

[54] ELASTOMERIC MOUNTINGS

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[73] Assignee: Dunlop Limited

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May 26, 1972 Great Britain ..... 24869/72

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[51] Int. Cl. .... B60r 19/06, E02b 3/22

[58] Field of Search ..... 293/71 R, 88; 114/219;  
267/139, 140, 141, 153

[56] References Cited

UNITED STATES PATENTS

2,917,302 12/1959 Mattern et al. .... 267/153  
3,315,951 4/1967 Boschi et al. .... 267/153  
3,323,786 6/1967 Boschi ..... 267/153  
3,507,123 4/1970 Miura ..... 114/219  
3,533,242 10/1970 Narabu ..... 114/219

3,563,525 2/1971 Narabu ..... 267/140  
3,694,018 9/1972 Levering ..... 293/88  
3,752,462 8/1973 Wight, Jr. .... 293/88

FOREIGN PATENTS OR APPLICATIONS

1,456,507 10/1966 France ..... 267/153

Primary Examiner—M. Henson Wood, Jr.

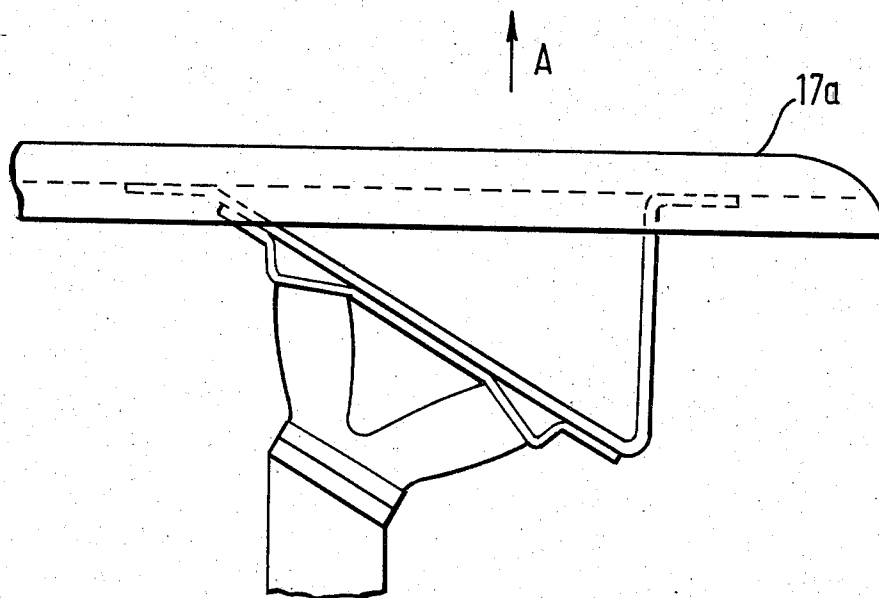
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Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] ABSTRACT

An elastomeric mounting which has, when viewed in cross-section, two deformable limbs of resilient elastomeric material, one part of each limb being adapted to be secured to a support member, and each limb being contoured along its length to provide a preferential region of bending and the limb being shaped and disposed so that when subjected to a load applied longitudinally of the two limbs the limb will first deform in a stable manner and then be caused to buckle.

16 Claims, 22 Drawing Figures



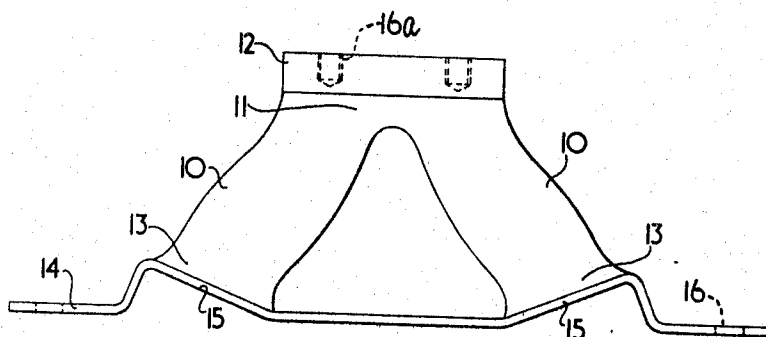


FIG. 1.

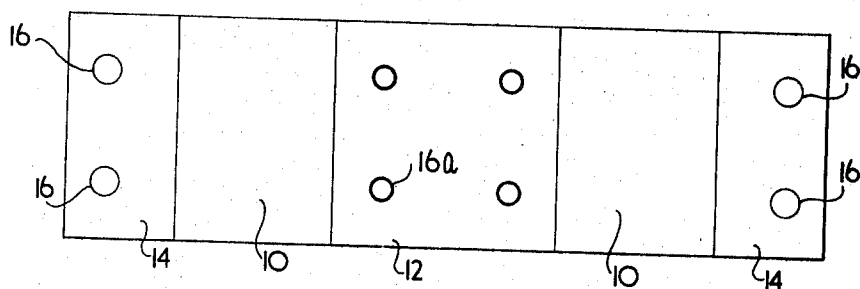


FIG. 2.

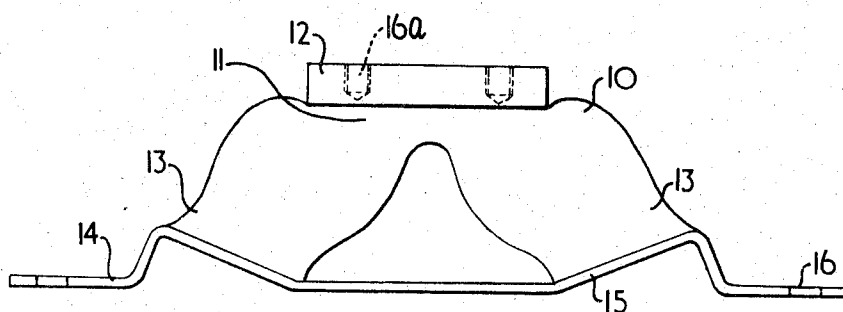


FIG. 3

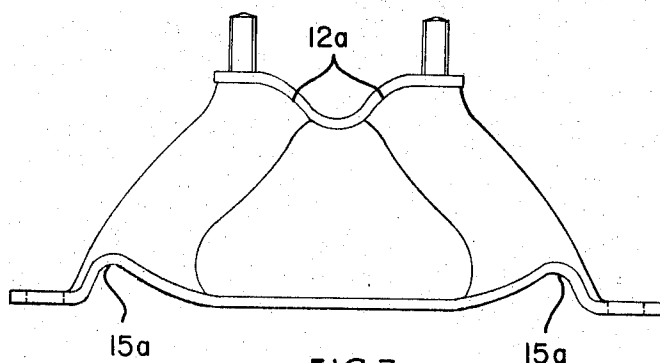


FIG. 7



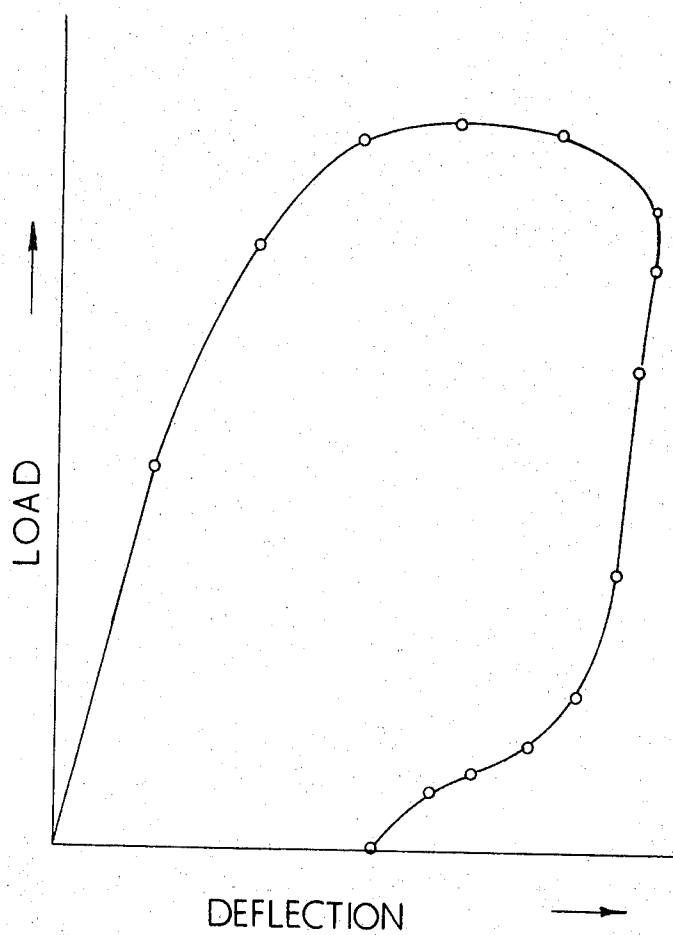


FIG. 6.

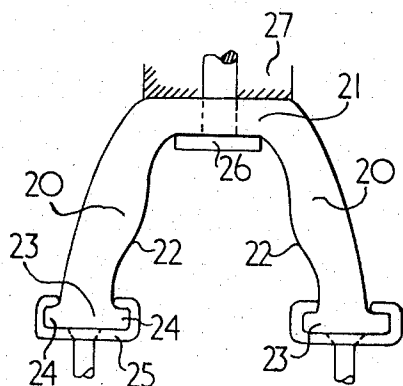


FIG. 8.

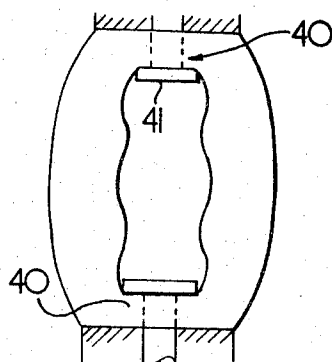


FIG. 11.

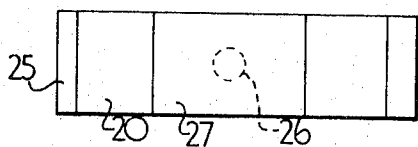


FIG. 9.

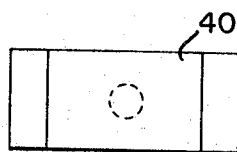


FIG. 12.

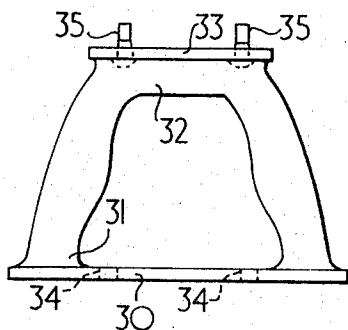


FIG. 10.

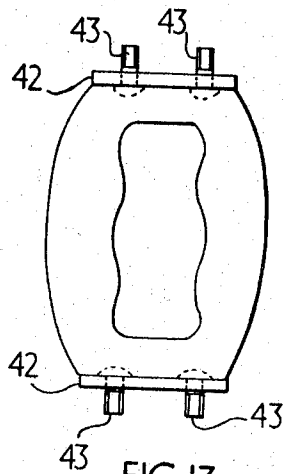


FIG. 13.

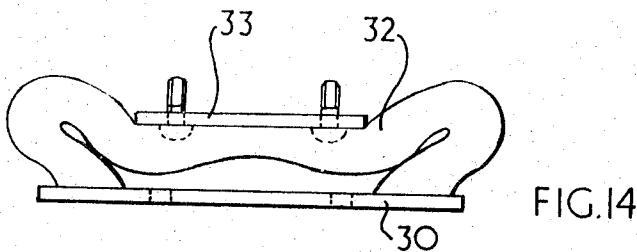


FIG. 14

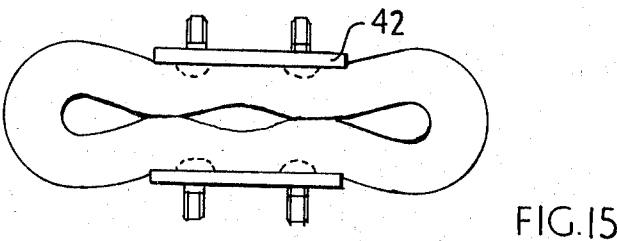


FIG. 15

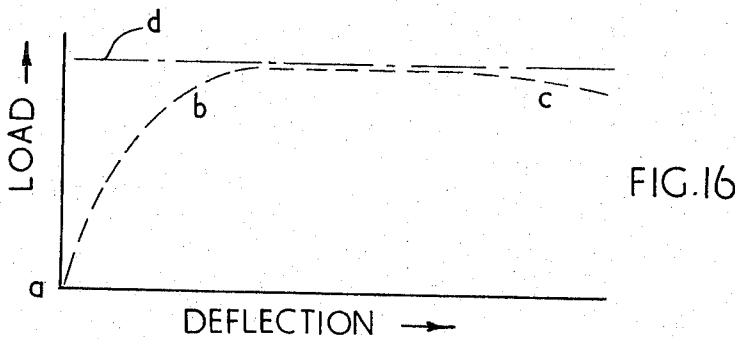


FIG. 16

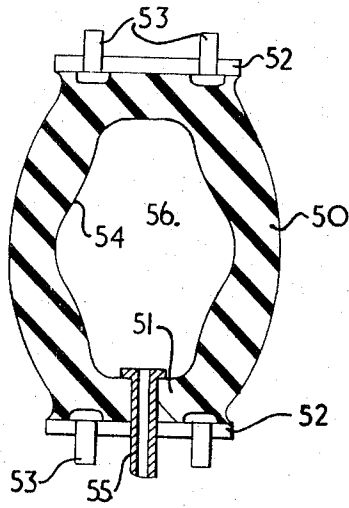


FIG. 17

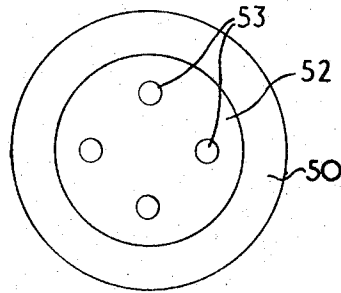


FIG. 18

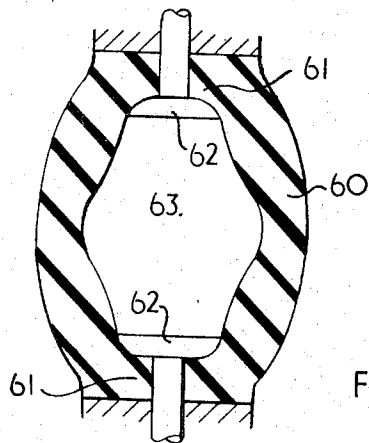


FIG. 20

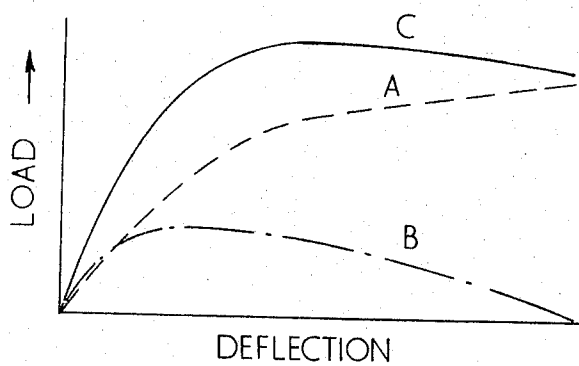


FIG. 19

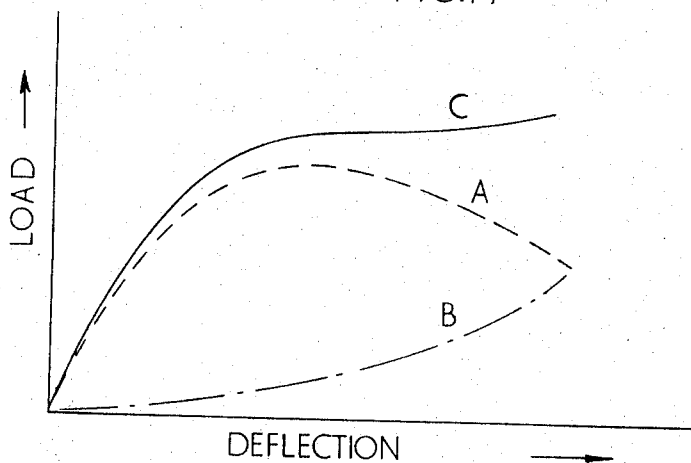
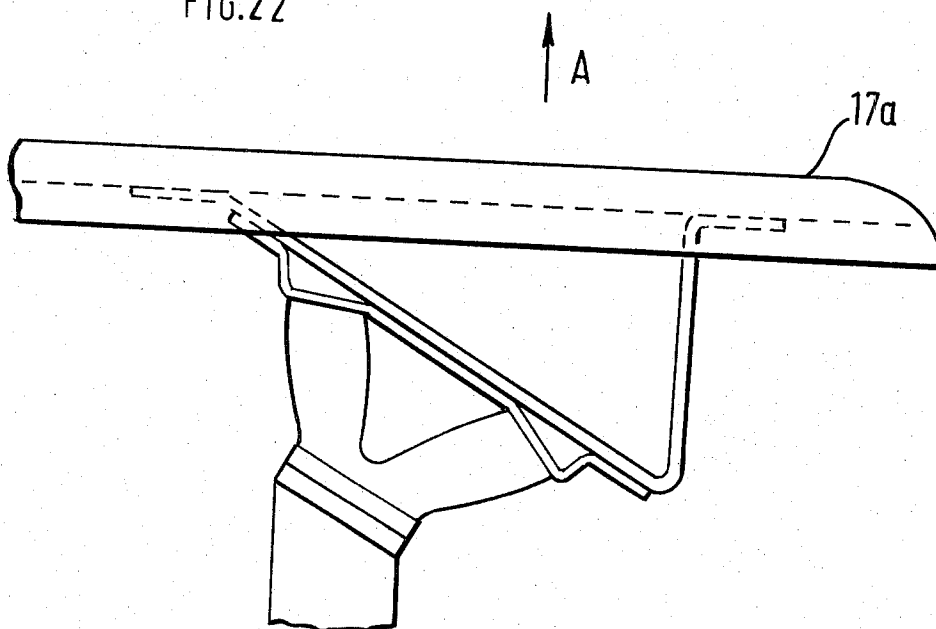


FIG. 21

FIG.22



## ELASTOMERIC MOUNTINGS

This invention relates to elastomeric mountings for energy absorption and in particular, though not exclusively, to energy-absorbing mountings suitable for resiliently attaching bumpers to vehicles.

In the case of, for example, a bumper mounted on a moving vehicle it is usually desirable that, in order to safeguard against damage to the vehicle body or chassis and excessive injury to the occupants of the vehicle at low impact speeds, the bumper be mounted on the vehicle by means of resilient energy-absorbing mountings which are capable of substantially limiting the transmission of energy in the event of a collision.

One object of the present invention is to provide an elastomeric mounting having improved energy-absorbing characteristics.

According to one aspect of the present invention an elastomeric mounting has, when viewed in cross-section, two deformable limbs of resilient elastomeric material, one part of each limb being adapted to be secured to a support member, and each limb being contoured along its length to provide a preferential region of bending and the limb being shaped and disposed so that when subjected to a load applied longitudinally of the two limbs the limb will first deform in a stable manner and then be caused to buckle.

Preferably the limbs are arranged to deform first in a stable manner under the action substantially only of compressive forces.

According to another aspect of the present invention the mounting is formed from a single annular hollow member of deformable elastomeric material constructed so that when viewed in cross-section it has two deformable limbs of resilient elastomeric material.

The two limbs may, alternatively, be in the form of legs separate from one another along a greater part of each of their lengths as opposed to being part of a hollow member.

The cross-section in which the limbs are located may be a single cross-sectional plane or a cross-section taken in two planes angled relative to each other. Thus, in addition to relating to a mounting formed either with a hollow member or having just two individual legs or limbs, the present invention relates also to mountings having more than two individual limbs.

The limbs may be shaped and disposed such that when caused to buckle the two limbs will move inwardly towards each other or they may be shaped and disposed so that when caused to buckle they will separate away from one another. Preferably in the case where the mounting is formed from a hollow member the limbs as seen in cross-section are shaped and disposed to move outwards when caused to buckle.

In mountings in accordance with the present invention at least part of the opposing faces of the limbs, forming internal faces of the mounting, may be contoured so as to provide the preferential regions of bending or buckling.

Preferably the limbs have similar deflection characteristics and are symmetrically disposed relative to each other in such a manner that when a load is applied to the mounting in a direction substantially longitudinally of the limbs the forces created by each limb in a plane perpendicular to said direction are balanced.

The limbs may be formed integral with each other at one or both of their ends or they may be spaced and/or separate from each other at one or both of their ends.

Where the limbs are spaced they may be secured in spaced relationship by a linking portion of material which, for example, can itself be formed integral with an end of each limb. The linking portion may be in the form of a cross-member which maintains at least one end of each limb in a predetermined spaced relationship from one end of the limb.

The cross-member may be rigid or it may be formed of resilient elastomeric material.

The ends of the limbs may be bonded to a support member or may be provided with securing means to permit attachment to a support member. Preferably the ends of the limbs are directly engaged or engageable by two members between which the mounting may be located so that at least any initial relative movement between said members results in the limbs being subjected substantially only to tension or compression forces.

The limbs may be formed substantially integral with each other at one of their ends and the other ends of the limbs may be arranged spaced from each other in such a manner that the mounting is substantially V-shaped, or V-shaped when viewed in cross-section. The other ends of the limbs may be secured in spaced relationship by means of a rigid cross-member. The ends of the limbs may be bonded to the rigid cross-member or formed integrally with securing means for attachment to the rigid cross-member.

The rigid cross-member may be formed from a strip of sheet metal material shaped along its length to provide inclined surfaces and the spaced ends of the limbs may be adapted to engage said inclined surfaces. In the case of a mounting having just two limbs the sheet metal strip may be formed with a pair of symmetrically disposed inclined surfaces.

By contrast to a mounting formed with two or more independent limbs or legs and having contours on the opposing faces of the limbs, in the case of a mounting having a single annular hollow member, preferential regions of bending or buckling may be formed by contouring those internal surfaces of the member which form parts of the hollow member constituting the limbs.

In mountings formed with a hollow member it is preferable that a cross-member, which may be rigid or of resilient elastomeric material, extends over each end of the hollow member so as to form a closed internal chamber within the mount or else the limbs as seen in cross-section may be joined together integrally at their ends. The internal chamber may be sealed permanently and filled with a damping fluid, or an orifice may be provided in the hollow member or one of the cross-members to permit a flow of damping fluid to and/or from the internal chamber.

In preferred embodiments of the invention the limbs are contoured such that as the mounting is subjected to load in a direction longitudinally of the two limbs, each limb will first undergo axial compression until a point of instability is reached when further application of a substantially constant load will cause the limb to buckle and deflect further by bending. Preferably the limbs are contoured such that up to the point of instability at least the forces due to axial compression are substantially greater than shear forces in the limbs.

The elastomeric material of mountings in accordance with the present invention may be natural or synthetic rubber, ethylene propylene diene monomer, polybuta-

diene, or polyurethane. They may, alternatively, be formed from any other suitable material, the most suitable materials being those which have a high dynamic stiffness and preferably also a good damping capability. Furthermore, the material may be of a kind which has an increasing dynamic to static stiffness ratio over the deflection range of the mounting.

The invention also provides an assembly and article including an assembly in which a first member is resiliently supported relative to a second member by means of one or more elastomeric mountings in accordance with the present invention. In particular the invention provides an arrangement in which a vehicle bumper is mounted on a vehicle by means of, for example, two elastomeric mountings in accordance with the present invention. The mountings may be disposed parallel to the direction of the length of the vehicle or the mountings may be disposed obliquely relative to said direction so as to provide better energy absorption to oblique impacts.

Six embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings in which:

FIG. 1 shows a side elevation of a mounting and attachment means for a mounting in accordance with the present invention;

FIG. 2 shows a plan view of the mounting and attachment means shown in FIG. 1;

FIG. 3 shows the mounting of FIG. 1 in a deflected condition;

FIG. 4 shows in plan view an arrangement of a bumper mounted to a vehicle by the use of mountings shown in FIGS. 1 and 2;

FIG. 5 shows a side elevation of the arrangement shown in FIG. 4;

FIG. 6 shows a dynamic load-deflection characteristic for the mounting shown in FIG. 1;

FIG. 7 shows a modified form of the mounting and attachment means shown in FIG. 1;

FIG. 8 shows a side elevation of another mounting in accordance with the present invention;

FIG. 9 shows a plan view of the mounting of FIG. 8; FIG. 10 shows a modified form of the mounting shown in FIG. 8;

FIG. 11 shows a side elevation of yet another mounting in accordance with the present invention;

FIG. 12 shows a plan view of the mounting of FIG. 11;

FIG. 13 shows a modified form of the mounting shown in FIG. 11;

FIGS. 14 and 15 show the mountings of FIGS. 12 and 13 respectively, in a deflected position;

FIG. 16 shows a typical static load-deflection graph for mounting of the kind shown in FIGS. 8 and 10;

FIG. 17 shows a sectional elevation of another mounting in accordance with the present invention;

FIG. 18 shows a plan view of the mounting of FIG. 17;

FIG. 19 shows a typical load-deflection graph for mounting of FIG. 17;

FIG. 20 shows a cross-sectional elevation of a modified form of the mounting shown in FIG. 17, and

FIG. 21 shows a typical load-deflection graph for the mounting of FIG. 20.

FIG. 22 shows a side elevation of another modified form of mounting.

In one embodiment of the invention, illustrated in FIGS. 1 and 2, an energy-absorbing mounting of elastomeric material comprises a pair of limbs 10 in the form of leg members of solid cross-section, and the leg members 10 are formed integral with each other at one end of each leg member. The mounting is therefore substantially V-shaped in cross-section, and has at the junction of the two leg members, an apex region 11 to which a support member or plate 12 is bonded.

The free ends 13 of the leg members, being the ends furthest from the apex region 11, are maintained spaced from each other by a sheet metal steel strip 14. The sheet metal strip 14 is formed with two symmetrically disposed inclined surfaces 15 to which the free ends of the leg members are bonded with each inclined surface extending substantially though not necessarily exactly, at right angles to the longitudinal direction of the associated leg member 10.

The elastomeric material of each leg member 10 is a high damping, and high dynamic to static stiffness ratio rubber having a butyl base and being highly loaded with carbon black to give a shore hardness of 80. A rubber of this or a similar kind is particularly suitable since it ensures a minimum of rebound force subsequent to deflection, provides a good energy-absorbing capacity, and an adequate resistance to deflection. The material may be formed into the desired shape by, for example, an injection molding or a compression molding technique.

The support plate 12 is provided with four screw threaded holes 16a to facilitate attachment of the mounting to the body of a vehicle, and each end of the steel strip 14 is formed with two holes 16 to permit the attachment of a bumper to the mounting. While the mounting may alternatively be arranged with the support member against the bumper and the cross-member adjacent the vehicle body, the aforementioned arrangement has the advantage that the bumper is supported over a greater portion of its length. It will therefore not necessarily be subjected to such high bending moments during impact and accordingly will experience less deformation.

FIGS. 4 and 5 show the manner in which a vehicle bumper 17 may be supported on a vehicle 18 by the use of two mountings of the kind described above with the four leg members 10 arranged to lie in a common horizontal plane. The depth of the molding is selected to provide a mounting having the required degree of energy absorption and preferably, as shown in FIG. 5, to fit inside the bumper so that it may deform and fold therein when under deflection.

Under frontal impact of the mountings when arranged as shown in FIGS. 4 and 5 the elastomeric leg members will absorb energy initially substantially only in compression, and after buckling, in bending inwardly and outwardly up to the end of the predetermined deflection position as shown in FIG. 3. If the impact speed is of such a magnitude that all of the impact energy is not then absorbed, the deformed leg members 10 will undergo further direct compression and thus continue to provide a cushioning effect.

In addition to absorbing direct frontal impact the V-shaped arrangement of each pair of leg members, and the provision of inclined surfaces to support the ends of the leg members, enables the mountings satisfactorily to absorb impact energy associated with oblique or side impacts at an angle of, for example, 30° to the lon-

gitudinal direction of each mounting. Mountings may, however, be mounted (as shown in FIG. 22) with their axes of symmetry oblique relative to the normal direction of travel (see arrow A) of the vehicle so as to improve further their ability to absorb energy associated with oblique or side impacts acting on a bumper 17a.

The dynamic load-deflection characteristic typically associated with a mounting of the kind described in respect of this embodiment of the invention is shown in FIG. 6. The curve shows the manner of variation in dynamic load and the deflection of the mounting as measured when attached to a solid barrier and impacted in a horizontal direction.

The energy absorbed by the elastomeric mounting is represented by the area under the relevant curve which indicates a typical mounting efficiency of 80 percent for a particular impact speed at ambient temperature compared with the energy associated with a square wave impulse of similar maximum deflection and maximum force. Furthermore, due to the very high damping properties of the aforementioned rubber material typically only 11 percent of the impact energy acts as rebound energy.

Depending on the particular properties of the material from which the mounting is formed, and in particular on the extent to which the dynamic to static stiffness ratio of the material increases with increase in rate of compression, for a given maximum deflection the energy absorbed may increase with increase of impact velocity.

The mounting may alternatively be formed in various other sizes while still retaining the basic deformation and buckling characteristics described, and the associated characteristics of high efficiency and high energy absorption. In addition to varying the sizes and properties of the mountings, the characteristics and load capability of a mounting may be modified for example by providing curved inclined surfaces 15a as shown in FIG. 7 as opposed to substantially flat inclined surfaces as shown in FIG. 1 while still retaining the basic deformation and buckling characteristics described. As also shown in FIG. 7, the ends of the limbs 10a at an apex region may alternatively or in addition be supported or arranged to be supported by inclined surfaces 12a.

In a second embodiment of the invention, illustrated in FIGS. 8 and 9, an energy absorbing mounting of elastomeric material comprises a pair of similar limbs 20 in the form of leg members of solid cross-section extending substantially parallel to one another and maintained spaced from each other by an integral elastomeric cross-member portion 21 which extends between one end of each leg member. The two leg members 20 are contoured on their opposing, or inner, faces 22 in order to provide points of preferential bending, and the similar leg members are symmetrically disposed relative to the cross-member so that they can deflect in a common plane with zero resultant force in any direction perpendicular to the direction during normal compression. The elastomeric material of each leg member 20 is a high damping and high dynamic to static stiffness rubber compound so as to ensure the minimum of rebound force subsequent to deflection, and to provide a good energy-absorbing capacity.

The free end 23 of each leg member, being the end furthest from the cross-member 21, is formed with a pair of lip portions 24 to permit the mounting to be secured by means of a metal clamp 25 to, for example,

the bumper of a motor car. The cross-member 21 is formed with a hole through which a flanged pin 26 may extend to secure the mounting to the body or chassis of a motor car.

In a third embodiment of the invention illustrated in FIG. 10 an energy-absorbing mounting is constructed substantially as described in respect of the second embodiment of the invention except that a first support plate 30 is bonded to the free ends 31 of the leg members and a second support plate 33 is bonded to the cross-member 32.

The first support plate 30 maintains the free ends 31 of the leg members in a predetermined spaced relationship, and a pair of holes 34 are provided in the plate to permit attachment to a first support member. The second support plate is provided with a pair of screw-threaded studs 35 by means of which the mounting may be secured to a second support member.

In a fourth embodiment of the invention, illustrated in FIGS. 11 and 12, a mounting is constructed substantially as described in respect of the second embodiment of the invention except that a cross-member portion 40 is provided at each end of the mounting. The mounting may be secured to first and second support members by means of flanged pins 41 extending through holes provided in the cross-members 40 or in an alternative arrangement, illustrated in FIG. 13, there may be bonded to each cross-member a support plate 42 provided with a pair of screw-threaded studs 43.

When a mounting of the kind described in any of the three preceding embodiments is subjected to compression by movement of the support members towards each other, the leg members are initially subjected substantially only to axial compression until a point of instability is reached when the mounting will continue to deflect for as long as the magnitude of the applied load is increased. At a particular value of the applied load, dependent on the manner in which the leg members have been contoured, buckling will occur at the preferential regions of bending and further deflection of the mounting will occur as the leg members bend away and separate from each other under the action of a substantially constant applied load approximately equal to the load at which buckling first occurred.

FIGS. 14 and 15 show in a fully-deflected condition mountings having one and two cross-members, respectively, and FIG. 16 shows a typical static load-deflection graph for mountings of this kind.

On initial application and increase of applied load the mountings will deflect in the manner shown by the first part of the dotted line, between points "a" and "b" approximately, and determined substantially by the stiffness of the mountings in axial compression. Buckling then occurs and the mounting continues to deflect under the application of a substantially constant load as shown in regions "b" to "c" approximately. Beyond this deflection, not shown on the graph, the limb will be subjected to further direct compression and the stiffness of the mounting will increase.

Where the mounting is used to attach a bumper to a motor car the load under which the mounting buckles, and continues to deflect with substantially zero stiffness, is selected to correspond to the maximum acceptable rate of deceleration which can be imposed on the vehicle as energy is absorbed by the mounting.

A theoretically ideal mounting arranged to offer maximum resistance to deflection throughout the

whole of its deflection range, corresponding to the maximum rate of deceleration which would acceptably be experienced by occupants of the vehicle, would have the ability to absorb the maximum amount of energy within those limitations of load and deflection. Its efficiency would be 100 percent and its load deflection curve would be as shown by the straight zero-stiffness line "d" of FIG. 16.

A mounting of the kind described herein typically has, by comparison, an efficiency of at least 75 percent at ambient temperature in that it is capable of absorbing three-quarters of the energy which could be absorbed by a theoretically ideal mounting as impacted when mounted on a vehicle. This is shown in FIG. 16 in which the area under the load-deflection curve *a-b-c* is approximately three-quarters of the area under the load deflection curve (in this case a straight line) of the theoretically ideal mounting. It therefore represents a significant improvement over conventional elastomeric mountings which have a constant non-zero stiffness throughout the greater part of their deflection range and which are therefore inefficient insofar as they cause less than the maximum acceptable rate of deceleration over the greater part of their deflection range when impacted in such a manner that said maximum rate is attained over a part at least of the deflection range.

Where it is desired for a particular application to provide a mounting which is an even better approximation to a theoretically ideal mounting, a mounting of a kind in accordance with the present invention may be prestressed by limiting the movement of the ends of the mounting away from each other so that the leg members are always stressed under a load at least equal, for example, to that which would cause buckling.

In the case of a mounting for securing a bumper to a motor car it may, however, be preferred not to prestress the mounting in this manner. Thus, by providing a non-zero stiffness characteristic during initial deflection of the mounting, the mounting may absorb low energy bumps without subjecting the occupants of the vehicle to a level of deceleration which while acceptable in an emergency would be undesirable in cases of normal low-energy bumps.

In a fifth embodiment of the invention, illustrated in FIGS. 17 and 18 an energy-absorbing mounting formed of rubber comprises a limb 50 in the form of a single annular hollow limb member sealed at each end by a circular cross-member or end member 51. A support plate 52 is bonded to each end member and provided with four screw-threaded studs 53 by which the mounting may be secured to a support member.

The internal surface 54 of the leg member is contoured to provide an annular depression midway between the ends of the mounting, the region of the annular depression acting as a preferential region of bending. A small pipe 55 extends through a hole in the base member 51 and support plate 52 at one end of the mounting to permit gas or other fluid to flow to and from the internal chamber 56 formed within the mounting.

In a mounting of this type the overall load-deflection characteristic may be modified by arranging fluid flow through the small pipe 55 to provide damping supplementary to that of the rubber leg member 50. Thus, as shown in FIG. 19, the rate of energy absorption by gas damping (see curve B) may be comparatively high dur-

ing initial deflection of the mounting so as to supplement the energy absorption by the rubber (curve A) and thereby provide the improved resultant load-deflection characteristic indicated by curve C.

In a sixth embodiment of the invention, illustrated in FIG. 20 an energy-absorbing mounting is formed from rubber and comprises an annular leg member 60 sealed at each end by a circular base member 61. A flanged pin 62 extends through a hole in each base member to permit the mounting to be secured to a first and second movable member.

The internal chamber 63 of the mounting contains pressurized gas which may have been admitted to the chamber through a suitable orifice in the mounting, or which may have been sealed within the mounting by molding the mounting in a pressurized environment.

In a mounting of this kind the leg member 60 is contoured so that it provides a high stiffness during later deflection, as shown by curve A of FIG. 21. Curve B shows that the stiffness of the mounting due to the action of the gas increases continually with deflection and, in conjunction with the effect of the rubber material of the leg member, there results the load-deflection curve of the mounting as shown by curve C.

In the fifth and sixth embodiments of the invention the elastomeric material of the leg member is subjected to hoop stresses in addition to stresses associated with buckling as described in respect of the earlier embodiments of the invention. These mountings are therefore capable of absorbing greater levels of energy and hence are particularly suitable for heavy duty applications.

Energy-absorbing mountings in accordance with the present invention are suitable not only for the mounting of bumpers on motor vehicles, but also for applications such as fenders, protection of equipment on board ship, and the mounting of equipment in transit packagings. Particularly, as compared with hydraulic dampers, they are easy to install and have the added advantages of being able to absorb energy associated with forces acting over a wide range of angles relative to the axis of symmetry of the mounting.

Having now described my invention — what I claim is:

1. A resilient vehicle bumper mounting comprising two discrete leg members of resilient elastomeric material formed integral with each other at one of their ends and arranged in a substantially V-formation, a rigid cross member which maintains the other ends of the leg members in spaced relationship with the other ends being bonded to support surfaces of the cross member which are inclined relative to a plane perpendicular to an axis of symmetry between the leg members, each leg member being contoured along its length to provide a preferential region of bending, and each leg member being shaped and disposed so that when subjected to a load applied longitudinally of the two leg members the leg members will first deform in a stable manner and then be caused to bend or buckle.

2. A mounting according to claim 1 wherein said deformation of the leg member in a stable manner occurs under the action substantially only of compressive forces.

3. A mounting according to claim 1 wherein the ends of the leg members are engaged or engageable by two elements between which the mounting may be located.

4. A mounting according to claim 1 wherein the leg members are shaped and disposed such that when

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caused to buckle the two leg members will move inwardly towards each other.

5. A mounting according to claim 1 wherein the leg members are shaped and disposed such that when caused to buckle the two leg members will separate away from one another.

6. A mounting according to claim 1 wherein at least part of the opposing faces of the leg members are contoured to provide preferential regions of bending and buckling.

7. A mounting according to claim 1 wherein the leg members have similar deflection characteristics.

8. A mounting according to claim 7 wherein the leg members are shaped and disposed such that when a load is applied to the mounting in a direction substantially longitudinally of the leg members there is no relative movement between the integral ends and the spaced ends of the leg members in a plane perpendicular to said direction.

9. A mounting according to claim 1 wherein one end at least of the mounting is provided with means to permit attachment to a supported or a supporting element.

10. A mounting according to claim 9 wherein a support plate is bonded to the one end of the leg members to permit attachment of the mounting to a supporting or supported member.

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11. A mounting according to claim 1 wherein the plane of each inclined surface is substantially normal to the longitudinal direction of the leg member bonded thereto.

12. A mounting according to claim 1 wherein the leg members are shaped and disposed such that when caused to buckle the two leg members move inwards towards each other in the region of the apex of the mounting and separate away from one another in regions of the leg members distant from the apex of the mounting.

13. An assembly comprising a mounting according to claim 1 and a supporting member secured thereto.

14. An assembly according to claim 13 wherein the mounting is located between a supported member and said supporting member.

15. An assembly according to claim 13 wherein at least two mountings are provided and at least two mountings are disposed with their axes of symmetry oblique relative to the normal direction in which forces would be transmitted to the supporting member by said mountings.

16. An assembly according to claim 13 in which the mounting is attached to a vehicle body.

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