring arm **132**. Thus a direct electrical path is made from each electrical contact **134***a*, **134***b* on the convex surface **130** to a respective one of the spring arms **132**. The central part **128***c*, which is not conductively coated, prevents any short circuit between the two paths.

When the upper end of the bracket **30** is mounted to a mounting button **100** the spring arms **132** engage conductive tracks (not shown) on the inside surface of the windscreen, such tracks providing vehicle power and ground which are thereby transferred to the respective contacts **134***a*, **134***b* via the conductive coatings on the sides of the body **128**. The contacts **134***a*, **134***b* are slidingly engaged by the lead frame spring contacts **102***a*, **102***b* over a range of angular movement of the EC cell **22** for supplying power to the PCB **34** from the vehicle electrical system.

The body **128** may be manufactured in three pieces **128***a*, **128***b* and **128***c* which are slid side-by-side into the bore **126** as indicated for the part **128***b* in FIG. **23**(*a*). In such a case the outer parts **128***a* and **128***b* are preferably hollow (as shown for the part **128***b*) and individually moulded of polysulphide or other electroplatable material and subsequently plated with conductive coatings. The centre part **128***c* can be moulded of the same material but left unplated, or it can be moulded, like the rest of the bracket **10**, of a polymeric material such as PP or nylon. However, a two-shot moulding process may be used. In the first shot, the central part **128***c* is moulded using a material which cannot be electroplated. Then, in the second shot, the outer semi-cylindrical parts **128***a* and **128***b* are moulded to opposite sides of the centre part **128***c* but using a material such as polysulphide which can be plated. Then the entire body **128** is subject to electroplating, but the plating only "takes" to the outer parts **128***a* and **128***b*.

In an alternative embodiment of the bracket **30**, FIG. **25**, the spring contacts **132** are replaced by a plug **136** of a standard plug and socket connector and the conductive coatings on the body **128** extend onto the plug **136**.

In a modification of the above embodiment, the body **128** could comprise more than two independently plated parts **128***a*, and **128***b*, e.g. three such parts each subtending an angle of about 120 degrees at the centre and each insulated from the others. In such a case two of the parts would provide power and ground connections for the PCB, while the third part could provide a data connection to other equipment mounted in the mirror housing.

Alternatively, FIG. **26**, the data connection could be provided by a solid conductor **134***c* embedded in and extending the full length of the central part **128***c*. The surface of the conductor **134***c* exposed at the lower end of the part **128***c* could be slidingly engaged by a further spring contact extending from the lead frame, similar to the contacts **102***a*, **102***b*. In all embodiments of bracket, however, cooperating stop means (not shown) on or in the ball member **33** and socket member **32** respectively are designed to limit the degree of angular adjustment of the mirror to ensure that each spring contact remains in engagement with its respective contact on the lower end of the body **128**.

The invention is not limited to the embodiments described herein which may be modified or varied without departing from the scope of the invention.

The invention claimed is:

1. A rearview mirror assembly for a vehicle comprising:
an electro-optic mirror unit whose reflectivity is variable in response to an electrical voltage applied thereto;
at least one light sensor;
an electrical circuit for controlling operation of said mirror unit in response to said at least one light sensor;
a bracket for supporting said rearview mirror assembly from an interior portion of the vehicle;
wherein said mirror unit is mounted on one side of a backplate;
wherein said backplate comprises an electrically non-conductive material comprising a conductive lead frame;
wherein said electrical circuit is mounted on the side of said backplate opposite to said one side; and
wherein said electrical circuit is electrically connected to said mirror unit by contacts extending from said lead frame out of said backplate.

2. The assembly of claim **1**, wherein said bracket connects to said mirror unit via a ball and socket pivot assembly, said ball being fixed relative to said bracket and said socket being fixed relative to said mirror unit.

3. The assembly of claim **2**, said pivot assembly including a plurality of electrical contacts and counter-contacts for supplying electrical power to said electrical circuit from a vehicle electrical system external to said mirror assembly, the power provided to said electrical circuit over a range of angular movement of said mirror unit relative to said bracket.

4. The assembly of claim **3**, wherein said ball includes a convex surface, said electrical contacts being disposed at said convex surface.

5. The assembly of claim **2**, including a mirror housing containing the said mirror unit, wherein said socket member is disposed on said mirror housing.

6. The assembly of claim **1** wherein said electrical circuit is electrically connected to said mirror unit by spring contacts extending from the lead frame out of said backplate.

7. The assembly of claim **1**, wherein said lead frame includes a plurality of spring contacts extending from opposite edges of said backplate and making electrical contact with opposite edges of said mirror unit for allowing said electrical circuit to control the operation of said mirror unit.

8. The assembly of claim **1** wherein said electro-optic mirror unit comprises an electrochromic mirror unit.

9. A rearview mirror assembly for a vehicle comprising:
an electro-optic mirror unit whose reflectivity is variable in response to an electrical voltage applied thereto;
at least one light sensor;
an electrical circuit for controlling operation of said mirror unit in response to said at least one light sensor;
a bracket for supporting said rearview mirror assembly from an interior portion of the vehicle;
wherein said mirror unit is mounted on one side of a backplate;
wherein said backplate comprises an electrically non-conductive material comprising a conductive lead frame;
wherein said electrical circuit is mounted on the side of said backplate opposite to said one side; and
wherein said lead frame includes a plurality of spring contacts extending from opposite edges of said backplate and making electrical contact with opposite edges

of said mirror unit for allowing said electrical circuit to control the operation of said mirror unit.

10. The assembly of claim **9**, wherein said bracket connects to said mirror unit via a ball and socket pivot assembly, said ball being fixed relative to said bracket and said socket being fixed relative to said mirror unit.

11. The assembly of claim **10**, said pivot assembly including a plurality of electrical contacts and counter-contacts for supplying electrical power to said electrical circuit from a vehicle electrical system external to said mirror assembly, the power provided to said electrical circuit over a range of angular movement of said mirror unit relative to said bracket.

12. The assembly of claim **11**, wherein said ball includes a convex surface, said electrical contacts being disposed at said convex surface.

13. The assembly of claim **9** wherein said electrical circuit is electrically connected to said mirror unit by contacts extending out of said backplate.

14. The assembly of claim **13**, wherein said contacts comprise spring contacts extending from said lead frame out of said backplate.

15. The assembly of claim **9**, wherein said electrical circuit is electrically connected to said mirror unit by contacts extending from said lead frame out of said backplate.

16. The assembly of claim **9** wherein said electro-optic mirror unit comprises an electrochromic mirror unit.

17. A rearview mirror assembly for a vehicle comprising:

an electrochromic mirror unit whose reflectivity is variable in response to an electrical voltage applied thereto;

at least one light sensor;

an electrical circuit for controlling operation of said mirror unit in response to said at least one light sensor;

a bracket for supporting said rearview mirror assembly from an interior portion of the vehicle;

wherein said mirror unit is mounted on one side of a backplate;

wherein said backplate comprises an electrically non-conductive material comprising a conductive lead frame;

wherein said electrical circuit is mounted on the side of said backplate opposite to said one side;

wherein said lead frame includes a plurality of spring contacts extending from opposite edges of said backplate and making electrical contact with opposite edges of said mirror unit for allowing said electrical circuit to control the operation of said mirror unit;

wherein said bracket connects to said mirror unit via a ball and socket pivot assembly, said ball being fixed relative to said bracket and said socket being fixed relative to said mirror unit; and

wherein said electrical circuit is electrically connected to said mirror unit by contacts extending out of said backplate.

18. The assembly of claim **17**, said pivot assembly including a plurality of electrical contacts and counter-contacts for supplying electrical power to said electrical circuit from a vehicle electrical system external to said mirror assembly, the power provided to said electrical circuit over a range of angular movement of said mirror unit relative to said bracket.

19. The assembly of claim **17**, wherein said contacts extending out of said backplate comprise spring contacts extending from the lead frame out of said backplate.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,209,278 B2
APPLICATION NO. : 11/498420
DATED : April 24, 2007
INVENTOR(S) : Patrick J. Lawlor et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1
Line 7, Insert --copending-- before "U.S.".

Column 4
Line 26, "for" should be --from-- in the second occurrence.
Line 32, Delete "to form a pivot assembly" after "interengage".

Signed and Sealed this

Sixteenth Day of September, 2008

JON W. DUDAS
Director of the United States Patent and Trademark Office