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UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA

SAN FRANCISCO DIVISION

ARSUS, LLC, Plaintiff, v. **TESLA, INC.,** Defendant.	PATENT Case No. 3:20-cv-00313-RS **SECOND AMENDED COMPLAINT FOR PATENT INFRINGEMENT AGAINST TESLA, INC.** **DEMAND FOR JURY TRIAL**

Plaintiff Arsus, LLC, for its second amended complaint, complains against Defendant Tesla, Inc., formerly known as Tesla Motors, Inc., alleging that:

I. THE PARTIES

1. Plaintiff Arsus, LLC ("Arsus" or "Plaintiff") is a Utah limited liability company with its principal place of business at 350 West 2000, South Perry, Utah 84302.

2. Defendant Tesla, Inc. ("Defendant") is a corporation organized and existing under the laws of Delaware, with a place of business at 380 Fairview Way, Milpitas, CA 95035.

3. This action arises under the patent laws of the United States, Title 35 of the United States Code. This Court has subject matter jurisdiction of such action under 28 U.S.C. §§ 1331 and 1338(a).

4. Venue is proper in this district under 28 U.S.C. sections 1381(b) and 1400(b).

5. On January 21, 2014, United States Patent No. 8,634,989 ("the '989 Patent"), entitled *Rollover Prevention Apparatus*, was duly and legally issued by the United States Patent and Trademark Office. On April 16, 2019, United States Patent No. 10,259,494 ("the '494 Patent"), entitled *Rollover Prevention Apparatus*, was duly and legally issued by the United States Patent and Trademark Office. Copies of the '989 and '494 patents are attached to this complaint as Exhibit A.

6. Within this District, Defendant has sold and offered for sale Tesla vehicles (the "accused vehicles") which directly infringe the '989 patent's claims 1 to 4, and which directly infringe the '494 patent's claims 21 and 22, and is continuing to sell and offer for sale accused vehicles, namely, Tesla vehicles, such

as Tesla models S, X, and M, equipped with Tesla's so-called Autopilot system, within this District. Claims 1-4 of the '989 patent and claims 21 and 22 of the '494 patent are collectively called the "asserted claims". See the claim charts attached to this Second Amended Complaint as Exhibit B, incorporated herein by reference.

7. The asserted claims of the '494 and '989 patents call for **rollover prevention apparatus**, and read as follows:

> 1. A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle. (From the '989 patent)
>
> 2. The apparatus of claim 1, wherein said apparatus prevents said vehicle from being steered to the point of vehicle rollover. (From the '989 patent)
>
> 3. The apparatus of claim 1, wherein said apparatus is automatically actuated in response to the speed of said vehicle. (From the '989 patent)
>
> 4. The apparatus of claim 1, wherein said apparatus prevents said vehicle from being steered to the point of vehicle rollover in a first direction but allows said vehicle to be freely steered in a second direction. (From the '
>
> '989 patent)
>
> 21. A steering apparatus configured to allow a vehicle to be steered out of an SOA path but not to the extent of vehicle rollover. (From the '494 patent)
>
> 22. The steering apparatus of claim 21 wherein said apparatus includes

an active mode, an inactive mode, a steering wheel, an actuator, at least one sensor, and an electronic control unit, and wherein said actuator is configured to actuate upon receipt of an actuation signal, and wherein said sensor is configured to sense the magnitude of at least one driving parameter, and wherein said electronic control unit is configured to send an actuation signal to said actuator when a sensed driving parameter exceeds a predetermined magnitude, and wherein said apparatus is configured such that when said vehicle rounds a curve at any rollover capable speed, the steering angle of said vehicle is prevented from being increased to beyond a rollover threshold of said vehicle when said apparatus is in said active mode. (From the '494 patent)

8. All asserted claims are apparatus claims. No asserted claim, either expressly or impliedly, calls for, or refers to, a human being driving the car. A human driver (as distinct from a robotic driver such as Tesla's Autopilot) is referred to hereinafter as a "driver". No asserted claim includes the word "driver", or requires that there be a driver. No asserted claim calls for, or requires any driver to make steering input to the claimed apparatus. The accused Autopilot-equipped Tesla vehicles are steered by the Autopilot system alone, when the Tesla Autopilot system is turned on (i.e., is in *active mode*). Moreover, **so long as the Tesla Autopilot is turned on (i.e., is in *active mode*)** the Tesla Autopilot system alone steers the Tesla vehicle, without needing or allowing steering input from any person such as a driver or passenger in the vehicle, and without needing any such

person to even be present in the vehicle.

9. No court has yet defined the term “driver.”

10. In 2014, Elon Musk, Tesla’s CEO/President/Controlling Shareholder said that, with Autopilot deployed: “We [meaning Tesla vehicles] can basically go between San Francisco and Seattle **without the driver doing anything**.” See page 63 of the Exhibits to this SAC.

11. The specification of the ‘989 patent mentions *driver* just four times, and then only in the Background of the Invention specification section at column 1, lines 37 (twice), 41 and 43. The specification does not call for, or require, a driver to provide any steering input to any apparatus described in the Summary of the Invention, or in the Detailed Description of the Invention, sections of the specification. The specification does not say or imply that a driver is any part of the **apparatus** called for in the asserted claims.

12. Nor does anything in the ‘989 or ‘494 patents anywhere say or imply that a driver is required for the claimed apparatus to steer a vehicle within a non-rollover steering range of motion of the vehicle, or to prevent the vehicle from being steered beyond a rollover threshold of the vehicle.

13. This Court’s 8/14/2020 order (Docket #27), at page 3, says that the 11/16/2018 Utah District Court decision (in the *ARSUS v Firmage* suit involving ADAP-equipped BMW vehicles) found as a fact that BMW’s ADAP system “at no point in time prevented a driver from manually steering the [BMW] vehicle to the

point of rollover," thus precluding infringement. That decision expressly declined to define or construe any claim term, or any term that is not in any claim, such as the term "driver."

14. BMW's ADAP system and Tesla's Autopilot system are **materially different** from one other. The 11/15/2018 Utah district court decision found as a fact that:

> "[BMW's] *ADAP never actually prevents the vehicle from being steered beyond a rollover threshold at any point, **including when ADAP is in the engaged mode**. Plaintiff has thus failed to show infringement of the asserted claims.*"

In short, this statement in the Utah district court decision, says that BMW's ADAP system, even when **turned on** (i.e., when in "***engaged mode***") **never** prevents BMW vehicles from being steered beyond a rollover threshold at any point.

15. In contrast to BMW's ADAP system, Tesla's Autopilot system, when and so long as the Tesla Autopilot system is turned on (i.e., is in *active mode*), **does prevent** an Autopilot-equipped Tesla vehicle from being steered beyond a rollover threshold. When and so long as the Tesla Autopilot system is activated (i.e., is in ***active mode***), the Autopilot system prevents a person such as a driver or passenger from making steering input. When and so long as the Tesla Autopilot is activated (i.e., is in *active mode*), the Tesla Autopilot **alone** steers the Tesla vehicle, and prevents the Tesla vehicle from being steered beyond a rollover

threshold, which directly infringes the asserted claims.

16. A person such as a driver or passenger in an accused Tesla vehicle that is being steered by Tesla's Autopilot, with Autopilot in *active mode*, cannot manually turn the steering wheel of the Tesla but that Autopilot is turned off (inactivated) such manual steering. A person manually turning the steering wheel **turns off** the Tesla Autopilot system (i.e., puts the Tesla Autopilot system into *inactive mode*). **Turning off** the Tesla Autopilot (i.e., putting the Autopilot in *inactive mode*), by a person manually turning the steering wheel, returns the Tesla vehicle to being steered manually, **instead of being steered** by the Tesla Autopilot system.

17. A driver turning the Tesla Autopilot off (i.e., switching the Tesla Autopilot from *active mode* to *inactive mode*), by the driver turning the steering wheel, to steer the Tesla manually, does **not** prevent the accused Tesla vehicles from infringing any asserted claim, when the Tesla Autopilot system is turned *on (i.e., is in active mode)*.

18. As this Court's order (Dkt#27) at 3:13-16 states, "a patent can be successfully asserted against an accused product that infringes **some of the time** or under some conditions, even if it does not infringe all of the time, or under all conditions." The Tesla Autopilot system steering Tesla vehicles, when the Autopilot is operating (i.e., is in *active mode*), directly infringes the asserted claims.

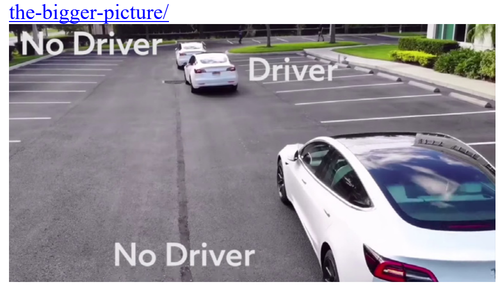
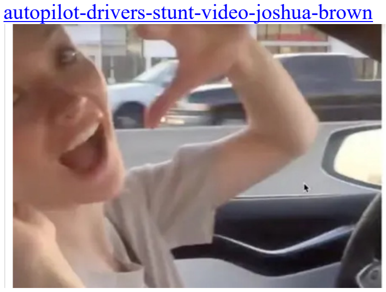
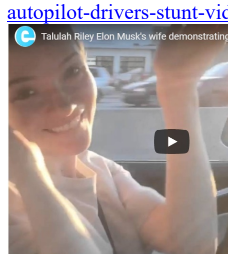
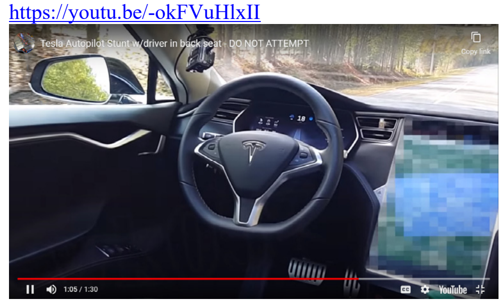
19. Tesla vehicles do not avoid directly infringing the asserted claims, when

Tesla Autopilot, operating in *active mode,* and steering the Tesla vehicle, is turned off by a person such as a driver (i.e., putting Tesla Autopilot into *inactive mode)*, taking over manual steering of the vehicle.

20. No asserted claim calls for an apparatus that precludes a person, such as a driver or a passenger, from **turning off** (i.e., switching to *inactive mode*) the Tesla Autopilot, when the Autopilot system is **turned on** (i.e., is in *active mode*), by such a person manually turning the wheel of the Tesla vehicle. Such a person manually turning the wheel of the Tesla vehicle **turns off** (switches to *inactive mode*) the Autopilot system, returning the vehicle to manual steering.

21. With the Autopilot system *off (i.e., switched to inactive mode),* a person such as a driver or passenger can manually drive a Tesla vehicle beyond a threshold of rollover, either willfully or unintentionally. But when such a person takes over steering from the Tesla Autopilot and steers the Tesla vehicle beyond a threshold of rollover, that person is steering the vehicle, not the Tesla Autopilot.

22. Tesla's publicity for the accused vehicles says that the accused vehicles can steer themselves with no driver in the vehicles. See Exhibit D to this complaint for the following Tesla publicity images showing accused Tesla vehicles steering themselves, with no driver in the vehicle:

https://www.youtube.com/watch?v=ZhObsMnipS8  **Autopilot preventing steering beyond a threshold of roll while the human so-called "driver" sleeps.**	https://cleantechnica.com/2020/08/16/tesla-patents-elon-musk-the-bigger-picture/  **"No driver present" scenario – Autopilot is driving**
https://www.theguardian.com/technology/2016/jun/30/tesla-autopilot-drivers-stunt-video-joshua-brown  **Tesla "drivers" post self-driving "stunts" using Autopilot**	https://www.theguardian.com/technology/2016/jun/30/tesla-autopilot-drivers-stunt-video-joshua-brown  **Talulah Riley, Elon Musk's, shows Tesla fans the wrong way to "drive" (hands-free) on Autopilot**
https://youtu.be/-okFVuHlxII  **Tesla Autopilot with "driver" in the back seat**	https://youtu.be/-okFVuHlxII  **Tesla Autopilot with "driver" in the back seat**

23. No asserted claim calls for, or requires, an apparatus that **<u>prevents</u>** a person such as a driver or passenger of a vehicle such as the accused Autopilot equipped vehicles here, **<u>from turning off the rollover prevention apparatus</u>** called for in the asserted claims. A person such as a driver or passenger **<u>switching off</u>** the Tesla Autopilot, by taking over steering the Tesla manually (which places the Tesla Autopilot into *inactive mode*), does not prevent the Autopilot equipped Tesla vehicles from infringing the asserted claims, when the Tesla Autopilot is turned on (i.e., is in *active mode*). The reason: When in active mode, Tesla

Autopilot alone steers a Tesla vehicle, preventing the Tesla vehicle from being steered to or beyond a threshold of rollover.

24. No asserted claim says how the claimed apparatus is turned *on* (i.e., is put into *active status*), or is turned *off* (i.e., is put into *inactive status*). Therefore, all asserted claims permit, but do not require, that the claimed apparatus may be **switched off** by a person, such as a driver or passenger, who manually turns the Tesla steering wheel.

25. Tesla has issued statements that Tesla vehicles, equipped with Tesla's Autopilot, can steer a Tesla vehicle, including for trips hundreds of miles long, with no (human) driver in the car, meaning that Tesla's Autopilot can and does steer a Tesla vehicle, with no driver, or human of any kind, such as a passenger, in the Tesla vehicle.

26. When there is no person such as a driver or passenger in a Tesla vehicle, there is no one to take over steering the Tesla manually. Therefore, in these "no driver present" events, there is no one to turn off the Tesla Autopilot, such as by manually taking over steering. In these "no driver present" events, the Tesla is steered **solely** by the Tesla Autopilot, which prevents the Tesla from being steered beyond a threshold of rollover.

27. In contrast, in the 11/15/2018 Utah district court case where Arsus, LLC sued Firmage [BMW] for patent infringement, Firmage denied that BMW's ADAP system could drive a BMW with no driver in the BMW vehicle. The "no driver

present" scenario, in which a Tesla vehicle is steered by Tesla Autopilot, with no driver in the Tesla vehicle, is therefore materially different from the ADAP-equipped BMW vehicles at issue in the Utah case. That case did not consider, or decide, whether vehicles such as the accused Tesla vehicles, steered by the Tesla Autopilot apparatus alone, with no person such as a driver or passenger present or needed, infringe the asserted claims.

28. Tesla's Autopilot system, so long as it is **switched on** (i.e., is in *active mode*), does not need, and does not accept, steering input from a person such as a driver or passenger. So long as it is **switched on** (i.e., is in *active mode*), the Tesla Autopilot system **alone** steers the Tesla vehicle, preventing the Tesla vehicle from being steered beyond a threshold of rollover. This is true if there is no person in the vehicle, and is also true if there is a person such as a driver or passenger in the vehicle, so long as the Tesla Autopilot system is **turned on** (i.e. is in *active mode*).

29. Tesla's Autopilot system **alone** steers manned, and unmanned, accused Tesla vehicles, when and so long as the Tesla Autopilot system is switched *on* (i.e., is in *active mode*); and steers the Tesla vehicle without needing, receiving, or accepting steering input from any human such as a driver or passenger. So long as the Tesla Autopilot system is switched on, the Tesla Autopilot system prevents the accused Tesla vehicles, whether manned or unmanned, from steering beyond a threshold of rollover, thereby directly infringing all asserted claims.

30. Plaintiff ARUS is the assignee of all right, title and interest in the '989

and ‘494 patents, including all rights to enforce and prosecute actions for infringement of these patents.

31. Plaintiff ARSUS has been damaged as a result of Defendant’s infringing conduct. Defendant Tesla is liable to Plaintiff ARSUS for damages in an amount that adequately compensates Plaintiff ARSUS for this damage.

32. Plaintiff ARSUS gave Defendant Tesla proper written notice of the ‘989 patent. See the notice correspondence attached as Exhibit C

IV. PRAYER FOR RELIEF

WHEREFORE, Plaintiff ARSUS requests that the Court find in ARSUS’ favor, against Defendant Tesla, and that the Court grant Plaintiff ARSUS the following relief:

a. Judgment that one or more claims of Plaintiff ARSUS’ ‘989 and ‘494 patents have been infringed by Defendant Tesla’s vehicles, when those Tesla vehicles are steered by Tesla’s Autopilot;

b. Judgment that Defendant Tesla account for and pay to Plaintiff ARSUS all damages to and costs incurred by Plaintiff because of Defendant’s infringing activities, and an accounting of all infringements and damages not presented at trial;

c. That Plaintiff ARSUS be granted pre-judgment and post-judgment interest on the damages caused by Defendant’s infringing activities;

d. That Plaintiff ARSUS be granted such other and further relief as the Court may deem just and proper under the circumstances.

September 7, 2020

By /s/*Steven A. Nielsen*

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JURY DEMAND

Plaintiff, under Rule 38 of the Federal Rules of Civil Procedure, requests a trial by jury of all issues so triable.

September 7, 2020

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ARSUS Tesla Second Amended Complaint

Exhibit A

Asserted US Patents

8,634,989 and 10,259,494

US008634989B1

(12) **United States Patent**
Schramm

(10) **Patent No.: US 8,634,989 B1**
(45) **Date of Patent: Jan. 21, 2014**

(54) **ROLLOVER PREVENTION APPARATUS**

(76) Inventor: **Michael R. Schramm**, Perry, UT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 26 days.

(21) Appl. No.: **13/222,157**

(22) Filed: **Aug. 31, 2011**

Related U.S. Application Data

(60) Provisional application No. 61/378,482, filed on Aug. 31, 2010, provisional application No. 61/385,535, filed on Sep. 22, 2010.

(51) **Int. Cl.**
G06F 19/00 (2011.01)

(52) **U.S. Cl.**
USPC **701/41**; 701/42; 701/43; 701/45; 701/71; 180/420; 180/422; 180/446; 280/149.2; 280/775; 446/289; 446/444; 74/493

(58) **Field of Classification Search**
USPC 701/41, 42, 43, 45, 71; 180/420, 422, 180/446; 280/149.2, 775; 446/289, 444; 91/375; 74/493
See application file for complete search history.

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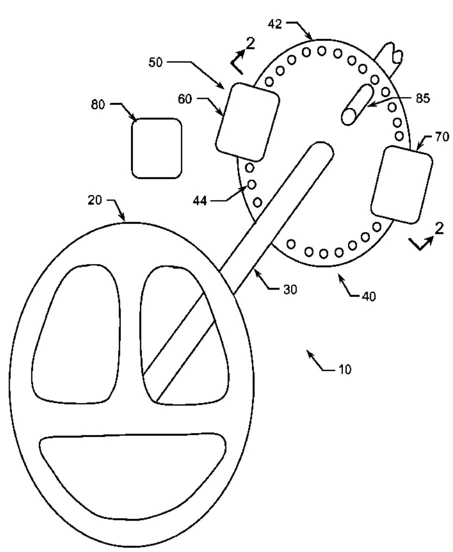
Primary Examiner — McDieunel Marc
(74) *Attorney, Agent, or Firm* — Michael R. Schramm

(57) **ABSTRACT**

The rollover prevention apparatus defines an adaptive steering range limiting device comprising a control unit and a pair of opposing unidirectional brake assemblies mounted to a steering column position detection disc. The rollover prevention apparatus prevents the steering wheel of the vehicle from being turned beyond the threshold of vehicle rollover, but otherwise does not restrict the rotational range of motion of the steering wheel of a vehicle.

22 Claims, 10 Drawing Sheets



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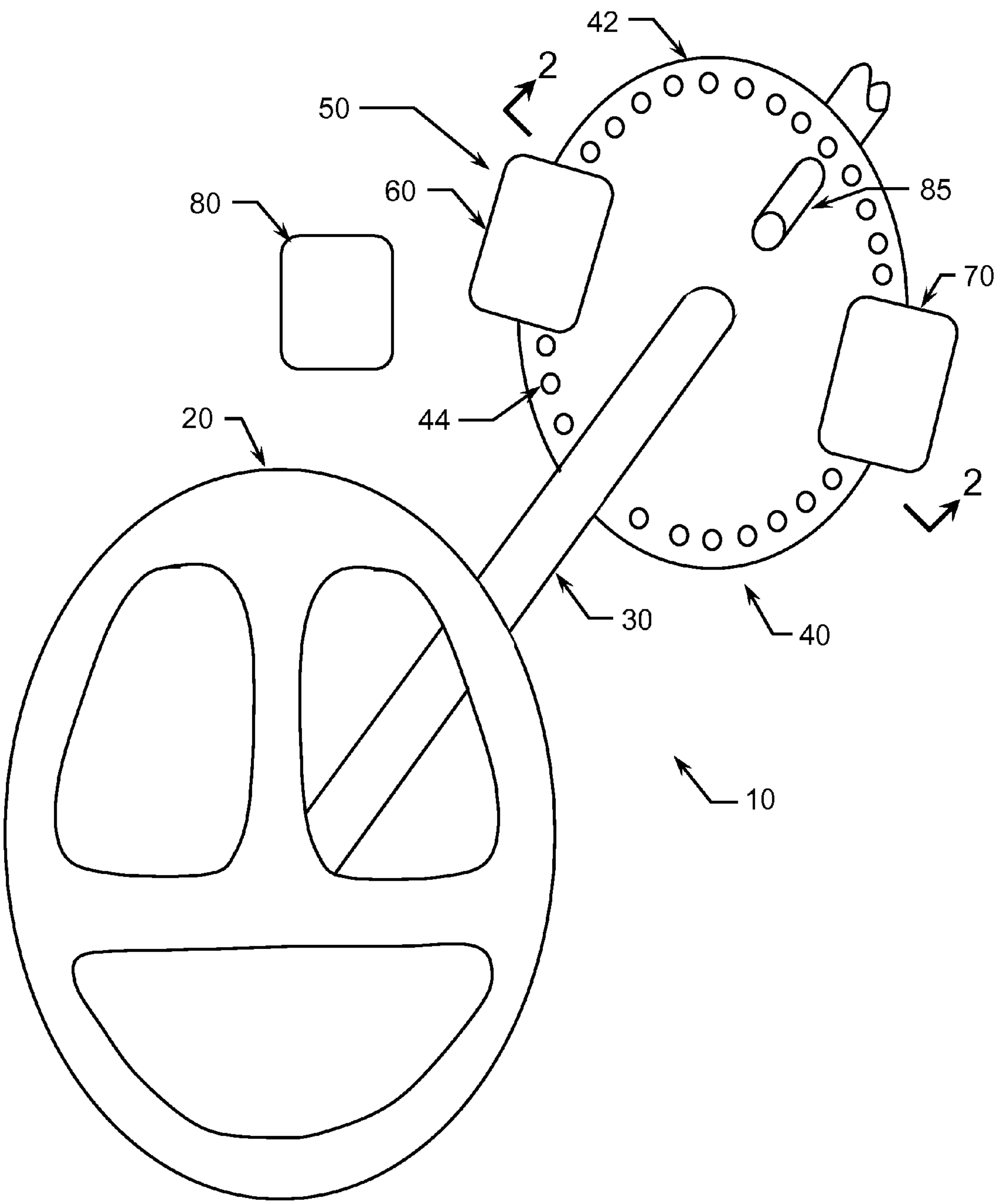

Figure 1

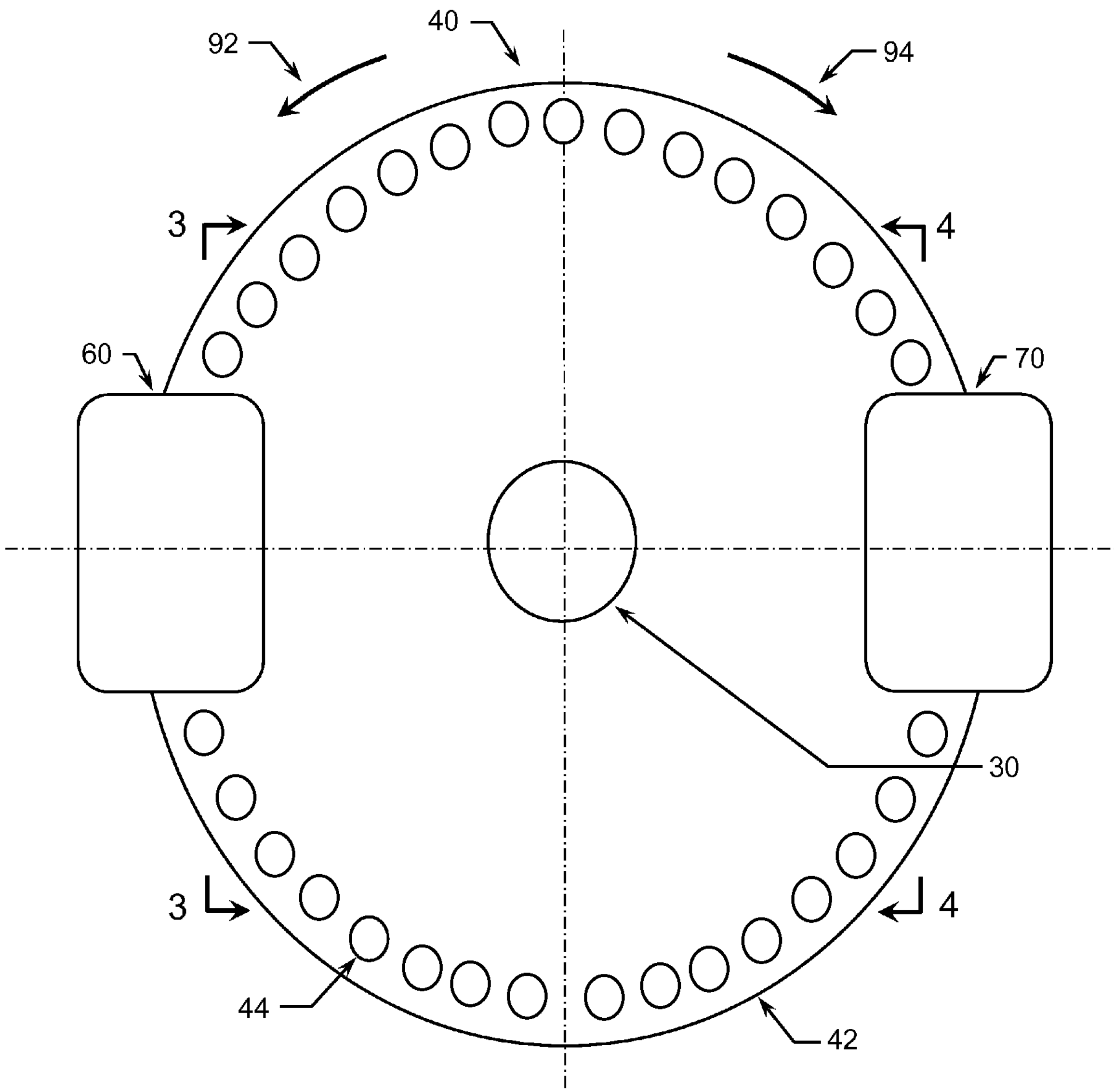

Figure 2

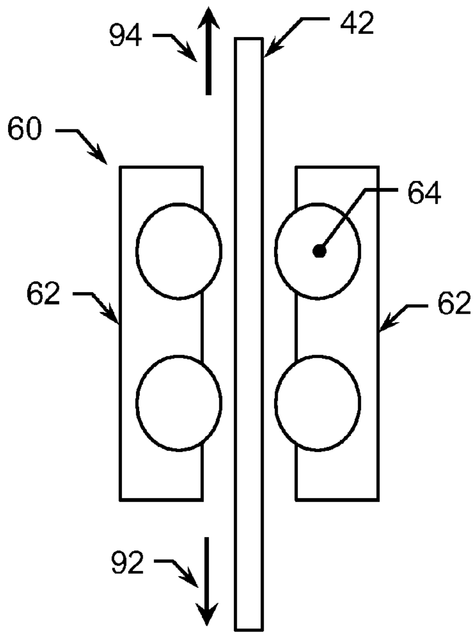

Figure 3A

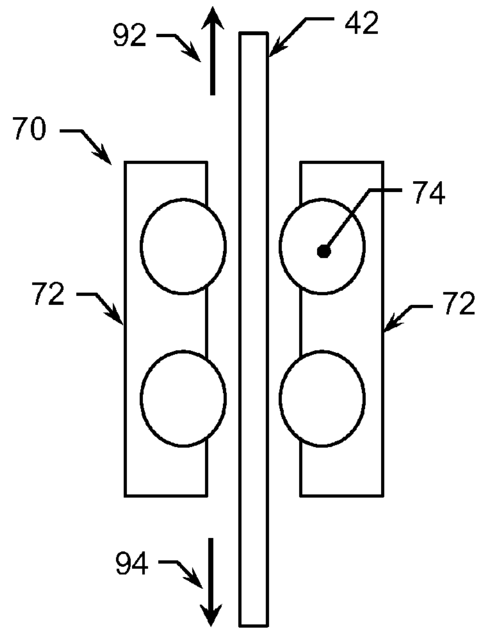

Figure 4A

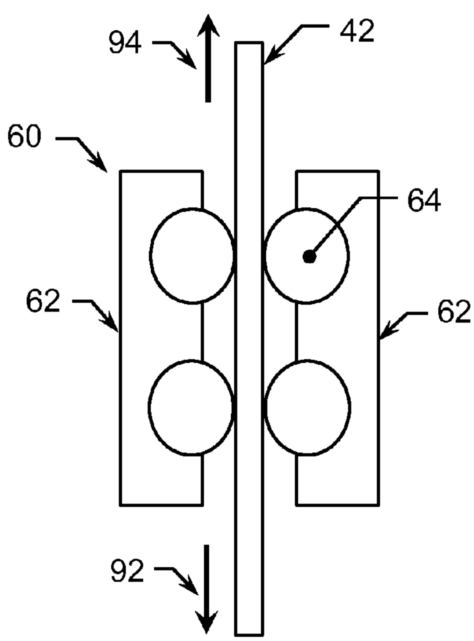

Figure 3B

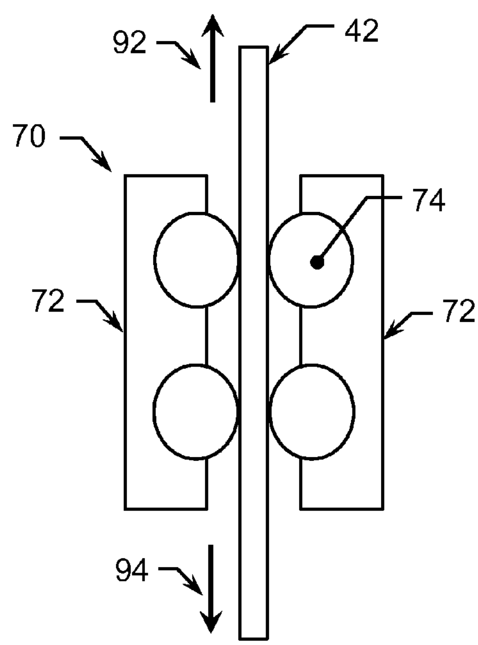

Figure 4B

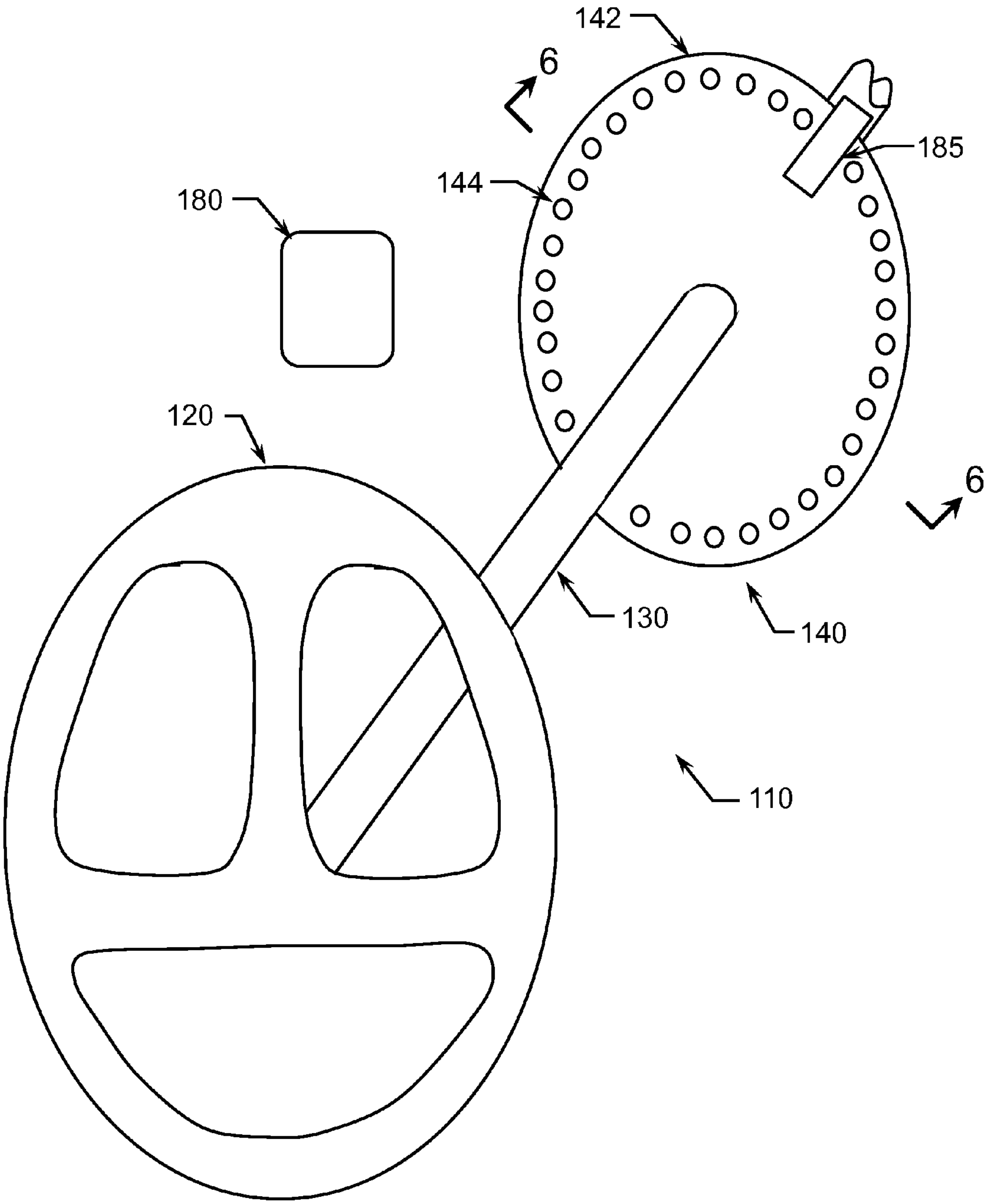

Figure 5

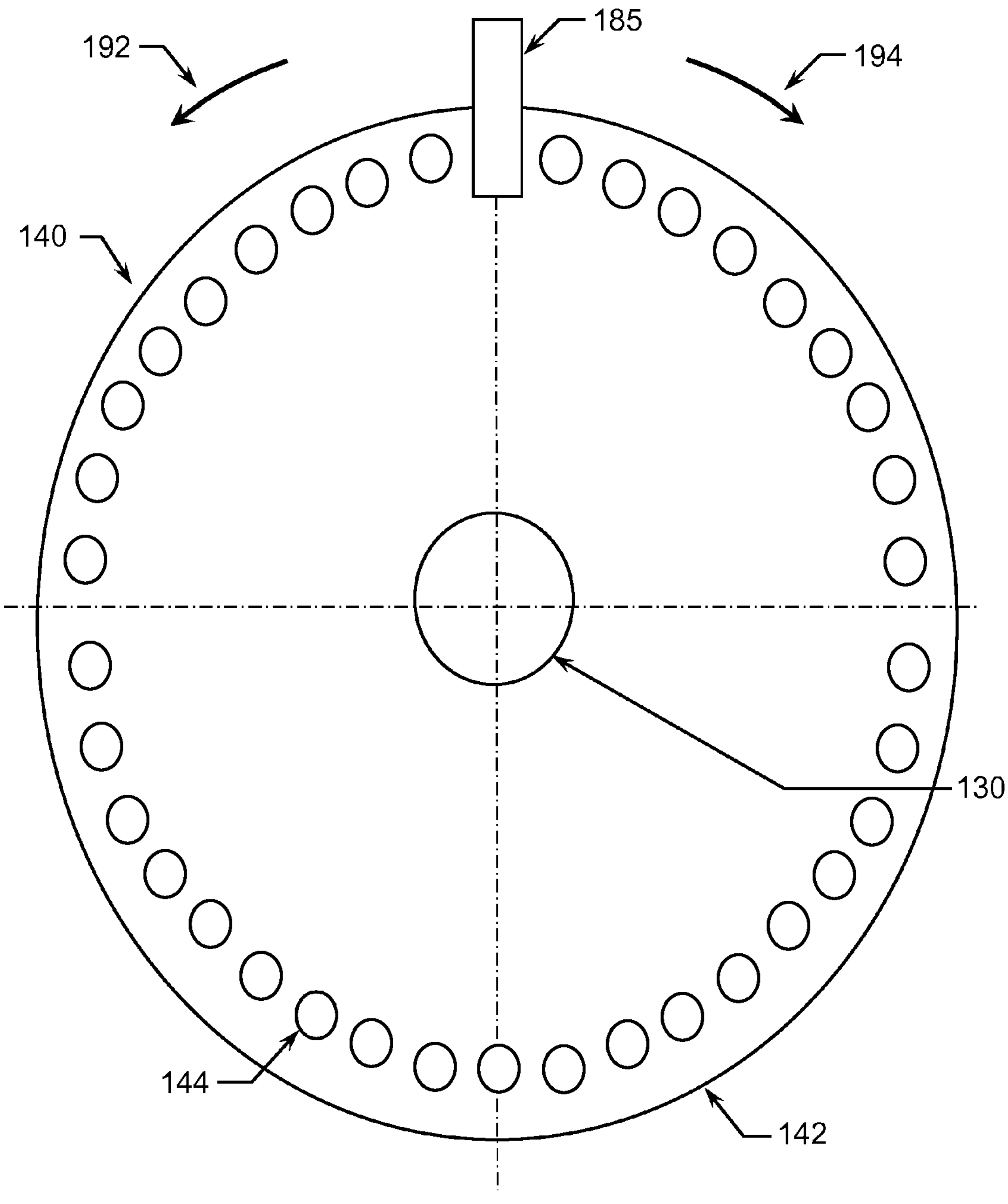

Figure 6A

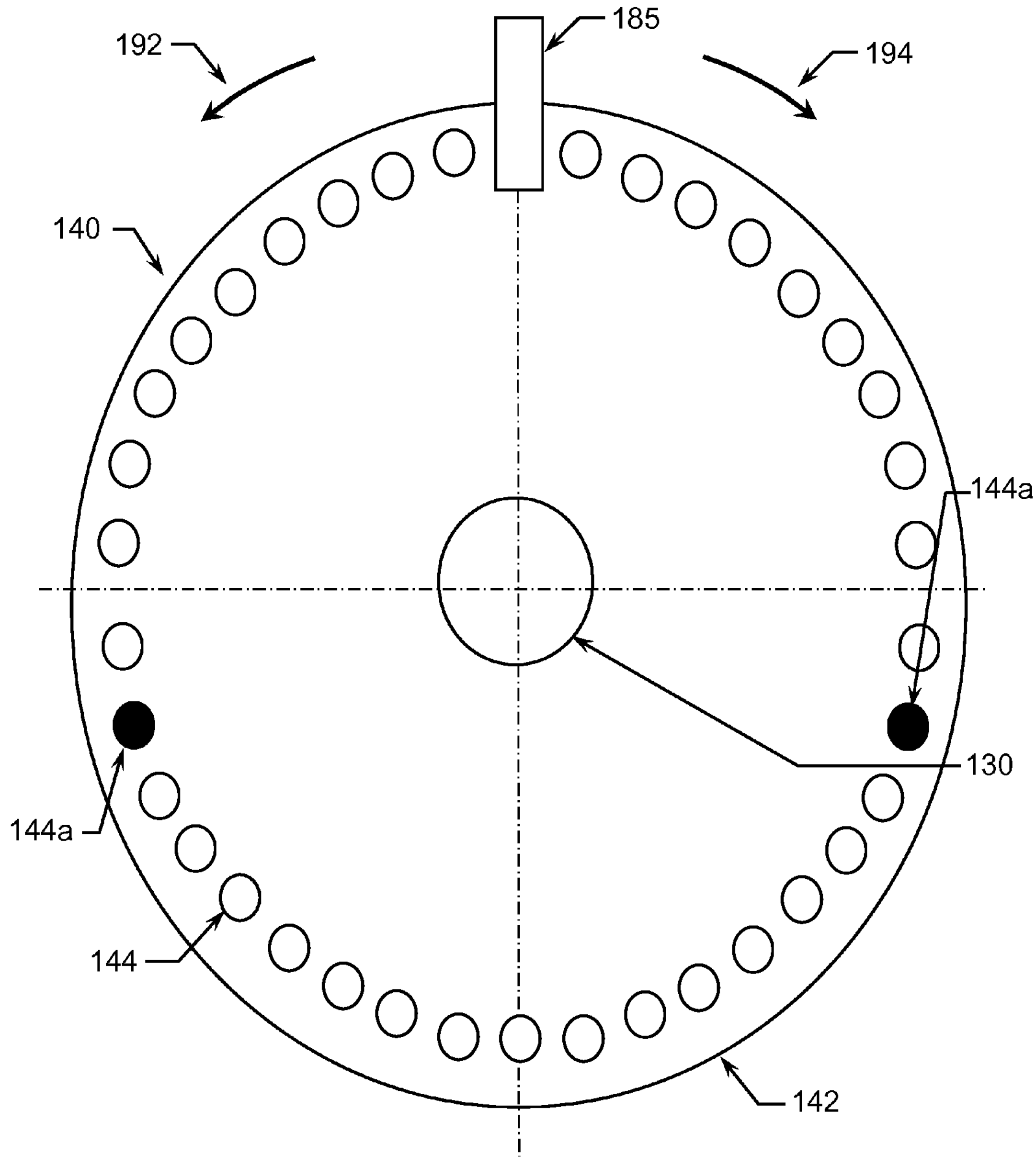

Figure 6B

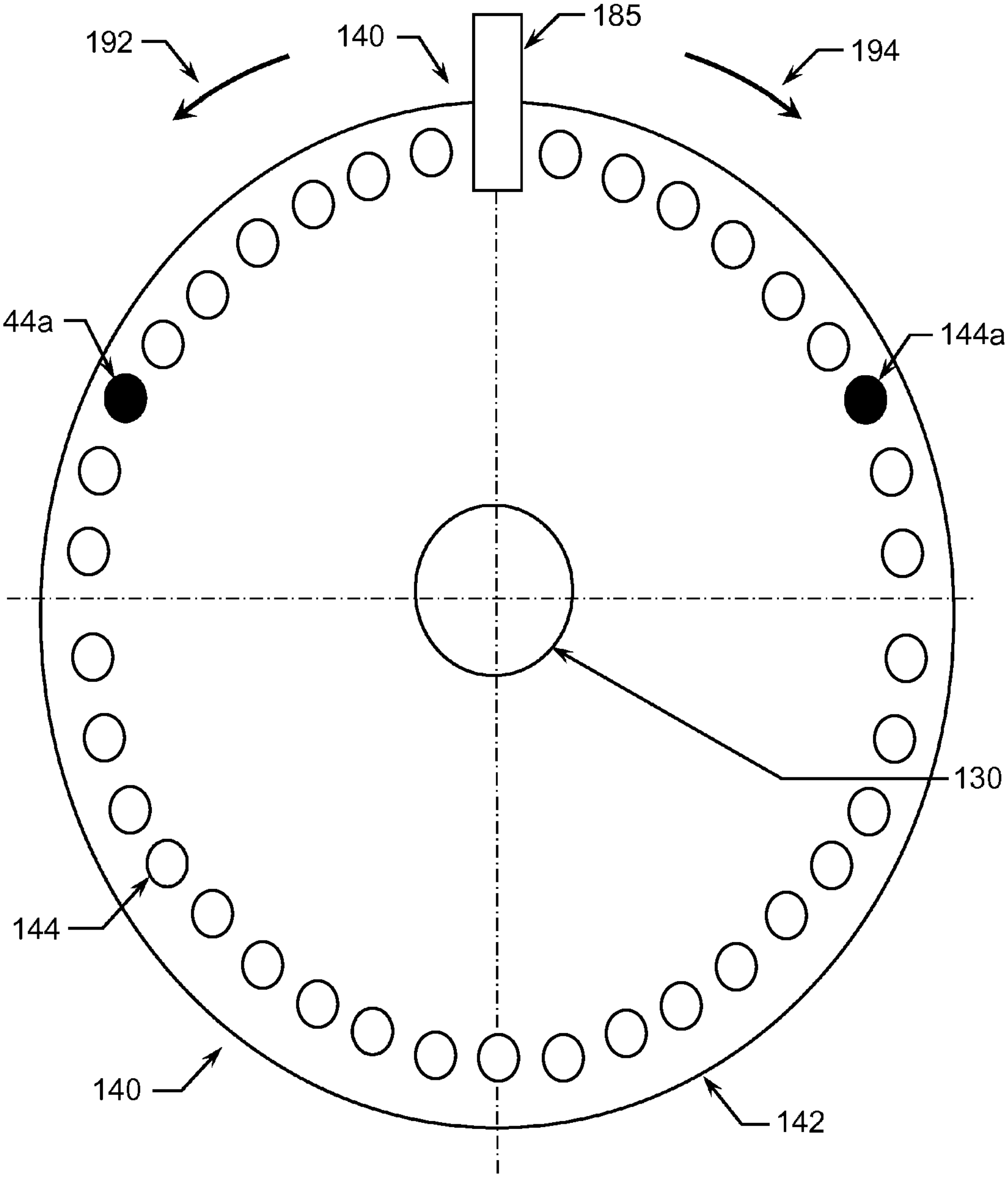

Figure 6C

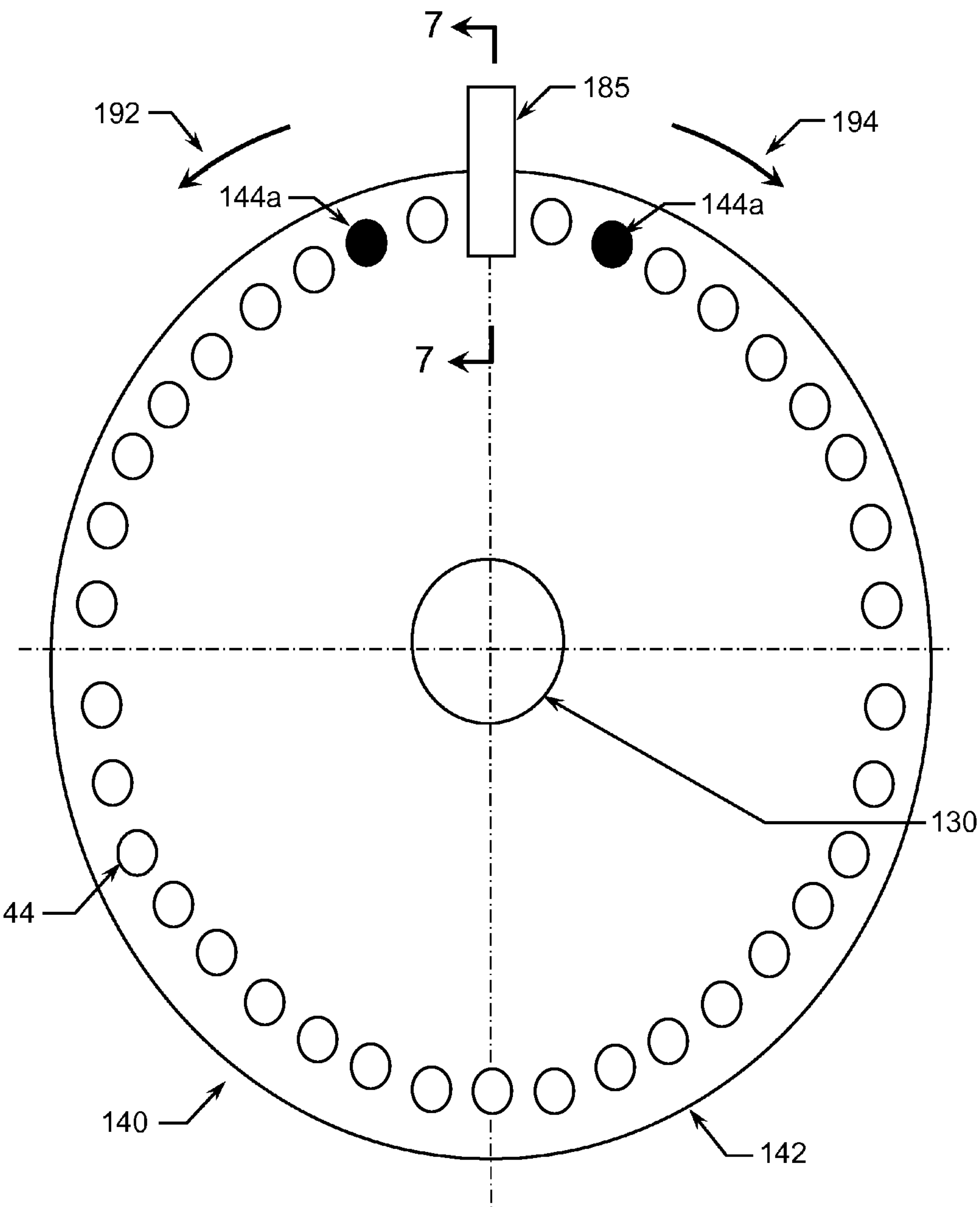

Figure 6D

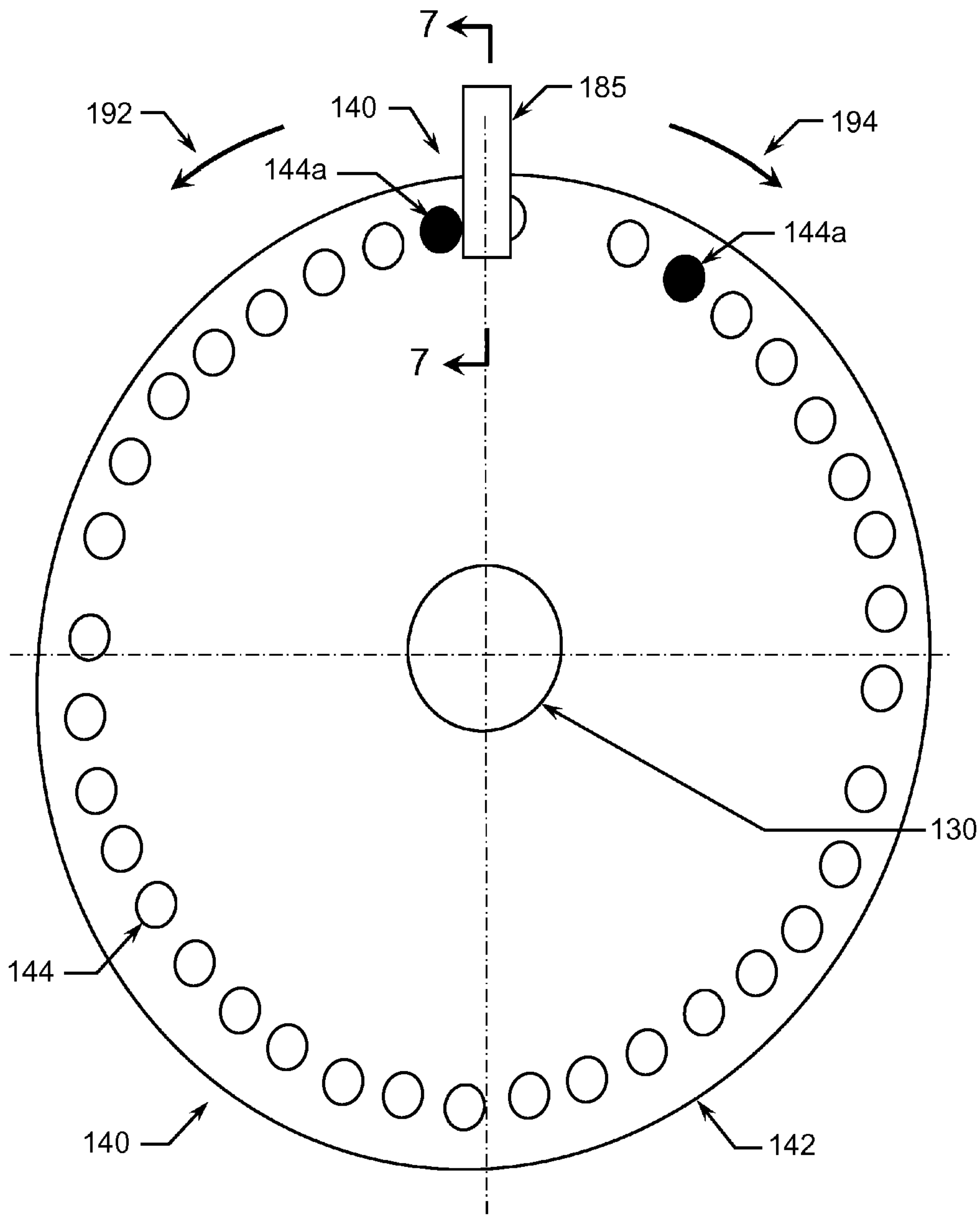

Figure 6E

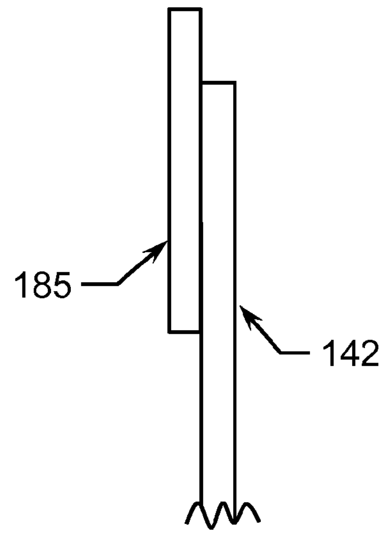

Figure 7

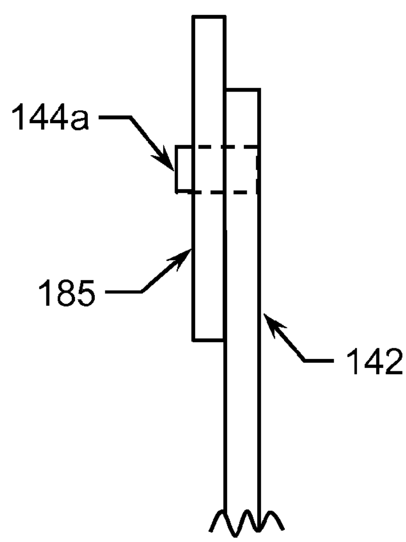

Figure 7A

ROLLOVER PREVENTION APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This nonprovisional utility patent application claims the benefit under 35 U.S.C. §119(e) of U.S. provisional application No. 61/378,482 filed Aug. 31, 2010 and of U.S. provisional application No. 61/385,535 filed Sep. 22, 2010 both of which are incorporated, in their entirety, by this reference.

FIELD OF THE INVENTION

The present invention relates to steering control devices and more especially devices for use in preventing steering to the point of vehicle rollover.

BACKGROUND OF THE INVENTION

Vehicle rollover—generally defined as vehicular accident in which a vehicle turns over on its side or roof—is an extremely dangerous form of a vehicle crash. Vehicle rollover accidents while relatively rare—estimated at approximately 3% of all vehicle crashes—account for a disproportionately high number of fatal crashes—estimated at approximately 31% of all fatal vehicle crashes. The Nation Highway Transportation Safety Administration (NHTSA) reported that 10,666 people were killed in the US in vehicle rollover crashes in 2002. Many factors are involved in a vehicle rollover including for instance vehicle center of gravity, vehicle suspension stiffness, vehicle tire traction, etc. However, according to Wikipedia, "The main cause for rolling over is turning too sharply while moving too fast" (see Appendix A, page 1, first paragraph). While there may be several factors for a vehicle to be turned or steered beyond the vehicle threshold of roll such as driver hurry or impatience and driver inexperience, a well know cause for excessive turning or steering to the point of vehicle roll is the occurrence of an object such as a tumble weed or squirrel suddenly appearing in the drivers path (hereafter referred to Sudden Object Appearance or SOA). In such SOA, even the most experienced drivers can feel the inherent and immediate urge to rapidly turn the steering wheel. It is just such turning of the steering wheel that causes many vehicle rollovers.

In recent years, a system commonly referred to as Electronic Stability Control or ESC has, by automatically selectively apply torque or braking force to certain of a vehicles wheels, been used in significantly improving stability of vehicles, especially when such vehicles would have otherwise "spun out" or "fish-tailed" when cornering. However, such ESC systems, which typically require complex rollover prediction schemes, cannot prevent vehicle rollover when a vehicle steering wheel is turned too sharply for the vehicle speed as in a SOA situation. Further, a number of inventions dealing with vehicle steering control have been developed over the years. However, such inventions have typically merely dealt with preventing damage to a driving surface (i.e. turf) or prevention of a power steering system, and no such systems are known to prevent vehicle rollover, especially in a SOA situation. Examples of such inventions are provided in the following list of US patents and applications, the whole of which are incorporated herein by reference: U.S. Pat. Nos. 5,489,006, 6,584,388, 6,588,799, 6,714,848, 6,954,140, 7,107,136, 7,261,303, 7,325,644, 7,440,844, 7613,555, 20030055549, 20030088349, 20030093201, 20040102894, 20040104066, 20040215384, 20050060069, 20050110227,

20060030991, 20060129298, 20060162987, 20070299583, 20080133101, 20090228173, 20100191423, and 20110060505.

SUMMARY OF THE INVENTION

The present invention is a vehicle rollover prevention apparatus. In a first embodiment, the apparatus defines an adaptive steering range limiting device (ASRLD) comprising a control unit and a pair of opposing unidirectional brake assemblies mounted to a steering column position detection disc (SCPDD). The unidirectional brake assemblies comprise a first left hand unidirectional brake assembly (LHUBA) and a second right hand unidirectional brake assembly (RHUBA), with the LHUBA operable to brake in a left hand or counterclockwise (CCW) direction and yet roll substantially freely in a right hand or clockwise (CW) direction, and with the RHUBA operable to brake in a right hand or clockwise (CW) direction and yet roll substantially freely in a left hand or counterclockwise (CCW) direction. The SCPDD includes at least one and preferably a plurality of sensors that sense the angular position of a vehicle steering wheel and provide such angular position information to the control unit. The control unit also receives speed data from a vehicle speed sensor. In practice, when a vehicle in which the ASRLD is installed is moving at less than a predetermined rate of speed, the unidirectional brake assemblies are not applied, and the vehicle steering wheel may be turned to the full hand range of steering motion. However, when a vehicle in which the ASRLD is installed is moving at no less than a predetermined rate of speed and the vehicle steering wheel is turned to no less than a predetermined left hand angle, the LHUBA is automatically applied, and the vehicle steering left hand range of motion is restricted such that the steering wheel may not be turned beyond the threshold of left hand rollover for the particular vehicle for the given vehicle speed. When the vehicle speed and/or steering wheel left hand angle is reduced, the LHUBA is automatically released. Further, when a vehicle in which the ASRLD is installed is moving at no less than a predetermined rate of speed and the vehicle steering wheel is turned to no less than a predetermined right hand angle, the RHUBA is automatically applied, and the vehicle steering right hand range of motion is restricted such that the steering wheel may not be turned beyond the threshold of right hand rollover for the particular vehicle for the given vehicle speed. When the vehicle speed and/or steering wheel right hand angle is reduced, the RHUBA is automatically released. It is noted that when the unidirectional brake assemblies are (separately) applied, although the steering wheel is prevented from being turn beyond a predetermined left hand or right hand angle, the steering wheel is free to be turned back toward a steering wheel centered or neutral position. In this method, a vehicle is prevented from being steered beyond the threshold of vehicle role and yet the vehicle steering wheel remains otherwise usable over the unrestrained rotational range of travel.

DESCRIPTION OF DRAWINGS

In order that the advantages of the invention will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

FIG. **1** is a trimetric view of a first embodiment of the invention;

FIG. **2** is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**2**" in FIG. **1**;

FIG. **3**A is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**3**" in FIG. **2**, the invention is shown with the LHUBA in an unactuated or open position;

FIG. **3**B is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**3**" in FIG. **2**, the invention is shown with the LHUBA in an actuated or closed position;

FIG. **4**A is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**4**" in FIG. **2**, the invention is shown with the RHUBA in an unactuated or open position;

FIG. **4**B is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**4**" in FIG. **2**, the invention is shown with the RHUBA in an actuated or closed position;

FIG. **5** is a trimetric view of a fourth embodiment of the invention;

FIG. **6**A is an orthographic cross-sectional view of the fourth embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**6**" in FIG. **5**;

FIG. **6**B is substantially similar to FIG. **6**A except that a first set of actuator pins are shown as extended;

FIG. **6**C is substantially similar to FIG. **6**A except that a second set of actuator pins are shown as extended;

FIG. **6**D is substantially similar to FIG. **6**A except that a third set of actuator pins are shown as extended;

FIG. **6**E is substantially similar to FIG. **6**D except that SCDD **140** is shown rotated to the limit of its right hand rotational range of motion;

FIG. **7** is an orthographic cross-sectional view of the fourth embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**7**" in FIG. **6**D, with the invention shown without an actuation pin **144** blocking rotational motion of SCDD **140**, and;

FIG. **7**A is an orthographic cross-sectional view of the fourth embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "**7** " in FIG. **6**E, with the invention shown with an actuation pin **144***a* blocking rotational motion of SCDD **140**.

DETAILED DESCRIPTION OF THE INVENTION

Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

Furthermore, the described features, structures, or characteristics of the invention may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are included to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

In order to facilitate the understanding of the present invention in reviewing the drawings accompanying the specification, a feature table is provided below. It is noted that like features are like numbered throughout all of the figures.

FEATURE TABLE

#	Feature
10	adaptive steering range limiting device
20	steering wheel
30	steering column
40	steering column position detection disc
42	disc
44	magnetic target
50	unidirectional brake assemblies
60	left hand unidirectional brake assembly
62	caliper housing
64	unidirectional roller
70	right hand unidirectional brake assembly
72	caliper housing
74	unidirectional roller
80	electronic control unit
85	sensor
92	left hand or CCW direction indication arrow
94	right hand or CW direction indication arrow
110	adaptive steering range limiting device
120	steering wheel
130	steering column
140	steering column disc device
142	disc
144	actuator pin
144a	actuator pin-extended
180	electronic control unit
185	block
192	left hand or CCW direction indication arrow
194	right hand or CW direction indication arrow

Referring now to FIGS. **1** through **4** of the drawings, a first embodiment of the invention is an adaptive steering range limiting device (ASRLD) **10** comprising a steering wheel **20**, a steering column **30**, a steering column position detection disc (SCPDD) **40**, a pair of opposing unidirectional brake assemblies **50**, an electronic control unit **80** and a sensor **85**. Furthermore arrow **92** defines a left hand or counterclockwise (CCW) direction indication arrow and arrow **94** defines a right hand or clockwise (CW) direction indication arrow. Steering wheel **20** defines a conventional steering wheel as may commonly be found in a commercially available passenger vehicle. Steering column **30** defines a conventional steering column that serves to transmit steering torque from steering wheel **20** to a rack and pinion or other such vehicle wheel control device. SCPDD **40** defines a substantially thin preferably aluminum cylinder shaped disc **42** having a plurality of magnetic targets **44** embedded within disc **42** and spaced substantially equally about the periphery of disc **42**. Unidirectional brake assemblies **50** define an assembly comprising a left hand unidirectional brake assembly (LHUBA) **60** and a right hand unidirectional brake assembly (RHUBA) **70**. LHUBA **60** defines a brake assembly having a caliper housing **62**, and a plurality of actuatable or extendable and retractable unidirectional rollers **64**. Unidirectional roller **64** preferably comprises a generally hard rubber roller mounted on at least one unidirectional bearing. Unidirectional bearings are well known in the art and are for instance taught in U.S. Pat. Nos.

3,805,932 and 5,547,055, which are incorporated herein by reference. RHUBA **70** defines a brake assembly having a caliper housing **72**, and a plurality of actuatable or extendable and retractable unidirectional rollers **74**. Unidirectional roller **74** preferably comprises a generally hard rubber roller mounted on at least one unidirectional bearing. Electronic control unit **80** defines an electronic control unit such as are commonly in use in automobiles, and is adapted to electronically receive speed, position and other sensor input and is adapted to electronically transmit actuation signals based on predetermined inputs. Sensor **85** preferably defines an electronic sensor such as reed switch type sensor that is operable to detect near proximity to magnetic targets **44**, and thus is operable to detect rotational positioning of SCPDD **40**.

ASRLD **10** is assembled such that steering column **30** is connected to steering wheel **20** on a first end of steering column **30** and to SCPDD **40** on a second end of steering column **30**. Unidirectional brake assemblies **50** are positioned near SCPDD **40** such that disc **42** may rotatingly pass between rollers **64** and between rollers **74**. Electronic control unit **80** is electronically connected to unidirectional brake assemblies **50** and electronically connected to sensor **85**. ASRLD **10** is mounted in a vehicle such that second end of steering column **30** is steeringly connected to a rack and pinion or like steering mechanism of the vehicle such that ASRLD **10** is operable to steer the vehicle. Unidirectional brake assemblies **50** are further connected to a structural member of the vehicle such that unidirectional brake assemblies **50** remain stationary relative to a rotation movement of SCPDD **40** and such that unidirectional brake assemblies **50** are able to react or withstand a steering stopping load. Electronic control unit **80** is further connected to a structural member of the vehicle such that electronic control unit **80** remains stationary regardless of rotation movement of SCPDD **40**. Sensor **85** is further connected to a structural member of the vehicle such that sensor **85** remains stationary relative to a rotation movement of SCPDD **40** and such that sensor **85** is able to detect magnetic targets **44** as magnetic targets **44** move into a near proximity position to sensor **85**.

In practice, with ASRLD **10** operably mounted in a vehicle, when the vehicle is moving below a predetermined speed, for instance less than 10 miles per hour (mph), unidirectional brake assemblies **50** are not actuated as shown in FIGS. **3**A and **4**A, and steering wheel **20** may be freely rotated through its the full rotational range of motion. It is noted that when steering wheel **20** is rotated, SCPDD **40** correspondingly rotates between rollers **64** and between rollers **74** and sensor **85** and electronic control unit **80** monitors the rotational orientation of SCPDD **40**. However, when the vehicle is moving at or above a predetermined speed, for instance 10 miles per hour (mph), and SCPDD **40** is sensed at being at or above a left hand rotational orientation of greater than a predetermined amount, for instance 10 degrees CCW from a center or neutral steering position, electronic control unit **80** determines a steering prevention threshold has been achieved and sends an actuation signal to LHUBA **60**, and LHUBA **60** actuates by moving unidirectional rollers **64** into unidirectional braking contact with SCPDD **40** as shown in FIG. **3**B and steering wheel **20** is prevented from rotating further in a left hand or CCW direction but is free to rotate in a right hand or CW direction. When the vehicle slows to less than the predetermined speed or when steering wheel **20** is rotated to a rotational orientation of below the predetermined amount, LHUBA **60** "deactuates" by moving unidirectional rollers **64** out of braking contact with SCPDD **40** as shown in FIG. **3**A, and steering wheel **20** may again be rotated freely in both directions (CCW and CW) unless and until another steering prevention threshold is reached. Further, when the vehicle is moving at or above a predetermined speed, for instance 10 miles per hour (mph), and SCPDD **40** is sensed at being at or above a right hand rotational orientation of greater than a predetermined amount, for instance 10 degrees CW from a center or neutral steering position, electronic control unit **80** determines a steering prevention threshold has been achieved and sends an actuation signal to RHUBA **70**, and RHUBA **70** actuates by moving unidirectional rollers **74** into unidirectional braking contact with SCPDD **40** as shown in FIG. **4**B and steering wheel **20** is prevented from rotating further in a right hand or CW direction but is free to rotate in a left hand or CCW direction. When the vehicle slows to less than the predetermined speed or when steering wheel **20** is rotated to a rotational orientation of below the predetermined amount, RHUBA **70** "deactuates" by moving unidirectional rollers **74** out of braking contact with SCPDD **40** as shown in FIG. **4**A, and steering wheel **20** may again be rotated freely in both directions (CCW and CW) unless and until another steering prevention threshold is reached.

It is noted that ASRLD **10** is preferably adapted such that the various steering prevention thresholds are of substantially fine increments such that the braking of steering wheel **20** is accomplished in a fashion that approximates a smooth non-stair-stepped method. For example, if a vehicle equipped with ASRLD **10** were to be traveling on a substantially large flat horizontal paved surface at a high rate of speed, such as for instance 100 mph, and steering wheel **20** were to be turned hard to the right (or the left), ASRLD **10** would prevent steering wheel **20** from being turned to the right (or the left) to the point that the vehicle would rollover to the left (or to the right), and would more specifically, allow steering wheel **20** to be turned to the right (or the left) very near to but just less than the threshold of vehicle rollover. Further, in the above described scenario, if the right hand (or left hand) steering load were maintained on steering wheel **20** and the vehicle was to be allowed to decelerate, such as by coasting or by braking, the vehicle would turn to the right (or to the left) at an substantially continuously sharper right hand (or left hand) turn (e.g. a substantially decreasing turn radius) corresponding to the decreased rate of speed until the vehicle slowed to the point that it would be traveling at less than the first or slowest steering prevention threshold (such as less than 10 mph). Once the vehicle slowed to the first or slowest steering prevention threshold, the vehicle would then turn to the right (or to the left) at a constant turn rate which would be the full unrestricted turn rate of the vehicle. Thus by this description, it can be seen that at substantially any speed of the vehicle, the vehicle is allowed to turn at a rate approaching but just less than the vehicle rollover threshold for such given "any" speed. ASRLD **10** is somewhat analogous to "anti-lock braking". With anti-lock braking, braking and vehicle control is maximized (breaking distance minimized) by allowing the brakes to apply a braking force that approaches but is never allowed to exceed the tire-to-ground traction breaking threshold. Analogously, with ASRLD **10**, steering and vehicle control is maximized by allowing the vehicle to be steered to a degree that approaches but is never allowed to exceed the vehicle rollover threshold.

It is noted that each vehicle model or alteration thereof may have a different propensity for roll. In the first embodiment, such propensity is predetermined and corresponding combinations of turn degree and vehicle speed are determined for various vehicle rollover thresholds. However, it is also understood that vehicle roll propensity is influenced a plurality of factors. In addition to speed and turn degree, such factors may include for instance vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and the vehicle tires, road angle/banking, etc. Thus in a second embodiment, the second embodiment is substantially identical to the first embodiment except that in the second embodiment, factors in addition to vehicle speed and turn degree are monitored and rollover thresholds are determined on-the-fly.

It is noted that inasmuch as there may be a belief by some that certain circumstances may exist wherein the likelihood of injury or death may be less if a vehicle is allowed to be steered beyond a vehicle threshold of rollover than if a vehicle is restricted from being steered beyond a vehicle threshold of rollover. To satisfy such potential concerns, in a third embodiment, the third embodiment is substantially identical to the second embodiment except that the third embodiment includes an override mode. In such override mode the steering rotational range of motion is automatically not restricted even if a steering prevention threshold is exceeded if an override logic criterion is satisfied. Such override logic criteria may comprise for instance, the detection of a human in near proximity of the drive path of the vehicle or for instance, the detection of a road surface having less than a predetermined coefficient of friction (e.g. an ice packed road).

Referring now to FIGS. **5** through **7** of the drawings, a fourth embodiment of the invention is an adaptive steering range limiting device (ASRLD) **110** comprising a steering wheel **120**, a steering column **130**, a steering column disc device (SCDD) **140**, an electronic control unit **180** and a block **185**. Furthermore arrow **192** defines a left hand or counterclockwise (CCW) direction indication arrow and arrow **194** defines a right hand or clockwise (CW) direction indication arrow. Steering wheel **120** defines a conventional steering wheel as may commonly be found in a commercially available passenger vehicle. Steering column **130** defines a conventional steering column that serves to transmit steering torque from steering wheel **120** to a rack and pinion or other such vehicle wheel control device. SCDD **140** defines a substantially thin preferably aluminum cylinder shaped disc **142** having a plurality of actuator pins **144** affixed to disc **142** and spaced substantially equally about the periphery of disc **142**. Actuator pins **144** are mounted to disc **142** such that in an un-actuated or retracted position, actuator pins **144** are positioned substantially flush with disc **142** and such that in an actuated or extended position, actuator pins **144** are positioned substantially in a position so as to potentially interfere with block **185**. Electronic control unit **80** defines an electronic control unit such as are commonly in use in automobiles, and is adapted to electronically receive speed input and is adapted to electronically transmit actuation signals based on predetermined inputs. Block **185** preferably defines rigidly fixed preferably metallic block that is connect to a vehicle structural member and does not move with disc **142**.

ASRLD **110** is assembled such that steering column **130** is connected to steering wheel **120** on a first end of steering column **130** and to SCDD **140** on a second end of steering column **130**. Electronic control unit **180** is electronically connected to actuator pins **144**. ASRLD **110** is mounted in a vehicle such that second end of steering column **130** is steeringly connected to a rack and pinion or like steering mechanism of the vehicle such that ASRLD **110** is operable to steer the vehicle. Block **185** is connected to a structural member of the vehicle such that block **185** remains stationary relative to a rotation movement of SCDD **140** and such that block **185** is able to react or withstand a steering stopping load. Electronic control unit **180** is further connected to a structural member of the vehicle such that electronic control unit **180** remains stationary regardless of rotation movement of SCDD **140**.

In practice, with ASRLD **110** operably mounted in a vehicle, when the vehicle is moving below a predetermined speed, for instance less than 5 miles per hour (mph), none of actuator pins **144** are actuated as shown in FIGS. **6**A and **6**, and steering wheel **120** may be freely rotated through its the full (unrestricted) rotational range of motion. It is noted that when steering wheel **120** is rotated, SCDD **140** correspondingly in very near proximity to stationary block **185**. However, when the vehicle is moving at or above a first predetermined speed, for instance 10 miles per hour (mph), electronic control unit **80** determines a first steering prevention threshold has been achieved and sends an actuation signal to a first set of actuator pins **144** as shown in FIG. **6**B and steering wheel **120** is prevented from rotating beyond a first restricted range of rotational motion. When the vehicle is moving at or above a second predetermined speed, for instance 35 miles per hour (mph), electronic control unit **80** determines a second steering prevention threshold has been achieved and sends an actuation signal to a second set of actuator pins **144** as shown in FIG. **6**C and steering wheel **120** is prevented from rotating beyond a second restricted range of rotational motion. When the vehicle is moving at or above a third predetermined speed, for instance 65 miles per hour (mph), electronic control unit **80** determines a third steering prevention threshold has been achieved and sends an actuation signal to a third set of actuator pins **144** as shown in FIG. **6**D and steering wheel **120** is prevented from rotating beyond a third restricted range of rotational motion. When the vehicle slows to less than a given predetermined speed threshold, or when a more restrictive set of actuator pins **144** are actuated or extended, electronic control unit **80** sends an retraction signal to a given set of actuator pins **144**, and actuator pins **144** "deactuate" or retract and return to their home position, steering wheel **120** may again be rotated freely in both directions (CCW and CW) unless and until another steering prevention threshold is reached. It is noted that in the fourth embodiment of the invention, in contrast to systems that react to initiation of vehicle rollover. ASRLD **110** functions in a "proactive" mode by preventing the vehicle from initiating a rollover.

It is noted that ASRLD **110** is preferably adapted such that the various steering prevention thresholds are of substantially fine increments such that the varying of steering range of motion of steering wheel **120** is accomplished in a fashion that approximates a smooth non-stair-stepped method. For example, if a vehicle equipped with ASRLD **110** were to be traveling on a substantially large flat horizontal paved surface at a high rate of speed, such as for instance 100 mph, and steering wheel **120** were to be turned hard to the right (or the left), ASRLD **110** would prevent steering wheel **120** from being turned to the right (or the left) to the point that the vehicle would rollover to the left (or to the right), and would more specifically, allow steering wheel **120** to be turned to the right (or the left) very near to but just less than the threshold of vehicle rollover. Further, in the above described scenario, if the right hand (or left hand) steering load were maintained on steering wheel **120** and the vehicle was to be allowed to decelerate, such as by coasting or by braking, the vehicle would turn to the right (or to the left) at an substantially continuously sharper right hand (or left hand) turn (e.g. a substantially decreasing turn radius) corresponding to the decreased rate of speed until the vehicle slowed to the point that it would be traveling at less than the first or slowest steering prevention threshold (such as less than 10 mph). Once the vehicle slowed to the first or slowest steering prevention threshold, the vehicle would then turn to the right (or to the left) at a constant turn rate which would be the full unrestricted turn rate of the vehicle. Thus by this description, it can be seen that at substantially any speed of the vehicle, the vehicle is allowed to turn at a rate approaching but just less than the vehicle rollover threshold for such given "any" speed. ASRLD **110** is somewhat analogous to "anti-lock braking". With anti-lock braking, braking and vehicle control is maximized (breaking distance minimized) by allowing the brakes to apply a braking force that approaches but is never allowed to exceed the tire-to-ground traction breaking threshold. Analogously, with ASRLD **110**, steering and vehicle control is maximized by allowing the vehicle to be steered to a degree that approaches but is never allowed to exceed the vehicle rollover threshold.

What is claimed is:

1. A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle.

2. The apparatus of claim **1**, wherein said apparatus prevents said vehicle from being steered to the point of vehicle rollover.

3. The apparatus of claim **1**, wherein said apparatus is automatically actuated in response to the speed of said vehicle.

4. The apparatus of claim **1**, wherein said apparatus prevents said vehicle from being steered to the point of vehicle rollover in a first direction but allows said vehicle to be freely steered in a second direction.

5. The apparatus of claim **1**, wherein said apparatus includes at least one unidirectional brake operatively and adaptively mounted to a steering member such that said vehicle may be freely steered in response to a first condition, and such that said vehicle is automatically prevented from being steered in at least one direction in response to a second condition.

6. The apparatus of claim **5**, wherein said first condition defines a combination of vehicle speed and degree of steering position that substantially does not approach a vehicle rollover threshold, and wherein said second condition defines a combination of vehicle speed and degree of steering position that substantially approaches a vehicle rollover threshold.

7. The apparatus of claim **5**, wherein said first condition defines a combination of rollover factors that do not substantially approach a vehicle rollover threshold, said factors comprising vehicle speed, degree of steering position, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and vehicle tires, and road bank angle, and wherein said second condition defines a combination of rollover factors that substantially approach a vehicle rollover threshold, said factors comprising vehicle speed, degree of steering position, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, fraction between a road and vehicle tires, and road bank angle.

8. The apparatus of claim **6**, wherein said at least one direction defines a direction that increased steering of said vehicle in said at least one direction would cause said vehicle to rollover.

9. A steering range of motion control apparatus defining at least one unidirectional control device, wherein said at least one unidirectional control device is automatically applied when a vehicle's steering approaches a rollover threshold of said vehicle.

10. The steering range of motion control apparatus of claim **9**, wherein said apparatus automatically prevents a vehicle from being steered beyond a threshold of rollover of said vehicle.

11. The steering range of motion control apparatus of claim **9**, wherein said unidirectional control device defines a unidirectional brake, and wherein when said unidirectional brake is applied, a steering wheel of said vehicle is allowed to be rotated in a first direction but is prevented from being rotated in a second direction.

12. The apparatus of claim **9**, wherein said rollover threshold is automatically determined based upon a combination of vehicle speed and degree of steering position.

13. The apparatus of claim **9**, wherein said rollover threshold is automatically determined based upon a combination of vehicle speed, degree of steering position, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and vehicle tires, and road bank angle.

14. An adaptive steering apparatus that automatically adaptively prevents a vehicle from being steered beyond the threshold of roll of said vehicle at any speed of said vehicle while also providing for maximal non-rollover steering range of motion of said vehicle, wherein said apparatus that automatically adjusts a steering range of motion in response to at least one predetermined input.

15. The apparatus of claim **14**, wherein said adaptively adjusted steering range of motion defines a steering range of motion that does not exceed a vehicle rollover threshold.

16. The apparatus of claim **14**, wherein said apparatus adjusts in response to vehicle speed.

17. The apparatus of claim **16**, wherein said adaptively adjusted steering range of motion defines a steering range of motion that is inversely proportional to vehicle speed.

18. The apparatus of claim **14**, wherein said apparatus adjusts in response to at least one of vehicle speed, degree of steering position, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, fraction between a road and vehicle tires, and road bank angle.

19. The apparatus of claim **14**, wherein said apparatus includes a unidirectional motion control device.

20. The apparatus of claim **19**, wherein said unidirectional motion control device defines a unidirectional brake, and wherein when said unidirectional brake is applied, a steering wheel of a vehicle is allowed to be rotated in a first direction but is prevented from being rotated in a second direction.

21. An adaptive steering apparatus for use in automatically adaptively preventing a vehicle from being steered beyond the threshold of roll of said vehicle at any speed of said vehicle while also providing for maximal non-rollover steering range of motion of said vehicle at any speed of said vehicle, wherein said apparatus automatically and adaptively adjusts the steerable range of motion of a vehicle such that said steerable range of motion does not exceed the rollover threshold of said vehicle at substantially any speed of said vehicle.

22. The apparatus of claim **21**, wherein said apparatus adjusts in response to at least one input comprising vehicle speed, degree of steering position, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and vehicle tires, and road bank angle.

* * * * *

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Schramm

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(45) **Date of Patent: *Apr. 16, 2019**

(54) **ROLLOVER PREVENTION APPARATUS**

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

(63) Continuation of application No. 14/733,042, filed on Jun. 8, 2015, now Pat. No. 9,580,103, which is a continuation of application No. 14/145,950, filed on Jan. 1, 2014, now Pat. No. 9,050,997, which is a continuation-in-part of application No. 13/222,157, filed on Aug. 31, 2011, now Pat. No. 8,634,989.

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(51) **Int. Cl.**

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(52) **U.S. Cl.**
CPC ***B62D 6/002*** (2013.01); ***B62D 1/16*** (2013.01); ***B62D 5/005*** (2013.01); ***B62D 6/008*** (2013.01); ***B62D 15/025*** (2013.01); ***B62D 15/0215*** (2013.01)

(58) **Field of Classification Search**
CPC B62D 6/002; B62D 5/005; B62D 6/008; B62D 15/0215; B62D 1/16; B62D 15/025
See application file for complete search history.

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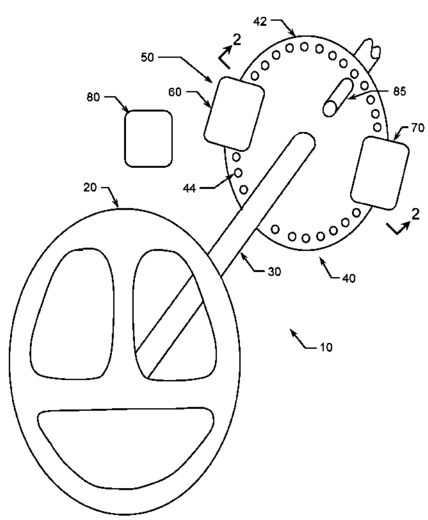
(57) **ABSTRACT**

The rollover prevention apparatus defines an adaptive steering range limiting device comprising a control unit and a pair of opposing unidirectional brake assemblies mounted to a steering column position detection disc. The rollover prevention apparatus prevents the steering wheel of the vehicle from being turned beyond the threshold of vehicle rollover, but otherwise does not restrict the rotational range of motion of the steering wheel of a vehicle.

23 Claims, 10 Drawing Sheets



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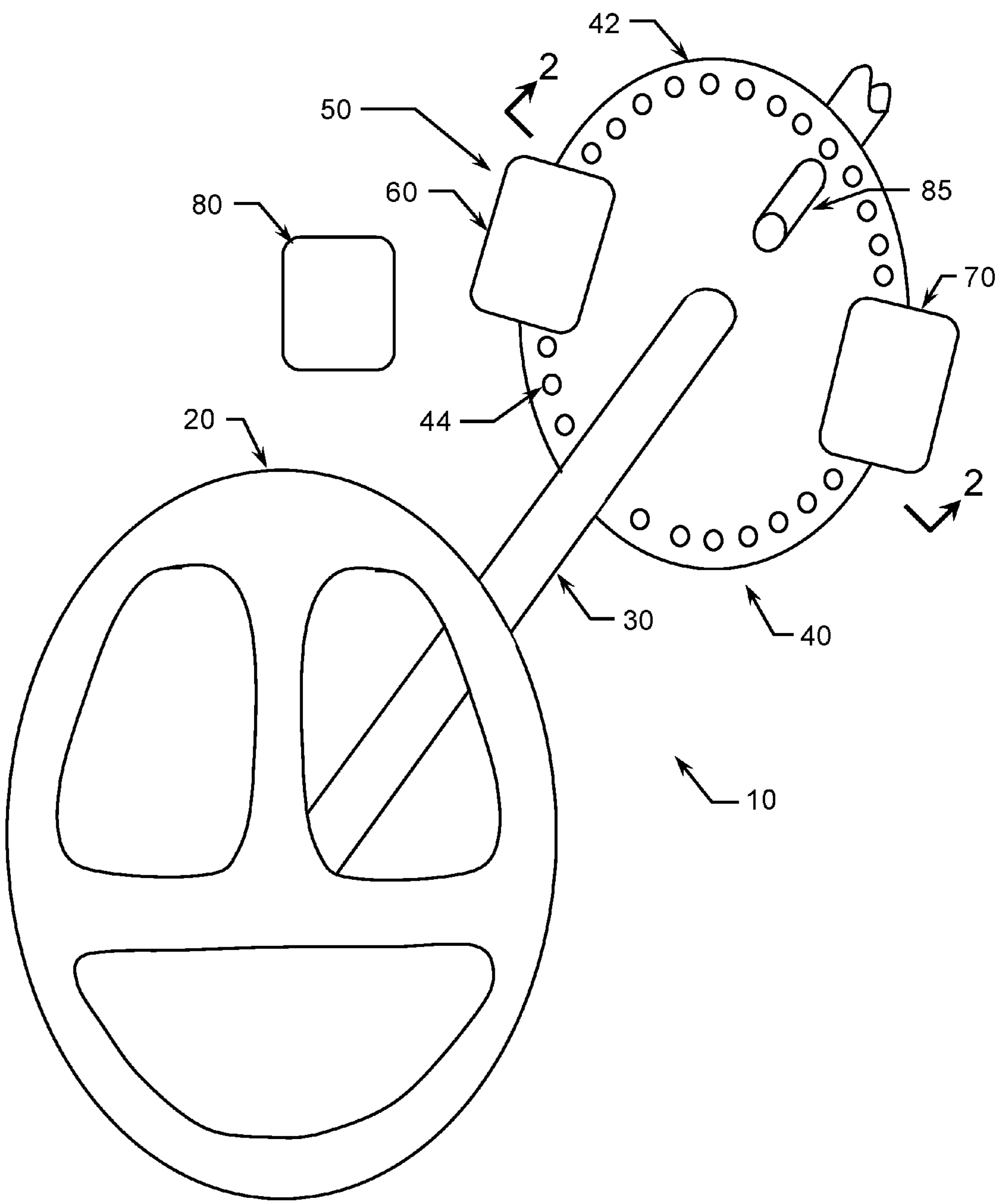


Figure 1

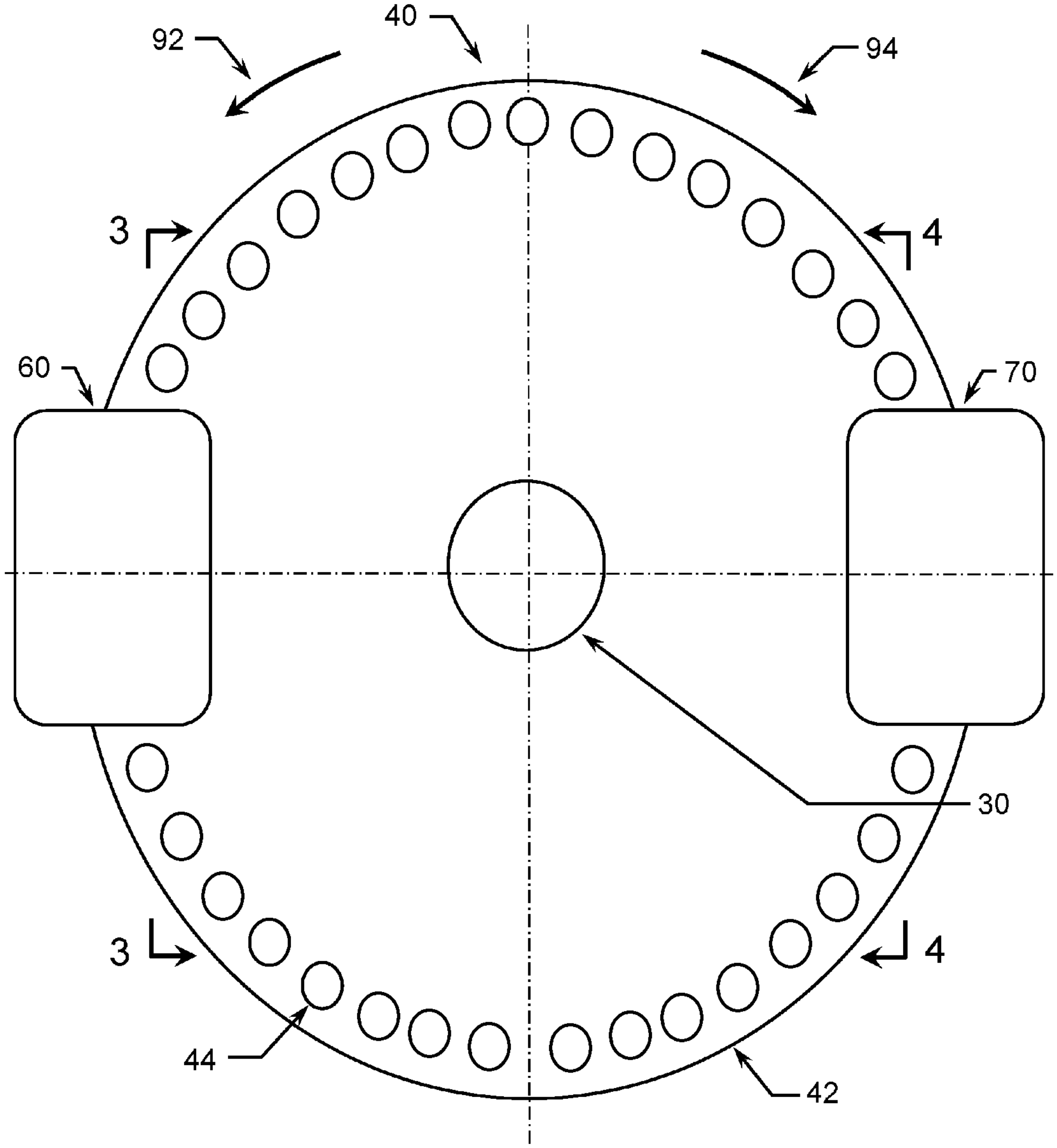


Figure 2

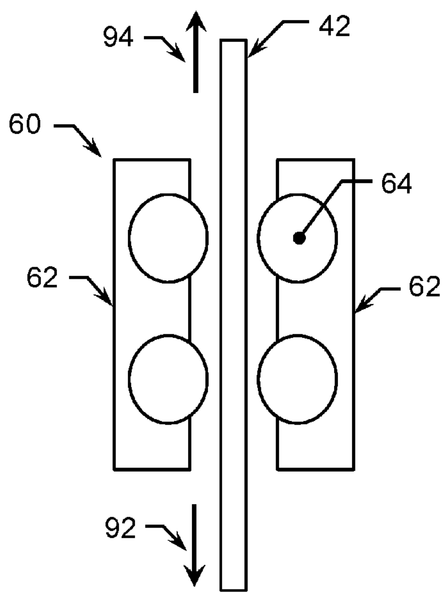


Figure 3A

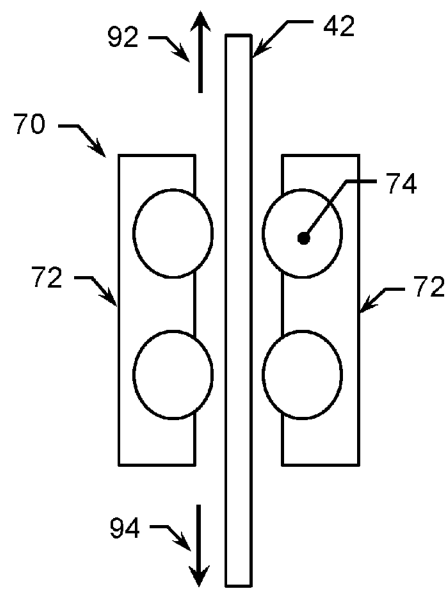


Figure 4A

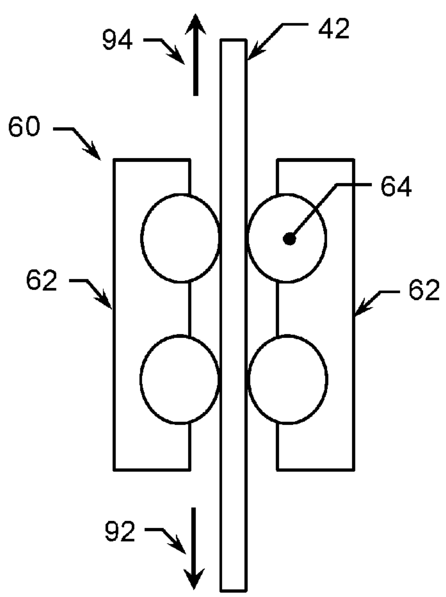


Figure 3B

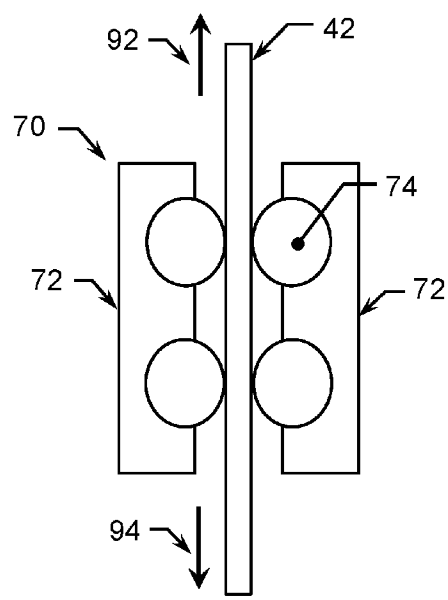


Figure 4B

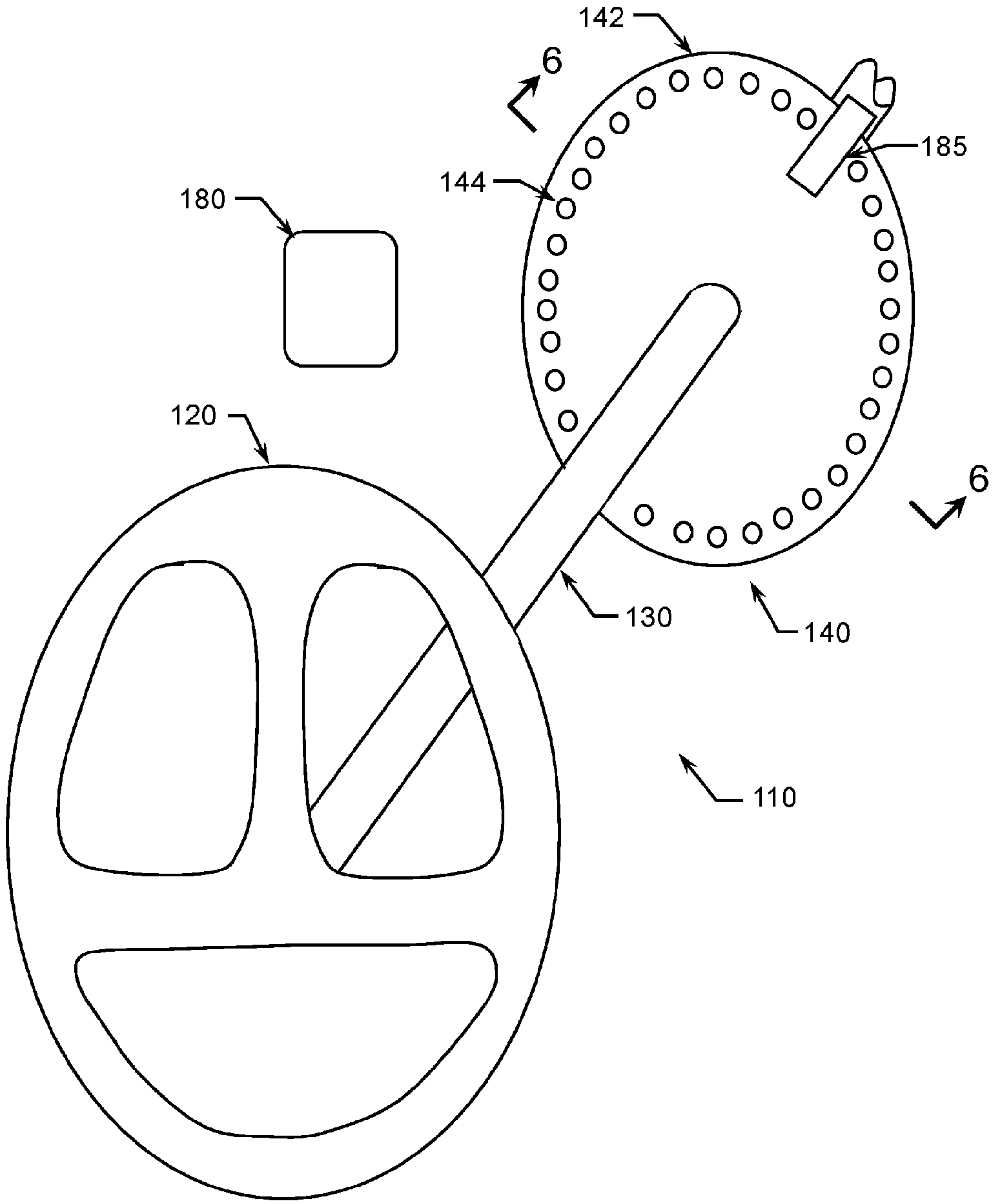


Figure 5

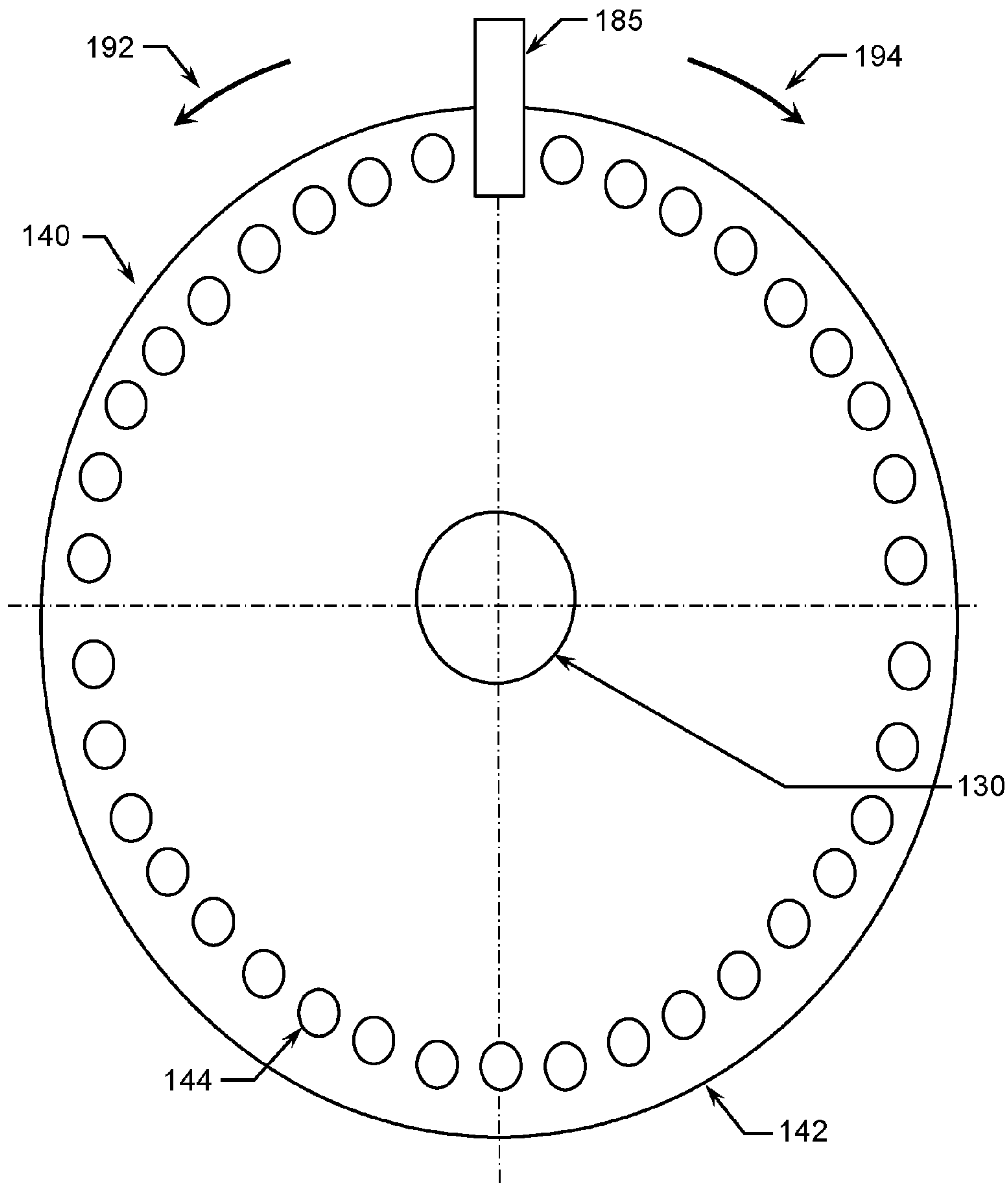


Figure 6A

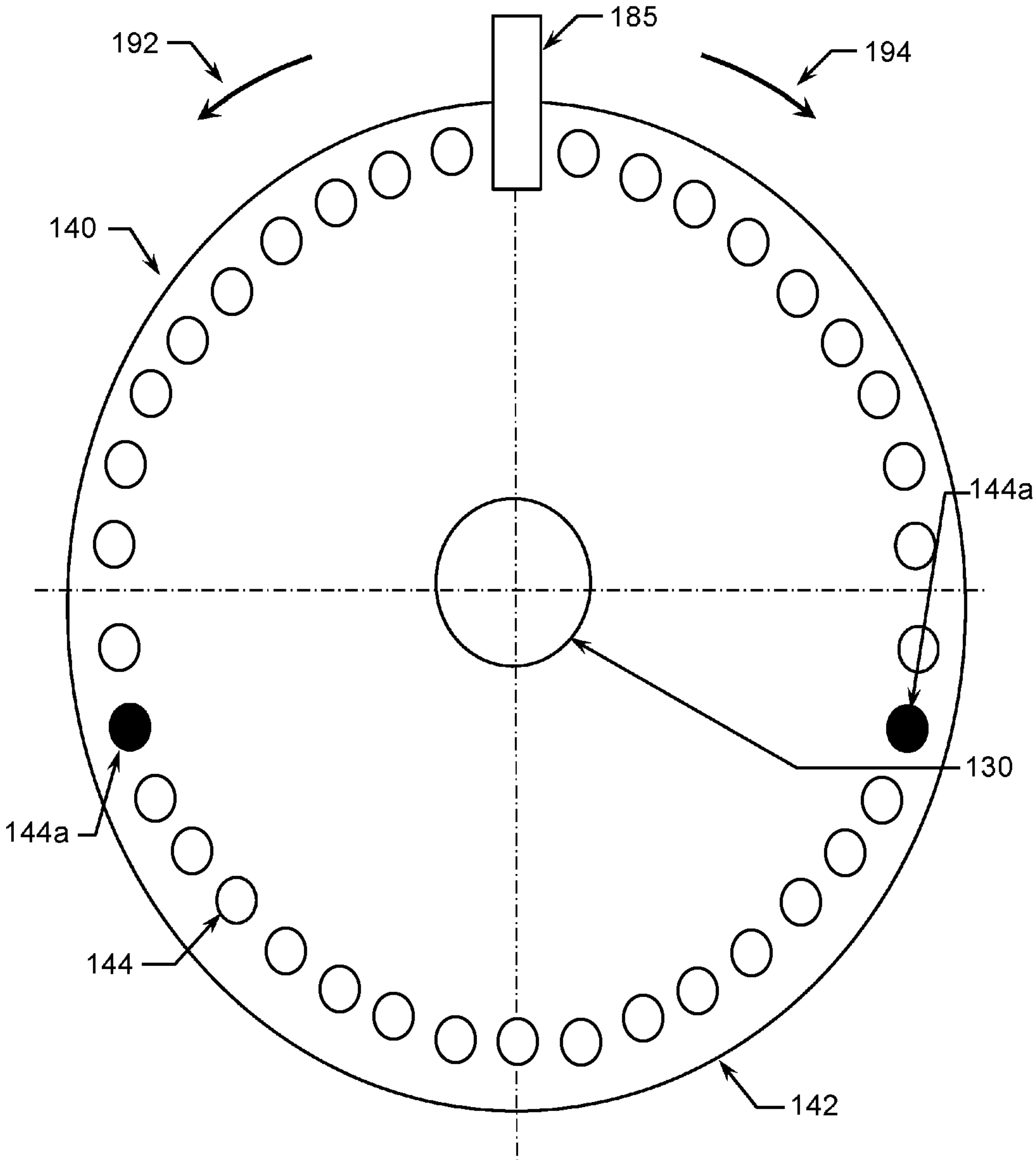


Figure 6B

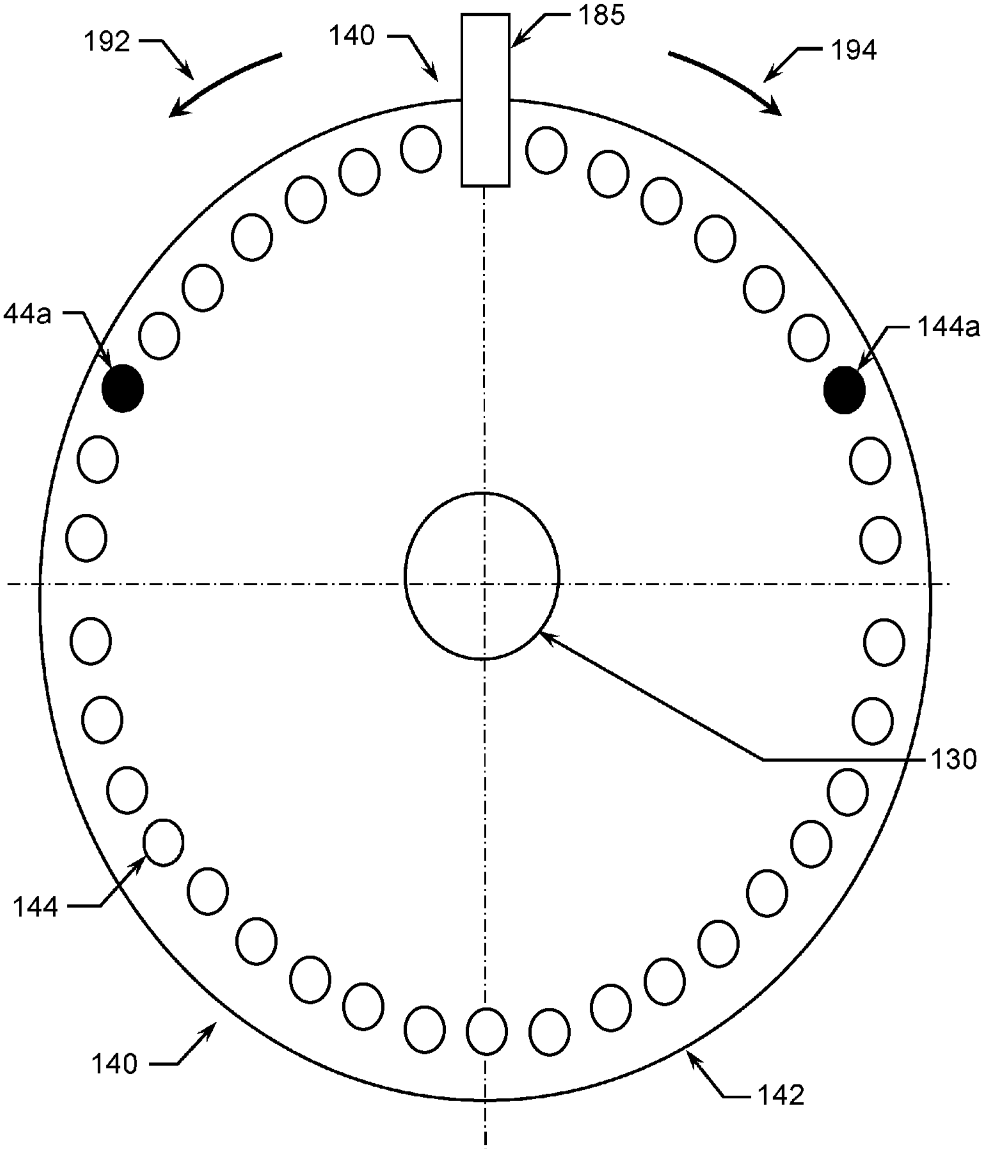


Figure 6C

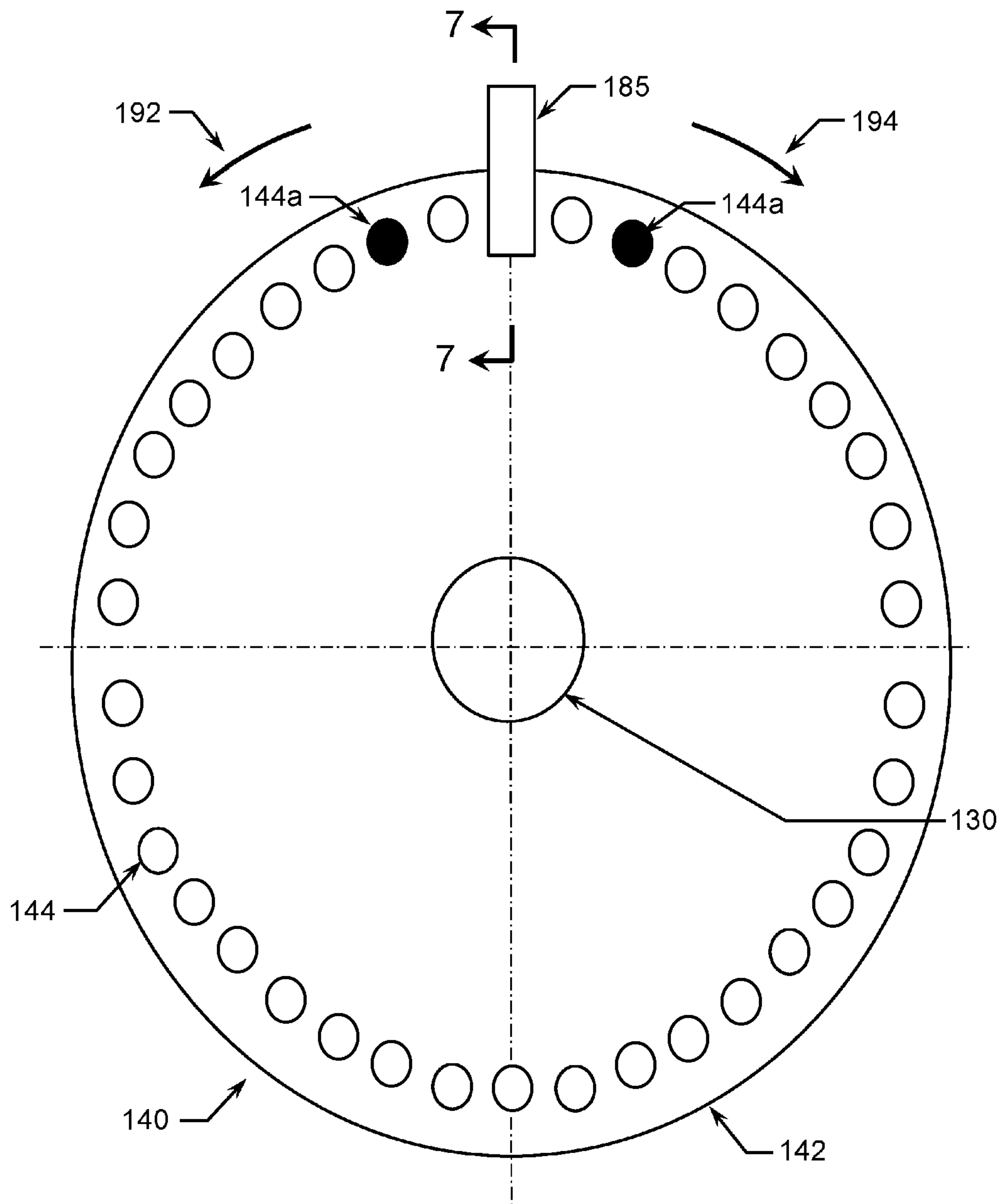


Figure 6D

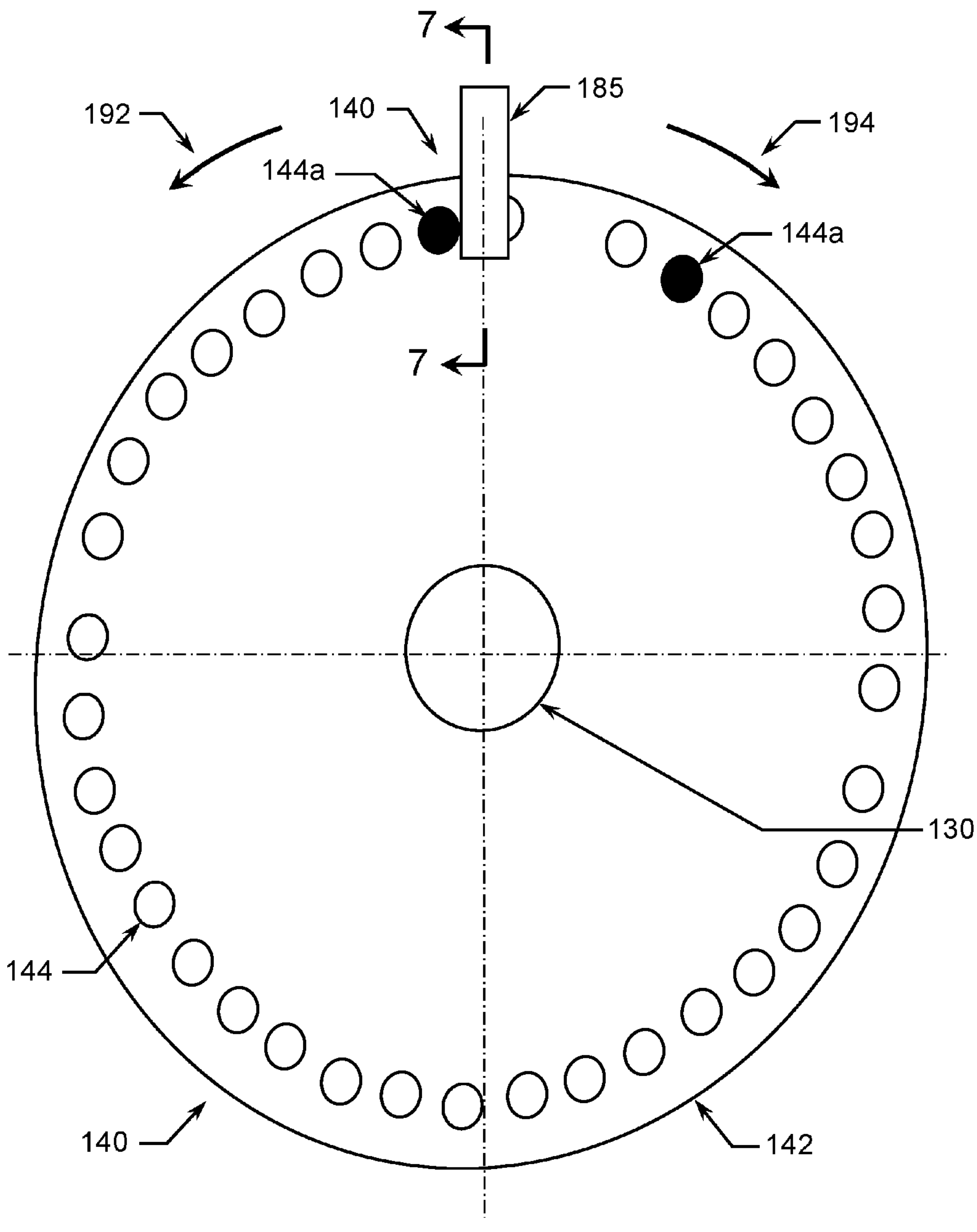


Figure 6E

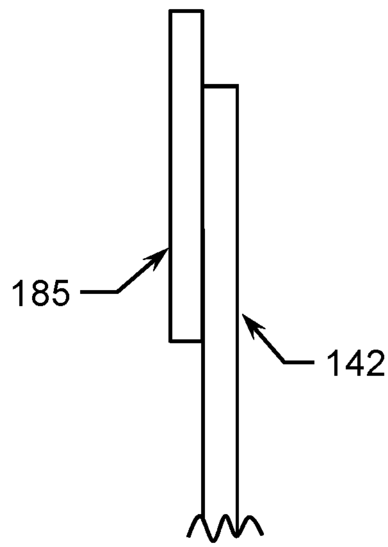


Figure 7

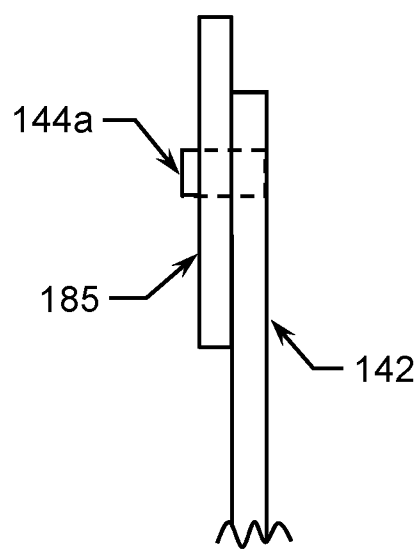


Figure 7A

ROLLOVER PREVENTION APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This nonprovisional utility patent application is a continuation of and claims the benefit under 35 USC § 120 to U.S. application Ser. No. 14/733,042 filed Jun. 8, 2015 and expected to issue as U.S. Pat. No. 9,580,103 on Feb. 28, 2017, which is a continuation of and claims the benefit under 35 USC § 120 to U.S. application Ser. No. 14/145,950 filed Jan. 1, 2014 and since issued as U.S. Pat. No. 9,050,997 on Jun. 9, 2015, which is a continuation-in-part of and claims the benefit under 35 USC § 120 to U.S. application Ser. No. 13/222,157 filed Aug. 31, 2011 and since issued as U.S. Pat. No. 8,634,989 on Jan. 21, 2014, which claims the benefit under 35 USC § 119(e) of U.S. provisional application No. 61/378,482 filed Aug. 31, 2010 and of U.S. provisional application No. 61/385,535 filed Sep. 22, 2010, all of which are expressly incorporated herein in their entirety by this reference.

FIELD OF THE INVENTION

The present invention relates to steering control devices and more especially devices for use in preventing steering to the point of vehicle rollover.

BACKGROUND OF THE INVENTION

Vehicle rollover—generally defined as vehicular accident in which a vehicle turns over on its side or roof—is an extremely dangerous form of a vehicle crash. Vehicle rollover accidents while relatively rare—estimated at approximately 3% of all vehicle crashes—account for a disproportionately high number of fatal crashes—estimated at approximately 31% of all fatal vehicle crashes. The Nation Highway Transportation Safety Administration (NHTSA) reported that 10,666 people were killed in the US in vehicle rollover crashes in 2002. Many factors are involved in a vehicle rollover including for instance vehicle center of gravity, vehicle suspension stiffness, vehicle tire traction, etc. However, according to Wikipedia, "The main cause for rolling over is turning too sharply while moving too fast" (see Appendix A, page 1, first paragraph). While there may be several factors for a vehicle to be turned or steered beyond the vehicle threshold of roll such as driver hurry or impatience and driver inexperience, a well know cause for excessive turning or steering to the point of vehicle roll is the occurrence of an object such as a tumble weed or squirrel suddenly appearing in the drivers path (hereafter referred to Sudden Object Appearance or SOA). In such SOA, even the most experienced drivers can feel the inherent and immediate urge to rapidly turn the steering wheel. It is just such turning of the steering wheel that causes many vehicle rollovers.

In recent years, a system commonly referred to as Electronic Stability Control or ESC has, by automatically selectively apply torque or braking force to certain of a vehicles wheels, been used in significantly improving stability of vehicles, especially when such vehicles would have otherwise "spun out" or "fish-tailed" when cornering. However, such ESC systems, which typically require complex rollover prediction schemes, cannot prevent vehicle rollover when a vehicle steering wheel is turned too sharply for the vehicle speed as in a SOA situation. Further, a number of inventions dealing with vehicle steering control have been developed

over the years. However, such inventions have typically merely dealt with preventing damage to a driving surface (i.e. turf) or prevention of a power steering system, and no such systems are known to prevent vehicle rollover, especially in a SOA situation. Examples of such inventions are provided in the following list of US patents and applications, the whole of which are incorporated herein by reference: U.S. Pat. Nos. 5,489,006, 6,584,388, 6,588,799, 6,714,848, 6,954,140, 7,107,136, 7,261,303, 7,325,644, 7,440,844, 7,613,555, 20030055549, 20030088349, 20030093201, 20040102894, 20040104066, 20040215384, 20050060069, 20050110227, 20060030991, 20060129298, 20060162987, 20070299583, 20080133101, 20090228173, 20100191423, and 20110060505.

SUMMARY OF THE INVENTION

The present invention is a vehicle rollover prevention apparatus. Thus unless indicated otherwise, where used in this application, the term "Anti-Roll Steering" or "ARS" shall be understood to mean a system or apparatus that adaptively adjusts the steering range of motion of a vehicle such as to prevent rollover of the vehicle. Thus for instance, ARS allows a vehicle steering to be steered in a full unrestricted range of motion when the vehicle is moving substantially below a predetermined speed (such as the speed that correlates to a roll threshold of the vehicle at a given turn angle or turn rate of the vehicle), but prevents a vehicle steering from being steered in a full unrestricted range of motion when the vehicle is moving at or near the predetermined speed. In a first embodiment, the apparatus defines an adaptive steering range limiting device (ASRLD) comprising a control unit and a pair of opposing unidirectional brake assemblies mounted to a steering column position detection disc (SCPDD). The unidirectional brake assemblies comprise a first left hand unidirectional brake assembly (LHUBA) and a second right hand unidirectional brake assembly (RHUBA), with the LHUBA operable to brake in a left hand or counterclockwise (CCW) direction and yet roll substantially freely in a right hand or clockwise (CW) direction, and with the RHUBA operable to brake in a right hand or clockwise (CW) direction and yet roll substantially freely in a left hand or counterclockwise (CCW) direction. The SCPDD includes at least one and preferably a plurality of sensors that sense the angular position of a vehicle steering wheel and provide such angular position information to the control unit. The control unit also receives speed data from a vehicle speed sensor. In practice, when a vehicle in which the ASRLD is installed is moving at less than a predetermined rate of speed, the unidirectional brake assemblies are not applied, and the vehicle steering wheel may be turned to the full hand range of steering motion. However, when a vehicle in which the ASRLD is installed is moving at no less than a predetermined rate of speed and the vehicle steering wheel is turned to no less than a predetermined left hand angle, the LHUBA is automatically applied, and the vehicle steering left hand range of motion is restricted such that the steering wheel may not be turned beyond the threshold of left hand rollover for the particular vehicle for the given vehicle speed. When the vehicle speed and/or steering wheel left hand angle is reduced, the LHUBA is automatically released. Further, when a vehicle in which the ASRLD is installed is moving at no less than a predetermined rate of speed and the vehicle steering wheel is turned to no less than a predetermined right hand angle, the RHUBA is automatically applied, and the vehicle steering right hand range of motion is restricted such that the steering wheel may not be turned beyond the threshold of right hand rollover for the particular vehicle for the given vehicle speed. When the vehicle speed and/or steering wheel right hand angle is reduced, the RHUBA is automatically released. It is noted that when the unidirectional brake assemblies are (separately) applied, although the steering wheel is prevented from being turn beyond a predetermined left hand or right hand angle, the steering wheel is free to be turned back toward a steering wheel centered or neutral position. In this method, a vehicle is prevented from being steered beyond the threshold of vehicle role and yet the vehicle steering wheel remains otherwise usable over the unrestrained rotational range of travel.

DESCRIPTION OF DRAWINGS

In order that the advantages of the invention will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

FIG. **1** is a trimetric view of a first embodiment of the invention;

FIG. **2** is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "2" in FIG. **1**;

FIG. **3**A is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "3" in FIG. **2**, the invention is shown with the LHUBA in an unactuated or open position;

FIG. **3**B is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "3" in FIG. **2**, the invention is shown with the LHUBA in an actuated or closed position;

FIG. **4**A is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "4" in FIG. **2**, the invention is shown with the RHUBA in an unactuated or open position;

FIG. **4**B is an orthographic cross-sectional view of the first embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "4" in FIG. **2**, the invention is shown with the RHUBA in an actuated or closed position;

FIG. **5** is a trimetric view of a fourth embodiment of the invention;

FIG. **6**A is an orthographic cross-sectional view of the fourth embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "6" in FIG. **5**;

FIG. **6**B is substantially similar to FIG. **6**A except that a first set of actuator pins are shown as extended;

FIG. **6**C is substantially similar to FIG. **6**A except that a second set of actuator pins are shown as extended;

FIG. **6**D is substantially similar to FIG. **6**A except that a third set of actuator pins are shown as extended;

FIG. **6**E is substantially similar to FIG. **6**D except that SCDD **140** is shown rotated to the limit of its right hand rotational range of motion;

FIG. **7** is an orthographic cross-sectional view of the fourth embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "7" in FIG. **6**D, with the invention shown without an actuation pin **144** blocking rotational motion of SCDD **140**, and;

FIG. **7**A is an orthographic cross-sectional view of the fourth embodiment of the invention taken substantially at the location indicated by the cross-section arrows annotated with "7" in FIG. **6**E, with the invention shown with an actuation pin **144***a* blocking rotational motion of SCDD **140**.

DETAILED DESCRIPTION OF THE INVENTION

Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

Furthermore, the described features, structures, or characteristics of the invention may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are included to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

In order to facilitate the understanding of the present invention in reviewing the drawings accompanying the specification, a feature table is provided below. It is noted that like features are like numbered throughout all of the figures.

FEATURE TABLE

#	Feature
10	adaptive steering range limiting device
20	steering wheel
30	steering column
40	steering column position detection disc
42	disc
44	magnetic target
50	unidirectional brake assemblies
60	left hand unidirectional brake assembly
62	caliper housing
64	unidirectional roller
70	right hand unidirectional brake assembly
72	caliper housing
74	unidirectional roller
80	electronic control unit
85	sensor
92	left hand or CCW direction indication arrow
94	right hand or CW direction indication arrow
110	adaptive steering range limiting device
120	steering wheel
130	steering column
140	steering column disc device
142	disc

-continued

FEATURE TABLE

#	Feature
144	actuator pin
144a	actuator pin - extended
180	electronic control unit
185	block
192	left hand or CCW direction indication arrow
194	right hand or CW direction indication arrow

Referring now to FIGS. **1** through **4** of the drawings, a first embodiment of the invention is an adaptive steering range limiting device (ASRLD) **10** comprising a steering wheel **20**, a steering column **30**, a steering column position detection disc (SCPDD) **40**, a pair of opposing unidirectional brake assemblies **50**, an electronic control unit **80** and a sensor **85**. Furthermore arrow **92** defines a left hand or counterclockwise (CCW) direction indication arrow and arrow **94** defines a right hand or clockwise (CW) direction indication arrow. Steering wheel **20** defines a conventional steering wheel as may commonly be found in a commercially available passenger vehicle. Steering column **30** defines a conventional steering column that serves to transmit steering torque from steering wheel **20** to a rack and pinion or other such vehicle wheel control device. SCPDD **40** defines a substantially thin preferably aluminum cylinder shaped disc **42** having a plurality of magnetic targets **44** embedded within disc **42** and spaced substantially equally about the periphery of disc **42**. Unidirectional brake assemblies **50** define an assembly comprising a left hand unidirectional brake assembly (LHUBA) **60** and a right hand unidirectional brake assembly (RHUBA) **70**. LHUBA **60** defines a brake assembly having a caliper housing **62**, and a plurality of actuatable or extendable and retractable unidirectional rollers **64**. Unidirectional roller **64** preferably comprises a generally hard rubber roller mounted on at least one unidirectional bearing. Unidirectional bearings are well known in the art and are for instance taught in U.S. Pat. Nos. 3,805,932 and 5,547,055, which are incorporated herein by reference. RHUBA **70** defines a brake assembly having a caliper housing **72**, and a plurality of actuatable or extendable and retractable unidirectional rollers **74**. Unidirectional roller **74** preferably comprises a generally hard rubber roller mounted on at least one unidirectional bearing. Electronic control unit **80** defines an electronic control unit such as are commonly in use in automobiles, and is adapted to electronically receive speed, position and other sensor input and is adapted to electronically transmit actuation signals based on predetermined inputs. Sensor **85** preferably defines an electronic sensor such as reed switch type sensor that is operable to detect near proximity to magnetic targets **44**, and thus is operable to detect rotational positioning of SCPDD **40**.

ASRLD **10** is assembled such that steering column **30** is connected to steering wheel **20** on a first end of steering column **30** and to SCPDD **40** on a second end of steering column **30**. Unidirectional brake assemblies **50** are positioned near SCPDD **40** such that disc **42** may rotatingly pass between rollers **64** and between rollers **74**. Electronic control unit **80** is electronically connected to unidirectional brake assemblies **50** and electronically connected to sensor **85**. ASRLD **10** is mounted in a vehicle such that second end of steering column **30** is steeringly connected to a rack and pinion or like steering mechanism of the vehicle such that ASRLD **10** is operable to steer the vehicle. Unidirectional brake assemblies **50** are further connected to a structural member of the vehicle such that unidirectional brake assemblies **50** remain stationary relative to a rotation movement of SCPDD **40** and such that unidirectional brake assemblies **50** are able to react or withstand a steering stopping load. Electronic control unit **80** is further connected to a structural member of the vehicle such that electronic control unit **80** remains stationary regardless of rotation movement of SCPDD **40**. Sensor **85** is further connected to a structural member of the vehicle such that sensor **85** remains stationary relative to a rotation movement of SCPDD **40** and such that sensor **85** is able to detect magnetic targets **44** as magnetic targets **44** move into a near proximity position to sensor **85**.

In practice, with ASRLD **10** operably mounted in a vehicle, when the vehicle is moving below a predetermined speed, for instance less than 10 miles per hour (mph), unidirectional brake assemblies **50** are not actuated as shown in FIGS. **3**A and **4**A, and steering wheel **20** may be freely rotated through its the full rotational range of motion. It is noted that when steering wheel **20** is rotated, SCPDD **40** correspondingly rotates between rollers **64** and between rollers **74** and sensor **85** and electronic control unit **80** monitors the rotational orientation of SCPDD **40**. However, when the vehicle is moving at or above a predetermined speed, for instance 10 miles per hour (mph), and SCPDD **40** is sensed at being at or above a left hand rotational orientation of greater than a predetermined amount, for instance 10 degrees CCW from a center or neutral steering position, electronic control unit **80** determines a steering prevention threshold has been achieved and sends an actuation signal to LHUBA **60**, and LHUBA **60** actuates by moving unidirectional rollers **64** into unidirectional braking contact with SCPDD **40** as shown in FIG. **3**B and steering wheel **20** is prevented from rotating further in a left hand or CCW direction but is free to rotate in a right hand or CW direction. When the vehicle slows to less than the predetermined speed or when steering wheel **20** is rotated to a rotational orientation of below the predetermined amount, LHUBA **60** "deactuates" by moving unidirectional rollers **64** out of braking contact with SCPDD **40** as shown in FIG. **3**A, and steering wheel **20** may again be rotated freely in both directions (CCW and CW) unless and until another steering prevention threshold is reached. Further, when the vehicle is moving at or above a predetermined speed, for instance 10 miles per hour (mph), and SCPDD **40** is sensed at being at or above a right hand rotational orientation of greater than a predetermined amount, for instance 10 degrees CW from a center or neutral steering position, electronic control unit **80** determines a steering prevention threshold has been achieved and sends an actuation signal to RHUBA **70**, and RHUBA **70** actuates by moving unidirectional rollers **74** into unidirectional braking contact with SCPDD **40** as shown in FIG. **4**B and steering wheel **20** is prevented from rotating further in a right hand or CW direction but is free to rotate in a left hand or CCW direction. When the vehicle slows to less than the predetermined speed or when steering wheel **20** is rotated to a rotational orientation of below the predetermined amount, RHUBA **70** "deactuates" by moving unidirectional rollers **74** out of braking contact with SCPDD **40** as shown in FIG. **4**A, and steering wheel **20** may again be rotated freely in both directions (CCW and CW) unless and until another steering prevention threshold is reached.

It is noted that ASRLD **10** is preferably adapted such that the various steering prevention thresholds are of substantially fine increments such that the braking of steering wheel **20** is accomplished in a fashion that approximates a smooth non-stair-stepped method. For example, if a vehicle equipped with ASRLD **10** were to be traveling on a substantially large flat horizontal paved surface at a high rate of speed, such as for instance 100 mph, and steering wheel **20** were to be turned hard to the right (or the left), ASRLD **10** would prevent steering wheel **20** from being turned to the right (or the left) to the point that the vehicle would rollover to the left (or to the right), and would more specifically, allow steering wheel **20** to be turned to the right (or the left) very near to but just less than the threshold of vehicle rollover. Further, in the above described scenario, if the right hand (or left hand) steering load were maintained on steering wheel **20** and the vehicle was to be allowed to decelerate, such as by coasting or by braking, the vehicle would turn to the right (or to the left) at an substantially continuously sharper right hand (or left hand) turn (e.g. a substantially decreasing turn radius) corresponding to the decreased rate of speed until the vehicle slowed to the point that it would be traveling at less than the first or slowest steering prevention threshold (such as less than 10 mph). Once the vehicle slowed to the first or slowest steering prevention threshold, the vehicle would then turn to the right (or to the left) at a constant turn rate which would be the full unrestricted turn rate of the vehicle. Thus by this description, it can be seen that at substantially any speed of the vehicle, the vehicle is allowed to turn at a rate approaching but just less than the vehicle rollover threshold for such given "any" speed. ASRLD **10** is somewhat analogous to "anti-lock braking". With anti-lock braking, braking and vehicle control is maximized (breaking distance minimized) by allowing the brakes to apply a braking force that approaches but is never allowed to exceed the tire-to-ground traction breaking threshold. Analogously, with ASRLD **10**, steering and vehicle control is maximized by allowing the vehicle to be steered to a degree that approaches but is never allowed to exceed the vehicle rollover threshold.

It is noted that each vehicle model or alteration thereof may have a different propensity for roll. In the first embodiment, such propensity is predetermined and corresponding combinations of turn degree and vehicle speed are determined for various vehicle rollover thresholds. However, it is also understood that vehicle roll propensity is influenced a plurality of factors. In addition to speed and turn degree, such factors may include for instance vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and the vehicle tires, road angle/banking, etc. Thus in a second embodiment, the second embodiment is substantially identical to the first embodiment except that in the second embodiment, factors in addition to vehicle speed and turn degree are monitored and rollover thresholds are determined on-the-fly. Further in the second embodiment, in order to prevent vehicle rollover due to continued or increased acceleration post-actuation of ASRLD **10**, electronic control unit **80** is adapted such that whenever ASRLD **10** is actuated, electronic control unit **80** sends a signal to an accelerator control device such that a vehicle is prevented from further acceleration during the duration of ASRLD **10** actuation.

It is noted that inasmuch as there may be a belief by some that certain circumstances may exist wherein the likelihood of injury or death may be less if a vehicle is allowed to be steered beyond a vehicle threshold of rollover than if a vehicle is restricted from being steered beyond a vehicle threshold of rollover. To satisfy such potential concerns, in a third embodiment, the third embodiment is substantially identical to the second embodiment except that the third embodiment includes an override mode. In such override mode the steering rotational range of motion is automatically not restricted even if a steering prevention threshold is exceeded if an override logic criterion is satisfied. Such override logic criteria may comprise for instance, the detection of a human in near proximity of the drive path of the vehicle or for instance, the detection of a road surface having less than a predetermined coefficient of friction (e.g. an ice packed road).

Referring now to FIGS. **5** through **7** of the drawings, a fourth embodiment of the invention is an adaptive steering range limiting device (ASRLD) **110** comprising a steering wheel **120**, a steering column **130**, a steering column disc device (SCDD) **140**, an electronic control unit **180** and a block **185**. Furthermore arrow **192** defines a left hand or counterclockwise (CCW) direction indication arrow and arrow **194** defines a right hand or clockwise (CW) direction indication arrow. Steering wheel **120** defines a conventional steering wheel as may commonly be found in a commercially available passenger vehicle. Steering column **130** defines a conventional steering column that serves to transmit steering torque from steering wheel **120** to a rack and pinion or other such vehicle wheel control device. SCDD **140** defines a substantially thin preferably aluminum cylinder shaped disc **142** having a plurality of actuator pins **144** affixed to disc **142** and spaced substantially equally about the periphery of disc **142**. Actuator pins **144** are mounted to disc **142** such that in an un-actuated or retracted position, actuator pins **144** are positioned substantially flush with disc **142** and such that in an actuated or extended position, actuator pins **144** are positioned substantially in a position so as to potentially interfere with block **185**. Electronic control unit **80** defines an electronic control unit such as are commonly in use in automobiles, and is adapted to electronically receive speed input and is adapted to electronically transmit actuation signals based on predetermined inputs. Block **185** preferably defines rigidly fixed preferably metallic block that is connect to a vehicle structural member and does not move with disc **142**.

ASRLD **110** is assembled such that steering column **130** is connected to steering wheel **120** on a first end of steering column **130** and to SCDD **140** on a second end of steering column **130**. Electronic control unit **180** is electronically connected to actuator pins **144**. ASRLD **110** is mounted in a vehicle such that second end of steering column **130** is steeringly connected to a rack and pinion or like steering mechanism of the vehicle such that ASRLD **110** is operable to steer the vehicle. Block **185** is connected to a structural member of the vehicle such that block **185** remains stationary relative to a rotation movement of SCDD **140** and such that block **185** is able to react or withstand a steering stopping load. Electronic control unit **180** is further connected to a structural member of the vehicle such that electronic control unit **180** remains stationary regardless of rotation movement of SCDD **140**.

In practice, with ASRLD **110** operably mounted in a vehicle, when the vehicle is moving below a predetermined speed, for instance less than 5 miles per hour (mph), none of actuator pins **144** are actuated as shown in FIGS. **6**A and **6**, and steering wheel **120** may be freely rotated through its the full (unrestricted) rotational range of motion. It is noted that when steering wheel **120** is rotated, SCDD **140** correspondingly in very near proximity to stationary block **185**. However, when the vehicle is moving at or above a first predetermined speed, for instance 10 miles per hour (mph), electronic control unit **80** determines a first steering prevention threshold has been achieved and sends an actuation signal to a first set of actuator pins **144** as shown in FIG. **6**B and steering wheel **120** is prevented from rotating beyond a first restricted range of rotational motion. When the vehicle is moving at or above a second predetermined speed, for instance 35 miles per hour (mph), electronic control unit **80** determines a second steering prevention threshold has been achieved and sends an actuation signal to a second set of actuator pins **144** as shown in FIG. **6**C and steering wheel **120** is prevented from rotating beyond a second restricted range of rotational motion. When the vehicle is moving at or above a third predetermined speed, for instance 65 miles per hour (mph), electronic control unit **80** determines a third steering prevention threshold has been achieved and sends an actuation signal to a third set of actuator pins **144** as shown in FIG. **6**D and steering wheel **120** is prevented from rotating beyond a third restricted range of rotational motion. When the vehicle slows to less than a given predetermined speed threshold, or when a more restrictive set of actuator pins **144** are actuated or extended, electronic control unit **80** sends an retraction signal to a given set of actuator pins **144**, and actuator pins **144** "deactuate" or retract and return to their home position, steering wheel **120** may again be rotated freely in both directions (CCW and CW) unless and until another steering prevention threshold is reached. It is noted that in the fourth embodiment of the invention, in contrast to systems that react to initiation of vehicle rollover. ASRLD **110** functions in a "proactive" mode by preventing the vehicle from initiating a rollover.

It is noted that ASRLD **110** is preferably adapted such that the various steering prevention thresholds are of substantially fine increments such that the varying of steering range of motion of steering wheel **120** is accomplished in a fashion that approximates a smooth non-stair-stepped method. For example, if a vehicle equipped with ASRLD **110** were to be traveling on a substantially large flat horizontal paved surface at a high rate of speed, such as for instance 100 mph, and steering wheel **120** were to be turned hard to the right (or the left), ASRLD **110** would prevent steering wheel **120** from being turned to the right (or the left) to the point that the vehicle would rollover to the left (or to the right), and would more specifically, allow steering wheel **120** to be turned to the right (or the left) very near to but just less than the threshold of vehicle rollover. Further, in the above described scenario, if the right hand (or left hand) steering load were maintained on steering wheel **120** and the vehicle was to be allowed to decelerate, such as by coasting or by braking, the vehicle would turn to the right (or to the left) at an substantially continuously sharper right hand (or left hand) turn (e.g. a substantially decreasing turn radius) corresponding to the decreased rate of speed until the vehicle slowed to the point that it would be traveling at less than the first or slowest steering prevention threshold (such as less than 10 mph). Once the vehicle slowed to the first or slowest steering prevention threshold, the vehicle would then turn to the right (or to the left) at a constant turn rate which would be the full unrestricted turn rate of the vehicle. Thus by this description, it can be seen that at substantially any speed of the vehicle, the vehicle is allowed to turn at a rate approaching but just less than the vehicle rollover threshold for such given "any" speed. ASRLD **110** is somewhat analogous to "anti-lock braking". With anti-lock braking, braking and vehicle control is maximized (breaking distance minimized) by allowing the brakes to apply a braking force that approaches but is never allowed to exceed the tire-to-ground traction breaking threshold. Analogously, with ASRLD **110**, steering and vehicle control is maximized by allowing the vehicle to be steered to a degree that approaches but is never allowed to exceed the vehicle rollover threshold.

What is claimed is:

1. A steering apparatus having a steering input device, an actuator, at least one sensor, and an electronic control unit, wherein said steering input device is adapted such that an input to said steering input device causes a corresponding change to a turn angle of a vehicle, and wherein said actuator is operatively adapted to actuate upon receipt of an actuation signal, and wherein said sensor is adapted to sense the magnitude of at least one driving parameter, and wherein said electronic control unit is adapted to send an actuation signal to said actuator when a sensed driving parameter exceeds a predetermined magnitude, and wherein said steering apparatus is adapted to allow a vehicle to be steered within a non-rollover steering range of motion of said vehicle but said steering apparatus is adapted to prevent said vehicle from being steered beyond a rollover threshold of said vehicle.

2. The apparatus of claim **1**, wherein said steering input device defines a steering wheel.

3. The apparatus of claim **1**, wherein said at least one driving parameter defines at least one of vehicle speed, degree of steering turn, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and vehicle tires, and road bank angle.

4. The apparatus of claim **1**, wherein said actuation signal is sent by said electronic control unit when the combination of sensed vehicle speed and degree of steering turn approach a rollover threshold of said vehicle.

5. The apparatus of claim **1**, wherein said apparatus has a first mode and a second mode, and wherein when said apparatus is in said first mode, said apparatus allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle, wherein when said apparatus is in said second mode, said apparatus automatically prevents said vehicle from being steered beyond a rollover threshold of said vehicle, and wherein said apparatus automatically performs at least one of a transition from said first mode to said second mode and a transition from said second mode to said first mode.

6. The apparatus of claim **1**, wherein said apparatus has a first mode and a second mode, and wherein when said apparatus is in said first mode, said apparatus allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle, wherein when said apparatus is in said second mode, said apparatus automatically prevents said vehicle from being steered beyond a rollover threshold of said vehicle, and wherein said apparatus transitions from said second mode to said first mode in response to application of load to a steering wheel.

7. The apparatus of claim **6**, wherein said application of load to a steering wheel further defines application of load to a steering wheel such that said steering wheel is rotated to a rotational orientation of below a steering prevention threshold.

8. A steering apparatus having a steering input device, an actuator, at least one sensor, and an electronic control unit, wherein said steering input device is adapted such that an input to said steering input device causes a corresponding change to a turn angle of a vehicle, and wherein said actuator is operatively adapted to actuate upon receipt of an actuation signal, and wherein said sensor is adapted to sense the magnitude of at least one driving parameter, and wherein said electronic control unit is adapted to send an actuation signal to said actuator when a sensed driving parameter exceeds a predetermined magnitude, and wherein said steering apparatus is adapted to allow a vehicle to be steered within a non-rollover steering range of motion of said vehicle but said steering apparatus is adapted to prevent said vehicle from being steered such that said vehicle would roll over when rounding a curve of such a magnitude and at such a speed that said vehicle would roll over if the turn angle of said vehicle were to exceed a rollover threshold of said vehicle.

9. The apparatus of claim **8**, wherein said steering input device defines a steering wheel.

10. The apparatus of claim **8**, wherein said at least one driving parameter defines at least one of vehicle speed, degree of steering turn, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and vehicle tires, and road bank angle.

11. The apparatus of claim **8**, wherein said actuation signal is sent by said electronic control unit when the combination of sensed vehicle speed and degree of steering turn approach a rollover threshold of said vehicle.

12. The apparatus of claim **8**, wherein said apparatus has a first mode and a second mode, and wherein when said apparatus is in said first mode, said apparatus allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle, wherein when said apparatus is in said second mode, said apparatus automatically prevents said vehicle from being steered beyond a rollover threshold of said vehicle, and wherein said apparatus automatically performs at least one of a transition from said first mode to said second mode and a transition from said second mode to said first mode.

13. The apparatus of claim **8**, wherein said apparatus has a first mode and a second mode, and wherein when said apparatus is in said first mode, said apparatus allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle, wherein when said apparatus is in said second mode, said apparatus automatically prevents said vehicle from being steered beyond a rollover threshold of said vehicle, and wherein said apparatus transitions from said second mode to said first mode in response to application of load to a steering wheel.

14. The apparatus of claim **13**, wherein said application of load to a steering wheel further defines application of load to a steering wheel such that said steering wheel is rotated to a rotational orientation of below a steering prevention threshold.

15. A vehicle having steering apparatus comprising a steering wheel, an actuator, at least one sensor, and an electronic control unit, wherein said steering wheel is adapted such that an input to said steering wheel causes a corresponding change to a turn angle of said vehicle, and wherein said actuator is operatively adapted to actuate upon receipt of an actuation signal, and wherein said sensor is adapted to sense the magnitude of at least one driving parameter, and wherein said electronic control unit is adapted to send an actuation signal to said actuator when a sensed driving parameter exceeds a predetermined magnitude, and wherein said vehicle is adapted to be steerable within a non-rollover steering range of motion of said vehicle but said steering apparatus is adapted to prevent said steering wheel from being rotated to the point that said vehicle would roll over when rounding a curve of such a magnitude and at such a speed that said vehicle would roll over if said steering wheel were rotated beyond said point.

16. The vehicle of claim **15**, wherein said at least one driving parameter defines at least one of vehicle speed, degree of steering turn, vehicle center of gravity, vehicle suspension stiffness, vehicle wheel base width, vehicle loading, vehicle tire pressure, traction between a road and vehicle tires, and road bank angle.

17. The vehicle of claim **15**, wherein said actuation signal is sent by said electronic control unit when the combination of sensed vehicle speed and degree of steering turn approach a rollover threshold of said vehicle.

18. The vehicle of claim **15**, wherein said apparatus has a first mode and a second mode, and wherein when said apparatus is in said first mode, said apparatus allows said vehicle to be steered within a non-rollover steering range of motion of said vehicle, wherein when said apparatus is in said second mode, said apparatus automatically prevents said vehicle from being steered beyond a rollover threshold of said vehicle, and wherein said apparatus automatically performs at least one of a transition from said first mode to said second mode and a transition from said second mode to said first mode.

19. The vehicle of claim **15**, wherein said apparatus has a first mode and a second mode, and wherein when said apparatus is in said first mode, said apparatus allows said vehicle to be steered within a non-rollover steering range of motion of said vehicle, wherein when said apparatus is in said second mode, said apparatus automatically prevents said vehicle from being steered beyond a rollover threshold of said vehicle, and wherein said apparatus transitions from said second mode to said first mode in response to application of load to said steering wheel.

20. The vehicle of claim **19**, wherein said application of load to said steering wheel further defines application of load to said steering wheel such that said steering wheel is rotated to a rotational orientation of less than said point.

21. A steering apparatus configured to allow a vehicle to be steered out of an SOA path but not to the extent of vehicle rollover.

22. The steering apparatus of claim **21** wherein said apparatus includes an active mode, an inactive mode, a steering wheel, an actuator, at least one sensor, and an electronic control unit, and wherein said actuator is configured to actuate upon receipt of an actuation signal, and wherein said sensor is configured to sense the magnitude of at least one driving parameter, and wherein said electronic control unit is configured to send an actuation signal to said actuator when a sensed driving parameter exceeds a predetermined magnitude, and wherein said apparatus is configured such that when said vehicle rounds a curve at any rollover capable speed, the steering angle of said vehicle is prevented from being increased to beyond a rollover threshold of said vehicle when said apparatus is in said active mode.

23. The steering apparatus of claim **22**, wherein said inactive mode defines a manual steering mode and said active mode is automatically activated.

* * * * *

ARSUS Tesla Second Amended Complaint

Exhibit B

Claim Charts of Asserted US Patents

8,634,989 and 10,259,494

200406 Comparison of Autopilot vs US Asserted Claims.doc

Claim 1 of US patent 8,634,989 is analyzed in comparison to a Tesla vehicle (e.g. Tesla model S, X, or 3) equipped with "Autopilot". See Appendix A for the definition of Autopilot.

TAP = The product – A **T**esla Vehicle Equipped with **Auto**p**ilot or the "Autopilot" apparatus of a Tesla vehicle.

US 8,634,989, claim 1 reads verbatim = "*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle*".

Lmt #	**Limitations Contained in Subject Claim of 8,634,989** (**"statements of intended use" and/or comments are *italicized***)	**Claim 1**	**TAP**
1	The product is a rollover prevention apparatus.	Y	Y[*1]
2	The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle.	Y	Y[*1]
3	The apparatus prevents the vehicle from being steered beyond a rollover threshold of the vehicle.	Y	Y[*1]

Inasmuch as the product (Autopilot) practices every limitation of claim 1, it is shown that the product practices claim 1 (in its entirety). Or in other words, the product infringes claim 1.

*1: See definition of Autopilot in Appendix A.

Claim 2 of US patent 8,634,989 is analyzed in comparison to a Tesla vehicle (e.g. Tesla model S, X, or 3) equipped with "Autopilot". See Appendix A for the definition of Autopilot.

TAP = The product – A **T**esla Vehicle Equipped with **A**uto**p**ilot or the "Autopilot" apparatus of a Tesla vehicle.

US 8,634,989, claims 1 and 2 read verbatim = "*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle*" and "*The apparatus of claim 1, wherein said apparatus prevents said vehicle from being steered to the point of vehicle rollover*".

Lmt #	Limitations Contained in Subject Claim of 8,634,989 ("statements of intended use" and/or comments are *italicized*)	Claim 2	TAP
1	The product is a rollover prevention apparatus.	Y	Y[*1]
2	The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle.	Y	Y[*1]
3	The apparatus prevents the vehicle from being steered beyond a rollover threshold of the vehicle.	Y	Y[*1]
4	The apparatus prevents the vehicle from being steered to the point of vehicle rollover.	Y	Y[*1]

Inasmuch as the product (Autopilot) practices every limitation of claim 2, it is shown that the product practices claim 2 (in its entirety). Or in other words, the product infringes claim 2.

*1: See definition of Autopilot in Appendix A.

Claim 3 of US patent 8,634,989 is analyzed in comparison to a Tesla vehicle (e.g. Tesla model S, X, or 3) equipped with "Autopilot". See Appendix A for the definition of Autopilot.

TAP = The product – A **T**esla Vehicle Equipped with **A**uto**p**ilot or the "Autopilot" apparatus of a Tesla vehicle.

US 8,634,989, claims 1 and 3 read verbatim = "*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle*" and "*The apparatus of claim 1, wherein said apparatus is automatically actuated in response to the speed of said vehicle*".

Lmt #	Limitations Contained in Subject Claim of 8,634,989 ("statements of intended use" and/or comments are *italicized*)	Claim 3	TAP
1	The product is a rollover prevention apparatus.	Y	Y*1
2	The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle.	Y	Y*1
3	The apparatus prevents the vehicle from being steered beyond a rollover threshold of the vehicle.	Y	Y*1
4	The apparatus is automatically actuated in response to the speed of the vehicle.	Y	Y*2

Inasmuch as the product (Autopilot) practices every limitation of claim 3, it is shown that the product practices claim 3 (in its entirety). Or in other words, the product infringes claim 3.

*1: See definition of Autopilot in Appendix A.
*2: Autopilot self-steering actuates in response inter alia to vehicle speed - see Appendix A.

Claim 4 of US patent 8,634,989 is analyzed in comparison to a Tesla vehicle (e.g. Tesla model S, X, or 3) equipped with "Autopilot". See Appendix A for the definition of Autopilot.

TAP = The product – A **T**esla Vehicle Equipped with **Auto****p**ilot or the "Autopilot" apparatus of a Tesla vehicle.

US 8,634,989, claims 1 and 4 read verbatim = "*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle*" and "*The apparatus of claim 1, wherein said apparatus prevents said vehicle from being steered to the point of vehicle rollover in a first direction but allows said vehicle to be freely steered in a second direction*".

Lmt #	Limitations Contained in Subject Claim of 8,634,989 ("statements of intended use" and/or comments are *italicized*)	Claim 4	TAP
1	The product is a rollover prevention apparatus.	Y	Y*1
2	The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle.	Y	Y*1
3	The apparatus prevents the vehicle from being steered beyond a rollover threshold of the vehicle.	Y	Y*1
4	The apparatus prevents the vehicle from being steered to the point of vehicle rollover in a first direction.	Y	Y*1
5	The apparatus allows the vehicle to be freely steered in a second direction.	Y	Y*1

Inasmuch as the product (Autopilot) practices every limitation of claim 4, it is shown that the product practices claim 4 (in its entirety). Or in other words, the product infringes claim 4.

*1: See definition of Autopilot in Appendix A.

Claim 21 of US patent 10,259,494 is analyzed in comparison to a Tesla vehicle (e.g. Tesla model S, X, or 3) equipped with "Autopilot". See Appendix A for the definition of Autopilot.

TAP = The product – A **T**esla Vehicle Equipped with **Auto p**ilot or the "Autopilot" apparatus of a Tesla vehicle.

US 10,259,494, claim 21 reads verbatim = "*A steering apparatus configured to allow a vehicle to be steered out of an SOA path but not to the extent of vehicle rollover*".

Lmt #	Limitations Contained in Subject Claim of 8,634,989 (**"statements of intended use" and/or comments are *italicized***)	Claim 21	TAP
1	The product is a rollover steering apparatus.	Y	Y*1
2	The apparatus is configured to allow a vehicle to be steered out of an SOA path but not to the extent of vehicle rollover.	Y	Y*1

Inasmuch as the product (Autopilot) practices every limitation of claim 21, it is shown that the product practices claim 21 (in its entirety). Or in other words, the product infringes claim 21.

*1: See definition of Autopilot in Appendix A.

200406 Comparison of Autopilot vs US Asserted Claims.doc

Claim 22 of US patent 10,259,494 is analyzed in comparison to a Tesla vehicle (e.g. Tesla model S, X, or 3) equipped with "Autopilot". See Appendix A for the definition of Autopilot.

TAP = The product – A **T**esla Vehicle Equipped with **A**uto**p**ilot or the "Autopilot" apparatus of a Tesla vehicle.

US 10,259,494, claims 21 and 22 read verbatim = "*A steering apparatus configured to allow a vehicle to be steered out of an SOA path but not to the extent of vehicle rollover*" and "*The steering apparatus of claim 21 wherein said apparatus includes an active mode, an inactive mode, a steering wheel, an actuator, at least one sensor, and an electronic control unit, and wherein said actuator is configured to actuate upon receipt of an actuation signal, and wherein said sensor is configured to sense the magnitude of at least one driving parameter, and wherein said electronic control unit is configured to send an actuation signal to said actuator when a sensed driving parameter exceeds a predetermined magnitude, and wherein said apparatus is configured such that when said vehicle rounds a curve at any rollover capable speed, the steering angle of said vehicle is prevented from being increased to beyond a rollover threshold of said vehicle when said apparatus is in said active mode*".

Lmt #	Limitations Contained in Subject Claim of 8,634,989 ("statements of intended use" and/or comments are *italicized*)	Claim 22	TAP
1	The product is a rollover steering apparatus.	Y	Y*1
2	The apparatus is configured to allow a vehicle to be steered out of an SOA path but not to the extent of vehicle rollover.	Y	Y*1
	The apparatus includes an active mode.	Y	Y*2
	The apparatus includes an inactive mode.	Y	Y*2
	The apparatus includes a steering wheel.	Y	Y*1
	The apparatus includes an actuator.	Y	Y*3
	The apparatus includes at least one sensor.	Y	Y*4
	The apparatus includes an electronic control unit.	Y	Y*5
	The actuator is configured to actuate upon receipt of an actuation signal.	Y	Y*1
	The sensor is configured to sense the magnitude of at least one driving parameter.	Y	Y*6
	The electronic control unit is configured to send an actuation signal to the actuator when a sensed driving parameter exceeds a predetermined magnitude.	Y	Y*5
	The apparatus is configured such that when the vehicle rounds a curve at any rollover capable speed, the steering angle of the vehicle is prevented from being increased to beyond a rollover threshold of the vehicle when the apparatus is in the active mode.	Y	Y*7

Inasmuch as the product (Autopilot) practices every limitation of claim 22, it is shown that the product practices claim 22 (in its entirety). Or in other words, the product infringes claim 22.

---

*1: See definition of Autopilot in Appendix A.

*2: Autopilot can be selectively turned on (placed in an active mode) and turned off (placed in an inactive mode) - see Appendix A.

*3: The actuator of Autopilot is the device that actually effects a change in the steering angle of the vehicles drive (rolling) wheels - see Appendix A.

*4: Autopilot has and uses a plurality of sensors of a plurality of types - see Appendix A.

*5: Autopilot has an ECU which receives input and provides output - see Appendix A.

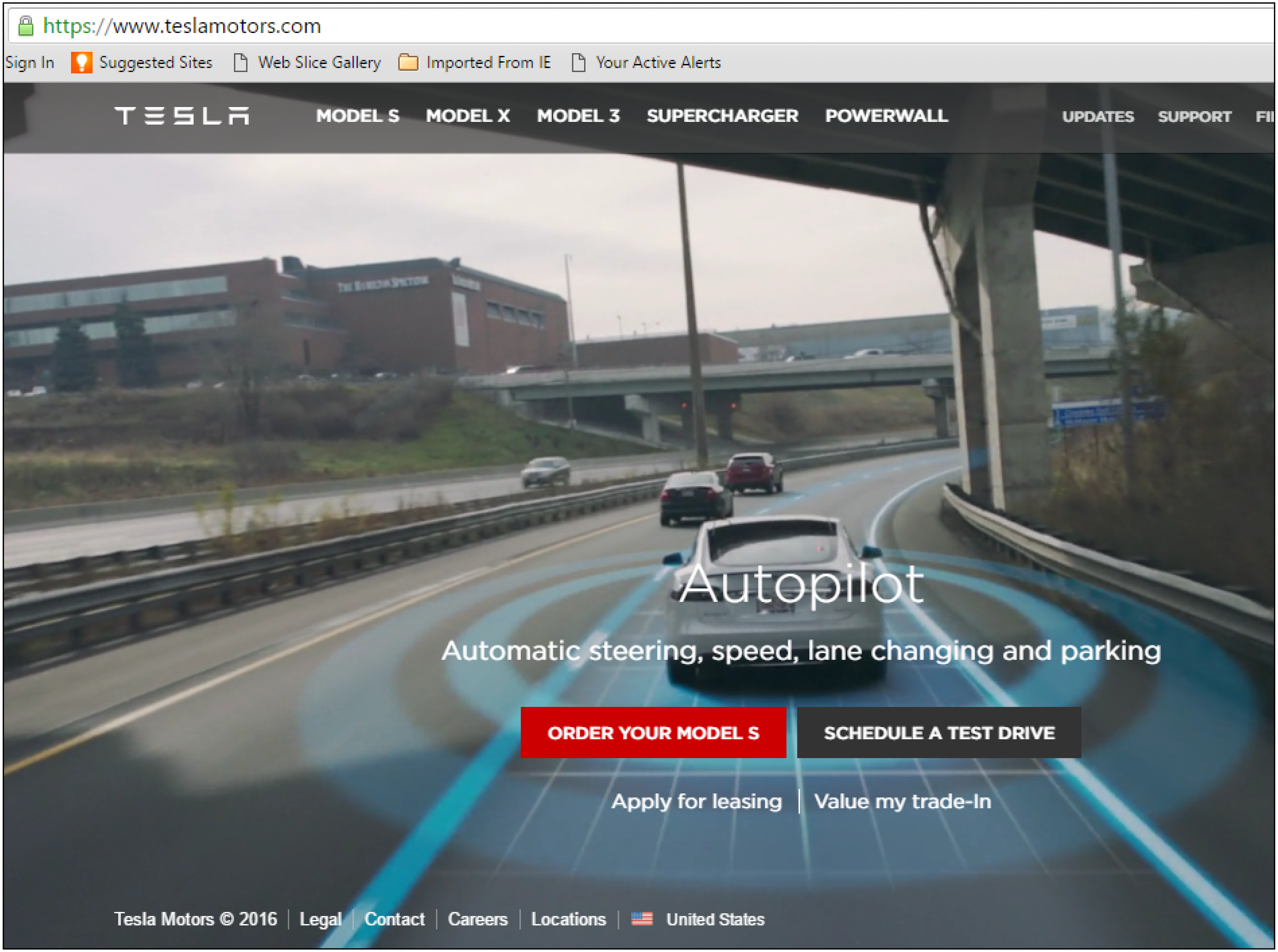
*6: Autopilot's sensors sense a plurality of driving parameters including vehicle speed and vehicle steering angle - see Appendix A.

*7: See for instance the "Tesla in Iceland" video of Appendix A.

200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

As derived from Tesla's website circa 2015, publically available statements by Elon Musk, and publically posted sources: Autopilot is a system provided by Tesla Motors that automatically controls the steering and braking of a vehicle in which it is installed such that when Autopilot is activated (i.e. the vehicle is placed in autonomous mode) and traveling at a speed wherein a rollover threshold of the vehicle exists (e.g. typical freeway speeds), the vehicle is autonomously driven down a path and yet is prevented from being steered beyond a threshold of roll of the vehicle. This is true whether the vehicle is traveling along a straight path or along a curved a path. Were this not so, then when in the noted mode, the vehicle would be steered beyond a threshold of roll (i.e. the vehicle would roll over) when encountering a curve in the road or at least would only be by chance if the vehicle happened to not roll. With Autopilot activated, a vehicle will automatically slow so as to negotiate a curve if the combination of vehicle speed and curve radius are determined to be excessive to safely negotiate. Every Tesla vehicle in which Autopilot is installed also includes (and by law must include) a manual steering mode such that the vehicle operator may steer the vehicle in a conventional manner within a non-rollover steering range of motion (not to mention within a rollover steering range of motion). Every Tesla vehicle since October of 2014 is Autopilot hardware equipped. All instances of the recently announced Tesla model 3 will be Autopilot hardware equipped. Autopilot is a customer option (currently $2,500 upon order or $3,000 after delivery) that may be enabled via an over-the-air software update.

200406 Comparison of Autopilot vs US Asserted Claims – Appendix A



200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

ps://www.teslamotors.com/models

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Autopilot

Autopilot allows Model S to steer within a lane, change lanes with the simple tap of a turn signal, and manage speed by using active, traffic-aware cruise control. Digital control of motors, brakes, and steering helps avoid collisions from the front and sides, as well as preventing the car from wandering off the road. Model S can also scan for a parking space, alert you when one is available, and parallel park on command.

Autopilot features are progressively enabled over time with software updates. The current software is 7.1, adding automatic steering and parallel parking. Read more in our Tesla blog.

200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

https://www.teslamotors.com/blog/your-autopilot-has-arrived

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Your Autopilot has arrived

The Tesla Motors Team • October 14, 2015

SCHEDULE TEST DRIVE

Experience Autopilot today

Tesla's commitment to developing and refining the technologies to enable self-driving capability is a core part of our mission. In October of last year we started equipping Model S with hardware to allow for the incremental introduction of self-driving technology: a forward radar, a forward-looking camera, 12 long-range ultrasonic sensors positioned to sense 16 feet around the car in every direction at all speeds, and a high-precision digitally-controlled electric assist braking system. Today's Tesla Version 7.0 software release allows those tools to deliver a range of new active safety and convenience features, designed to work in conjunction with the automated driving capabilities already offered in Model S. This combined suite of features represents the only fully integrated autopilot system involving four different feedback modules: camera, radar, ultrasonics, and GPS. These mutually reinforcing systems offer realtime data feedback from the Tesla fleet, ensuring that the system is continually learning and improving upon itself. Autopilot allows Model S to steer within a lane, change lanes with the simple tap of a turn signal, and manage speed by using active, traffic-aware cruise https://www.teslamotors.com/blog/your-autopilot-has-arrived

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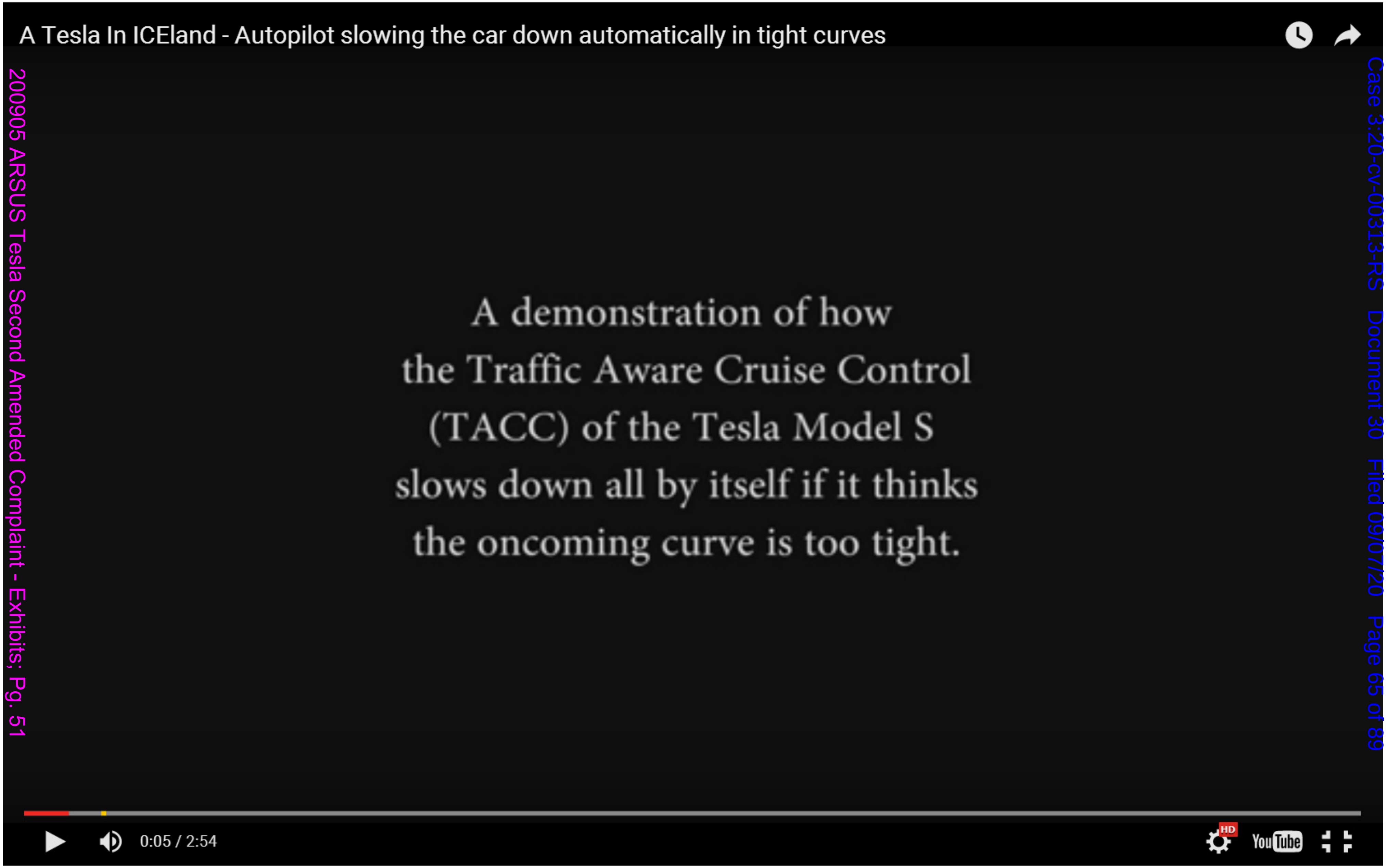
lanes with the simple tap of a turn signal, and manage speed by using active, traffic-aware cruise control. Digital control of motors, brakes, and steering helps avoid collisions from the front and sides, as well as preventing the car from wandering off the road. Your car can also scan for a parking space, alert you when one is available, and parallel park on command.

Tesla Autopilot relieves drivers of the most tedious and potentially dangerous aspects of road travel. We're building Autopilot to give you more confidence behind the wheel, increase your safety on the road, and make highway driving more enjoyable. While truly driverless cars are still a few years away, Tesla Autopilot functions like the systems that airplane pilots use when conditions are clear. The driver is still responsible for, and ultimately in control of, the car. What's more, you always have intuitive access to the information your car is using to inform its actions.

This release also features the most significant visual refresh yet of the digital displays for every single Model S around the world. The Instrument Panel is focused on the driver and includes more functional apps to help monitor your ride.

The release of Tesla Version 7.0 software is the next step for Tesla Autopilot. We will continue to develop new capabilities and deliver them through over-the-air software updates, keeping our customers at the forefront of driving technology in the years ahead.

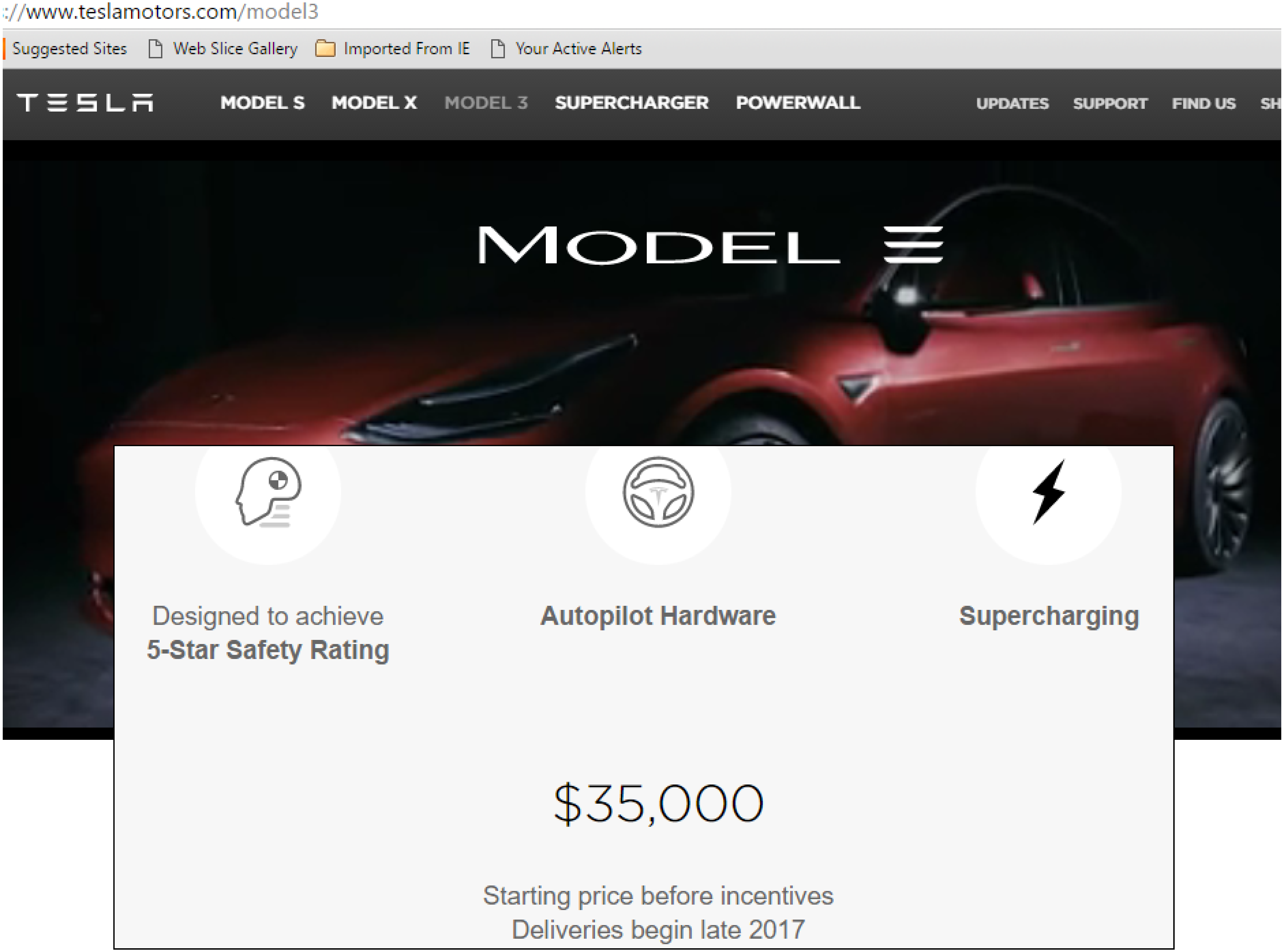
200406 Comparison of Autopilot vs US Asserted Claims – Appendix A



200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

200406 Comparison of Autopilot vs US Asserted Claims – Appendix A



200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

THE VERGE

Tesla's Model S will add self-driving 'autopilot' mode in three months

By Chris Welch on March 19, 2015 12:41 pm

Tesla's preparing a software update that will bring powerful auto-steering functionality to its Model S fleet. During today's press call — which mostly focused on curing range anxiety — CEO Elon Musk revealed that Tesla will ship a software update "in about three months" that will turn on auto-steering, or "autopilot" as Musk often refers to it. "We can basically go between San Francisco and Seattle without the driver doing anything," Musk said of the autonomous system that Tesla

200406 Comparison of Autopilot vs US Asserted Claims – Appendix A

has developed. For now, you'll only be able to engage auto-steering on highways. We got a preview of the autopilot functionality during our initial test drive in the P85D, which you can watch below.

ELON DOESN'T WANT YOU TO CONFUSE AUTOPILOT WITH A SELF-DRIVING CAR

"It is technically capable of going from parking lot to parking lot," said Musk. "But we won't be enabling that for users with this hardware suite, because we don't think it's likely to be safe in suburban neighborhoods," he said, noting that such streets often lack posted speed limit signs and pose obstacles like children playing in the street. In the future, drivers will be able to summon an unmanned Model S to their location or direct the car to drive itself into a garage.

Musk noted that these features remain illegal on most US roads, so he cautioned that drivers will be restricted to using them on private property. He also made clear that autopilot isn't to be confused with a proper self-driving car. "There's certainly an expectation that when autopilot on the Model S is enabled, that you're paying attention. But it should also take care of you if you have moments of distraction."

ARSUS Tesla Second Amended Complaint

Exhibit C

Correspondence between

Schramm and Tesla

Michael R. Schramm
350 West 2000 South
Perry, UT 84302
801-710-7793
E-mail: mikeschramm@besstek.net

March 2, 2015

Todd A. Maron, General Counsel
Tesla Motors
3500 Deer Creek Road
Palo Alto, CA 94304-1317

Re: <u>Offer of License to Anti-Roll Steering Invention via USPS #7014 2120 0000 6763 7910</u>

Dear Mr. Maron:

It has come to my attention that Tesla Motors may possibly have developed or be developing a vehicle or components therefor which provide for the vehicle to be steered within a non-rollover steering range of motion of the vehicle but that prevents the vehicle from being steered beyond a rollover threshold of the vehicle (see enclosed from October 10, 2014 “Elon Musk: Don't Fall Asleep at the Wheel for Another 5 Years” by CNet).

I note that I have invented and patented Anti-Roll Steering ™ (ARS ™). As a general explanation, ARS is analogous to ABS (Anti-Lock Braking System) in that whereas ABS prevents an operator from applying excessive brake force so as to avoid breaking traction of the vehicle’s tires from a road surface (i.e. skidding), thus minimizing vehicle stopping distance (maximizing braking effectiveness) without otherwise altering normal brake function, ARS prevents an operator from steering too sharply (i.e. oversteer) so as to avoid vehicle rollover, thus minimizing vehicle safe turn radius (maximizing steering effectiveness) without otherwise altering normal steering function.

The substantial uniqueness of the ARS invention has enabled exceedingly broad patent claims[*1]. I point to for instance claim 1 of US patent 8,634,989 (see enclosed copy of US 8,634,989) which reads verbatim:

> “*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle.*”

It is noted that in essence, there are three limitations of claim 1, all of which if practiced would constitute the practice of the entire claim, namely; 1) The apparatus is a rollover prevention apparatus, 2) The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle, and 3) The apparatus prevents the vehicle from being steered beyond a rollover threshold of the vehicle.

Inasmuch as I do not know the specifics of the functioning of what Tesla may possibly have developed or be developing, I will compare here claim 1 with a Theoretical Autonomous Vehicle (TAV). The TAV includes both an autonomous mode and a manual mode. In the autonomous mode, the TAV is prevented from being steered beyond a rollover threshold of the TAV (e.g. the TAV is adapted to automatically steer around a curve at a speed above a TAV rollover threshold but, by virtue of TAV programming, not so sharply that the TAV rolls over), and in the manual mode, the TAV is allowed to be steered within a non-rollover steering range of motion of the TAV (e.g. the TAV may be steered manually similar to a conventional vehicle). It is seen that the TAV (when in manual mode) practices limitation #2, and that the TAV (when in autonomous mode) practices limitation #3 and consequently by definition limitation #1. Further, by virtue of practicing all three limitations, it is seen that the TAV practices claim 1 in its entirety.

Given that Tesla may possibly have developed or be developing an actual vehicle or components therefor which function according to the described TAV, I am writing to offer Tesla a license to rights under my steering related patents/applications. I ask that you please respond by May 2, 2015 informing me of your interest in acquiring rights under my patents. I look forward to hearing from Tesla and I would be glad to discuss a license for reasonable terms and conditions.

Thank you,

Michael R. Schramm

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*1: A CIP application of the ‘898 patent has recently been allowed and includes three independent claims consisting in length of twelve, six, and one words respectively. The one-word claim, consisting of a mere three letters (ARS), may possibly be the shortest US utility patent claim ever.

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City, State, ZIP+4 PALO ALTO, CA 94304-1317

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Total Postage & Fees	$ $6.49	03/02/2015

Sent To TODD A. MARON, SEN. COUNSEL, TESLA

Street & Apt. No., or PO Box No. 3500 DEER CREEK ROAD

City, State, ZIP+4 PALO ALTO, CA 94304-1317

PS Form 3800, July 2014 See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

TODD A. MARON, GEN. COUNSEL
TESLA MOTORS
3500 DEER CREEK ROAD
PALO ALTO, CA 94304-1317

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature]
☐ Agent
☐ Addressee

B. Received by *(Printed Name)*

C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

PALO ALTO POST OFFICE
MAR - 5 2015
94303
USPS

3. Service Type
☒ Certified Mail® ☐ Priority Mail Express™
☐ Registered ☒ Return Receipt for Merchandise
☐ Insured Mail ☐ Collect on Delivery

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7014 2120 0000 6763 7910

PS Form 3811, July 2013 Domestic Return Receipt

UNITED STATES POSTAL SERVICE

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06 MAR '15
PM 3 L

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Permit No. G-10

• Sender: Please print your name, address, and ZIP+4® in this box•

MIKE SCHRAMM
350 WEST 2000 SOUTH
PERRY, UT 84302-4510

TESLA

March 10, 2015

Michael R. Schramm
350 West 2000 South
Perry, UT 84302

Re: Letter re offer of license

Dear Mr. Schramm:

Your letter to Tesla's General Counsel was brought to my attention. Thanks for the offer to license the patent, but Tesla is currently not interested in this technology.

Best regards,

/j richard soderberg/

J. Richard Soderberg
Patent counsel

TESLA MOTORS, INC 3500 Deer Creek Rd, Palo Alto, CA 94304 p 650.681.5000 f 650.681.5200

Michael R. Schramm
350 West 2000 South
Perry, UT 84302
801-710-7793
E-mail: mikeschramm@besstek.net

March 19, 2015

J. Richard Soderberg, Patent Counsel
Tesla Motors
3500 Deer Creek Road
Palo Alto, CA 94304-1317

Re: Response to March 10, 2015 Tesla Letter and Renewed Offer of License

Dear Mr. Soderberg:

Although your response was not as hoped, I thank you for your prompt acknowledgement of receipt of my offer and response to the same. However, given the succinctness of your answer unsupported by any justification or rationale for your stated lack of interest, I fear you may not fully appreciate the results of a detailed comparison of Tesla products versus my patent claims. To that end, I am attaching for your review an analysis of Tesla products versus claim 1 of my '989 patent. As you will see from the analysis, the question of whether or not Tesla already practices claim 1 "turns" on the question of whether or not Tesla products are adapted to autonomously steer a vehicle at a speed above a roll threshold without the vehicle rolling over. While you are of course much more familiar with Tesla's products than I and inevitably must know the answer to the question, I do note that according to press releases, just today, "*CEO Elon Musk revealed that Tesla will ship a software update "in about three months" that will turn on auto-steering, or "autopilot" as Musk often refers to it. "We can basically go between San Francisco and Seattle without the driver doing anything," Musk said of the autonomous system that Tesla has developed. For now, you'll only be able to engage auto-steering on highways*" (see "Tesla's Model S will add self-driving 'autopilot' mode in three months" March 19, 2015, The Verge).

If by chance the attached analysis causes you to reconsider Tesla's position and Tesla would like to arrange a license, I ask that you please contact me at your earliest opportunity.

Thank you,

Michael R. Schramm

Michael R. Schramm

cc: Todd A. Maron, General Counsel

150319 Comparison of AVs vs US 8,634,989 patent.doc

A method to determine if a product practices a patent claim is to perform an analysis of the claim as compared to the product on a limitation by limitation basis. If every required limitation of the claim is practiced by the product, the product practices the claim. Conversely, if every required limitation of the claim is not practiced by the product, the product does not practice the claim.

In this case, claim 1 of US 8,634,989 is analyzed in comparison to a TAV product.

TAV = A **T**heoretical **A**utonomous (automotive) **V**ehicle having a manual operational mode wherein the TAV is manually steerable within a non-rollover steering range of motion (e.g. the TAV may be steered manually similar to a conventional vehicle) and an autonomous operational mode wherein the TAV is prevented from being steered beyond a rollover threshold of the TAV (e.g. the TAV is adapted to autonomously steer along a curve at a speed above a TAV rollover threshold but, by virtue of TAV programming, not so sharply that the TAV rolls over).

US 8,634,989, claim 1 = "*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle*".

Lmt #	**Limitations Contained in Subject Claim of 8,634,989** **("statements of intended use" and/or comments are *italicized*)**	**Claim 1**	**TAV**
1	The item is a rollover prevention apparatus.	Y	Y[*1]
2	The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle.	Y	Y
3	The apparatus prevents the vehicle from being steered beyond a rollover threshold of said vehicle.	Y	Y

*1: Limitation #1 is satisfied by definition because limitation #3 is satisfied.

150319 Comparison of AVs vs US 8,634,989 patent.doc

A method to determine if a product practices a patent claim is to perform an analysis of the claim as compared to the product on a limitation by limitation basis. If every required limitation of the claim is practiced by the product, the product practices the claim. Conversely, if every required limitation of the claim is not practiced by the product, the product does not practice the claim.

In this case, claim 1 of US 8,634,989 is analyzed in comparison to Tesla's model S equipped with auto-steering "autopilot" autonomous vehicle product.

TAP = **T**esla model S autonomous vehicle equipped with auto-steering **A**uto**P**ilot having a manual operational mode wherein the TAP is manually steerable within a non-rollover steering range of motion (e.g. the TAP may be steered manually similar to a conventional vehicle) and an autonomous operational mode wherein it is (speculated but) unknown if the TAP is prevented from being steered beyond a rollover threshold of the TAP (e.g. is the TAP adapted to autonomously steer at a speed above a TAP rollover threshold but, by virtue of TAP programming, not so sharply that the TAP rolls over?).

US 8,634,989, claim 1 = "*A rollover prevention apparatus that allows a vehicle to be steered within a non-rollover steering range of motion of said vehicle but prevents said vehicle from being steered beyond a rollover threshold of said vehicle*".

Lmt #	Limitations Contained in Subject Claim of 8,634,989 ("statements of intended use" and/or comments are *italicized*)	Claim 1	TAP
1	The item is a rollover prevention apparatus.	Y	TBD*1
2	The apparatus allows a vehicle to be steered within a non-rollover steering range of motion of the vehicle.	Y	Y
3	The apparatus prevents the vehicle from being steered beyond a rollover threshold of said vehicle.	Y	TBD*2

*1: It is unknown if limitation #1 is satisfied because it is unknown if limitation #3 is satisfied.

*2: It is unknown if limitation #3 is practiced. However, it is known that if limitation #3 is practiced, then claim 1 is practiced which would mean that Tesla is directly infringing claim 1. If limitation #3 is not practiced, then claim 1 is not practiced and Tesla does not infringe claim 1. However, if Tesla's TAP does not practice limitation #3, then Tesla's TAP, by definition, is preprogrammed to roll over in autonomous mode and Tesla would have bigger problems than potentially infringing claim 1 (i.e. product liability problems). It may be that the press reports that will inevitably follow the release of Tesla's announced auto-steering **A**uto**P**ilot software update, will answer the question of the practice of limitation #3 of claim 1.

THE VERGE

Tesla's Model S will add self-driving 'autopilot' mode in three months

By Chris Welch on March 19, 2015 12:41 pm

Tesla's preparing a software update that will bring powerful auto-steering functionality to its Model S fleet. During today's press call — which mostly focused on curing range anxiety — CEO Elon Musk revealed that Tesla will ship a software update "in about three months" that will turn on auto-steering, or "autopilot" as Musk often refers to it. "We can basically go between San Francisco and Seattle without the driver doing anything," Musk said of the autonomous system that Tesla has developed. For now, you'll only be able to engage auto-steering on highways. We got a preview of the autopilot functionality during our initial test drive in the P85D, which you can watch below.

ELON DOESN'T WANT YOU TO CONFUSE AUTOPILOT WITH A SELF-DRIVING CAR

"It is technically capable of going from parking lot to parking lot," said Musk. "But we won't be enabling that for users with this hardware suite, because we don't think it's likely to be safe in suburban neighborhoods," he said, noting that such streets often lack posted speed limit signs and pose obstacles like children playing in the street. In the future, drivers will be able to summon an unmanned Model S to their location or direct the car to drive itself into a garage.

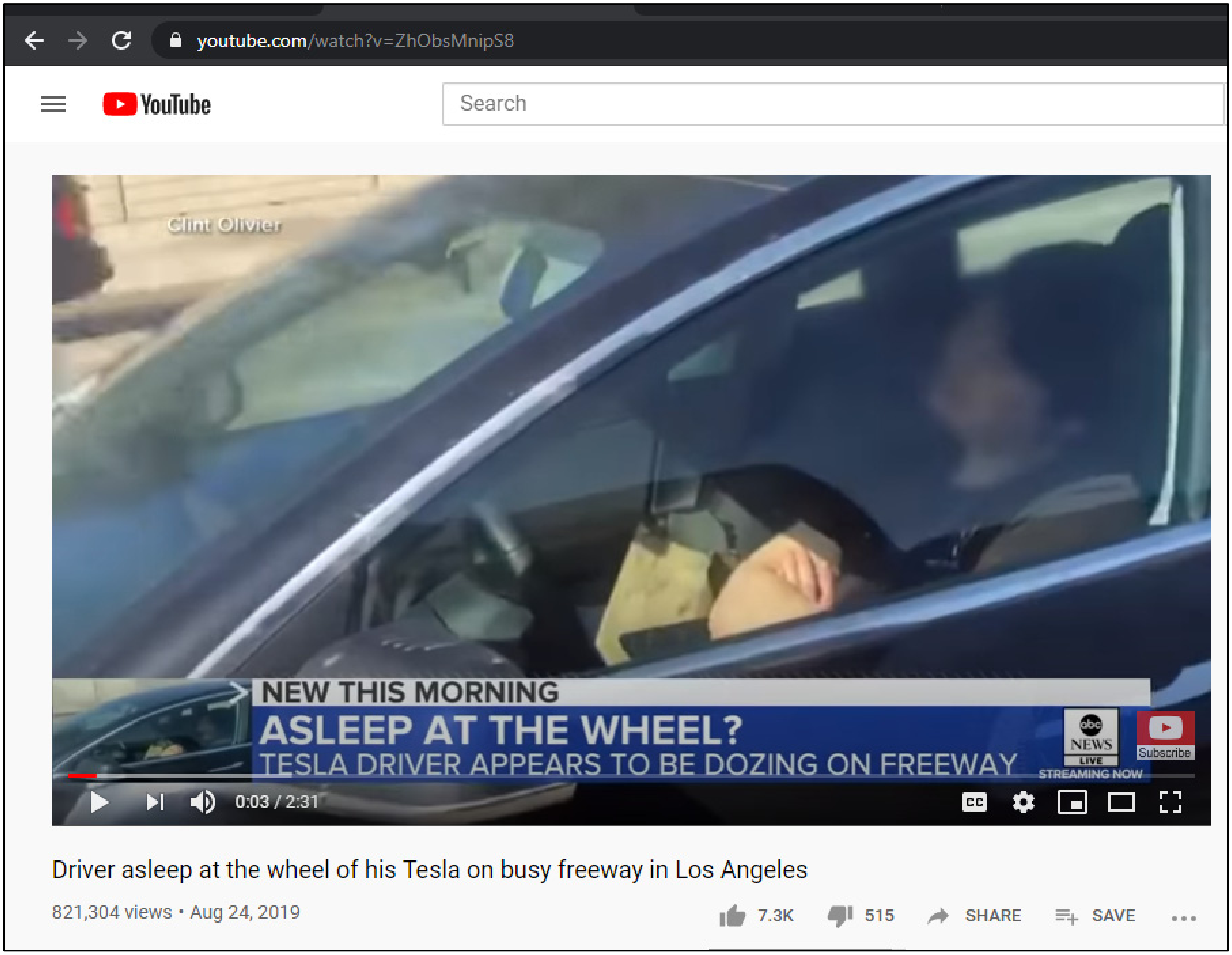
Musk noted that these features remain illegal on most US roads, so he cautioned that drivers will be restricted to using them on private property. He also made clear that autopilot isn't to be confused with a proper self-driving car. "There's certainly an expectation that when autopilot on the Model S is enabled, that you're paying attention. But it should also take care of you if you have moments of distraction."

ARSUS Tesla Second Amended Complaint

Exhibit D

Examples of Tesla Vehicles being Autonomously “Driven” and Prevented from being Steered beyond a Threshold of Roll by Autopilot without Human “Driver” Intervention

https://www.youtube.com/watch?v=ZhObsMnipS8



Autopilot preventing steering beyond a threshold of roll while the human so-called "driver" sleeps.

https://cleantechnica.com/2020/08/16/tesla-patents-elon-musk-the-bigger-picture/

“No driver present” scenario – Autopilot is driving.

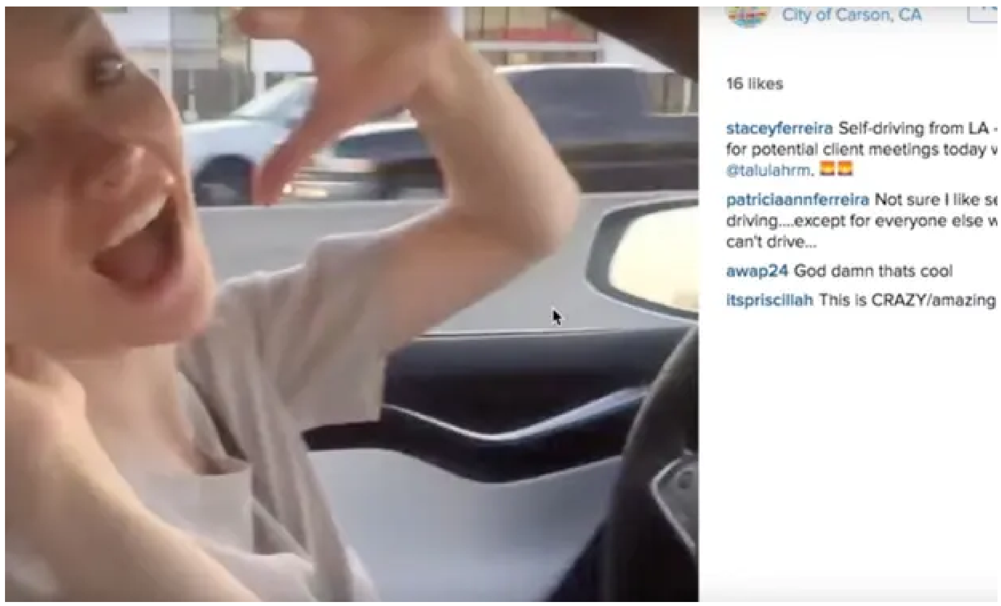
https://www.theguardian.com/technology/2016/jun/30/tesla-autopilot-drivers-stunt-video-joshua-brown

Tesla drivers post viral, self-driving 'stunts' using autopilot technology

First driver known to have died using Tesla autopilot may not have been at fault - but death highlights trend of drivers posting self-driving videos

Dan Tynan *and* **Olivia Solon** *in San Francisco*

Thu 30 Jun 2016 22.24 EDT



▲ Talulah Riley, wife of Tesla CEO Elon Musk, in her own hands-free self-driving video. Photograph: YouTube

Federal investigators are examining the first known fatality involving a Tesla using self-driving technology. Joshua Brown, a 40-year-old from Ohio, was killed when his Tesla Model S collided with a large truck while in autopilot mode.

It may take months before the US National Highway Traffic Safety

Tesla "drivers" post self-driving "stunts" using Autopilot.

https://www.theguardian.com/technology/2016/jun/30/tesla-autopilot-drivers-stunt-video-joshua-brown

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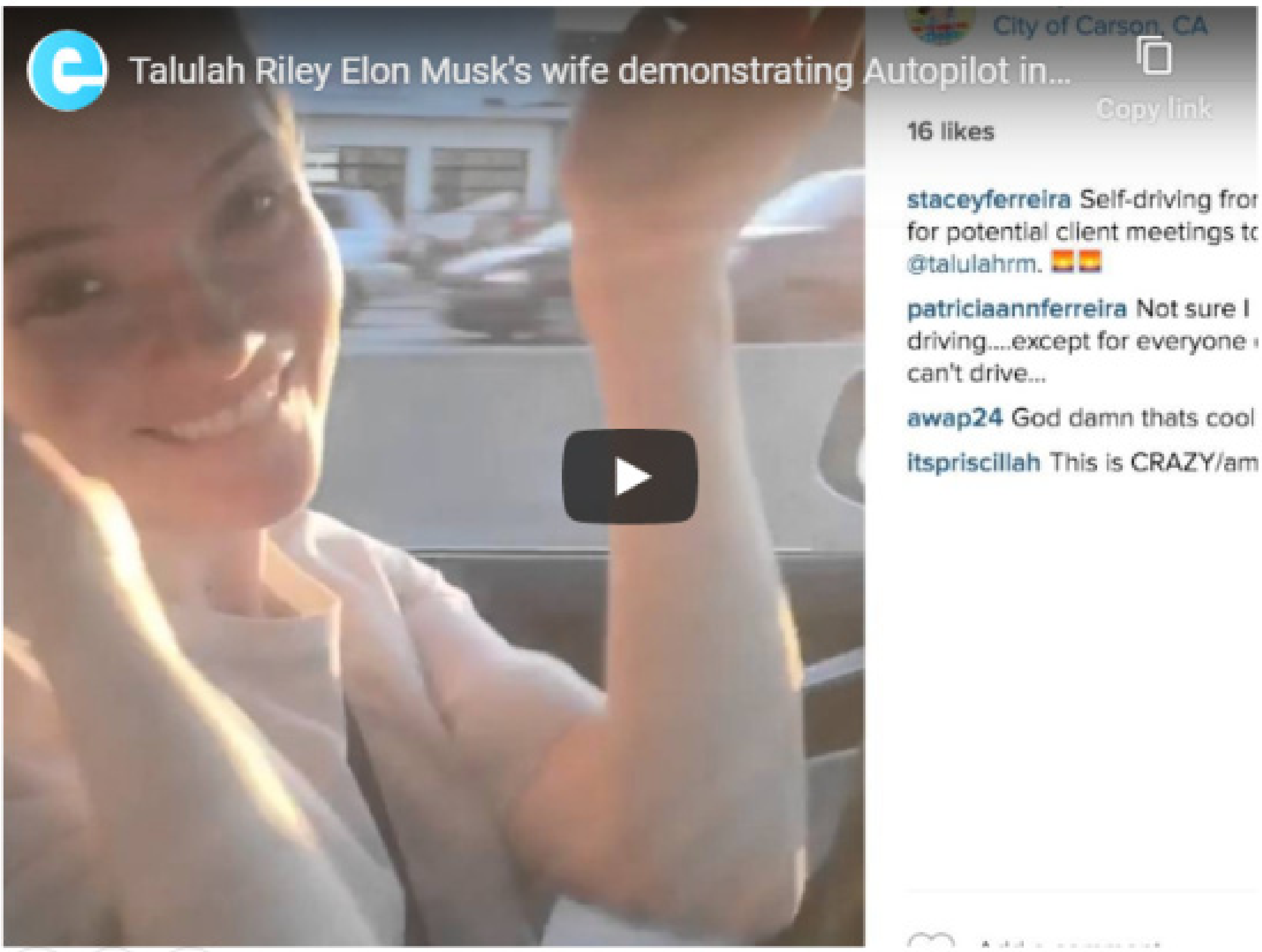
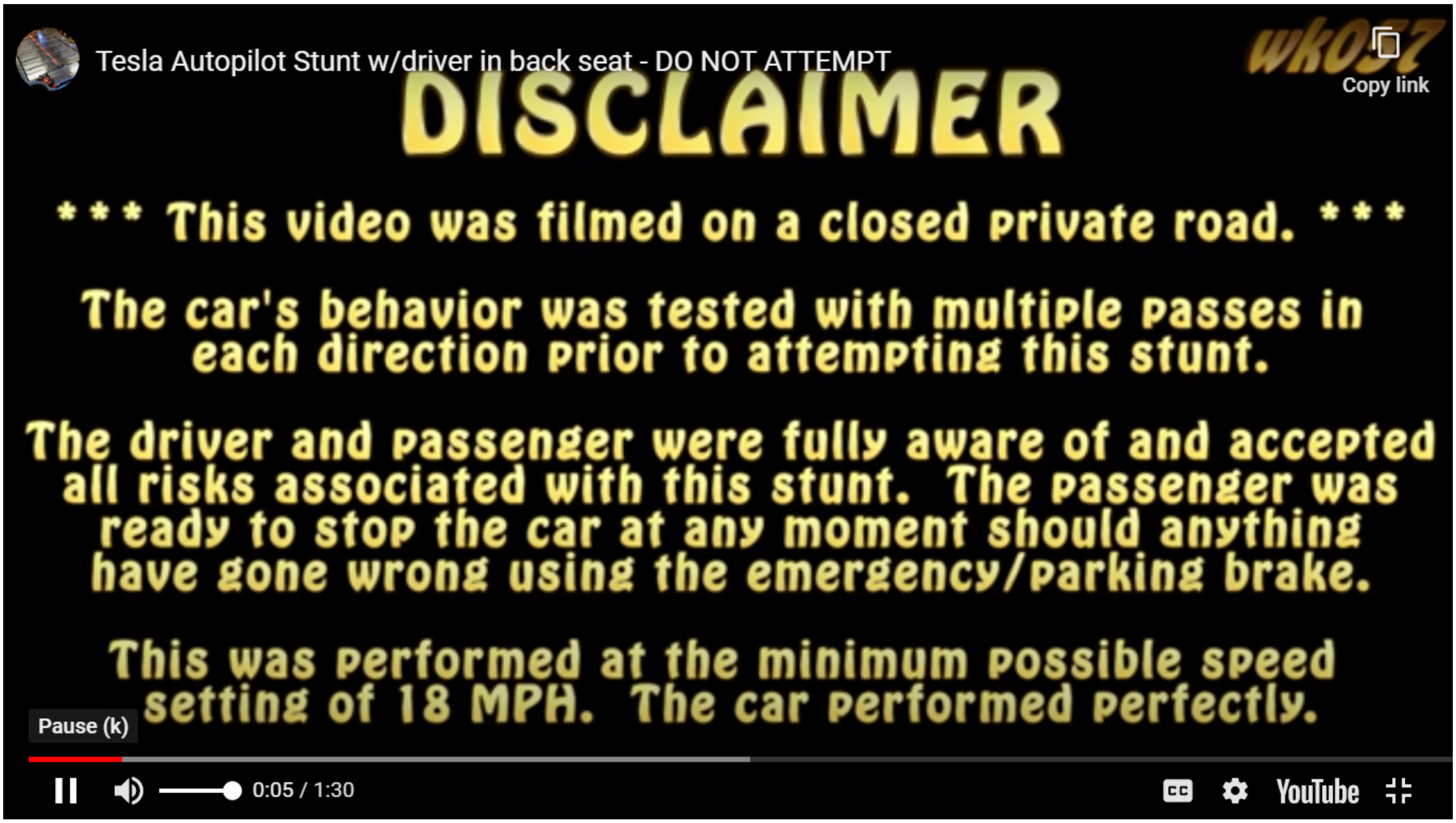
It's not the only one. In this video, Talulah Riley (Musk's wife) shows Tesla fans the wrong way to drive on autopilot:



Talulah Riley, Elon Musk's, shows Tesla fans the wrong way to "drive" (hands-free) on Autopilot.

https://youtu.be/-okFVuHlxII



Tesla Autopilot with "driver" in the back seat.

https://youtu.be/-okFVuHlxII

Tesla Autopilot with "driver" in the back seat.

CERTIFICATE OF SERVICE

I, the undersigned, hereby certify that the foregoing document, namely, PLAINTIFF ARSUS, LLC's SECOND AMENDED COMPLAINT, WITH EXHIBITS A-D, is being served electronically, by the court's e-serve system, at the same time it is being e-filed with the Court, on September 7, 2020, to all attorneys of record for Defendant TESLA, INC., who are COOLEY LLP, by the following attorneys:

Michael Rhodes, Esq. rhodesmg@coolely.com

Heidi L. Keefe, Esq. hkeefe@coolely.com

Adam Pivovar, Esq., apivovar@cooley.com

Dated: September 7, 2020

/s/ Patrick F. Bright

PATRICK F. BRIGHT