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Ettlinger et al.

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(45) **Date of Patent: Apr. 28, 2009**

(54) **ALPINE SKI BINDING SYSTEM HAVING RELEASE LOGIC FOR INHIBITING ANTERIOR CRUCIATE LIGAMENT INJURY**

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(73) Assignee: **Vermont Safety Developments**, Underhill Center, VT (US)

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

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

A63C 9/00	(2006.01)
A63C 9/08	(2006.01)
A63C 9/081	(2006.01)
A63C 9/082	(2006.01)

(52) **U.S. Cl.** **280/617**; 280/611; 280/613; 280/614; 280/615; 280/DIG. 13; 280/618; 280/623; 280/626; 280/627; 280/628; 280/629; 280/14.23; 280/14.24

(58) **Field of Classification Search** ..... 280/611, 280/613, 614, 615, 616, 617, 618, 623, 626, 280/627, 628, 629, 14.23, DIG. 13, 14.24
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,091,475	A	5/1963	Wunder	
3,876,218	A *	4/1975	Von Besser	280/618
5,064,215	A	11/1991	Ferdinand et al.	
5,071,155	A	12/1991	Stepanek et al.	
5,551,720	A	9/1996	Ruffinengo	
5,722,681	A	3/1998	Merino	
6,007,086	A *	12/1999	Hopkins	280/612
6,450,526	B1	9/2002	Bressand	
7,063,345	B2	6/2006	Holzer	
7,086,662	B2	8/2006	Dodge	
2004/0145154	A1 *	7/2004	Holzer	280/611
2004/0173994	A1	9/2004	Howell	

OTHER PUBLICATIONS

International Search Report of related International Application No. PCT/US07/75334 dated Aug. 22, 2008.

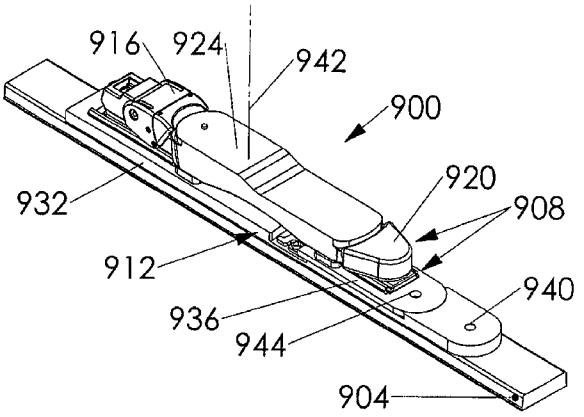
(Continued)

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(57) **ABSTRACT**

An alpine ski binding system for releasably securing a ski boot to a ski. The binding system includes a secondary toe release that provides an attenuated release threshold under lateral shear loading conditions that can cause anterior cruciate ligament injuries. The secondary toe release responds to a trigger that senses the lateral shear loads applied to the inside (medial) afterbody of the ski and triggers the secondary toe release the boot at an attenuated release torque. Lateral shear loads applied to the ski along the leading (medial) forebody and along the entire outside (lateral side) of the ski substantially do not cause the trigger to trip.

61 Claims, 22 Drawing Sheets



OTHER PUBLICATIONS

Gordon Lipe, The ALLSOP-Pegged for Safety, Know Your Binding: 18, Ziff-Davis Publishing Company, Oct. 1973.

Gordon Lipe, The Allmat 8000, Jet, and PSC, Know Your Bindings: 19, Nov. 1973, pp. 155, 158 and 163.

Gordon Lipe, The Americana: Heel Release on a Plate, Know Your Bindings: 21, pp. 12-14, published prior to Aug. 7, 2005.

Carl Ettlinger, Bindings Performance Report: The Salomon 727, Reprinted from Skiing Magazine, Oct. 1978, Ziff-Davis Publishing Company.

Carl Ettlinger, Bindings Performance Report: The Moog Delta S, Reprinted from Skiing Magazine, Nov. 1978, Ziff-Davis Publishing Company.

Carl Ettlinger, Bindings Performance Report: The Burt II, Reprinted from Skiing Magazine, Dec. 1978, Ziff-Davis Publishing Company.

Carl Ettlinger, Bindings Performance Report: The Tyrolia 60 Series, Reprinted from Skiing Magazine, Oct. 1979, Ziff-Davis Publishing Company.

Carl Ettlinger, Bindings Performance Report: The New Spademan Line, Reprinted from Skiing Magazine, Dec. 1979, Ziff-Davis Publishing Company.

Carl Ettlinger, Bindings Performance Report: Look Again, Reprinted from Skiing Magazine, Feb. 1983, Ziff-Davis Publishing Company, pp. 109-111.

Carl Ettlinger, How Your Bindings Work, Marker's Twincam Series, Skiing, Oct. 1987, pp. 225, 228, 230.

Carl Ettlinger, How Your Bindings Work, The Ess V.A.R., Skiing, Feb. 1988, pp. 94, 116.

Carl Ettlinger, The New Geze Line, Skiing, Oct. 1988, pp. 190, 192, 194.

Carl Ettlinger, The Salomon '37 Line, Skiing, Nov. 1982, pp. 175, 176, 178, 180.

* cited by examiner

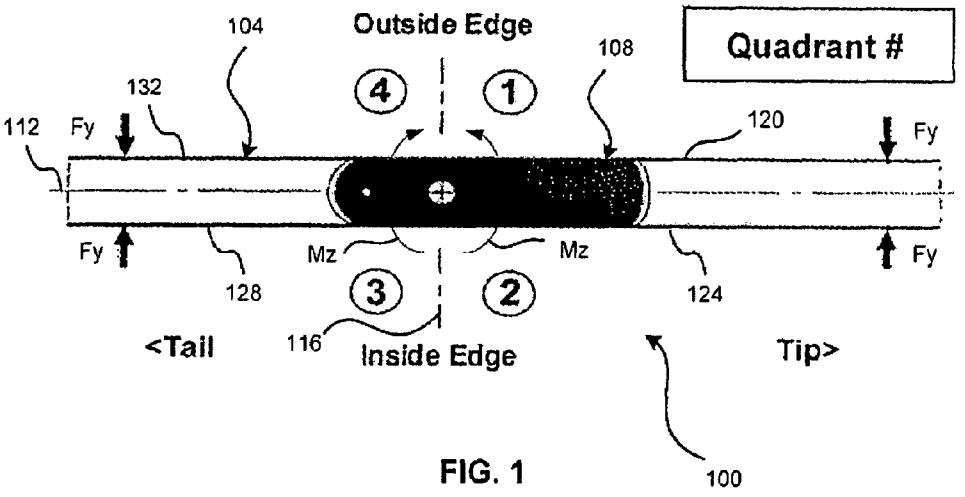

104
Outside Edge
108
Quadrant #
132
4
1
112
Fy
120
Fy
Fy
Mz
Mz
Fy
128
3
2
124
<Tail
116
Inside Edge
Tip>
100

FIG. 1

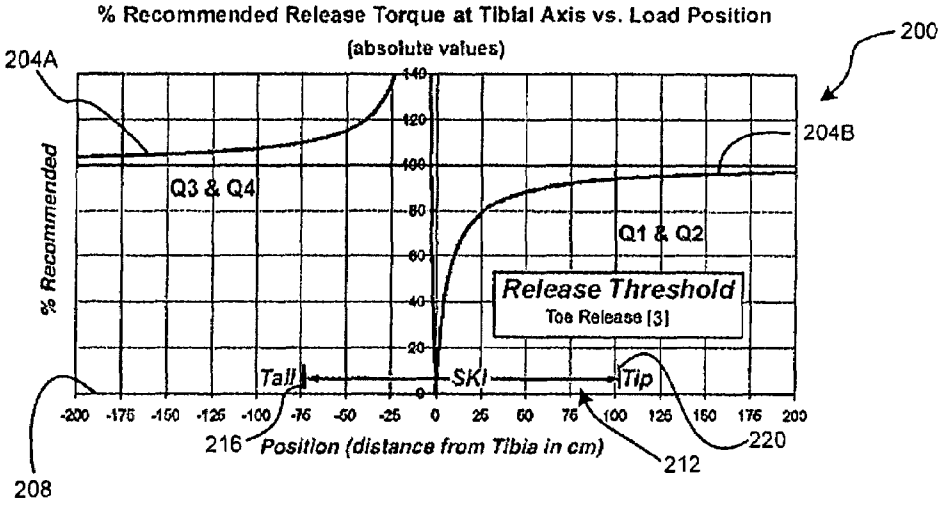

% Recommended Release Torque at Tibial Axis vs. Load Position
(absolute values)
200
204A
204B
% Recommended
Q3 & Q4
Q1 & Q2
Release Threshold
Toe Release [3]
Tail
SKI
Tip
-200 -175 -150 -125 -100 -75 -50 -25 0 25 50 75 100 125 150 175 200
216
Position (distance from Tibia in cm)
208
212
220

FIG. 2

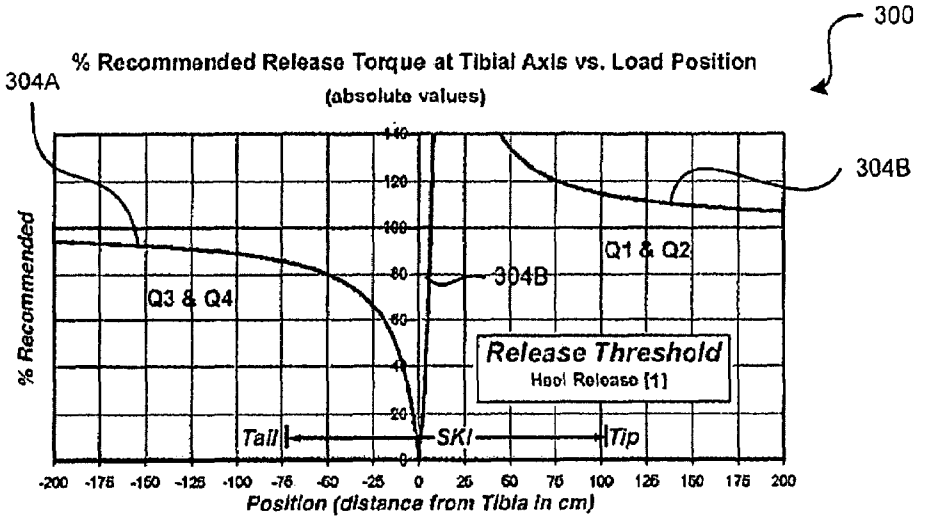

300
% Recommended Release Torque at Tibial Axis vs. Load Position
(absolute values)
304A
304B
Q1 & Q2
Q3 & Q4
304B
Release Threshold
Heel Release [1]
Tail
SKI
Tip
% Recommended
Position (distance from Tibia in cm)

FIG. 3

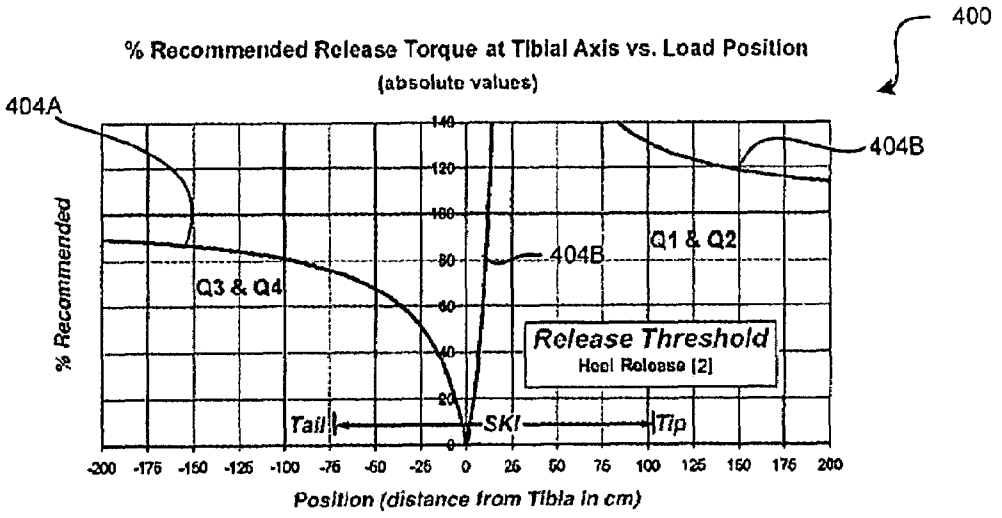

400
% Recommended Release Torque at Tibial Axis vs. Load Position
(absolute values)
404A
404B
Q1 & Q2
Q3 & Q4
404B
Release Threshold
Heel Release [2]
Tail
SKI
Tip
% Recommended
Position (distance from Tibia in cm)

FIG. 4

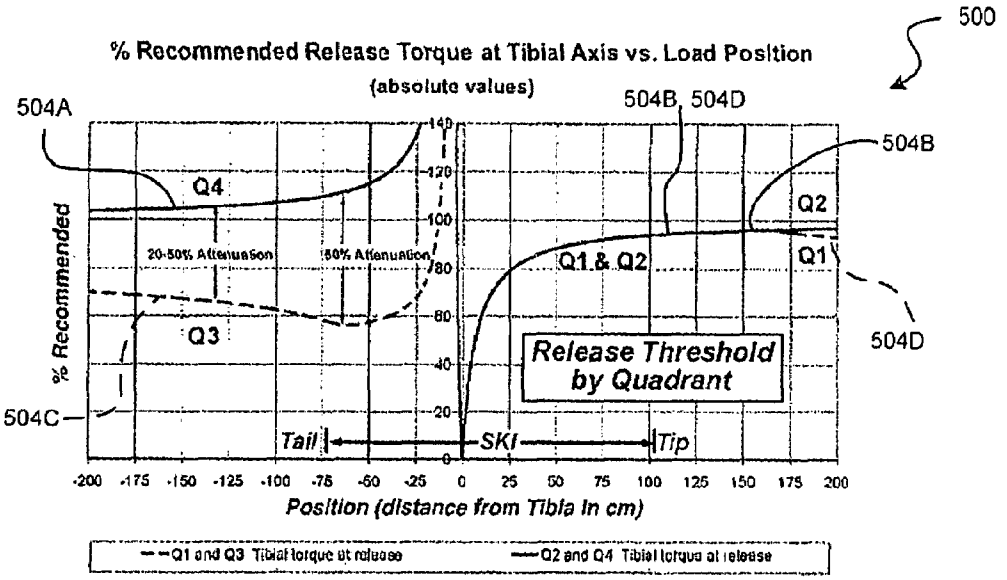

500
% Recommended Release Torque at Tibial Axis vs. Load Position
(absolute values)
504A
504B, 504D
504B
Q4
Q2
Q1
Q1 & Q2
Q3
20-50% Attenuation
50% Attenuation
Release Threshold by Quadrant
504D
504C
% Recommended
Tail
Ski
Tip
Position (distance from Tibia in cm)
Q1 and Q3 Tibial torque at release
Q2 and Q4 Tibial torque at release

FIG. 5

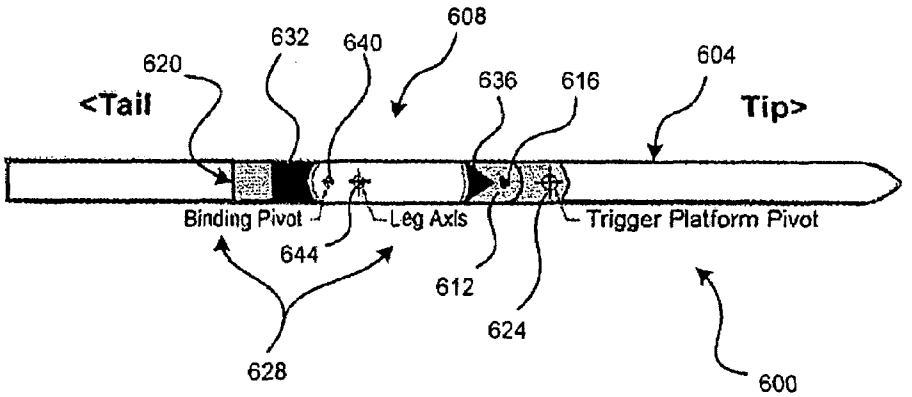

608
632
640
620
636
616
604
<Tail
Tip>
Binding Pivot
Leg Axis
Trigger Platform Pivot
644
612
624
628
600

FIG. 6

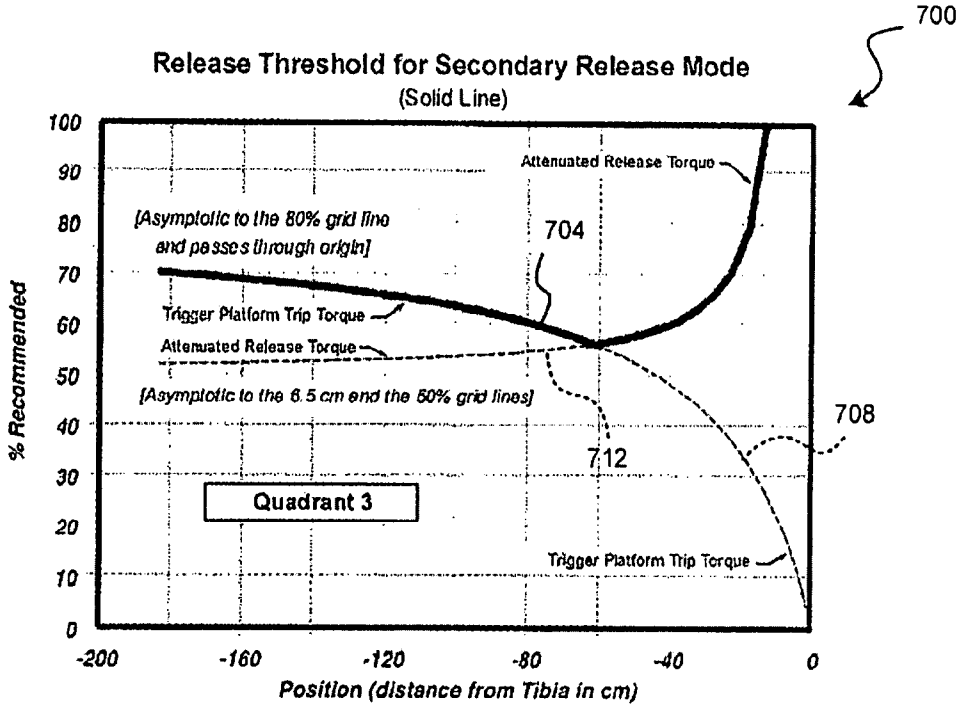

700
Release Threshold for Secondary Release Mode
(Solid Line)
% Recommended
100
90
80
70
60
50
40
30
20
10
0
Attenuated Release Torque
[Asymptotic to the 80% grid line and passes through origin]
704
Trigger Platform Trip Torque
Attenuated Release Torque
[Asymptotic to the 6.5 cm and the 50% grid lines]
708
712
Quadrant 3
Trigger Platform Trip Torque
-200
-160
-120
-80
-40
0
Position (distance from Tibia in cm)

FIG. 7

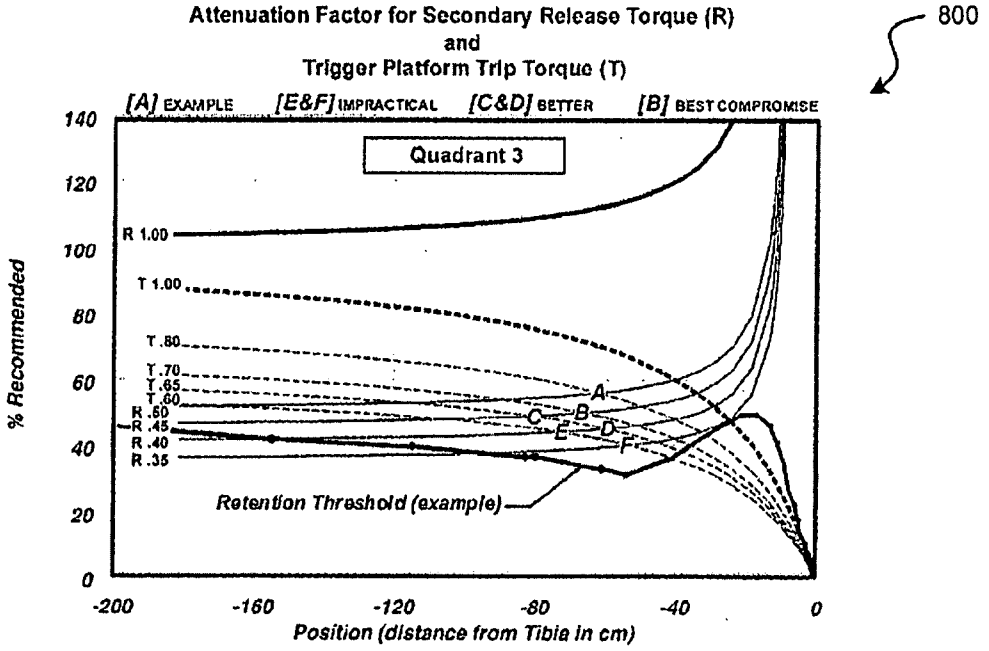

800
Attenuation Factor for Secondary Release Torque (R)
and
Trigger Platform Trip Torque (T)
[A] EXAMPLE
[E&F] IMPRACTICAL
[C&D] BETTER
[B] BEST COMPROMISE
% Recommended
140
120
100
80
60
40
20
0
Quadrant 3
R 1.00
T 1.00
T .80
T .70
T .65
T .60
R .50
R .45
R .40
R .35
A
B
C
D
E
F
Retention Threshold (example)
-200
-160
-120
-80
-40
0
Position (distance from Tibia in cm)

FIG. 8

FIG. 9A

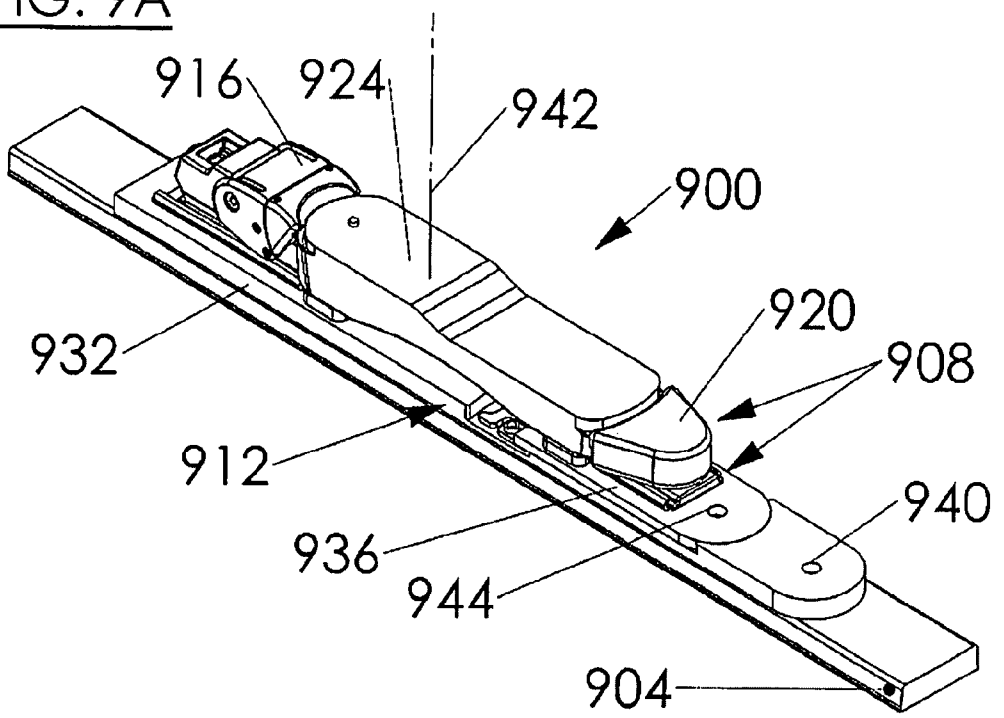


FIG. 9B

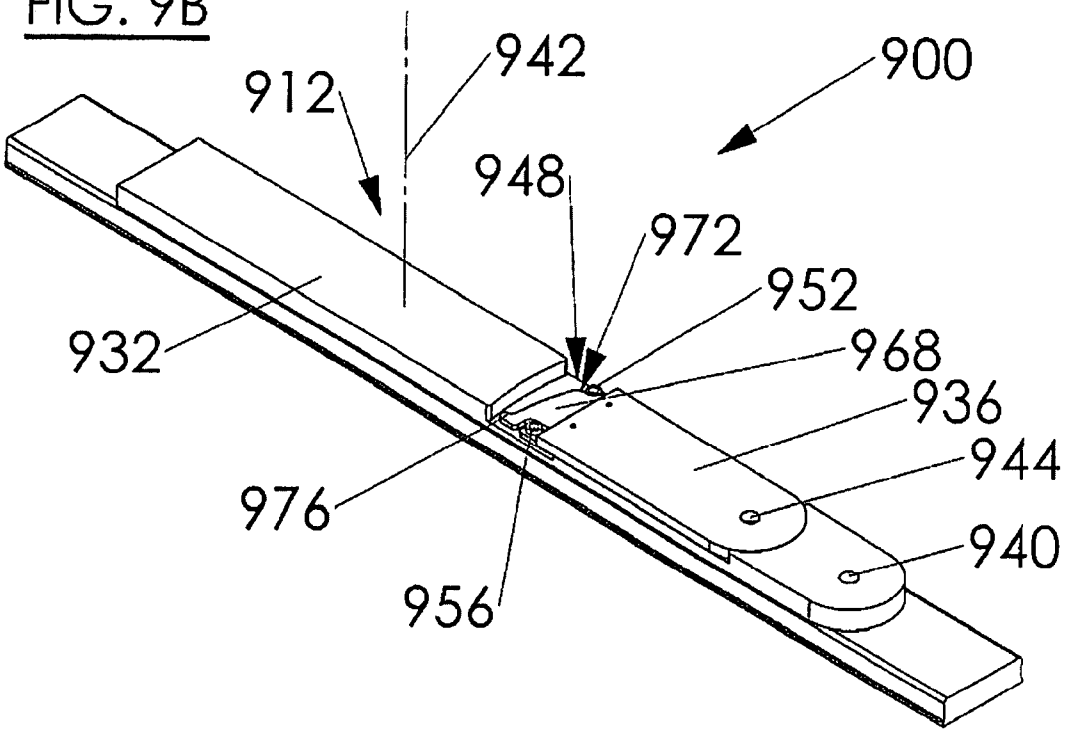


FIG. 10A

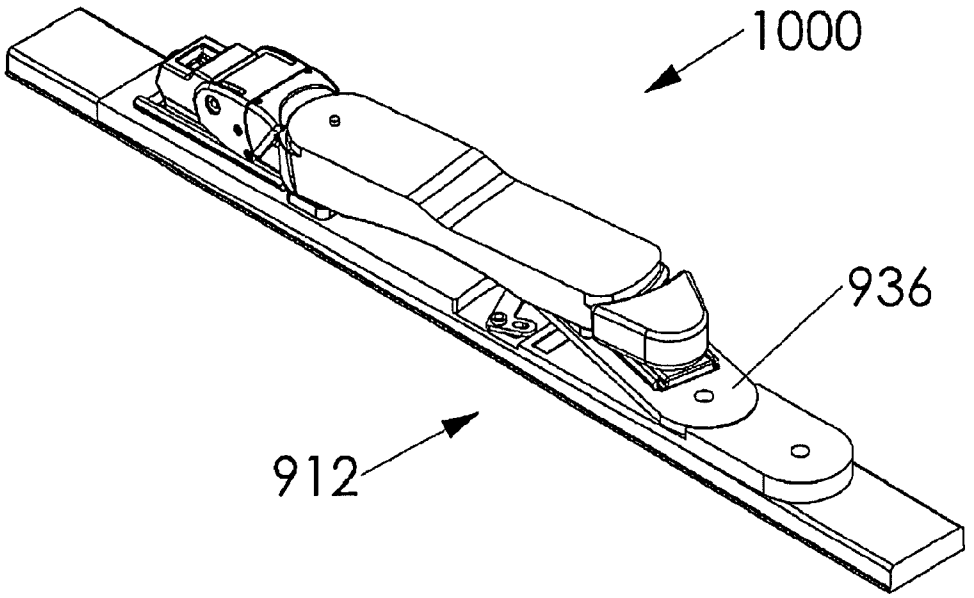
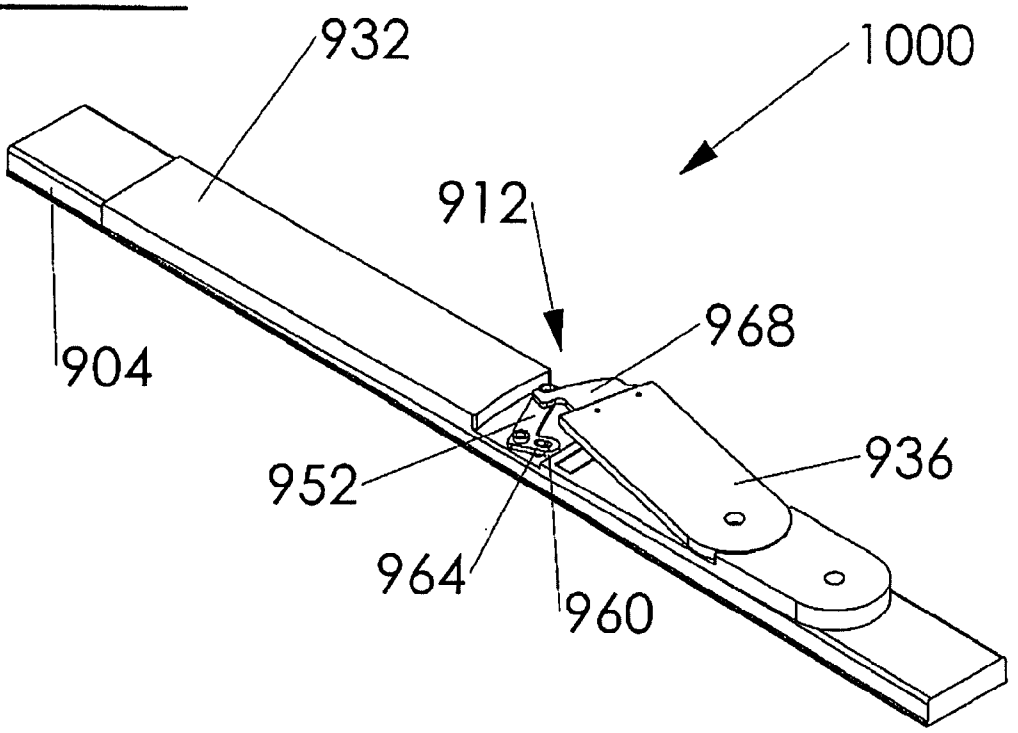


FIG. 10B



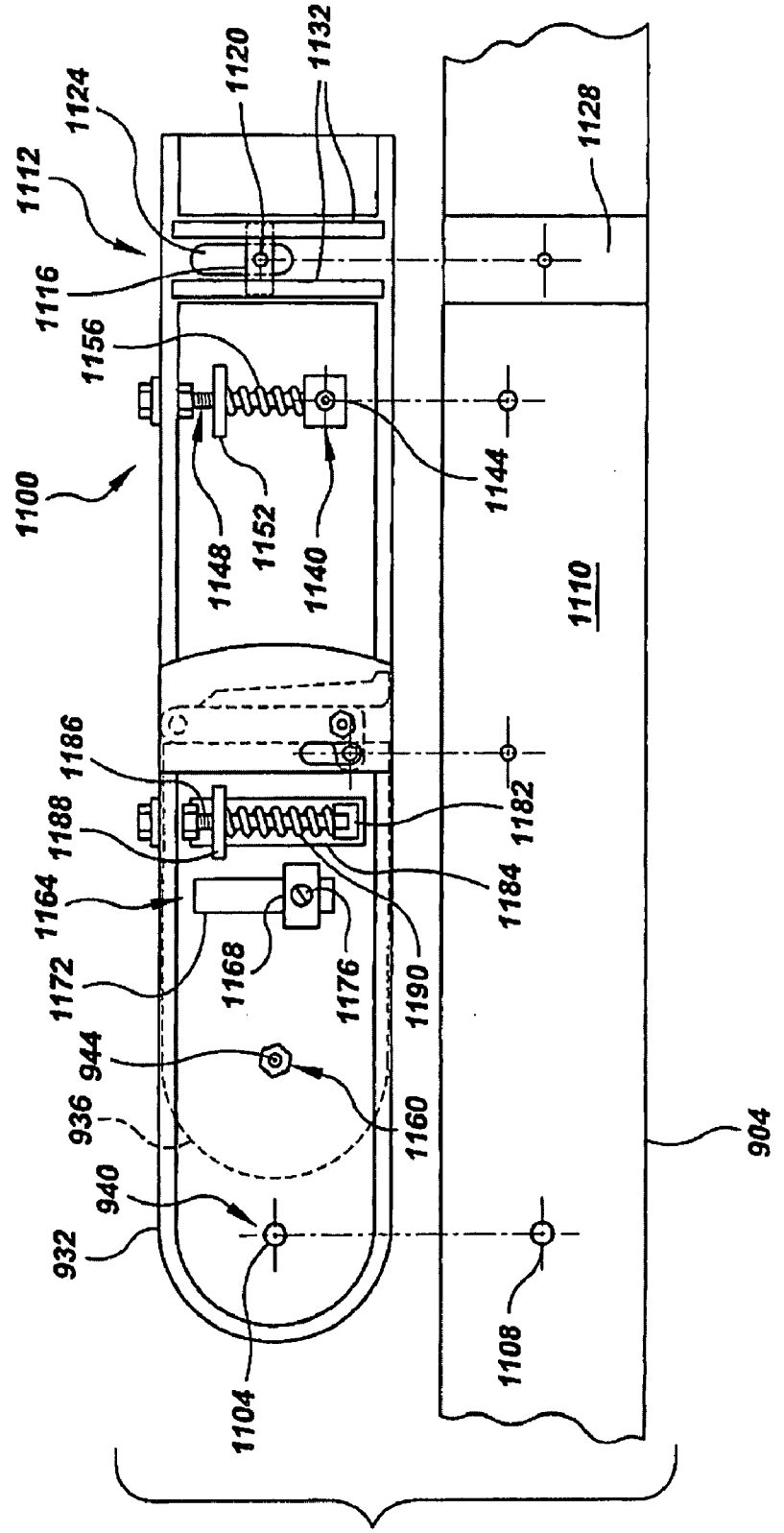

1120
1132
1124
1128
1112
1116
1156
1144
1100
1148
1152
1140
1110
1186
1182
1188
1184
1164
1168
1176
1190
1172
944
936
1160
904
940
932
1108
1104

FIG. 11

FIG. 12

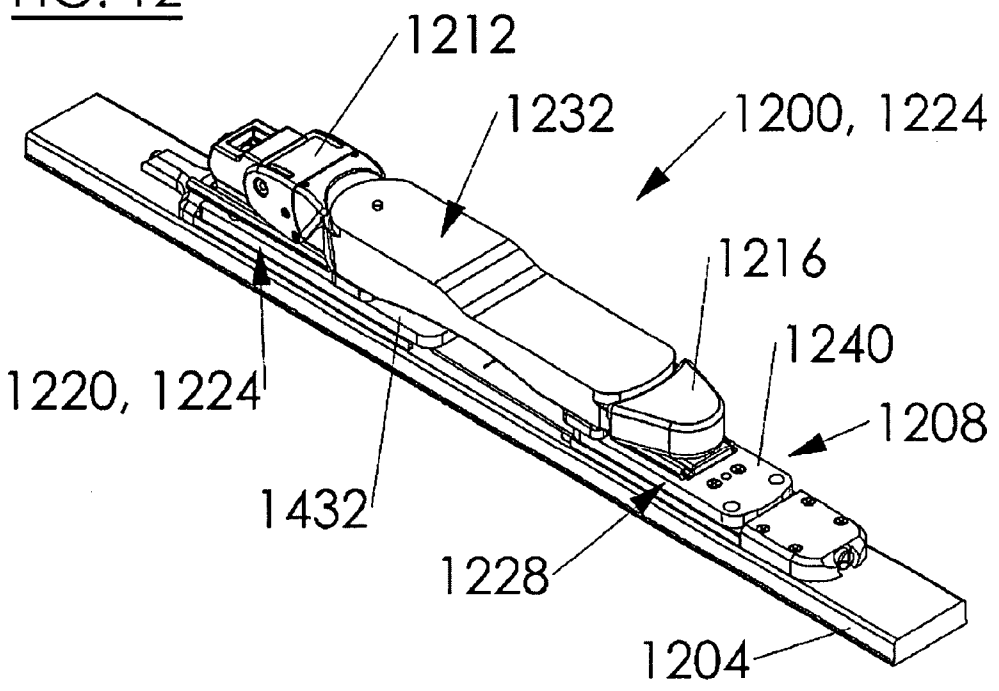


FIG. 13

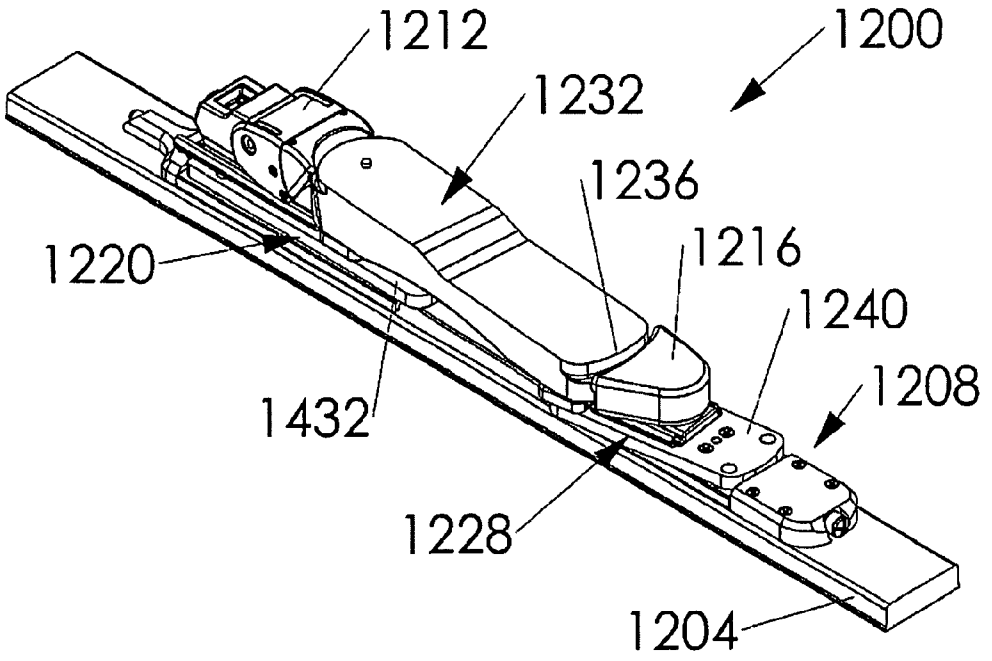


FIG. 14

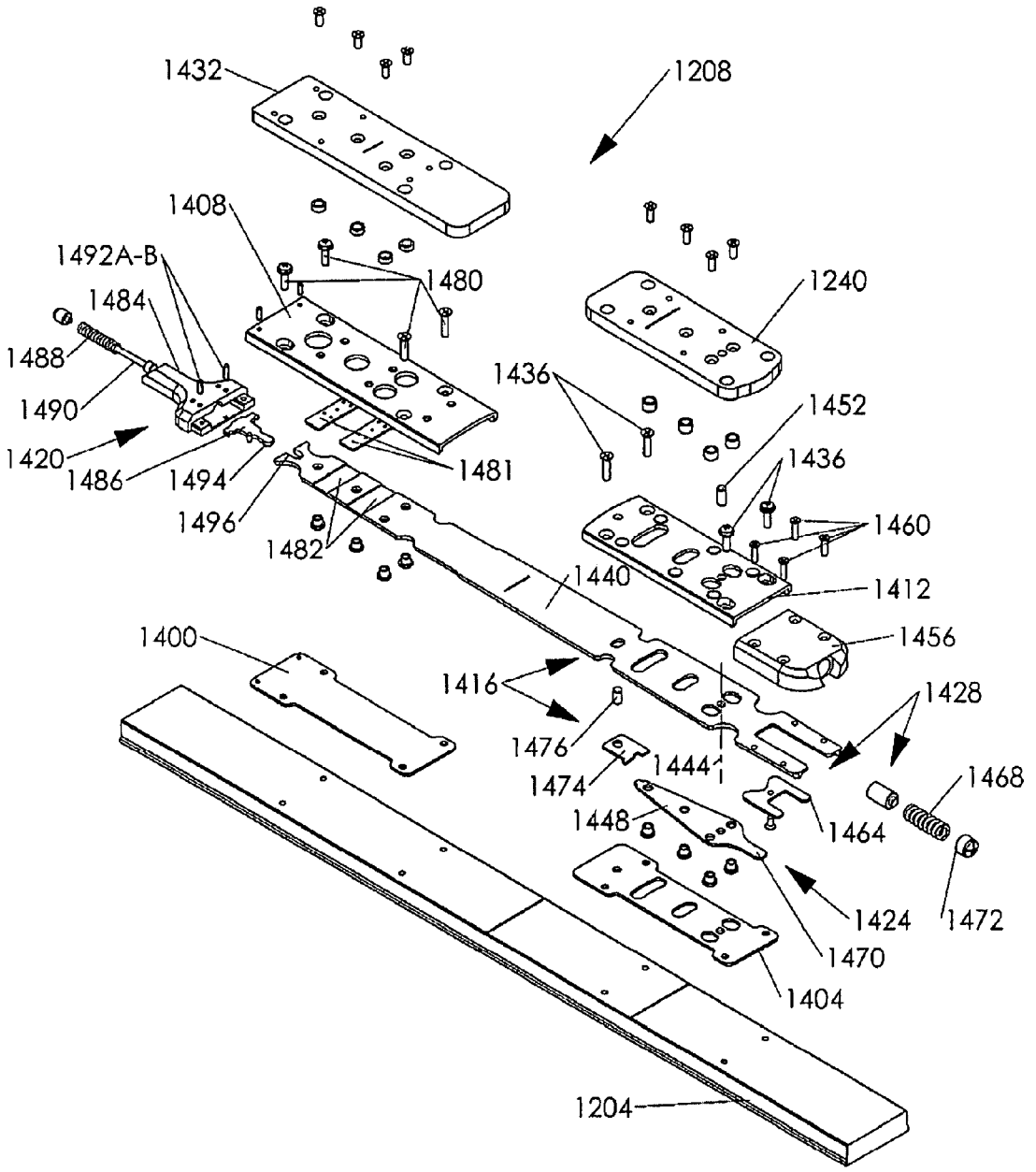

1432
1208
1408
1492A-B
1480
1484
1240
1488
1436
1452
1490
1436
1420
1481
1486
1494
1460
1496
1482
1440
1412
1400
1456
1416
1428
1476
1444
1474
1468
1448
1464
1424
1472
1470
1404
1204

FIG. 15

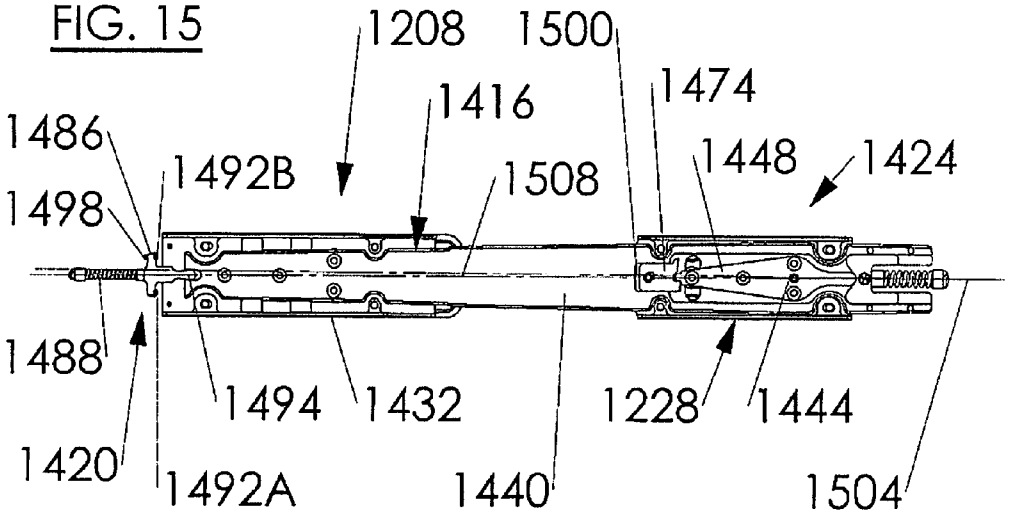

1208
1500
1474
1416
1486
1492B
1508
1448
1424
1498
1488
1494
1432
1228
1444
1420
1492A
1440
1504

FIG. 16

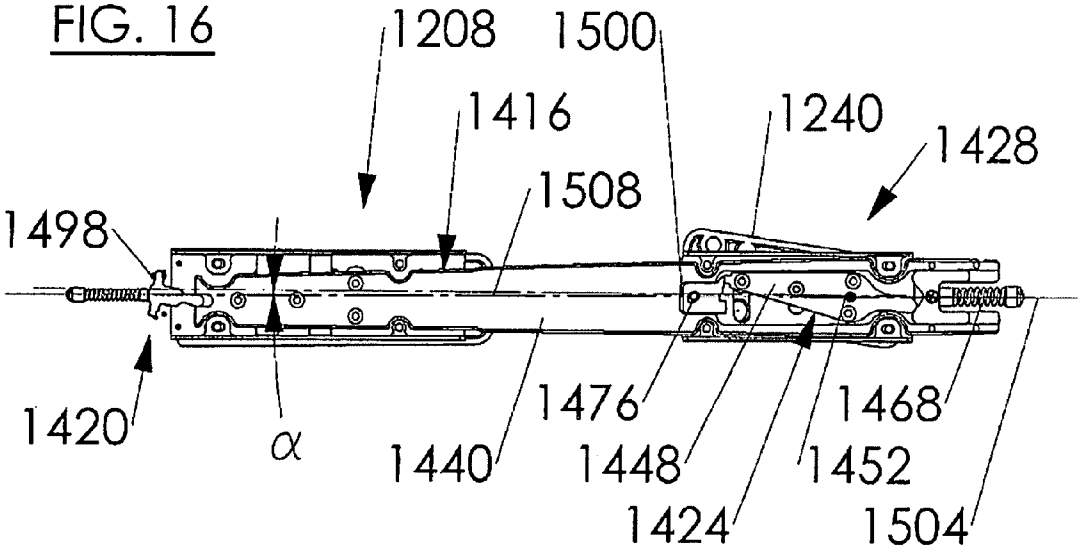

1208
1500
1416
1240
1428
1508
1498
1420
α
1440
1476
1448
1424
1452
1468
1504

FIG. 17

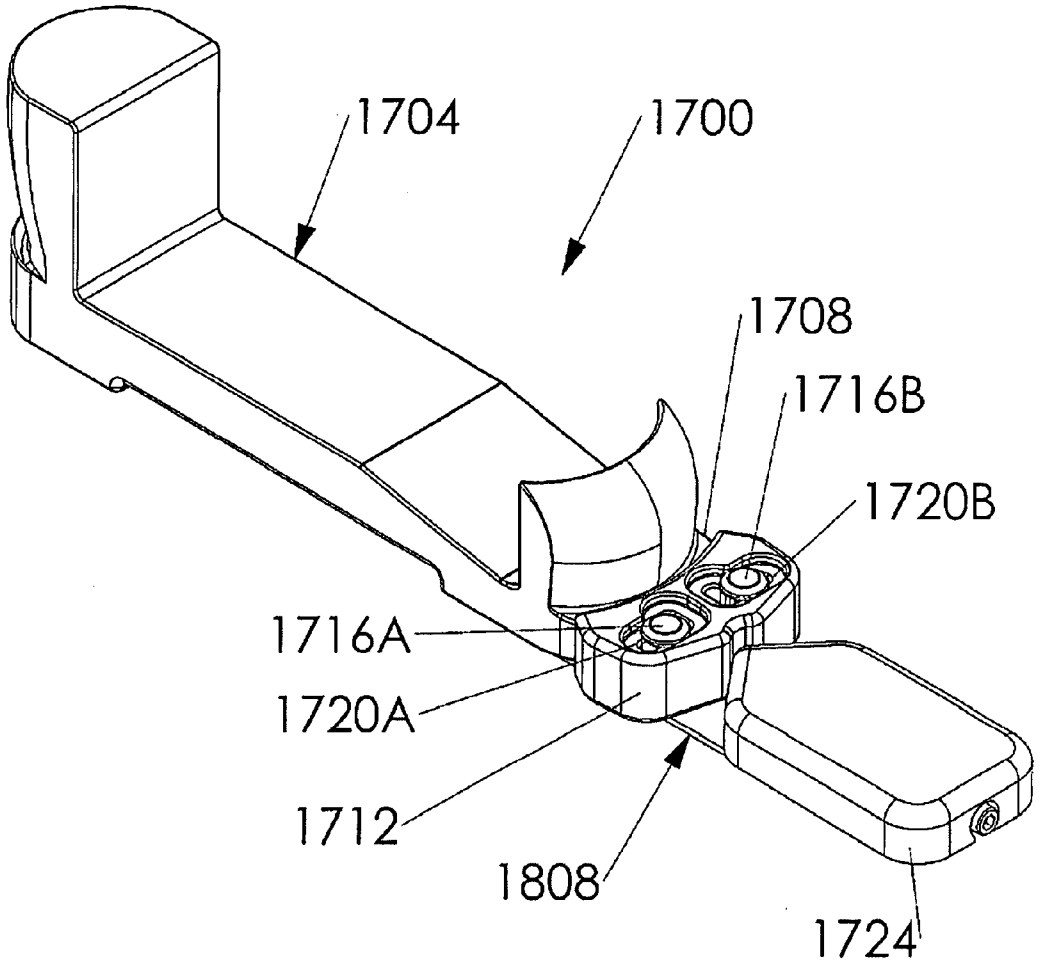


FIG. 18

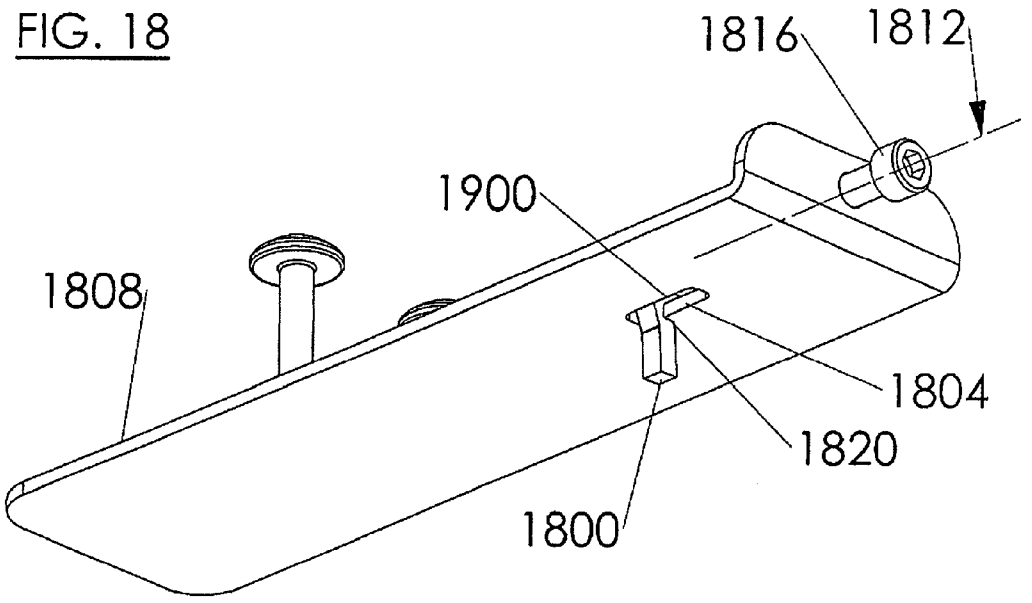


FIG. 19

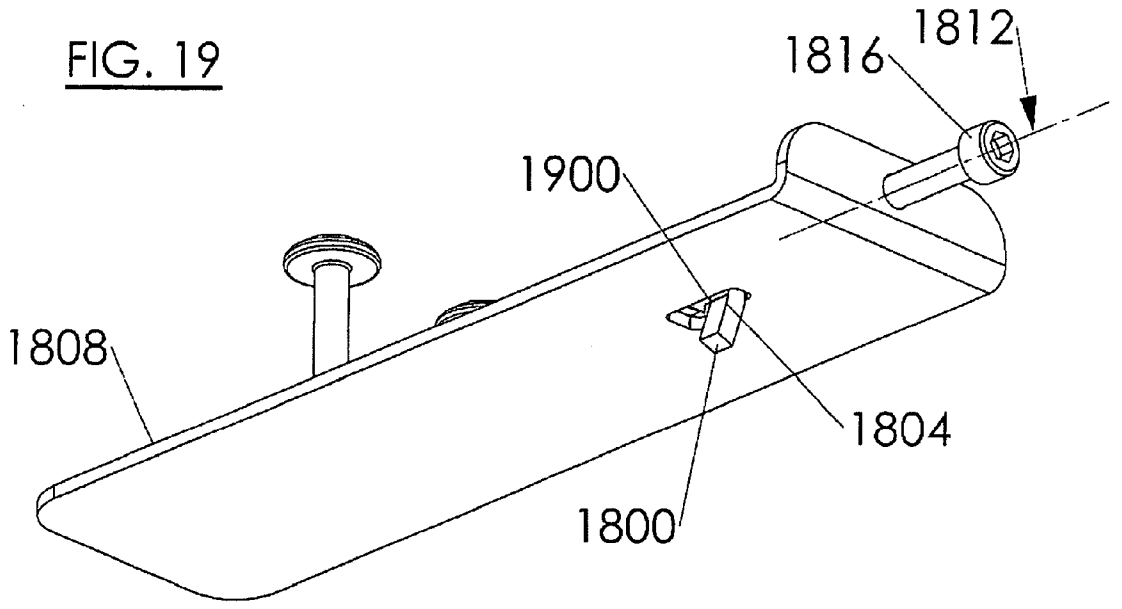


FIG. 20

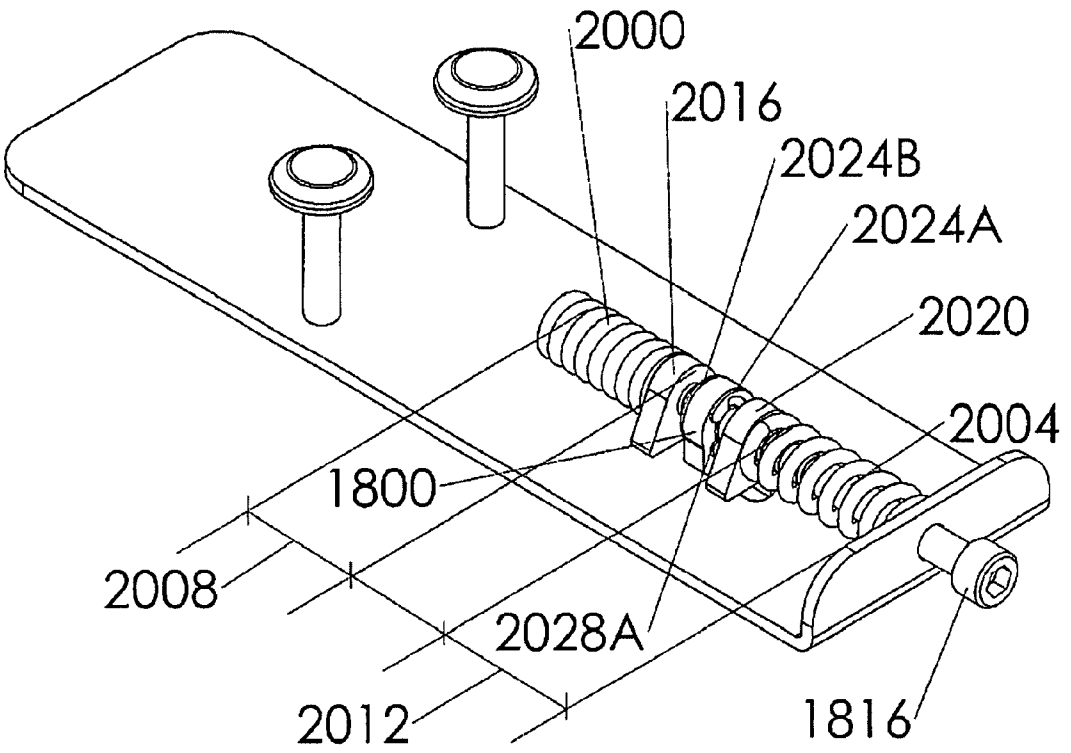


FIG. 21

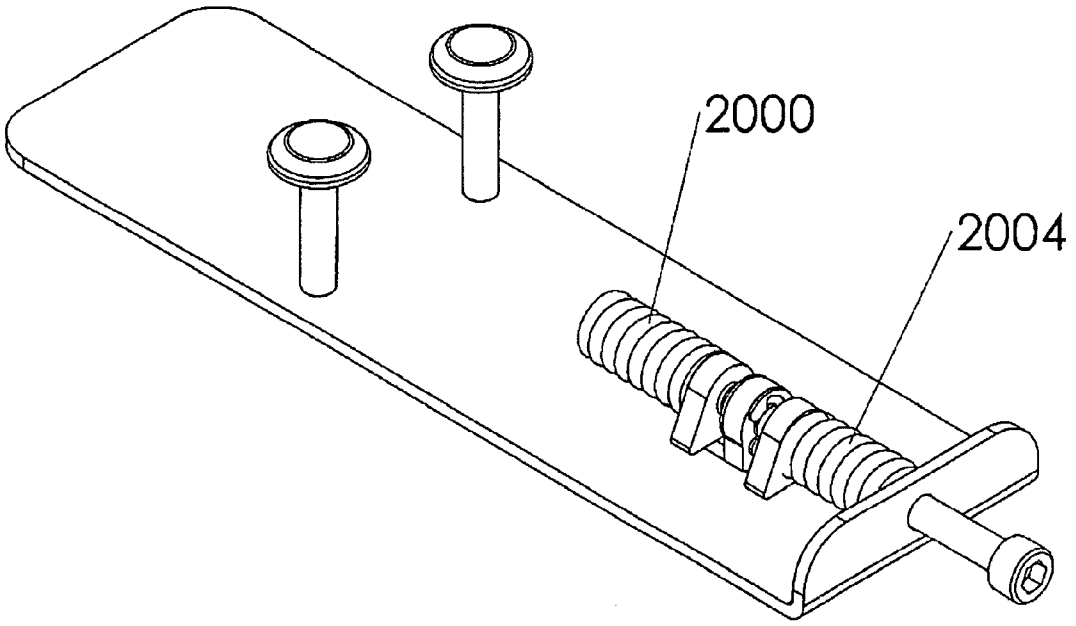


FIG. 22

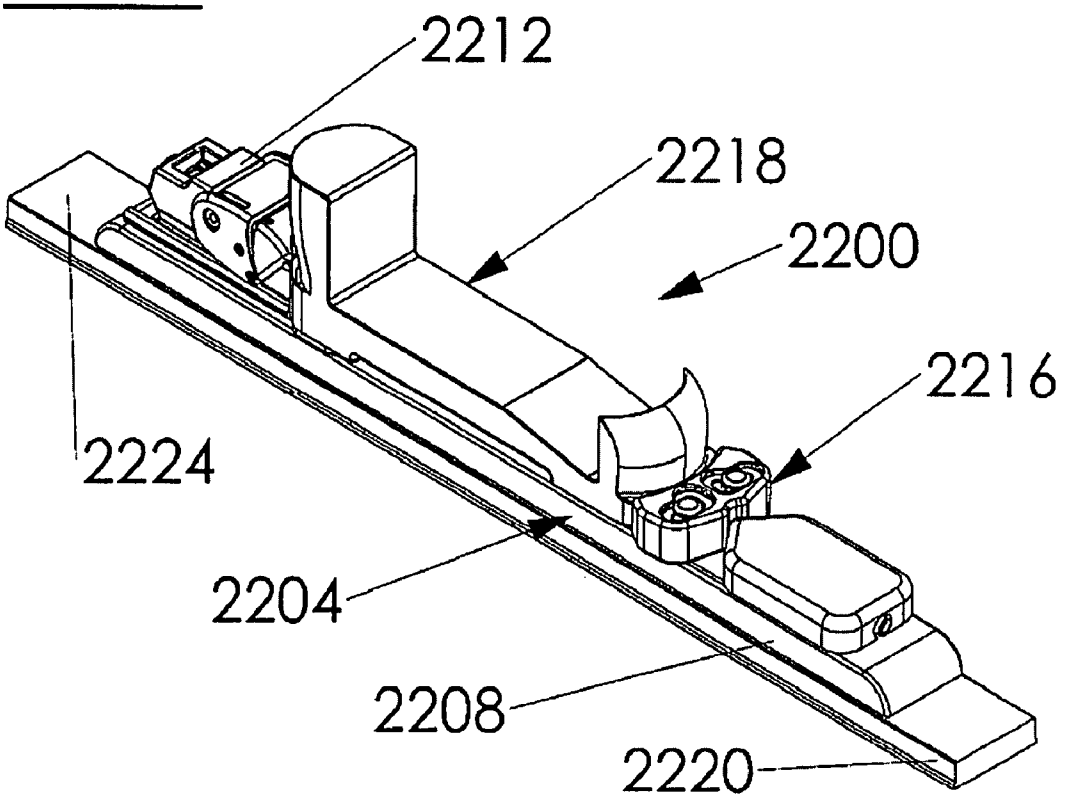
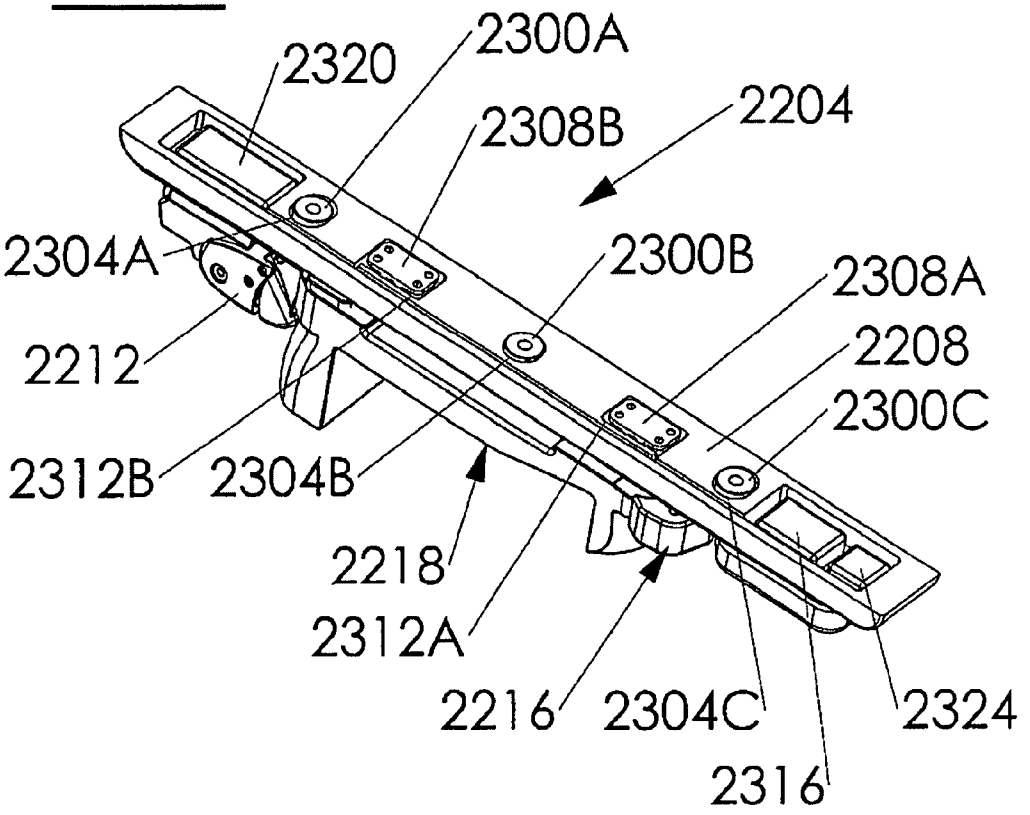


FIG. 23


2320
2300A
2308B
2204
2304A
2300B
2308A
2212
2208
2300C
2312B
2304B
2218
2312A
2216
2304C
2324
2316

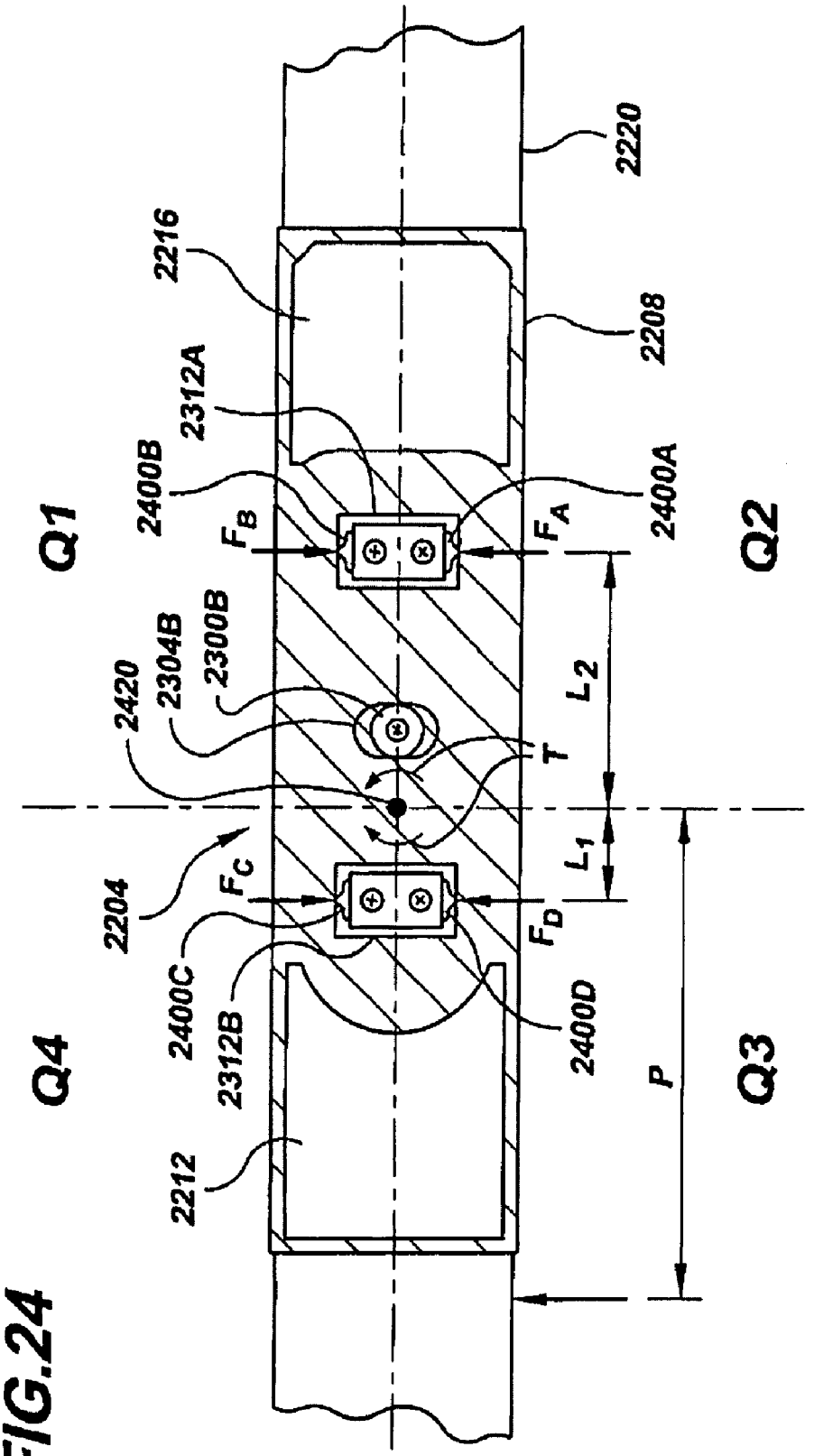

2220
2216
2208
2312A
2400B
2400A
Q1
Q2
F_B
F_A
2304B
2300B
2420
L_2
T
L_1
2204
F_C
F_D
2400C
2400D
2312B
Q4
Q3
P
2212

FIG.24

ALPINE SKI BINDING SYSTEM HAVING RELEASE LOGIC FOR INHIBITING ANTERIOR CRUCIATE LIGAMENT INJURY

RELATED APPLICATION DATA

This application claims the benefit of priority of U.S. Provisional Patent Application Ser. No. 60/836,454, filed Aug. 8, 2006, and titled "Knee-Friendly Ski Binding," which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention generally relates to the field of alpine ski bindings. In particular, the present invention is directed to an alpine ski binding system having release logic for inhibiting anterior cruciate ligament injury.

BACKGROUND

Sprains and other injuries of the anterior cruciate ligament (ACL) of the human knee are painful, debilitating, and expensive and time consuming to repair and rehabilitate. In skiing, the incidence of ACL injury began to rise in the late 1970s to become the sport's most common serious injury by the late 1980s. Since the early to mid 1990s the risk of sustaining this injury has stabilized and then declined modestly. However, at 15% to 20% of all ski-related injuries, it still remains the most common injury, with more than 20,000 per year in the U.S. alone. From 1983 on, changes in the incidence of ACL injury have been tracked by a series of "Trends" papers published as Special Technical Publications (STPs) by the American Society for Testing and Materials (ASTM).

In October, 1995, the American Journal of Sports Medicine published a paper titled "A Method To Help Reduce The Risk Of Serious Knee Sprains Incurred In Alpine Skiing." The paper documented the results of a training program for on-slope ski-area employees at 20 ski areas in the U.S. and compared injury rates for the group with both a historical control group (the same ski areas for the two prior seasons) and an ad hoc control group of 20 ski areas that had not yet joined the training regime. The training involved a highly structured, video-based discussion format. Actual footage of ACL injuries was used to create a kinesthetic awareness of the events leading to the most common types of ACL injury. The program reported a 62% reduction in ACL injuries overall, and for ski patrollers, the highest risk subgroup, the reduction was 76%. This program identified the "phantom foot" scenario as the most likely mechanism of ACL injury. In this scenario the skier is off-balance to the rear with most of the weight on the downhill (outside) ski.

In later studies published in ASTM STPs, it was shown that the equipment associated with ACL injuries was comparable in quality and overall release performance to the equipment of the general population at risk but superior in every quality to equipment associated with sprains and fractures below the knee. These studies show that contemporary ski bindings, regardless of their condition, are not capable of reducing the risk of ACL injuries.

SUMMARY OF THE DISCLOSURE

One aspect of the present invention is a ski binding configured to be secured to a snow ski and selectively retain a ski boot having a heel and a toe and worn by a skier having a tibial axis, the snow ski having a first-quadrant edge, a second-quadrant edge, a third-quadrant edge, a fourth-quadrant edge and a trailing end, the ski binding comprising: a heel piece for releasably engaging the heel of the ski boot; a toe piece for releasably engaging the toe of the ski boot, wherein the toe piece and the heel piece provide the ski binding with a non-attenuated release torque about the tibial axis of the skier when: the ski binding is mounted to the snow ski; the skier is wearing the ski boot; and the ski boot is properly captured in the ski binding; and release logic providing the ski binding with an attenuated release torque about the tibial axis in response substantially only to a lateral shear force being applied to the snow ski at a location along the third-quadrant edge.

Another aspect of the present invention is a ski binding system configured to be secured to a snow ski and selectively retain a ski boot having a heel and a toe and worn by a skier having a tibial axis, the snow ski having a first-quadrant, a second-quadrant, a third-quadrant, a fourth-quadrant and a trailing end, the ski binding system comprising: an attenuated release logic mechanism for being secured to the snow ski and being configured to fixedly receive a heel piece and a toe piece, the attenuated logic mechanism including: a secondary toe release for providing, when the ski binding system is secured to the snow ski, the heel and toe pieces are fixedly secured to the attenuated release logic mechanism, and the ski boot is properly engaged between the heel and toe pieces: an attenuated release in response to lateral shear loads applied to the snow ski in the third-quadrant of the snow ski; and a non-attenuated release in response to lateral shear forces applied to the snow ski in the fourth-quadrant of the snow ski; a trigger operatively configured, when the ski binding system is secured to the snow ski, to trigger the secondary toe release to switch from the non-attenuated release to the attenuated release in responses to a triggering third-quadrant shear force.

Still another aspect of the present invention is a method of releasing a ski boot from an alpine ski binding system, comprising: sensing lateral shear forces applied to a snow ski having a first-quadrant, a second-quadrant, a third-quadrant and a fourth-quadrant; determining when a virtual net shear force present in the third-quadrant exceeds a threshold value; in response to the net virtual shear force applied to the snow ski in the third-quadrant exceeds the threshold value, triggering a secondary toe release; and releasing via the secondary toe release the ski boot from the binding system.

BRIEF DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, the drawings show aspects of one or more embodiments of the invention. However, it should be understood that the present invention is not limited to the precise arrangements and instrumentalities shown in the drawings, wherein:

FIG. **1** is a partial top view of a conventional left-leg ski illustrating conventions used in the present disclosure;

FIG. **2** is a graph of a theoretical release envelope, as seen relative to the tibial axis of a skier's leg, illustrating release/retention characteristics typical of a contemporary conventional ski binding having a binding pivot point located between the heel piece and the tibial axis of the skier's leg;

FIG. **3** is a graph of a theoretical release envelope, as seen relative to the tibial axis of a skier's leg, illustrating release/retention characteristics typical of a contemporary conventional ski binding having a binding pivot point located between the tibial axis of the skier's leg and the toe of the ski boot;

FIG. **4** is a graph of a theoretical release envelope, as seen relative to the tibial axis of a skier's leg, illustrating release/retention characteristics typical of a contemporary conven-

tional ski binding having a binding pivot point located forward of the toe of the ski boot;

FIG. **5** is graph of a theoretical release envelope, as seen relative to the tibial axis of a skier's leg, illustrating release/retention characteristics typical of a ski binding system having a third-quadrant attenuated secondary toe release;

FIG. **6** is a top view/diagrammatic view of an exemplary ski system having the theoretical release envelope of FIG. **5**;

FIG. **7** is a graph of the release threshold for the secondary release mode of the binding system of FIG. **6**;

FIG. **8** is a graph of the attenuation factor for the secondary release torque and trigger platform trip torque for the binding system of FIG. **6**;

FIG. **9**A is an isometric partial top view of a ski system that includes a third-quadrant release-logic mechanism of the present disclosure mounted to a left-leg ski, showing the mechanism in an unreleased state; FIG. **9**B is an isometric partial top view (rotated 180° relative to FIG. **9**A) of the third-quadrant release-logic mechanism of FIG. **9**A with the boot sole and the heel and toe pieces removed for clarity;

FIG. **10**A is an isometric partial top view of the ski system of FIG. **9**A showing the third-quadrant release-logic mechanism in a released state; FIG. **10**B is an isometric partial top view (rotated 180° relative to FIG. **10**A) of the third-quadrant release-logic mechanism of FIG. **10**A with the boot sole and the heel and toe pieces removed for clarity;

FIG. **11** is an enlarged plan view of the ski system of FIGS. **9**A-**10**B showing the upper surface of the ski and the trigger platform (and the secondary toe release) removed and placed upside-down next to the ski so as to illustrate exemplary components that may be used to make the third-quadrant release-logic mechanism work;

FIG. **12** is an isometric partial top view of a second embodiment of a ski system that includes a third-quadrant release-logic mechanism of the present disclosure mounted to a right-leg ski, showing the mechanism in an unreleased state;

FIG. **13** is an isometric partial top view of a second embodiment of the ski system of FIG. **12** showing the third-quadrant release-logic mechanism in a released state;

FIG. **14** is an isometric exploded partial view of a second embodiment of the ski system of FIGS. **12** and **13** showing the various components of the system;

FIG. **15** is a bottom view of a second embodiment of the third-quadrant release-logic mechanism of FIG. **12** with bottom plates removed to illustrate the state of components of the mechanism when the mechanism is in its unreleased state;

FIG. **16** is a bottom view of a second embodiment of the third-quadrant release-logic mechanism of FIG. **13** with bottom plates removed to illustrate the state of components of the mechanism when the mechanism is in its released state;

FIG. **17** is an isometric top view of a boot sole and a dual-release-threshold toe assembly that can be substituted for the secondary to release mechanisms of FIGS. **3**A-**5** and FIGS. **12**-**16**, respectively;

FIG. **18** is an isometric bottom view of the base of the toe assembly of FIG. **17** showing the actuator in its unreleased position;

FIG. **19** is an isometric bottom view of the base of the toe assembly of FIG. **17** showing the actuator in a released position;

FIG. **20** is an isometric top view of the toe assembly showing the housing, toe retainer and toe retainer studs removed, illustrating the unreleased state of the toe assembly;

FIG. **21** is an isometric top view of the toe assembly showing the housing, toe retainer and toe retainer studs removed, illustrating the unreleased state of the toe assembly;

FIG. **22** is an isometric partial top view of a ski system that includes an electronic third-quadrant release-logic binding system;

FIG. **23** is an isometric bottom view of the electronic third-quadrant release-logic binding system of FIG. **22**; and

FIG. **24** is a partial top view/cross-sectional view/diagrammatic view of the electronic third-quadrant release-logic binding system of FIGS. **22** and **23** illustrating the operation of the binding.

DETAILED DESCRIPTION

The present disclosure is directed to an alpine ski binding system having release logic configured to have an attenuated release torque when a shear force is applied to the medial side of the ski, rearward of the tibial axis of the leg of a skier. As discussed below, this region is denoted for convenience "quadrant **3**," "Q**3**," "third quadrant," or a like term. During skiing maneuvers there are many lateral shear forces acting simultaneously along the physical edge of the ski as well as inertial forces between the various masses of the skier and his equipment that generate lateral shear forces between the boot and binding. All these lateral shear forces can be resolved to one virtual force at one location along a virtual, infinitely long, ski plus a couple (pure torque). In the discussion below any references to "shear force" are meant to describe this virtual force acting on a virtual ski. As mentioned in the Background section above, it is believed that certain third-quadrant loadings, when applied to skiers' legs via current generation bindings, are frequently implicated in injuries to the skiers' anterior cruciate ligaments (ACLs). The studies cited in the Background section above, careful analysis of video footage of skiers as ACL injuries occurred, tests of contemporary release bindings, results of skier strength in near ACL postures and measurements of the loads applied to a ski during actual skiing maneuvers have led the present inventors to develop a computer model for a ski binding with selective release characteristics and working prototypes of several examples of the underlying principles of the present disclosure, which are discussed below. The computer model uses a coordinate system based on FIG. X1.4 of the Appendix to ASTM Test Method F504 and creates a partial release envelope as described in that Appendix. (ASTM Test Method F504 and its Appendix are incorporated herein by reference in their entireties.) Using the computer model, the present inventors can shape the release envelope to accommodate the retention requirements of skiers so that a narrow but predictable margin of retention is provided in the area of the envelope associated with the most common mechanism of ACL injury.

An alpine ski binding system of the present disclosure provides a reduced retention in areas of the release envelope that may influence ACL injury. Such a binding system creates a depression in the portion of the release envelope most likely to be associated with ACL injury. The location of the depression and the magnitude of its effect are adjustable, as described in more detail below. To the best of the present inventors' knowledge, no one has yet devised a binding having release logic designed to provide a reduced release threshold (relative to contemporary conventional bindings that have a fixed release threshold regardless of the location of the shear load on the ski) only when the net shear force on the ski resolves to a load in the third quadrant. With such a reduced third-quadrant release threshold, a binding made in accordance with the present disclosure can advantageously release before a skier's ACL is put at risk of injury. As seen below, such release threshold logic may be implemented in a number of ways using various mechanisms and/or electronics. In

addition, with these mechanisms and/or electronics, the release envelope for third-quadrant loadings can be shaped to accommodate the retention requirements of skiers so that a narrow but predictable margin of retention is provided in the area of the envelope associated with the most common mechanism of ACL injury. However, prior to describing several ski binding systems that include unique release-threshold logic, it is beneficial to understand the release-threshold profile of most current ski bindings.

Referring now to FIG. **1**, this figure illustrates a naming convention used throughout the following disclosure and in the appended claims. FIG. **1** shows a ski system **100** that includes a left ski **104** having a boot region **108** that receives a ski boot (not shown) during use of the ski. The dark boot region **108** represents the area of ski **104** confronted or overlain by the sole of the ski boot when the boot is properly engaged in a binding (not shown) affixed to the ski. In this figure, the tail end of ski **104** is located out of the view of the figure to the left along longitudinal central axis **112** of the ski, and the leading tip of the ski is located out of the view of the figure and to the right along longitudinal central axis **112**. It should be noted that quadrants **1** and **2** extend to infinity beyond the tip of the ski and quadrants **3** and **4** extend to infinity beyond the tail of the ski. While not shown, those skilled in the art can readily envision the heel and toe pieces of a conventional alpine binding being generally located, respectively, to the immediate left and right of boot region **108**. The location of the longitudinal central axis of a skier's tibia bone (i.e., tibial axis) along ski **104** is represented by dashed line **116**.

For convenience, left ski **104** is parsed into four shear loading quadrants, i.e., quadrants **1** through **4**, with tibial axis **116** and longitudinal central axis **112** demarcating the differing quadrants. Each net resolved lateral shear force (or "virtual" force) (Fy) applied in a corresponding quadrant **120**, **124**, **128**, **132** of ski **104** and the corresponding moment (Mz) this force causes at tibial axis **116** are related by the basic equation, Force times Distance equals Torque. Here, the Force is the net resolved lateral shear force Fy, the Distance is the distance of shear force Fy from tibia axis **116** and the Torque is the tibial moment Mz.

Forces on ski **104** during skiing in each quadrant **1-4** produce a unique combination of force Fy and moment Mz at tibial axis **116**, i.e., on the leg of the skier. A ski binding system made in accordance with the present invention is designed to recognize when loads on a ski are in quadrant **3** and respond by enabling release of the ski binding at a lower than normal release torque, as represented here as tibial moment Mz. In the following FIGS. **2-5**, **7** and **8**, the twisting moment Mz on the leg is expressed in terms of "(%) of Recommended," as defined by section 5 of ASTM standard F939, "Selection of Release Torque Values for Alpine Ski Bindings," which is incorporated herein by reference in relevant part. While only the left ski **104** of a pair of skis is shown, it will be readily appreciated that for consistency of the noted convention, the convention for the right ski (not shown) would be a mirror image of the convention shown for the left ski about a line (not shown) parallel to longitudinal central axis **112** and spaced from the left ski. That is, quadrants **1** and **4** would be located on the outside (lateral side) of the right ski when worn by a skier, and quadrants **2** and **3** would be located on the inside (medial side) of the right ski.

FIG. **2** is a graph **200** of a release envelope **204**A-B, as seen by a skier's leg, of a conventional "toe release" type alpine ski binding having a binding pivot point at the center of the radius of the heel piece, here 6.6 cm behind the tibial axis of the skier. Again, graph **200** is of the type shown in ASTM F504, FIG. X1.4 and relates torque (Mz of FIG. **1**) about the reference axis of the leg (here, tibial axis **116** of FIG. **1**) at release to the position of the single force (Fy of FIG. **1**) on the ski that creates that torque. The "Position" (i.e., the horizontal axis **208**) in FIG. **2**, and in FIGS. **2-5**, **7** and **8**, refers to the virtual position of the single force Fy on an infinitely long ski that replaces all loads on the finite ski and produces the moment Mz. Here, position is measured from the tibial axis of the skier's leg. In the graph **200** of FIG. **2**, as well as in the graphs **300**, **400**, **600** of FIGS. **3**, **4** and **6**, respectively, virtual "position" is plotted from (−)200 cm to +200 cm from the tibial axis, which is located at "0" on the horizontal axes of the corresponding respective graphs. Changes in the tibial moment Mz beyond these distances along the virtual ski are small in comparison to changes within these distances. The relationship of this virtual ski to an actual typical ski can be seen by the representation **212** of a ski placed in proper relation to the tibial axis, with the tail and tip of the ski being indicated by vertical lines **216**, **220**, respectively.

In conventional binding designs, the release envelope of the ski binding about the binding's pivot axis, which in the example is at the center of the heel radius 6.6 cm behind the tibial axis, is symmetrical in all four quadrants Q**1**-Q**4**. However, as seen in FIG. **2** the release torque on the skier's leg as indicated by release envelope portion **204**A is much higher for loads applied to the after body of the ski than release envelope portion **204**B for loads applied to the fore body of the ski. The reason for this difference is the offset (here, 6.6.cm) in the location of the binding pivot axis from the location of the tibial axis. That said, it is readily seen from after-body release envelope portion **204**A that the release envelope is symmetrical for loadings in quadrants Q**3** and Q**4** and from fore-body release envelope **204**B that the release envelope is symmetrical for loadings in quadrants Q**1** and Q**2**.

Whereas FIG. **2** shows graph **200** for a conventional toe release type ski binding, FIGS. **3** and **4** illustrate graphs **300**, **400**, respectively, for two contemporary heel release type ski bindings. In FIG. **3**, the binding has a pivot axis located forward of the tibial axis ("0" on the horizontal axis of graph **300**) but behind the boot toe, and in FIG. **4**, the binding has a pivot axis located forward of the boot toe. As seen from each of envelopes **304**A-B (FIG. **3**) and **404**A-B, the release torques on the leg are symmetrical for after body loadings in quadrants Q**3** and Q**4** and for fore body loadings in quadrants Q**1** and Q**2**. In each of the examples of FIGS. **2-4**, the binding senses the same torque at release with respect to its own pivot axis, while the skier's leg, which has a different reference axis, senses a release torque that is dependent on the position of the load on the ski. It is noted that the foregoing analyses ignore the effects of friction and combined loading that may influence individual bindings in actual skiing.

Each of the above graphs **200**, **300**, **400** of FIGS. **2-4**, respectively, demonstrates a different problem. The toe release type binding of FIG. **2** fails to sense the true load on the skier's leg in quadrant Q**3**. The heel release type binding of FIG. **3** fails to sense the true load on the skier's leg in quadrant Q**1** and Q**2**. Although the binding of FIG. **3** does lower the release threshold in quadrant Q**3**, it does not lower it sufficiently near the tail of the ski, which is the area of greatest risk to the ACL. The other heel release type binding of FIG. **4** demonstrates the same problems as the binding of FIG. **3**. Although it does lower the release threshold in quadrant Q**3** more than the binding of FIG. **3**, the improvement is insufficient. Bindings of this type also lack an adequate margin of retention in response to loads applied to the after body of the ski near the tibial axis.

In contrast to graphs **200**, **300**, **400** of FIGS. **2-4**, respectively, FIG. **5** contains a graph **500** illustrating a release envelope **504**A-D achievable using a ski system made in accordance with the present invention. As seen in FIG. **5**, the ski system is able to distinguish loads applied in quadrant Q**3** and provide an attenuated release (represented by release envelope portion **504**C) relative to the non-attenuated release (represented by release envelop **504**A) relative to loads applied in quadrant Q**4**. As is readily seen by comparing graph **500** to graph **200** of FIG. **2** for a conventional toe release type binding, it is seen that release envelope portions **504**A-B are nearly identical to release envelope **204**A-B of FIG. **2**. In this case, this is so because graph **500** of FIG. **5** is based on a ski system that utilizes the conventional toe release type binding of graph **200** of FIG. **2**. However, it is seen from FIG. **5** that augmentations made to such a conventional binding in the exemplary ski system used to generate graph **500** provide the ski system with an attenuated release envelope portion **504**C for loads in quadrant Q**3**, which appears to be the quadrant most implicated in ACL injury. Release envelope portion **504**D for a small portion of quadrant Q**1** is an artifact of the configuration of the particular ski system used to generate graph **500**. FIG. **6** illustrates an alpine ski system **600** that can be used to achieve release envelope **504**A-D of FIG. **5**.

Referring now to FIG. **6**, and also to FIG. **5**, FIG. **6** shows ski system **600** as including a ski **604** and a binding system **608**. Binding system **608** includes, in this example, a pivotable secondary toe release **612** pivotable about a pivot axis **616** and a pivotable trigger, here a trigger platform **620**, pivotable about a pivot axis **624**. Binding system **608** also includes a toe release type boot binding **628** that includes a heel piece **632** and a toe piece **636** and has a binding pivot axis **640** close to the heel piece. Not shown, but readily envisioned as being captured between heel and toe pieces **632**, **636**, is a ski boot, which may be a conventional ski boot. Also shown for context is the location of the tibial axis **644** of a skier when ski system **600** is properly secured to the skier's boot. Graph **500** of FIG. **5** was created using ski system **600** as a model and using the particular input and calculated values shown in the following table.

Input Values for Example Calculations		
Ski Length	175.0	cm
Ski Tip length	14.0	cm
Ski Tail Length	5.0	cm
Boot Length	30.3	cm
Boot Heel to Binding Pivot	3.5	cm (+ forward – rearward)
Boot Heel to Tibial Axis	10.1	cm (+ forward – rearward)
Boot Toe to Plate pivot	7.5	cm (+ forward – rearward)
Release Torque	100	% of recommended release torque
Plate Trip Torque	80	% of recommended release torque
Release Attenuation	50	% of recommended release torque
Calculated Values:	From tibial axis	
Tail	−72.9	cm
End of running surface	−67.9	cm
Mid running surface	10.1	cm
Boot Heel	−10.1	cm
Boot Toe	20.2	cm
Binding pivot	−6.6	cm
Tibial axis	0.0	cm
Plate pivot	27.7	cm
Start of surface	88.1	cm
Tip	102.1	cm

In ski system **600** of FIG. **6**, distinguishing quadrant Q**3** loads is accomplished by isolating the boot and binding **628** from ski **604** by means of trigger platform **620** that pivots about pivot axis **624** forward of tibial axis **644**. In this example, pivot axis **624** of trigger platform **620** is also located forward of the toe of the ski boot. The performance of binding system **608** is controlled by a number of factors, including the location of the trigger platform pivot axis **624**, the location of the binding pivot axis **640**, the nominal release torque setting, the trigger platform trip torque setting, and the release attenuation setting. Until trigger platform **620** senses the trip torque specified in the table above, binding **628** functions in its primary release mode. However, once the specified trip torque is reached, trigger platform **620** enables an attenuated release when the torque specified in Table 1 is reached (FIG. **5**). Therefore the logic for a secondary release of the present invention requires two criteria to be met before release can take place. For ACL protection, this capability is limited to quadrant Q**3**. Although a small effect is created in quadrant Q**1** (as represented by release envelope portion **504**D of FIG. **5**), it does not cause a retention problem and may in fact reduce excess retention.

The example graph **500** shown in FIG. **5** describes a complex release threshold for quadrant Q**3** with a 50% attenuation in torque sensed by the leg at release over the full length of the after body of the finite ski **604** (FIG. **6**). Beyond that point the complex load on the leg simplifies and approaches a pure couple, a load not associated with the principle mechanism of ACL injury. Therefore, in the example of FIG. **5**, the release threshold is programmed to go asymptotic to the 80% grid line as it approaches infinity (a pure couple).

FIG. **7** is a graph **700** illustrating the secondary release threshold **704** (solid line) provided by ski binding system **608** of FIG. **6**, i.e., the torque sensed by the skier's leg for loads in quadrant Q**3** when the trip torque and attenuated release torque criteria are met. As seen, the secondary release threshold **704** follows a portion of the trip torque profile **708** of trigger platform **620** and a portion of the attenuated release torque profile **712** of secondary toe release **612** (FIG. **6**). Graph **700** demonstrates how binding system **608** makes use of portions of both the heel release type binding of FIG. **4** and the toe release type binding of FIG. **2** in its logic for a secondary release in quadrant Q**3**. FIG. **7** also shows that the release logic of binding system **608** calls for a series, not a parallel solution. This means that the criteria for both actuation of trigger platform **620** and attenuated release of secondary toe release **612** must be met for the attenuated release to take place.

FIG. **8** is a graph **800** that introduces the concept of a retention threshold and various combinations of inputs of the table appearing above. A goal of the process of selecting the attenuated release torque threshold, the trigger platform trip torque, and the locations of the trigger platform and secondary toe release pivot axes **616**, **624** is to provide the lowest practical secondary release threshold in areas of quadrant Q**3** associated with the greatest risk of ACL injury, while providing an appropriate margin of retention in all other areas of the quadrant. Line A in FIG. **8** refers to the example solution shown in FIGS. **5-7** and in the foregoing table, above. It is noted that line B may be a better compromise. Note that the threshold shown in this figure is for example only. As the requirements for retention in quadrant Q**3** are refined, changes will be required to the input values of the foregoing table of inputs and the resulting architecture of an ideal "knee-friendly" binding.

As those skilled in the art will appreciate, the principles outlined above could also be used to modify the release threshold in other quadrants should the need arise.

Whereas FIGS. **5-8** address general concepts of the present invention, the following FIGS. **9A-24** illustrate examples of binding system configurations that can be used to achieve the release logic that provides an attenuated release in response to substantially only loads applied in the third quadrant. Referring now to FIGS. **9A-11**, FIG. **9**A illustrates an alpine ski system **900** made in accordance with the present invention. Ski system **900** includes a left ski **904** and a binding system **908** that includes a third-quadrant release-logic mechanism **912** and heel and toe pieces **916**, **920**, respectively. In this example, heel and toe pieces **916**, **920** are contemporary conventional heel and toe pieces available from manufacturers such as Tyrolia, Marker, Salomon, Atomic, Rossignol, etc. The selection of conventional heel and toe pieces for this example serves to clearly illustrate the general concept of the third-quadrant release logic (here provided by third-quadrant release-logic mechanism **912**) and its relation to current conventional bindings that consist essentially only of heel and toe pieces **916**, **920**. This selection also serves to illustrate that third-quadrant release-logic mechanism **912** could readily be sold as a retrofit component for conventional ski systems or otherwise separately from conventional skis and binding. FIG. **9**A also illustrates, for the sake of context, a ski-boot sole **924** clamped into binding system **908** in a conventional manner between heel and toe pieces **916**, **920**. Third-quadrant release-logic mechanism **912** is essentially configured to change the release-threshold envelope **204**A-B (FIG. **2**) for shear forces applied to ski **904** in the third quadrant.

Referring now to FIG. **9**B, which is similar to FIG. **9**A but shows ski system **900** without ski-boot sole **924** and heel and toe pieces **916**, **920** for the sake of illustration, FIG. **9**B shows two primary components of release-logic mechanism **912**, i.e., a trigger platform **932** and a secondary toe release **936**. Heel piece **916** (FIG. **9**A) is fixedly secured to trigger platform **932**, and toe piece **920** is fixedly secured to secondary toe release **936**. As will be described below in detail, trigger platform **932** is pivotably secured to ski **904** at a pivot point **940** located forward (toward the tip of the ski) of the toe end of ski-boot sole **924** (FIG. **9**A) and, since ski **904** is a left-leg ski, is secured to the ski so as to be pivotable relative to the ski only in a counterclockwise direction from the position shown in FIG. **9**B. For a right-foot ski (not shown), a comparable trigger platform would be secured to the right-foot ski so as to be pivotable only in a clockwise direction. In addition to being pivotable only in the counterclockwise direction, trigger platform **932** is constrainably pivotable in the counterclockwise direction such that a non-zero threshold shear force, which translates into a "trigger trip torque", is needed in the third quadrant before the trigger platform begins to move appreciably and provide its triggering effect. One example of a trigger trip torque mechanism for providing this trigger threshold is an adjustable trip torque mechanism **1100**, described below in connection with FIG. **11**. As discussed below, this trip torque is a function of the location of pivot point **940** relative to tibial axis **942**, as well as the setting of the trip torque mechanism. For the present discussion, however, it is necessary only to understand that trigger platform **932** is constrainably pivotable only in the counterclockwise direction. Otherwise, trigger platform **932** is secured to ski **904** so that substantially no movement occurs between these two components in a direction normal to the width of the ski.

Secondary toe release **936** is secured to trigger platform **932** so as to be constrainably pivotable about a pivot point **944** located between the toe end of ski-boot sole **924** (FIG. **9**A) and pivot point **940** of the trigger platform and to be pivotable substantially only in a clockwise direction relative to the trigger platform from the position shown in FIG. **9**B. Third-quadrant release-logic mechanism **912** also includes an attenuated release threshold mechanism, such as adjustable release threshold mechanism **1104** of FIG. **11**, that provides secondary toe release **936** with a constrained pivoting action. The resistance torque of secondary toe release **936** caused by the secondary-release threshold mechanism is referred to herein as "attenuated release torque." When trigger platform **932** is in a non-triggering position, such as shown in FIG. **9**B, secondary toe release **936** is held in the unreleased position shown in FIG. **9**B by a triggerable latch mechanism, such as latch mechanism **948**. Latch mechanism **948** includes a latch **952** pivotably secured to trigger platform **932** at a pivot point **956**. Latch **952** includes an opening **960** (FIG. **10**B) that receives a pin **964** (FIG. **10**B), which is fixed relative to ski **904**. In the unreleased position of secondary toe release **936** shown, latch **952** engages a catch **968** that is fixed to the secondary toe release.

When trigger platform **932** pivots counterclockwise relative to ski **904** in response, for example, to a threshold-exceeding torque in response to a shear force in the third quadrant (see FIG. **1**), latch **952** and its pivot point **956** (which is fixed relative to the trigger platform) move, thereby causing stationary pin **964** (FIG. **10**B) to pivot the latch about its pivot point and cause the distal end **972** of the latch to move out of engagement with catch **968** on secondary toe release **936**. With distal end **972** of latch **952** out of the way, secondary toe release **936** is free to pivot in response to a torque exceeding the secondary release torque clockwise relative to trigger platform **932**, thereby releasing ski-boot sole **924** (FIG. **9**A) from binding system **908** (FIG. **9**A). If desired, secondary toe release **936** may be provided with a secondary catch **976** for engaging distal end **972** of latch **952** when third-quadrant release-logic mechanism **912** is in a released state so as to limit the pivoting of the secondary toe release. FIGS. **10**A-B each show third-quadrant release-logic mechanism **912** in a released state **1000**, with trigger platform **932** pivoted counterclockwise relative to ski **904**, latch **952** pivoted counterclockwise out of engagement with catch **968** and secondary toe release **936** pivoted clockwise relative to the trigger platform. Again, this released state **1000** is substantially only achieved from the unreleased state upon application of a shear force to the third-quadrant of ski **904** that exceeds both the trip plate trigger torque and the secondary toe release torque.

Referring now to FIG. **11**, it was mentioned above that trigger platform Q**332** is secured to ski **904** so as to be constrainably pivotable about pivot point **940**. FIG. **11** illustrates examples of mechanisms that can be used to provide this type of securement. In this example, trigger platform **932** is fastened to ski **904** by a threaded fastener **1104** that threadedly engages a matching threaded opening **1108** in the ski. The engagement of fastener **1104** with trigger platform **932** and ski **904** is such that when the trigger platform is properly secured to the ski it is substantially freely pivotable about pivot point **940** but constrained from moving away from the upper surface **1110** of the ski. In other embodiments, a fastener other than a threaded fastener may be used. In addition, if desired, a torsion mechanism (not shown) or other pivot-constraining connection may be provided to provide a desired amount of resistance to pivoting.

Trigger platform **932** is also held down by a sliding hold-down mechanism **1112** that, when the trigger platform is properly installed on ski **904**, allows the trigger platform to pivot about pivot point **940** but not substantially move away from upper surface **1110** of the ski. In this example, hold-

down mechanism **1112** includes a slidable hold-down **1116** that is fixedly secured to ski **904**, for example, using a threaded fastener **1120**. Hold-down **1116** is movable within a generally T-shaped slot **1124** on trigger platform **932** that is preferably, but not necessarily, sized to limit the range of pivot of the trigger platform. The T-shape of slot **1124** generally conformally receives the combination of hold-down **1116** and fastener **1120** that largely forms a like T-shape. To reduce friction, ski **904** may be provided with a low-friction bearing plate **1128** and/or trigger platform **932** may be provided with one or more low-friction bearings **1132**.

As mentioned, the resistance to pivoting of trigger platform **932** relative to ski **904** that provides the trigger platform with a trigger trip torque threshold is provided by adjustable trip torque mechanism **1100**. In this example, trip torque mechanism **1100** includes a fixed screw-guide bracket **1140** that is fixedly secured to ski **904**, for example, using a threaded fastener **1144**. Screw-guide bracket **1140** receives an adjustment screw **1148** in a manner that secures the adjustment screw to the bracket, but allows it to rotate freely in a non-threaded way. A rectangular threaded adjustment nut **1152** is threadedly engaged with adjustment screw **1148** so that when the trigger platform is properly secured to ski **904** and the adjustment screw is turned, the adjustment nut moves longitudinally along the screw (the rotation of the adjustment nut is inhibited by its engagement with the underside of the trigger platform). A spring, here a coil spring **1156**, is provided between fixed screw-guide bracket **1140** and threaded adjustment nut **1152** such that the spring can be selectively compressed/decompressed by turning adjustment screw **1148** so that the adjustment nut moves closer to or farther away from the screw-guide bracket. With this trip torque mechanism **1100**, when trigger platform **932** is properly secured to ski **904**, it can be seen that the trip torque threshold of the trigger platform can be increased by turning adjustment screw **1148** so that adjustment nut **1152** further compresses spring **1156**, and, conversely, the trigger threshold of the trigger platform can be decreased by turning the adjustment screw so that the adjustment nut moves away from screw-guide bracket **1140** and decompresses the spring. In other embodiments, other trigger trip torque adjusting mechanisms may be provided by those having ordinary skill in the art without undue experimentation using the present disclosure as a guide.

As mentioned above, secondary toe release **936** is secured to trigger platform **932** so that it is pivotable about pivot point **944** in a constrained manner. In this example, secondary toe release **936** is secured to trigger platform **932** using a locking nut/bolt combination **1160** at pivot point **944** and a sliding hold-down mechanism **1164** spaced from pivot point **940**. Sliding hold down mechanism **1164** includes a slidable hold-down **1168** that is fixedly secured to secondary toe release **936** through a slot **1172** in trigger platform **932** using a suitable fastener **1176**. Hold-down **1168** is wider than slot **1172**, and fastener **1176** is tightened to the point that movement of the secondary toe release away from the trigger platform is substantially constrained, but not to the point that the secondary toe release cannot pivot substantially freely.

Similar to trigger platform **932** relative to ski **904**, secondary toe release **936** is provided with adjustable attenuated release threshold mechanism **1104** that allows a user to set a desired resistance to pivoting of the secondary toe release relative to the trigger platform. In this example, adjustable attenuated release threshold mechanism **1104** includes a screw-guide bracket **1182** fixed to secondary toe release **936** through a slot **1184** in trigger platform **932**. Screw-guide bracket **1182** receives an adjustment screw **1186** in a manner that secures the adjustment screw to the bracket, but allows it to rotate freely in a non-threaded way. A rectangular threaded adjustment nut **1188** is threadedly engaged with adjustment screw **1186** so that the adjustment nut moves longitudinally along the screw (the rotation of the adjustment nut is inhibited by its engagement with the underside of the trigger platform). A spring, here a coil spring **1190**, is provided between fixed screw-guide bracket **1182** and threaded adjustment nut **1188** such that the spring can be selectively compressed/decompressed by turning adjustment screw **1186** so that the adjustment nut moves closer to or farther away from the screw-guide bracket. With this adjustable attenuated release threshold mechanism **1104**, it can be seen that the pivot-resistance of secondary toe release **936** can be increased by turning adjustment screw **1186** so that adjustment nut **1188** further compresses spring **1190**, and, conversely, the pivot-resistance of the secondary toe release can be decreased by turning the adjustment screw so that the adjustment nut moves away from screw-guide bracket **1182** and decompresses the spring. In other embodiments, other attenuated release threshold-adjusting mechanisms may be provided by those having ordinary skill in the art without undue experimentation using the present disclosure as a guide.

Those skilled in the art will readily appreciate that the embodiment of FIGS. **9A-11** is merely one example of release logic that provides an attenuated release envelope for shear forces applied in the third quadrant. Following are descriptions of three additional examples to illustrate this point. As will be seen in reviewing these additional examples, there are a number of ways to implement the differing aspects of the release logic, such as the implementation of the trigger and the setting of the trigger trip torque, and the implementation of the secondary toe release and the setting of attenuated-release threshold, among other things.

Turning now to the first of the additional examples, FIGS. **12** and **13** each show an alpine ski system **1200** generally similar to ski system **900** of FIGS. **9A-11** in that it includes a ski **1204**, a third-quadrant release-logic mechanism **1208** mounted to the ski and heel and toe pieces **1212**, **1216** mounted to the third-quadrant release-logic mechanism. Similar to ski system **900** of FIGS. **9A-11**, heel and toe pieces **1212**, **1216** of FIGS. **12** and **13** may be any suitable alpine heel and toe pieces, if desired. FIG. **12** shows third-quadrant release-logic mechanism **1208** in an unreleased state, and FIG. **13** shows the third-quadrant release-logic mechanism in a released state. As described below, third-quadrant release-logic mechanism **1208** includes a trigger **1220** that is generally similar to the trigger mechanism of ski system **900**, above. Heel piece **1212** is secured to an elongate trigger assembly **1224** near the trailing end of the assembly, and similarly to ski system **900** of FIGS. **9A-11**, toe piece **1216** is secured to a pivoting secondary toe release **1228**. A conventional standard boot sole **1232** is shown for context. As readily seen in FIG. **13**, ski system **1200** is set up for the right leg of a skier since the pivoting of the toe **1236** of boot sole **1232** is clockwise in response to a shear force being applied to ski **1204** in the third quadrant. FIGS. **14-16** show details of the various components of third-quadrant release-logic mechanism **1208** that provide the attenuated release of toe **1236** of boot sole **1232** in response to only loads in the third quadrant.

Referring now to FIG. **14**, this figure illustrates the various components of third-quadrant release-logic mechanism **1208**. Major components of third-quadrant release-logic mechanism **1208** include: rearward and forward lower mounting plates **1400**, **1404**; rearward and forward upper mounting plates **1408**, **1412**; a trigger mechanism **1416**; a trigger trip torque mechanism **1420**; a secondary toe release mechanism **1424**, an attenuated release threshold mechanism

1428 and a heel piece mounting plate 1432. As seen in FIGS. 12 and 13, heel piece 1212 is fixedly secured to heel piece mounting plate 1432 and toe piece 1216 is fixedly secured to a toe piece mounting plate 1240 of secondary toe release mechanism 1424. Referring again to FIG. 14, forward upper and lower mounting plates 1412, 1404 are fixedly secured to ski 1204 using suitable fasteners 1436. Trigger 1220 includes a pivotable, flexible (in a direction normal to the upper surface of ski) trigger member 1440, which is captured between forward upper and lower mounting plates 1412, 1404 so as to be slightly pivotable about a pivot axis 1444 normal to upper surface of ski 1204.

Secondary toe release mechanism 1424 includes in addition to toe piece mounting plate 1240 a pivotable latch 1448 that is captured between trigger member 1440 and forward lower mounting plate 1404. Toe piece mounting plate 1240 is fixedly secured to latch 1448 and, for the purpose discussed below, the composite of these components is pivotably secured to trigger member 1440 about a pivot pin 1452 so that the toe piece mounting plate and latch (and toe piece 1216 (FIG. 12)) pivot in unison under a release condition. The attenuated release threshold for pivoting action of these components is provided by attenuated release threshold mechanism 1428, which includes a housing 1456 fixedly secured to trigger member 1440 with screws 1460 and a movable cam 1464 and spring 1468 located in the housing. Cam 1464 engages a cam follower 1470 on pivotable latch 1448. The attenuated release threshold is set using an adjustment screw 1472, which adjusts the length of spring 1468, and therefore the force applied by cam 1464 to cam follower 1470. In the unreleased state of third-quadrant release-logic mechanism 1208, latch 1448 is securely engaged with a catch 1474, which as described below, is seated in a groove 1500 (FIG. 15) in trigger member 1440 that inhibits its lateral movement relative to the trigger member, but, as described below in detail, allows it to move longitudinally relative to the trigger member as a result of its interaction with a pin 1476 that is fixed relative to forward upper and lower mounting plates 1412, 1404. When latch 1448 is securely engaged with catch 1474, the attenuated release of secondary toe release 1228 is not active and toe piece 1216 (FIG. 12) functions as it would in a conventional ski system.

Rearward upper and lower mounting plates 1408, 1400 are secured to ski 1204 using suitable fasteners 1480 and capture the rear end of trigger member 1440 therebetween. Heel piece mounting plate 1432 is fixedly secured to trigger member 1440 so that they pivot in unison with one another about pivot point 1444 of the trigger member when permitted by trigger trip torque mechanism 1420. In general, it is the lateral loads from heel piece 1212 (FIG. 12) that are the input to trigger mechanism 1420. A pair of low friction members 1481 that engage a corresponding respective pair of grooves 1482 in trigger member 1440 are provided to reduce the amount of frictional resistance between rearward upper mounting plate 1408 and the trigger member during pivoting of the trigger member.

Trigger trip torque mechanism 1420 is fixedly secured to ski 1204 via rearward upper and lower mounting plates 1408, 1400 and includes a housing 1484, a T-shaped resistance toggle 1486, a spring 1488 and an adjustment screw 1490. Spring 1488 biases toggle 1486 into engagement with a pair of fulcrum pins 1492A-B that are fixed relative to housing 1484. Toggle 1486 includes a lever arm 1494 that engages a notch 1496 in trigger member 1440. As will be described below in more detail, as trigger member 1440 pivots it applies a force to lever arm 1494 of toggle 1486 that works against the biasing force applied to the trigger by spring 1488 as the toggle pivots about the appropriate one of fulcrum pins 1492A-B. A locking pin 1498 (FIG. 15) is provided so as to capture toggle 1486 between it and one of fulcrum pins 1492A-B so as to inhibit the toggle from pivoting about the other fulcrum pin. By switching the location of locking pin 1498 (FIG. 15), trigger mechanism 1416 can be set up for either a left-leg ski or a right-leg ski (the right-leg setup being shown). When changing the location of locking pin 1498 (FIG. 15), catch 1474 must also be flipped to change the pivot direction of secondary toe release 1228. This should become apparent from the following description of the working of third-quadrant release-logic mechanism 1208 relative to FIGS. 15 and 16.

Referring now to FIGS. 15 and 16, which are "upside down" views of third-quadrant release-logic mechanism 1208 relative to FIGS. 12-14, FIG. 15 shows the third-quadrant release-logic mechanism in its unreleased state, and FIG. 16 shows the mechanism in an attenuated release state caused by a triggering shear force in the third quadrant of ski 1204 (FIGS. 12-14). In FIG. 15, the longitudinal centerline 1504 of trigger member 1440 is aligned with the longitudinal centerline 1508 of the ski, latch 1448 of secondary toe release mechanism 1424 is securely engaged with catch 1474. Consequently, secondary toe release 1228 is securely held by catch 1474 from pivotably releasing. In this state, heel and toe pieces 1212, 1216 (FIGS. 12 and 13) act in the same manner they would if affixed to a ski in a conventional manner. Note the location of locking pin 1498 of trigger trip torque mechanism 1420. In this example, it is located so that trigger member 1440 can pivot only in a counterclockwise direction about pivot axis 1444. Therefore, any shear loads applied in the second and fourth quadrants will not allow trigger mechanism 1416 to trigger. However, when a shear load is applied to ski 1204 (FIGS. 12 and 13) in the third quadrant, and is counteracted in part by a force applied through heel piece mounting plate 1432, this shear force causes trigger member 1440 to apply a toggling force to lever arm 1494 of toggle 1486. Once this toggling force overcomes the resistance and preload of the spring 1488, trigger member 1440 will pivot about pivot axis 1444, as illustrated in FIG. 16, albeit by a relatively small angle α relative to the ski's longitudinal axis 1504.

Since catch 1474 is laterally captured in groove 1500 in trigger member 1440, this pivoting of the trigger member causes the catch to move and interact with fixed pin 1476 that is fixed relative to ski 1204 (FIGS. 12-14) via forward upper and lower mounting plates 1412, 1404 (FIG. 14). This interaction with fixed pin 1476 moves catch 1474 just enough for latch 1448 to disengage the catch. With latch 1448 disengaged from catch 1474, it can pivot about pivot pin 1452 once the force applied to toe piece mounting plate 1240 from toe 1236 of boot sole 1232 (FIGS. 12 and 13) is large enough to overcome the attenuated release threshold bias of spring 1468 of attenuated release threshold mechanism 1428. After the attenuated secondary release has occurred, trigger mechanism 1416 and secondary toe release mechanism 1424 automatically return to their unreleased states. It is noted that the shape of catch 1474 is such that latch 1448 can pivot only clockwise when secondary toe release mechanism 1424 has been triggered and is in a released state. As mentioned above, a right-leg ski setup can be switched to a left-leg setup by flipping catch 1474 generally about longitudinal axis 1508 of trigger member 1440 and by switching the location of locking pin 1498 of trigger trip torque mechanism 1420.

While third-quadrant release-logic mechanisms 912, 1208 of FIGS. 9A-11 and FIGS. 12-16, respectively, are similar in the context of the ability to utilize conventional heel and toe pieces, the second of the additional examples illustrated in

FIGS. **17-21** utilizes a unique toe assembly **1700** (FIG. **17**) that provides the secondary toe release and the adjustable attenuated release threshold without the need for the pivotable secondary release plate. In addition to toe assembly **1700**, FIG. **17** shows a conventional standard boot sole **1704** having its toe **1708** engaged with the toe assembly. Referring to FIGS. **12** and **14**, toe assembly **1200** of FIG. **17** replaces both of secondary toe release mechanism **1424** and attenuated release threshold mechanism **1428**, but can be used, if desired, with a trigger mechanism and trigger trip torque mechanism substantially similar to, respectively, trigger mechanism **1416** and trigger trip torque mechanism **1420** of FIGS. **12** and **14**. Modifications to third-quadrant release-logic mechanism **1208** of FIGS. **12** and **14** to accommodate toe assembly **1700** of FIG. **17** would include removing the pivotable toe piece mounting plate **1240** and latch **1448**, removing attenuated release threshold mechanism **1428** and removing catch **1474**. Then, toe assembly **1700** of FIG. **17** would be fixedly secured to forward upper mounting plate **1412**. As seen in FIGS. **18** and **19**, toe assembly **1700** of FIG. **17** includes a movable actuator **1800** that is guidably movable within an L-shaped slot **1804** formed in a base **1808** of the toe assembly. Actuator **1800** is movable both pivotably about the longitudinal centerline **1812** of an adjustment screw **1816** and translationably in a direction parallel with longitudinal centerline **1812**. It is this movable actuator **1800** that trigger member **1440** (FIG. **14**) would pivot above longitudinal centerline **1812**. For reasons that might not be apparent until after reading the following description, trigger member **1440** would need to be slotted substantially along its longitudinal axis (**1504**, FIG. **15**) to allow the actuator to translate along longitudinal centerline **1812** of adjustment screw **1816**. Otherwise, the trigger member and trigger trip torque mechanism for toe assembly **1700** may be the same as shown in FIG. **14**. Those skilled in the art will readily appreciate that third-quadrant release-logic mechanism **912** of FIGS. **9A-11** may also be modified in a similar manner. In addition, it is noted that the trigger for toe assembly **1700** of FIG. **17** may be of some other type, such as an electronic trigger that is responsive to input from, e.g., one or more force, displacement and/or acceleration transducers.

Referring to FIGS. **17**, **20** and **21**, in addition to base **1808**, actuator **1800** and adjustment screw **1816**, toe assembly **1700** includes a toe retainer **1712** movably secured to the base, for example, by a pair of studs **1716**A-B. Toe retainer **1712** includes a pair of L-shaped slots **1720**A-B that, under the right loading conditions, allows the toe retainer to pivot either clockwise or counterclockwise so as to release toe **1708** of boot sole **1704**. Toe retainer **1712** is biased into engagement with studs **1716**A-B by a force-applying member, such as housing **1724**, that is movable relative to base **1808** and that, in turn is biased by either one or both of springs **2000**, **2004** (FIGS. **20** and **21**) located within the housing, depending on whether or not toe assembly **1700** is in its unreleased or released state.

Referring to FIGS. **20** and **21**, adjustment screw **1816** has a left-hand thread region **2008** and a right-hand thread region **2012**, with actuator **1800** located between these two regions. Each of the left- and right-hand thread regions **2008**, **2012** is threadedly engaged by a corresponding movable stop **2016**, **2020** that moves in an opposite direction from the other when adjustment screw **1816** is turned. In this manner, either both springs **2000**, **2004** are being compressed or both springs are being decompressed, depending on which direction adjustment screw **1816** is turned. Actuator **1800** is not threadedly engaged with adjustment screw **1816**. Rather, adjustment screw **1816** is free to rotate within an unthreaded opening in actuator **1800**. However, actuator **1800** is substantially fixed from moving along longitudinal centerline **1812** of adjustment screw **1816** using, in this example, a C-clip **2024**A-B on either side of the actuator that engages a corresponding groove **2028**A-B (only groove **2028**A can be seen) in the adjustment screw.

Consequently, and referring to FIGS. **17-21**, toe assembly **1700** operates as follows to provide a "normal" release (i.e., a release akin to the release of a conventional binding secured to a ski in a conventional manner) and an attenuated release in response to a suitable shear loading in the third quadrant. With actuator **1800** in its unreleased position, i.e., locked in the transverse portion **1820** of slot **1804** as shown in FIGS. **18** and **20**, only spring **2000** is active in biasing housing **1724** against toe retainer **1812**. Therefore, the force applied to toe retainer **1812** is equal to the spring constant of spring **2000** multiplied by the compression of this spring. However, when actuator **1800** is triggered and moved into its released position in the longitudinal portion **1900** (FIG. **19**) of slot **1804** in base **1808** as shown in FIGS. **19** and **21**, housing **1724** is now biased by both springs **2000**, **2004** (assuming the longitudinal portion of slot **1804** is long enough to not interfere with activation of the second spring **2004**). If springs **2000**, **2004** have equal spring rates and are compressed the same amount, the effective force of housing **1724** on toe retainer **1712** remains the same as before but the combined spring rate is halved in this example. Of course, the spring constants, compression distances and other variables will be selected so that both the unreleased and attenuated release forces housing **1724** applies to toe retainer **1712** will be selected to achieve the desired results, which in the context of the present invention includes inhibiting ACL injuries. Referring to FIG. **18**, it is noted that the right-leg set up of toe assembly **1700** (FIG. **17**) can be changed to a left-leg setup by locating longitudinal portion **1900** (FIG. **19**) of slot **1804** in base **1808** on the other side of transverse portion **1820**.

Whereas the embodiments of FIGS. **9A-21** are generally purely mechanical in nature, the third-quadrant release logic described above in connection with FIGS. **1** and **5-9** can be implemented electronically using either a digital controller or an analog controller, or a combination of both. FIGS. **22-24** illustrate one example of a ski system **2200** that includes an electronic third-quadrant release-logic binding system **2204**. Referring first to FIGS. **22** and **23**, binding system **2204** includes a base **2208** that supports heel and toe pieces **2212**, **2216**. For context, a conventional ski boot sole **2218** is shown being clamped between heel and toe pieces **2212**, **2216** as it would during an unreleased state of electronic binding system **2204**. Base **2208** is secured to a ski **2220** so as to be substantially fixed in the fore and aft direction relative to the ski and also substantially fixed in a direction normal to the upper surface **2224** of the ski. However, base **2208** is secured to ski **2220** so as to be movable laterally relative to ski. In this example, base **2208** is secured using three studs **2300**A-C that are fixed to ski **2220** and engage corresponding respective slots **2304**A-C in the base. As those skilled in the art will appreciate, in this example studs **2304**A, **2304**C include a head (not shown) that engages base **2208** in a manner that inhibits movement of the base in a direction normal to upper surface **2224** of ski **2220**.

Electronic binding system **2204** also includes at least two sensors for sensing information regarding the lateral (shear) forces being transmitted between base **2208** and ski **2220** at two distinct locations along the longitudinal axis of the ski. In this example, such sensors are two pairs of load cells **2400**A-D (FIG. **24**) that are fixed to ski **2200** by corresponding load cell supports **2300**A-B (FIG. **23**) and extend into

corresponding respective cavities **2312**A-B in base **2208**. As is seen more particularly in FIG. **24** and as described below, with this arrangement, load cells **2400**A-D are able to sense the lateral forces between base **2208** and ski **2220** at two distinct locations. In this example, each of heel and toe pieces **2212**, **2216** is responsive to a trigger signal to cause a release of boot sole **2218**. As those skilled in the art will readily appreciate, heel and toe pieces **2212**, **2216** may release in any of a number of manners. In the example shown, heel piece **2212** releases the heel of ski boot **2218** vertically, whereas toe piece **2216** releases the toe of the ski boot by pivoting laterally, in the manner of toe assembly **1700** of FIGS. **17-21**. Indeed, toe assembly **1700** of FIGS. **17-21** may readily be adapted for use with electronic binding system **2204** of FIGS. **22-24**, by providing a suitable actuator **2316** (FIG. **23**) for moving actuator **1800** (FIG. **18**) of toe assembly **1700**. Actuator **2316** of FIG. **23** may be any suitable electronic or electromechanical actuator. In this example, electronic binding system **2204** would also be provided with a suitable electronic or electromechanical actuator **2320** (FIG. **23**) for activating the release of heel piece **2212**. In other embodiments, toe piece **2216** may be replaced by a vertical-release toe piece (not shown) that releases vertically in the manner of heel piece **2212**. In yet other embodiments, only toe piece **2216** or heel piece **2212** may provide the desired release.

Electronic binding system **2204** includes a controller **2324** for implementing the release logic. Controller **2324** may be either a digital controller that utilizes, for example, a microprocessor such as an application specific integrated circuit (not shown), or an analog computer, or a combination of both. Those skilled in the art understanding the release logic of electronic binding system **2204** will readily be able to implement a suitable controller **2324** without undue experimentation. Similarly, those skilled in the art will readily understand how to implement all communications required between/among actuators **2316**, **2320**, sensors **2400**A-D and controller **2324** using any suitable wired or wireless technology, or a combination of both. Therefore, such details are not presented in FIGS. **22-24**.

Referring now to FIG. **24**, this figure is used to explain the release logic used by electronic binding system **2204**, and particularly controller **2324**, to release heel and toe pieces **2212**, **2216** with an attenuated release in response to virtual forces Fy in quadrant **3** that exceed a predetermined trigger trip threshold. Of course, the release logic in the other quadrants **1**, **2** and **4** may be programmed so that heel and/or toe pieces **2212**, **2216** provide an appropriate non-attenuated release relative to the third-quadrant attenuated release. In FIG. **24**, base **2208** is shown in cross-section to expose load cells **2400**A-D and corresponding cavities **2304**A-B and ski **2208** is shown for context.

For consistency with the analyses corresponding to FIGS. **1-8** and with the implementations of the embodiments of FIGS. **9**A-**21**, the reference axis used for the release logic of electronic binding **2204** is the tibial axis **2420**. With this reference, the torque T (which is equivalent to Mz in the context of FIGS. **1-8**, above) about tibial axis **2420** is $T=T_1+T_2$. Since only one load cell **2400**A-D in each of cavities **2304**A-B can be loaded (with a compressive load) at a time, the output forces F_A, F_B of load cells **2400**A, **2400**B can be added, and the output forces F_C, F_D of load cells **2400**C, **2400**D can be added such that $F_A+F_B=F_2$ and $F_C+F_D=F_1$. Therefore, $T=(L_1\times F_1)+(L_2\times F_2)$, where L_1 is the distance between tibial axis **2420** and the transverse (relative to ski **2220**) centerline of load cells **2400**C, **2400**D and L_2 is the distance between the tibial axis and the transverse centerline of load cells **2400**A, **2400**B. The virtual force Fy on ski **2220** is the sum of F_1 and F_2, i.e., $Fy=F_1+F_2$, and the position, P, of the virtual force Fy relative to tibial axis **2420** is determined by P=T/Fy.

As will be appreciated, the quadrant of virtual force Fy is determined by the signs of position P and torque T. Here, for quadrant **3**, position P is negative and torque is positive. For the attenuated quadrant **3** release, the attenuated release logic of controller **2324** is designed to trigger actuators **2316**, **2320** when the value of calculated torque T exceeds the value of the predetermined release torque calculated from the appropriate equations for the trigger trip torque and attenuated release torque, which are represented graphically for one example in FIG. **7**, above. In other words, if T is greater than both the trigger trip torque and the attenuated release torque, then controller **2324** will send a release signal to actuators **2316**, **2320**. This same procedure can be used in all other quadrants with as much complexity as is required to satisfy the desired retention threshold in each quadrant. The raw forces F_1 and F_2 can be sampled and filtered to best predict the true loads on the lower extremities of a skier using ski system **2200** (FIG. **22**). A mechanical spring (not shown) may, for example, be used in series with each of load cells **2400**A-D to filter out very short duration loads that likely do not impact ACL injury.

Exemplary embodiments have been disclosed above and illustrated in the accompanying drawings. It will be understood by those skilled in the art that various changes, omissions and additions may be made to that which is specifically disclosed herein without departing from the spirit and scope of the present invention.

What is claimed is:

1. A ski binding configured to be secured to a snow ski and selectively retain a ski boot having a heel and a toe and worn by a skier having a tibial axis, the snow ski having a first-quadrant, a second-quadrant, a third-quadrant, a fourth-quadrant and a trailing end, the ski binding comprising:

a heel piece for releasably engaging the heel of the ski boot;

a toe piece for releasably engaging the toe of the ski boot, wherein said toe piece and said heel piece provide the ski binding with a non-attenuated release torque about the tibial axis of the skier when:

the ski binding is mounted to the snow ski;

the skier is wearing the ski boot; and

the ski boot is properly captured in the ski binding; and

release logic providing the ski binding with an attenuated release torque about the tibial axis in response substantially only to a lateral shear force being applied to the snow ski at a location in the third-quadrant.

2. The ski binding of claim **1**, wherein, when the ski binding is mounted to the snow ski, the skier is wearing the ski boot and the ski boot is properly captured in the ski binding, said attenuated release torque induces a tibial torque about the tibial axis of the skier, said release logic configured so that the tibial torque is diminished as a function of the location of the lateral shear force in the third-quadrant from the tibial axis toward the trailing end of the snow ski.

3. The ski binding of claim **1**, wherein said release logic comprises a trigger and a secondary toe release responsive to said trigger so as to release the toe of the ski when the ski binding is mounted to the snow ski, the skier is wearing the ski boot and the ski boot is properly captured in the ski binding, said trigger being triggerable in response substantially only to a lateral shear force being applied to the snow ski at a location in the third-quadrant of the snow ski.

4. The ski binding of claim **3**, wherein said trigger comprises a trigger mechanism and a trigger trip torque mechanism for providing said trigger mechanism with a trip torque

threshold for substantially only lateral shear forces applied at locations in the third-quadrant of the snow ski.

5. The ski binding of claim **4**, wherein said trigger mechanism includes, when the ski binding is secured to the snow ski, a trigger member pivotably secured to the snow ski and having a pivot point located forward of the toe of the boot when the boot is properly engaged with the snow ski.

6. The ski binding of claim **5**, wherein said trigger mechanism further includes a pivotable latch releasably securing said secondary toe release, said pivotable latch pivotably secured to said trigger member.

7. The ski binding of claim **6**, wherein said pivotable latch is actuated by pivoting of said trigger member relative to said ski about said pivot point.

8. The ski binding of claim **5**, wherein said trigger mechanism further includes a movable catch releasably securing said secondary toe release, said movable catch movable in response to said trigger member being pivoted about said pivot point.

9. The ski binding of claim **5**, wherein said trigger trip torque mechanism includes a biasing member biased between the snow ski and said trigger member so as to provide the trip torque threshold when the ski binding is affixed to the snow ski.

10. The ski binding of claim **5**, wherein said trigger trip torque mechanism includes a biased toggle that includes a lever arm functionally engaging said trigger member.

11. The ski binding of claim **10**, wherein, when said trigger member is in an unreleased state, said biased toggle is biased against a pair of fulcrums spaced from one another and, when said trigger member is in a release state, said biased toggle is pivoted about one or the other of said pair of fulcrums.

12. The ski binding of claim **11**, wherein said trigger trip torque mechanism includes a locking pin for allowing said biased fulcrum to pivot substantially only about one of said pair of fulcrums.

13. The ski binding of claim **3**, wherein said secondary toe release includes a secondary toe release mechanism that, when the ski boot is properly secured in the ski binding, provides the toe of the ski boot with an attenuated release in response to a lateral shear force being applied to the snow ski at a location in the third-quadrant of the snow ski.

14. The ski binding of claim **13**, wherein said trigger includes, when the ski binding is secured to the snow ski, a trigger member pivotably secured to the snow ski and has a first pivot point located forward of the toe of the boot when the boot is properly engaged with the snow ski, said secondary toe release mechanism secured to said trigger member.

15. The ski binding of claim **14**, wherein said secondary toe release mechanism includes a toe piece support plate pivotably secured to said trigger member, said toe piece being fixedly secured to said toe piece support plate.

16. The ski binding of claim **15**, wherein said toe piece support plate has a second pivot point located between said first pivot point of said trigger member and the toe of the ski boot when the ski boot is properly engaged in the ski binding.

17. The ski binding of claim **15**, wherein said secondary toe release mechanism includes a catch fixed relative to said toe piece support plate, said trigger including a movable latch for releasably engaging said catch.

18. The ski binding of claim **15**, wherein said secondary toe release mechanism includes a latch fixed relative to said toe piece support plate, said trigger including a movable catch for releasably engaging said latch.

19. The ski binding of claim **15**, further comprising an attenuated release threshold mechanism providing said secondary toe release with an attenuated release threshold.

20. The ski binding of claim **19**, wherein said attenuated release threshold mechanism includes a biasing member biased between said trigger member and said toe piece support plate so as to provide said attenuated release threshold.

21. The ski binding of claim **19**, wherein said secondary toe release includes a latch fixed relative to said toe piece support plate and including a cam follower, said attenuated release threshold mechanism including a biased cam biased into engagement with said cam follower of said latch.

22. The ski binding of claim **14**, wherein said secondary toe release mechanism includes a toe assembly configured to selectively provide a non-attenuated toe release and an attenuated toe release in response to a triggering of said trigger.

23. The ski binding of claim **22**, wherein said toe assembly includes a base, a toe retainer movable secured to said base, and a movable member biased against said toe retainer.

24. The ski binding of claim **23**, wherein said toe assembly further includes a first spring, a second spring in series with said first spring and a movable actuator movable so as to 1) cause only said first spring to be active in biasing said movable member against said toe retainer and 2) cause both said first and second springs to be active in biasing said movable member against said toe retainer depending on the position of said movable actuator, said movable actuator being movable in response to a triggering of said trigger.

25. The ski binding of claim **1**, wherein the attenuated release torque is at least 20% less than the non-attenuated release torque.

26. The ski binding of claim **1**, wherein said release logic is configured to provide the non-attenuated release torque for lateral shear forces applied in the fourth-quadrant of the snow ski.

27. The ski binding of claim **1**, further comprising:

one or more sensors for obtaining information for determining forces being transmitted between a skier and a ski when the binding is secured to the ski and the ski binding is secured to the skier;

an electronic controller in communication with said one or more sensors, said electronic controller configured to generate a third-quadrant attenuated release signal in response to a virtual loading applied in the third-quadrant;

at least one actuator operatively connected to said toe piece or said heel piece, or both, said at least one actuator being responsive to the third-quadrant attenuated release signal.

28. The ski binding of claim **27**, wherein said electronic controller is configured to generate the third-quadrant attenuated release signal as a function of a tibial torque about a tibial axis of a skier, a net virtual force and a position of the net virtual force relative to the tibial axis.

29. The ski binding of claim **28**, further comprising:

a base supporting said heel and toe pieces and laterally movably securable to a ski;

a first pair of load cells spaced from the tibial axis; and

a second pair of load cells spaced from the tibial axis so that the tibial axis is located between said first and second pairs of load cells, said first and second pairs of load cells for sensing lateral forces between said base and the ski when the ski binding is secured to a ski and a skier is skiing with the ski binding and providing force data to said controller;

wherein said controller is configured to generate the third-quadrant attenuated release signal as a function of the force data from said first and second plurality of load cells.

30. An apparatus for securing a ski boot to a ski so as to from a ski system, the apparatus comprising:

a ski binding assembly configured to be attached to the ski and to releasably secure the ski boot to the ski during use, said ski binding assembly having a first release, said ski binding assembly including release logic that causes the ski binding assembly to release the ski boot at said first release in response to a release condition, said ski binding assembly configured to:

assess, relative to a first axis, a first loading internal to the ski system caused by an external loading applied to the ski system; and

assess, relative to a second axis spaced from said first axis and substantially parallel to said first axis, a second loading internal to the ski system caused by the external loading;

wherein said release logic is configured to:

determine whether or not the release condition is occurring as a function of both of the first loading and the second loading; and

cause said ski binding assembly to provide said first release if the release logic determines that the release condition is occurring;

wherein said ski binding assembly is configured to determine a force-couple at a third axis from said first loading and said second loading, and said release logic is configured to determine whether or not the release condition is occurring as a function of the force-couple.

31. An apparatus according to claim 30, wherein said third axis is substantially coincident with a tibial axis of a user when the user is wearing the ski boot and the ski boot is releasably engaged in the binding assembly.

32. An apparatus according to claim 30, wherein said first loading is a first shear force on said first axis and said second loading is a second shear force on said second axis, and said ski binding assembly is configured to determine the force-couple from the first shear force and the second shear force.

33. An apparatus according to claim 30, wherein said first loading is a shear force on said first axis and said second loading is a moment on said second axis, and said ski binding assembly is configured to determine the force-couple from the shear force and the moment.

34. An apparatus according to claim 30, wherein said first loading is a first moment on said first axis and said second loading is a second moment on said second axis, and said ski binding assembly is configured to determine the force-couple from the first moment and the second moment.

35. An apparatus according to claim 30, wherein said ski binding assembly has a second release, said first release being an attenuated release relative to said second release.

36. An apparatus according to claim 35, wherein said first release is at least 20% less than said second release.

37. An apparatus according to claim 35, wherein said first release is a first release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly and said second release is a second release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly.

38. An apparatus according to claim 37, wherein said first release torque is at least 20% less than said second release torque.

39. An apparatus according to claim 35, wherein:

the ski boot has a toe and a heel and is worn by a skier having a tibial axis; and

the ski has a first-quadrant, a second-quadrant, a third-quadrant, a fourth-quadrant and a trailing end;

said ski binding assembly including:

a heel piece for releasably engaging the heel of the ski boot; and

a toe piece for releasably engaging the toe of the ski boot, wherein said toe piece and said heel piece provide the ski binding with a non-attenuated release torque about the tibial axis of the skier when:

said ski binding assembly is mounted to the ski;

the skier is wearing the ski boot; and

the ski boot is properly captured in said ski binding assembly;

wherein said release logic provides said ski binding assembly with an attenuated release torque about the tibial axis in response substantially only to a lateral shear force being applied to the snow ski at a location in the third-quadrant.

40. An apparatus according to claim 39, wherein said release logic comprises a trigger and a secondary toe release responsive to said trigger so as to release the toe of the ski when said ski binding assembly is mounted to the ski, the skier is wearing the ski boot and the ski boot is properly captured in said ski binding assembly, said trigger being triggerable in response substantially only to a lateral shear force being applied to the ski at a location in the third-quadrant of the snow ski.

41. An apparatus according to claim 39, further comprising:

one or more sensors for obtaining information for determining forces being transmitted between a skier and the ski when said ski binding assembly is secured to the ski and said ski binding assembly is secured to the skier;

an electronic controller in communication with said one or more sensors, said electronic controller configured to generate a third-quadrant attenuated release signal in response to a virtual loading applied in the third-quadrant; and

at least one actuator operatively connected to said toe piece or said heel piece, or both, said at least one actuator being responsive to the third-quadrant attenuated release signal.

42. An apparatus for securing a ski boot to a ski so as to form a ski system, the apparatus comprising:

a ski binding assembly configured to be attached to the ski and to releasably secure the ski boot to the ski during use, said ski binding assembly having a first release, said ski binding assembly including release logic that causes the ski binding assembly to release the ski boot at said first release, said release logic set to activate said first release substantially only when:

a first loading, internal to the ski system along or about a first axis and caused by an external loading applied to the ski system, exceeds a first defined level and has a first defined sense; and

a second loading, internal to the ski system along or about a second axis and caused by the external loading, exceeds a second defined level and has a second defined sense;

wherein the ski system has a first-quadrant, a second-quadrant, a third-quadrant and a fourth-quadrant and the external loading resolves into a single virtual lateral shear force on the ski, said release logic set to activate said first release substantially only when the single virtual lateral shear force is located within the third-quadrant.

43. An apparatus according to claim 42, wherein said first and second axes are spaced from, and substantially parallel to, one another.

44. An apparatus according to claim 42, wherein said first loading is a first force and said second loading is a second force parallel to, and spaced from, said first force.

45. An apparatus according to claim 42, wherein said first loading is a force and said second loading is a moment.

46. An apparatus according to claim 42, wherein said first loading is a first moment and said second loading is a second moment and said first and second axes are spaced from, and substantially parallel to, one another.

47. An apparatus according to claim 42, wherein said ski binding assembly has a second release, said first release being an attenuated release relative to said second release.

48. An apparatus according to claim 47, wherein said first release is a first release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly and said second release is a second release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly.

49. An apparatus according to claim 48, wherein said first release torque is at least 20% less than said second release torque.

50. An apparatus according to claim 47, wherein:

the ski boot has a toe and a heel and is worn by a skier having a tibial axis; and

the ski has a first-quadrant, a second-quadrant, a third-quadrant, a fourth-quadrant and a trailing end;

said ski binding assembly including:

a heel piece for releasably engaging the heel of the ski boot; and

a toe piece for releasably engaging the toe of the ski boot, wherein said toe piece and said heel piece provide the ski binding with a non-attenuated release torque about the tibial axis of the skier when:

said ski binding assembly is mounted to the ski;

the skier is wearing the ski boot; and

the ski boot is properly captured in said ski binding assembly;

wherein said release logic provides said ski binding assembly with an attenuated release torque about the tibial axis in response substantially only to a lateral shear force being applied to the snow ski at a location in the third-quadrant.

51. An apparatus according to claim 50, wherein said release logic comprises a trigger and a secondary toe release responsive to said trigger so as to release the toe of the ski when said ski binding assembly is mounted to the ski, the skier is wearing the ski boot and the ski boot is properly captured in said ski binding assembly, said trigger being triggerable in response substantially only to a lateral shear force being applied to the ski at a location in the third-quadrant of the snow ski.

52. An apparatus according to claim 51, further comprising:

one or more sensors for obtaining information for determining forces being transmitted between a skier and the ski when said ski binding assembly is secured to the ski and said ski binding assembly is secured to the skier;

an electronic controller in communication with said one or more sensors, said electronic controller configured to generate a third-quadrant attenuated release signal in response to a virtual loading applied in the third-quadrant; and

at least one actuator operatively connected to said toe piece or said heel piece, or both, said at least one actuator being responsive to the third-quadrant attenuated release signal.

53. An apparatus for securing a ski boot to a ski so as to form a ski system, the apparatus comprising:

a ski binding assembly configured to be attached to the ski and to releasably secure the ski boot to the ski during use, said ski binding assembly having a first release, said ski binding assembly including release logic that causes the ski binding assembly to release the ski boot at said first release in response to a release condition, said ski binding assembly configured to:

assess, relative to a first axis, a first loading internal to the ski system caused by an external loading applied to the ski system; and

assess, relative to a second axis spaced from said first axis and substantially parallel to said first axis, a second loading internal to the ski system caused by the external loading;

wherein said release logic is configured to:

determine whether or not the release condition is occurring as a function of both of the first loading and the second loading; and

cause said ski binding assembly to provide said first release if the release logic determines that the release condition is occurring;

wherein said ski binding assembly has a second release, said first release being an attenuated release relative to said second release.

54. An apparatus according to claim 53, wherein said first release is at least 20% less than said second release.

55. An apparatus according to claim 53, wherein said first release is a first release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly and said second release is a second release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly.

56. An apparatus according to claim 55, wherein said first release torque is at least 20% less than said second release torque.

57. An apparatus according to claim 53, wherein:

the ski boot has a toe and a heel and is worn by a skier having a tibial axis; and

the ski has a first-quadrant a second-quadrant, a third-quadrant, a fourth-quadrant and a trailing end;

said ski binding assembly including:

a heel piece for releasably engaging the heel of the ski boot; and

a toe piece for releasably engaging the toe of the ski boot, wherein said toe piece and said heel piece provide the ski binding with a non-attenuated release torque about the tibial axis of the skier when:

said ski binding assembly is mounted to the ski;

the skier is wearing the ski boot; and

the ski boot is properly captured in said ski binding assembly;

wherein said release logic provides said ski binding assembly with an attenuated release torque about the tibial axis in response substantially only to a lateral shear force being applied to the snow ski at a location in the third-quadrant.

58. An apparatus for securing a ski boot to a ski so as to form a ski system, the apparatus comprising:

a ski binding assembly configured to be attached to the ski and to releasably secure the ski boot to the ski during use, said ski binding assembly having a first release, said ski binding assembly including release logic that causes the ski binding assembly to release the ski boot at said

first release, said release logic set to activate said first release substantially only when:

a first loading, internal to the ski system along or about a first axis and caused by an external loading applied to the ski system, exceeds a first defined level and has a first defined sense; and

a second loading, internal to the ski system along or about a second axis and caused by the external loading, exceeds a second defined level and has a second defined sense;

wherein said ski binding assembly has a second release, said first release being an attenuated release relative to said second release.

59. An apparatus according to claim **58**, wherein said first release is a first release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly and said second release is a second release torque about a tibial axis of a skier when the skier is wearing the ski boot and the ski boot is secured to the ski by said ski binding assembly.

60. An apparatus according to claim **59**, wherein said first release torque is at least 20% less than said second release torque.

61. An apparatus according to claim **58**, wherein:

the ski boot has a toe and a heel and is worn by a skier having a tibial axis; and

the ski has a first-quadrant, a second-quadrant, a third-quadrant, a fourth-quadrant and a trailing end;

said ski binding assembly including:

a heel piece for releasably engaging the heel of the ski boot; and

a toe piece for releasably engaging the toe of the ski boot, wherein said toe piece and said heel piece provide the ski binding with a non-attenuated release torque about the tibial axis of the skier when:

said ski binding assembly is mounted to the ski;

the skier is wearing the ski boot; and

the ski boot is properly captured in said ski binding assembly;

wherein said release logic provides said ski binding assembly with an attenuated release torque about the tibial axis in response substantially only to a lateral shear force being applied to the snow ski at a location in the third-quadrant.

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