INERTIA SENSOR SWITCH ASSEMBLIES WITH MAGNETIC HOLDING MEANS OR THE LIKE

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ABSTRACT

An impact detecting device for use in a motor vehicle safety device, in which the detecting device is made up of a movable contact assembly having a conductive weight which is rockingly suspended in a housing by a conductive support means, a stationary contact assembly having at least a conductive contact member which is in alignment with the weight, and a biasing means such as a magnet which urges the weight, by a predetermined biasing force, to a rest position which is spaced apart from the contact member of the stationary contact assembly. When a force of inertia greater than a predetermined magnitude overcoming the biasing force is applied to the weight, then the weight is moved from the rest position to contact the contact member to the stationary contact assembly whereby electrical connection is established between the movable and stationary contact assemblies. An arrangement is also proposed which uses the above noted detecting device so as to be operable to actuate the safety device at different rates depending upon the speed of the motor vehicle involved in a collision.
INERTIA SENSOR SWITCH ASSEMBLIES WITH MAGNETIC HOLDING MEANS OR THE LIKE

The present invention relates to impact detecting devices and, more particularly, to the impact detecting devices which are responsive to forces of inertia resulting from changes in deceleration of moving objects. Although the impact detecting devices of this character may find applications in various quarters of the industry, they are specifically advantageous for use in motor vehicle safety devices which are adapted protect vehicle occupants from incurring serious injuries in the event the motor vehicles encounter collisions with obstructions during cruising.

The motor vehicle safety devices generally use inflatable protector bags or stretchable protector nettings which are usually stowed in folded or collapsed conditions when they are held inoperative. The protector bags or nettings are connected to suitable actuating means which are adapted to actuate the protector bags or nettings to into protective positions as soon as the collision conditions are encountered by the motor vehicles. The protector bags or nettings thus brought into the protective positions intervene between the vehicle occupants and relatively hard structural parts of the vehicle cabins such as windshields, instrument panels, steering wheels and columns, seat backs and so forth. The vehicle occupants who are violently flung or bounded around during the collision condition are relatively softly received by the thus actuated protector bags or nettings so that the energy of impact on the vehicle occupants is absorbed in a considerable proportion and the vehicle occupants consequently are protected from incurring serious injuries. For the purpose of providing full assurance of protection of the vehicle occupants during the collision condition, it is of critical importance that the protector bags or nettings be brought into the protective positions as rapidly as possible after the collision conditions have incipiently been encountered. The actuating means for the motor vehicle safety devices of any type are, therefore, connected to impact detecting devices which are constructed in a manner to be responsive to the collision condition immediately when the collisions take place.

Typical of the prior art impact detecting devices of this nature are inertia responsive switches using a combination of a permanent magnet and a solid ball of an electrically conductive, ferromagnetic material. The magnetic ball is placed in a magnetic field established by the permanent magnet and is usually held in a rest position under the influence of an attractive force exerted thereon by the magnetic field. The intensity of the magnetic field is predetermined so that the magnetic ball can be freed of the restraint of the magnetic field when the ball is subjected to a force of inertia greater than a predetermined magnitude in response to a sudden change in the velocity of the motor vehicle. The magnetic ball thus serving as an inertial mass is moved to an actuated position interconnecting, for instance, spaced electric contacts which are respectively connected to a source of electric power and the actuating means which is above mentioned. An electric circuit is consequently completed between the power source and the actuating means through the electrically conductive magnetic ball so that the protector bag or netting is caused to instantaneously assume the protective position. The prior art impact devices of the above outlined character are advantageous for their relatively simple constructions which are easy and economical to manufacture on a large-scale production basis. In spite of this particular advantage, these impact detecting devices are not fully acceptable for use in the motor vehicle safety devices because of the drawbacks which are still involved in the detecting devices. One important difficulty is that the magnetic ball, which serves not only as the inertial mass but as an electric contact element, rebounds from the actuated position instantaneously after it has hit the electric contacts so that the duration of the interconnection between the two electric contacts is extremely shortened. It is, in this instance, known that the electric contacts of the detecting devices for use in the motor vehicle safety devices using protector bags should be kept connected for at least 5 milliseconds for achieving the purpose of complete expansion of the protector bags. Thus, the shortened duration of the connection between the electric contacts results in instability of switching performance of the detecting device and accordingly in incomplete actuation of the safety device. Another important difficulty encountered by the impact detecting devices of the prior art inertia responsive switch type is that the magnetic force which the magnetic ball undergoes is subject to variation resulting from the upward and or sideward shocks applied to the detecting device as caused when the motor vehicle encounters holes or turns a corner as it is cruising. If, in this instance, the permanent magnet is positioned underneath the magnetic ball so that the magnetic ball is moved in a horizontal plane when subjected to a force of inertia, the attractive force exerted on the magnetic ball from the permanent magnet is changed by the upward or downward tendency or movement of the magnetic ball relative to the permanent magnet. When, thus, the magnetic ball floats over the magnet in response to upward shocks applied to the motor vehicle, then the attractive force on the magnetic ball will decreases so that the magnetic ball could be readily dislocated from the rest position by a force of inertia which is smaller than the predetermined magnitude, thereby causing the protector bag or netting to objectionably assume the protective position. If, on the contrary, the magnetic ball is subjected to a downward tendency in response to downward shocks imparted to the motor vehicle, then an increased magnetic force is exerted on the magnetic ball with the result that the magnetic ball could not be released from the rest position even in an occasion in which the force of inertia developed in the magnetic ball is in excess of the predetermined magnitude. In this condition, the protector bag or netting will remain inoperative by the time at which the deceleration of the motor vehicle reaches a certain critical degree, thus failing to properly protect the vehicle occupant. If, on the other hand, the impact detecting device is of the construction in which the magnetic ball is suspended by a flexible wire over the permanent magnet, the magnetic ball will now be susceptible to sideward shocks of the motor vehicle although it can be considerably freed of the influence of the upward and downward inertia. In this instance, the protector bag or netting will be moved to the protective position even in the event of a sidewise collision of the motor vehicle in which the protector bag or netting is practically useless for the protection of the vehicle occupant.
In the case of the motor vehicle safety devices of the type using the inflatable protector bags, the instantaneous expansion of the protector bag is accompanied by a sudden rise in the air pressure in the vehicle cabin and loud detonation of an explosive charge which is fired to open a container of a pressurized gas which is usually employed for blowing the protector bag in the collapsed condition. Such sudden rise in the air pressure and the loud detonation are liable to have the vehicle occupant seriously injured at his eardrums and even lungs and, moreover, the expanded protector bag or the stretched protector netting will block the frontal viewing of the driver. Thus, the objectionable or unnecessary actuation of the protector bag as brought about by the above described causes should be avoided to protect the vehicle occupants from incurring an injury which might otherwise be avoided.

It is, thus, an important object of the present invention to provide an improved impact detecting device of the inertia responsive type having a stabilized switching performance.

It is another important object of the invention to provide an improved impact detecting device of the inertia responsive switch type in which the duration of the interconnection between the spaced electric contacts is prolonged to a satisfactory extent.

It is still another important object of the invention to provide an improved impact detecting device of the inertia responsive switch type which is adapted to be responsive to forces of inertia which are developed only in limited directions.

It is still another important object of the invention to provide an improved impact detecting device of the inertia responsive type which is useful, when incorporated in the motor vehicle safety device of any construction, for the prevention of the objectionable or unnecessary actuation of the safety device.

Still another important object is to provide an improved impact detecting device which is easy and economical to manufacture and which is ready for installation on the motor vehicle safety device.

These objects of the present invention are accomplished basically in an impact detecting device which comprises a movable contact having a predetermined weight, a substantially stationary contact associated with the movable contact, and biasing means which urged the movable contact to a rest position spaced from the movable contact. The movable contact is moved from the rest position to contact the associated stationary contact when a force of inertia greater than a predetermined magnitude is developed in the movable contact so as to overcome the biasing force exerted by the biasing means. The biasing means may be magnet means comprising a permanent magnet or a solenoid which is usually kept energized. In this instance, the movable contact is made of a ferromagnetic material so as to be attracted by the permanent magnet or solenoid with a magnetic force which is overcome by a force of inertia greater than the predetermined magnitude developed in the movable contact serving as an inertial mass. The permanent magnet or solenoid may be positioned underneath the magnetic movable contact for attracting the same downwardly or may be positioned sidewise of the movable contact for attracting the movable contact horizontally. The movable contact may be in the form of a solid ball or may be supported by suitable support means positioning the movable contact relative to the stationary contact. The movable and stationary contacts and the support means are usually accommodated within a substantially rigid receptacle having a chamber formed therein. For the purpose of holding the movable and stationary contacts in abutting engagement with each other for a sufficiently prolonged period of time when the movable contact is moved to the actuated position, at least either of the movable and stationary contacts may be formed of or include a resilient member which is adapted to avoid the instantaneous rebounding of the movable contact from the stationary when the former hits the latter. The stationary contact which is formed of the resilient member or material is fast on the receptacle and extends into the chamber in the receptacle in association with the movable contact. The support means may comprise an electrically conductive, flexible member which is positioned within the chamber of the receptacle and which is secured to at least one end wall of the receptacle so as to have the movable contact positioned in the neighborhood of the stationary contact. This flexible member may be constructed of a wire or a pliable metal rod or strip which has one end secured to an upper end wall of the receptacle and the other end connected to the movable contact for thereby suspending the movable contact within the chamber in the receptacle. The support of the above described nature means may further comprise a pivotal pin which is secured in position in the chamber in the receptacle, wherein the flexible member is pivotally supported at its upper end portion by the pivotal pin and supports the movable contact at its lower end for thereby suspending the movable contact in alignment with the stationary contact. The flexible member may be secured to opposite end walls of the receptacle and support the movable contact substantially centrally thereof and in alignment with the stationary contact. The flexible member thus arranged may be constructed of a diaphragm. The flexible member which may be the metal wire or the pliable metal rod may be associated with suitable adjusting means which is adapted to vary the spacing between the movable contact and biasing means during production of the detecting device. The support means, in a modified form, may comprise an electrically conductive, resilient member extending from at least one end wall of the receptacle and positioning the movable contact in the neighborhood of the stationary contact. In this instance, the resilient member may extend substantially vertically from a lower end wall of the receptacle and support the movable contact at its uppermost free end for thereby allowing the movable contact to swing toward the stationary contact when the movable contact is subjected to a force of inertia opposing the biasing force. Or otherwise, the resilient member may extend substantially horizontally from a side wall of the receptacle and support the movable contact at its free end for allowing the movable contact to swing toward the stationary contact when the movable contact is subjected to a force of inertia opposing the biasing force. Or still otherwise, the resilient member may be secured to opposite end walls of the receptacle so as to support the movable contact substantially centrally thereof and in alignment with the stationary contact. The support means, in a further modified form, may comprise at least one pivotal pin which is substantially horizontally supported by the receptacle and which supports the movable contact piv-
totally movably about the pivotal pin and substantially upright when the movable contact is held in the rest position. In this instance, the pivotal pin may be secured to opposite side walls of the receptacle through the chamber formed therein so as to pivotally support the movable contact through a hole which is formed in the movable contact. Where it is desired that two pivotal pins are to be used, they may be supported on opposite side walls of the receptacle through the chamber formed therein and in line with each other. These pivotal pins may be secured to the side walls of the receptacle so as to pivotally receive the movable contact at their leading end portions through aligned bottomed holes formed in the movable contact. If preferred, however, the two pivotal pins may be secured to the movable contact and pivotally received on the side walls of the receptacle through their free end portions extending outwardly of the movable contact. Where the movable contact is supported by the aid of the pivotal pin or pins, the movable contact may be supported at its upper end portion by the pivotal pin or pins so that the movable contact depends therefrom with its lower end portion aligned with and spaced from the stationary contact. Or otherwise, the movable contact may be received at its lower end portion by the pivotal pin or pins so that the movable contact extends toward an upper end wall of the receptacle with its upper end portion aligned with and spaced from the stationary contact when the movable contact is maintained in the rest position. The support means of the impact detecting device according to the present invention may be further modified in a manner that the same comprises a substantially rigid support member which is fast on the receptacle and on which the movable contact is movably received at its upper end portion and held substantially upright in the rest position with its lower end portion located adjacent the stationary contact. Where the support means is constructed and arranged in this manner, the support member may be connected to the receptacle through a central aperture, in which instance the movable contact has an outer projection which is formed at its leading end portion. The movable contact thus depends from the support member through the central aperture with its outer projection resting upon an inner peripheral edge portion defining the central aperture when the movable contact is held in the rest position. The movable contact is thus displaceable from the rest position with its lower end portion moved toward the stationary contact and with its outer projection at least partly disengaged from the support member when the movable contact is subjected to a force of inertia opposing the biasing force. Or otherwise, the support member may be fast on an upper end wall of the receptacle defining the chamber therein and have formed therein a substantially conical recess with a pointed bottom. In this instance the movable contact has a pointed upper end which is in abutting engagement with the pointed bottom of the conical recess, in the support member. Thus the movable contact is displaceable from the rest position with its lower end portion dislocated toward the stationary contact with its pointed upper end kept received in the conical recess when the movable contact is subjected to a force of inertia opposing the biasing force. In this instance, the movable contact may directly rest at its lowermost end on an inner face of a bottom wall of the receptacle, extending substantially vertically through-out the chamber in the receptacle. Or still otherwise, the rigid support member may be arranged so as to project from an inner face of a lower end wall of the receptacle toward an upper end wall thereof. In this instance the movable contact comprises an upper end wall resting on a leading end of the support member and a side wall surrounding the support member and having a lower end portion which is aligned with the stationary contact. Thus, the movable contact is displaceable from the rest position with its lower end portion dislocated toward the stationary contact when the movable contact is subjected to a force of inertia opposing the biasing force. The support member thus arranged may be configured generally as frusto-conical with its side wall downwardly enlarged or as substantially cylindrical. The support means, in a still further modified form, may be a substantially rigid member which is fast on the lower end wall of the receptacle and which has a generally semi-spherical recess formed in the inner side thereof. In this instance, the movable contact has a generally spherical bottom portion which is received on the semispherical recess in the support member and a substantially vertically extending upper portion which is aligned at its uppermost free end with the stationary contact. The movable contact thus constructed is held substantially upright in the rest position by the biasing force and is displaceable toward the stationary contact with its upper end portion dislocated toward the stationary contact when the movable contact is subjected to a force of inertia opposing the biasing force. The uppermost end portion of the movable contact may preferably be rounded so as to reliably abut against the stationary contact when the movable contact swings. If desired, the movable contact may include a resilient electrically conductive member and a rigid electrically conductive member which is usually spaced from the former so that the former is brought into contact with the latter in a warped condition. In whichever manner the support means may be constructed and arranged, the movable contact can be constructed and positioned in various manners. For instance, the stationary contact may be constructed of at least one pliable metal plate extending substantially in alignment with an adjacent portion of the associated movable contact. The pliable metal plate, where used as only one in number, may be disposed so as to surround the adjacent portion of the stationary contact and/or to be generally in the form of a comb having a plurality of spaced strips extending forwardly from a base portion at which they are combined together. The stationary contact may otherwise be constructed of at least two pliable metal plates which are spaced apart from each other and which are positioned substantially in a manner to surround the movable contact. The pliable metal plate or plates may be positioned substantially in parallel to the adjacent portion of the stationary contact or at an angle or angles to the adjacent portion of the movable contact. Or otherwise, the stationary contact may be made up of a pair of pliable metal plates which are positioned at a spacing gradually reducing toward leading ends of the metal plates. Such gradually narrowed spacing is aligned with the movable contact so as to receive the same between the two metal plates when it is moved from the rest position by a force of inertia developed therein opposing the biasing force. The stationary contact, in a still modified form, may be made up of a substantially rigid plate.
which is aligned with and spaced apart from the movable contact and cushioning means such as a spring for resiliently supporting the rigid plate.

The magnitude of the force of inertia by which the biasing force exerted on the movable contact may be predetermined so as to meet various operational requirements of the motor vehicle safety device by varying the weight of the movable contact and/or the biasing force such as a magnetic or spring force of the biasing means. In this regard, it is empirically known that the momentum and accordingly the velocity at which the vehicle occupant is forwardly flung during a frontal collision, for example, vary with the speed of the motor vehicle encountering the collision. If, for example, the motor vehicle encounters the frontal collision while it is cruising at a relatively low speed, then the vehicle occupant is flung forward at a relatively low velocity so that the protector bag or netting is pressed upon by a relatively small force. On the contrary, the force to press upon the protector bag or netting is of a considerably greater magnitude as is the case with the collision encountered by the motor vehicle at a relatively high speed. The protector bags or nettings are usually so designed as to be fully actuated to the protective positions when the collisions take place when the motor vehicle is being driven at relatively high speeds. During the collision condition encountered by the motor vehicles at relatively low speeds, therefore, the occupants of the vehicles are caused to violently strike against the seat backs by the full expanded protector bags and are thus liable to be seriously hurt. On the other hand, arrangements are usually made on the inflatable protector bags so that the pressurized gas which has been blown into the expanded bags is allowed out of the bags at controlled rates when the bags are forcefully pressed upon by the vehicle occupants who are received thereby. Such arrangements are useful for protecting the vehicle occupants from being violently forced against the seat backs. In order that these arrangements be fully useful in the event of the collision encountered by the motor vehicles cruising at relatively high speeds, the arrangements should be capable of discharging the pressurized gas from the expanded protector bags at reasonably high rates so that the protector bags are caused to rapidly collapse. During the collision encountered by the motor vehicle at relatively low speed, the vehicle occupants are flung at relatively low velocities so that the pressurized gas is discharged from the expanded protector bags at premature timings, then the vehicle occupants will be objectionably released from the restraint of the expanded protector bags and, as consequence will be caused to strike against the relatively hard structural parts of the vehicle cabins. The impact detecting device proposed by the present invention finds useful applications for solving the problems of the above described nature.

Thus, the present invention further contemplates provision of a motor vehicle safety device having an arrangement by which the collisions encountered at different speeds can be properly responded to. The arrangement of this character generally comprises first and second actuating means for actuating the safety device at different rates, at least one first inertia responsive switch means and second inertia responsive switch means. The first and second switch means are associated respectively with the first and second actuating means and are responsive to accelerations greater than different degrees. Each of the first and second switch means is constructed preferably similarly to the impact detecting device of any of the constructions which have been hereinbefore described. If desired, the first inertia responsive switch means may be provided as two in number, in which instance the two first switch means are connected serially to each other. In order to prevent erroneous or unnecessary actuation of the safety device when those shocks or collisions which are unlikely to lead to serious dangers are encountered by the motor vehicle, the arrangement may further comprise at least one mechanical pressure responsive switch means which is responsive to a mechanical pressure greater than a predetermined magnitude as applied to a body structure of the motor vehicle. This mechanical pressure responsive may be connected to the above mentioned first inertia responsive switch means or, where such mechanical pressure responsive switch means are used as two in number, the two such switch means may be connected respectively to the first and second inertia responsive switch means.

Other objects, features and advantages of the impact detecting device and the useful application of such device will become more apparent from the following detailed description taken in conjunction with the accompanying drawings in which functionally corresponding parts and elements are represented by like reference numerals and characters and in which:

FIG. 1 is a sectional view showing an example of the prior art inertia responsive switch device using a magnetic ball;

FIG. 2 is a graph showing curves which indicate examples of the variation in the attractive force exerted on the magnetic ball as the magnetic ball is moved away from a magnet in the switch device illustrated in FIG. 1;

FIG. 3A is a diagram showing a condition in which a given inertial mass is subjected to a mechanical impact containing an upward vector component;

FIG. 3B is a graph showing a desired relation between a force applied to the inertial mass and a magnitude of the force of inertia to be responded to by the inertial mass;

FIG. 4A is a diagram showing a condition in which a given inertial mass is subjected to a mechanical impact at an angle to a given direction;

FIG. 4B is a graph showing a relation between the angle of the impact applied to the inertial mass in FIG. 4A and a vector component in the given direction of the impact;

FIG. 5 is a vertical sectional view showing a preferred embodiment of the mechanical impact detecting device according to the present invention;

FIG. 6 is a view similar to FIG. 5 but shows another preferred embodiment of the pressure detecting device according to the present invention;

FIGS. 7A and 7B are perspective views showing preferred examples of the stationary contact forming part of the detecting device which is illustrated in FIG. 6;

FIG. 8A is a view which is also similar to FIG. 5 but which shows still another preferred example of the detecting device according to the present invention;

FIG. 8B is a section on line VIII—VIII of FIG. 8A;

FIG. 9 is a cross sectional view showing a preferred example of the stationary contact forming part of the detecting device shown in FIG. 8A and 8B;
FIG. 10 is a horizontal sectional view showing still another preferred embodiment of the detecting device according to the present invention; 

FIG. 11 is a perspective view showing the stationary contact of the split type forming part of the device shown in FIG. 10; 

FIG. 12 is a vertical sectional view showing still another preferred embodiment of the impact detecting device according to the present invention; 

FIG. 13 is a fragmentary sectional view showing position adjusting means for the movable contact of the device shown in FIG. 12; 

FIG. 14 is a sectional view showing still another preferred embodiment of the detecting device according to the present invention; 

FIG. 15 is a fragmentary perspective view showing the movable contact and the associated support means forming part of the detecting device shown in FIG. 14; 

FIG. 16 is a sectional view showing a modification of the detecting device shown in FIGS. 14 and 15; 

FIG. 17 is a perspective view showing a preferred example of the movable contact and the associated support means forming part of the detecting device shown in FIG. 16; 

FIG. 18 is a vertical sectional view showing another modification of the detecting device shown in FIG. 14; 

FIG. 19 is also a vertical sectional view showing still another preferred embodiment of the impact detecting device according to the present invention; 

FIG. 20 is a view similar to FIG. 19 but shows a modification of the detecting device shown therein; 

FIG. 21 is a vertical sectional view showing still another preferred embodiment of the impact detecting device according to the present invention; 

FIG. 22 is a fragmentary vertical sectional view showing a modification of the detecting device which is shown in FIG. 21; 

FIG. 23 is a vertical sectional view showing another modification of the detecting device which is illustrated in FIG. 21; 

FIG. 24 is also a vertical sectional view showing still another preferred embodiment of the impact detecting device according to the present invention; 

FIG. 25 is a view similar to FIG. 24 but now shows a modification of the detecting device shown therein; 

FIG. 26 is a vertical sectional view showing still another preferred embodiment of the impact detecting device according to the present invention; 

FIGS. 27 to 29 are views similar to FIG. 26 but show various modifications of the detecting device shown in FIG. 26; 

FIGS. 30A and 30B are perspective views showing the movable contacts which may be preferably applicable to the detecting device which is illustrated in FIG. 29; 

FIG. 31 is a graph showing curves indicating typical examples of the variation, in terms of time, of the rates of acceleration to which the vehicle occupant is subjected during the collision conditions of different degrees; 

FIG. 32 is a graph showing a curve representative of a general relationship between a desirable timing at which the actuation of the motor vehicle safety device should be complete and a speed of the motor vehicle at the time at which the collision is encountered; 

FIG. 33 is a block diagram showing a preferred embodiment of the collision detecting arrangement using the impact detecting device of any one of the constructions which have been shown in the preceding figures; and 

FIGS. 34 to 36 are views similar to FIG. 33 but now show some modifications of the collision detecting arrangement illustrated in FIG. 33. 

In order that the problems which have thus far been experienced in the prior art inertia responsive switch device, reference is first made to FIG. 1 illustrating a typical example of the switch device. The exemplified switch device includes a rigid receptacle 40 having a horizontally elongated cavity 41 formed therein. Two conductor elements 42 and 42' which are electrically isolated from each other exposed to this cavity 41 and are connected to leads 43 and 43', respectively, of electric lines (not numbered). One conductor element 42 is placed on an inner surface of a bottom wall 40a of the receptacle 40 while the other conductor element 42' is attached to an inner surface of a side end wall 40b of the receptacle, as illustrated. A permanent magnet 44 is embedded in the bottom wall 40a and positioned at a suitable spacing from the vertically extending conductor element 42'. A magnetic ball 45 made of an electrically conductive material which has a considerable weight is placed an inner surface of the horizontally extending conductor element 42 and is held in a neutral or rest position by an attractive force of a magnetic field which is established by the underlying permanent magnet 44. The switch device as a whole is so positioned as to receive an impact in the direction of arrow P in FIG. 1. When, in operation, the switch device thus constructed is subjected to an impact of a certain degree, then the magnetic ball 45 acting as an inertial mass is moved from the rest position toward the vertical conductor element 42'. If, in this condition, the force of inertia developed in the magnetic ball 45 is greater than a predetermined magnitude, then the force of inertia overcomes the restraint of the magnetic field so that the magnetic ball 45 is caused to contact the vertical conductor element 42', thereby connecting the conductor elements 42 and 42' to each other. An electric circuit having the leads connected to these conductor elements 42 and 42' is consequently completed through the magnetic ball 45 which now acts as a movable contact. If, however, the force of inertia developed in the magnetic ball 45 fails to reach the predetermined magnitude, the magnetic ball is caused to return to the initial position under the influence of an attractive force of the magnetic force exerted on the magnetic ball. This attractive force, which is effective to urge the magnetic ball toward the rest position, will vary if the magnetic ball is upwardly thrown from the underlying conductor element. An example of such variation as caused when the magnetic ball is in a position floating over the inner surface of the underlying conductor element is illustrated in FIG. 2, in which the attractive force of the magnetic ball which is moved over a distance X from the rest position is denoted by F(X). For comparison purposes, it is herein assumed that the magnetic ball is in the floating conditions at different spacings D and d (where D>d) from the inner surface of the underlying conductor element, as indicated by curves B and A, respectively. These curves apparently show that the larger the spacing between the magnetic ball and the underlying conductor element and accordingly between the ball and the magnet, the smaller the attractive force exerted on the magnetic
ball becomes, and vice versa. If, conversely, the magnetic ball is subjected to an impact containing a downward component, the magnetic ball will be pressed against the surface of the underlying conductor element and, as a consequence, the downward component will give rise to an increase in the restraint on the magnetic ball although the attractive force exerted thereon may not vary.

When, thus, the magnetic ball acting as the inertial mass undergoes an impact with a force \( F \) in a direction which is angled upwards at \( \theta \) from a horizontal plane as indicated in FIG. 3A, then the inertial mass denoted by \( M \) is subjected to an upward component \( F \sin\theta \) which is operable to reduce the attractive force on the inertial mass. In order that the switch device using the magnetic ball as the inertial mass be advantageously used in the motor vehicle safety device, such reduction in the attractive force on the magnetic ball should be avoided for the reasons previously explained. It is therefore desired that the magnetic ball or other forms of inertial mass be mechanically constrained in a vertical direction so that the magnetic ball or the inertial mass is moved to the actuated position irrespective of the angle \( \theta \) when the horizontal component \( F \cos\theta \) of the force \( F \) is greater than a predetermined magnitude \( G \), as indicated by a broken line in the graph of FIG. 3B.

When, furthermore, the magnetic ball undergoes an impact with a force \( f \) in a direction which is angled at \( \delta \) from the fore-and-aft direction of the switch device or the motor vehicle on which the switch device is used, the component of the force in the fore-and-aft direction is \( f \cos\delta \) so that the magnetic ball will be moved to the actuated position if the force \( f \cos\delta \) is greater than the predetermined magnitude \( G \). As previously noted, the motor vehicle safety devices in general are rather useless for the purpose of protecting the vehicle occupants during side impact collisions of the motor vehicles and, in addition, it is objectionable for avoiding the secondary injuries to the vehicle occupants that the safety devices are actuated to the protective positions during the side impact collisions in which the impacts in the fore-and-aft direction of the motor vehicles are usually of limited degrees. FIG. 4B indicates, as hatched, a desirable range in which the magnetic ball or an inertial mass of any other form should respond to the impact which is angled at \( \delta \) from the fore-and-aft direction of the motor vehicle. In FIG. 4B, the hatched area is defined by a curve representing \( f = G/\cos \delta \) and its asymptotic lines occurring when the angle \( \delta \) is \( \pm \pi/2 \). From this, it is apparent that the magnetic ball or the or the inertial mass is actuated only when the impact applied on the motor vehicle at the angle \( \delta \) from the fore-and-aft direction is in excess of the amplitude \( G/\cos \delta \).

The various embodiments of the impact detecting device according to the present invention having an inertial mass behaving in the above described manners will now be described with reference to the accompanying drawings. It should be borne in mind that the shown embodiments are solely for illustration purposes and, as such, are not limitative of the gist of the present invention.

Reference is first had to FIG. 5 showing a first preferred embodiment of the present invention. The impact detecting device herein shown includes a substantially rigid receptacle 50 having upper and lower end walls 50a and 50b, respectively. This receptacle 50 is usually made of an insulating material such as hard plastics and has a chamber or cavity 51 formed therein with a suitable configuration. The receptacle 50 and accordingly the cavity 51 are herein assumed to have cylindrical configurations. A weight 52 of a magnetic and electrically conductive material is suspended from the upper end wall 50a of the receptacle 50 through a wire 53 which is connected to the upper end wall 50a. The lower end wall 50b, on the other hand, has embedded therein a permanent magnet 54 which is aligned with the overlying magnetic weight 52 so that the magnetic weight is biased to a rest position by an attractive force of the magnetic field which is established by the permanent magnet 54. This permanent magnet 54 may be replaced with a solenoid which is constantly energized from a d-c power source or a suitable preload spring which is adapted to urge the weight 52 to the rest position, if desired. An electric conductor element 55 in a generally cylindrical form is positioned on an inner surface of the lower end wall 50b of the receptacle 50 in a manner to surround the magnetic weight 52 at a suitable spacing therefrom. This conductor element 55 is made of a pliable metal material and is secured to the cylindrical wall of the receptacle. The wire 53 and the conductor element 55 are connected to lead 56 and 56', respectively, of electric lines so that the magnetic weight 52 and the conductor element 55 serve respectively as movable and stationary contact. The spacing between the magnetic weight 52 and conductor element 55, the mass of the magnetic weight 52 and the magnetic field to be established by the permanent magnet 54 may be selected in such a manner that the magnetic weight 52 is moved from the rest position to contact the conductor element 55 when the detecting device is subjected to an impact and accordingly a force of inertia greater than a predetermined magnitude is developed in the magnetic weight 52. When, thus, the magnetic weight 52 is forced against the conductor element 55, the leads 56a and 56b are electrically connected to each other through the magnetic weight 52 and conductor element 55 acting as the movable and stationary contacts, respectively. If these leads are connected to a source of electric power and the actuating means such as a solenoid-actuated valve of a pressurized gas container of the motor vehicle safety device, the safety device is actuated to the protective position immediately when the electric circuit is completed through the leads thus connected to each other. Since, in this condition, the conductor element 55 acting as the stationary contact is made of a pliable metal and is consequently outwardly warped in situ with the magnetic weight 52 bearing against the inner surface of the conductor element, the magnetic weight 52 acting as the movable contact is prevented from instantaneously rebounding from the conductor element 55. The duration of the contact between the movable and stationary contacts 52 and 55, respectively, is thus sufficient for the complete actuation of the safety device. Although the conductor element 55 has thus far been assumed as having a generally cylindrical configuration, such is merely by way of example and, therefore, can be modified in any desired manner. For the purpose that the detecting device be capable of responding only to those impact which are applied to the device within a limited range of direction, the conductor element 55 may be split to a desired number of spaced
plates which are positioned to each other. Thus, the embodiment shown in FIG. 5 may be understood to have a stationary contact made up of a pair of conductor elements which are diametrically opposite to each other with the magnetic weight positioned intermediate between the thus spaced conductor elements. In this instance, the two conductor elements should be connected to the power source or the actuating means of the safety device independently from each other, though not illustrated. A modification of the detecting device which is thus adapted to respond to impacts within a limited range of direction is shown in FIG. 6.

In FIG. 6, the detecting device of the modified construction also includes a rigid receptacle 50 having a cavity or chamber 51 formed therein. The magnetic weight 52 is invariably suspended from the upper end wall 50a of the receptacle 50 through a wire 53. Different magnetic embodiments shown in FIG. 5, the receptacle 50 of the detecting device herein shown has an outwardly protruded side wall 50c in which the permanent magnet 54 is embedded so as to exert an attractive force on the magnetic weight 52 in a horizontal plane. A conductor element 57 serving as a stationary contact is positioned at a spacing from the magnetic weight 52 and is secured to a side wall (not numbered) which is opposite to the protruded side wall 50c of the receptacle 50. This conductor element 57 is shown as projectingly generally downward and directed toward the magnetic weight 52 at a suitable angle to the vertical plane which is substantially parallel to the wire 53 supporting the magnetic weight in the rest position. The receptacle element 57 is preferably made of a pliable metal plate so as to be warped or bent outwardly when the magnetic weight 52 is forced thereagainst by a force of inertia greater than the predetermined magnitude. The conductor element 57 may be shaped as a substantially flat unitary plate as shown in FIG. 7A or, for the purpose of providing an increased cushioning effect, the same may be shaped in such a manner as to have two or more spaced strips 57a which are usually reduced toward their leading ends as illustrated in FIG. 7B. It is, in this instance, apparent that the specific configuration of the conductor element 57 shown in FIG. 7B is applicable to the conductor element shown in FIG. 5. For such purpose, the generally cylindrical conductor element 55 of the device shown in FIG. 5 should be shaped substantially in the form of a ring-like comb having a number of spaced strips extending upwardly in parallel to or at angles to the vertical direction, though not illustrated.

FIGS. 8A and 8B show a further modified embodiment of the detecting device according to the present invention. This modified embodiment is essentially similar to the embodiment shown in FIG. 6 except for the construction of the stationary contact. The stationary contact is made up of a conductor element 58 in a plane form and a coil spring 59 of a conductive material. The conductor element 58 is positioned at a spacing from the magnetic weight 52 in the rest position while the coil spring 59 is connected at its inner end to the conductor element 58 and is seated at its outer end on the inner surface of the side end wall (not numbered) which is opposite to the protruded side end wall 50c of the receptacle 50. The coil spring 59 is connected to the lead 56b of the electric line connected to the power source of the actuating means for the safety device. When, thus, the magnetic weight 52 is brought into abutting engagement with the conductor element 58 by a force of inertia overcoming the force of the magnetic field, the coil spring 59 is compressed away from the permanent magnet 54 so as to provide a cushioning effect to the magnetic weight 52 and to add to the duration of the contact condition between the weight 52 and conductor element 59, similarly to the above described embodiments. The embodiments shown in FIG. 6 and FIGS. 8A and 8B are thus useful for responding to impacts applied in a certain narrow range of direction because the cavity or chamber 51 accommodating the movable and stationary contacts is elongated with the permanent magnet 54, magnetic weight 52 and conductor element 56 or 58 positioned in line with each other, as best seen in FIG. 8B. If, in this instance, it is desired that the impacts on the detecting device be responded to within a wider range of direction with reliability, the arrangement shown in FIG. 9 may suit the purpose. As seen in FIG. 9, an outwardly curved conductor element 60 is supported at opposite edges of a centrally outwardly curved leaf spring 61 which is secured to the side end wall of the receptacle 50 by suitable fastening means such as a screw 62. The shown arrangement is operable to accurately receiving the magnetic weight which is thrown in a direction within a range defined by arrows q and q' as indicated.

FIGS. 10 and 11 illustrate a further modification of the embodiments above described. The embodiment herein shown is essentially similar to the embodiment shown in FIGS. 8A and 8B insofar as the configurations of the receptacle 50, magnetic weight 52 and permanent magnet 54 are concerned. Different from the embodiment of FIGS. 8A and 8B, the detecting device now includes a stationary contact which is made up of a pair of conductor elements 63 and 63' which are secured to inwardly stepped wall sections of the cavity 51 by suitable fastening means such as screws 64 and 64', respectively, and are positioned at a spacing which is gradually narrowed toward the leading ends of the conductor elements, viz., away from the magnetic weight 52 in the rest position. These conductor elements 63 and 63' are constructed of pliable metal plates so that the weight 52 which is swung to the conductor elements is snugly received therebetween by a cushioned force and is thus permitted to be in contact with the conductor elements for a sufficiently prolonged period of time. In the embodiment having the construction herein shown, the conductor elements 63 and 63' are connected to the leads (not shown) of electric lines and are connected to each other through the electrically conductive magnetic weight 52 which is being received between the spaced conductor elements. Thus, the magnetic weight serving as the movable contact in this particular embodiment can be suspended from the upper end wall of the receptacle by the use of a support member which is made of an electrically non-conductive material.

The impact responsive characteristics of the embodiments thus far described in detail may be determined by properly selecting the magnitude of the magnetic force to which the magnetic weight is to be subjected and/or the amount of mass of the magnetic weight serving as the inertial mass. The magnitude of the magnetic force to be effective on the magnetic weight, in turn, may be selected by varying the intensity of the magnetic field to be established by the magnetic weight.
The intensity of the magnetic field, further in turn, may be varied by properly selecting the magnetic force of the permanent magnet and/or the spacing between the magnetic weight and the permanent magnet. FIGS. 12 and 13 illustrate a preferred example of adjusting means which is adapted to vary the spacing between the magnetic weight 52 and the permanent magnet 54 which is positioned sidewise of the magnetic weight 52.

Referring to FIGS. 12 and 13, the adjusting means comprises a stationary disc 65 which is positioned relative to the wire or other flexible support member 53 by which the magnetic weight 52 is suspended from the upper end wall 50a of the receptacle 50. The stationary disc 65 is fast on the receptacle 50 and supports on one face thereof a rotatable member 66 having a projection 66a and a threaded shaft 66b through which the rotatable member 66 is rotatably screwed to the stationary disc 65. The projection 66a is so located as to contact or receive the wire or flexible line 53. For the adjustment of the spacing between the magnetic weight 52 and the permanent magnet 54 in the course of production of the detecting device, the rotatable disc 66 should be rotated about the threaded shaft 66b relative to the stationary disc 65 so that the wire or flexible line 53 received by the projection 66a is relocated relative to the receptacle 50. The rotatable member 66 should be fixed in a position in which the wire or flexible line 53 depending from the projection 66a is moved so that the permanent magnet 52 is positioned at a desired calibrated spacing from the permanent magnet 54. The adjusting means as illustrated herein is merely by way of example and may, therefore, be modified in various manners insofar as the magnetic weight 52 is supported by a flexible line.

FIG. 14 illustrates still another preferred embodiment of the impact detecting device according to the present invention. The detecting device as shown invariably includes a receptacle 50 made of a substantially rigid material and having a cavity or chamber 51 formed therein. The receptacle 50 has a thickened end wall 50d in which a permanent magnet 54 is embedded thereby to establish a magnetic field in the cavity or chamber 51. A magnetic piece 67 is positioned adjacent the permanent magnet 54 in the end wall 50d and is supported on the receptacle 50 by means of a support member 68 of an electrically conductive, pliable metal material. It is, in this instance, important that the support member 68 supports the magnetic piece 67 in such a manner as to permit the magnetic piece 67 to swing away from the inner surface of the end wall 50d by a force of inertia opposing the attractive force of the magnetic field established by the permanent magnet 54. A conductor element 69 serving as a stationary contact is positioned outboard of the support member 68 so as to be engageable with the electrically conductive support member 68 when the magnetic piece 67 acting as an inertial mass is caused to swing away from the end wall 50d against the magnetic force. This conductor element 69 may be preferably made of pliable metal for being warped outwardly when pressed upon by the support member 68 or have a portion which is so configured as to provide a cushioning effect such as a rounded portion formed at the leading end of the conductor element as shown in FIG. 14. The support member 68 acting as a movable contact and the conductor element 69 acting as a stationary contact are connected to leads 56a and 56b, respectively, of electrical lines. A protuberance (not shown) may be formed substantially centrally on an inner surface of an end wall opposite to the thickened end wall 50d of the receptacle 50, protruding toward the magnetic piece 67 so as to limit the displacement of the magnetic piece from the rest position. In this instance, the conductor element serving as the stationary contact may be mounted at the end face of such protuberance so as to be directly engageable with the magnetic piece 67 which is made of an electrically conductive ferromagnetic substance to serve as a moving contact.

With the construction and arrangement of the detecting device shown in FIG. 14, the magnetic piece 67 is usually spaced apart from the inner surface of the thickened end wall 50d by the attractive force exerted thereon by the permanent magnet 54 so that the electrically conductive support member 68 and the conductor element 69 as the stationary contact are kept disconnected from each other. If, however, the detecting device is subjected to an impact greater than a predetermined magnitude, then the magnetic piece 67 and accordingly the support member 68 are relocated from the rest positions against the attractive force whereupon the support member 68 is brought into contact with the conductor element 69. Since, this condition, the support member 68 and preferably the conductor element 69 as well are made of pliable materials, they are kept together for a relatively prolonged period of time so as to maintain the leads 56a and 56b to be connected to each other in a stable condition.

In contrast to the embodiments shown in FIGS. 5 to 12 in which the magnetic weight 52 is suspended by a flexible line such as a wire, the magnetic piece 67 is supported by means of the support member 68 which is in the form of a strip as seen in FIG. 15. The detecting device shown in FIG. 14 can therefore be held in any desired working position because of the fact that the magnetic piece 67 and supporting member 68 are practically free from the influence of the gravity resulting from their own weights. The detecting device may thus be positioned with the support member 68 extending in a horizontal plane or in a vertical plane. If the detecting device is positioned with the support member 68 extending in the vertical plane, then the magnetic piece 67 serving as the inertial mass is substantially insensitive to an upward or downward impact so that the shocks applied to the motor vehicle in a vertical direction are not responded to. If, on the other hand, the detecting device is so positioned as to make the support member 68 extend in the vertical plane, then the device will remain insensitive to a sideward impact so that the shocks applied to the motor vehicle in a lateral direction is not responded to. In this instance, the detecting device may be positioned so that the magnetic piece 67 is suspended downwardly or supported at the top of the support member 68.

In the embodiment shown in FIG. 14, the magnetic piece 67 is supported on one end wall of the receptacle 50 by means of the cantilever support member 68. If desired, however, the magnetic piece 67 may be supported on the opposite end walls defining the cavity or chamber 51. An embodiment thus arranged is illustrated in FIG. 16. Referring to FIG. 16, the magnetic piece 67 is supported by a support member 70 extending throughout the chamber 51 and connected at both ends to the opposite end walls 50e and 50f. This support member 70 is usually in the form of a strip of a pliable
material carrying the magnetic piece 67 at its substantially central portion as seen in FIG. 17. If preferred, however, the support member 70 may be a sheet of diaphragm which is secured to the surrounding end walls at its entire periphery and carrying the magnetic piece 67 substantially centrally thereof, though not shown in the drawing. In the detecting device shown in FIG. 16, the conductor element which is now designated by reference numeral 71 is positioned in front of the magnetic piece 67 and, as such, the magnetic piece 67 is made of an electrically conductive ferromagnetic material. During operation, the magnetic piece 67 is directly brought into contact with the thus positioned conductor element 71 so as to permit the leads 56a and 56b to be connected to each other. The conductor element 71 is preferably made of pliable metal and/or so configured as to provide a cushioning effect when receiving the magnetic piece 67 thereon.

FIG. 18 illustrates another embodiment shown in FIG. 14 using a support member 72 in the form of a pliable strip. The support member 72 is positioned up-right within the cavity or chamber 51 in the receptacle supported on the lower end wall 50b of the receptacle. The support member 72 carries the magnetic piece 67 at its uppermost end which is aligned with the permanent magnet 54 embedded in the side wall of the receptacle 50. A conductor element 73 serving as a stationary contact is positioned adjacent the magnetic piece 67 thus positioned atop the support member 72 and is secured to a side end wall which is opposite to the wall carrying the permanent magnet 54. The conductor element 73 in the embodiment herein shown extends generally upwardly and is inclined at a suitable angle toward the magnetic piece 67 in the rest position. This conductor element 73 is preferably made of pliable metal and may be shaped in a manner described with reference to FIGS. 7A and 7B. The magnetic piece 67 and support member 72 are of the electrically conductive nature and are connected to one lead 56a while the conductor element 73 serving as the stationary contact is connected to the other lead 56b.

In the detecting device shown in FIG. 18, when the magnetic piece 67 is moved from the rest position by a force of inertia overcoming the attractive force by the permanent magnet 54, then the magnetic piece 67 is brought into abutting engagement with the associated conductor element 73 for a prolonged duration due to the warpage of the resilient conductor element 73. The leads 56a and 56b of the electric lines are consequently kept connected to each other for a period of time which is sufficient to completely actuate the motor vehicle safety device in which the detecting device is incorporated.

FIGS. 19 to 25 are views showing a variety of preferred embodiments in which the magnetic piece acting as the inertial mass is mechanically constrained by a pivotal shaft in a manner to be movable only in the fore-and-aft direction of the device.

In the embodiment shown in FIG. 19, a magnetic weight 52 is suspended by a pliable support member 74 from a stationary shaft or pin 75 which is fast on an upper portion of the substantially rigid receptacle 50 defining the cavity or chamber 51 therein. The combination of the magnetic weight 52 and support member 74 thus constitute a pendulum which is capable of swinging about the shaft or pin 75. The support member 74 is connected to this pin 75 through a rounded portion formed at its upper end, as illustrated. A permanent magnet 54 is embedded in one side end wall (not numbered) of the receptacle 50 while a conductor element 76 is positioned at a spacing from the magnetic weight 52. This conductor element 76 is secured to the opposite side end wall of the receptacle 50. The conductor element 76 is directed generally upwardly and is upwardly inclined toward the magnetic weight 52 at a suitable angle to the vertical. The conductor element 76 may be of either of the configurations which have been described with reference to FIGS. 7A and 7B and may be directed generally downwardly as is the case with its counterpart of the detecting device shown in FIG. 6, if desired. The magnetic weight 52 serving as the movable contact and inertial mass, the conductor element 76 serving as the stationary contact and the permanent magnet 54 are all aligned with each other in a horizontal direction as illustrated. The operation of the detecting device thus constructed will be self-explanatory because such is essentially similar to the operation of the embodiment shown in FIG. 6 except in that the magnetic weight 52 and the support member 74 are moved together in a manner to swing about the pivotal shaft or pin 75 like a pendulum.

FIG. 20 illustrates a modification of the embodiment shown in FIG. 19. This modified embodiment uses a non-magnetically electrically conductive weight 77 as an inertial mass and a preloaded compression spring 78 as biasing means for the inertial mass. The weight 77 depends from a pivotal shaft or pin 75 through a support member 74 having a mounting eye (not numbered) formed at its upper end for being pivotally movable about the shaft or pin 75, similarly to the detecting device shown in FIG. 19. The preloaded compression spring 78 is positioned between the weight 77 and an end wall of an extension 50g of the receptacle 50. The compression spring 78 is thus seated at one end on one side face of the weight 77 and at the other on an inner surface of the end wall (not numbered) of the extension 50g in a manner to press the weight 77 upon an end wall of the receptacle opposite to the end wall of the extension 50g, as illustrated. A substantially rigid conductor element 79 extends inwardly from the end wall of the extension 50g of the receptacle 50 toward the weight 77 through the interior of the compression spring 78, terminating halfway in the extension 50g. The conductor element 79 carries at its free end a curved leaf spring 80 which is made of an electrically conductive material and which is suitably spaced from the opposite face of the weight 77. The support member 74 and weight 77 may be made up of two parts which are rigidly connected to each other or may be formed as a unitary member. In either case, the support member 74 and weight 77 are made of an electrically conductive material or materials. The support member 74 and conductor element 79 are connected to leads 56a and 56b of electric lines. The amount of mass of the weight 77, the spring constant and/or amount of preload of the compression spring 78 and/or the spacing between the weight 77 and leaf spring 80 should be so selected that the weight 77 serving as a movable contact is moved from the rest position to contact the leaf spring 80 serving as a stationary contact when the weight is subjected to a force of inertia of a magnitude greater than the opposing biasing force exerted by the preloaded compression spring 78. It is, in this instance, apparent that essentially the same effect can be
achieved if the compression spring 78 is substituted by a tension spring which is positioned on the opposite side of the weight 77 so as to pull the weight constantly. Or, otherwise, the spring arrangement illustrated in FIG. 9 as using a curved leaf spring may find application in the detecting device shown in FIG. 20.

FIG. 21 illustrates another preferred embodiment of the detecting device using a magnetic piece which is supported by a pivotal shaft or pin. As illustrated, the detecting device also has a receptacle 50 of a substantially rigid material in which a cavity or chamber 51 is formed. A shaft or pin 81 is securely connected to opposite side end walls of the receptacle, extending substantially horizontally through the cavity 51. The shaft or pin supports a magnetic piece 82 through a hole 82a which is formed at its upper end portion. Both the pin 81 and magnetic piece 82 are made of an electrically conductive material or materials and the former is connected to a lead of an electric line as at 56a. The magnetic piece 82 in the embodiment shown is shaped substantially as cylindrical, depending downwardly from the pin 81 toward an inner surface of the bottom wall 50b of the receptacle 50. A permanent magnet 54 is embedded in this bottom wall 54b and is positioned in alignment with the overlying magnetic piece 82 so as to exert an attractive force on the magnetic piece. A conductor element 83 serving as a stationary contact projects upwardly from the inner surface of the bottom wall 50b of the receptacle and is positioned at a spacing from the magnetic piece 82. The conductor element 83 is preferably made of pliable metal and is connected to a lead 56b of an electric line. The conductor element 83 may be constructed either by a unitary, substantially cylindrical plate surrounding a lower end portion of the magnetic piece 82 or by at least two spaced plates spaced so as to enable the magnetic piece 82 to respond to impacts applied to the shown detecting device in a direction of a limited range, as previously mentioned in connection with the embodiment illustrated in FIG. 5.

When the impact detecting device constructed substantially in a manner above described is subjected to an impact or a component of an impact in a direction perpendicular to the drawing, then the magnetic piece 82 is urged to turn about the pivotal pin 81 backwardly or forwardly against the attractive force exerted thereon. If, then, a force of inertia greater than a predetermined magnitude overcoming the attractive force develops in the magnetic piece 82 as a result of such impact, the magnetic piece 82 is released from the restraint of the magnetic field and is thus permitted to abut against the inner surface of the conductor element 83. The magnetic piece 82 and pin 81 being made of the electrically conductive materials, the leads 56a and 56b of the electric lines are connected to each other as soon as the magnetic piece 82 swings and contacts the conductor element 83. Since, in this condition, the conductor element 83 is pliable, the same is warped or curved outwardly with the magnetic piece 82 borne against its inner surface so that the magnetic piece 82 can be prevented from instantaneously rebounded from the actuated position.

With the construction of the detecting device illustrated in FIG. 21, the magnetic piece 82 is precluded from moving in the direction of its axis by reason of the restraint by the horizontally extending pivotal pin 81 and is thus insensitive to an impact applied to the detecting device in a vertical direction. The magnetic piece 82, however, is allowed to slide on the pin 81 and is thus capable of appreciably moving in the direction of the pin 81 so that an impact applied to the detecting device in a direction transversing the drawing is responded to by the magnetic piece 82 to a certain extent. In order to avoid such lateral movement of the magnetic piece 82, the pivotal pin 81 may be split into two halves 84 and 84' as indicated in FIG. 22. In the embodiment shown in FIG. 22, the halves 84 and 84' of the pivotal pin are secured at their outer ends to the opposite side walls of the receptacle 50 and are journaled at their inner ends to the magnetic piece 82 through aligned bottomed holes 85 and 85', respectively, formed therein, as illustrated. With this construction, the magnetic piece 82 is prevented from moving in the direction of the pin 82 so as to be responsive only to an impact exerted on the detecting device in a direction perpendicular to the drawing. The same result will also be achieved through use of the construction shown in FIG. 23. In the modified embodiment shown in FIG. 23, the pivotal pin is integral with the magnetic piece 82, thus forming a pair of projections 86 and 86' which are diametrically opposed to each other and which are pivotally received in aligned holes 87 and 87' which are formed in the opposite side walls of the receptacle. Thus, the magnetic piece 82 and the pivotal pin comprising the projections 86 and 86' are made of the same ferromagnetic, electrically conductive material and are connected to the lead 56a of the electric line through one of the projections such as the projection 86' as shown. To enable the projection 86' to be in contact with the lead 56a in a stable condition, a bearing 88 of an electrically conductive material may be received in the hole 87' and interposed between the projection 86' and lead 56a.

FIGS. 24 and 25 illustrate embodiments in which the movable contacts each serving as an inertial mass are held substantially upright and directed upwardly in their rest positions.

In the embodiment shown in FIG. 24 in the first place, the receptacle 50 of a substantially rigid material has a bottom wall 50b in which a substantially semi-spherical recess 89 is formed adjoining the cavity or chamber 51 formed in the receptacle 50. A pair of spaced permanent magnets 90 and 90' are embedded in this bottom wall 50b and are positioned on both sides of the semi-spherical recess 89. The movable contact of the detecting device herein shown includes a ball 91 of a substantially rigid non-magnetic material. The non-magnetic ball 91 has a generally annular magnetic piece 92 which is anchored to an outer peripheral wall of the ball 91 so as to be aligned with the spaced permanent magnets 90 and 90' at its diametrically opposed portions. The non-magnetic ball 91 is slidably or rollably received in the semi-spherical recess 89 and is supported through a hole 91a formed therein by a shaft or pin 93 extending substantially in parallel to the spaced permanent magnets 90 and 90', viz., in a direction perpendicular to the drawing. The non-magnetic ball 91 supports at its top a first conductor element 94 projecting toward an upper end wall 50a of the receptacle 50. The magnetic forces exerted on the magnetic piece 92 are substantially equal to each other so that the non-magnetic ball 91 is usually maintained in a balanced position in which the conductor element 91 is held substantially upright in the rest position. If desired, the
magnetic piece 92 mounted on the non-magnetic ball 91 may be split into two halves which are generally diametrically opposed to each other and which are aligned respectively with the spaced permanent magnets 90 and 90', respectively. A second conductor element 95 serving as a stationary contact is positioned at a suitable spacing from the first conductor element 94 of the movable contact and is secured at its outer end to the side wall of the receptacle 50. This second conductor element 95 is generally downwardly directed and is inclined at a suitable angle from the vertical direction as seen in FIG. 24. The conductor element 95 is preferably made of pliable metal and may be configured in a manner illustrated in FIG. 7A or 7B, if desired. The first and second conductor elements 94 and 95 are connected to leads 56a and 56b, respectively, of electric lines. With the construction above described, the first conductor element 94 is usually held upright in the rest position by reason of the balanced magnetic fields which are established by the spaced permanent magnets 90 and 90', respectively. When, however, an impact is imparted to the detecting device, then the non-magnetic ball 91 having a considerable weight and the first conductor element 94 are caused to turn about the shaft or pin 93 in the direction of an arrow by a force of inertia developed therein. If, in this condition, the force of inertia is greater than a predetermined magnitude over coming the magnetic forces exerted by the permanent magnets 90 and 90', the first conductor element 94 rocks and contacts the second conductor element 95. The second conductor element 95, which is made of the pliable metal, is warped or curved downwardly as it is pressed upon by the first conductor element 94 bearing thereagainst so that the two conductor elements 94 and 95 are maintained in contact with each other for a sufficiently period of time. The contact between the two conductor elements 94 and 95 will be made even if the first conductor element 94 is provided with a rounded portion 94a at its top so as to provide a cushioning effect as previously mentioned. If, on the other hand, the force of inertia resulting from the impact is smaller than the predetermined magnitude, then the non-magnetic ball 91 and the first conductor element 94 will be caused to restore the initial positions under the influence of the magnetic fields established by the spaced permanent magnets 90 and 90'. The sensitivity of the detecting device to the impact can be varied by selecting the magnetic forces of the two permanent magnets, the spacing between the magnets, the total weight of the movable contact comprising the ball, magnetic piece and first conductor element, the spacing between the first and second conductor elements and/or the center of gravity of the movable contact. If, thus, the magnetic piece 92 is positioned at a level lower than the center of gravity of the movable contact constructed by the first conductor element 94, ball 91 and magnetic piece 92 per se, the sensitivity to the impact will be increased considerably.

The first conductor element 94 is connected directly to the lead 56a in the embodiment shown in FIG. 24. If desired, however, the first conductor element 94 may be provided with a resilient member through which the conductor element is connected to the second conductor element when the detecting device is brought into the actuated condition, an example of such arrangement being shown in FIG. 25. As illustrated in FIG. 25, an apertured conductor plate 96 of a disc form is placed on the inner surface of the bottom wall 50b of the receptacle 50 with its inner peripheral edge located in alignment with the circular edge of the semispherical recess 89, the conductor plate 96 being connected to the lead 56b. The first conductor element 94 previously mentioned is provided with a generally conical resilient member 97 having its outer peripheral edge positioned over the apertured conductor plate 96, as shown. The second conductor element, now designated by reference numeral 95', is herein shown as configured substantially as an annular, which conductor element is inwardly and downwardly inclined toward the stem portion of the first conductor element 94. When, thus, the first conductor element 94 sways and contacts the second conductor element 95 under the condition previously discussed in connection with FIG. 24, then the conical resilient member 97 is brought into contact with the conductor plate 96 relatively softly by reason of its resilience. The movable contact as a whole is in this manner afforded with a cushioning effect which is increased by the resilient contact between the conical member 97 and the conductor plate 96. The magnetic piece 92 is to be used in the construction shown in FIG. 25 is preferably shaped as annular so as to enable the movable contact to be responsive to an impact in any direction.

The embodiments thus far described with reference to FIGS. 21 to 25 all utilize the pivotal or rocking motions of the magnetic pieces in response to the forces of inertia developed when the magnetic pieces are subjected to the impacts. FIGS. 26 to 29 now illustrate various embodiments in which an inertial mass is seated in the rest position and dislocated by a force of inertia to an actuated position connecting the electric lines to each other.

Referring first to FIG. 26, the detecting device of the modified construction includes a generally cylindrical receptacle 50 made of a substantially rigid material in which a cavity or chamber 51 is formed. Similarly to the previously described embodiments. A support member 98 is secured to a relatively upper portion of the cylindrical wall of the receptacle 50 defining the cavity 51. The support member 98 has formed substantially centrally thereof an aperture which is defined by an upwardly rounded inner peripheral edge 98a. The support member 98 carries thereon a cylindrical magnetic piece 99 having a flange 99a at its top through abutting engagement between the upwardly rounded peripheral edge 98a of the support member 98 and a lower face of the flange 99a of the magnetic piece 99, as shown. The magnetic piece 99 thus serving as a movable contact depends downwardly from the support member 98 toward a bottom wall 50b of the receptacle 50. Aligned with this magnetic piece 99 is a permanent magnet 54 which is embedded in the bottom wall 50b and which is positioned at a suitable spacing from the overlying magnetic piece 99. A downwardly stepped wall section (not numbered) is formed in the cavity 51 and an electrically conductive coil spring 100 serving as a stationary yet elastic contact is seated on a bottom face of the thus formed depression in such a manner as to surround a relatively lower portion of the magnetic piece 98 at a suitable spacing therefrom when the magnetic piece is held in a rest position which is illustrated. The support member 98, magnetic piece 99 and coil spring 100 are all made of electrically conductive materials and the support member 98 and coil spring 100
are connected to leads 56a and 56b, respectively, of electric lines. Under a normal condition in which the detecting device is free from an impact, the magnetic piece 99 is held substantially upright so as to be disengaged from the coil spring 100 which is electrically conductive. When, however, the detecting device is subjected to an impact of a certain magnitude, then the magnetic piece 99 is moved from the rest position toward the coil spring 100 against the attractive force exerted thereon from the permanent magnet 54. If, in this condition, the magnitude of the force of inertia is smaller than the restraint of the magnetic field, the magnetic piece 99 which has once been dislocated is moved back to its initial position by the attractive force of the magnet 54. If, conversely, the magnitude of the force of inertia developed in the magnetic piece 99 is greater than a predetermined degree overcoming the intensity of the magnetic field, the magnetic piece 99 is perfectly relocated against the magnetic force to a position in which it contacts the coil spring 100 with its top flange 99a partly disengaged from the rounded edge 99a of the magnetic piece 99 whereby the leads 56a and 56b are connected to each other. The cushioning effect for the magnetic piece 99 thus moved to the actuated position is provided by the spring characteristics of the coil spring 100.

FIG. 27 illustrates a modification of the embodiment of FIG. 26. The modified embodiment now illustrated in FIG. 27 has a receptacle 50 having a top wall 50a part of which is formed by an electrically conductive support member 101 having a conical recess 101a with a pointed bottom. A generally cylindrical magnetic piece 102 having a pointed upper end 102a is positioned on an inner face of the bottom wall 50b of the receptacle and is supported in an upright position with its upper pointed end 102a received at the pointed bottom of the conical recess 101a in the support member 101. A generally cylindrical conductor element 103 of pliable metal projects from the bottom wall 50b of the receptacle 50 and extends generally vertically into the cavity 51 in the receptacle at a suitable spacing from the magnetic piece 102. A permanent magnet 54 is embedded in the bottom wall 50b of the receptacle 50 and is positioned substantially in line with the overlying magnetic piece 102 which is held in the upright rest position. The support member 101 and conductor element 103 are connected to leads 56a and 56b, respectively, of electric lines. With the magnetic piece 102 thus held in the rest position, the support member 101 and conductor element 103 are usually kept disconnected from each other. When the detecting device is subjected to an impact, the magnetic piece 102 is dislocated from the rest position by a force of inertia and, if the force of inertia is greater than a predetermined magnitude overcoming the attractive force exerted from the underlying permanent magnet 54, the magnetic piece 102 is perfectly relocated so as to be brought into abutting engagement with the pliable conductor element 103 which serves as a stationary contact. In this condition, the support member 101 and conductor element 103 are connected to each other by means of the magnetic piece 102 which now acts as a movable contact. It is, in this instance, apparent that the duration of contact between the magnetic piece 102 and conductor element 103 is prolonged by the warpage of the conductor element 103 which is resilient.

FIG. 28 illustrates still another preferred embodiment using an inertial mass which is held in a rest position by reason of its own gravity. The detecting device shown invariably has a substantially rigid receptacle having a cavity or chamber 51 formed therein. A support member 104 having embedded therein a permanent magnet 54 projects upwardly from a bottom wall 50b of the receptacle 50. The support member 104 receives at its top a magnetic piece 105 of a generally trapezoidal vertical section. The support member 104 and magnetic piece 105 are made of electrically conductive materials. The magnetic piece 105 serving as a movable contact an inertial mass may be shaped in various manners. For instance, the magnetic piece 105 may have a suitable number of spaced side walls extending vertically alongside the support member 104. In this instance, the spaced side walls of the magnetic piece 105 may be directed straight downwardly or inclined outwardly at suitable angles from a vertical direction as illustrated. Or otherwise, the magnetic piece 105 may have a cylindrical or frusto-conical wall surrounding the support member 105. A pliable conductor element 106 projects from the bottom wall 50b of the receptacle 50 and is positioned at a spacing from the magnetic piece 105. Where the magnetic piece 105 includes the spaced side walls as above mentioned, the conductor element 106 may also be split into spaced plates which are respectively aligned with the spaced side walls of the magnetic piece 105. Where, on the other hand, the magnetic piece 105 includes the cylindrical or frusto-conical wall, the conductor element 106 may be positioned in a manner to surround a lower end portion of such cylindrical or frusto-conical wall. The support member 104 and conductor element 106 are connected to leads 56a and 56b, respectively, of electric lines. The magnetic piece 105 in either of the above mentioned forms is usually received through its top wall on the top of the support member 104 under the influence of the attractive force exerted thereon from the permanent magnet 54 embedded in the support member 104. When, however, the detecting device is subjected to an impact, the magnetic piece 105 is dislocated from the support member 104 by a force of inertia developed therein. If the force of inertia of the magnetic piece 105 acting as an inertial mass is smaller than the attractive force biasing the magnetic piece toward the rest position, the magnetic piece 105 is caused to return to the rest position so that the leads 56a and 56b, remain disconnected from each other. If, on the contrary, the force of inertia of the magnetic piece 105 is greater than a predetermined magnitude overcoming the attractive force which is effective on the magnetic piece 105, then the magnetic piece is relocated from the rest position until it is brought into contact with the pliable conductor element 106. The conductor element 106 thus receiving the magnetic piece 105 on its inner surface is warped outwardly so that the magnetic piece and conductor element are kept in contact with each other for an adequately prolonged period of time.

FIG. 29 illustrates a modification of the embodiment of FIG. 28. In the embodiment shown in FIG. 29, the receptacle 50 has formed therein a frusto-conical cavity 51 which is gradually reduced in diameter toward its bottom end. On an inner surface of the thus formed bottom wall 50b is placed a conductor plate 107. A permanent magnet 54 is embedded underneath this conductor plate 107. A magnetic piece 108 rests on an
upper surface of the conductor plate 107, extending toward a top wall 50a of the receptacle 50. This magnetic piece 108 in either of such forms has a bottom end having a diameter substantially equal to the diameter of the bottom area of the cavity 51. The magnetic piece 108 thus configured is made of a ferromagnetic, electrically conductive material so as to serve as a movable contact in the shown detecting device. A conductor element 109 of an apertured disc form serving as a stationary contact is positioned around an upper portion of the magnetic piece 108 and is secured to the surrounding wall of the receptacle 50. This conductor element 109 is suitably spaced apart from the magnetic piece 108 in the rest position and is upwardly inclined with its inner peripheral edge located adjacent the inner face of the top wall 50a of the receptacle 50, as shown. The conductor plate 107 and conductor element 109 are connected to leads 56a and 56b, respectively, of electric lines. The magnetic piece 108 in the rest position is thus spaced apart from the conductor element 109 so that the conductor plate 107 and conductor element 109 remain disconnected from each other under usual conditions of the detecting device. When, the detecting device undergoes an unusual impact, then the magnetic piece 108 is dislodged from the rest position by a force of inertia and is inclined toward the conductor element 109 with its lowermost peripheral edge partly in contact with the conductor plate 107. If, in this condition, the force of inertia of the magnetic piece 108 is greater than a predetermined magnitude overcoming the attractive force exerted on the magnetic piece 108 from the underlying permanent magnet 54, then the magnetic piece 108 contacts an inner face of the pliable conductor element 109, which is consequently connected to the conductor plate 107 through the magnetic piece now acting as a movable contact. In order that the magnetic piece 108 be capable of contacting the conductor element 109 with a higher degree of resilience, the magnetic piece may be provided at its upper end portion with a flange 108a of a resilient material as indicated in FIG. 30A whereby the magnetic piece will relatively softly hit the conductor element 109 through such flange. If desired, the flange 108a may be split into a number of spaced strips 108b which radially outwardly project from the upper end portion of the magnetic piece.

The magnitude of the force of inertia by which the biasing force exerted on the movable contact serving as the inertial mass may be predetermined so as to meet various operational requirements of the motor vehicle safety device. In this instance, it is known that the momentum and accordingly the velocity at which the motor vehicle occupant is forwardly flung during a frontal collision vary with the speed of the motor vehicle at the very instant of the collision. This will be visually ascertained from the graphic illustration of FIG. 31.

In FIG. 31, there are shown examples of the variations, in terms of time, of the rates of acceleration which is developed in a vehicle occupant who is subjected to collisions of different degrees, wherein curves a and b indicate collisions at relatively low and high speeds, respectively, of the motor vehicle. It is apparent from these curves that the rates of acceleration of the vehicle occupant resulting from the collisions vary markedly depending on the speeds of the motor vehicle encountering the collisions, thus the degree of acceleration resulting from the collision at the high vehicle speed is greater than that resulting from the collision at the low vehicle speed and vice versa. It is also understood from the curves of FIG. 31 that the same degree of acceleration is reached earlier in the high-speed collision than in the low-speed collision. These facts will account for the requirement that the actuation of the safety device should be completed more rapidly during the high-speed collision than during the low-speed collision condition. In this regard, it is desirable that the actuation of the safety device should be complete in a manner indicated in FIG. 32 depending upon the speed of the motor vehicle at the instant of the collision. The prior art safety devices are so constructed and arranged that they are actuated at rates which are determined without respect to the speed of the motor vehicle at the time of the collision. The actuation of the safety devices of such nature is, therefore, is prone to be completed at premature timings during the high-speed collisions and at belated timings during the low-speed collisions. The present invention thus further proposes an arrangement which is adapted to eliminate the above described drawback of the prior art motor vehicle safety devices.

A first preferred embodiment of such arrangement according to the present invention is shown in a block form in FIG. 33. Referring to FIG. 33, reference numeral 110 designates actuating means which is adapted to actuate the safety device to the predetermined protective position. The actuating means 110 may thus be connected to a solenoid-actuated valve (not shown) adapted to open a container of a pressurized gas which is usually used to expand the protector bag of the safety device. According to the present invention, the actuating means 110 comprises first and second actuating elements 110a and 110b, respectively, which are operable to actuate the safety device at different rates and timings. The constructions of these actuating elements 110a and 110b per se are well known in the art and can be selected as desired. The first and second actuating elements 110a and 110b are connected to first and second inertia responsive switch means 111a and 111b, respectively, which are responsive to forces of inertia of different magnitudes. Referring concurrently to FIG. 31, these first and second switch means are respectively assumed to be responsive to forces of inertia resulting from the accelerations of the rates G1 and G2 (where G1 < G2). The lower rate G1 of the acceleration is reached at time T1 during the low-speed collision and at time T1 during the high-speed collision. The higher rate G2 of the acceleration, on the other hand, is reached at time T2 during the low-speed collision and at time T2 during the high-speed collision. It is, in this instance, apparent from FIG. 31 that the time interval between the times T1 and T2 for the low-speed collision is greater than the time interval between the times T1 and T2 for the high-speed collision. Thus, the safety device using the arrangement of FIG. 33 is operable to be actuated at a relatively slow timing during the low-speed collision and held in the protective position for a relatively long time interval. During the high-speed collision in which the time interval between the times T1 and T2 is extremely short and in which the time T2 is reached approximately immediately after the time
has been reached, the safety device can be actuated sufficiently rapidly as compared to the case with the low-speed collision. The inertia responsive switch means 111a and 111b of the arrangement herein proposed may preferably use the impact detecting device of any of the constructions which have been described with reference to FIGS. 5 to 30, although the same may be constructed otherwise as using the known switch means of the described nature. If desired, the first and second inertia responsive switch means 111a and 111b, respectively, may be connected to a common switch means 112 which is constructed and arranged entirely similarly to the first switch means 111a, as shown in FIG. 34. Or otherwise, the first inertia responsive switch means 111a may be connected to pressure responsive switch means 113 of the nature which is responsive to a forceful contact, as shown in FIG. 35. This pressure responsive switch means 113 usually includes an impact pressure detecting element which is mounted on a front or rear part of the motor vehicle and detects a mechanical pressure resulting from the collision upon sensing of the local deformation or unusual dislocation of the front or rear member as caused by the impact imparted to the particular part in the collision. Preferred examples of the detecting element of this general character are disclosed in the copending U.S. Pat. application Ser. No. 228,975 filed 2/25 1972. Thus, no detailed description of the construction and operation of the pressure responsive switch means will be incorporated herein. Provision of such pressure responsive switch means is useful for the prevention of the safety device from being actuated by the inertia switch arrangements alone in the event relatively soft shocks or impacts which are unlikely to invite a serious danger on the vehicle occupant are applied to the motor vehicle as during garaging, when the door is shut violently or when a hole in the road is encountered. FIG. 36 illustrates a further modified arrangement in which the first and second inertia responsive switch means 111a and 111b are connected to two pressure responsive switch means 113a and 113b, respectively, of the above described character.

What is claimed is:

1. An impact detecting device comprising:
an insulating housing having an upper end wall, side walls, a lower end wall and a cavity defined by said walls;
a movable contact assembly positioned within said cavity and comprising an electrically conductive weight having a predetermined weight and an electrically conductive support means secured to said housing and connected to said weight and rockingly suspending said weight within said cavity;
a stationary contact assembly secured on said housing and having an electrically conductive contact member extending into said cavity substantially in alignment with said weight of said movable contact assembly; and
biasing means embedded in said housing and urging, by a predetermined biasing force, said weight to a rest position which is spaced apart from said stationary contact assembly,
said weight of said movable contact assembly being moved from said rest position to contact said contact member of said stationary contact assembly when a force of inertia greater than a predetermined magnitude overcoming said biasing force is developed in said movable contact assembly in response to an impact applied to said detecting device.

2. An impact detecting device according to claim 1, in which said contact member of said stationary contact assembly is constructed of at least one pliable metal plate extending substantially in alignment with said weight of said movable contact assembly.

3. An impact detecting device according to claim 2, in which said at least one pliable metal plate is positioned to surround said weight of said movable contact assembly.

4. An impact detecting device according to claim 2, in which said at least one pliable metal plate is generally in the form of a comb having a plurality of spaced strips extending forwardly from a base portion at which said strips are combined together.

5. An impact detecting device according to claim 2, in which said at least one pliable metal plate is positioned substantially in parallel to said weight of said movable contact assembly.

6. An impact detecting device according to claim 2, in which said at least one pliable metal plate has at least one portion positioned at a predetermined angle to said weight of said movable contact assembly.

7. An impact detecting device according to claim 1, in which said contact member of said stationary contact assembly is constructed of at least two pliable metal plates which are spaced apart from each other and which are positioned substantially around said weight of said movable contact assembly.

8. An impact detecting device according to claim 1, in which said contact member of said stationary contact assembly is constructed of a pair of pliable metal plates which are positioned at a spacing from each other, said spacing being gradually reduced toward leading ends of said metal plates and aligned with said weight of said movable contact assembly for receiving said weight between said metal plates when said weight is moved from said rest position by a force of inertia opposing said biasing force.

9. An impact detecting device according to claim 1, in which said contact member of said stationary contact assembly is constructed on an electrically conductive rigid plate which is aligned with and spaced apart from said weight of said movable contact assembly, and further comprising cushioning means disposed between said insulating housing said rigid plate.

10. An impact detecting device according to claim 9, in which said cushioning means comprises a spring which is secured at one end thereof to said rigid plate and held in position for biasing said rigid plate in a direction in which said weight of said movable contact assembly is moved when subjected to a force of inertia opposing said biasing force of said biasing means.

11. An impact detecting device according to claim 9, in which said cushioning means is disposed in a horizontal alignment with said weight of said movable contact assembly.

12. An impact detecting device according to claim 1, in which said biasing means comprises magnet means, said magnet means producing a magnetic field having an intensity which is predetermined to provide said biasing force, and said weight of said movable contact assembly is at least partly formed of a ferromagnetic material for being attracted by said magnet means.

13. An impact detecting device according to claim
12, in which said magnet means is a permanent magnet.
14. An impact detecting device according to claim 12, in which said magnet means is a solenoid which is
constantly energized.
15. An impact detecting device according to claim 12, in which said magnet means is positioned under-
neath said weight of said movable contact assembly for
downwardly attracting said weight thereto.
16. An impact detecting device according to claim 12, in which said magnetic means is positioned to a side
of said weight of said movable contact assembly for
horizontally attracting said weight thereto.
17. An impact detecting device according to claim 1,
in which said biasing means comprises a spring which
is connected at one end thereof to said weight of said
movable contact assembly for retaining said weight
with a force which is predetermined to provide said bi-
assing force.
18. An impact detecting device according to claim 61,
in which said support means of said movable
contact assembly comprises an electrically conductive
flexible member for allowing said weight of said mov-
able contact assembly to swing toward said contact
member of said stationary contact assembly when said
weight is subjected to a force of inertia opposing said
biasing force.
19. An impact detecting device according to claim 18,
in which said flexible member is a metal wire.
20. An impact detecting device according to claim 18,
in which said flexible member is a pliable metal rod.
21. An impact detecting device according to claim 18,
in which said support means of said movable
contact assembly further comprises a pivotal pin which
is secured to said housing in position in said cavity, said
flexible member being pivotally supported at its upper
end portion by said pivotal pin.
22. An impact detecting device according to claim 18,
in which said flexible member is secured to oppo-
site end walls of said housing and supports said weight
of said movable contact assembly substantially cen-
trally thereof and in alignment with said contact mem-
ber of said stationary contact assembly.
23. An impact detecting device according to claim 22,
in which said flexible member is a diaphragm mem-
ber.
24. An impact detecting device according to claim 18,
further comprising adjustable means for varying a
spacing between said weight of said movable contact
assembly and said biasing means.
25. An impact detecting device according to claim 24,
in which said adjusting means is a stationary disc
which is disposed on said housing and which is posi-
tioned relative to said flexible member suspending said
weight of said movable contact assembly from said
upper end wall of said housing, and further comprising
a rotatable member supported by and rotatable on said
stationary disc, said rotatable member having a projec-
tion engageable with said flexible member.
26. An impact detecting device according to claim 1,
in which said support means of said movable contact
assembly comprises an electrically conductive resilient
member for positioning said weight of said movable
contact assembly adjacent said contact member of said
stationary contact assembly.
27. An impact detecting device according to claim 26,
in which said resilient member extends substantially
vertically from said lower end wall of said housing and
supports said weight of said movable contact assembly
at its uppermost free end for allowing said weight to
swing toward said contact member of said stationary
contact assembly when said weight is subjected to a
force of inertia opposing said biasing force.
28. An impact detecting device according to claim
26, in which said resilient member extends substantially
horizontally from said side wall of said housing and sup-
ports said weight of said movable contact assembly for
allowing said weight to swing toward said contact mem-
ber of said stationary contact assembly when said
weight is subjected to a force of inertia opposing said
biasing force.
29. An impact detecting device according to claim
26, in which said resilient member is secured to oppo-
site end walls of said housing and supports said weight
of said movable contact assembly substantially cen-
trally thereof and in alignment with said contact mem-
ber of said stationary contact assembly.
30. An impact detecting device according to claim 1,
in which said support means of said movable contact
assembly comprises at least one pivotal pin which is
supported by said housing and which extends substan-
tially horizontally through said cavity, said pivotal pin
supporting said weight of said movable contact assem-
bly pivotally movably about said pin and substantially
upright when said weight is in said rest position.
31. An impact detecting device according to claim 30,
wherein said pivotal pin is secured to opposite side
walls of said housing through said cavity, means defin-
ing a hole in said weight, said pivotal pin extending
through the hole and pivotally supporting said weight
of said movable contact assembly.
32. An impact detecting device according to claim 30,
in which said weight of said movable contact assem-
bly is supported at its upper end portion by said at least
one pivotal pin so that said weight depends from said
pin with its lower end portion aligned with and spaced
apart from said contact member of said stationary
contact assembly.
33. An impact detecting device according to claim 1,
in which said support means of said movable contact
assembly comprises a pair of pivotal pins which are
supported on opposite side walls of said housing
through said cavity and which are in line with each other.
34. An impact detecting device according to claim 33,
in which first ends of said pivotal pins are secured to
said side walls, means defining aligned holes in said
weight, and the ends of said pins opposite said first ends
disposed to extend into associate aligned holes to pivot-
ally support said weight of said movable contact assem-
bly.
35. An impact detecting device according to claim 33,
in which said pivotal pins are respectively secured at a
first end portion to said weight of said movable
contact assembly, means defining holes in said side
walls and in spaced but aligned position, and the end
portions of said pins opposite said first end portions are
pivotally received in respective holes.
36. An impact detecting device according to claim
35, in which said pivotal pins are integral with said
weight of said movable contact assembly.
37. An impact detecting device according to claim 1,
in which said support means of said movable contact
assembly comprises a substantially rigid support mem-
ber which is disposed on said housing and on which said
weight of said movable contact assembly is movably received at its upper end portion and held substantially upright in said rest position with its lower end portion positioned adjacent said contact member of said stationary contact assembly.

38. An impact detecting device according to claim 37, in which said support member is connected to said housing and is formed with a central aperture, and in which said weight of said movable contact assembly has an outer projection resting upon an upper face of an inner peripheral edge portion defining said central aperture when said weight is in said rest position and is displaceable from said rest position with its lower end portion moved toward said contact member of said stationary contact assembly with said outer projection at least partly disengaged from said support member when said weight is subjected to a force of inertia opposing said biasing force.

39. An impact detecting device according to claim 38, in which said support member has an upwardly projecting portion formed at said inner peripheral edge portion.

40. An impact detecting device according to claim 39, in which upward projection has a rounded end edge.

41. An impact detecting device comprising:
an insulating housing having an upper end wall, side walls, a lower end wall and a cavity defined by said walls, said lower end wall formed with a substantially semi-spherical recess conjoining said cavity;
a movable contact assembly comprising an insulating ball member which is received in said semi-spherical recess so as to slide on a semi-spherical surface defining said recess and which has at least one magnetic piece anchored thereto, and an electrically conductive rockable contact member extending upwardly from said ball member;
a stationary contact assembly which is fast on said housing and includes electrically conductive contact member extending into said cavity substantially in alignment with said rockable contact member of said movable contact assembly; and
biasing means comprising a pair of magnets which are embedded in said lower end wall of said housing and disposed on opposite sides of said ball member and which urge, by a predetermined biasing force, said rockable contact member of said movable contact assembly through said magnetic piece of said ball member to a rest position which is spaced apart from said contact member of said stationary contact assembly.

42. An impact detecting device according to claim 41, in which said stationary contact assembly further comprises an electrically conductive apertured contact member which is disposed on said lower end wall of said housing, and said movable contact assembly further comprises an electrically conductive conical resilient contact member which extends into said cavity from said rockable contact member of said movable contact assembly, said resilient contact member being normally spaced apart from said apertured contact member of said stationary contact assembly and being movable into engagement therewith when said rockable contact member is moved by a force of inertia opposing said biasing force of said biasing means.

43. An impact detecting device according to claim 41, in which said movable contact assembly further comprises a pivotal pin which is supported on opposite side walls of said housing through said recess, means defining a hole in said ball, said pin extending through said hole and pivotally supporting said weight of said movable contact assembly.

44. An impact detecting device comprising:
an insulating housing having an upper end wall, side walls, a lower end wall and a cavity defined by said walls;
a movable contact assembly positioned within said cavity and having an electrically conductive weight having a predetermined weight and an electrically conductive rigid support means which is fast on said housing to keep said weight within said cavity; a stationary contact assembly which is positioned on said housing and which has electrically conductive contact member extending into said cavity substantially in alignment with said weight of said movable contact assembly; and
biasing means embedded in said housing and urges, by a predetermined biasing force, said weight to a rest position which is spaced apart from said contact member of said stationary contact assembly,
said weight of said movable contact assembly being moved from said rest position to contact said contact member of said stationary contact assembly when a force of inertia greater than a predetermined magnitude overcoming said biasing force is developed in said weight of said movable contact assembly in response to an impact applied to said detecting device.

45. An impact detecting device according to claim 44, in which said rigid support means of said movable contact assembly is disposed on said upper end wall of said housing and formed therein a substantially conical recess with a pointed bottom, and in which said weight of said movable contact assembly has a pointed upper end which is in abutting engagement with said pointed bottom of said conical recess, said weight being displaceable from said rest position with its lower end portion relocated toward said contact member of said stationary contact assembly when said weight is subjected to a force of inertia opposing said biasing force.

46. An impact detecting device according to claim 45, in which said weight of said movable contact assembly directly rests at its lowermost end on an inner surface of said lower end wall of said housing and extends substantially vertically through said cavity when held in said rest position.

47. An impact detecting device according to claim 44, in which said rigid support means of said movable contact assembly projects substantially vertically from an inner surface of said lower end wall of said housing toward said upper end wall of said housing, and in which said weight of said movable contact assembly comprises an upper end wall resting upon a leading end of said rigid support means and a side wall which extends alongside said support means which has a lower
end portion aligned with said and which member of said stationary contact assembly, said weight being displaceable from said rest position with its lower end portion moved toward said contact member of said stationary contact assembly when said weight is subjected to a force opposing said biasing force.

48. An impact detecting device according to claim 47, in which said side wall of said weight is downwardly outwardly inclined toward said contact member of said stationary contact assembly.

49. An impact detecting device according to claim 107, in which said side wall of said weight is substantially cylindrical and surrounds an adjacent portion of said support means.

50. An impact detecting device according to claim 107, in which said side wall of said weight has a plurality of plate portions which are disposed in spaced apart relationship with respect to each other.

51. An impact detecting device according to claim 107, in which said side wall of said weight is substantially frustoconical in shape.

52. An impact detecting device according to claim 107, in which said rigid support member is substantially cylindrical in shape.

53. In a motor vehicle safety device for protecting an occupant of the motor vehicle from incurring an injury during a collision affecting the motor vehicle, the improvement comprises:

first and second actuating means for actuating said safety device at different rates,

at least one first inertia responsive switch means connected to said first actuating means, and

second inertia responsive switch means connected to said second actuating means,

said first and second inertia responsive switch means being responsive to accelerations of the rates higher than predetermined rates, each of said first and second inertia responsive switch means comprising:

an insulating housing having an upper end wall, side walls, a lower end wall and a cavity defined by said walls;

a movable contact assembly positioned within said cavity and comprising an electrically conductive weight having a predetermined weight and an electrically conductive support means which is secured to said housing and to said weight to keep said weight within said cavity;

a stationary contact assembly which is disposed on said housing and has an electrically conductive contact member extending into said cavity substantially in alignment with an adjacent portion of said weight of said movable contact assembly; and

biasing means embedded in said housing and urges, by a predetermined biasing force, said weight to a rest position spaced apart from said stationary contact assembly, said weight of said movable contact assembly being moved from said rest position to contact said contact member of said stationary contact assembly when a force of inertia greater than a predetermined magnitude overcoming said biasing force is developed in said movable contact assembly in response to an impact applied to said inertia responsive switch means.

54. The improvement according to claim 53, further comprising at least one mechanical pressure responsive switch means connected to said first inertia responsive switch means and responsive to a mechanical pressure greater than a predetermined magnitude.

55. The improvement according to claim 53, further comprising first and second mechanical pressure responsive switch means which are respectively connected to said first and second inertia responsive switch means, each of said first and second mechanical pressure responsive switch means being responsive to a mechanical pressure greater than a predetermined magnitude.

56. The improvement according to claim 53, further comprising another first inertia responsive switch means connected to the first named first inertia responsive switch means and to said second inertia responsive switch means.