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(71) Applicant: **Nagamine, Kenzo**
Yokohama City, Kanagawa Prefecture (JP)

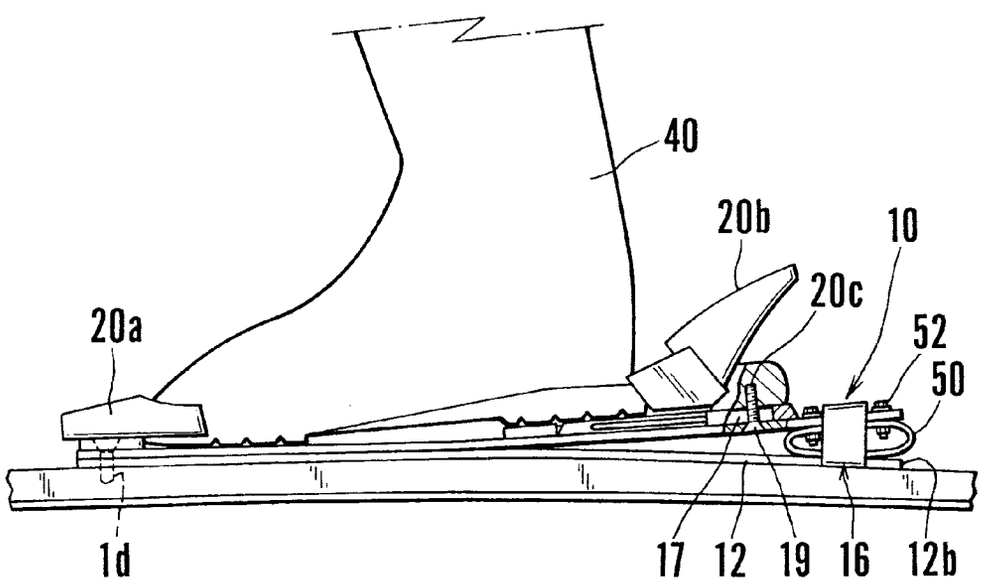
(72) Inventor: **Nagamine, Kenzo**
Yokohama City, Kanagawa Prefecture (JP)

(74) Representative: **Piésold, Alexander J.**
Frank B. Dehn & Co.,
European Patent Attorneys,
179 Queen Victoria Street
London EC4V 4EL (GB)

(54) Auxiliary apparatus for a ski

(57) The invention provides auxiliary apparatus (10) for a snow ski which comprises a V-shaped elastic body having a first spring (12) and a second elastic plate spring (14), a restraining member (16) and an elastic ring (50), said first elastic plate spring (12) being integrally provided on a ski plate (1), a rear free end portion (14b) of said second elastic plate spring (14) being vertically movable, said restraining member (16) being integrally fixed on said ski plate (1) at a rear end portion (12b) of said first elastic plate (12), said elastic ring (50) being integrally provided under said second elastic plate spring (14) to locate between said first and second plate springs and also in said restraining member (16), and an elastic sheet (58) being integrally mounted on an upper surface of the upper plate spring (14) to locate between the screw openings (14e), (14e) whereby vertical lift can be generated between an upper ski surface and a ski boot (40) in order to obtain greater control and stability for a skier running on an uneven snow surface.

FIG. 1



EP 0 914 846 A2

Description

[0001] This invention relates to improvements to an auxiliary apparatus for a ski of the European Patent Application No. 97305127.9 filed on 7 November 1997.

[0002] It has been necessary for many skiers, even including some who are relatively experienced, to bend their knees softly to absorb shock and vibration from the vibration from the uneven snow surfaces and also to decrease resistance between their ski plates and the snow surface.

[0003] A skier usually skis on the snow surface with a slouch. A ski boot is originally locked between a toe binding and a heel binding so as to maintain a safe posture of the skier and to determine a correct direction of the skiing.

[0004] As shown in FIGS. 9 and 10, a skier whose knees are rather stiff cannot bend his knees softly (an angle θ_1 of the skier's knee shown in FIG. 9 is equal to an angle θ_2 of that shown in FIG. 10).

[0005] The bottom surface of the ski plate 1 has been waxed to improve its gliding surface and to decrease resistance between the ski plate 1 and the snow surface.

[0006] On the other hand, as shown in FIGS. 11 and 12, another skier having soft knees can bend his knees to absorb shock and vibration delivered from the uneven snow surfaces. The angle θ_4 of the skier's knee shown in FIG. 12 is smaller that the angle θ_3 of that shown in FIG. 11)

[0007] When a skier tries to absorb vibration and shock from the snow surfaces by bending his knees by himself, there is a difficult problem that he cannot maintain the slouch for long hours due to his muscular and physical strength.

[0008] There has been another problem that many skiers, even including beginners or some who are relatively experienced, can neither glide on an uneven steep slope smoothly and at full speed, nor enjoy smooth skiing.

[0009] It is known that a running ski plate is usually subject to a composite vibration which includes a vertical curve vibration shown by a broken line (A) in FIG. 18 and a torsional vibration shown by a broken line (B) in FIG. 19.

[0010] In order to control the composite vibration acting on the running ski, it has been proposed to provide a vibration absorber in or at the front or mid portion of the ski plate 1.

[0011] A conventional vibration absorber for a snow ski can control or absorb the composite vibration of the ski 1 itself, but it cannot control the vibration acting on a skier's feet.

[0012] Accordingly, it has been proposed to use a device having a vibration absorber and a heart-wood element for absorbing shock and vibration caused by uneven snow surfaces (see the Japanese Utility Model Publication No. 23318/1994).

[0013] In accordance with the conventional vibration absorber shown in FIGS. 15-17 however, a longitudinal cavity 7 is formed in a central heart-wood plate 2 to locate at a ski boot 40, a vibration absorbing material 8 having a thin layer and an independent heart-wood element 9 having a shape corresponding to the cavity 7 is inserted into the cavity 7, and is integrally sandwiched between a top ski plate 4 and the central heart-wood plate 2 so that the thickness of the ski 1 inevitably becomes larger, thus making it difficult to generate a sufficient lift for the ski boots and also to maintain the strength of the ski plate. The heel binding 20b is firmly fixed on the ski.

[0014] One of the biggest disadvantages of the conventional device is that due to the increased thickness, the ski plate cannot achieve independent flexibility of the various parts of the ski itself.

[0015] According to one aspect of the present invention, there is provided an auxiliary apparatus which comprises: a V-shaped elastic body having a lower elastic plate and an upper elastic plate, an auxiliary elastic ring, and a restraining member, said lower elastic plate being integrally provided on the ski plate, a rear free end portion of said upper elastic plate being vertically movable, said auxiliary elastic ring being provided (e.g. integrally) under the upper elastic plate to locate between the rear end portions of the lower and upper elastic plates, and said restraining member being integrally fixed on the ski plate to locate at a rear end portion of said lower elastic plate whereby vertical lift can be generated between an upper ski surface and a ski boot in order to obtain greater control and stability for a skier running on the uneven snow surfaces.

[0016] From a further aspect, the invention provides an auxiliary apparatus for a snow ski which comprises a U-shaped elastic body having a first elastic plate spring and a second elastic plate spring, a restraining member, and an elastic ring said first elastic plate spring being integrally provided on a ski plate, a rear free end portion of said second elastic plate spring being vertically movable and said restraining member being integrally fixed on said ski plate to locate at a rear end portion of said first elastic plate spring, and said elastic ring being provided (e.g. integrally) underneath a lower surface of said second plate spring to locate within said restraining member whereby vertical lift can be generated between an upper ski surface and a ski boot in order to obtain greater control and stability for a skier running on an uneven snow surface.

[0017] From a yet further aspect, the invention provides an auxiliary apparatus for a ski, comprising a lower longitudinal portion for attachment to a ski, an upper longitudinal portion, and a spring located between the upper and lower portions, said spring resiliently upwardly biasing the rear part of the upper longitudinal portion from the rear part of the lower longitudinal portion so that the rear parts of the upper and lower portions are spaced from one another, whereby in use the spacing is reducible against the resilient bias of the spring in re-

sponse to an upward force exerted on the ski.

[0018] At least in its preferred embodiments, the invention provides an auxiliary apparatus which can be secured on the conventional ski plate without troublesome improvement therefor.

[0019] Preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a partial side elevation, partly in section showing a ski plate and a first embodiment of an auxiliary apparatus provided on the ski plate;
FIG. 2 is a partial side elevation, partly in section of another embodiment of the auxiliary apparatus shown in FIG. 1;
FIG. 3 is a perspective view of the exploded parts of the auxiliary apparatus shown in FIG. 2;
FIG. 4 is a side elevation of a V-shaped elastic body of the auxiliary apparatus taken out from the embodiments shown in FIG. 2;
FIG. 5 is a partial side elevation, partly in section, of still another embodiment of the auxiliary apparatus shown in FIGS. 1-4;
FIG. 6 is a side elevation of another embodiment of the elastic body shown in FIG. 5;
FIG. 7 is an enlarged partial vertical sectional view of another elastic body provided between the rear end portions of the lower and upper elastic plates;
FIG. 8 is an enlarged partial perspective view of the elastic body shown in FIG. 7 and a restraining member;
FIG. 9 is a schematic illustration showing a skier running on a flat snow surface;
FIG. 10 is a schematic illustration showing a skier running on an uneven snow surface, with stiff knees not being sufficiently bent;
FIG. 11 is a schematic illustration showing a skier running on a flat snow surface, with his sufficiently soft knees;
FIG. 12 is a schematic illustration showing a skier having sufficiently soft knees and running on an uneven snow surface;
FIG. 13 is a schematic illustration showing a skier running on a flat snow surface with the auxiliary apparatus of this invention;
FIG. 14 is a schematic illustration showing a skier running on an uneven snow surface, with his knees not being sufficiently bent, and with the auxiliary apparatus of this invention;
FIG. 15 is a schematic illustration showing a conventional ski having a shock absorbing device;
FIG. 16 is an exploded schematic illustration showing the conventional ski having the shock absorbing device shown in FIG. 15;
FIG. 17 is a schematic sectional view of the shock absorbing device shown in FIGS. 15 and 16;
FIG. 18 is a schematic illustration showing the vertical vibration of a ski; and
FIG. 19 is a schematic illustration showing the torsional vibration of a ski.

[0020] Referring to the accompanying drawings, in which like reference numerals designate like parts throughout the several views thereof, there is shown in FIG. 1 a first embodiment of an auxiliary apparatus 10 provided on the ski plate 1.

[0021] The V-shaped elastic auxiliary apparatus 10 comprises a pair of lower and upper plate springs 12 and 14, the front portions 12a and 14a of which are integrally secured to each other, and a restraining member 16 provided on the ski plate 1 to locate at a ski boot 40 in such a way that narrowed rear end portions 12c and 14c are freely enclosed within the restraining member 16 to allow easy vertical oscillations of the lower and upper plate springs 12 and 14.

[0022] It should be understood that the lower plate spring 12 is slightly movable in a longitudinal direction along the ski plate 1.

[0023] As shown in FIG. 6, the angle between the lower and upper plate springs 12 and 14 becomes progressively wider toward the rear of the plate springs.

[0024] In FIGS. 3-4 showing the second auxiliary apparatus of this invention, an insert 18 is sandwiched integrally into between the top end portions 12a and 14a of the lower and upper plate springs 12 and 14.

[0025] As shown in these drawings, both side portions of the lower and upper plate springs 12 and 14 are restricted so as to form narrowed portions 12c and 14c so that the rear end portions 12b and 14b can be freely inserted into the restraining member 16.

[0026] In another embodiment of this invention, an elastic auxiliary apparatus 10 having a lower plate spring 12 and an upper plate spring 14 is secured to the ski plate 1 and positioned so as to extend between a toe binding 20a and a heel binding 20b so that a bottom surface near the heel binding 20b can be pushed upwardly to absorb the shock and vibration acting on a skier's feet from the snow surface.

[0027] At the same time, resistance between the ski plate 1 and the snow surface can be decreased in order that a skier having rather stiff knees can ski on uneven snow surfaces with greater stability and at full speed.

[0028] The lower plate spring 12 is mounted on the upper surface of the ski plate 1 to locate the V shaped front portion of the elastic auxiliary apparatus 10 at the toe binding 20a so that the bottom surface near the heel of the ski boot 40 is pushed upwardly, and the upper plate spring 14 is made to produce elasticity in order to flex the ski plate 1 toward the snow surface.

[0029] More particularly, as shown in FIG. 7, the lower plate spring 12 is mounted on the ski plate at the toe binding 20a, and an auxiliary elastic ring 50 is integrally provided under the upper plate 14 to locate between the rear end portions of the lower and upper plate springs 12 and 14.

[0030] As explained in the foregoing paragraphs, the

elastic auxiliary apparatus 10 comprises a pair of lower and upper plate springs 12 and 14, their front end portions 12a and 14a being integrally combined with each other so as to produce elasticity making the other free end portions 12b and 14b flex relative to one another so as to separate them from each other. The auxiliary elastic ring will also act to resiliently bias the free end portions 12b and 14b away from one another.

[0031] The V-shaped elastic auxiliary apparatus 10 comprises a restraining member 16 which is mounted on the ski plate 1. The combined front portions 12a and 14a are secured on the ski plate 1 to locate at the toe binding 20a, and the restraining member 16 is provided on the ski plate 1 to be positioned at the heel binding 20b so that the narrowed rear end portion 12c of the lower plate is freely inserted into the restraining member 16 to allow longitudinal movement of the lower plate spring 12 relative to the ski.

[0032] In addition, the upper plate spring 14 is vertically restrained by the restraining member.

[0033] It should be appreciated that the rear end portions 12b and 14b of the V-shaped elastic auxiliary apparatus 10 are bent outwardly, thus being separated from each other. The width of each of the lower and upper plate springs 12 and 14 is almost the same as that of the ski plate 1, and these plate springs have a sufficient rigidity to withstand torsion.

[0034] In FIG. 3, the binding 20 has a toe binding 20a and a heel binding 20b, four screw openings 14d are provided on the upper plate spring 14 to locate at the position of the toe binding 20a, four screw openings 18d are provided on an insert 18 at the corresponding positions 14d, and also four screw openings 12d are provided on the lower plate spring 12 at the position of the toe binding 20a.

[0035] In addition, a ski stopper 22 is provided on the heel binding 20b in a manner that the ski stopper 22 can rotate so as to direct its lower end portions 22a downwardly.

[0036] With the auxiliary elastic ring 50 provided between the lower and upper plate springs 12 and 14 on the ski plate 1, the position for securing the binding 20 is slightly higher than if no elastic ring were provided, but the ski 1 of the invention is designed in such a way that the lower end portions 22a of the ski stopper 22 can extend downwardly sufficiently to locate below a lower surface of the ski plate 1 when the ski plate 1 is disengaged accidentally from the ski boot 40, thus enabling to stop the ski plate 1 on the snow surface.

[0037] As shown in FIGS. 1, 2, 5 and 7, the upper plate spring 14 gives a force of bending the ski plate 1 upwardly at the front portion 14a of the upper plate spring 14 and when making contact with the restraining member 16 which acts as a fulcrum.

[0038] On the other hand, the lower plate spring 12 gives a force of bending the ski plate 1 downwardly at the front portion 12a of the lower plate spring 12 and with the rear portion 12b acting as a fulcrum.

[0039] In consequence, the action of the upper plate spring 14 bending the ski plate 1 upwardly is cancelled by the action of the lower plate spring 12 bending the ski plate 1 downwardly so that an originally designed bowed curvature of the ski plate 1 may be maintained without deteriorating the elasticity of the ski plate 1.

[0040] Even when a skier's weight acts on the auxiliary apparatus 10, the ski plate 1 is not deformed downwardly. When shock and vibration act on the ski plate 1 due to the snow surface, in addition to the skier's weight, the space between the lower and upper plate springs 12 and 14 is narrowed to absorb the shock and vibration.

[0041] As shown in FIGS. 1, 2, 3, 5 and 8, a ceiling of the upper transverse portion 16b of the restraining member 16 is angled upwardly in the rear direction so that the rear end portion of the upper plate spring 14 may be moved without causing any trouble to the restraining member 16.

[0042] The width of the restraining member 16 is substantially the same as that of the upper surface of the ski plate 1.

[0043] In FIGS. 3, 7 and 8, the auxiliary elastic ring 50 provided between the rear end portions of the lower and upper plate springs 12 and 14 has a pair of openings 50a, 50a at an upper portion of the ring 50 to locate at both side portions which are slightly wider than the width of the upper transverse portion 16b of the restraining member 16.

[0044] A pair of screw openings 14e, 14e are longitudinally provided at a rear end portion of the upper plate spring 14 to locate at the corresponding portions of the openings 50a, 50a of the auxiliary elastic ring 50.

[0045] A flat elastic sheet such as rubber sheet 58 is integrally mounted on an upper surface of the upper plate spring 14 to locate between the screw openings 14e, 14e.

[0046] For mounting, an upper portion of the elastic ring 50 is made into contact with a lower surface of the upper plate spring 14 to locate the screw openings 50a, 50a at the screw openings 14e, 14e, and a pair of set screws 52, 52 are screwed into the screw openings 14e, 14e and 50a, 50a with a pair of washers 54, 54 and nuts 56, 56 so that the elastic ring 50 is integrally provided at the lower surface of the upper plate spring 14, thus locating the elastic ring 50 in the restraining member 16 and also between the lower and upper plate springs 12 and 14.

[0047] In this way, shock and vibration by the skier's knees is assisted by the elastic ring 50 of the auxiliary apparatus 10 so that the skier whose muscular and physical strength has declined can ski on the rough snow surface easily, smoothly and at high speed.

[0048] When the skier is skiing down the rough snow surface, the ski plate 1 itself moves up and down along the snow surface, but the shock and vibration are absorbed by the elastic ring 50 of the auxiliary apparatus so as to restrain an up-and-down motion of the skier's body.

[0049] In other words, kinetic energy is not consumed for the up and down motion of the skier's body, thus preventing decrease of the skiing speed instead.

[0050] This is due to the fact that only the front end portions 12a and 14a of the lower and upper plate springs 12 and 14 are secured on the ski plate 1, and the rear end portions 12b and 14b thereof are loosely located within the restraining member 16.

[0051] If both of the front end portions 12a and 14a and the rear end portions 12b and 14b were rigidly secured on the ski plate 1, the latter could not bend itself freely by the lower and upper plate springs 12 and 14, resulting in deteriorating elasticity of the ski plate 1.

[0052] It can be well understood that only the front portions 12a and 14a of the plate springs 12 and 14 described in the drawings are directly secured on the ski plate 1 and the rear end portions 12b and 14b are slidably inserted into the restraining member 16 so that the ski plate 1 can bend itself freely without losing elasticity of the plate springs 12 and 14.

[0053] Since the width of the upper plate spring 14 is substantially the same as that of the inner length of the restraining member 16, transverse vibrations of the upper plate spring 14 are restrained by the restraining member 16.

[0054] In addition, the width of both of the lower and upper plate springs 12 and 14 is substantially the same as that of the ski plate 1, and they are made of material having a high rigidity to torsion so that the lower and upper plate springs 12 and 14 are not twisted, thus enabling the skier to exhibit a desired excellent biting edge of the ski plate 1.

[0055] With reference to the third embodiment of this invention shown in FIGS. 5 and 6, the auxiliary apparatus 10 is a plate spring which is curved at a mid portion into a U-shaped front portion 12a (or 14a) to form a lower plate spring 12 and an upper plate spring 14. A plurality of screw springs 12d and 14d are provided in the straight portions of the lower and upper plate springs 12 and 14.

[0056] As in the former embodiments, both of the side portions 12c and 14c adjacent the rear end portions 12b and 14b of the lower and upper plate springs 12 and 14 are transversely restricted so that the narrowed portions 12c and 14c may be freely inserted into the restraining member 16 provided at a position of the heel binding 20b.

[0057] The screw bolts 19 are inserted through the screw openings 14d and screwed into the screw openings 12d and 14d in order to secure the lower plate springs 12 to the upper plate springs 14.

[0058] As shown in FIG. 5, a toe binding 20a is provided on the front portion of the upper plate spring 14, the lower plate spring 12 being integrally mounted on the upper surface of the ski plate 1.

[0059] The auxiliary elastic ring 50 is provided between the rear end portions of the lower and upper plate springs 12 and 14.

[0060] For mounting, an upper portion of the elastic ring 50 is made into contact with a lower surface of the upper plate spring 14 to locate the screw openings 50a, 50a at the screw openings 14e, 14e, and a pair of set screws 52, 52 are screwed into the screw openings 14e, 14e and 50a, 50a with a pair of washers 54, 54 and nuts 56, 56 so that the elastic ring 50 is integrally provided at the lower surface of the upper plate spring 14, thus locating the elastic ring 50 in the restraining member 16 and also between the lower and upper plate springs 12 and 14.

[0061] In accordance with the above embodiments, the shock and vibration acting on the bottom face of the ski boot 40 from the snow surface can be absorbed by the auxiliary apparatus 10 having an elastic ring 50 which is mounted between the ski surface and the ski boot 40, extending assistance in the absorption of the shock and vibration by the soft knees of the skier and also to decrease the burden on the skier.

[0062] As a result, a decline in muscular power of the skier and the consumption of the physical strength of the skier can be decreased, resulting in maintaining safe, smooth and high speed skiing for long hours.

[0063] It is shown in FIG. 13 that the skier equipped with the auxiliary apparatus 10 is skiing on the flat snow surface, while it is shown in FIG. 14 that he is skiing on the rough or uneven snow surface.

[0064] In accordance with the auxiliary apparatus 10 having the elastic ring 50 of this invention, an unexpected sudden shock given to a skier can be safely controlled irrespective of his skill of skiing.

[0065] It can be well understood that the skier equipped with the auxiliary apparatus 10 can ski on the flat or uneven snow surface, irrespective of his stiff or soft knees safely, smoothly and at high speed by a vertical lift generated between the upper ski surface and the bottom of the ski boot 40.

[0066] It will therefore be seen that at least in the preferred forms of the invention, vertical lift can be generated between an upper ski surface and a ski boot 40 in order to obtain greater control and stability for a skier running on an uneven snow surface, and the skier can obtain the capacity of the skis to conform flexibly to the uneven snow surface.

Claims

1. Auxiliary apparatus (10) for a snow ski which comprises: a V-shaped elastic body having a first plate spring (12) and a second plate spring (14), a restraining member (16) and an elastic ring (50), said first elastic plate spring (12) being integrally provided on a ski plate (1), a rear free end portion (14b) of said second plate spring (14) being vertically movable, said restraining member (16) being integrally fixed on said ski plate (1) at a rear end portion (12b) of said first elastic plate (12), and said elastic ring (50) being provided underneath a lower surface

of said second plate spring (14) to locate within said restraining member (16) whereby vertical lift can be generated between an upper ski surface and a ski boot (40) in order to obtain greater control and stability for a skier running on an uneven snow surface.

2. Auxiliary apparatus (10) for a snow ski as claimed in claim 1, wherein said first plate spring (12) is a lower plate spring and said second plate spring (14) is an upper plate spring.

3. Auxiliary apparatus (10) for a snow ski as claimed in claim 1 or 2 further comprising an insert (18) sandwiched between the front portions (12a, 14a) of the first (12) and second (14) plate springs.

4. Auxiliary apparatus (10) for a snow ski as claimed in any of claims 1 to 3, wherein said restraining member (16) has a rectangular frame (16a) having a pair of bottom plates (16c), the upper transverse portion (16b) of said rectangular frame being angled upwardly in the rearward direction to allow easy movement of a rear portion of said second elastic plate spring (14).

5. Auxiliary apparatus (10) for a snow ski as claimed in any of claims 1 to 4, wherein the front portions (12a, 14a) of the in-shaped elastic body are mounted on the ski plate (1) to locate at a rear position of a toe binding (20a).

6. Auxiliary apparatus (10) for a snow ski which comprises a U-shaped elastic body having a first elastic plate spring (12) and a second elastic plate spring (14), a restraining member (16), and an elastic ring (50), said first elastic plate spring being integrally provided on a ski plate (1), a rear free end portion (14b) of said second elastic plate spring being vertically movable and said restraining member being integrally fixed on said ski plate to locate at a rear end portion (12b) of said first elastic plate spring, and said elastic ring (50) being provided underneath a lower surface of said second plate spring (14) to locate within said restraining member (16) whereby vertical lift can be generated between an upper ski surface and a ski boot (40) in order to obtain greater control and stability for a skier running on an uneven snow surface.

7. Auxiliary apparatus (10) for a snow ski as claimed in claim 6, wherein said first plate spring (12) is a lower plate spring and said second elastic plate spring (14) is an upper plate spring.

8. Auxiliary apparatus (10) for a snow ski which comprises: an elastic ring (50) and a flat elastic sheet (58) , said elastic ring (50) including a pair of screw openings (50a), (50a) provided at an upper portion of said elastic ring (50) to locate at the positions corresponding to a pair of screw openings (14e), (14e) which are slightly wider than the width of the upper transverse portion (16b) of the restraining member (16), said upper portion of said elastic ring (50) integrally provided by a pair of set screws (52), (52) screwed into the screw openings (14e), (14e) and a pair of washers (54), (54) and nuts (58), (58) to locate under the rear end portion of said upper plate spring (14) to locate between the rear end portions (12b), (14b) of said lower plate spring (12) and said upper plate spring (14) and also within said restraining member (16), and said flat elastic sheet (58) being integrally mounted on an upper surface of the upper plate spring (14) to locate between the screw openings (14e), (14e).

9. Auxiliary apparatus (10) for a snow ski as claimed in claim 8, wherein said flat elastic sheet (58) is a rubber sheet.

10. Auxiliary apparatus for a ski, comprising a lower longitudinal portion (12) for attachment to a ski, an upper longitudinal portion (14), and a spring (50) located between the upper (14) and lower (12) portions, said spring resiliently upwardly biasing the rear part (14b) of the upper longitudinal portion (14) from the rear part (12b) of the lower longitudinal portion (12) so that the rear parts of the upper and lower portions are spaced from one another, whereby in use the spacing is reducible against the resilient bias of the spring in response to an upward force exerted on the ski.

11. Auxiliary apparatus as claimed in claim 10 wherein said spring (50) is an elastic ring.

12. A ski provided with auxiliary apparatus (10) as claimed in any preceding claim.

FIG. 1

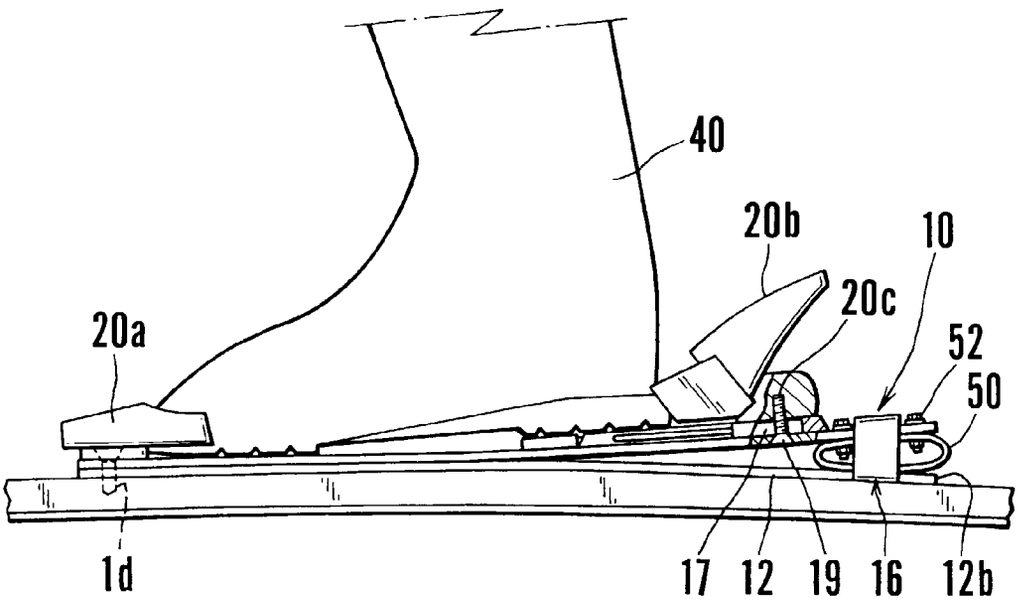

40
20b
10
20c
20a
52
50
1d
17
12
19
16
12b

FIG. 2

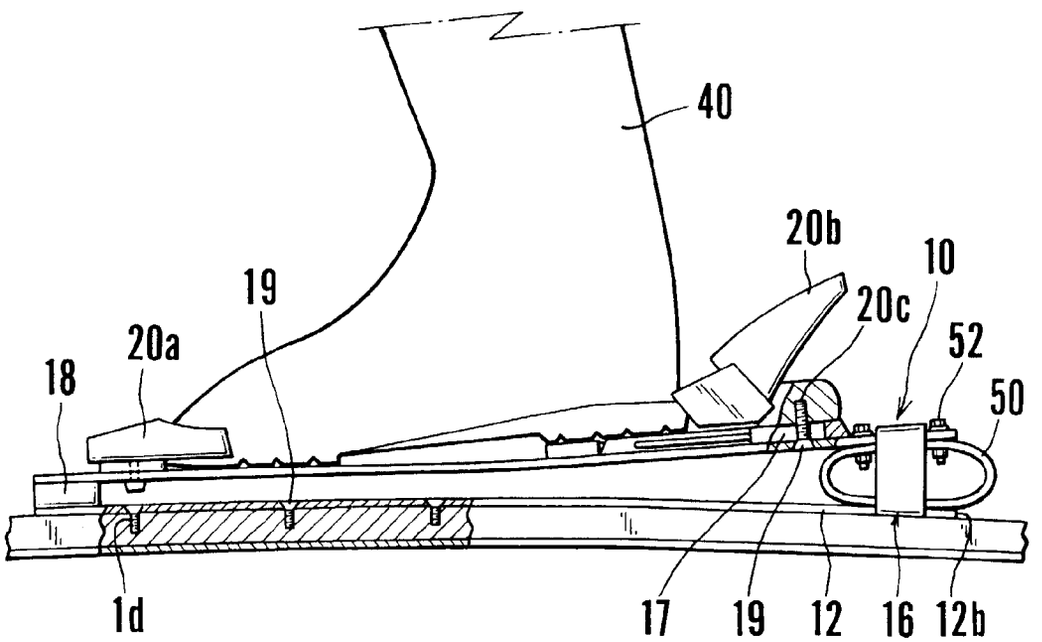

40
20b
10
19
20c
20a
52
18
50
1d
17
19
12
16
12b

FIG. 3

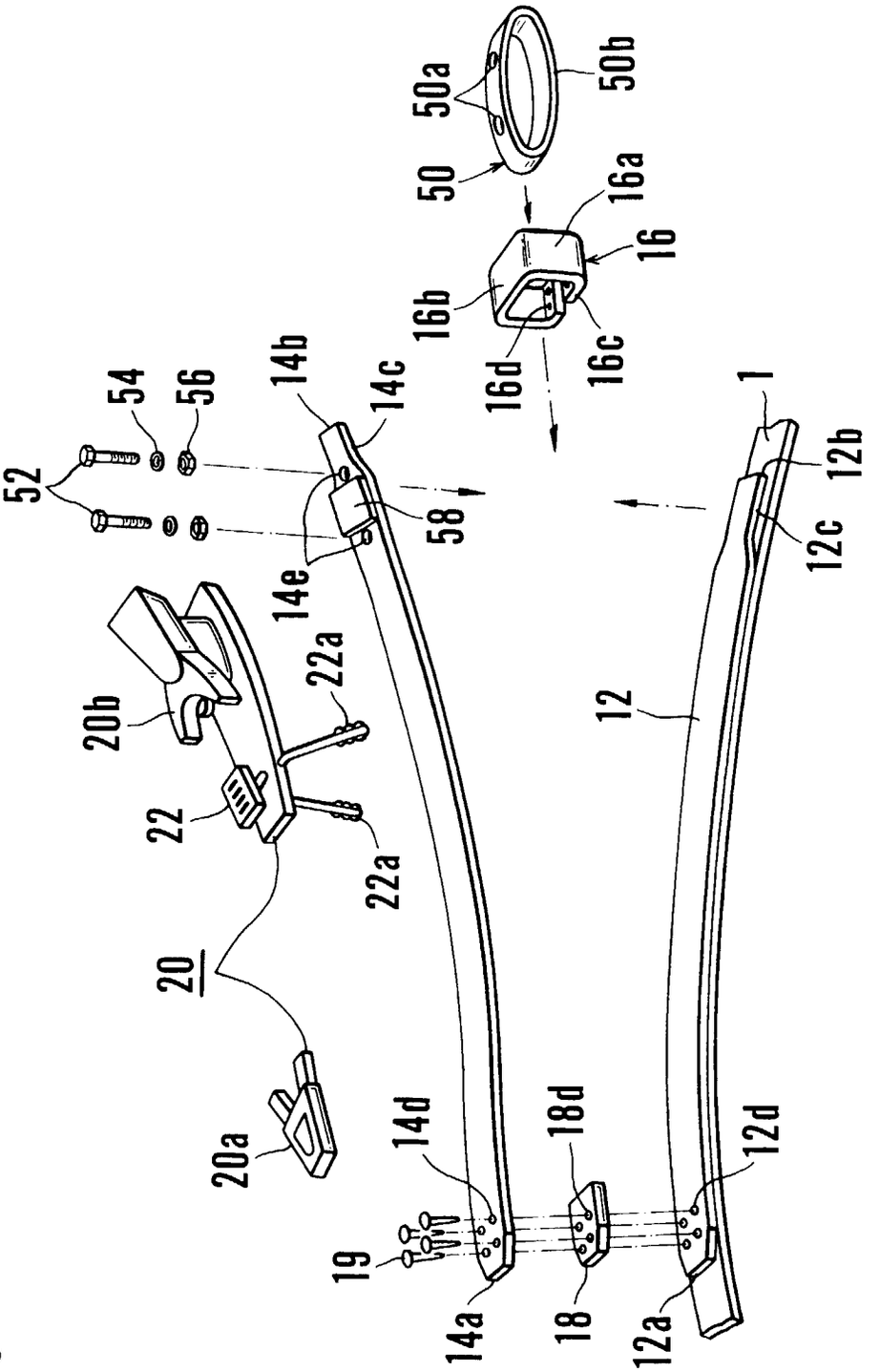

50a
50b
50
16a
16
16b
16d
16c
1
12b
12c
54
56
52
14b
14c
58
14e
22a
20b
22
12
20
20a
14d
18d
12d
19
14a
18
12a

FIG. 4

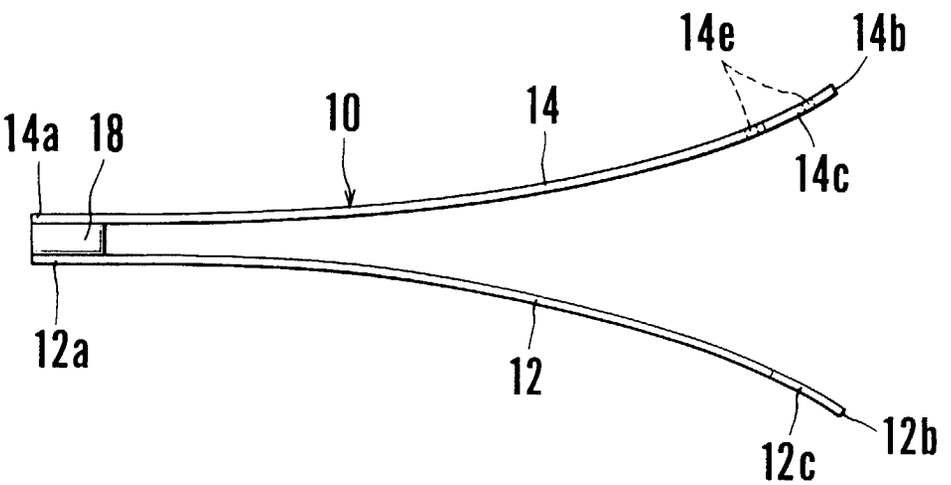


FIG. 5

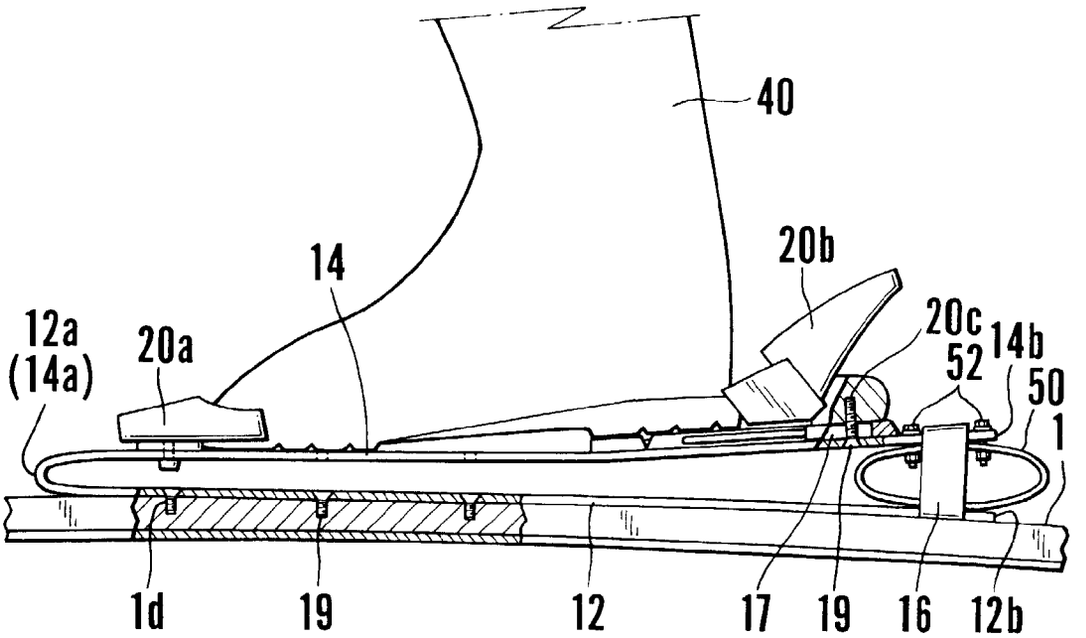

40
14
20b
12a
(14a)
20a
20c
52
14b
50
1
1d
19
12
17
19
16
12b

FIG. 6

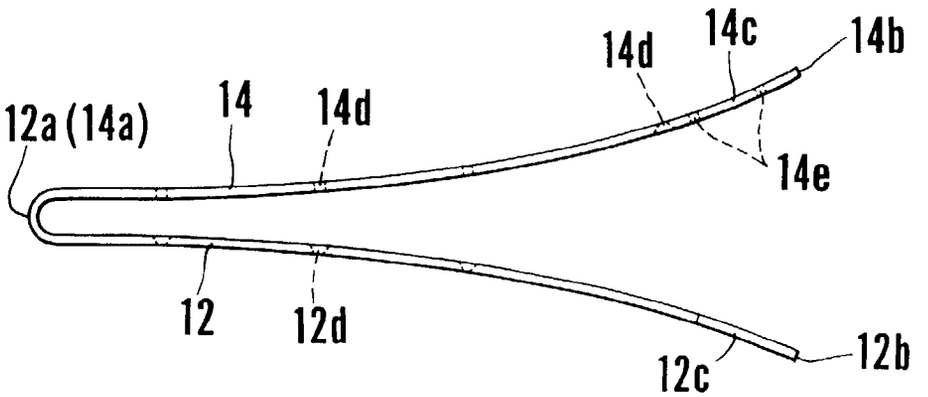

14d
14c
14b
12a (14a)
14
14d
14e
12
12d
12c
12b

FIG. 7

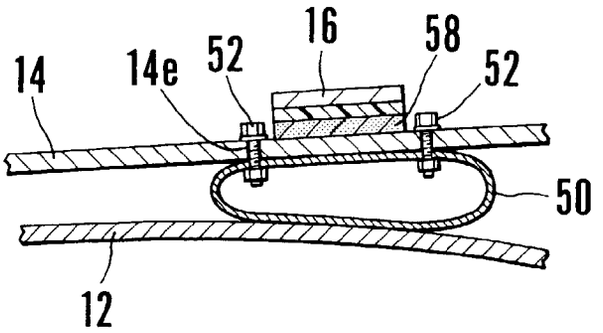

16
58
14
14e
52
52
50
12

FIG. 8

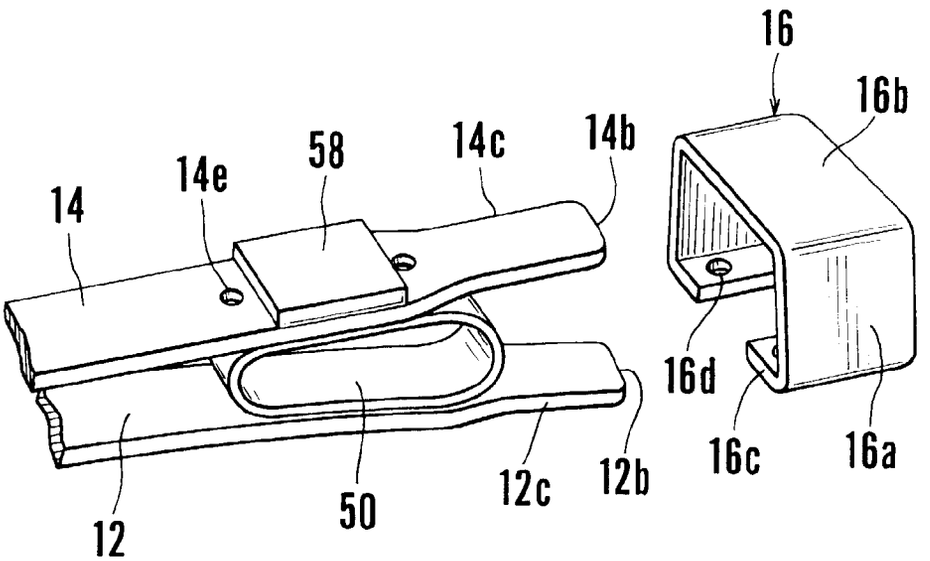

16
16b
58
14c
14b
14e
14
16d
16c
16a
12
50
12c
12b

FIG. 10

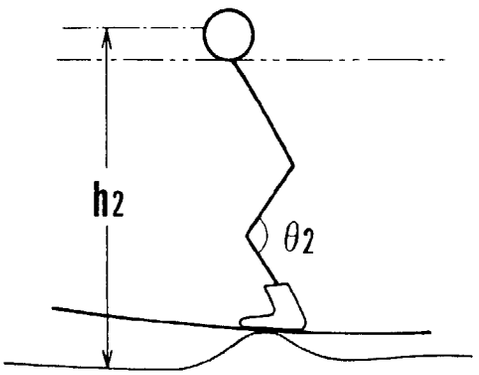
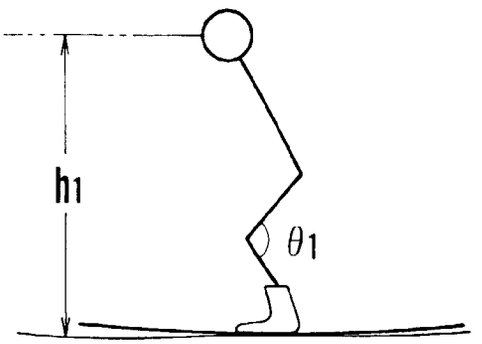


FIG. 9



$h_2 > h_1$ $\theta_2 = \theta_1$

FIG. 12

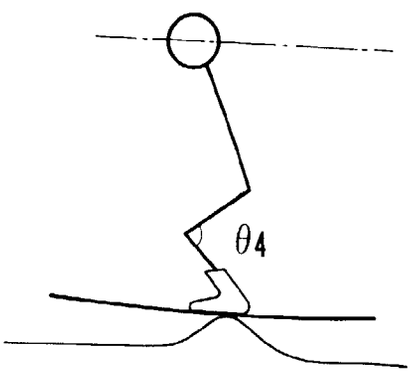
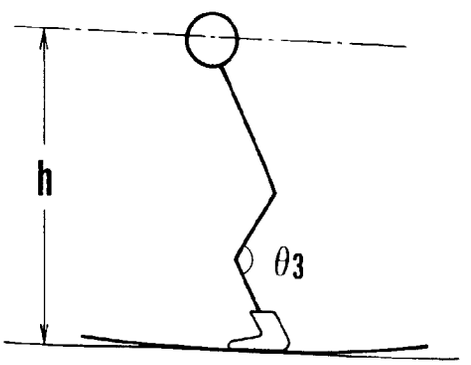


FIG. 11



$\theta_4 < \theta_3$

FIG. 14

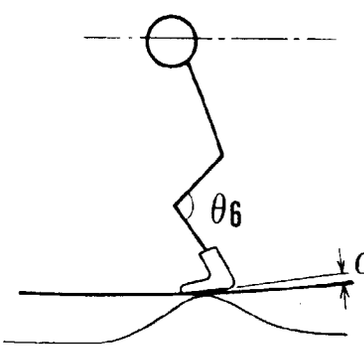
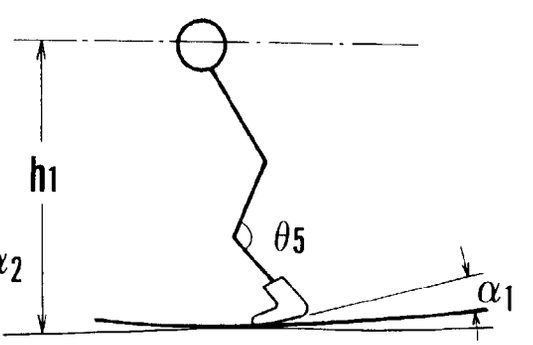


FIG. 13



$\theta_4 < \theta_6 \leqq \theta_5$

FIG. 15

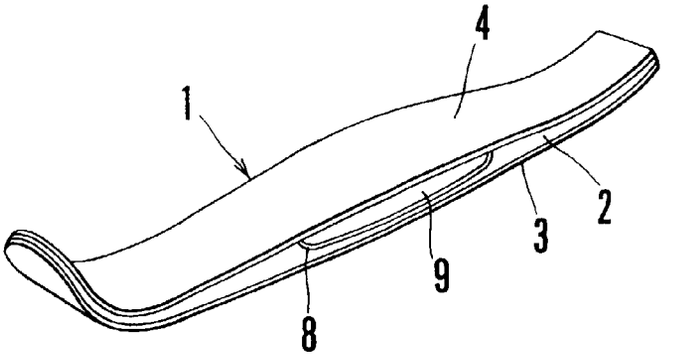


FIG. 16

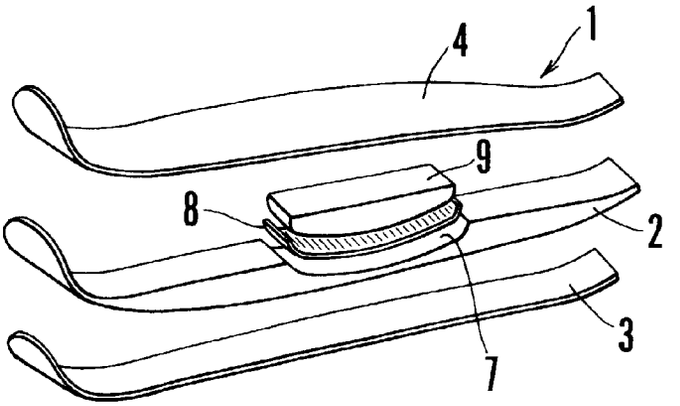


FIG. 17

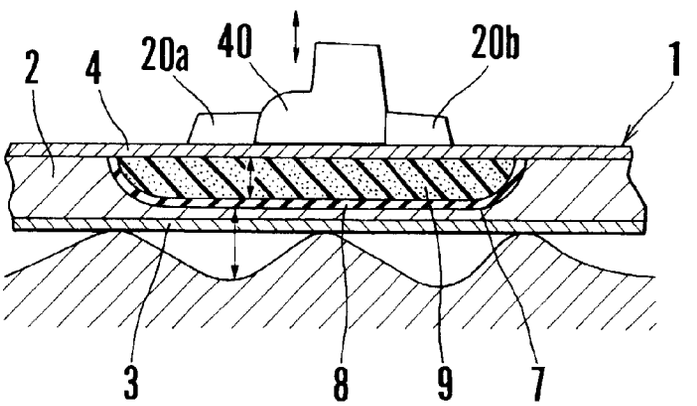


FIG. 18

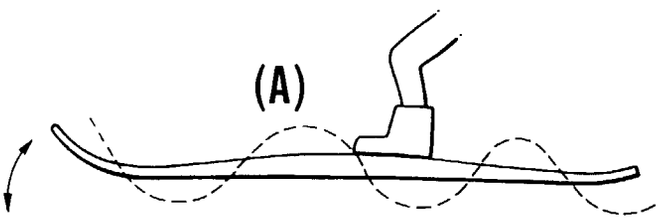


FIG. 19