United States Patent

[11] 3,572,745

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[21] Appl. No. **843,288**
[22] Filed **July 14, 1969**
[45] Patented **Mar. 30, 1971**
Continuation-in-part of application Ser. No. 721,558, Apr. 1, 1968, now abandoned, which is a continuation-in-part of application Ser. No. 562,344, July 1, 1966, now abandoned, and a continuation-in-part of 649,502, June 28, 1967, now abandoned.

[54] **MULTIPLE AXLE SUSPENSION**
10 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **280/104.5,** 267/21
[51] **Int. Cl.** **B60g 5/00**
[50] **Field of Search** 280/104.5; 267/21, 63

[56] **References Cited**

UNITED STATES PATENTS

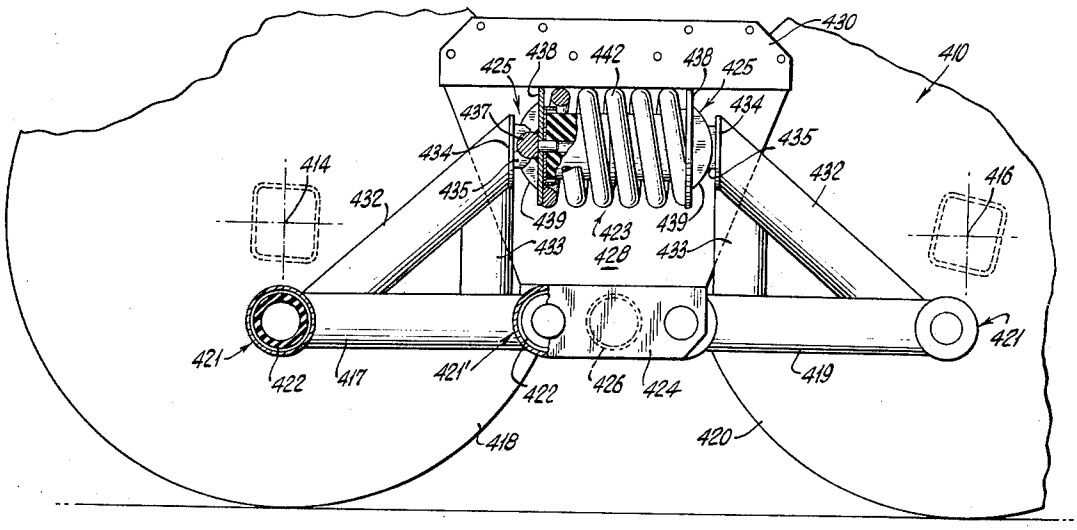
3,003,781	10/1961	Black	280/104.5
2,872,207	2/1959	Hirst	280/104.5
2,131,083	9/1938	Winn	280/104.5
2,197,727	4/1940	Ledwinka	267/21
1,701,292	2/1929	Broadwell	267/21

FOREIGN PATENTS

1,050,691	9/1953	France	267/21
461,583	2/1937	Great Britain	280/104.5

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ABSTRACT: The present invention includes a multiple axle articulated suspension structure for vehicles wherein road and tire excitations of each axle are isolated from its opposing axle as well as from the sprung mass, through deflections of pressure-resistant, load-equalizing supports. The load-equalizing supports include elastomeric members which interconnect vertically extending arms of opposing rocker beams, said rocker beams being trunnioned to a supporting structure and having longitudinally extending arms supported by opposing axles. The elastomeric members exhibit varying spring rate when deflected.



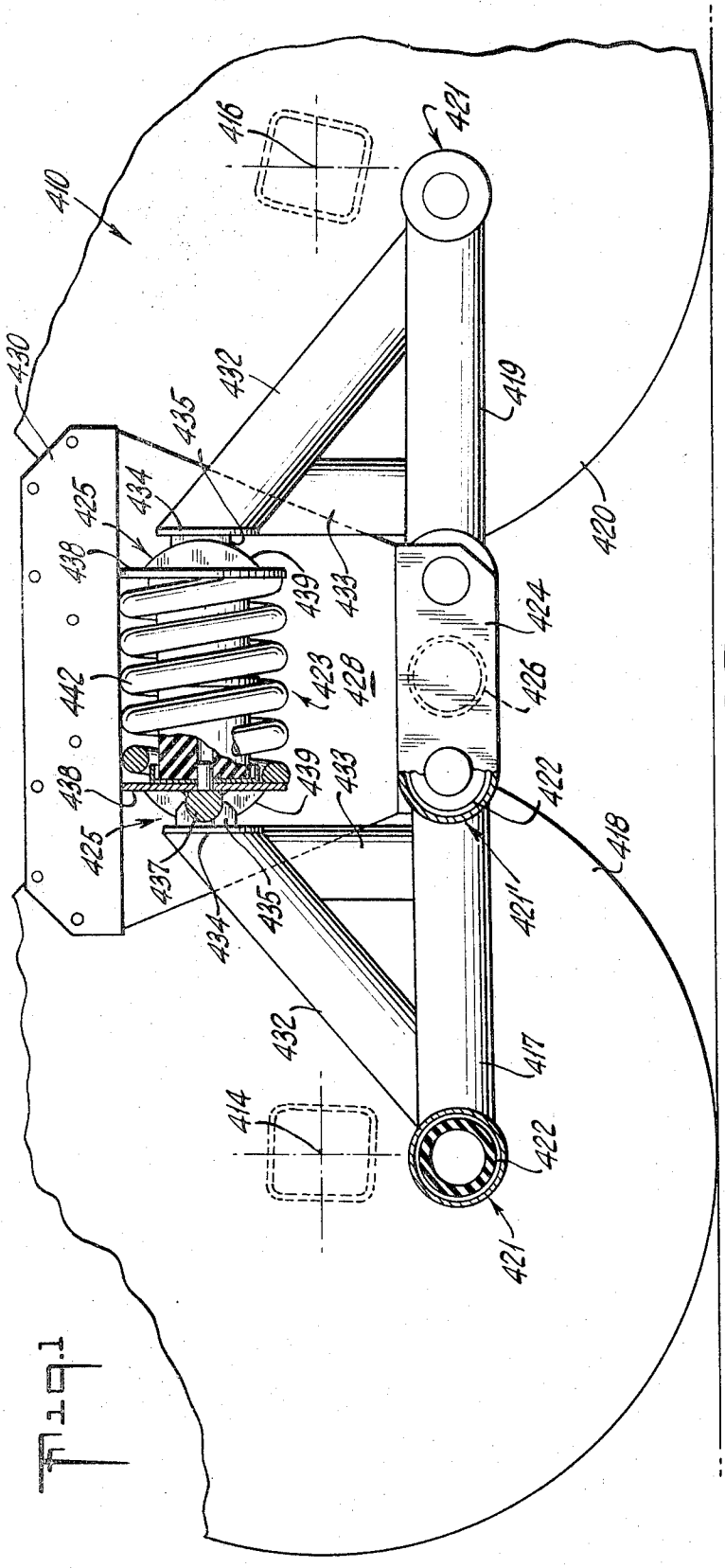


FIG. 1

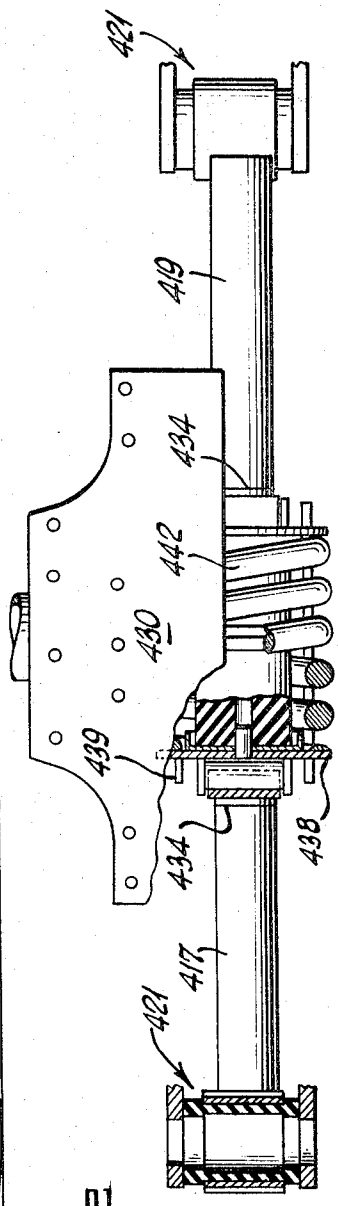
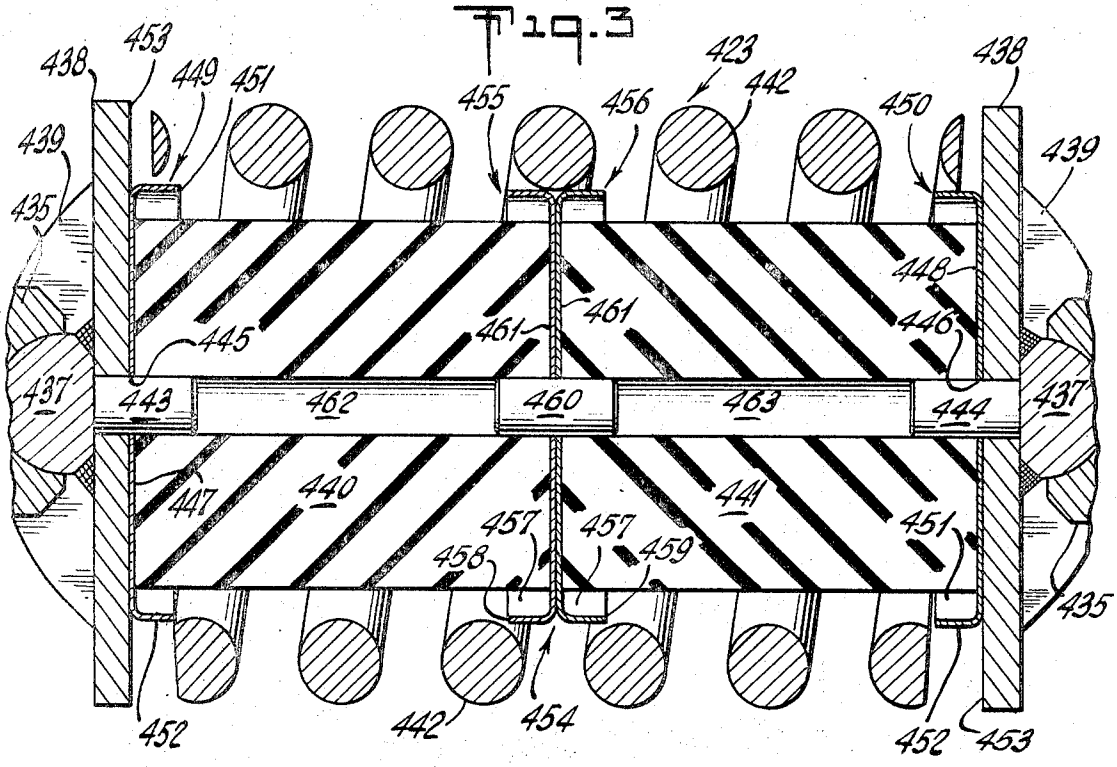


FIG. 2

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FIG. 3



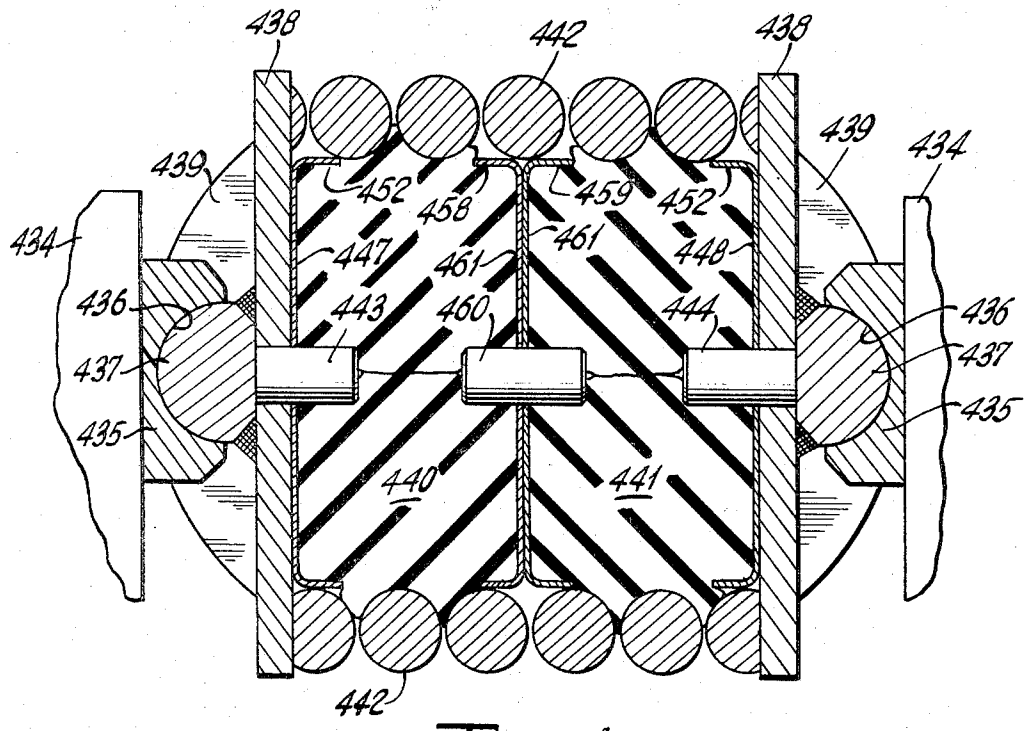


FIG. 4

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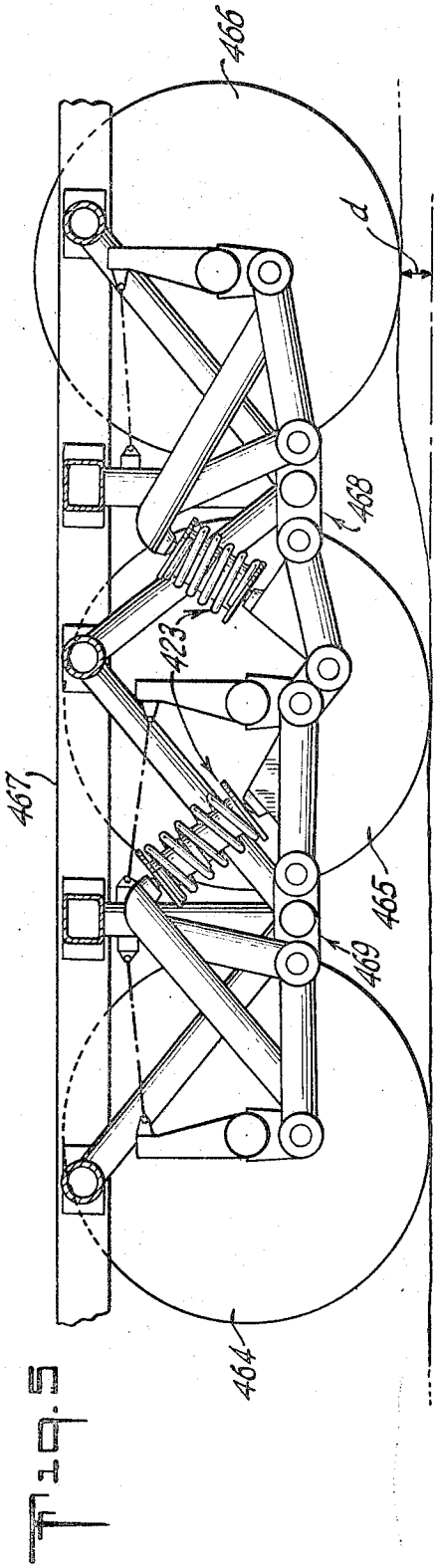


Fig. 5

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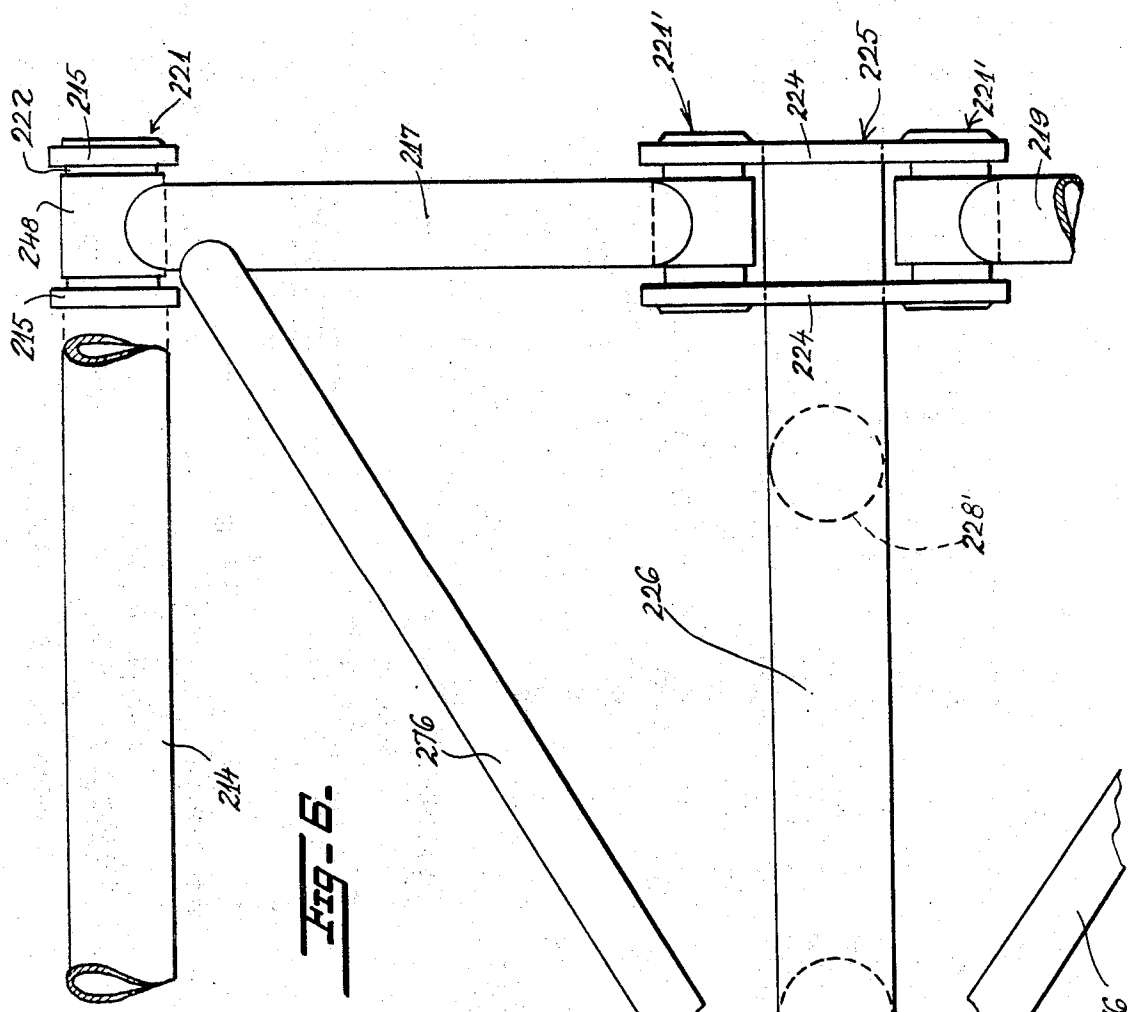


Fig-6.

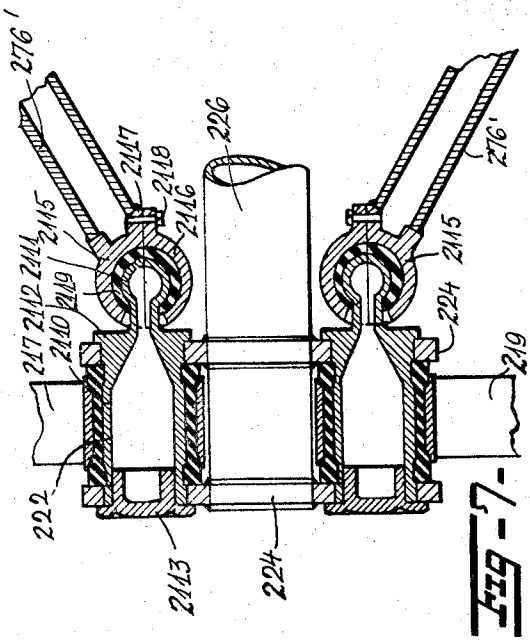


Fig-7.

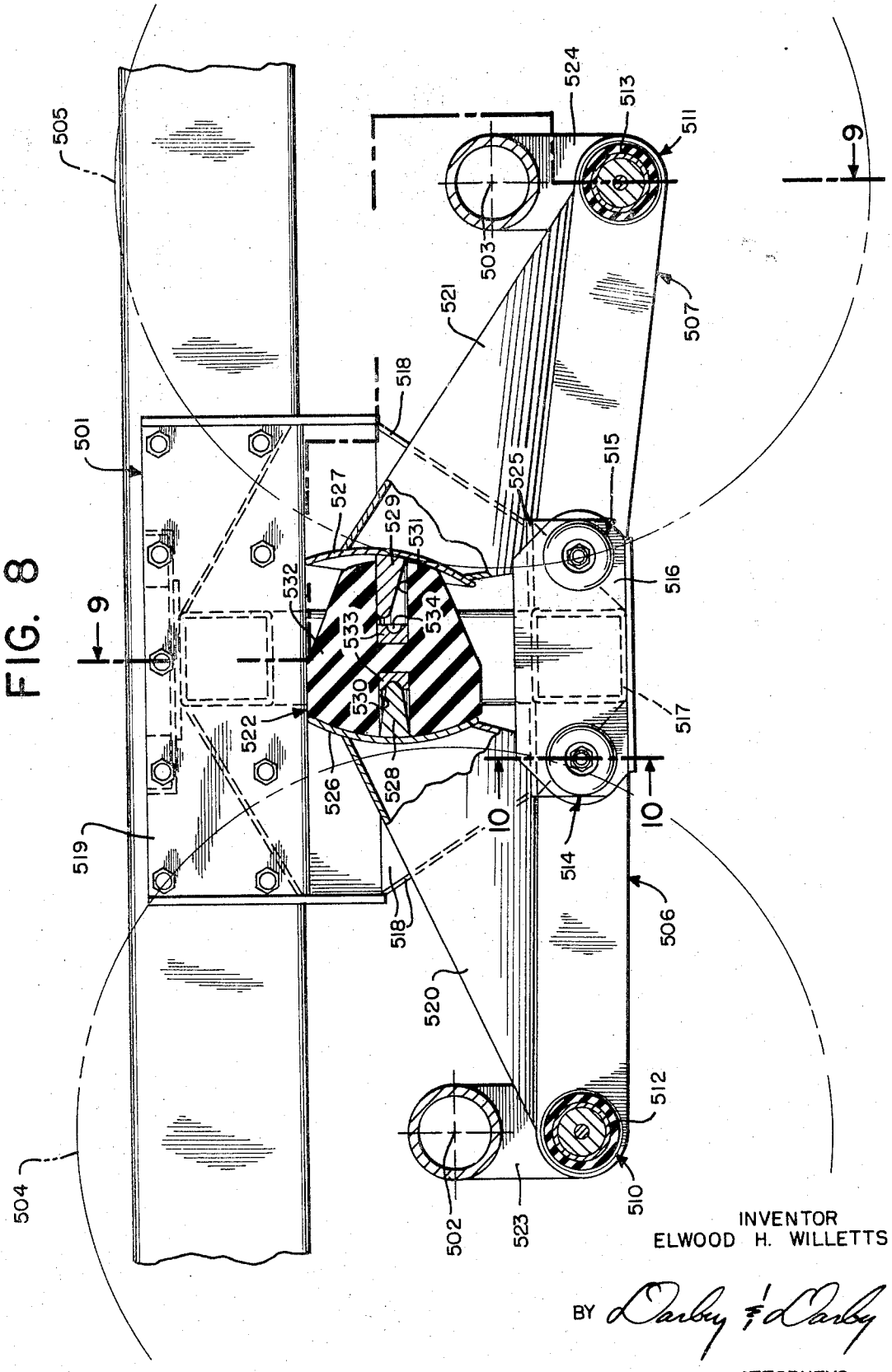
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FIG. 8



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FIG. 9

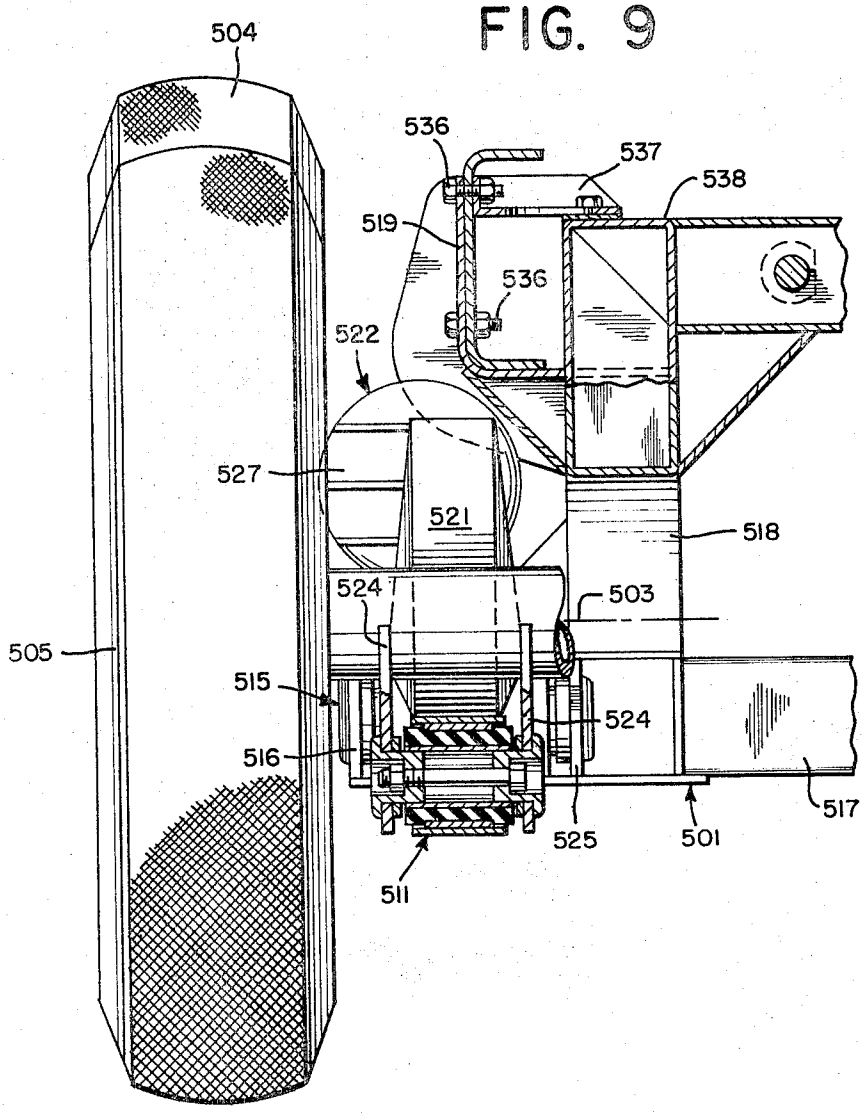
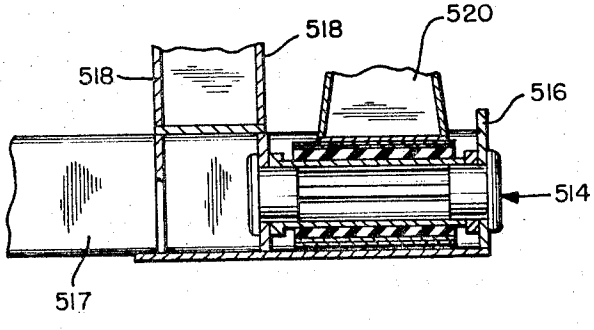


FIG. 10



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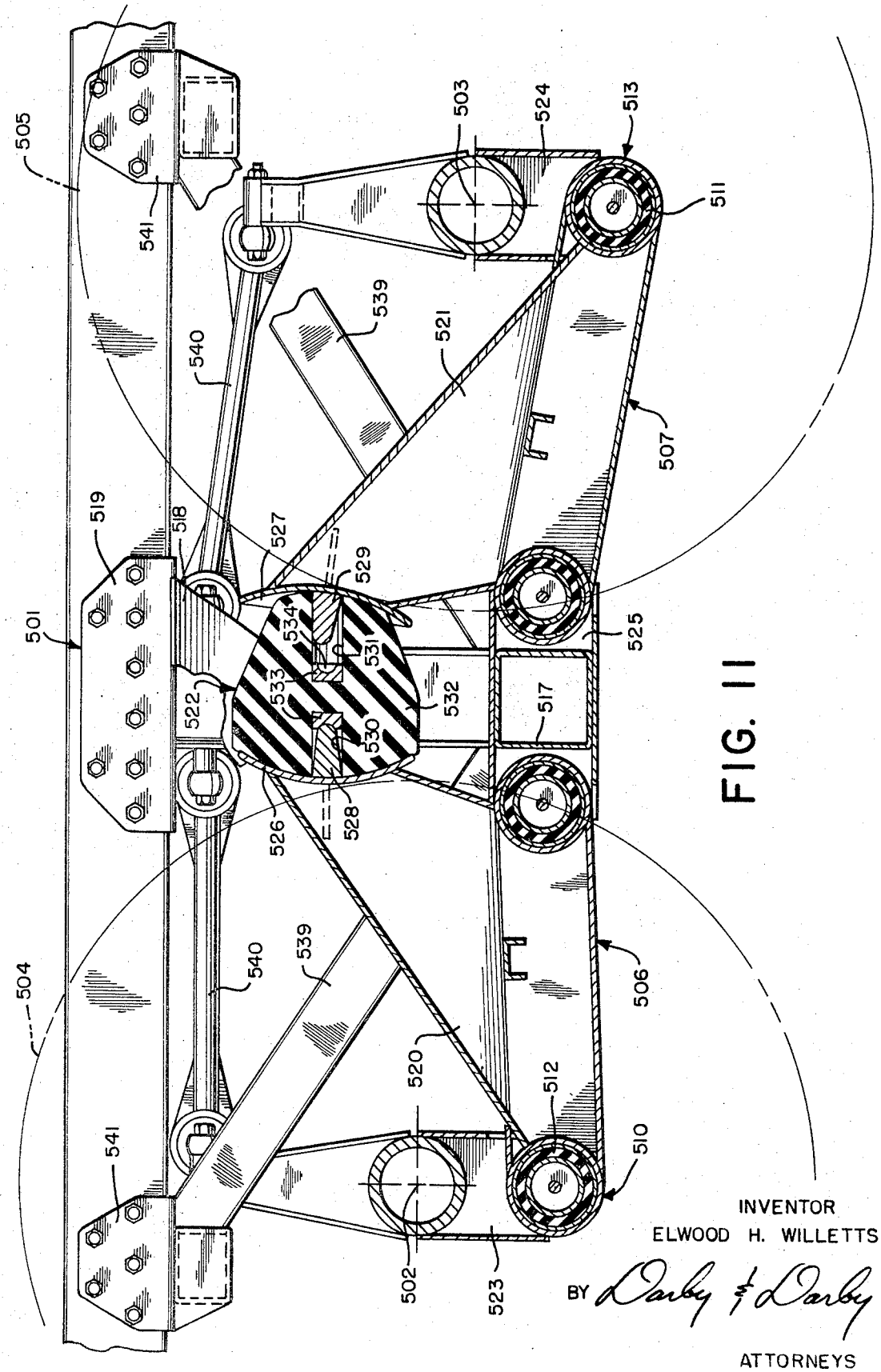


FIG. 11

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MULTIPLE AXLE SUSPENSION

This is a continuation-in-part application of Ser. No. 721,558, filed Apr. 1, 1968, now abandoned, which in turn is a continuation-in-part application of both Ser. No. 562,344, filed Jul. 1, 1966 and now abandoned, and Ser. No. 649,502, filed Jun. 28, 1967 and now abandoned.

This invention relates generally to suspension structures for use with multiple axle bogies of trucks, trailers and railroad cars, and more specifically this invention relates to a composite elastomerically damped compression-resistant helical spring isolator for use with a multiple axle suspension structure.

A great deal of interest has been directed toward suspension systems for use in bogies, trailers railroad cars and the like because of the stalemate that appears to have come about in efforts to produce a suspension structure which will effectively minimize or eliminate the undesirable conditions commonly known as wheel hop, impact transfer from one axle to another, and other vibrational phenomena tending to produce driver fatigue and uneven riding. Suspension systems currently in use employ means such as an undamped beam affixed to both axles or an undamped beam hingedly interconnecting axle mounted leaf springs. In both of these cases, as an example, the excitations of each axle, which may be produced by road conditions, are transmitted to other respective axles by such undamped means, and in some cases the excitation is amplified in transmission.

Presently known suspension structures include a geometry of construction which produces either no assistance in directional control of the path of a vehicle or a harmful misdirection of control through converging axle structures extending outwardly from, rather than inwardly to, the center of path curvature. Furthermore, no constructions freeze the wheelbase against change, but rather divert same to an opposite directional path of movement, the latter case obviously mitigates against use of such a suspension in highway transport.

A principal object of this invention is to provide an elastomerically damped resilient load-equalizing support means, reactive on opposing axles of a multiple axle vehicle suspension, whereby equalization of loads between axles are cushionedly preserved by the same means which deflectively isolate the excitations of each axle from an opposing axle as well as from the sprung mass.

Another object of this invention is to provide a multiple axle suspension structure as above attachable externally of a vehicle frame or subframe, which further provides transverse support for the frame.

Still another object is to provide a suspension structure which exhibits relatively low frequency for an unladen vehicle, while also providing progressive resistance against transverse roll of the vehicle when loaded.

A further object of this invention is to provide consistently uniform equalization of load among the respective wheels of the suspension.

Yet another object is to provide a suspension which eliminates wheel hop thereby reducing the necessary stopping distance of the associated vehicle upon brake application. Vertical brake torque reactions in the vehicle frame structure are avoided.

Another object of the present invention is to isolate the excitations of one axle from its counterpart for the prevention of resonance in semirigid sprung-mass structures.

A yet further object is to provide reactive resistance to suspension deflection so as to reduce by one-half the amplitude of reflection of the sprung-mass, and to enable a lower spring rate per axle for any given natural frequency of a suspension.

Another object if to provide an elastomeric damper acting in series with a helical spring to isolate dynamic forces of road shock and to dampen natural vibrations of the spring.

A still further object is to provide an elastomerically damped compression-resistant isolator for use with a multiple axle vehicle suspension structure.

Yet another object of the present invention is to provide a suspension structure wherein there is a relative vertical disposition of the hinge location of an articulated suspension beam, a suspension spring, and axle centers in order to provide inherent self-steering control of the bogie to a changing path of vehicle movement. Operational advantages include a reduced turning radius of the vehicle with less tire scuffing and less tractive resistance.

The present invention fulfills the aforementioned objects and overcomes limitations and disadvantages of prior art solutions to the aforementioned problems as follows:

In one embodiment of the present invention an elastomerically damped compression-resistant isolator is provided for use with a multiple axle vehicle suspension structure. A vehicle frame structure including axles journaled in axle housings have secured thereto transversely spaced load support brackets extending intermediate the axles. Means for isolating excitations of each of said axles from the sprung mass of the vehicle and from each other include a composite deformable spring assembly. This spring assembly includes a pair of opposed parallel end plates extending at right angles with respect to a longitudinal axis of the assembly. Cup-shaped members each defining a receptacle portion having an open end are disposed adjacent each of the end plates such that the respective open ends of the receptacle portions face one another.

A hole is formed through the bottom of each cup-shaped member such that a pin integral with each of the end plates extends therethrough. A double cup-shaped assembly is disposed coaxially intermediate the aforementioned cup-shaped members and end plates in integral back-to-back relationship such that each of two receptacle open ends, facing opposite directions, each face a respective open end of the receptacle portions of the cup-shaped members adjacent the end plates. A pin extends coaxially through the double cup-shaped assembly such that the extremities thereof extend beyond both of the opposed openings.

A cylindrical mass of elastomeric material in two equal lengths is formed with cavities extending axially therethrough, each length extending between and into the two resulting pairs of receptacles facing one another such that the pins engage portions of the respective cavities in the elastomer.

The helical spring is coaxially disposed about the elastomer such that the inner diameter of the helical spring is in contact with the outermost peripheral portions of all cup-shaped members. The resulting spring assembly thus includes said helical spring and elastomer core being stressed in parallel upon compressive forces moving the end plates toward one another.

In a preferred form of the invention the vertically extending arms of opposing rocker beams terminate in spherically concave seats which are arcuately engaged by interconnecting load equalizing support means. An initially low spring rate is afforded the unloaded vehicle, while a progressively increased spring rate is exhibited as increased loads are applied to an elastomeric member having a varying cross section.

The invention will be more clearly understood from the following description of specific embodiments of the invention together with the accompanying drawings, wherein similar reference characters denote similar elements throughout the several views, and in which:

FIG. 1 is a longitudinal sectional view of an articulated beam suspension structure wherein an elastomerically damped composite helical spring assembly is used according to the present invention;

FIG. 2 is a fragmentary sectional plan view of the embodiment of the present invention shown in FIG. 1;

FIG. 3 is a fragmentary sectional view through the spring assembly shown in FIG. 1;

FIG. 4 is a fragmentary sectional view of the spring assembly of FIG. 3 in a compressed state;

FIG. 5 is a fragmentary longitudinal elevational view of another embodiment of the present invention utilizing an elastomerically damped composite spring assembly;

FIG. 6 is a partial plan view showing a track bar assembly which can be used with the articulated beam suspension structure;

FIG. 7 is a fragmentary sectional view of a ball-shaped track bar connection;

FIG. 8 is a fragmentary sectional elevational view of an embodiment of the invention;

FIG. 9 is a fragmentary sectional elevational view looking along the line 9–9 of FIG. 8;

FIG. 10 is a fragmentary sectional elevational view looking along the line 10–10 of FIG. 8; and

FIG. 11 is a fragmentary sectional plan view of a trailer suspension structure according to this invention.

Referring now in detail to the drawings, FIGS. 1—5 show structures of this invention wherein an elastomerically damped composite helical spring assembly is provided which is pivotally interacting with a rocker beam assembly to form an articulated suspension structure which pressure reactively joins axles of a tandem axle structure.

FIG. 1 shows a suspension system or assembly **410** employed in association with a truck or trailer frame. The suspension system includes a pair of axles having centers **414** and **416**, respectively, defined by the centerlines shown in FIG. 1, said axles being longitudinally spaced along the vehicle with supporting wheels **418** and **420**, respectively. Beams **417** and **419** are trunnioned in bushing assemblies **421**, which bushing assemblies may be carried by beam hanger brackets (not shown) or other suitable support means. Bushing assemblies **421** are lined with bushings **422** which are deflectable radially, torsionally and axially. The ends of beams **417** and **419** are trunnioned in bushing assemblies **421'**, which are connected to and support the sprung load at flanges **424** located at the ends of transversely extending horizontal tube **426**, tube **426** transmitting the load upwardly through brackets **428** on transversely opposite sides of the structure and thence through flanged supports **430** to opposite sides of the vehicle frame. It is within the scope of the present invention to include gussets and stiffening members such that brackets **428** are transversely supported.

Each of beams **417** and **419** is provided with a tubular member **432** and a substantially vertically extending tubular member **433**. Tubular members **433** are secured as by welding to beam **417** and member **432**, and beam **419** and member **432**, all of which extend upwardly to spring assembly **423**.

Spring assembly **423** is pivotally interconnected to each of tubular members **432** by means of joint **425**. A flange **434** is integrally formed on the upper ends of each of tubular members **432**, as by welding, such that flanges **434** are spaced from one another in substantially vertical planes. Socket members **435** extend normally with respect to flanges **434** such that concave cylindrical bearing surfaces **436** (FIG. 4) engage in pivotal sliding relationship, cylindrical members **437** having smooth convex bearing surfaces. Members **437** are secured as by welding to spring seat plates **438**, which are spaced apart and form the outer extremities of spring assembly **423**. Cylindrical members **437** are, at their transverse extremities, secured as by welding to plate members **439**.

Referring now to FIGS. **3** and **4**, spring assembly **423** is shown in an enlarged representation wherein two cylindrical elastomeric members **440** and **441** of substantially equal length are coaxially disposed within an outer helical spring **442**. Pins **443** and **444** are integral with spring seat plates **438** and extend coaxially toward one another through openings **445** and **446** in base portions **447** and **448** of end cup-shaped members **449** and **450**, respectively. In a preferred embodiment of the present invention end cup-shaped members **449** and **450** are secured as by welding to spring seat plates **438** and each includes a receptacle portion **451** bounded by flanges **452**. The outer surfaces of flanges **452** of end cup-shaped members **449** and **450** support the extremities of helical spring **442** and the inside diameters thereof. Surfaces **453** serve as bearing surfaces for the ends of spring **442**, upon spring seat plates **438** being moved toward one another to engage spring **442**.

Intermediate end cup-shaped members **449** and **450** is a double-cupped assembly **454** which has as one of its purposes the elimination of buckling of elastomeric members **440** and **441** upon axial compression thereof. Assembly **454** comprises two cup-shaped members **455** and **456** in back-to-back relationship and secured to each other such that receptacle portions **457** thereof formed by flanges **458** and **459** face in opposite directions toward the receptacle portions **451** of end cup-shaped members **449** and **450**, respectively. A pin or stud **460** is secured as by welding to the base portions **461** of cup-shaped members **455** and **456** and extends coaxially with pins **443** and **444**.

As shown in an unstressed condition in FIG. **3**, elastomeric member **440** extends into and between receptacle portions **451** and **457** and has formed axially therethrough a cavity **462** into which pins **443** and **460** project. Similarly, elastomeric member **441** extends between receptacle portions **457** and **451** on the opposite side of spring assembly **423** and has formed axially therethrough cavity **463** into which pins **460** and **444** project. It is within the scope of the present invention to have the overall length of the extremities of elastomeric members **440** and **441** exceed the relaxed length of helical spring **442** such that compression resistance is initially exhibited by the elastomeric members only and, upon further movement of spring seat plates **438** toward one another, the helical spring **442** and the elastomeric members will be loaded in parallel. During movement of spring seat members **438** toward one another, substantially frictionless guiding of spring **442** by the outer surfaces of the respective cup-shaped members engaging same is exhibited. Furthermore, the arrangement aforedescribed preserves axial alignment of the respective components such that warping or buckling is prevented, thereby insuring more favorable spring and dampening characteristics. The resistance to compression of the elastomeric members may be at least equal to that of the spring **442**. The relative dampening quality of the elastomeric members **440** and **441** may be selected for a given load deflection rate by proper selection of the material for the elastomer of the members. If pure rubber is used, for example, a very elastic deformation will be exhibited and the members will provide very little dampening and high deflection. If less elastic butyl rubber compound is employed, the elastomeric members may provide greater vibration dampening and yet less deflection per unit force applied thereto.

It is to be noted that it is within the scope of the present invention to vary the mean pitch diameter and the wire diameter of the helical spring **442** such that assemblies of varying combined spring constant are exhibited. Thus by interchanging helical springs with the elastomeric members disposed therewithin it is possible with the present invention to provide varying permutations and combinations of spring rate. It should also be noted that the present invention contemplates the use of elastomeric members exhibiting selected hysteresis characteristics which will not only supplement the compressive resistance of the helical spring but will also dampen the natural tendency of the helical spring to recycle or reverberate on impact. In addition, in a metal-to-metal bump position illustrated in FIG. **4**, the elastomeric members deform such that they protect the helical spring from excessive stresses in such solid condition.

The durometer of the elastomeric members may be preselected to give desired deflection and flow characteristics. Also, with the combined spring factors of these two effective spring members acting in parallel, a much lighter structure accomplishes isolation properties currently exhibited by much heavier structures. The presence of the elastomeric members within the helical spring **442** increases the spring rate of the spring system, and the helical spring is seen to be a desirable adjunct of the elastomeric members, which will offset the high ratio of static to dynamic deflections of the elastomeric members resulting from transverse roll on curves.

FIG. 4 shows spring seat plates **438** having been moved toward one another due to deflection of the axles of the vehicle between which spring assembly **423** is situated. Helical

spring 442 is compressed such that the outer surfaces of the helically wound wire component are adjacent one another or in contact. In the metal-to-metal condition shown in FIG. 4, it is to be noted that axial alignment of the respective components of spring assembly 423 has been maintained and the parallelism of spring seat plates 438 has also been maintained before, during, and after full load conditions.

FIG. 5 illustrates a further use of the composite helical spring assembly previously designated numeral 423. A three-axle structure is shown wherein three tires 464, 465 and 466 support a longitudinal extending frame 467. Two helical spring assemblies 423 form part of articulated beam structures which effectively transmit one-half the deflection load from each of the axles supported by wheels 464 and 466 to the centermost structure carried by wheel 465. FIG. 5 shows wheel 466 and its associated axle raised at an elevation *d* above the elevation of wheels 464 and 465 such that articulation of beam assembly 468 is exhibited, while relatively no articulation of beam assembly 469 is experienced. It is within the scope of the present invention to include constructions in which stub axles are used, as opposed to axles extending transversely across the entire width of a vehicle frame.

FIG. 6 shows a track bar arrangement which can be used with a suspension assembly according to this invention. Track bars 276 and 276' are rigidly secured at one side of the assembly to the outer axle end of the beams 217 and 219 adjacent axle beam hanger brackets 215, and extend transversely inwardly toward opposite ends of horizontal tube 226 to the opposite side of the assembly. These track bars are pivotally attached to ball-shaped elastomer bushings 278 located on the horizontal diametrical plane of horizontal tube 226. Relative transverse positioning of the axles and frame is provided through axle brackets 215, bushings assemblies 221, track bars 276, ball bushings 278, horizontal tube 226, laterals 228 and transverse members 229. This arrangement of track bars avoids frame stress concentrations occurring in conventional track bar frame anchorages, by distributing the load through the entire frame support structure assembly.

In FIG. 7, a modified form of construction is shown in which track bars 276' are pivoted upon ball head bolts 2110 having a ball head 2111, and are flanged at 2112 to be secured between spaced flanges 224 at the end of the horizontal tube 226 and secured to the opposite flange 224 by a nut 2113. Bolt 2110 serves as the pivot connection to the flanges 224 for the inner ends of beams 217 and 219 with sleeve bushings 222 therebetween. Track bars 276' are provided with split cap halves 2115 and 2116, the split half 2115 being integral with the end of the track bar 276' and the half 2116 being split therefrom and retained by flanges 2117 and bolts 2118 about an elastomer cover 2119 surrounding the ball head portion 2111 of the bolt 2110. This arrangement provides a hinge connection for the track 276' in the axial line of the articulated beam hinges thus avoiding an additional joint, otherwise required and transferring transverse loads thereby directly through the frame supports to the frame structure without supplemental brackets and connections therefor. The elastomer cover 2119 serves as an isolator of vibratory noise from the articulated suspension beam to the sprung mass.

The above-described forms of suspension have been found to improve isolation of destructive road shocks and to eliminate harmonic vibrations from rigid sprung structures throughout the entire load range. They will be lighter in weight and more economical in mass production than prior comparable suspension structures.

The use of undamped helical coil springs which are reactive on opposing levers of a tandem suspension are known to the art. In such structures wheel spindles in levers are hinged to the structure as closely as feasible to the ground, in order to minimize forward wheels wedging aft and upward upon the application of brakes. In such an undesirable condition, there is an increased loading of the forward wheels with a resultant unloading of the vehicle's rearward wheels, whereby the rear wheels slide and wheel hop results. This condition is compounded when road surface undulations are in phase with reverberations of the coil spring since, again, wheel hop results.

Among the shortcomings of prior art structures is the marked absence of widely spaced torsional connections with wheel spindles to minimize the wedging action tending to upset the load distribution between the vehicle wheels upon brake applications, as well as the absence of adequate damping means which will dampen spring reverberations.

In the present invention each axle is torsionally restrained within a widely spaced parallelogram pattern wherein the axle is hingedly positioned below by a connection to a rocker beam, and from above by a torque rod hinged to the top of a pillar which is integral with the axle.

A steel spring, such as mentioned above, usually has the advantage over an elastomer of exhibiting more favorable load-equalizing properties. Its resistance to static deflection is comparable to its resistance to dynamic deflection. Currently available commercial elastomers do not resist static deflection as well as they resist dynamic deflection. In the usual compounds of rubber or synthetic elastomers which are stressed in shear or compression, the ratio of static deflection to dynamic deflection as a result of loading ranges from 1.2 to 1, to 1.5 to 1. In the use of such load deflective elastomers for vehicle suspensions, the desired dynamic deflection to effect a low-frequency vibration or soft ride is limited by the permissible transverse roll of a moving loaded vehicle as its path is changed and centrifugal force imposes a static load on the already dynamically loaded elastomers disposed outwardly of the center of directional change of vehicle path.

An ideal elastomer for suspensions should have a ratio of static to dynamic deflections reversed such that transverse roll will not limit or restrict the softness of the ride for vehicles with current maximum legal heights.

Referring now in more detail to FIGS. 8—11 in which suspension structures are shown which will accommodate both trailer as well as truck frames, FIG. 8 includes an assembly 501 employed in association with a truck frame. The suspension system includes a pair of axles having centers 502 and 503, respectively, defined by the centerlines shown in FIG. 8, said axles being longitudinally spaced along the vehicle with supporting wheels 504 and 505, respectively. Wheels 504 and 505 are shown in phantom outline.

Beams 506 and 507 of rocker beam assemblies 508 and 509 are trunnioned in bushing assemblies 510 and 511. It is within the scope of this invention for bushing assemblies 510 and 511 to be carried by beam hanger brackets or other suitable support means. Bushing assemblies 510 and 511 are lined with bushings 512 and 513 which are deflectable radially, torsionally and axially. Opposite ends of beams 506 and 507 are trunnioned in bushing assemblies 514 and 515, which are connected to and support the sprung load at flanges 516 located at the ends of transversely extending horizontal tube 517, tube 517 transmitting the load upwardly through brackets 518 on transversely opposite sides of the structure and thence through flanged supports 519 to opposite sides of the vehicle frame. It is further within this invention to include gussets and stiffening members such that brackets 518 are transversely supported.

Each of beams 506 and 507 is integral with an upstanding, steel member 520 and 521, each of which extends to a load equalizer assembly 522. Steel members 520 and 521 are secured, such as by welding, to beams 506 and 507. It is to be noted that the entire suspension structure is constructed basically of light gauge, high-tensile strength steel to enable a minimum of tare weight, even where top torque rods are included to preclude the possibility of wheel hop, regardless of road surface or braking conditions. The isolation of the excitations of each axle from the opposite axle and from the sprung mass, without external forces or controls is unequalled by existing structures. All hinge centers are closely machined and rubber bushed so as to do away with adjustments and excessive lubrication requirements.

In the embodiment of the invention shown in FIG. 8, for example, bushing assemblies are carried by beam hanger brackets 523 and 524, each of which is welded to the lowermost side of the axle housings associated with axles 502 and 503. A suspension bolster 525 associated with flange 516 provides the support to which forces from beams 506 and 507 are conveyed via bushing assemblies 514 and 515.

Cup-shaped members 526 and 527 are secured, such as by welding, to the inner and uppermost portions of members 520 and 521 of rocker beam assemblies 508 and 509, respectively. Cup-shaped members 526 and 527 are situated such that their concave surfaces face one another, each of these surfaces providing the supporting surface for tapered, inwardly extending pilot members 528 and 529, respectively. Pilot members 528 and 529 extend into cavities 530 and 531 formed within a double-tapered elastomeric member 532 located between cup-shaped members 526 and 527. Member 532 includes a maximum diameter midlength portion, away from which tapered portions extend toward the cup-shaped members. In a preferred embodiment of the invention, the convex ends of the tapered elastomeric member terminate in a generally spherical surface.

A bumper member 533 is disposed within the innermost portions of each of cavities 530 and 531, this bumper member being formed with a receiving cavity 534 adapted to be penetrated by the tapered end of the pilot member already described.

For purposes of illustration, FIG. 8 shows vehicle wheel 504 in a position which it would reach if deflected as a result of a road discontinuity, while wheel 505 is shown in an unloaded or unexcited condition. It should be obvious that upon wheel 504 encountering the aforementioned discontinuity, the entire wheel is lifted with the result that rocker beam assembly 508 pivots arcuately such that cup-shaped member 526 engages the spherical end of the tapered portion of elastomeric member 532 initially adjacent its concave surface. As the rocker beam pivots, the elastomeric member is further arcuately compressed, exhibiting a progressively increasing spring rate or constant commonly defined in terms of its defective resistance to force. The extreme loaded position is reached after pilot member 528 engages cavity 534 of opposing bumper 533, then positively subjecting that portion of elastomer 532 between the adjacent opposing faces of bumper 533 to direct pressure, rather than from the deformative movement within the elastomer resulting from contact on elastomer 532 being squeezed between the opposing seats 526—527. Further resistance to deflection is provided by the entire cross-sectional diameter of the maximum-diameter midlength area of elastomeric member 532. Thus, we see that dampening is achieved in this invention by providing means, including the above structure, in which a progressively increasing spring rate is achieved.

Isolation of excitations of opposing axles is achieved via compression of an equalizer. Contact between the rocker beam assemblies and the equalizer through engagement of the cup-shaped members 526 and 527 is arcuate with a high initial deflection or low spring rate being exhibited by the equalizer. The pilot members serve the dual purpose of both supporting elastomeric member 532 within cavities 530 and 531, as well as transmitting forces from the rocker beam to the equalizer upon engagement with the bumper members at load position. Bumper members may be molded within the elastomer or may be assembled by other suitable conventional methods.

FIG. 9 shows the suspension of FIG. 8 attachable in an outwardly position, rather than as an integral part of the frame of a motor vehicle, wherein the forces of a 40° steering angle may be met without the four diagonal struts shown in FIG. 11 as means for resisting trailer jackknifing. In this embodiment the vehicle frame channel is shown as being entirely removable once bolts 536 are removed therefrom. A removable bracket member 537 extends from within the vehicle frame channel to a top bolster 538 of the suspension structure. Drive and braking torque reactions are transmitted directly to the vehicle frame member through bracket member 537 without the necessity of inward location of the suspension portions just described within the vehicle frame, and with the added feature of relieving the central frame bracket from torsional reactions transmitted from the axles through torque rods secured to the top bolster. Thus, a full-length box section interconnects the frame bracket and each end of the bottom bolster, according to this invention.

FIG. 10, which is a view looking along the line 10–10 of FIG. 8, illustrates the inner details of bushing assembly 514 and its connection to bolster member 525.

FIG. 11 illustrates the same basic inventive concept as applied to a suspension structure which is particularly adapted to cooperate with a tandem axle trailer arrangement. Referring to FIG. 11 wherein a cross-sectional elevational view depicts four upwardly extending struts which transfer forces between the bolster and the vehicle frame, reference character 539 designates each of said struts, while identical reference characters with FIG. 8 represent the same functional suspension components already described for FIG. 9.

It is within the purview of this invention to include torque rods 540 which are shown in FIG. 11, for example, secured in a manner set forth in various of my previous U.S. patents.

In the structure shown in FIG. 11 resistance to the couple forces associated with jackknifing of a semitrailer is effected through the four tubular struts 539 extending down and inwardly from end brackets 541 on each side of the suspension structure to the bottom bolster at which each strut is attached at a pad which also serves to transversely stiffen an inner hinge bracket, together with a gusset, to the bolster. Longitudinal shear forces, as a result of deceleration, for example, are absorbed through all four struts from the bottom bolster to the end brackets 541. Pairs of transversely opposite brackets are interconnected by a tubular crossmember thereunder.

Actual weight savings of up to 225 pounds on a 36,000 pound capacity tandem suspension have been experienced utilizing the aforedescribed spherically ended elastomer construction, in contrast to a helically coiled steel spring requiring hingedly contacting seats on opposing rocker beams. The length of the elastomeric member between bumpers may be varied to effect a predetermined deflection beyond loaded vehicle condition by varying the thickness or diameter of the pilot contact seats or bumpers which are located in the elastomer. It is this bumper member within the elastomer which provides added resistance to deflection at loaded vehicle conditions where transverse roll forces are greatest and where inherent static resistance of the elastomer is increasingly deficient.

While the embodiments of the invention described above for FIGS. 8—11 include pilot members which are integral with the cup-shaped members and which extend into cavities formed in the elastomer in an amount sufficient to prevent displacement thereof as a result of extreme rebound at unloaded condition, one of alternative embodiments of this invention comprises cup-shaped members which are formed with relatively deeper cavities. Spherically tipped convex ends of the elastomer project into and seat themselves within these cavities of the cup-shaped members, thereby preventing similar displacement as just described, without affecting the progressive spring rate exhibited by the combination.

It is further within the scope of the present invention to include a rodlike member projecting from the spherical end of the elastomer through an opening formed through a cup-shaped member, to effect desired pilot characteristics.

The embodiments of the invention particularly disclosed are presented merely as examples of the invention. Other embodiments, forms and modifications of the invention coming within the proper scope of the appended claims will of course readily suggest themselves to those skilled in the art.

I claim:

1. A multiple axle vehicle suspension structure, comprising transversely extending longitudinally spaced axles, torque pedestals supported by said axles, transversely spaced frame

brackets disposed between said axles, a top bolster member having torque rod connections integral therewith, torque rods interconnecting said axle pedestals and said top bolster member, a bottom bolster member, columns interconnecting said top and bottom bolster members, opposing rocker beams separately trunnioned in said structure and pivotally supported at their longitudinally extending ends by said axles, cupped discs integral with substantially vertically extending arms of said opposing rocker beams, a compression-resistant elastomeric member having a cross-sectional area which tapers from the center to the ends of said elastomeric member being disposed between the cupped discs of said opposing rocker beams, and pilot members projecting from the central portion of said cupped discs into said elastomeric member.

2. A multiple axle vehicle suspension structure according to claim 1, wherein said elastomeric member has a static resistance to deflection at least equalling its dynamic resistant to deflection.

3. A multiple axle vehicle suspension structure, comprising transversely extending longitudinally spaced axles, torque pedestals supported by said axles, transversely spaced frame brackets disposed between said axles, a top bolster member having torque rod connections integral therewith, torque rods interconnecting said axle pedestals and said top bolster member, a bottom bolster member, columns interconnecting said top and bottom bolster members, opposing rocker beams separately trunnioned in said structure and pivotally supported at their longitudinally extending ends by said axles, cupped discs integral with substantially vertically extending arms of said opposing rocker beams, opposing pilots centered in said cupped discs, pressure resistant, load-equalizing means disposed between the cupped discs of said opposing rocker beams, said load-equalizing means comprising a substantially cylindrical elastomeric member formed with axially extending cavities in each of spherically convex ends thereof, said elastomeric member being tapered with a maximum diameter midlength, metallic discs disposed within said elastomeric member on opposite sides of said midlength, said discs being formed with cavities for registry with adjacent ends of said pilots at predetermined load positions, said elastomeric member exhibiting progressively increasing resistance to axial deflection.

4. A multiple axle vehicle suspension structure, comprising transversely extending longitudinally spaced axles, torque pedestals supported by said axles, transversely spaced frame brackets disposed between said axles, a top bolster member having torque rod connections integral therewith, torque rods interconnecting said axle pedestals and said top bolster member, a bottom bolster member, columns interconnecting said top and bottom bolster members, opposing rocker beams separately trunnioned in said structure and pivotally supported at their longitudinally extending ends by said axles, cupped discs integral with substantially vertically extending arms of said opposing rocker beams, opposing pilots centered in said cupped discs, pressure-resistant, load-equalizing means disposed between the cupped discs of said opposing rocker beams, said cupped discs surrounding the base of said pilots, said equalizing means being formed with end cavities adapted to receive portions of said pilots during movement of said rocker beams in an arcuate path.

5. The suspension structure recited in claim 4 further including means for attaching the suspension structure to a vehicle frame, said attaching means including brackets disposed outwardly and below the frame, detachable members extending between said top bolster member and the inside of the frame, said top bolster member extending transversely with respect to the frame and terminating within the inside width of the frame.

6. The suspension structure recited in claim 4 wherein said equalizing means comprises a generally cylindrical elastomeric member having spherically tapering ends and a metallic disc centrally disposed within said elastomeric member whereby the resistance of said elastomeric members to axial deflections increases progressively from the ends to the center of said elastomeric member.

7. A suspension system for a vehicle having a frame upon which a load is supported and a pair of stub axles or transversely extending axles, comprising:

a first supporting member attached to the vehicle frame and positioned between the pair of axles; and

means for isolating excitations on each of the axles from the vehicle frame and from the other axle, said isolating means including a pair of rocker beam members, each of said rocker beam members being pivotally connected to said first supporting member and having a horizontally extending component and a vertically extending component; said horizontally extending component of each of said rocker beam members being supported by said axles; a cup-shaped disc being attached to the top end of said vertically extending component of each of said rocker beam members, a pilot member being centered in each of said discs, and a compression-resistant elastomeric member being disposed between said cupped discs, said pilot members extending axially within said elastomeric member, said elastomeric member having a varying cross-sectional area in order to provide a progressively increasing resistance to deflection.

8. The suspension system recited in claim 7 wherein the diameter of the midlength portion of said elastomeric member is greater than the diameter of the ends of said elastomeric member when said elastomeric member is in an uncompressed state and wherein the ends of said elastomeric member terminate in a generally spherical shape.

9. The suspension system recited in claim 7, further comprising a metallic disc bonded within said elastomeric member in order to progressively increase the axial resistance of elastomeric member to load deflections.

10. The suspension system recited in claim 9 wherein said metallic disc is bonded centrally of the length of said elastomeric member.