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(54) Temperature-responsively operated drive mechanism

(57) A temperature-responsively operated drive mechanism 29 is designed to provide a switching drive force to switching-type indicating means 10 placed on a freeze-indicating sign system. The temperature-responsively operated drive mechanism 29 includes members 35 and 36 made of a shape memory alloy for providing the switching drive force to the switching-type indicating means 10 in accordance with a temperature such as a predetermined temperature, and a drive force assisting means 50 for providing an assist force for assisting in the switching drive force during switching operation of the members made 35 and 36 of the shape memory alloy. Therefore, the speed of switching turning movement of the switching-type indicating means 10 in the freeze-indicating sign system can be increased, whereby the switching of the indications on the switching-type indicating means 10 at the predetermined temperature corresponding to a freezing temperature can be conducted quickly and automatically, thereby informing a driver or a road manager or the like of the freezing of a road surface occurring in winter season.

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a temperature-responsively operated drive mechanism for use in a freeze-indicating sign system for warning a passer, a driver or a road manager of the freezing of a road surface occurring in winter season.

DESCRIPTION OF THE RELATED ART

[0002] A large number of such freeze-indicating sign systems have been proposed as disclosed in Japanese Utility Model Application Laid-open Nos.52-142392, 58-10913 and 62-12612, Japanese Patent Application Laid-open No.54-19760 and the like.

[0003] The present applicant has proposed a freeze-indicating sign system, for example, in Japanese Patent No.2889545 and the like, in which problems associated with the above conventional systems have been overcome. This freeze-indicating sign system includes a switching-type indicating means adapted to be turned to indicate "caution to freeze" and "caution to travel" in a switching manner. The switching-type indicating means can be turned based on a substantially freezing temperature by a temperature-responsively operated drive means formed using a shape memory alloy for applying a switching drive force to the switching-type indicating means, so that the indications in a housing provided in the switching-type indicating means can be switched over from one to another at the substantially freezing temperature. It is possible to inform a driver or a road manager or the like of the freezing of a road surface occurring in winter season without recourse to an external power source. Further, the size of the freeze-indicating sign system can be increased two-dimensionally without an increase in amount of temperature-responsively operated drive means displaced and an increase in driving energy.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide a temperature-responsively operated drive mechanism which is designed, so that the speed of switching turning movement of a switching-type indicating means in such a freeze-indicating sign system can be increased, whereby the switching of the indications at a predetermined temperature corresponding to the freezing temperature can be conducted quickly and automatically to promptly inform a driver or a road manager or the like of the freezing of a road occurring in winter season, thereby ensuring the safety of a road traffic.

[0005] To achieve the above object, according to the present invention, there is provided a temperature-responsively operated drive mechanism designed to provide a switching drive force to switching-type indicating means placed on a freeze-indicating sign system, comprising a member made of a shape memory alloy for providing the switching drive force to the switching-type indicating means in accordance with a temperature such as a predetermined temperature, and a drive force assisting means for providing an assist force for assisting in the switching drive force during switching operation of the member made of the shape memory alloy.

[0006] With the above arrangement, when the temperature of the outside air reaches a predetermined temperature at which the switching operation is required, the drive force assisting means provides the assist force for assisting in the switching drive force to the member of the shape memory alloy for providing the switching drive force to the switching-type indicating means. Therefore, the switching of the indications on the switching-type indicating means at the predetermined temperature corresponding to the freezing temperature can be conducted quickly and automatically. Thus, it is possible to quickly inform a driver or a road manager or the like of the freezing of a road occurring in winter season to ensure the safety of road traffic.

[0007] The drive force assisting means may be comprised of a permanent magnet and a ferromagnetic member disposed between a movable member in the switching-type indicating means and a stationary member of the freeze-indicating sign system for providing a magnetic force.

[0008] With the above arrangement, when the switching operation of the switching-type indicating means is started by the member made of the shape memory alloy, a magnetic force is provided between the permanent magnet and the ferromagnetic member to provide the assist force for assisting in the switching drive force provided by the member made of the shape memory alloy, whereby the switching of the indications on the switching-type indicating means can be conducted quickly and automatically.

[0009] The above and other objects, features and advantages of the invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig.1 is a perspective view of a freeze-indicating sign system which has a temperature-responsively operated drive mechanism according to an embodiment the present invention placed thereon and which is in a recurrent reflection operational state;

Fig.2 is a perspective view of the freeze-indicating sign system which has the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon

and which is in a mounted state;

Fig.3 is a perspective view of the freeze-indicating sign system which has the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon and which is in a service state;

Fig.4 is a front view of the freeze-indicating sign system which has the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon and which is in another service state;

Fig.5 is a back view of a housing of the freeze-indicating sign system having the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon;

Fig.6 is a sectional view of the housing of the freeze-indicating sign system having the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon, taken along a line A-A in Fig.5;

Fig.7 is a developed schematic view of parts of the freeze-indicating sign system having the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon;

Fig.8 is an enlarged developed view showing essential portions of switching-type indicating means mounted on the freeze-indicating sign system having the temperature-responsively operated drive mechanism according to the embodiment the present invention placed;

Figs.9a and 9b are diagrams for explaining the turning movement of the switching-type indicating means of the freeze-indicating sign system having the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon;

Fig.10a is a sectional view of an upper attaching member mounted on the freeze-indicating sign system having the temperature-responsively operated drive mechanism according to the embodiment the present invention placed thereon, and Fig.10b is a sectional view of the lower attaching member mounted on the freeze-indicating sign system;

Fig.11a is a plan view of the lower attaching member when the switching-type indicating means of the freeze-indicating sign system have been turned in a clockwise direction, Fig.11b is a plan view of the lower attaching member when the switching-type indicating means have been turned in a counterclockwise direction, and Fig.11c is a front view of only the lower attaching member;

Fig.12 is a sectional view of a movable member and the lower attaching member mounted on the freeze-indicating sign system;

Fig.13a is a view showing the relation between the movable member and pinions in the freeze-indicating sign system in a state in which the movable member has been moved rightwards, and Fig.13b is a view in a state the movable member has been moved leftwards;

Fig.14 is a plan view of the switching-type indicating means turned in the clockwise direction by the temperature-responsively operated drive mechanism according to the embodiment of the present invention;

Fig.15 is a plan view of the switching-type indicating means turned in the counterclockwise direction by the temperature-responsively operated drive mechanism according to the embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] The present invention will now be described by way of an embodiment of the present invention with reference to the accompanying drawings. The same reference characters in Figures designate the same or corresponding components or portions in the embodiments. Particularly, components or portions designated by reference character with suffixes A, B, C and D attached thereto to indicate the use of parts of the same construction are basically common with component or portions designated by reference characters with not suffix attached thereto.

[0012] First, a freeze-indicating sign system provided with a temperature-responsively operated drive mechanism according to the present invention will be described.

[0013] Referring to Figs.1 to 4, a freeze-indicating sign system is attached to a white support post 2 by a known attaching means 3, and has a side strip-indicating function for clearly indicating the presence of a side strip, for example, by a white or yellow recurrent reflection surface and a freeze-indicating function. The attaching means 3 in the present embodiment includes a grooved rail member 5 mounted to a housing 4 formed as a template made of aluminum, commercially available bolts whose heads are inserted into the rail member 5 to inhibit the turning movement, a saddle 6 fitted at its opposite ends over the inserted bolt, and nuts 7 threadedly engaged with the bolts, thereby clamping the support post 2 between the rail member 5 and the saddle 6. Of course, the attaching means 3 used to carry out the present invention may be integrally mounted directly to the support post 2 by bolts and nuts. The housing 4 may be formed into a box shape from an opaque synthetic resin material or a metal plate, a template or the like. In the present embodiment, the housing 4 is formed as a template of aluminum. A transparent plate 4a comprising a transparent acrylic plate or a transparent glass plate is disposed on a front surface of the housing 4. The transparent plate 4a is disposed on the front surface, but may be a plate provided with windows functioning at least as a side strip sign and a freeze sign, or a plate formed of a transparent material in correspond-

ence to front half of the housing 4. Of course, the transparent plate 4a may be a plate formed of a transparent material in correspondence to the entire housing 4.

[0014] As shown in Figs.1, 2, 5 and 6, the housing 4 in the present embodiment is the transparent plate 4a and a back lid 9 attached to a back of a case body 8 which will be described hereinafter. Side strip sign faces 11A, 11B, 11C and 11D (common "side strip sign faces" will be denoted simply by "11" hereinafter) and freeze sign faces 12A, 12B, 12C and 12D (common "freeze sign faces" will be denoted simply by "12" hereinafter) provided on switching-type indicating means 10A, 10B, 10C and 10D (common "switching-type indicating means" will be denoted simply by "11" hereinafter) are faces visually observed from the transparent plate 4a. In the present embodiment, the switching-type indicating means 10 are formed so that the indication can be switched over by turning the switching-type indicating means 10 about a vertical axis. It is of course that a sealant or a sealing material or an adhesive (not shown) is filled or interposed between the case body 8 and the transparent plate 4a and between the case body 8 and the back lid 9 to ensure a required sealability. Reference character 4b shown in Fig.5 is a screw bore for securing the back lid 9 to the housing 4, and reference characters 9a and 9b relatively show positions of the screw bores in the back lid 9.

[0015] Figs.3 and 4 show a freeze-indicating sign system according the embodiment of the present invention in a certain service state. A freeze-indicating sign device 1 (1U) located at an upper portion of the freeze-indicating sign system is adapted to indicate "tra" when the temperature is raised to exceed a first preset value, and to indicate "free" when the temperature is dropped to a level lower than a second preset value lower than the first preset value, and a freeze-indicating device 1 (1D) located at a lower portion of the freeze-indicating sign system is adapted to indicate "vel" when the temperature is raised to exceed a first preset value, and to indicate "ze" when the temperature is dropped to the level lower than the second preset value lower than the first preset value. An indicating plate 100 located at a lower portion of the freeze-indicating device 1 (1D) indicates letters of caution, and adapted to indicate "caution to freeze" by black letters on a red substrate when temperature is raised to exceed the first preset value, as in Fig. 4a which is a front view showing one mode of the service state, and to indicate "caution to travel" by black or blue letters on a yellow substrate when the temperature is equal to or higher than a predetermined value as in Fig. 4b. Of course, "caution to travel" and "caution to freeze" may be indicated by black letters on the same yellow substrate or the like.

[0016] In the present embodiment, the freeze-indicating sign system 1 may indicate a side strip sign and a freeze sign by colors such as yellow and red, white and red, or blue and red without provision of letters. In the embodiment shown in Fig.4, the freeze-indicating sign system 1 is divided into a freeze-indicating sign device 1U and a freeze-indicating sign device 1D. In the carrying-out of the embodiment, the freeze-indicating device 1 is vertically elongated or laterally elongated and capable of indicating one letter or a plurality of letters, e.g., "travel" or "freeze", or "caution to travel" or "caution to freeze" in the same housing 4. Particularly, when letters are written on a surface having a side strip sign and a freeze sign formed thereon, the recurrent reflection face can represent a side strip sign function and a freeze sign function by only letters indicated by one color selected from, for example, white, yellow, red and blue colors and by another complementary color.

[0017] In the freeze-indicating sign system 1 according to the embodiment of the present invention, the indication of freeze having no letter, the indication of freeze provided with letters and the indication of freeze provided with characters are not varied in concept from one another and hence, the following description is on the assumption that the concepts are common.

[0018] Referring to Fig.7, an upper attaching member 60 disposed at an upper portion of the housing 4 is secured to the back lid 9 by screws 60a in such a manner that the screws 60a threadedly engaged in a plurality of screw bores 60b are threadedly inserted into screw bores 9a in the back lid 9. A lower attaching member 20 disposed at a lower portion of the housing 4 is secured to the back lid 9 by screws 20a in such a manner that the screws 20a threadedly engaged in a plurality of screw bores 20b are threadedly inserted into screw bores 9b in the back lid 9.

[0019] In the present embodiment, four switching-type indicating means 10A, 10B, 10C and 10D are rotatably supported between the upper attaching member 60 and the lower attaching member 20.

[0020] The structures of the upper and lower attaching member 60 and 20 and the switching-type indicating means 10 will be described below with reference to Figs. 8 and 9 (lower portions of these figures correspond to the front side of the housing, and the same is true in Figs.11 and 13).

[0021] The switching-type indicating means 10 has an upper end member 13 formed at an upper portion thereof and a lower end member 14 formed at a lower portion thereof, and is rotatable about an upper end shaft 13a of the upper end member 13 and a lower end shaft 14a of the lower end member 14. In the switching-type indicating means 10 in the present embodiment, a V-shaped plate member 15 folded into a V-shape is bonded between the upper and lower end members 13 and 14, and a synthetic resin sheet containing a recurrent reflection material incorporated therein is adhered to an outer surface of the V-shaped plate member 15. One of faces of the V-shaped plate member 15 is a side strip sign face 11A, 11B, 11C, 11D, and the other face is a freeze sign face 12A, 12 B, 12C, 12D for indicating a frozen state of a road surface.

[0022] When the temperature of the outside air is

raised to exceed a value higher than the first preset value, the switching-type indicating means 10A, 10B, 10C and 10D disposed within the housing 4 are turned clockwise through approximately 120 degree from the state shown in Fig.9b, and as a result, the side strip sign faces 11A, 11B, 11C and 11D are on the side of the transparent plate 4a of the housing 4, as shown in Fig.9a. When the temperature of the outside air is dropped down to a value lower than the second preset value, the switching-type indicating means 10A, 10B, 10C and 10D disposed within the housing 4 are turned counterclockwise through approximately 120 degree from the state shown in Fig.9a, and as a result, the freeze sign faces 12A, 12B, 12C and 12D are on the side of the transparent plate 4a of the housing 4, as shown in Fig.9b. Namely, when the side strip sign faces 11A, 11B, 11C and 11D of the switching-type indicating means 10A, 10B, 10C and 10D are flush with one another, as shown in Fig.9a, light is reflected from the entire side strip sign faces 11A, 11B, 11C and 11D in a direction of incidence, thereby clearly indicating that a road surface is not in a frozen state. When the switching-type indicating means 10A, 10B, 10C and 10D are turned through approximately 120 degree from the states shown in Fig.9a and as a result, different faces are substantially on a plane, the freeze sign faces 12A, 12B, 12C and 12D are flush with one another, whereby light is reflected from the entire freeze sign faces 12A, 12B, 12C and 12D in the direction of incidence, thereby clearly indicating that the road surface is in a frozen state or in a freezable state.

[0023] The number of the switching-type indicating means 10A, 10B, 10C and 10D in the present embodiment is four, but is not limited to four. However, if the number of the switching-type indicating means 10A, 10B, 10C and 10D is in a range of 2 to 5 as in the present embodiment, each of the switching-type indicating means can be formed so that the contact resistance thereof is relatively small, and the mechanical strength thereof is also strong.

[0024] The upper end of the switching-type indicating means 10 in the present embodiment is mounted to the upper attaching member 60, as shown in Fig.10a.

[0025] The upper attaching member 60 is provided with through-bores 61 for mounting of the four switching-type indicating means 10A, 10B, 10C and 10D. The upper end shafts 13a of the upper end members 13 formed at the upper portion of the switching-type indicating means 10 are inserted into the through-bores 61 with a metal bearing 62 interposed between the through-bore 61 and the upper end shaft 13a. A portion of the upper end shaft 13a located in the metal bearing 62 is threadedly fixed by a bolt 65 with a slide ring 63 (constituting a slide bearing having a lower contact resistance surface, e.g., a thrust sphere bearing, a dry bearing and the like) interposed therebetween along with a washer 64 and the metal bearing 62. Namely, the upper end shaft 13a is clamped firmly by the bolt 65 with the washer 64 and the slide ring 63 interposed therebetween. Therefore, the switching-type indicating means 10 is turned in unison with the slide ring 63, and a flange portion on an upper surface of the metal bearing 62 and the slide ring 63 are turned in states of a low frictional resistance.

[0026] The lower end of the switching-type indicating means 10 is mounted to the lower attaching member 20, as shown in Fig.10b.

[0027] The lower attaching member 20 has columnar projections 21A, 21B, 21C and 21D formed thereon for mounting of the four switching-type indicating means 10A, 10B, 10C and 10D (common "projections" will be denoted simply by "21" hereinafter). A sleeve 23 is embedded in each of the projections 21A, 21B, 21C and 21D. The sleeve 23 has a low frictional resistance and functions as a bearing, and is embedded in a lower end of the lower end shaft 14a of the lower end member 14 of the switching-type indicating means 10. Pinions 14b (14bA, 14bB, 14bC and 14bD) are formed on outer sides of the lower ends of the lower end shafts 14a of the lower end members 14. The sleeve 23 is located inside the pinion 14b and fixed to the projection 21, so that the lower end shaft 14a of the lower end member 14 is inhibited from being horizontally moved by embedding the sleeve 23 into the lower end shaft 14a, but can be turned in a circumferential direction of the sleeve 23. In this case, a small distance is provided between the lower end of the lower end shaft 41a of the lower end member 14 and the upper surface of the lower attaching member 20, so that both of them are not brought into contact with each other. Namely, the switching-type indicating means is supported in a cantilever manner only on the side of the upper attaching member 60.

[0028] As shown in Figs.8 and 11, the lower attaching member 20 is provided on its upper surface with a clockwise turning-movement stopper 22R (22RA, 22RB, 22RC and 22RD) for restraining the clockwise turning movement of the switching-type indicating means 10, and a counterclockwise turning-movement stopper 22L (22LA, 22LB, 22LC and 22LD) for restraining the counterclockwise turning movement of the switching-type indicating means 10. An abutment projection 14c (14cA, 14cB, 14cC and 14cD) protruding downwards from the lower end member 14 restrains the leftward turning movement together with the counterclockwise turning-movement stopper 22L (22LA, 22LB, 22LC and 22LD) and at this time, the freeze sign faces 12A, 12B, 12C and 12D are flush with one another on the side of the transparent plate 4a of the housing 4, as shown in Fig. 9b and 11a. An abutment projection 14d (14dA, 14dB, 14dC and 14dD) protruding downwards from the lower end member 14 restrains the rightward turning movement together with the clockwise turning-movement stopper 22R (22RA, 22RB, 22RC and 22RD) and at this time, the side strip sign faces 11A, 11B, 11C and 11D are flush with one another on the side of the transparent plate 4a of the housing 4, as shown in Fig.9a and 11b.

[0029] The positions of the V-shaped plate member 15 of the switching-type indicating means 10 and the

side strip sign face and the freeze sign face 12 bonded to the V-shaped plate member 15 are determined depending on the distance between the upper and lower attaching members 60 and 20, and the turning movement of the switching-type indicating means 10 causes the flange portion on the upper surface of the metal bearing 62 and the slide ring 63 to be turned in the low frictional resistance state, thereby determining a torque required for turning the switching-type indicating means 10. However, the weights of the V-shaped plate member 15 and the side strip sign face 11 and the freeze sign face 12 between the upper and lower attaching members 60 and 20 exert little influence to the torque and hence, the lengths of the V-shaped plate member 15 and the side strip sign face 11 and the freeze sign face 12 between the upper and lower attaching members 60 and 20 of the switching-type indicating means 10 can be increased.

[0030] A temperature-responsively operated drive mechanism 29 according to the present invention will be described below with reference to Figs.11 to 13.

[0031] The temperature-responsively operated drive mechanism 29 according to the present invention is comprised of a movable member 40, compressed springs 35 and 36 made of a shape memory alloy, a driving-force assisting means 50 and the like.

[0032] The movable member 40 is mounted to the lower attaching member 20, as shown in Fig.12. Two guide projections 24 are formed on the upper surface of the lower attaching member 20, and a slide washer 25 having a small contact resistance of its upper surface is fitted over each of the projections 24. A bush 26 having a small contact resistance is fitted over an outer periphery of each of the guide projections 24, and a guide bore 42a and a guide bore 42c each comprising an elongated bore in the movable member 40 are fitted over the bush 26, thereby facilitating the straight movement of the movable member 40. To prevent the bush 26 from being separated off each of the guide projections 24, the bush 26 is threadedly fixed to each of the guide projections 24 by a mounting screw 27, so that the separation-off of the bush 26 and the movement of the bush 26 in a direction parallel to a direction of protrusion of the guide projection 24 are restrained.

[0033] As shown in Figs.8, 12 and 13, racks 41A, 41B, 41C and 41D are formed on lengthwise one side of the movable member 40, i.e., on longer sides of movable bores 41A, 42B, 42C and 42D of an oblong shape slightly larger than the guide bores 42a and 42c, so that they are meshed with the pinions 14b (14bA, 14bB, 14bC and 14bD) each formed at the lower end of the lower end shaft 14a of the lower end member 14. Therefore, the racks 41A, 41B, 41C and 41D are moved laterally by the lengthwise leftward and rightward straight movements of the movable member 40, whereby the pinions 14bA, 14bB, 14bC and 14bD meshed with the racks 41A, 41B, 41C and 41D are turned to turn the switching-type indicating means 10A, 10B, 10C and 10D. In this case, when the racks 41A, 41B, 41C and 41D are moved leftwards as viewed in Fig.13, the switching-type indicating means 10A, 10B, 10C and 10D are turned counterclockwise. When the racks 41A, 41B, 41C and 41D are moved rightwards as viewed in Fig.13, the switching-type indicating means 10A, 10B, 10C and 10D are turned clockwise.

[0034] Hook portions 43, 44, 45 and 46 are formed on both of front and rear sides of the movable member 40 perpendicularly to the lengthwise direction of the movable member 40, and compressed springs 35 and 36 each made of a shape memory alloy are disposed between the hook portions 43 and 44 and pins 35a and 36a disposed on the upper surface of the lower attaching member 20, so that the distance between the hook portions 43 and 44 and the pins 35a and 36a can be reduced. In addition, compressed springs 30 and 31 having such a characteristic that they are expanded and contracted to an extremely small extent depending on the temperature (linearly expanded to an extremely small extent) are disposed between the hook portions 45 and 46 and pins 30a and 31a disposed on the upper surface of the lower attaching member 20, so that the distance between the hook portions 45 and 46 and the pins 30a and 31a can be reduced. Further, the compression force of the compressed springs 35 and 36 exerts an influence larger than the resilient force of the compressed springs 30 and 31. In usual, a second preset lower temperature determined supposing that the temperature of the compressed springs 35 and 36 made of the shape memory alloy has been dropped, is set at a value substantially near the freezing point of the compressed springs 35 and 36, i.e., in a range of 0 to 3° but slightly varied in different localities. A first preset temperature determined supposing the temperature of the compressed springs 35 and 36 has been raised, depends on the second preset temperature of the compressed springs 35 and 36, and is set by the temperature raised in a range of 2 to 5° determined by a hysteresis. More specifically, the resilient force of the compressed springs 35 and 36 made of the shape memory alloy is memorized, so that for example, when the temperature of the outside air has been dropped to 1 to 2°C or less lower than the second preset temperature, each of turns of the spring is deformed to reduce the compressed density, and when the temperature of the outside air has been raised to 4 to 5°C or more to exceed the second preset temperature and the first preset temperature, each of the turns is deformed to increase the compressed density.

[0035] When the temperature of the outside air has been dropped from a higher level down to the second preset temperature and in the present embodiment to 1 to 2°C in the state shown in Fig.13b, the compressed springs 35 and 36 made of the shape memory alloy are deformed to reduce the compressed density of each of their turns, thereby biasing the movable member 40 leftwards together with the resilient force of the com-

pressed springs 30 and 31. Thus, the switching-type indicating means 10A, 10B, 10C and 10D are turned counterclockwise and finally, the freeze sign faces 12A, 12B, 12C and 12D are flush with one another on the side of the transparent plate 4a of the housing 4, as shown in Fig.13a.

[0036] When the temperature of the outside air has been raised from a lower level up to a temperature exceeding the first preset temperature, e.g., 1 to 2°C of the second preset temperature and the hysteresis in the state shown in Fig.13, the resilient force of the compressed springs 35 and 36 made of the shape memory alloy, because it increases the compressed density of each of the turns of the springs, is larger than that of the compressed springs 30 and 31 for biasing the movable member 40 in the lateral direction in the present embodiment, thereby biasing the movable member 40 rightwards. Thus, the switching-type indicating means 10A, 10B, 10C and 10D are turned clockwise and finally, the side strip sign faces 11A, 11B, 11C and 11D are flush with one another on the side of the transparent plate 4a of the housing 4, as shown in Fig.13a.

[0037] Therefore, when the temperature of the compressed springs 35 and 36 made of the shape memory alloy is substantially equal to or lower than the freezing point, the resilient force of the compressed springs 35 and 36 for moving the movable member 40 is weaker than that of the compressed springs 30 and 31 for biasing the movable member 40 in the opposite direction. However, when the temperature of the compressed springs 35 and 36 exceeds the first preset temperature higher than the freezing point, the resilient force of the compressed springs 35 and 36 for moving the movable member 40 is stronger than that of the compressed springs 30 and 31 for biasing the movable member 40 in the opposite direction. Therefore, when the temperature of the compressed springs 35 and 36 is equal to or lower than the freezing point, the switching-type indicating means 10A, 10B, 10C and 10D are turned counterclockwise, until such turning movement is limited, whereby the freeze sign faces 12A, 12B, 12C and 12D are flush with one another on the side of the transparent plate 4a of the housing 4. When the temperature of the compressed springs 35 and 36 is not equal to or lower than the freezing point, the switching-type indicating means 10A, 10B, 10C and 10D are turned clockwise, until such turning movement is limited, whereby the side strip sign faces 11A, 11B, 11C and 11D are flush with one another on the side of the transparent plate 4a of the housing 4.

[0038] As shown in Figs.8 and 11, the driving-force assisting means 50 in the present embodiment is comprised of the counterclockwise turning-movement stoppers 22L (22LA, 22LB, 22LC and 22LD) and the clockwise turning-movement stoppers 22R (22RA, 22RB, 22RC and 22RD) fixedly placed on the upper surface of the lower attaching member 20 for restraining the counterclockwise and clockwise turning-movement of the switching-type indicating means 10, respectively, and the abutment projections 14c (14cA, 14cB, 14cC and 14cD) and the abutment projections 14d (14dA, 14dB, 14dC and 14dD) protruding downwards from the lower end members 14 of the switching-type indicating means 10 for restraining the counterclockwise and clockwise turning movement of the switching-type indicating means 10, respectively. In the present embodiment, each of the counterclockwise turning-movement stoppers 22L (22LA, 22LB, 22LC and 22LD) and the clockwise turning-movement stoppers 22R (22RA, 22RB, 22RC and 22RD) is a permanent magnet, on the one hand, and each of the abutment projections 14c (14cA, 14cB, 14cC and 14cD) and the abutment projections 14d (14dA, 14dB, 14dC and 14dD) is made of a ferromagnetic member such as iron. A magnetic force applied between the permanent magnet (the counterclockwise turning-movement stopper 22L and the clockwise turning-movement stoppers 22R) and the ferromagnetic member (the abutment projection 14c and the abutment projection 14d) acts as an assist force for assisting in the switching drive force provided by the compressed springs 35 and 36 made of the shape memory alloy for applying the counterclockwise and clockwise switching drive force to the switching-type indicating means 10.

[0039] The freeze-indicating sign system 1 and the temperature-responsively operated drive mechanism 29 constructed in the above manner according to the present embodiment are operated as described below.

[0040] The temperature of the outside air is brought into a temperature capable of operating the compressed springs 35 and 36 made of the shape memory alloy by the heat transfer, heat emission or the like of the housing 4. For example, when the temperature of the outside air becomes the first preset temperature in a range of 4 to 5°C exceeding the substantially freezing temperature, the compressed springs 35 and 36 made of the shape memory alloy is deformed and compressed strongly more than the resilient force of the other compressed springs 30 and 31, whereby the movable member 40 is moved rightwards as viewed in Fig.13 by the resilient force of the compressed springs 35 and 36. Thus, the switching-type indicating means 10 are turned clockwise through approximately 120 degree from the state shown in Fig.9b to the state shown in Fig.9a, whereby the side strip sign faces 11 are turned to the side of the transparent plate 4a of the housing 4. When the clockwise turning movement of the switching-type indicating means 10 is started, the ferromagnetic members (the abutment projections 14d) of the temperature-responsively operated drive mechanism 29 are moved gradually toward the permanent magnets (the counterclockwise and clockwise turning-movement stoppers 22L and 22R), and a magnetic force between both of the ferromagnetic member and the permanent magnet acts, at an intensity inversely proportional to the square of the distance between the ferromagnetic member and the permanent magnet, as an assist force for assisting in

the clockwise switching drive force provided by the compressed springs 35 and 36 made of the shape memory alloy, whereby the clockwise turning movement of the switching-type indicating means 10 is accelerated so that it advances at a stroke. Finally, the ferromagnetic member (the abutment projection 14d) and the permanent magnet (the clockwise turning-movement stopper 22R) are put into abutment against each other and in this manner, the clockwise turning movement of the switching-type indicating means 10 is finished. At this time, light from a headlight of an automobile or the like is reflected in a direction toward the light source, i.e., the headlight by the side strip faces 11. Thus, the indications of "travel" and "caution" can be visually confirmed by the presence of the side strip sign faces 11. Consequently, a driver can travel the car, while confirming the presence of an end of a road by the presence of the side strip sign faces 11.

[0041] When the temperature of the outside air is dropped down to equal to or lower than the substantially freezing temperature, the density of each of the turns of the compressed springs 35 and 36 made of the shape memory alloy with the shape memorized is reduced at the second preset temperature in the range of 1 to 2°C and hence, the resilient force of the springs 35 and 36 in the compression direction, i.e., the repulsive force for moving the movable member 40 rightwards as viewed in Fig.13 is reduced. Therefore, the resilient force of the compressed springs 35 and 36 made of the shape memory alloy in the compressed direction is smaller than that of the compressed springs 30 and 31 in the compressed direction and hence, the compressed springs 35 and 36 are expanded, and the movable member 40 is moved leftwards as viewed in Fig.13 by the resilient force of the compressed springs 30, 31. Thus, the switching-type indicating means 10 is turned through approximately 120 degree from the state shown in Fig.9a to the state shown in Fig.9b and as a result, the freeze sign faces 12 are turned to the side of the transparent plate 41 of the housing 4. When this leftward turning movement of the switching-type indicating means 10 is started, the ferromagnetic members (the abutment projections 14c) of the temperature-responsively operated drive mechanism 29 are moved gradually toward the permanent magnets (the counterclockwise and clockwise turning-movement stoppers 22L and 22R), as shown in Fig.14, and a magnetic force between both of the ferromagnetic member and the permanent magnet acts at an intensity inversely proportional to the square of the distance between the ferromagnetic member and the permanent magnet to weaken the resilient force of the compressed springs 35 and 36 made of the shape memory alloy, and acts as an assist force for assisting in the counterclockwise switching drive force provided by the compressed springs 30 and 31, whereby the counterclockwise turning movement of the switching-type indicating means 10 is accelerated so that it advances at a stroke. Finally, the ferromagnetic member (the abutment projection 14c) and the permanent magnet (the counterclockwise turning-movement stopper 22L) are put into abutment against each other and in this manner, the counterclockwise turning movement of the switching-type indicating means 10 is finished. At this time, light from a headlight of an automobile or the like is reflected in a direction toward the light source, i.e., the headlight by the freeze sign faces 12. Thus, the indications of "freeze" and "caution" can be visually confirmed by the presence of the freeze sign faces 12. Consequently, a driver can travel the car, while confirming the freezable state of a road and the presence of a road end by the presence of the freeze sign faces 12. Particularly, the driver can confirm the frozen state of a road surface by perceiving the color of a recurrent reflected light from the freeze sign faces 12, the shape of the reflecting faces and the letters on the freeze sign faces.

[0042] According to the present invention, when the operation is conducted upon changing of the temperature of the outside air between the predetermined temperatures, i.e., between the first preset temperature in the range of 4 to 5°C to provide the indication of caution to travel and the second preset temperature in the range of 1 to 2°C or less to provide the indication of caution to freeze, the permanent magnets (the clockwise turning-movement stopper 22R and the counter clockwise turning-movement stopper 22L) and the ferromagnetic members (the abutment projections 14c and 14d) provide the assist force for assisting in the switching drive force to the shape memory alloy and the like providing the switching drive force to the switching-type indicating mans 10. Therefore, the switching of the indication at the predetermined temperature corresponding to the substantially freezing temperature of the switching-type indicating means 10 can be carried out promptly and automatically. Thus, it is possible to promptly inform the driver, the road manager or the like of the freezing of the road surface occurring in the winter season to ensure the stability of the road traffic.

[0043] The drive force-assisting means 50 placed on the temperature-responsively operated drive mechanism 29 according to the present invention may be constructed by disposing the permanent magnets and the ferromagnetic members for providing a magnetic force between the stationary housing 4 and the movable section comprising the V-shaped plate member 15, the movable member 40 and the like in the switching-type indicating means 10. For example, permanent magnets 51 may be mounted at left and right ends of the movable member 40, and stoppers 52 made of a ferromagnetic material may be secured to the lower attaching member 20, as shown by dashed lines in Fig.13a. In the disposition of the permanent magnets and the ferromagnetic members, in addition to the combination of the above-described permanent magnets (the clockwise turning-movement stopper 22R and the counterclockwise turning-movement stopper 22L) and the ferromagnetic members (the abutment projections 14c and 14d), the

permanent magnets may be placed on the movable member 40, and ferromagnetic members may be placed on the housing 4. the magnitude of the magnetic force provided between the permanent magnet and the ferromagnetic member and the distance between the permanent magnet and the ferromagnetic member may be determined properly in accordance with the design criterion such as the magnitude of the assist force provided by the drive force assisting means 50, the position of the movable member 40 in the middle of movement of the movable member 40, in which the assist force is required, and the like.

[0044] In the present embodiment, when the temperature of a road surface is equal to or lower than the substantially freezing temperature, the freeze sign faces 12 which are recurrent reflecting faces of the switching-type indicating mans 10 are turned to be perpendicular to the road surface, so that the driver can perceive the recurrent reflection indication on the freeze sign faces 12. When the temperature of a road surface is higher than the substantially freezing temperature, the side strip sign faces which are recurrent reflecting faces of the switching-type indicating mans 10 are turned through approximately 120 degree, so that the driver can perceive the recurrent reflection indication. Alternatively, according to the present invention, the compressed springs 35 and 36 made of the shape memory allot and the compressed springs 30 and 31 may be mounted in the arrangement opposite from that described above, and in this case, the recurrent reflection indications on the side strip sign faces 11 and the freeze sign faces 12 can be reversed.

[0045] In addition, the difference between the indications on the recurrent reflection faces can be represented by the difference between the patterns such as colors, letters, illustrations and the like by using the difference between the recurrent reflection indications on the side strip sign faces 11 and the freeze sign faces 12. For example, the letters of "caution to freeze", "cation to slip" and "frozen road" can be represented, and under the opposite condition, the letters of "caution to travel" can be represented, as in the reference example showing the indications of the letters in Fig.4. In other words, according to the present invention, the recurrent reflection indications on the side strip sign faces 11 and the freeze sign faces 12 are not limited to the coloration of the recurrent reflection faces, and letters may be formed, or the shape of the recurrent reflection faces may be figures meaning the freeze.

[0046] Further, in the present embodiment, the switching-type indicating means 10 is assembled to the back lid 9 constituting the housing 4 through the lower attaching member 20 and the upper attaching member 60, leading to an improved assemblability. However, according to the present invention, the switching-type indicating means 10 may be assembled to the case body 8 constituting the housing 4. Particularly, the switching-type indicating means 10 are disposed with the temperature-responsively operated drive mechanism 29 and the upper and lower attaching members 60 and 20 assembled to the flat plate-shaped back lid 9 constituting the housing 4 and hence, the assemblability is improved, and the confirmation of the characteristic after the assembling and the like can be easily carried out.

[0047] The temperature-responsively operated drive mechanism 29 is not adapted to detect a temperature equal to or lower than 0°C, but in the freeze-indicating sign system 1 placed at a location 0.8 to 1m above a road surface, a good freezing- temperature detecting effect was obtained by setting a temperature slightly higher than the freezing temperature of the ground surface from the relationship between a difference in temperature between a temperature-detecting point on the freeze-indicating sign system 1 and the ground surface. However, the temperature may be set at 0°C or lower than 0°C, depending on the surroundings of placement of the system such as the traffic volume, the region such as the mountainous region, the type of a road surface, the time lag and the like. The shape memory alloy having a hysteresis temperature in a range of 3 to 4°C, i.e., capable of being restored at 4 to 5°C was used. When a road surface is once frozen, even if the temperature of the outside air is raised, the temperature of the road surface is not raised immediately, and there is a time lag for the raising of the temperature. However, this can be corrected by the hysteresis temperature. For example, it is desirable that the hysteresis temperature is used in correspondence to the raising of temperature of the road surface frozen and defrozen at night and the temperature of the outside air before noon. The temperature-responsively operated drive means may be disposed at any portion of the housing 8 and preferably, can be disposed at any of a lower portion, a side portion, a back portion and an upper portion capable of detecting the temperature of the outside air with less time lag.

[0048] According to the present invention, the recurrent reflection face can be formed in the form of a small sphere, a prism face and the like, and the coloration of reflected light can be achieved by the coloration of the reflection faces, or by forming the transparent member as a colored transparent member. The recurrent reflection in the present embodiment is on the assumption that the angle of incidence of light and the angle of reflection of light are parallel to each other, as in a transparent sphere. According to the present invention, however, the recurrent reflection does not mean a recurrent reflection in a narrow sense, and it is obvious that any member may be used in which the angle of incidence of light and the angle of reflection of light are parallel to each other, as in a mirror surface. In addition, it is not required the angle of incidence of light and the angle of reflection of light are exactly parallel to each other and hence, basically, the present invention embraces a case where most of incident light is reflected as reflected light.

[0049] The switching-type indicating means 10 in the present embodiment comprises the side strip sign faces

11 adapted to provide the indication when the temperature is raised to exceed the first preset temperature, and the freeze sign faces 12 adapted to provide the indication when the temperature is dropped to lower than the second preset temperature lower than the first preset temperature, but such disposition may be reversed, as described above. The type of the disposition is determined by setting the second preset temperature and the hysteresis temperature and hence, according to the present invention, the side strip sign faces 11 adapted to provide the indication at a temperature equal to or higher than the first preset temperature can be first recurrent reflection faces, and the freeze sign faces 12 adapted to provide the indication at a temperature lower than the second preset temperature can be second recurrent reflection faces.

[0050] In the above-described embodiment, in the temperature-responsively operated drive mechanism 29 constructed by the compressed springs 35 and 36 made of the shape memory alloy and capable of providing the turning/displacing drive force depending on the temperature such as the second present temperature, the movable member 40 having the racks 41 meshed with the pinions 14b of the switching-type indicating means 10, the drive force assisting means 50 and the like, the expansion and contraction of the compressed springs 35 and 36 are carried out by meshing the pinions 14b of the switching-type indicating means 10 with the racks 41 of the movable member 40. In the temperature-responsively operated drive mechanism 29 according to the present invention, however, the compressed springs 35 and 36 may be made of a shape memory alloy capable of providing a turning/displacing drive force depending on the temperature such as the second preset temperature, and a predetermined torque may be provided directly by the shape memory alloy formed into a volute-coiled or spirally-coiled shape or of a leaf spring-shape. Either of the coiled shape and the leaf spring-shape can be selected depending on the temperature characteristic and the responsiveness. When the predetermined torque is provided by the shape memory alloy formed into a volute-coiled or spirally-coiled shape, the number of parts is smaller, which is advantageous. Of course, the shape memory alloy may be used as a heat-responsively operated means such as a shape memory plastic, a bimetal and the like. The compressed springs 30 and 31 may be omitted, and only the compressed springs 35 and 36 made of the shape memory alloy may be provided. However, if the shape memory alloy is used as in the above-described embodiment, the switching of the contents of the indication can be conducted rapidly at a temperature near the freezing temperature of a road.

[0051] In the upper attaching member 60 in the above-described embodiment, the upper support section comprising the upper end shaft 13a, the metal bearing 62 and the slide ring 63 for supporting the upper end of the switching-type indicating means 10 rotatably is disposed at the upper portion of the housing 4, but a ball bearing with balls rolled on opposite sides of the slide ring 63 may be used. Namely, the upper support section may be any means adapted to resist the load of the switching-type indicating means 10 by the surface contact with the upper attaching member 60 and to support the switching-type indicating means 10.

[0052] The lower attaching member 20 in the above-described embodiment, the lower support section comprising the lower end shaft 14a, the projection 21 and the sleeve 23 and adapted to support the lower end of the switching-type indicating means 10 and to obtain a rotating force from the temperature-responsively operated drive mechanism 29 is disposed at the lower portion of the housing 4. According to the present invention, however, the lower attaching member 20 may have a structure in which the lower end of the switching-type indicating means 10 is restrained so that it is not moved perpendicularly to the lengthwise direction thereof, and the rotating force is obtained from the temperature-responsively operated drive mechanism 29.

[0053] The embodiment has been described about the case where the four switching-type indicating means 10 have been mounted, wherein the four switching-type indicating means 10 are turned by the two compressed springs 30 and 31 and the two compressed springs 35 and 36 made of the shape memory alloy on the lower attaching member 20. More specifically, by only ensuring that the two switching-type indicating means 10 are turned by a pair of the compressed spring 30 and the compressed spring 35 made of the shape memory alloy, the back lid 9 is elongated laterally, the lengths of the upper and lower attaching members 60 and 20 and the length of the movable member 40 are set at required values, the freeze-indicating sign system can be increased in size by increasing the number of the compressed springs 30 and 31 and the compressed springs 35 and 36 made of the shape memory alloy, i.e., the number of pairs of these compressed springs without changing of the types of the compressed springs. Therefore, the temperature characteristic cannot be varied by the increase in size. Even in this case, the switching-type indicating means 10 are disposed with the temperature-responsively operated drive mechanism 29 and the upper and lower attaching member 60 and 20 assembled to the flat plate-shaped back lid 9 constituting the housing 4 and hence, the assemblability is improved, and the confirmation of the characteristic after the assembling and the fine regulation of the resilient strengths of the compressed springs 30 and 31 and the compressed springs 35 and 36 made of the shape memory alloy can be carried out easily. Particularly, when the freeze-indicating sign system is large-sized to indicate letters or the like, all the switching-type indicating means 10 are operated in operative association with one another and hence, the outside appearance of the entire system is improved, because. In addition, the switching of the side strip sign faces 11 and the switching of the

freeze sign faces 12 are conducted simultaneously and hence, the outside appearance during such operation is also improved. Of course, the switching of and the indication on the side strip sign faces 11 and the switching of and the indication on the freeze sign faces 12 can be conducted for every single letter and every group of letters, using a plurality of freeze-indicating sign systems having a predetermined length.

[0054] Even if the lengthwise length of the switching-type indicating means 10 is set at any value, as described above, the variation in load of the switching-type indicating means 10 does not change the rotational friction resistance directly. Therefore, the lengthwise length can be set at any value, and consequently, the enlargement of a two-dimensional plane can be achieved. Of course, the enlargement of a two-dimensional plane can be achieved even by disposing the switching-type indicating means 10 in a required number of rows such as two or three rows.

[0055] When the caution to freeze is represented by the indication of letters or characters or by the indication of red color, the movable member 40 can be divided into pair units of the compressed springs 30 and the compressed springs 35 made of the shape memory alloy, and the temperature characteristics and the hysteresis characteristics of the adjacent compressed springs 35 made of the shape memory alloy can be changed, whereby the switching of the side strip sign faces 11 and the switching of the freeze sign faces 12 can be conducted sequentially in a predetermined direction. Namely, the direction for conduction the switching sequentially can be specified. Of course, even when the freeze-indicating sign system is divided for every letter, the switching of the side strip sign faces 11 and the switching of the freeze sign faces 12 can be conducted sequentially in a predetermined direction by changing the temperature characteristics and the hysteresis characteristics of the adjacent compressed springs 35 made of the shape memory alloy.

[0056] In the above-described embodiment, the switching-type indicating means 10 turnably mounted to the housing 4 is capable of being turned through 120 degree, but according to the present invention, the angle of turning of the switching-type indicating means 10 is not limited to 120 degree. For example, each of the switching-type indicating means 10 mounted to the housing 4 for turning movement through 120 degree is substantially triangular in shape, and even if the distance between the adjacent switching-type indicating means 10 is reduced, an interference with other switching-type indicating means 10 is not arisen. In addition, the variate of the shape memory alloy can be reduced, and when a large variate can be taken, the reliability can be enhanced correspondingly.

[0057] In the switching-type indicating means 10 in the above-described embodiment, the side strip sign faces 11 adapted to provide the indication at the temperature equal to or higher than the first preset temperature are first recurrent reflection faces, and the freeze sign faces 12 adapted to provide the indication at the temperature lower than the second preset temperature are second recurrent reflection faces. According to the present invention, however, when the indicating faces are larger, it is suitable that the second recurrent reflection faces can be maintained as the freeze sign faces 12, the indication of freeze and the indication of information other than freeze can be distinguished from each other by describing various information such as a road situation other than the freeze, a geographical guidance, a local information, a commercial information and the like on the side strip sign faces 11 adapted to provide the indication at the temperature equal to or higher than the first preset temperature. If one or more letters, figures or characters creating the caution to freeze are provided on the second recurrent reflection face comprising the freeze sign face 12, so that words representing the caution to freeze are indicated by the letters, figures or characters on the adjacent indicating plates, the number of letters to be indicated is not increased and hence, it is not necessary to increase the size of the freeze-indicating sign system.

[0058] In the freeze-indicating sign system in the above-described embodiment, the switching-type indicating means 10 are hung vertically from the upper support section of the upper attaching member 60, but even if the switching-type indicating means 10 are supported horizontally, the burden of the load taken by the bearings on the opposite sides can be reduced to half, and an stable operation can be expected.

[0059] Therefore, In such an embodiment, the switching-type indicating mans 10 may be disposed between the side attaching members and hence, first recurrent reflection faces and second recurrent reflection faces comprising side strip sign faces 11 having any length can be formed by increasing the number of the switching-type indicating mans 10 disposed in the longitudinal direction. The weight of the switching-type indicating mans 10 is supported at its opposite ends and hence, the load is reduced to half. Even if the length of the switching-type indicating mans 10 is increased, the switching-type indicating mans 10 can be turned in such a manner that the contact frictional resistance is not influenced largely by the length, and the wearing at horizontally supported points can be reduced, and hence, the lengthwise dimension of the switching-type indicating mans 10 can be increased. Therefore, it is possible to accommodate a two-dimensional increase in size without an increase in amount of temperature-responsively operated drive mechanism displaced, i.e., an increase in energy for driving the compressed spring 35 made of the shape memory alloy, which forms the pair with the compressed spring 30.

[0060] Although the embodiments of the present invention have been described in detail, it will be understood that the present invention is not limited to the above-described embodiments, and various modifica-

tions in design may be made without departing from the spirit and scope of the invention defined in claims.

Claims

1. A temperature-responsively operated drive mechanism designed to provide a switching drive force to switching-type indicating means placed on a freeze-indicating sign system, comprising

   a member made of a shape memory alloy for providing the switching drive force to said switching-type indicating means in accordance with a temperature such as a predetermined temperature, and

   a drive force assisting means for providing an assist force for assisting in the switching drive force during switching operation of said member made of the shape memory alloy.

2. A temperature-responsively operated drive mechanism according to claim 1, wherein said drive force assisting means comprises a permanent magnet and a ferromagnetic member disposed between a movable member in said switching-type indicating means and a stationary member of said freeze-indicating sign system for providing a magnetic force.

Fig. 1

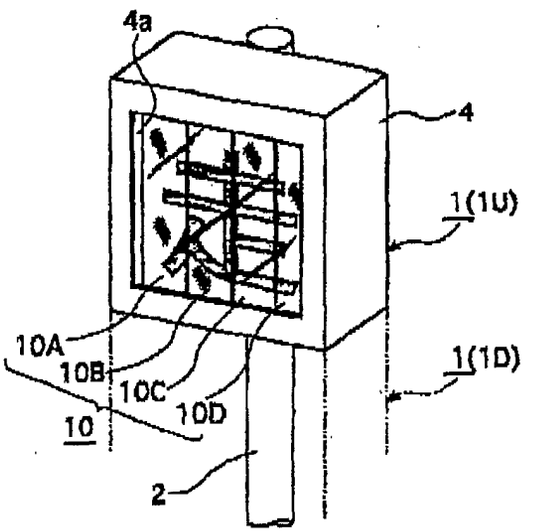


Fig. 2

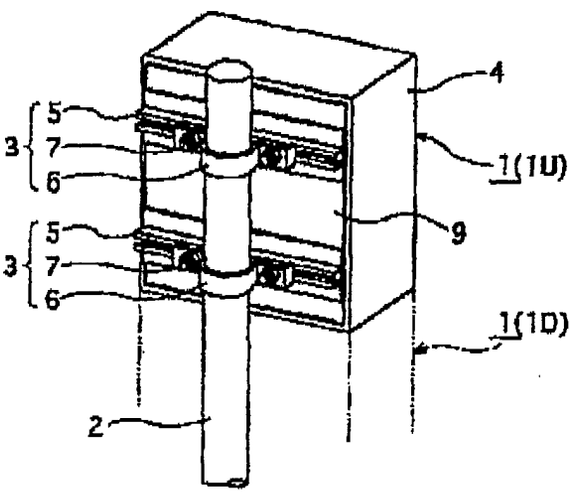


Fig. 3

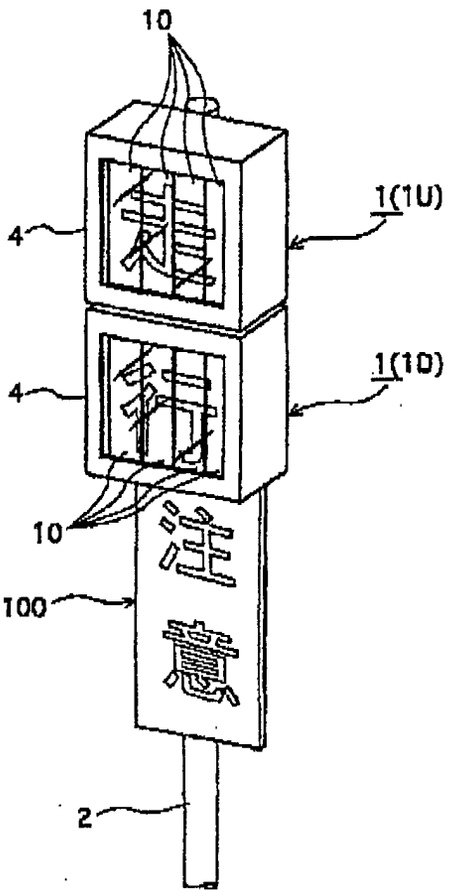


Fig. 4

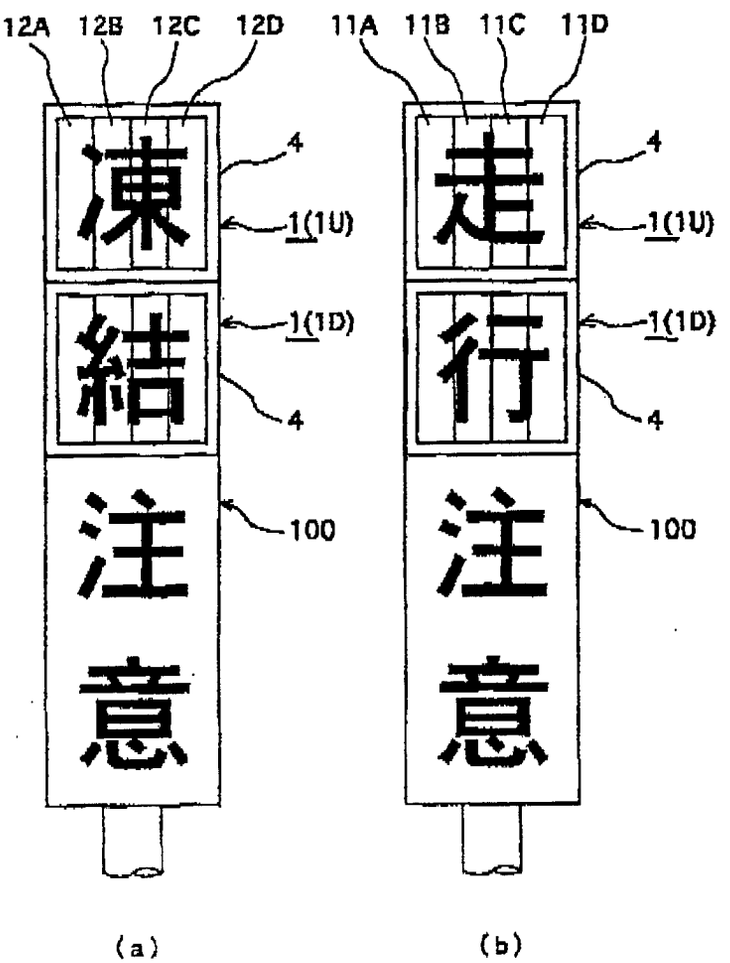

12A
12B
12C
12D
凍
結
注
意
4
1(1U)
1(1D)
4
100
(a)
11A
11B
11C
11D
走
行
注
意
4
1(1U)
1(1D)
4
100
(b)

Fig. 5

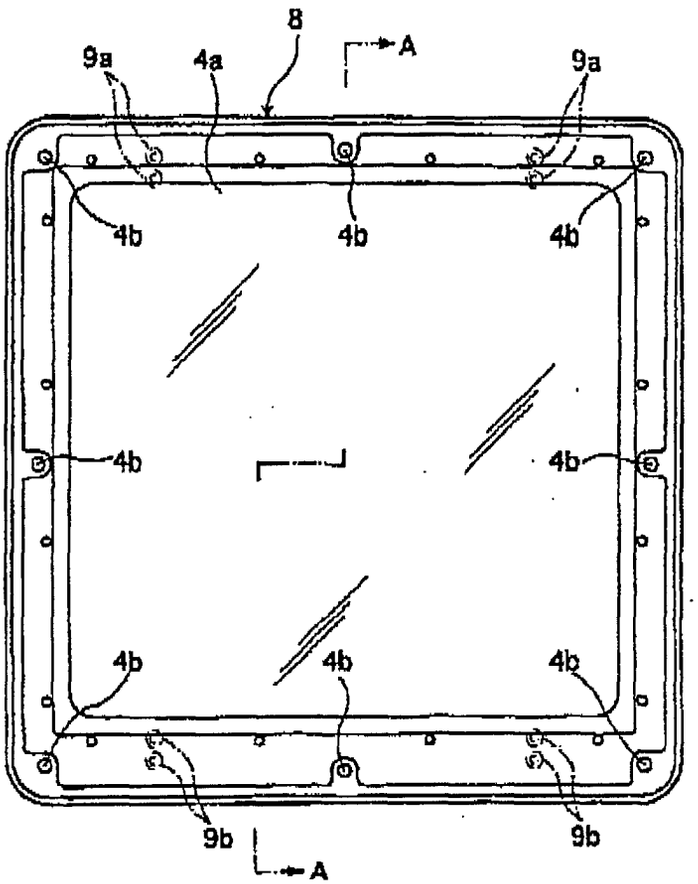


Fig. 6

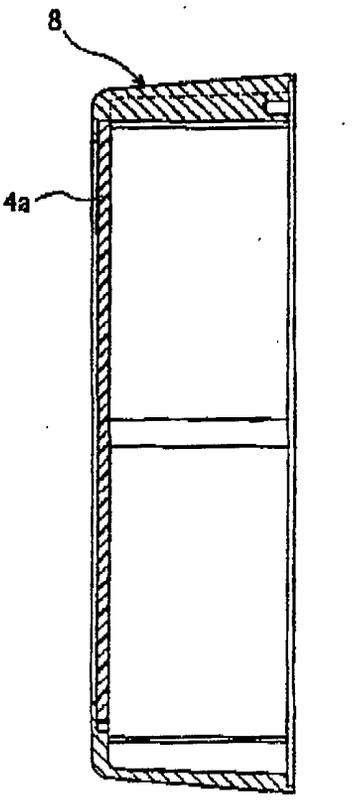
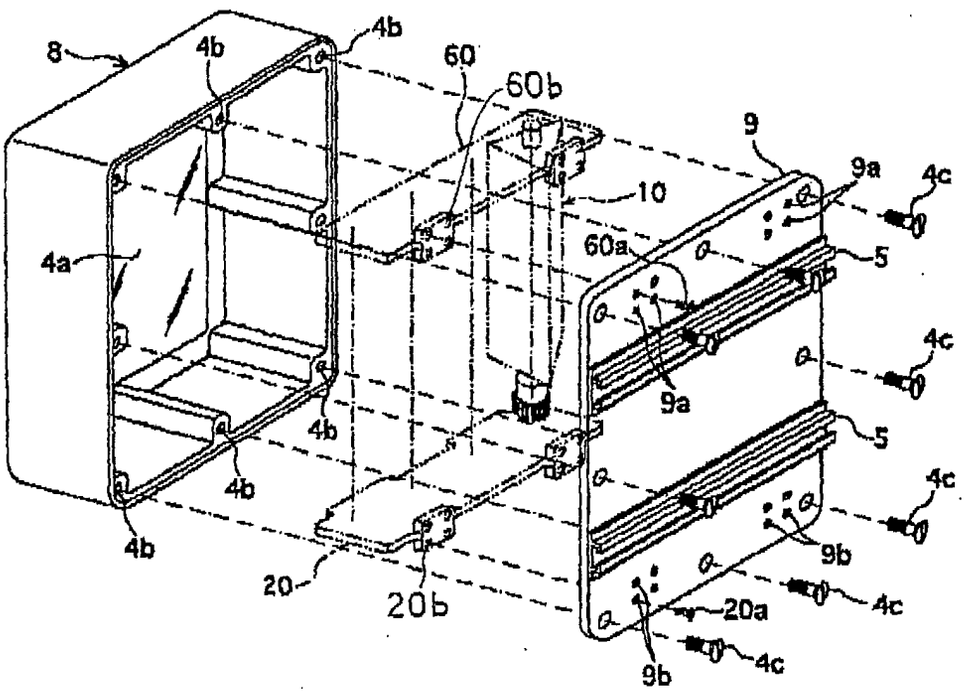


Fig. 7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60b
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9a
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60a
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20
20b
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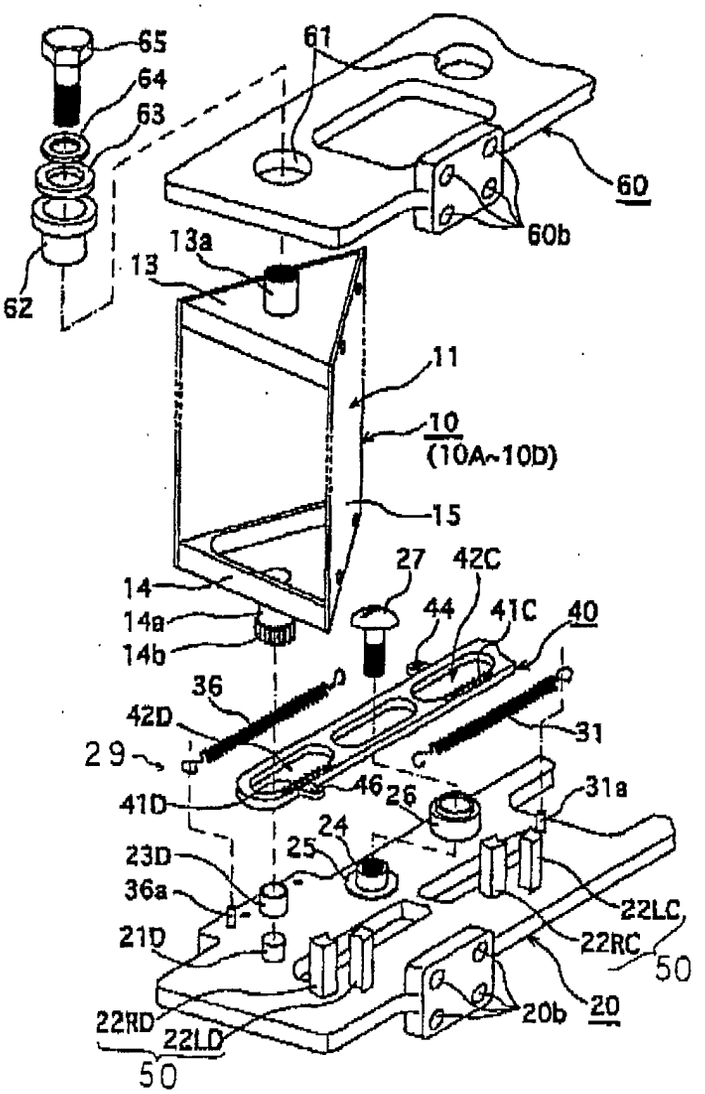
9b
4c

Fig. 8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14b
27
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44
41C
40
36
42D
29
31
46
26
31a
41D
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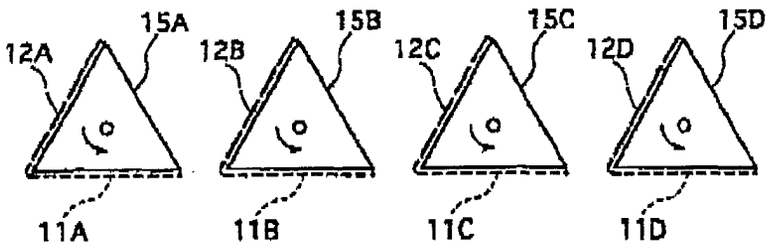
50
21D
22RD
22LD
50
20b
20

Fig. 9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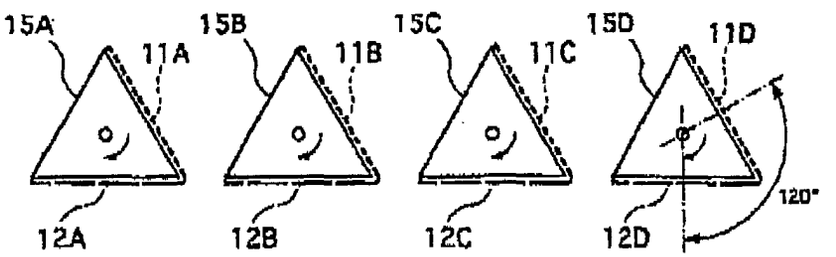
11A
11B
11C
11D

(a)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11B
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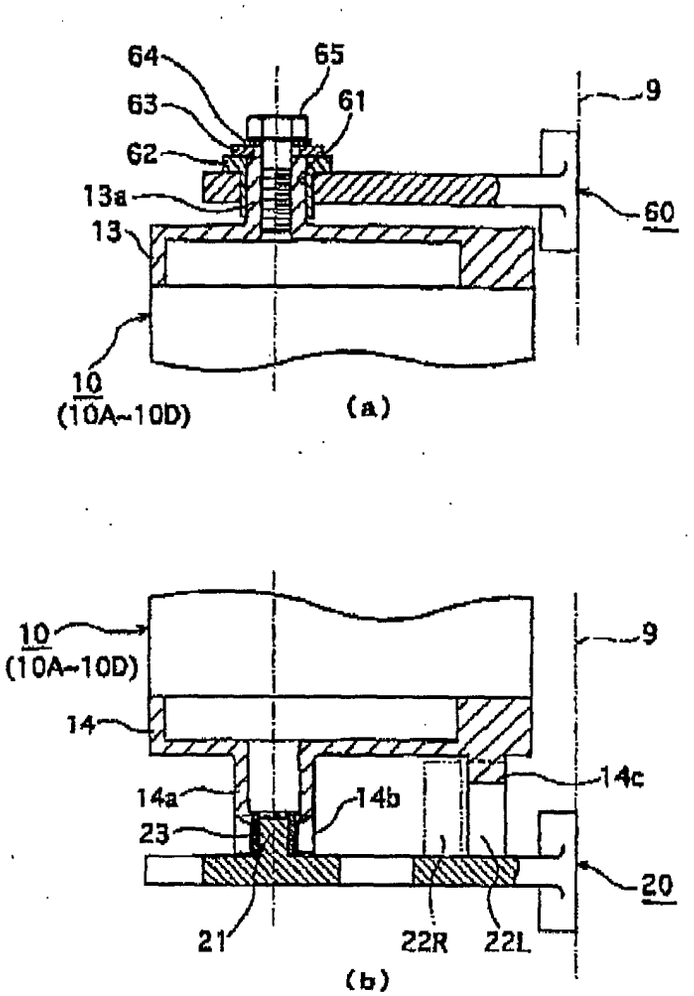
11D
12A
12B
12C
12D
120°

(b)

Fig. 10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(a)
10
(10A~10D)
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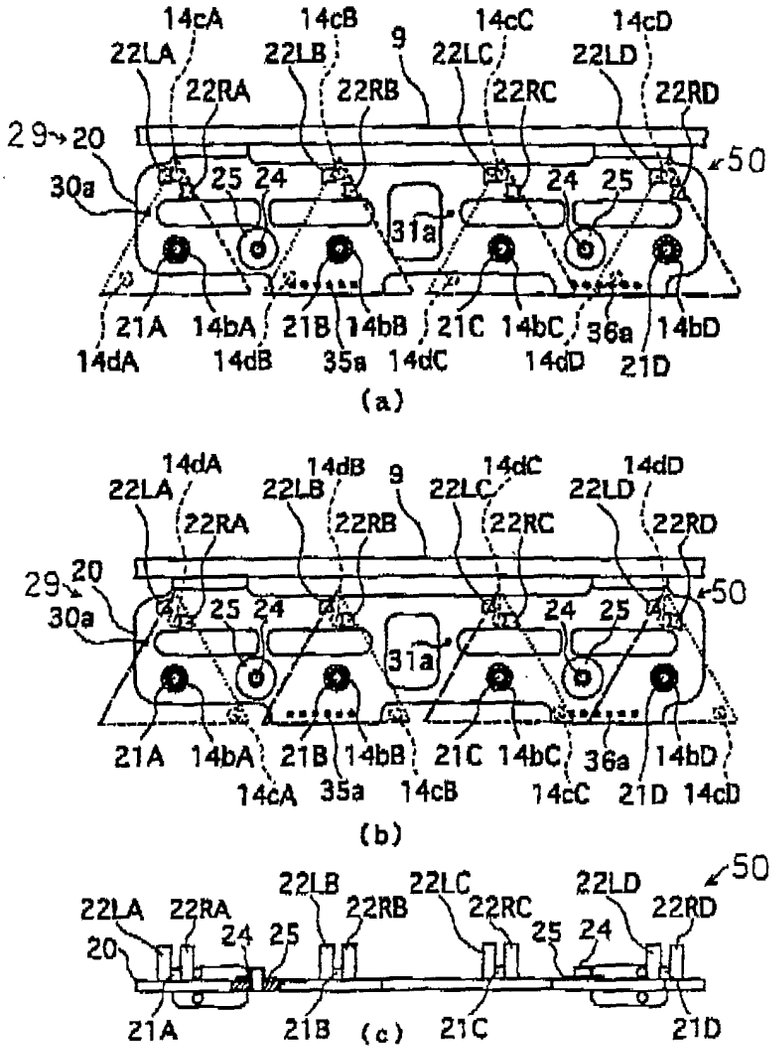
14b
23
20
21
22R
22L
(b)

Fig. 11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30a
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24
24
25
31a
21A
14bA
21B
14bB
21C
14bC
36a
14bD
14dA
14dB
35a
14dC
14dD
21D
(a)
14dA
14dB
14dC
14dD
22LA
22LB
9
22LC
22LD
22RA
22RB
22RC
22RD
29
20
50
30a
25
24
24
25
31a
21A
14bA
21B
14bB
21C
14bC
36a
14bD
14cA
35a
14cB
14cC
21D
14cD
(b)
50
22LB
22LC
22LD
22LA
22RA
22RB
22RC
22RD
20
24
25
25
24
21A
21B
(c)
21C
21D

Fig. 12

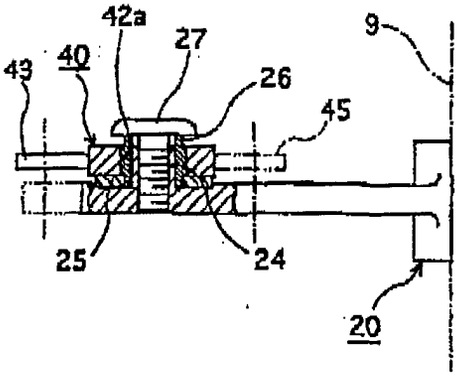
42a
27
9
43
40
26
45
25
24
20

Fig. 13

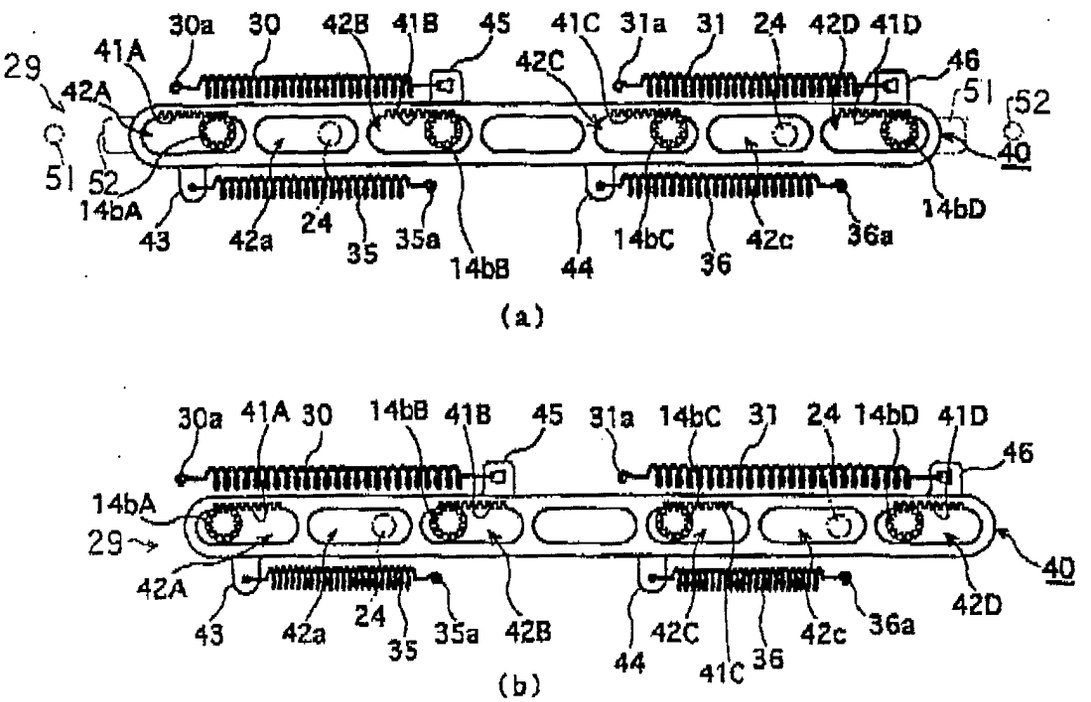
30a
30
42B
41B
45
41C
31a
31
24
42D
41D
46
29
41A
42A
42C
51
52
40
14bA
43
42a
24
35
35a
14bB
44
14bC
36
42c
36a
14bD
(a)
30a
41A
30
14bB
41B
45
31a
14bC
31
24
14bD
41D
46
14bA
29
42A
40
43
42a
24
35
35a
42B
42C
44
41C
36
42c
36a
42D
(b)

Fig. 14

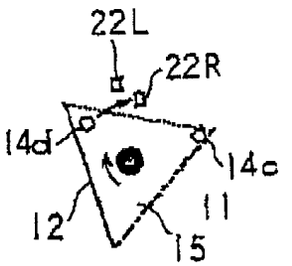

Fig. 15