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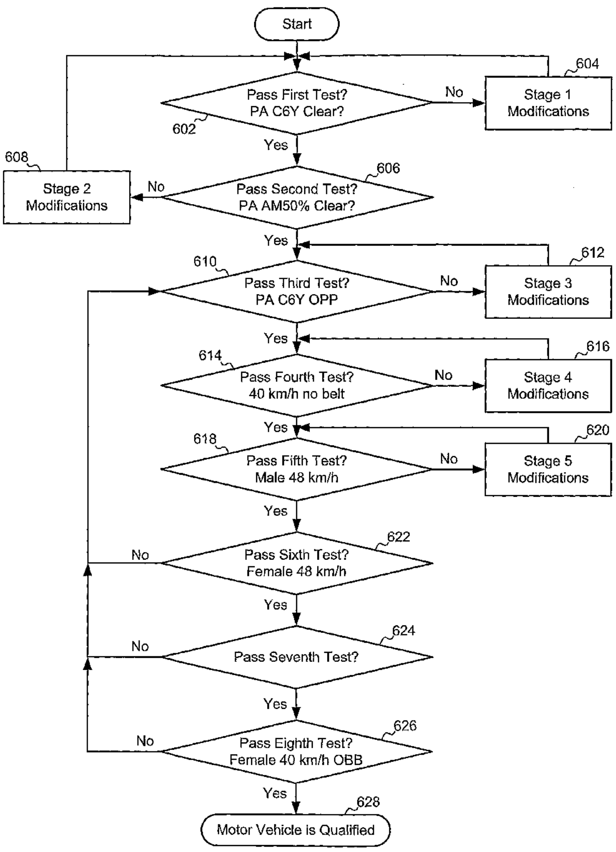
(54) **Title:** METHOD FOR PREPARING A MOTOR VEHICLE FOR A CRASH TEST



(57) **Abstract:** A method for preparing a motor vehicle for a crash test is disclosed. The method subjects the motor vehicle to a sequence of different tests and provides a system of staged modifications that can be made to help the motor vehicle pass the current test without invalidating test results obtained earlier in the sequence. In some cases, this method can be used to confirm that a particular motor vehicle qualifies for a certain crash test routine.

WO 2006/074366 A2

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METHOD FOR PREPARING A MOTOR VEHICLE FOR A CRASH TEST

DESCRIPTION

Technical Field

This invention relates to the field of motor vehicle restraint systems, and more particularly, to a method for crash testing a motor vehicle.

Background Art

Currently, some cars, trucks and vans provide some kind of supplemental restraint system (SRS). Often, these supplemental restraint systems take the form of inflatable devices or restraints. In some cases, airbags are used. The following related art references provide a general background of the field.

Cooper (U.S. patent number 6,696,933) discloses an air bag system with a biomechanical grey zone. The biomechanical grey zone is an attempt to comply with recent legislative changes that require airbags to restrain women and children as well as adult males. To help restrain women and children, Cooper proposes the use of a system where air bags include multi-level inflators that can adjust the inflation characteristics of the air bag. The biomechanical zone is defined as a region where it is acceptable to deploy the air bag using either a low power inflator or a high power inflator. While the use of biomechanical grey zones may help to comply with new governmental requirements, the grey zones introduce uncertainty in the deployment characteristics of the air bag and this makes system design and testing difficult. The Cooper reference is incorporated by reference in its entirety.

Corrado et al. (U.S. patent number 6,249,729) teaches an occupancy sensing system for an automobile. The system is used in conjunction with an airbag deployment system to determine the nature, location and motion parameters of an occupant within the vehicle interior. These parameters are determined by ultrasound and/or infrared sensors. The system establishes criteria for airbag disablement or for modified airbag deployment based on sensor information. In particular, Corrado teaches the use of a Keep Out Zone (KOZ) within the vehicle interior relative to the dashboard or instrument panel. Analyzing the relative location of an occupant with respect to the Keep Out Zone can be used to determine whether the airbag deployment is disabled or modified.

Wang et al. (U.S. patent number 6,662,092) teaches a control method for deploying an air bag using fuzzy logic. Wang attempts to provide a fuzzy logic deployment system that is more direct than previous fuzzy logic systems and where the calibration process if more user friendly. The method uses a deployment control algorithm to determine whether certain stages are deployed based on certain thresholds related to predicted occupant movement and crash severity.

There is currently a need for a way to increase the predictability of the deployment of an inflatable restraint to improve occupant safety and to simplify the process of crash testing the motor vehicle.

Disclosure of the Invention

A system and method for crash testing a motor vehicle is disclosed. The invention can be used in connection with a motor vehicle. The term "motor vehicle" as used throughout the specification and claims refers to any moving vehicle that is capable of carrying one or more human occupants and is powered by any form of energy. The term motor vehicle includes, but is not limited to cars, trucks, vans, minivans, SUV's, motorcycles, scooters, boats, personal watercraft, and aircraft.

Generally, the related art teaches systems and methods for a single deployment event and focus on correctly making a single deployment decision. In contrast, one aspect of the present invention is directed to providing a novel deployment map that applies to a number of different deployment scenarios and conditions. This novel map can help improve the predictability of a deployment of an inflatable restraint, and this predictability can help designers and engineers improve occupant safety over a wide range of different collision scenarios and conditions. In another aspect, the present invention is directed to a method of qualifying a motor vehicle to use the novel deployment map.

In another aspect, the invention provides a method for qualifying a motor vehicle for a crash test routine comprising the steps of: determining whether the motor vehicle passes a first test related to a hypothetical child passenger; and altering the motor vehicle using a first stage of modifications if the motor vehicle fails the first test.

In another aspect, the invention provides a step of determining whether the motor vehicle passes a second test related to a passenger; and altering the motor vehicle using a second stage of modifications if the motor vehicle fails the second test; and wherein the second stage of modifications is different than the first stage of modifications.

In another aspect, the invention provides a step of determining whether the motor vehicle passes a third test related to an out of position passenger; and altering the motor vehicle using a third stage of modifications if the motor vehicle fails the third test; and wherein the third stage of modifications is different than the first stage of modifications and the second stage of modifications.

In another aspect, the invention provides a step of determining whether the motor vehicle passes a fourth test related to a crash test conducted at a first speed; and altering the motor vehicle using a fourth stage of modifications if the motor vehicle fails the fourth test; and wherein the fourth stage of modifications is different than the first stage of modifications, the second stage of modifications and the third stage of modifications.

In another aspect, the invention provides a step of determining whether the motor vehicle passes a fifth test related to a crash test conducted at a second speed; and altering the motor vehicle using a fifth stage of modifications if the motor vehicle fails the fifth test; wherein the second speed is greater than the first speed; and wherein the fifth stage of modifications is different than the first stage of modifications, the second stage of modifications, the third stage of modifications and the fourth stage of modifications.

In another aspect, the invention provides a step of determining whether the motor vehicle passes a sixth test related to a female crash test conducted at the second speed.

In another aspect, the invention provides a method for preparing a motor vehicle for a crash test routine comprising a first test and a second test, the first test producing first test results; wherein first stage modifications are available to help pass the first test; wherein second stage modifications are available to help pass the second test; and wherein the second stage modifications are different than the first stage modifications.

In another aspect, changes made using the second stage modifications maintain the validity of the first test results.

In another aspect, first stage modifications include modifying a shape of an instrument panel associated with the motor vehicle.

In another aspect, first stage modifications include modifying a first thigh contact point.

In another aspect, first stage modifications include modifying a height of a seat associated with the motor vehicle.

In another aspect, wherein first stage modifications can be made by optionally changing any one of the group consisting essentially of: modifying a shape of an instrument panel associated with the motor vehicle, modifying a first thigh contact point, and modifying a height of a seat associated with the motor vehicle.

In another aspect, wherein second stage modifications include moving a position of a knee bolster associated with the motor vehicle.

In another aspect, wherein second stage modifications include moving a position of a windshield associated with the motor vehicle.

In another aspect, wherein second stage modifications include adjusting a stiffness of a knee bolster associated with the motor vehicle.

In another aspect, wherein second stage modifications can be made by optionally changing any one of the group consisting essentially of: moving a position of a knee bolster associated with the motor vehicle, moving a position of a windshield associated with the motor vehicle, and adjusting a stiffness of a knee bolster associated with the motor vehicle.

In another aspect, wherein the first test includes determining whether a hypothetical child enters a No Good Zone.

In another aspect, wherein the No Good Zone is associated with a passenger side inflatable device.

In another aspect, wherein the second test includes determining whether a hypothetical male passenger clears a windshield associated with the motor vehicle.

In another aspect, the second test includes determining a pelvic stroke of a hypothetical male passenger.

Other systems, methods, features and advantages of the invention will be, or will become, apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the following claims.

Brief Description of the Drawings

The invention can be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, in the figures, like reference numerals designate corresponding parts throughout the different views.

Figure 1 is a schematic diagram of a preferred embodiment of a method for improving a crash test routine for a motor vehicle.

Figure 2 is a schematic diagram of a conventional firing map for an inflatable restraint.

Figure 3 is a schematic diagram of a preferred embodiment of a firing map for an inflatable restraint.

Figure 4 is a table of a series of crash tests when using a conventional firing map.

Figure 5 is a table of a series of crash tests when using a preferred embodiment of a firing map.

Figure 6 is a flow diagram of a preferred embodiment of a method for qualifying a motor vehicle for a crash test routine.

Figure 7 is an enlarged schematic diagram of a preferred embodiment of step 604 of Figure 6.

Figure 8 is an enlarged schematic diagram of a preferred embodiment of step 608 of Figure 6.

Figure 9 is an enlarged schematic diagram of a preferred embodiment of step 616 of Figure 6.

Figure 10 is a schematic diagram of a preferred embodiment of a No Good Zone.

Figure 11 is a schematic diagram of a failed crash test.

Figure 12 is a schematic diagram of a preferred embodiment of a crash test that has been passed.

Figure 13 is a schematic diagram of a preferred embodiment of a motor vehicle interior and a child occupant.

Best Mode(s) for Carrying Out the Invention

Figure 1 is a flow diagram of a preferred embodiment of a method of improving a crash test regiment for a motor vehicle. The method shown in Figure 1 can include the following steps. The method begins with step 102 where a new firing map is designed. This new firing map helps to simplify the firing conditions of an inflatable restraint and reduce occupant injury. The simplified algorithm or firing map can help make the deployment conditions of the inflatable restraint more predictable and this helps to provide a supplemental restraint system that is more reliable and easier to test. This predictability also helps designers improve occupant safety. Another benefit of the new firing map is that it can help reduce the number of vehicles required to comply with government-mandated crash tests. In some cases, this reduction is substantial.

After the new firing map has been designed, the method can proceed to step 104 where a motor vehicle is qualified for using the new firing map. In step 104, the process helps to identify which motor vehicles can accept the new map and can also help tune or modify a motor vehicle so that it can become a motor vehicle capable of using the new firing map.

After the motor vehicle has been qualified to use the new firing map, the motor vehicle is then subjected to a simplified crash test routine in step 106. Preferably, step 106 includes the process of actually conducting real world crash tests with actual motor vehicles and crash test dummies.

Figure 2 is a schematic diagram of a conventional firing map 200 for an inflatable restraint. The conventional firing map 200 includes three deployment scenarios depending on the type of impact. The three types of impact are a conventional flat barrier scenario

202, a conventional angled barrier scenario 204 and a conventional offset barrier scenario 206. In each of the scenarios, the conventional firing map 200 also deploys the inflatable restraints differently depending on the speed of the impact. Generally, conventional firing map 200 considers the speed of the impact and the type of impact to determine how or if the inflatable restraint is deployed.

In the conventional flat barrier scenario 202, conventional firing map 200 includes three different deployment options, which are related to corresponding regions in the bar graph representing conventional flat barrier scenario 202. The first deployment option is a no fire option and this first option occurs in region 208. A second deployment option is a delay fire option, and this second option occurs in region 210. The third deployment option is a simultaneous fire option that occurs in region 212.

Generally, inflatable restraint systems can include two charges, a low power charge and a high power charge. The high power charge is generally designed to provide a low energy deployment that is suitable for smaller and less massive occupants, for example, a woman with physical characteristics similar to an AF5% crash test dummy. The low power charge is generally used to supplement the energy of the high power charge, and when these two charges are deployed simultaneously, they produce a high energy deployment that is suitable for larger and more massive individuals, for example, a male with physical characteristics similar to an AM50% crash test dummy.

A delay deployment can be conducted in many different ways. The system can delay deploying the inflatable restraint in the following ways: the system can immediately deploy the high power charge and delay deploying the low power charge, the system can delay first and then deploy the two charges simultaneously, or the system can deploy the low power charge immediately and delay deploying the high power charge. In a simultaneous deployment, the system deploys both the low power charge and the high power charge at the same time to inflate the restraint very quickly.

In some embodiments, a simultaneous deployment can include a slight delay. In these embodiments, the high power charge is initially deployed, and then a slight delay is provided. This delay can be used to provide the system with a little more time to decide whether to deploy the second low power charge. In some cases, the system has determined that the high power charge needs to be deployed. The slight delay can be used to retrieve information from other sensors or perform other computations. These steps can be used by the system to decide whether to also deploy the low power charge. This slight delay can range from about 0 to 10 milliseconds and in an exemplary embodiment, the delay is about 5 milliseconds.

The conventional firing map 200 includes transition zones between two adjacent deployment regions. Considering conventional flat barrier 202, a first transition zone 214 is disposed between first region 208 and second region 210. This first transition zone 214 is bounded, on the low speed end, at about 13 km/h and on the high speed end at about 19 km/h.

This first transition zone 214 determines the deployment characteristics for the inflatable restraint where the passenger or driver is unbelted. First transition zone 214 graphically represents the percentage chance between first region 208 and second region 210. In conventional map 200, first region 208 corresponds to a no fire condition and second region 210 corresponds to a delay fire condition. Thus, first transition zone 214 graphically represents the percentage chance that the inflatable device will either not deploy (no fire) or will deploy in a delay mode.

As shown in Figure 2, at the low end of first transition zone 214, the bar graph representing the conventional flat barrier scenario 202 is almost completely represented by first region 208. This means that there is almost a 100% chance that the deployment condition associated with first conventional region 208 will occur. Since first conventional region 208 represents a no fire condition, there virtually no chance that the inflatable device will deploy at the low end of first transition zone 214.

At the opposite end of first transition zone 214, at about 19 km/h, the bar graph representing first scenario 202 is almost completely represented by second region 210. Since second region 210 corresponds to a delay fire condition, it is virtually assured that inflatable restraint will deploy in a delay fire mode. At speeds between 13 km/h and 19 km/h, there is a generally linear relationship between speed and the likelihood that the inflatable device will be deployed in a delay mode. Generally, as speed increases, it becomes more and more likely that the inflatable restraint will be deployed in a delay mode.

Conventional flat barrier scenario 202 also includes a second transition zone 216. This second transition zone 216 extends from a low end of about 13 km/h to a high end of about 26 km/h. In order to accurately show first transition zone 214, Figure 2 shows only a portion of second transition zone 216, the slope of which should continue until 13 km/h. This second transition zone relates to a belted occupant, either driver or passenger. Second transition zone 216 provides the probability that the inflatable device will either not deploy or will deploy in a delay mode. Again, like first transition zone 214, the percentage chance of either a no fire condition or a delay fire condition is graphically related to ratio of the first region 208 compared to the second region 210 at a given speed.

Conventional flat barrier scenario 202 includes a third transition zone 218. This third transition zone 218 is disposed between second region 210 and third region 212 and provides the percentage chance of either a delay mode deployment or a simultaneous deployment.

Third transition region starts at about 30 km/h and extends to about 37 km/h. Similar to the first and second transition regions, third transition region 218 provides a percentage chance that the inflatable device will deploy in accordance with the pattern associated with second region 210 or third region 212. Recall that second region 210 is associated with a delay fire condition and third region 212 is associated with a simultaneous fire condition. Because of these associations, third transition zone 218 graphically represents the percentage chance that an inflatable device will deploy in a delay fire mode or a simultaneous fire mode.

As shown in conventional flat barrier scenario 202, the percentage chance that the inflatable device will deploy in a simultaneous fire mode increases as the speed of the impact increases. At about 37 km/h, it is a virtual certainty that the inflatable device will deploy in a simultaneous mode and at speeds above 37 km/h, the inflatable device is designed to deploy in simultaneous mode.

Conventional angle barrier scenario 204 includes three regions, first region 208, second region 210 and third region 212 corresponding to three different deployment patterns for an inflatable restraint. Conventional angle barrier scenario 204 includes a fourth transition zone 220 disposed between first region 208 and second region 210. Fourth transition zone 220 extends from a low end of about 13 km/h to a high end of about 19 km/h.

Fourth transition zone 220 is similar to first transition zone 214. As shown in Figure 2, at the low end of fourth transition zone 220, the bar graph representing the angle barrier scenario 204 is almost completely represented by first conventional region 208. This means that there is almost a 100% chance that the deployment condition associated with first conventional region 208 will occur. Since first conventional region 208 represents a no fire condition, there virtually no chance that the inflatable device will deploy at the low end of fourth transition zone 220.

At the opposite end of fourth transition zone 220, at about 19 km/h, the bar graph representing second scenario 204 is almost completely represented by second region 210. Since second region 210 corresponds to a delay fire condition, it is virtually assured that inflatable restraint will deploy in a delay fire mode. At speeds between 13 km/h and 19 km/h, there is a generally linear relationship between speed and the likelihood that the inflatable device will be deployed in a delay mode. Generally, as speed increases, it becomes more and more likely that the inflatable restraint will be deployed in a delay mode.

Conventional angle barrier scenario 204 also includes a fifth transition zone 222 disposed between second region 210 and third region 212. This fifth transition zone 222 extends from a low end of about 26 km/h to a high end of about 32 km/h and provides the percentage chance of either a delay mode deployment or a simultaneous deployment.

Fifth transition zone 222 starts at about 26 km/h and extends to about 32 km/h. Similar to other transition zones, fifth transition zone 222 provides a percentage chance that the inflatable restraint will deploy in accordance with the pattern associated with second region 210 or third region 212. Recall that second region 210 is associated with a delay fire condition and third region 212 is associated with a simultaneous fire condition. Because of these associations, fifth transition zone 222 graphically represents the percentage chance that an inflatable restraint will deploy in a delay fire mode or a simultaneous fire mode.

As shown in conventional angle barrier scenario 204, the percentage chance that the inflatable device will deploy in a simultaneous fire mode increases as the speed of the impact increases. At about 32 km/h, it is virtual assured that the inflatable restraint will deploy in a simultaneous mode and at speeds above 32 km/h, the inflatable restraint is designed to deploy in simultaneous mode.

Conventional offset barrier scenario 206 includes two regions, first region 208 and second region 210. Conventional offset barrier scenario 206 does not include a third region. Sixth transition zone 224 is disposed between first region 208 and second region 210. Sixth transition zone 224 is larger than some other transition zones and extends from about 26 km/h to about 40 km/h.

As shown in Figure 2, at the low end of sixth transition zone 224, the bar graph representing the offset barrier scenario 206 is almost completely represented by first conventional region 208. This means that there is almost a 100% chance that the deployment condition associated with first conventional region 208 will occur. Since first conventional region 208 represents a no fire condition, there virtually no chance that the inflatable restraint will deploy at the low end of sixth transition zone 224.

At the opposite end of sixth transition zone 224, at about 40 km/h, the bar graph representing offset barrier scenario 206 is almost completely represented by second region 210. Since second region 210 corresponds to a delay fire condition, it is virtually assured that inflatable restraint will deploy in a delay fire mode. At speeds between 26 km/h and 40 km/h, there is a generally linear relationship between speed and the likelihood that the inflatable device will be deployed in a delay mode. Generally, as speed increases, it becomes more and more likely that the inflatable restraint will be deployed in a delay mode.

Government rules generally require motor vehicles to undergo crash testing at certain speeds and under certain conditions. Currently, there are two government regulation zones, a first regulation zone between 32 km/h to 40 km/h for unbelted occupants and a second regulation zone between 0 km/h and 48 km/h for belted occupants. Motor vehicles sold in the United States must be subjected to a number of crash tests to establish passenger and occupant safety in these regulation zones in the event of a collision.

While transition zones have been used in the past as a way to decide how to deploy an inflatable restraint, they also introduce a number of problems. Deployments that occur within transition zones are unpredictable because the transition zones only provide percentage chances of two competing deployment conditions. In some cases, the response of a system using conventional firing map 200 is so unpredictable that it is possible for an inflatable restraint to deploy two different ways in two successive and identical crash tests.

Because the deployment of an inflatable restraint is unpredictable in a transition zone, the system must be tested at the government mandated speeds as well as at all endpoints of the transition zone.

In order to minimize the number of crash tests, engineering reasoning is generally used and a worst case scenario is tested. Using engineering reasoning, if a motor vehicle passes a crash test conducted under the worst case, then it can be assumed that the motor vehicle will also pass a crash test at under less severe conditions. This is one way to validate the response of the system under many different possible conditions. For example, if a motor vehicle passed a crash test at 40km/h, engineering reasoning dictates that the same motor vehicle, identically prepared and equipped, should pass the same crash test at 35 km/h. In fact, the motor vehicle should also pass the same crash test at any speed between 0 and 40 km/h.

Referring to Figure 4, which is a table of crash tests for conventional firing map 200, and Figure 2, the crash tests that are required can be observed. The crash tests are preferably conducted in sets, and each set preferably includes a driver and a passenger. Set 1 is conducted at a speed of 37 km/h and with a flat barrier collision condition. Set 1 is used to test the occupant safety of a typical female and an AF5% crash test dummy (which stands for American Female 5 percentile) can be used to model the behavior of a hypothetical female occupant. Set 1 is an unbelted test, meaning seat belts are not used during the test.

Set 2 is similar to set 1 except that set 2 is used to test the occupant safety of a typical male and an AM50% crash test dummy (which stands for American Male, 50 percentile) can be used to model the behavior of a hypothetical male. The conditions and attributes of the remaining eleven sets of crash tests are self-explanatory from the table shown in Figure 4.

Figure 3 is a schematic diagram of a preferred embodiment of firing map 300. It has been discovered that with careful design of motor vehicle 100, the simultaneous fire mode is not necessary to provide occupant safety and also meet government crash test requirements. In other words, it is possible to use a delay fire mode to meet government crash test requirements under conditions where conventional systems use a simultaneous fire mode.

This discovery can be used to create a firing map 300 that is less complex than conventional firing map 200. It is believed that this discovery will help to improve occupant safety because the reduction in the complexity of the new firing map 300 compared to the conventional firing map 200 can provide more predictable deployments of inflatable devices. This improved predictability can, in turn, be used to better understand the interplay between occupants and the inflatable restraint system at various different speeds and collision conditions. This can help engineers design safer motor vehicles and inflatable restraint systems. As a side benefit, this discovery also allows the locations of the various transition zones to be selected to prevent overlap with one or more government regulation zones.

Also, because a simultaneous fire mode is no longer required, this entire deployment mode can be omitted from firing map 300. In the embodiment shown in Figure 4, firing map 300 does not include a simultaneous deployment or firing condition. Firing map 300 includes just two deployment patterns, a no fire mode and a delayed deployment mode.

Preferably, the various transition zones are carefully selected so that none of the transition zones overlaps a regulation zone. In one embodiment shown in Figure 3, the transition zones have been moved away or separated from the regulation zones. This allows the crash test routine to be greatly simplified. Referring to Figure 5, which is a table of crash tests corresponding to firing map 300 reflected in Figure 3, differences between this table and the table shown in Figure 4 are readily apparent.

As shown in Figure 5, several crash tests are no longer needed. Set 1 is no longer needed because set 3 is conducted at 40 km/h under the same conditions, namely in delay mode. Note the arrows indicating that new set 3 is conducted in delay mode from the previous no delay mode. As discussed earlier, if a motor vehicle passes a crash test at a higher speed, then it can be assumed that the motor vehicle will pass the same crash test at a lower speed. Because the new firing map 300 uses the same deployment conditions at 40 km/h and 37 km/h, any motor vehicle using new firing map 300 that passes the 40 km/h crash test should also pass set 1 as well. For the same reasons, sets 2, 5, 6 and 12 are no longer required.

Returning to Figure 1, some embodiments include provisions 104 to determine if a motor vehicle is qualified to use new firing map 300. Although many different methods can be used to determine if a motor vehicle is qualified to use new firing map 300, the following method is preferred. Referring to Figure 6, which is a flow diagram of a preferred embodiment of a method 104 for determining if a motor vehicle is qualified to use new firing map 300, this method can both determine if a motor vehicle is qualified to use new firing map 300 and also help modify or "tune" the motor vehicle so it becomes qualified to use new firing map 300.

Method 104 can include a number of different tests and a number of modifications that can be made to help the motor vehicle to pass those tests. Preferably, these tests and modifications are arranged sequentially within method 104 in a systematic way so that a modification does not invalidate previous test results.

Preferably, method 104 begins with first test 602. In first test 602, the relative position of a hypothetical child with respect to a No Good Zone ("NGZ") 1002 is considered. In some cases, a C3Y (child, three year old) and/or C6Y (child, six year old) dummy is used to model the hypothetical child. Referring to Figure 10, NGZ 1002 is a zone roughly between inflatable restraint lid 1004 and windshield 1006. In some embodiments, NGZ 1002 is defined using particular relative offsets and spacing from various components.

In a preferred embodiment, NGZ 1002 is defined by one or more boundaries. These boundaries are preselected or predefined distances from various objects or lines. In the embodiment shown in Figure 10, inflator module 1020 includes an inflator center line 1022. In some embodiments, a boundary is established based on inflator center line 1022. In the embodiment shown in Figure 10, inflator center line boundary 1026 is defined as a boundary that is parallel and spaced from inflator center line 1022. The distance can be varied, however, any distance of about 30mm to 200mm can be used. In an exemplary embodiment, inflator center line boundary 1026 is disposed about 70mm away from inflator center line 1020 towards or into the passenger cabin of motor vehicle 100.

Inflator module 1020 can also include an edge 1024. In some embodiments, a boundary is established based on inflator edge 1024. In the embodiment shown in Figure 10, inflator edge boundary 1028 is defined as a boundary that is vertical and horizontally spaced from inflator edge 1024. The distance can be varied, however, any distance of about 30mm to 200mm can be used. In an exemplary embodiment, inflator edge boundary 1028 is disposed about 70mm away from inflator edge 1024 towards or into the passenger cabin of motor vehicle 100.

In some embodiments, a boundary can be established based on windshield 1006. In the embodiment shown in Figure 10, windshield boundary 1030 is defined as a boundary that is roughly parallel to windshield 1006. The distance between windshield 1006 and windshield boundary 1030 can be varied, however, any distance of about 50mm to 300mm can be used. In an exemplary embodiment, windshield boundary 1030 is disposed about 100mm away from windshield 1006 towards or into the passenger cabin of motor vehicle 100.

In some embodiments, a boundary can be established based on inflator lid 1004. In the embodiment shown in Figure 10, the arc or range of motion of the inflator lid is indicated by 1004. A lid boundary 1032 is defined as a locus of points equally spaced from arc 1004 and disposed outward or away from inflator module 1020. The distance between inflator lid 1004 and lid boundary 1032 can be varied, however, any distance of about 1mm to 50mm can be used. In an exemplary embodiment, lid boundary 1032 is disposed about 10mm away from arc 1004 towards or into the passenger cabin of motor vehicle 100.

One or more of these various different boundaries can be used to establish NGZ 1002. In an exemplary embodiment, shown in Figure 10, all of the above boundaries are used. However, other embodiments may use more or less boundaries to establish NGZ 1002.

Referring to Figure 6, if the hypothetical child passenger is clear of NGZ 1002, then the process moves on to step 606. However, if the hypothetical child passenger does not clear NGZ 1002, then the process moves to step 604.

Figure 7 is an enlarged view of step 604, and one or more of the modifications shown in Figure 7 can be made to help motor vehicle 100 pass first test 602. One option is to modify the Instrument Panel (IP) 1008 shape. The shape of IP 1008 can be extended into the passenger cabin to help prevent entry of the hypothetical child in to NGZ 1002. Another option is to modify the shape of first thigh bolster or first contact point. Another option is to modify the passenger seat height and/or angle. One or more of these options can be used to prevent the hypothetical child occupant from entering NGZ 1002.

Some of these modifications can be seen in Figure 13, which is a schematic diagram of a motor vehicle interior and an out of position child 1302. Motor vehicle interior includes a seat 1304. The forward edge 1306 of seat 1304 generally serves as the first contact point for child 1302. As shown schematically in Figure 13, the location of forward edge 1306 and/or the angle of seat 1304 can be modified to help motor vehicle 100 pass first test 602.

After these modifications are made, the process returns to first test 602 until it has been confirmed that the hypothetical child does not enter NGZ 1002.

After this has been confirmed, the process moves on to step 606, the second test, where the process determines whether or not the kinematic arc of an average male passenger will strike windshield 1006. Figures 11 and 12 are schematic diagrams of examples demonstrating contact with windshield 1006 and clearance of windshield 1006, respectively. In some cases, an AM50% crash test dummy (which stands for American Male, 50 percentile) is used in second test 606. Referring to Figure 11, crash test dummy 1100 is in a first position 1102 prior to the collision and is in a second position 1104 after the collision. As shown in Figure11, crash test dummy 1100 contacts windshield 1006 in second position 1104. It can also be observed that the pelvis 1105 of crash test dummy 1100 moves from a first position 1106 to a second position 1107 as indicated by arrow 1112 causing an excessive pelvic stroke during the collision. Both of these incidents are not desirable and would cause the design shown in Figure 11 to fail second test 606.

Because the motor vehicle failed second test 606, the process would move to step 608 where stage two modifications can be made. Figure 8 is an enlarged view of step 608, and from Figure 8, there are preferably three available stage two modifications that can be made. The Knee Bolster (K/B) 1108 can be moved; the windshield 1106 can be moved forward and away from the occupant; and finally the stiffness of knee bolster 1108 can be adjusted. One or more of the stage two modifications can be made, and eventually the goal is to design the motor vehicle to pass second test 606.

Figure 12 is a preferred embodiment of an example of a motor vehicle that passes second test 606. In Figure 12, crash test dummy 1200 moves from a first position 1202 prior to the collision to a second position 1204 after the collision. It can be observed in Figure 12, that crash test dummy 1200 clears windshield 1006 and no head contact with windshield 1006 occurs. It can also be observed that re-designed knee bolster 1208 helps to manage the motion of pelvis 1206 to acceptable levels.

After motor vehicle 100 passes second test 606, the process proceeds to third test 610 where an Out Of Position (OPP) child passenger is tested with a delayed firing inflatable restraint. In a preferred embodiment, the firing delay is about 20 to 30 milliseconds. Again, like other tests, a C6Y (child, six year old) dummy can be used for third test 610. If motor vehicle 100 fails third test 610, then the process moves to step 612, where stage three modifications, including tuning the passenger side inflatable restraint can be made. After the inflatable restraint has been tuned, the process returns to third test 610. Preferably, this is done until motor vehicle 100 passes third test 610.

After motor vehicle 100 passes third test 610, the process moves on to fourth test 614. Fourth test 614 determines whether motor vehicle 100 can protect occupants during a frontal 40 km/h collision who are not wearing their seat belts. Preferably, both a hypothetical male occupant and a hypothetical female occupant are tested in fourth test 614. In some embodiments, an AM50% crash test dummy (which stands for American Male, 50 percentile) is used to model the behavior of a hypothetical male and an AF5% crash test dummy (which stands for American Female 5 percentile) is used to model the behavior of a hypothetical female occupant.

If motor vehicle 100 fails fourth test 614, then the process moves to step 616 where stage four modifications can be made. Figure 9 is an enlarged view of step 616. Preferably, stage four modifications include the optional modifications of tuning the steering wheel and tuning the driver's side knee bolster.

In some embodiments, the size, shape, and collapsing stiffness of the steering wheel can be varied to help protect the occupants. Also, in some embodiments, the driver's side knee bolster can be repositioned and the stiffness of the driver's side knee bolster can be tuned.

The passenger side knee bolster 1108 (see Figures 11 and 12) can only be modified by stiffening knee bolster 1108. This is because any reduction in stiffness of passenger side knee bolster 1108 would invalidate the results of second test 606. Preferably, the process is designed so that no modification invalidates previous test results. Like other steps, the stage four modifications are preferably tuned until motor vehicle 100 passes fourth test 614.

After motor vehicle 100 passes fourth test 614, the process proceeds to fifth test 618. Fifth test 618 determines whether motor vehicle 100 can protect a male occupant during a frontal 48 km/h collision when the male occupant is wearing his seat belt. Preferably, a hypothetical male occupant is tested in fifth test 618 and in some embodiments an AM50% crash test dummy (which stands for American Male, 50 percentile) is used to model the behavior of a hypothetical male occupant.

If motor vehicle 100 fails fifth test 618, then the process moves to step 620 where stage five modifications can be made. Preferably, stage five modifications do not invalidate any of the test results from any of the previous tests. In one embodiment, stage five modifications include tuning the seat belt.

In some embodiments, the position, anchor points and/or tension of the seat belt can be adjusted to help protect the male occupant. Like other steps, the stage five modifications are preferably tuned until motor vehicle 100 passes fifth test 618.

One of the goals of method 600 is to avoid making a modification or adjustment during a current test that would invalidate a previous successful test result. At this point in the preferred embodiment of method 600, no other major modifications are available that would not invalidate previous test results and any modification could invalidate a previous successful test result. Therefore, there are no major modifications available for the remaining tests and the process attempts to confirm that motor vehicle 100 passes the next several tests.

After motor vehicle 100 passes fifth test 618, the process proceeds to sixth test 622, seventh test 624 and eighth test 626. Sixth test 622 determines whether motor vehicle 100 can adequately protect a female occupant during a frontal 48 km/h collision when the female occupant is wearing her seat belt. Preferably, a hypothetical female occupant is tested in sixth test 622 and in some embodiments an AF5% crash test dummy (which stands for American Female 5 percentile) is used to model the behavior of a hypothetical female occupant.

Seventh test 624 determines whether motor vehicle 100 can protect a male occupant during a collision with an angled barrier at 40 km/h when the male occupant is not wearing his seat belt. Preferably, a hypothetical male occupant is tested in seventh test 624 and in some embodiments an AM50% crash test dummy (which stands for American Male, 50 percentile) is used to model the behavior of a hypothetical male occupant.

Eighth test 626 determines whether motor vehicle 100 can adequately protect a female occupant during a collision with an offset barrier at 40 km/h when the female occupant is wearing her seat belt. Preferably, a hypothetical female occupant is tested in eighth test 626 and in some embodiments an AF5% crash test dummy (which stands for American Female 5 percentile) is used to model the behavior of a hypothetical female occupant.

Again, because no major modifications are available, the process determines if motor vehicle 100 passes sixth test 622, seventh test 624 and eighth test 626. If motor vehicle 100 passes all of those tests, then the process proceeds to step 628 where the process concludes that motor vehicle 100 is qualified to use new firing map 300.

If motor vehicle 100 fails any one of the last three tests, then the process returns to a previous stage of modification. In some embodiments, this previous stage of modification can be determined by considering which modification would assist motor vehicle 100 in passing the failed test. Preferably, the highest stage of modification is selected with a goal of minimizing the number of tests that are invalidated. In other embodiments, this previous stage of modification is predetermined and the process moves to a certain predetermined modification stage if motor vehicle 100 fails any of the last three tests. In a preferred embodiment, the process moves to third test 610 if motor vehicle 100 fails any of the last three tests.

Although, it is preferred that the inflatable restraint include only two deployment modes, a first mode where the inflatable restraint does not deploy and a second mode where the inflatable restraint is deployed with a delay, it is possible to provide embodiments where a simultaneous deployment mode is used at some speed greater than 48 km/h. If a simultaneous deployment mode is used, it is preferred that the transition zone between the simultaneous deployment mode and any adjacent mote would not overlap with any regulation zone.

Using principles disclosed above, it is possible to provide a simplified inflatable restraint system that has more predictable characteristics, improved safety and the operation of which is easier to test and validate.

Each of the various components or features disclosed can be used alone or with other components or features. Each of the components or features can be considered discrete and independent building blocks. In some cases, combinations of the components or features can be considered a discrete unit.

While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that may more embodiments and implementations are possible that are within the scope of the invention. Accordingly, the invention is not to be restricted except in light of the attached claims and their equivalents.

Industrial Applicability

The present invention can be used to assist in preparing a motor vehicle for a crash test. In one example, the method can be used to confirm that a particular motor vehicle qualifies for a certain crash test routine.

CLAIMS

1. A method for qualifying a motor vehicle for a crash test routine comprising the steps of:

determining whether the motor vehicle passes a first test related to a hypothetical child passenger; and

altering the motor vehicle using a first stage of modifications if the motor vehicle fails the first test.

2. The method according to claim 1, further comprising the step of determining whether the motor vehicle passes a second test related to a passenger; and

altering the motor vehicle using a second stage of modifications if the motor vehicle fails the second test; and

wherein the second stage of modifications is different than the first stage of modifications.

3. The method according to claim 2, further comprising the step of determining whether the motor vehicle passes a third test related to an out of position passenger; and

altering the motor vehicle using a third stage of modifications if the motor vehicle fails the third test; and

wherein the third stage of modifications is different than the first stage of modifications and the second stage of modifications.

4. The method according to claim 3, further comprising the step of determining whether the motor vehicle passes a fourth test related to a crash test conducted at a first speed; and

altering the motor vehicle using a fourth stage of modifications if the motor vehicle fails the fourth test; and

wherein the fourth stage of modifications is different than the first stage of modifications, the second stage of modifications and the third stage of modifications.

5. The method according to claim 4, further comprising the step of determining whether the motor vehicle passes a fifth test related to a crash test conducted at a second speed; and

altering the motor vehicle using a fifth stage of modifications if the motor vehicle fails the fifth test;

wherein the second speed is greater than the first speed; and

wherein the fifth stage of modifications is different than the first stage of modifications, the second stage of modifications, the third stage of modifications and the fourth stage of modifications.

6. The method according to claim 5, further comprising the step of determining whether the motor vehicle passes a sixth test related to a female crash test conducted at the second speed.

7. A method for preparing a motor vehicle for a crash test routine comprising a first test and a second test, the first test producing first test results;

wherein first stage modifications are available to help pass the first test;

wherein second stage modifications are available to help pass the second test; and

wherein the second stage modifications are different than the first stage modifications.

8. The method according to claim 7, wherein changes made using the second stage modifications maintain the validity of the first test results.

9. The method according to claim 7, wherein first stage modifications include modifying a shape of an instrument panel associated with the motor vehicle.

10. The method according to claim 7, wherein first stage modifications include modifying a first thigh contact point.

11. The method according to claim 7, wherein first stage modifications include modifying a height of a seat associated with the motor vehicle.

12. The method according to claim 7, wherein first stage modifications can be made by optionally changing any one of the group consisting essentially of: modifying a shape of an instrument panel associated with the motor vehicle, modifying a first thigh contact point, and modifying a height of a seat associated with the motor vehicle.

13. The method according to claim 7, wherein second stage modifications include moving a position of a knee bolster associated with the motor vehicle.

14. The method according to claim 7, wherein second stage modifications include moving a position of a windshield associated with the motor vehicle.

15. The method according to claim 7, wherein second stage modifications include adjusting a stiffness of a knee bolster associated with the motor vehicle.

16. The method according to claim 7, wherein second stage modifications can be made by optionally changing any one of the group consisting essentially of: moving a position of a knee bolster associated with the motor vehicle, moving a position of a windshield associated with the motor vehicle, and adjusting a stiffness of a knee bolster associated with the motor vehicle.

17. The method according to claim 7, wherein the first test includes determining whether a hypothetical child enters a No Good Zone.

18. The method according to claim 17, wherein the No Good Zone is associated with a passenger side inflatable device.

19. The method according to claim 7, wherein the second test includes determining whether a hypothetical male passenger clears a windshield associated with the motor vehicle.

20. The method according to claim 7, wherein the second test includes determining a pelvic stroke of a hypothetical male passenger.

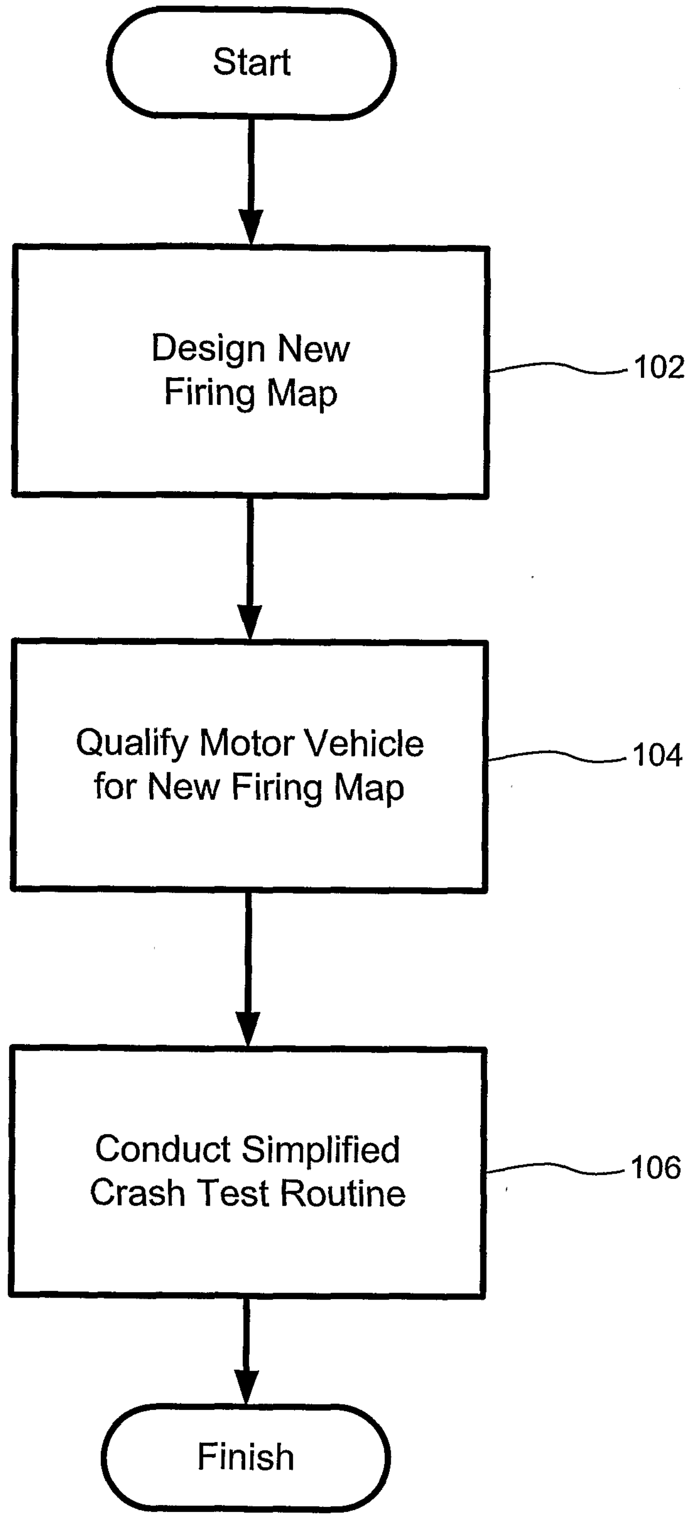

Start
Design New Firing Map
102
Qualify Motor Vehicle for New Firing Map
104
Conduct Simplified Crash Test Routine
106
Finish

Figure 1

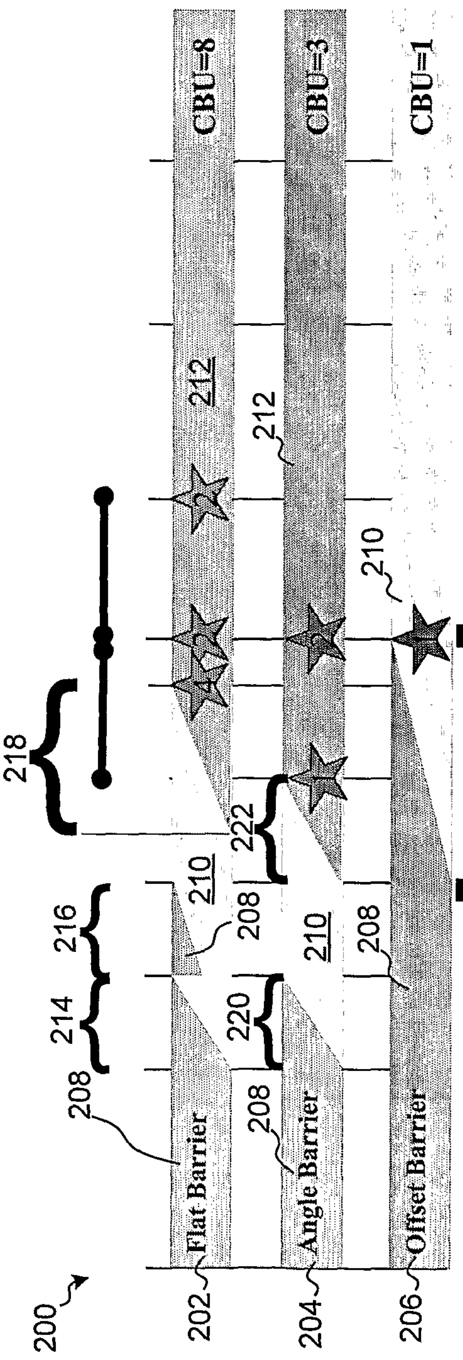


Figure 2

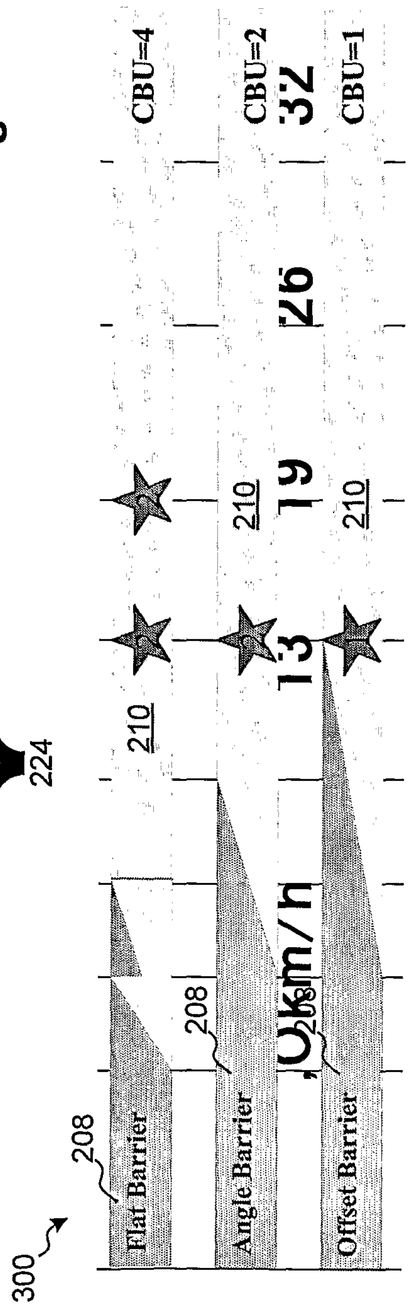


Figure 3

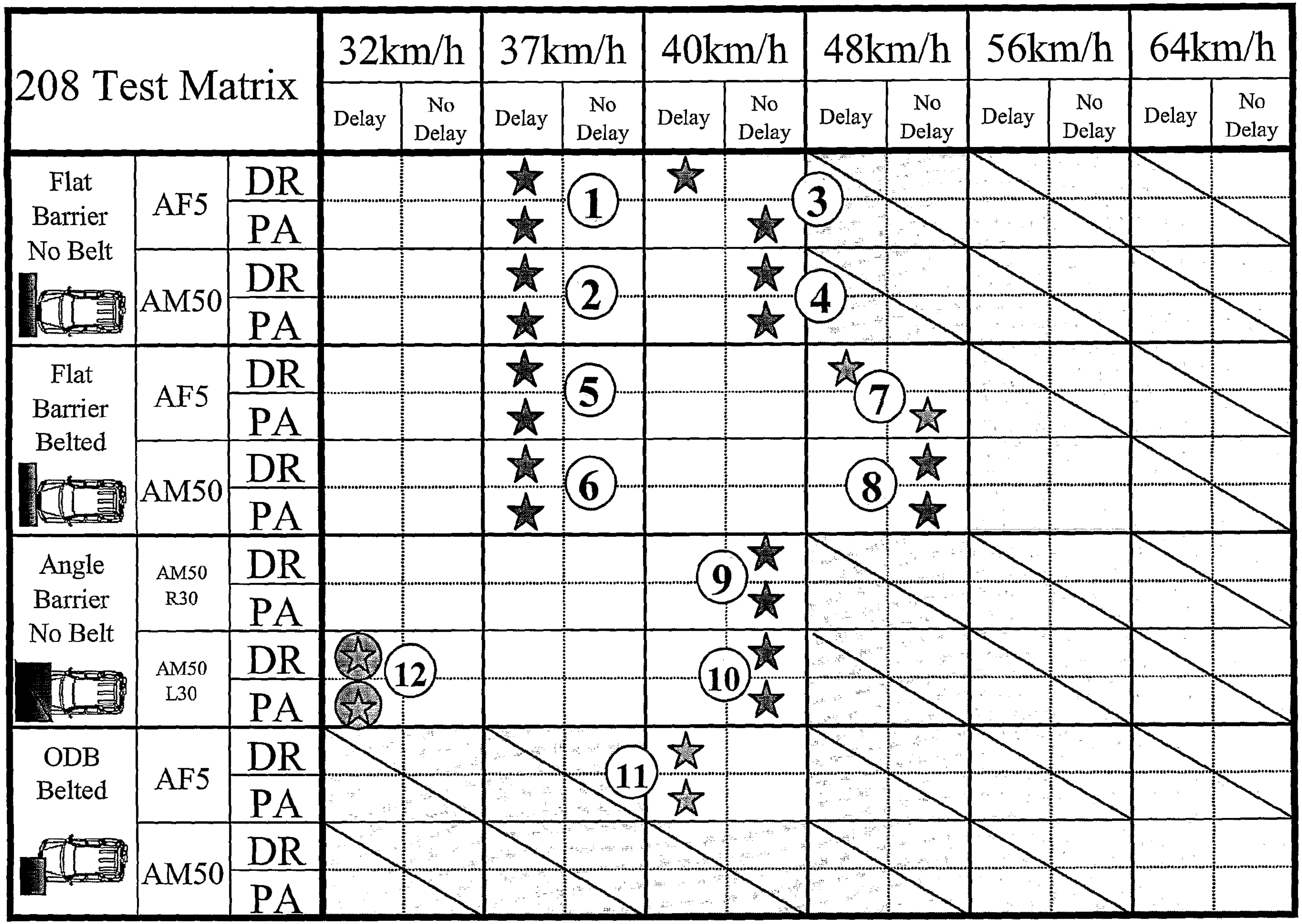

208 Test Matrix
32km/h
37km/h
40km/h
48km/h
56km/h
64km/h
Delay
No Delay
Flat Barrier No Belt
Flat Barrier Belted
Angle Barrier No Belt
ODB Belted
AF5
AM50
AM50 R30
AM50 L30
DR
PA
1
2
3
4
5
6
7
8
9
10
11
12

Figure 4

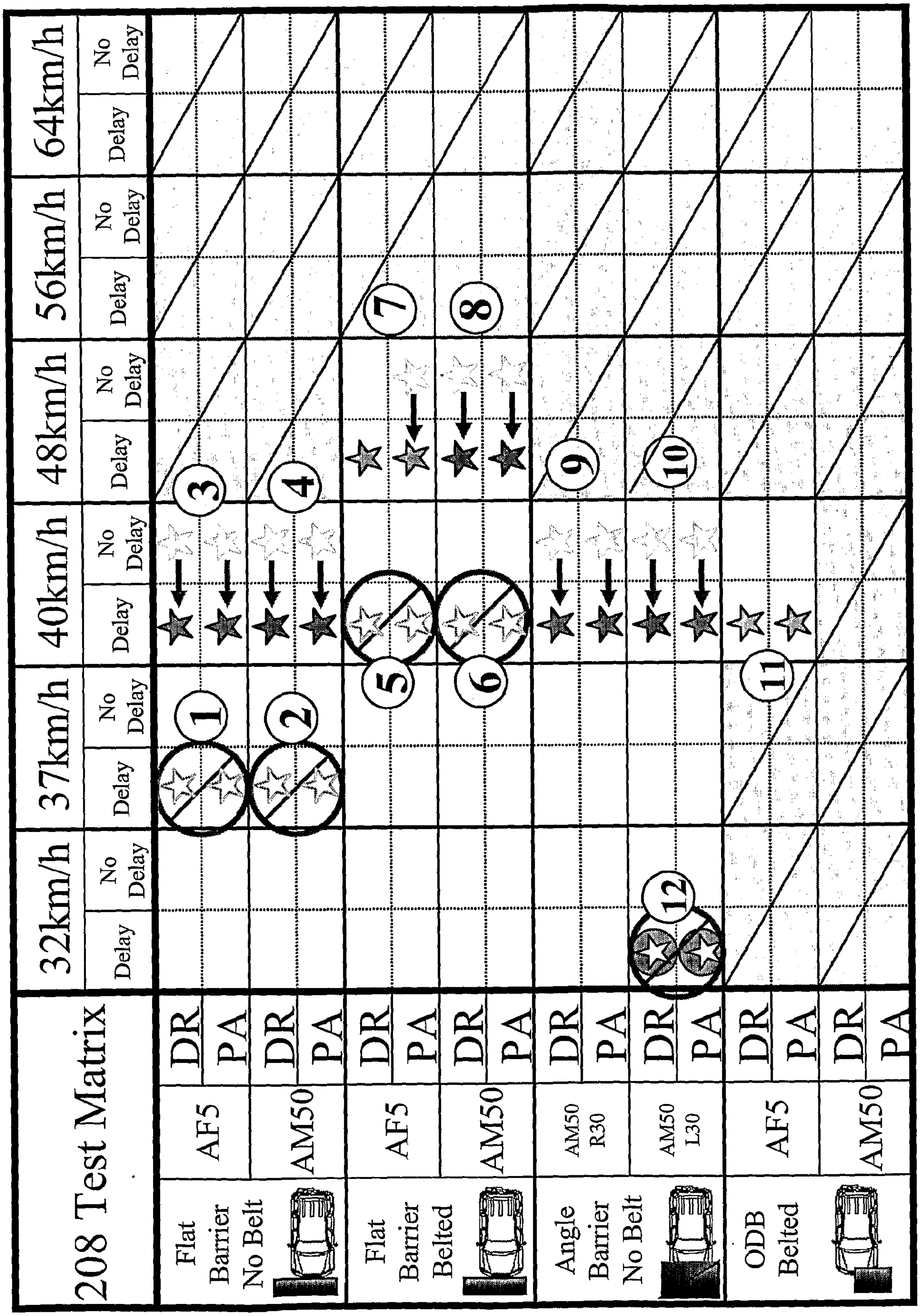

208 Test Matrix
32km/h
37km/h
40km/h
48km/h
56km/h
64km/h
Delay
No Delay
Flat Barrier No Belt
Flat Barrier Belted
Angle Barrier No Belt
ODB Belted
AF5
AM50
AM50 R30
AM50 L30
DR
PA
1
2
3
4
5
6
7
8
9
10
11
12

Figure 5

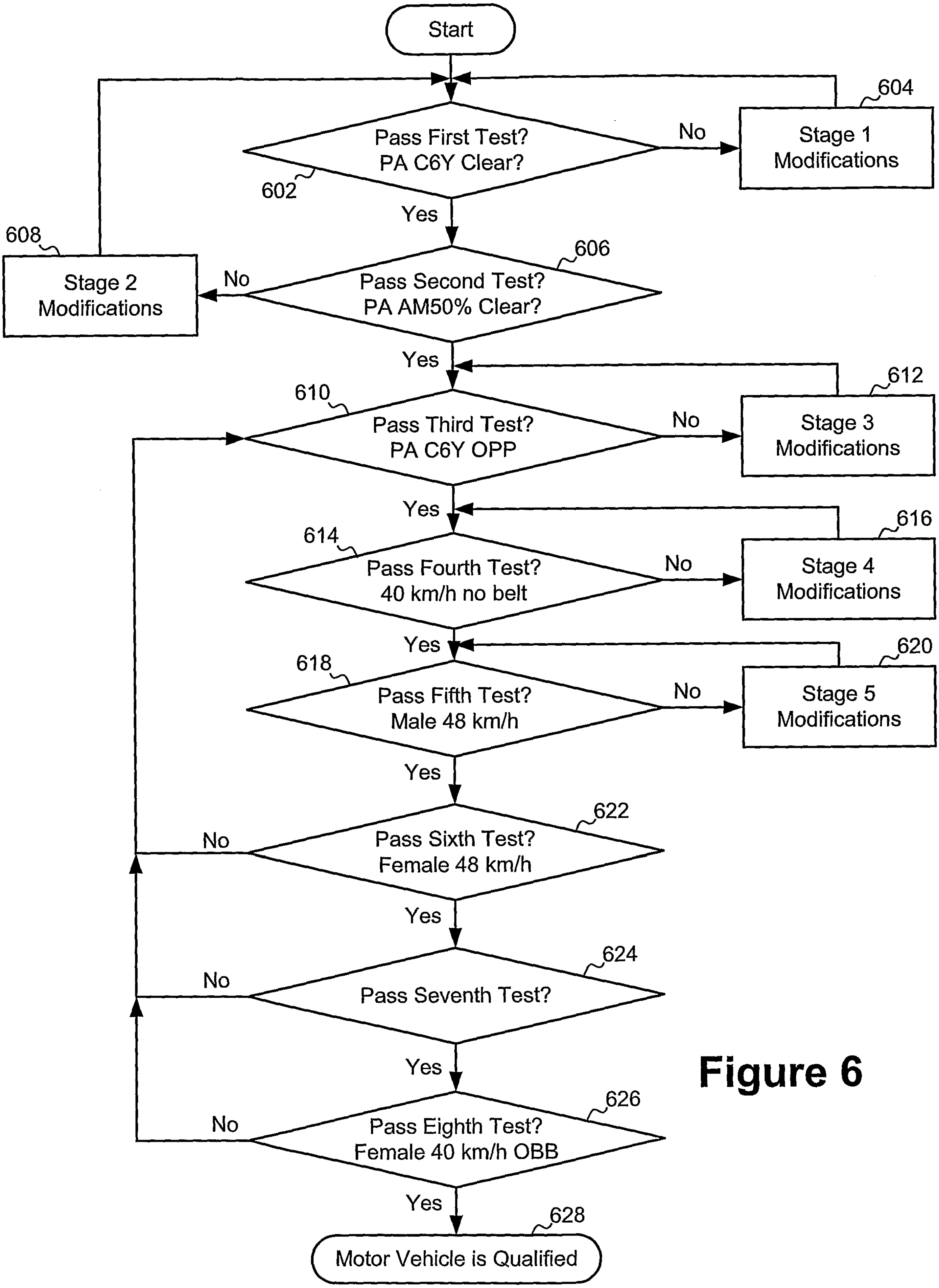

Start
Pass First Test?
PA C6Y Clear?
602
No
Stage 1
Modifications
604
Yes
Pass Second Test?
PA AM50% Clear?
606
No
Stage 2
Modifications
608
Yes
Pass Third Test?
PA C6Y OPP
610
No
Stage 3
Modifications
612
Yes
Pass Fourth Test?
40 km/h no belt
614
No
Stage 4
Modifications
616
Yes
Pass Fifth Test?
Male 48 km/h
618
No
Stage 5
Modifications
620
Yes
Pass Sixth Test?
Female 48 km/h
622
No
Yes
Pass Seventh Test?
624
No
Yes
Pass Eighth Test?
Female 40 km/h OBB
626
No
Yes
Motor Vehicle is Qualified
628

Figure 6

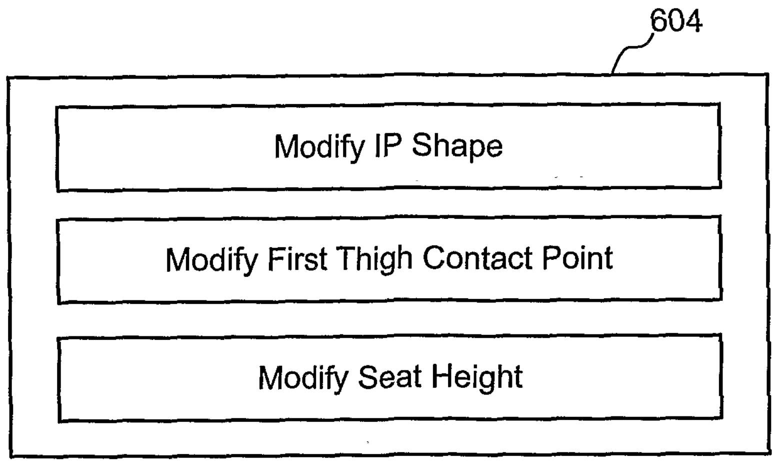


Figure 7

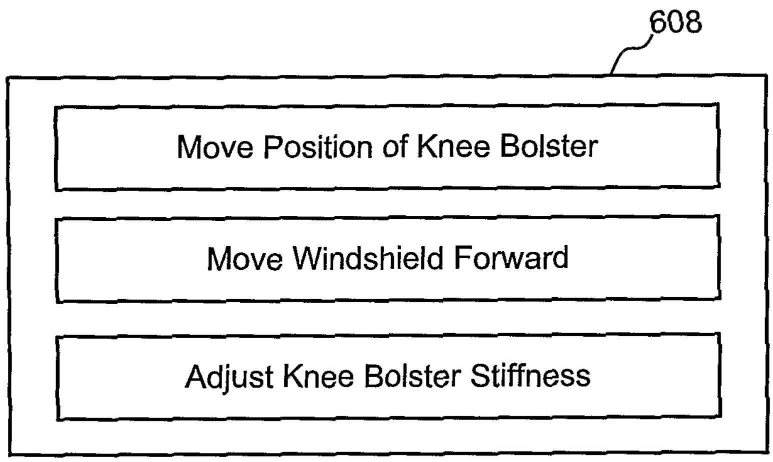


Figure 8

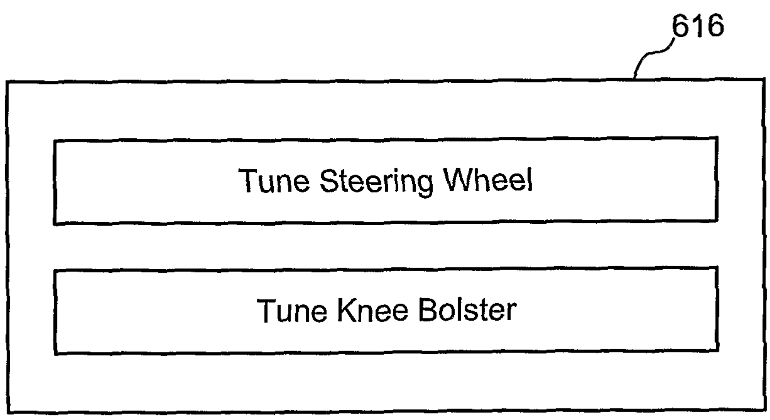


Figure 9

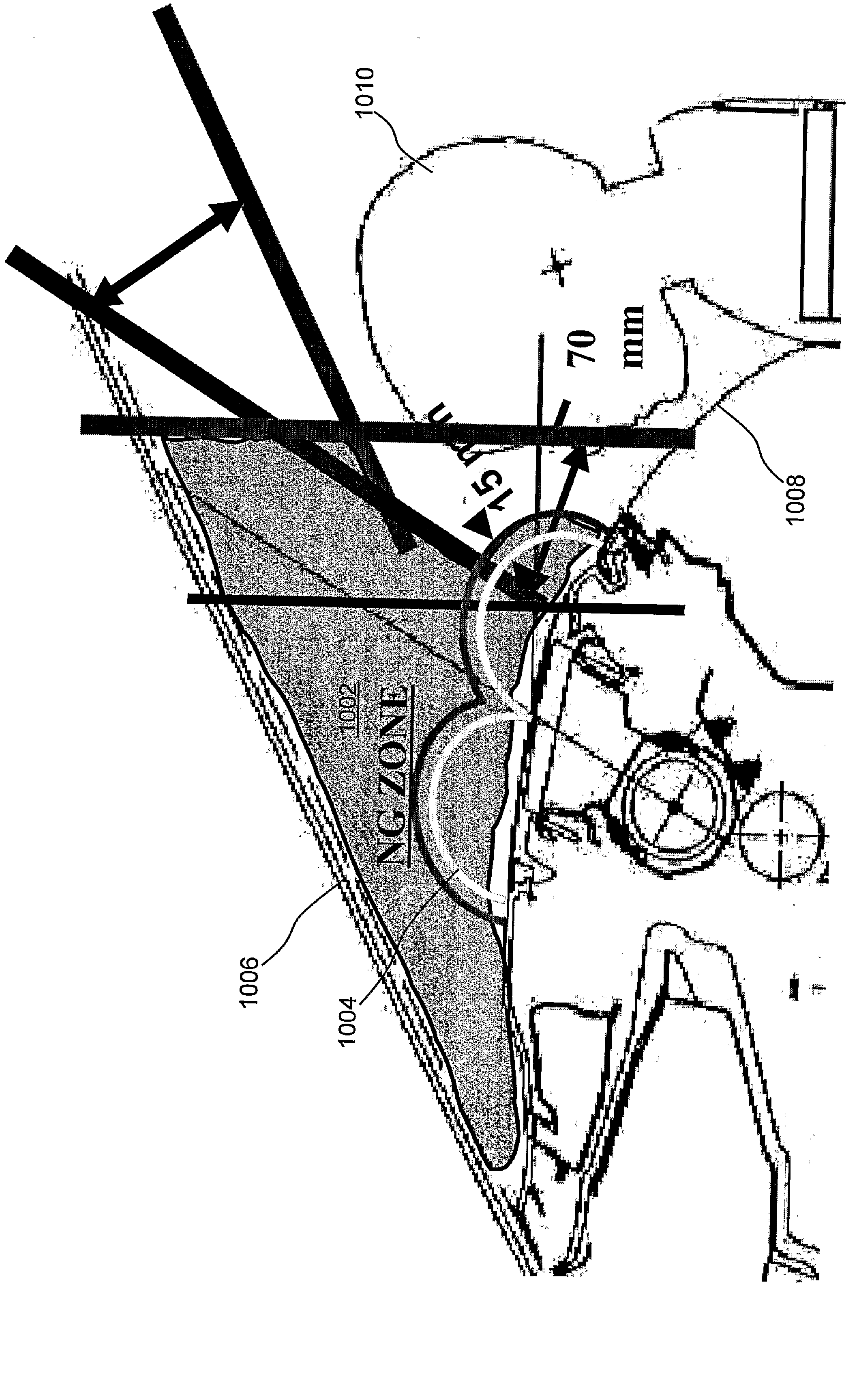


Figure 10

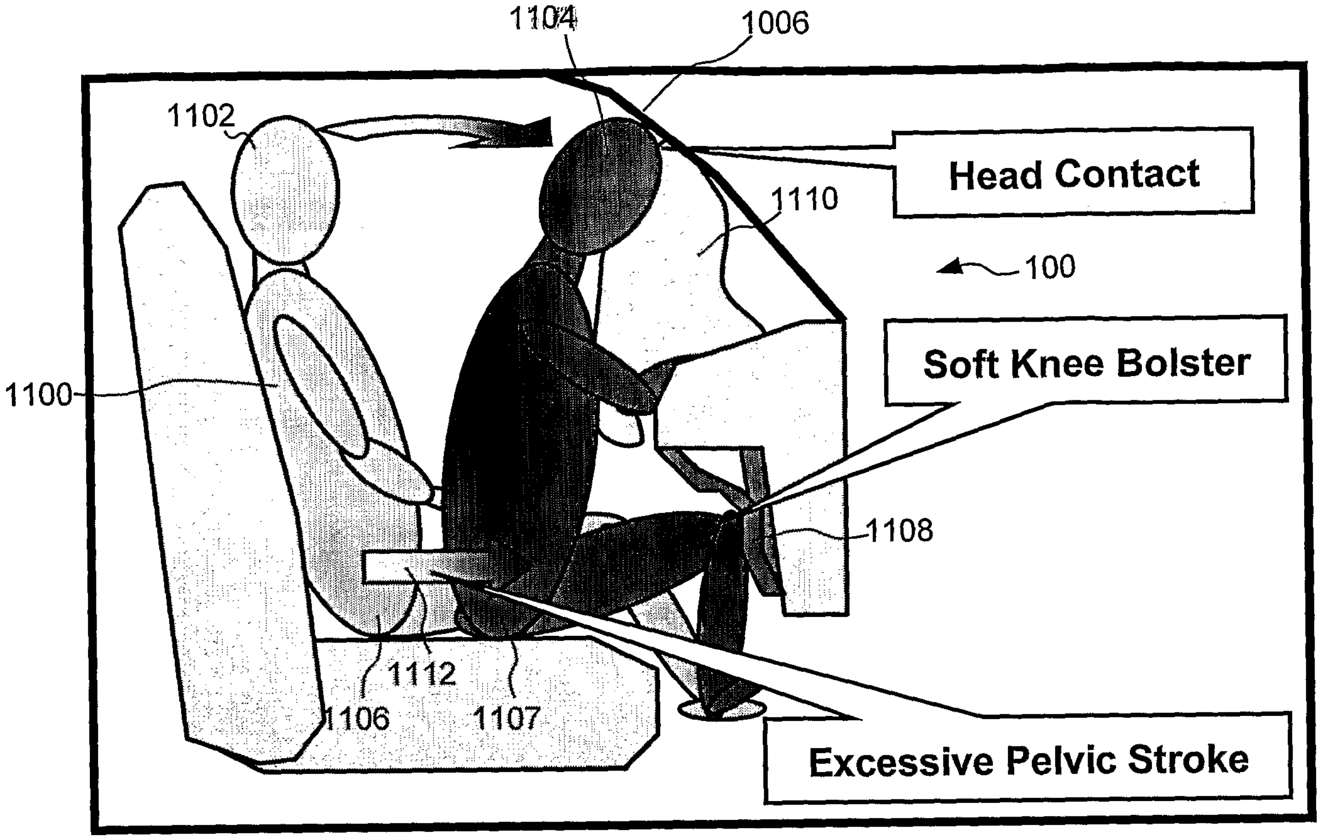


Figure 11

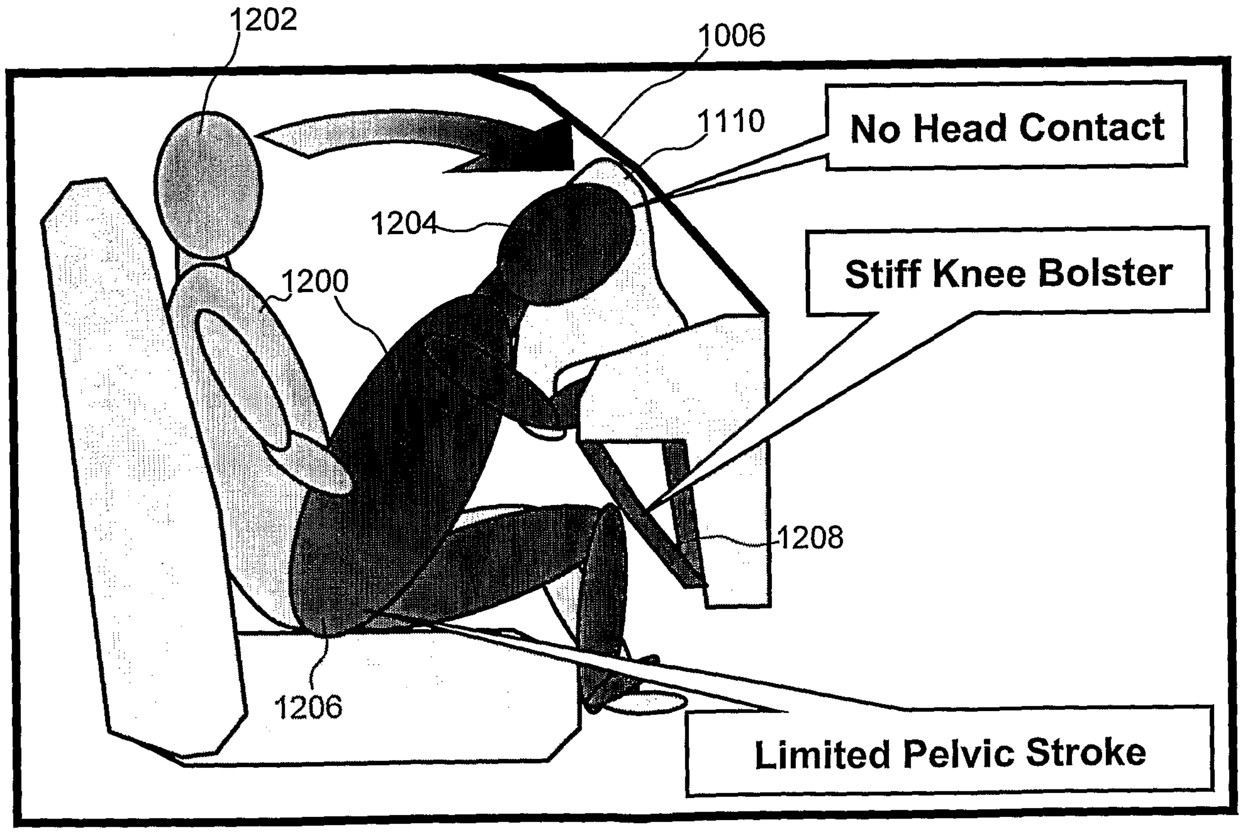
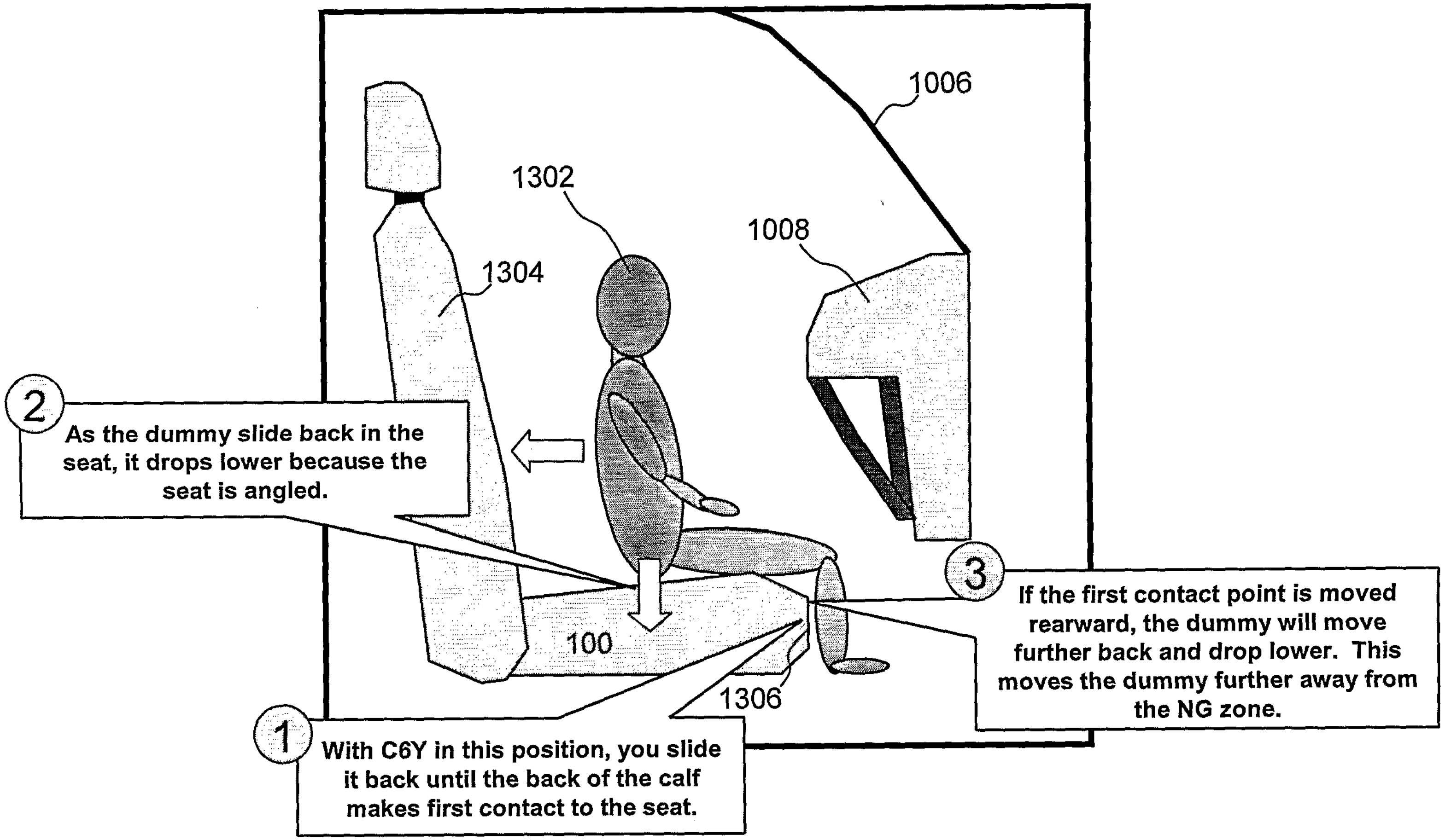


Figure 12



1006
1302
1008
1304
2
As the dummy slide back in the seat, it drops lower because the seat is angled.
100
3
If the first contact point is moved rearward, the dummy will move further back and drop lower. This moves the dummy further away from the NG zone.
1306
1
With C6Y in this position, you slide it back until the back of the calf makes first contact to the seat.

Figure 13