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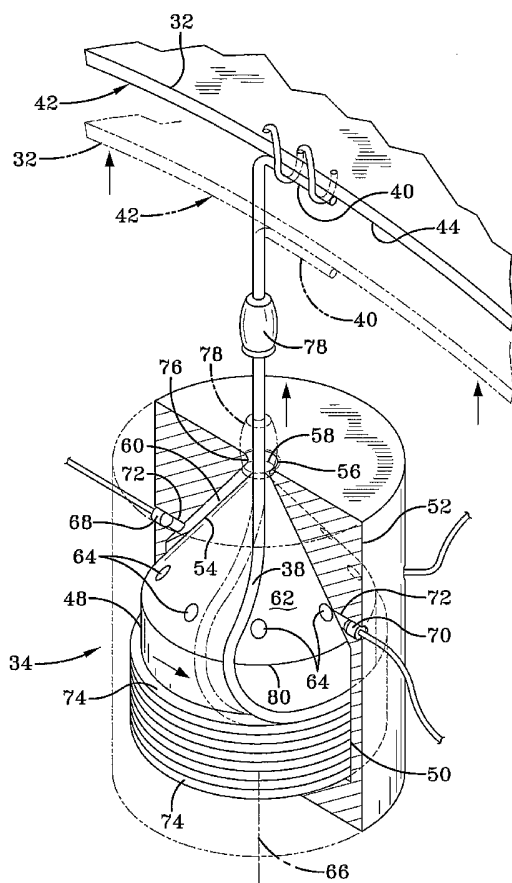
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- Declarations under Rule 4.17:**
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AT, AU, BR, CA, CN, CO, CZ, DE, DK, ES, FI, GB, HU, ID, IN, JP, KR, MX, NO, PL, PT, RU, SE, SG, TR, YU, ZA, European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR)*

[Continued on next page]

(54) Title: AIRBAG MODULE WITH DEPLOYMENT SENSOR



(57) Abstract: A cartridge (36) stores a quantity of string (38), one end of which is attached to the inside surface (42) of an airbag (32). A spool which transitions to a conical member (54) is situated within the cartridge. A narrow gap (50) around the spool forms a string storage space and a similar gap overlies the conical member (54) and leads to an opening (58). Positioned within the body of the cartridge (36) is a light source (68; 94; 110) and a light detector. As string (38) is drawn out of the cartridge, the string traverses between the light sources and a light detector generating a signal directly proportional to the rate at which string is withdrawn. The geometry of the cartridge (36) is arranged to provide friction against the string (38). The friction is created between the string and the junction between the cylindrical spool (48) and the conical member (54) and rapidly overcomes the momentum of the string (38) when the airbag (32) comes to a stop.



- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designations AT, AU, BR, CA, CN, CO, CZ, DE, DK, ES, FI, GB, HU, ID, IN, JP, KR, MX, NO, PL, PT, RU, SE, SG, TR, YU, ZA, European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR)

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AIRBAG MODULE WITH DEPLOYMENT SENSOR

The present invention relates to airbags and sensors used to control airbag deployment, and to sensors that monitor the actual deployment sequence in particular.

While airbags were originally developed as a passive restraint system, experience has shown that airbags work best in combination with seatbelts and other safety systems. Although airbags contribute to the overall safety of occupants of an automobile, they can present a danger to an occupant who is positioned too close to an airbag when it deploys. This condition, where the occupant is positioned so that airbag deployment might be dangerous, is referred to as the occupant being "out of position". Various systems have been developed to detect an "out of position" occupant. Sensor systems designed to detect the occupant's position often require constant monitoring so that in the event of a crash the occupant's position is known. Sensor systems designed to detect the position of the occupant have been proposed based on ultrasound, optical, or capacitance sensors. Constant monitoring of sensors, which may have high data rates, requires the design of algorithms which can reduce sensor data to a single condition or a limited number of data conditions which are used in an airbag deployment decision to prevent airbag deployment or for a dual stage airbag to select the level of deployment. Maintaining data integrity between the non-crash positional data, and positional data needed during airbag deployment is complicated by the noisy environment produced by a crash. Dealing with data integrity issues requires increased processor capabilities and algorithm development, which also requires additional testing.

Prior art approaches attempt to determine, based on various sensors, the distance between the airbag and the vehicle occupant before the airbag is deployed. In many instances, the vehicle occupant will not be too close to the airbag at the time the decision to deploy the airbag is made, but, because of the rate at which the occupant is approaching the airbag, the occupant will be too close when the airbag is actually deploying. To handle these situations,

more sophisticated sensors and algorithms are needed to attempt to predict the occupant's position when the airbag is actually deployed or nearly completely deployed. In other words, the ideal airbag deployment system functions such that the airbag deploys fully or nearly fully before the occupant engages the airbag. Existing systems inhibit airbag deployment when, based on various sensors and algorithms, it is determined that, because of the position of the vehicle occupant, the bag is more likely to harm than to benefit the occupant.

Therefore, a system which employs occupant position sensors and algorithms must be able to supply at all times an indication of whether airbag deployment should be inhibited so that the inhibit decision can be applied whenever the airbag deployment decision occurs. This means the sensors and algorithms used to develop the occupant position inhibit signal cannot be optimized to deal with a specific time frame in which the actual deployment decision is made. The end result is that such algorithms may be less accurate than desired because they must predict events relatively far in the future, perhaps tens of milliseconds.

One known type of sensor shown in EP 0990567A1 employs a plurality of tapes that extend between the front of the airbag and a tape dispensing cartridge mounted on the airbag housing. Tape extraction sensors within the cartridge monitor the rate at which tape is withdrawn from the cartridge and thus can detect airbag impact with an occupant by a decrease in airbag velocity. Improvements are needed to the known tape cartridges to improve the functionality and reliability of the tape type bag deployment monitoring sensors.

Brief Description of the Drawings

FIG. 1 is an isometric view partially cut-away in section of the airbag deployment sensor of this invention.

FIG. 2 is a side elevational view partly cutaway of the airbag deployment sensor of FIG. 1 positioned to detect the rate of deployment of an airbag.

FIG. 3 is a side elevational view, partially cut-away in section, of an alternative embodiment of the airbag deployment sensor of this invention.

FIG. 4 is a side elevational view, partially cut-away in section, of another alternative embodiment of the airbag deployment sensor of this invention.

FIG. 5 is a schematic top plan view of an alternative arrangement of the light sources and light detectors that could be used with the airbag deployment sensor of FIG. 1.

FIG. 6 is a schematic top plan view of arrangement of light sources and light detectors for use with the airbag deployment sensors of FIGs. 3 and 4.

FIG. 7 is a schematic top plan view of an another alternative arrangement of the light sources and light detectors that could be used with the airbag deployment sensor of FIG. 1.

FIG. 8 is a schematic top plan view of a further alternative arrangement of the light sources and light detectors which could be used with the airbag deployment sensor of FIG. 1.

FIG. 9 is a schematic top plan view of a yet further alternative arrangement of the light sources and light detectors which could be used with the airbag deployment sensor of FIG. 1.

Detailed Description of the Invention

Referring more particularly to FIGs. 1–9, wherein like numbers refer to similar parts, an airbag module 20 is shown in FIG. 2. The airbag module 20 is positioned opposite a vehicle occupant 22 seated on a vehicle seat 23. A housing 24 containing a quantity of gas generant 26 is positioned behind an instrument panel 28. When activated by an igniter 30, the gas generant 26 inflates an airbag 32 that extends through the instrument panel 28 towards the vehicle occupant 22. A plurality of airbag deployment sensors 34 are mounted to the housing 24.

Each sensor 34, as shown in FIG. 1, has a cartridge 36 that contains a quantity of string 38. As used herein and in the claims the term “string” is understood to mean an elongated flexible member having a cross section of any suitable shape, not just circular, including for example rectangular or oblong. One end 40 of the string 38 is attached to the inside surface 42 on the airbag 32. As the airbag 32 is deployed towards the vehicle occupant 22, string 38 is drawn from the cartridge 36. By monitoring the rate at which string 38 is withdrawn from the cartridge 36 it is possible to detect when a portion 44 of the airbag 32 impacts an object because, as the portion 44 of the airbag comes to a stop, it ceases to draw string 38 from the cartridge 36. This information can be used by a safety system controller (not shown) to control valves 46 on the housing 24 to vent the airbag 32 or to otherwise limit or control the continued inflation of the 32.

As shown in FIG. 1, the airbag deployment sensor 34 has a cartridge 36 within which is contained a cylindrical spool 48 about which the string 38 is wound. A gap 50 between the spool 48 and the body 52 of the cartridge 36 forms a reservoir for the storage of the string. Typically about three feet of string will be stored within the cartridge 36 before the airbag deployment begins. The cylindrical spool 48 is topped by a cone 54 that tapers towards an apex 56. The gap 50 forming the string reservoir continues to follow the cone 54 until it reaches an opening 58 positioned over the apex 56 of the

cone 54. The gap over the cone forms a passageway 60 through which the string 38 moves in reaching the opening 58.

The arrangement of the cylindrical spool 48 and the cone 54 is such that the string sweeps along the surface 62 of the cone 54 as it is pulled from the reservoir formed by the gap 50 about the cylindrical spool 48. The cone 54 is formed with a plurality of holes 64 that are perpendicular to an axis 66 defined by the cylindrical spool 48 and the cone 54. The holes 64 in the cone 54 are aligned to allow light from a light source 68 such as an LED to be transmitted through the cone 54 to a light sensor 70 such as a phototransistor positioned opposite the light source 68.

As shown in FIG. 1, the light sources and light sensors are mounted within the cartridge body 52 within collimating sockets 72. As the string 38 is withdrawn from the cartridge 36 and thus rotates, as illustrated in FIG. 1, along the surface 62 it twice passes between any particular light source 68 and light sensor 70 momentarily completely or partially blocking the reception of light by the light sensor 70. If there are four pairs of light sources 68 and light sensors 70 as shown in FIG. 1, each time a coil 74 of string 38 is withdrawn from the cartridge 36 the string will pass once completely around the surface 62 of the cone 54 causing eight interruptions of light passing from a light source to a light sensor. Thus the movement of the string 38 creates a periodicity which is proportional to the length of string withdrawn.

If the cylindrical spool has a diameter, for example of 1.9 centimeters, one coil 74 would have a length of about 5.9 centimeters and removal of about every 0.8 centimeters of string would be detected, if four sensors and light sources are used as shown in FIG. 1. By increasing the number of light sources and light sensors, a more precise and higher frequency signal can be generated by the withdrawal of string 38 from the cartridge 36.

The string 38 moves through the opening 58 which has a rounded outlet lip 76 to prevent binding, as the airbag motion during deployment may cause the string 38 to be pulled from varying directions, especially during the early phases of airbag deployment when flutter may be experienced.

To hermetically seal the cartridge 36 during the storage life of the airbag 20, a plug 78 attached to the string 38 may be used to seal the opening 58. The plug 76 is pulled away from the opening 58, as illustrated in FIG. 1. As the string 38 is drawn from the cartridge 36, the string rubs on the cylindrical edge 80 where the string transitions from being pulled upwardly along the cylindrical spool 48 to being pulled along the cone 54. This rubbing will produce a frictional force, which will retard the withdrawal of the string 38. The frictional force losses, act as a brake to overcome the momentum of the string already withdrawn so that when the portion 44 of the airbag to which the string is connected comes to a stop, the rate at which string is withdrawn from the cartridge 36 will rapidly reflect the velocity of the airbag portion 44 to which the string is attached. By adjusting the height of the cone 54, the angle at which the string is drawn over the cylindrical edge can be adjusted, which should control the amount of friction experienced by the string 38.

The string 38 may be woven of a single filament or of a twisted strand of fibers, selected from fibers such as high-strength & high-modulus polyethylene fiber (HSM-PE fiber) or an aromatic (polyamide) fiber. A sizing such as wax may be applied to the string 38 to prevent tangling as the string is withdrawn from the storage reservoir, and to hold the string within the gap 50 allowing only a single coil 74 to be withdrawn at one time. The second end (not shown) of the string may be attached to the body 52 of the cartridge 36.

An alternative embodiment of an airbag deployment sensor 82 is shown in FIG. 3. The airbag deployment sensor 82 has a cartridge 84 with an elliptical or oval spool 86. A string storage reservoir is defined by a gap between the oval spool 86 and the body 88 of the cartridge 84. String 90 is wound about the spool 86. Portions 92 of the cartridge 84 form the elliptical or oval conical space through which the string 90 is drawn. Light sources 94 and light sensors 96 are positioned about the conical space such that pulling the string 90 results in the string passing back and forth between the light sensors 96 and light sources 94.

A further embodiment of an airbag deployment sensor 98 is shown in FIG. 4. The deployment sensor 98 has a cartridge 100 and two elliptical- or

tear-shaped right prismatic spools 102 about which a string 104 is wound in a figure eight pattern. Portions 106 of the cartridge 100 form the oval conical space through which string 108 is drawn. Light sources 110 and light sensors 112 are positioned about the conical space such that pulling string 104 from the cartridge 100 results in the string passing back and forth between light sensors 112 and light sources 110.

The light sensors 70 and light sources 68 illustrated in FIG. 1 could be arranged in various ways. FIG. 5 illustrates three LEDs positioned opposite three photo transistors arranged in a linear array. FIG. 7 illustrates eight separate LEDs 68 positioned in the cone 54 that passes light to eight separate phototransistors 70. FIG. 8 shows an arrangement opposite the one shown in FIG. 7, with a single photodiode 70 mounted in the cone 54 receiving light from eight LEDs mounted in the body 52 of the cartridge 36. The arrangement of FIG. 8 has the advantage of a single light detector which produces a single higher frequency output signal which does not need to be created by adding the output of multiple light sensors.

FIG. 9 illustrates the use of mirrors 114 so that a single light source 68 such as a diode laser can make multiple passes through the space 116 through which the string is drawn before reaching a light sensor 70. The arrangement of FIG. 9 also provides simplified electronics, because only a single sensor is used. Using a single sensor avoids the additional electronics associated with adding the output of multiple sensors together to get a single signal indicative of the speed with which string is withdrawn from the cartridge.

FIG. 6 shows an alternative arrangement of a single light source 110 such as a diode laser and mirrors 118 which makes multiple passes across a conical space before reaching a light detector 112 which is suitable for use with the airbag deployment sensor 98 shown in FIG. 4. Again, the use of a single sensor simplifies the detecting electronics.

It should be understood that the string 38, 90, 104 can be a single filament or woven fiber or a tape, and will preferably be made of high strength lightweight material, for example high-strength & high-modulus polyethylene

fiber (HSM-PE fiber) or an aromatic (polyamide) fiber. The string may be coated with a size such as wax to facilitate the orderly withdrawal from the cartridge, the size holding the string in place within the string reservoir until the pulling action of the airbag causes the string to peel away from the string remaining in the reservoir. The size selected may also be used to control the amount of breaking friction by selecting a size that increases or decreases withdrawal friction as necessary. It should be understood that this string can be directly attached to the airbag interior surface, or could be attached indirectly by way of a string, tape or web which is attached to the airbag interior surface.

As the string is withdrawn from the cartridge, the string emerging from the cartridge opening defines a direction of string motion toward the airbag attachment point, even though in practice due to airbag flutter the airbag string will at times be pulled in a range of directions which on average defines the string motion.

CLAIMS:

1. An airbag module (20) comprising:
 - an airbag (32) defining an interior having an inside surface (42);
 - a housing (24) to which the airbag (32) is attached;
 - a sensor (34) mounted to the housing (24), and mounted internal to the airbag (32), the sensor comprising:
 - a cartridge (36) having portions defining a storage space within the cartridge, the storage space containing a quantity of string (38), the cartridge (36) having an opening (58) therethrough, wherein one end of the string is attached to a portion of the inside surface (42) of the airbag (32), so that deployment of the airbag (32) draws string (38) out of the storage space in the cartridge (36) through the opening (58), and the string (38) leaving through the opening (58) defines a direction of string withdrawal;
 - a conical member (54) positioned within the cartridge (36) to cause string (38) drawn out of the storage space to move transverse to the direction of string withdrawal, wherein the transverse motion caused has a periodicity which is proportional to the length of string (38) withdrawn;
 - at least one string sensor (70) positioned in the cartridge (36) between the storage space and the opening (58), the at least one string sensor positioned to detect the transverse motion of the string (38), so that the sensor output varies with a frequency proportional to the rate string is withdrawn from the cartridge (36).
2. The airbag module (20) of claim 1 wherein the conical member (54) positioned within the cartridge (36) is arranged to cause frictional engagement with the string (38), sufficient to overcome the momentum of the string.
3. The airbag module (20) of claim 1 wherein the storage space is defined by a gap (50) between at least one spool (48; 86; 102) and portions of the cartridge (36), and wherein the string (38) is contained in the storage space by being wound around the spool.

4. The airbag module (20) of claim 3 wherein the spool (48; 86; 102) has an upper edge over which the string (38) is drawn, the upper edge being positioned to cause frictional engagement with the string, sufficient to overcome the momentum of the string (38).

5. The airbag module (20) of claim 3 wherein the at least one spool (48) has a cylindrical shape and a conical member (54) extending from the spool, and wherein the opening (58) is positioned above the conical member, so that as string (38) is drawn out of the opening (58) it rotates about the conical member (54) creating the transverse motion.

6. The airbag module (20) of claim 5 wherein the at least one string sensor (70) comprises a light source (68; 94; 110) and a light detector (72; 96; 112) positioned so that as the string (38) is drawn out of the opening (58) and rotates about the conical member (54) it periodically passes between the light source and the light detector.

7. The airbag module (20) of claim 6 wherein a plurality of light sources (68; 94; 110) are mounted within the conical member (54) and portions of the conical member define openings which project light onto a plurality of light detectors (72; 96; 112) mounted in second portions of the cartridge (36) defining openings opposite the light sources.

8. The airbag module (20) of claim 6 wherein a plurality of light detectors (72; 96; 112) are mounted within the conical member (54) and portions of the conical member define openings which allow light from a plurality of light sources (68; 94; 110) opposite the light detectors (72; 96; 112) mounted in second portions of the cartridge (36) which defining openings to shine on the light detectors.

9. The airbag module (20) of claim 6 wherein a light path is established by means of reflectors between the light source (68; 94; 110) and the light detectors (72; 96; 112) so that as the string (38) travels once about the conical member (54), the light path is interrupted a plurality of times.

10. The airbag module (20) of claim 3 wherein there are two spools (102) and the string (38) is wrapped in a figure-eight pattern around both spools.

11. The airbag module (20) of claim 1 wherein the at least one string sensor (70) comprises a light source (68; 94; 110), and a light detector positioned so that as the string (38) is drawn out of the opening (58) and caused to move transverse to the direction of string withdrawal, the transverse motion causes a light path between the light source (68; 94; 110), and the light detector to be broken.

12. The airbag module (20) of claim 11 wherein the light path is established by means of reflectors between the light source (68; 94; 110) and the light detector (72; 96; 112) so that as the string (38) moves transverse to the direction of string withdrawal, the light path is interrupted a plurality of times for each cycle of transverse motion.

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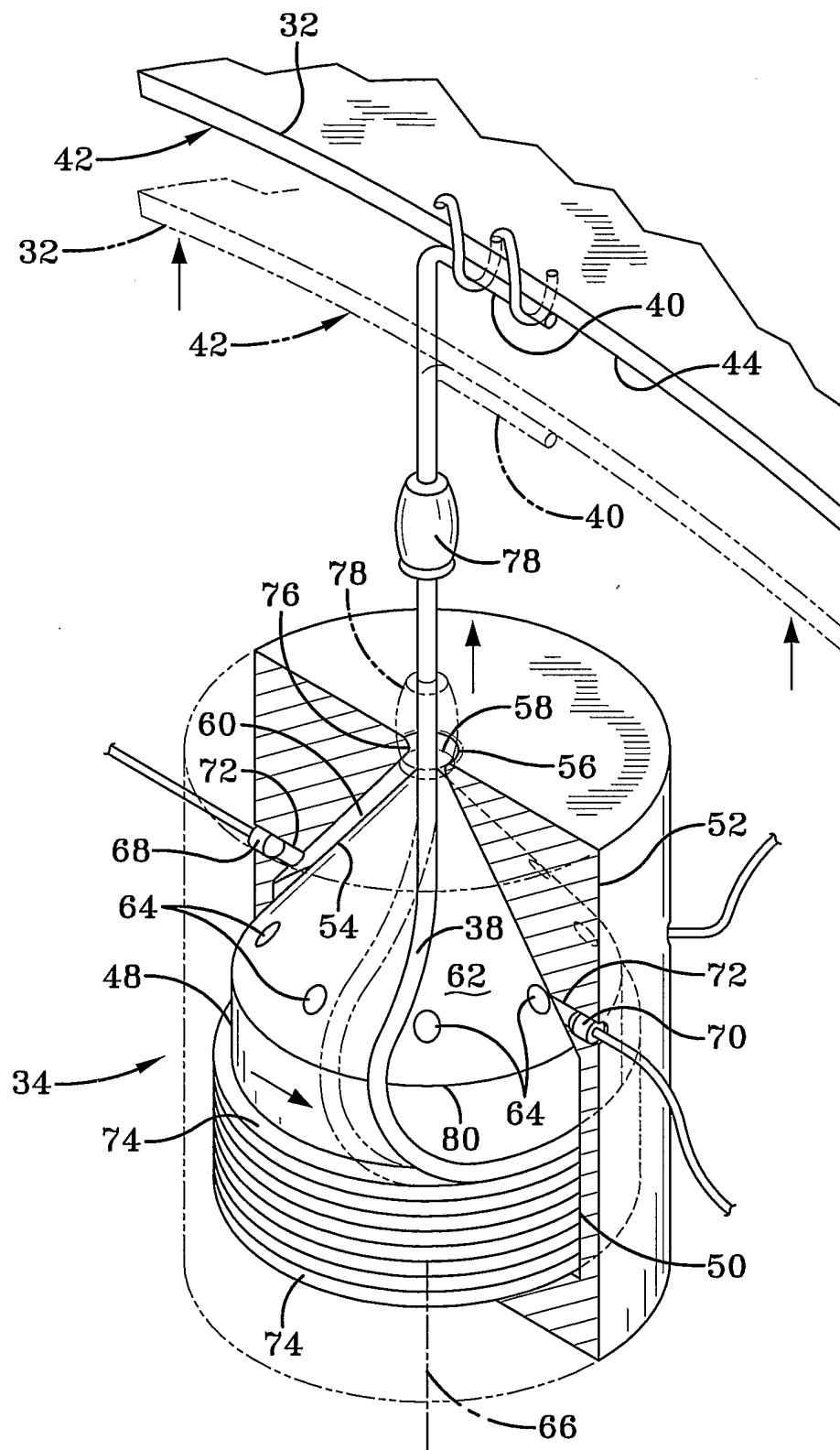


FIG-1

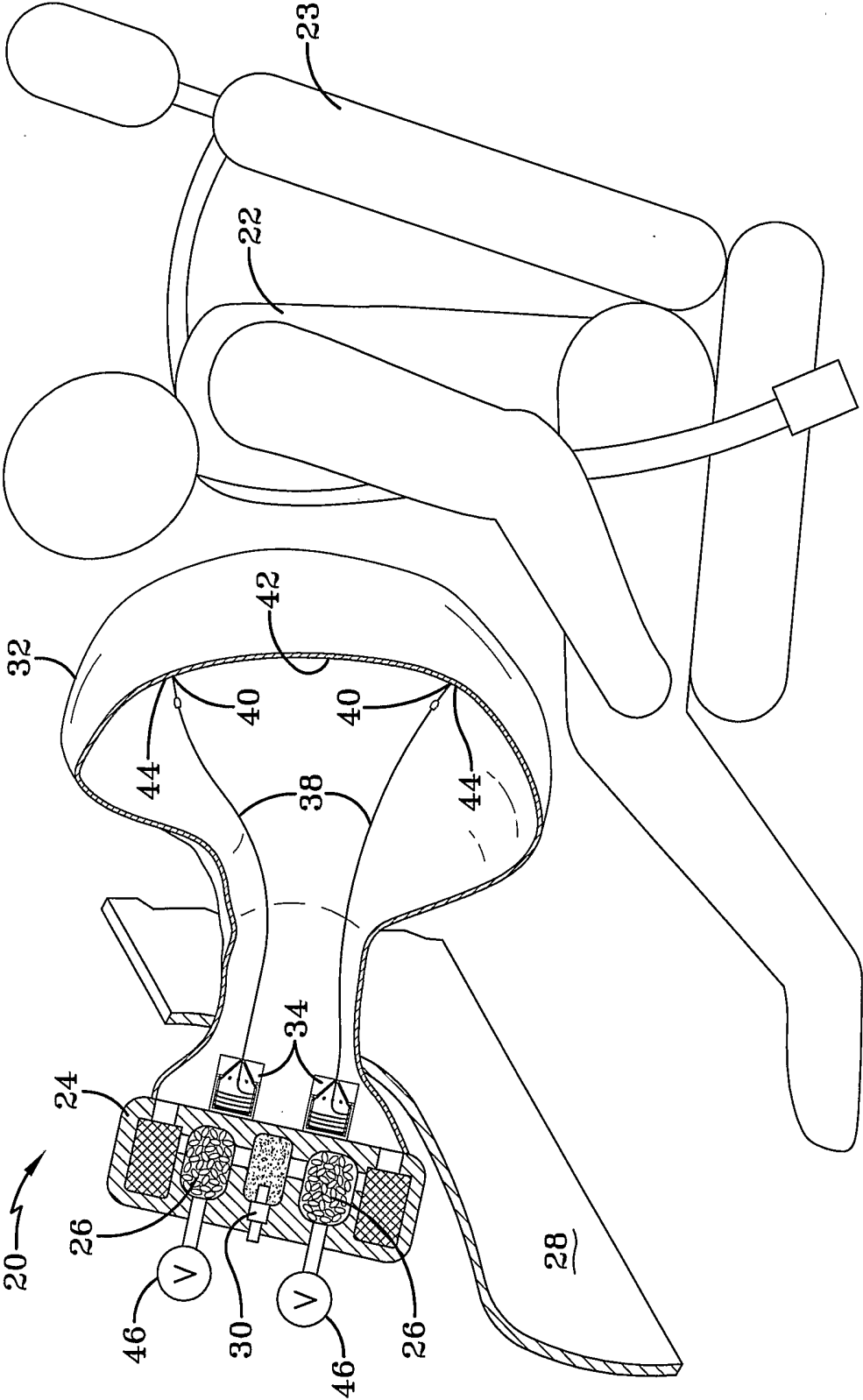


FIG-2

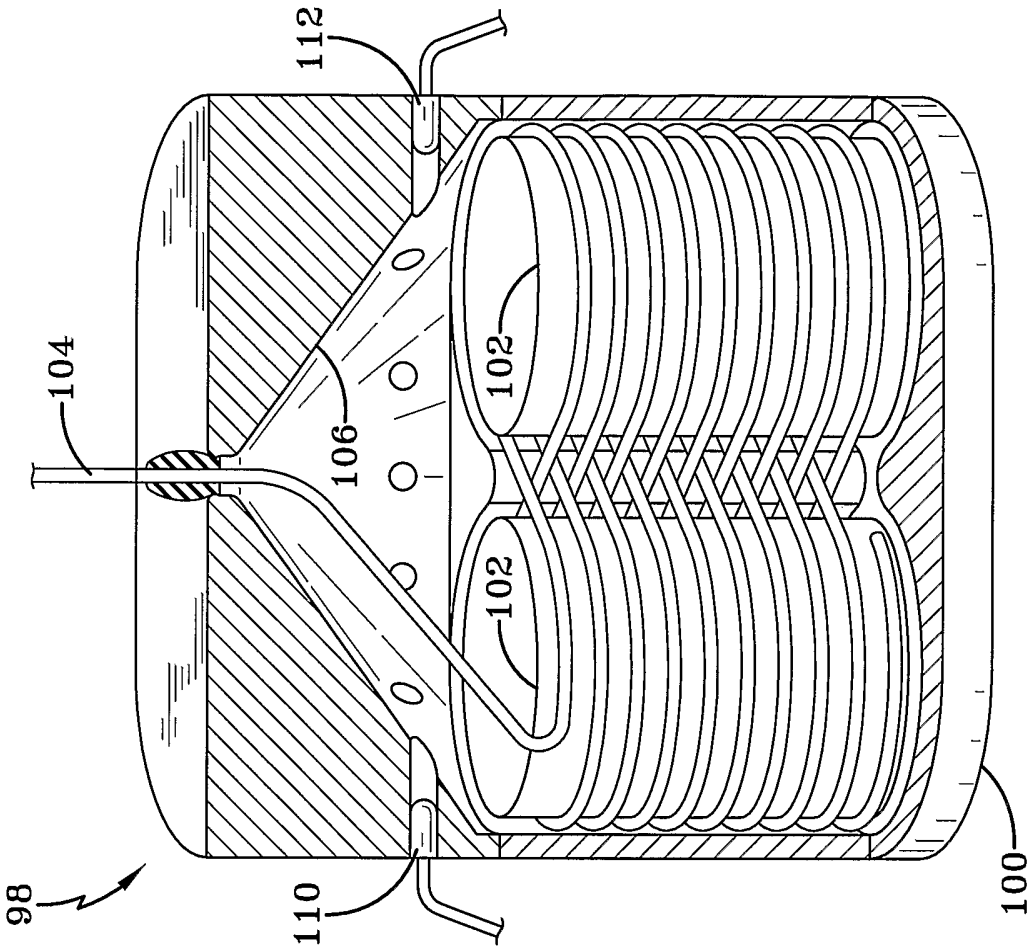


FIG-4

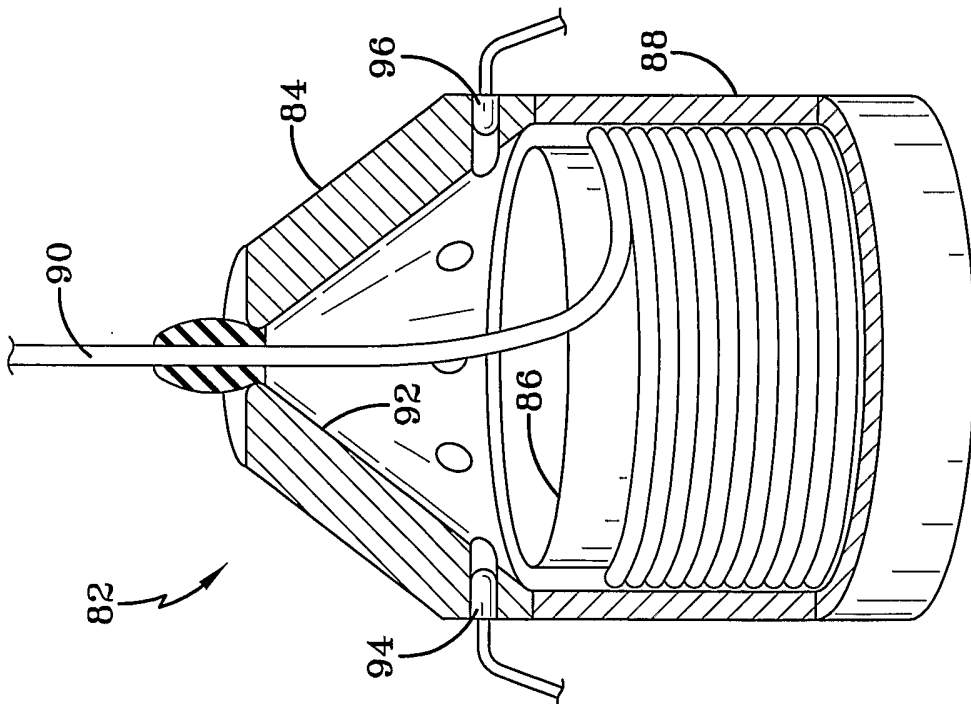


FIG-3

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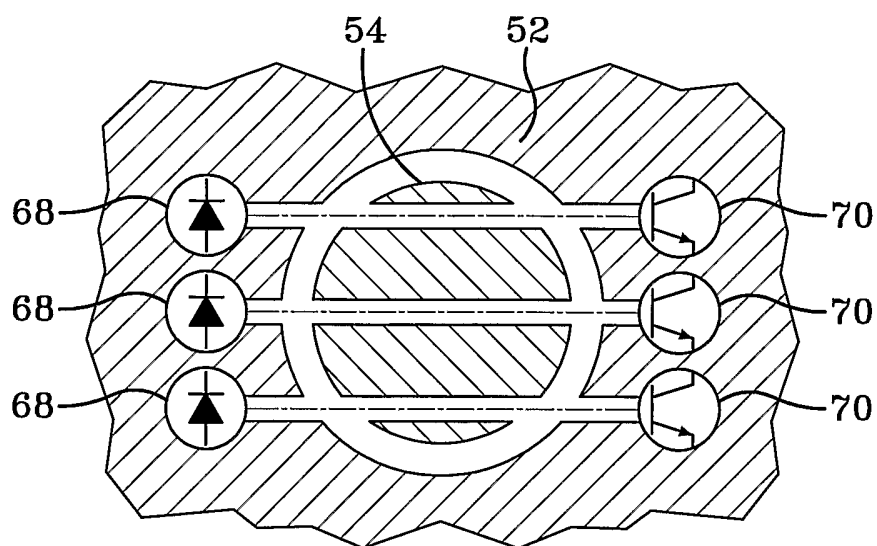


FIG-5

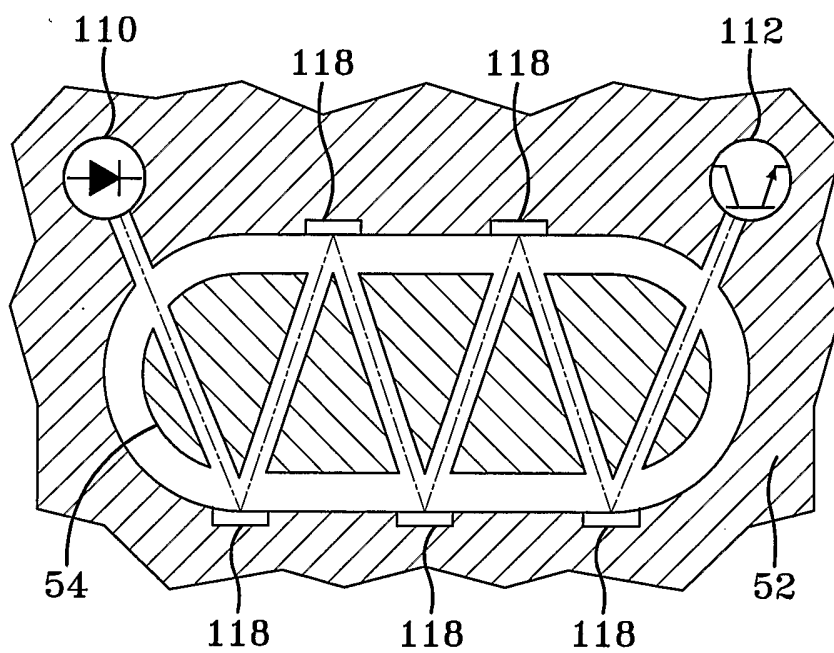


FIG-6

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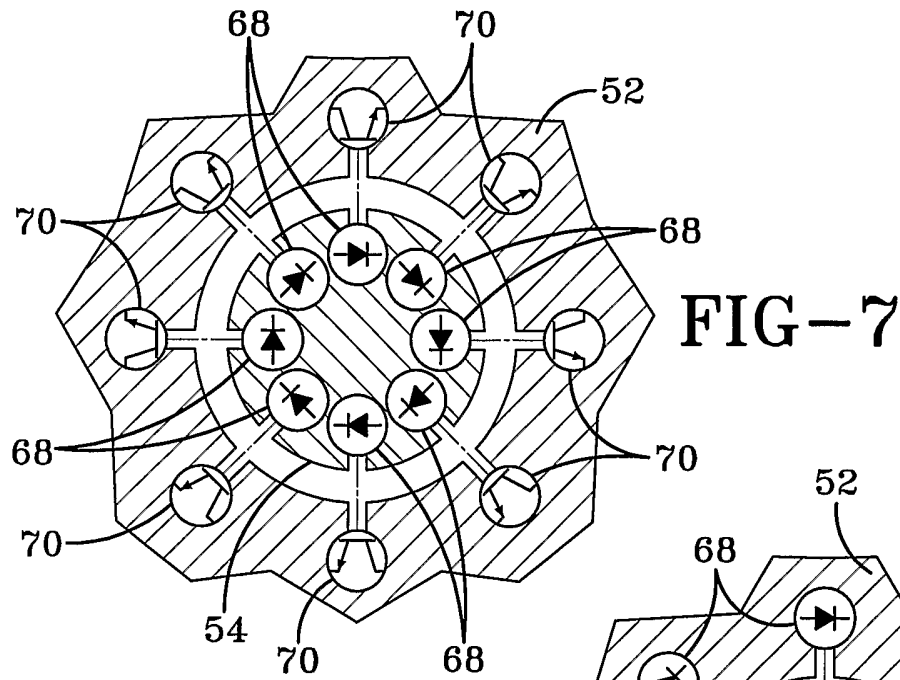
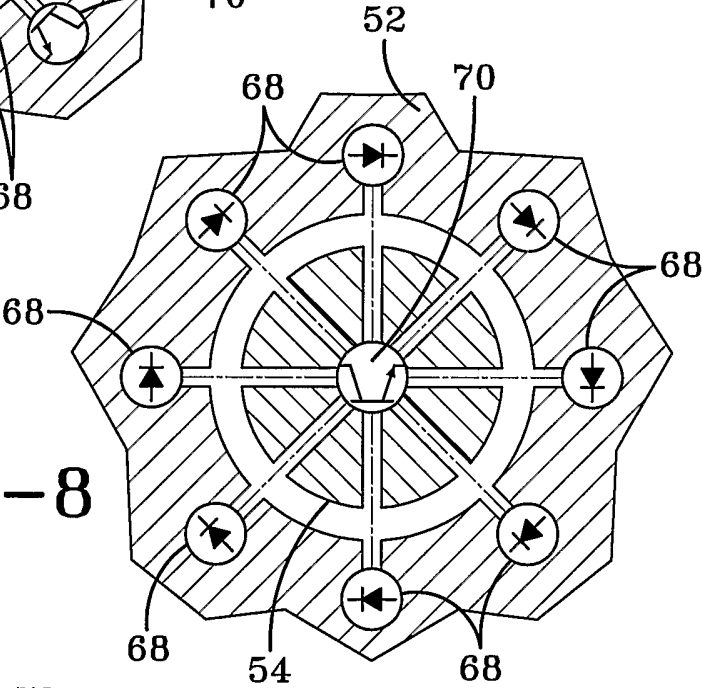
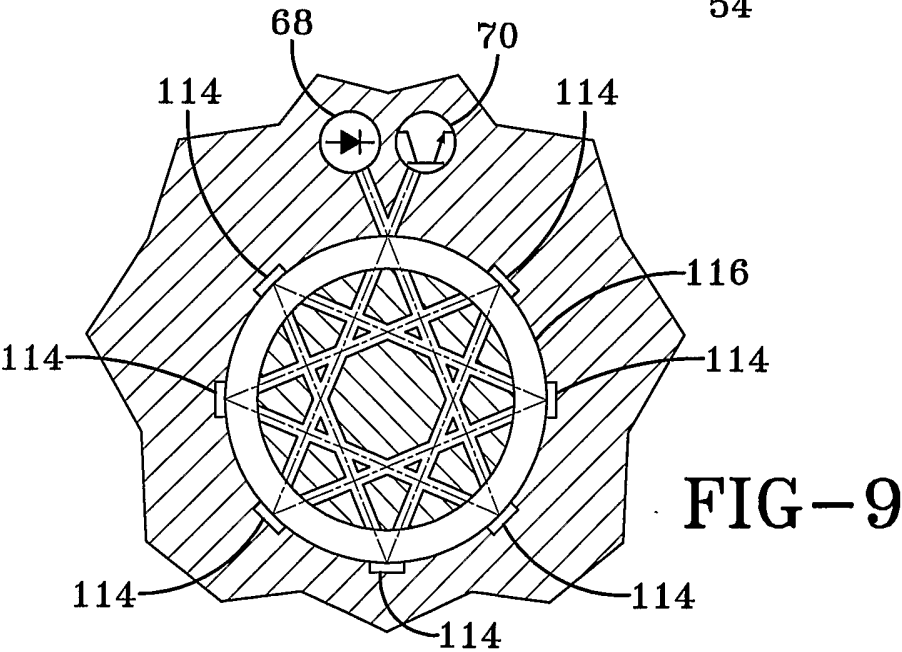


FIG-8



INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/40010

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60R21/01 B60R21/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0 943 499 A (BAYERISCHE MOTOREN WERKE AG) 22 September 1999 (1999-09-22) paragraph '0013! - paragraph '0014!; figure 1 -----	1
A	US 5 762 367 A (WOLANIN MICHAEL JOHN) 9 June 1998 (1998-06-09) column 4, line 4 - line 65; figures 1-3 -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

2 April 2004

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Ekbloom, H

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/40010

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