United States Patent

[11] 3,626,864

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[21] Appl. No. **801,884**
[22] Filed **Oct. 23, 1968**
[45] Patented **Dec. 14, 1971**
[73] Assignee **A. Stucki Company**
Pittsburgh, Pa.
Continuation-in-part of application Ser. No. 534,220, Mar. 14, 1966, now abandoned, which is a continuation-in-part of application Ser. No. 468,850, July 1, 1965, now abandoned, and a continuation-in-part of 579,709, Sept. 15, 1966, now abandoned. This application Oct. 23, 1968, Ser. No. 801,884

[54] **FLUID TRUCK SNUBBER**
42 Claims, 32 Drawing Figs.

[52] **U.S. Cl.** ..... **105/199 R,** 105/197 D, 105/199 C, 105/200, 188/298, 188/317, 213/43, 213/223, 267/4, 267/34, 267/64 A, 267/120, 267/122, 280/124, 280/136, 280/440, 308/136, 308/137, 308/138, 308/226

[51] **Int. Cl.** **B61f 5/12,** B61f 5/14, B61f 5/16

[50] **Field of Search** ..... 105/164, 199, 193, 197, 197 D, 200, 199 R, 199 C; 188/88, 88.503, 88.505, 88.506, 96.51, 96.6, 298, 317; 213/43, 223; 267/3, 4, 8, 34, 64, 65, 120, 122, 126, 64 A; 280/124, 136, 405, 439, 440; 293/71, 86; 308/26, 136, 137, 138, 163, 184, 223, 226

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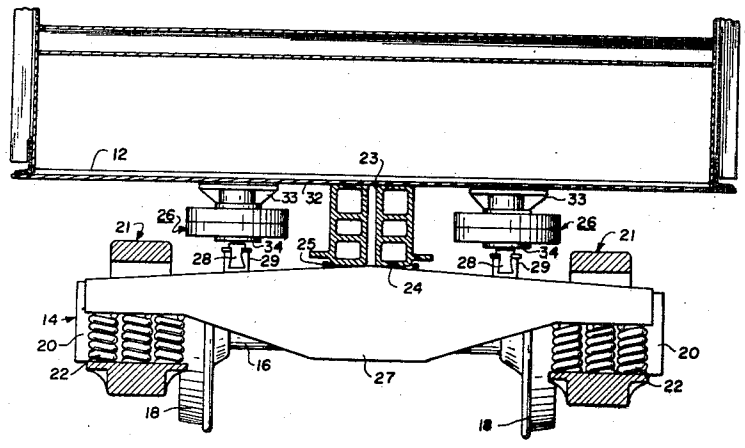
Primary Examiner—Arthur L. La Point
Assistant Examiner—Howard Beltran
Attorney—E. Wallace Breisch

ABSTRACT: A suspension system for railway freight cars having hydraulic energy-absorbing devices with reciprocable members effective to damp the movement of a railway car with respect to the supporting trucks therefor and the method of absorbing energy occurring during such movement.



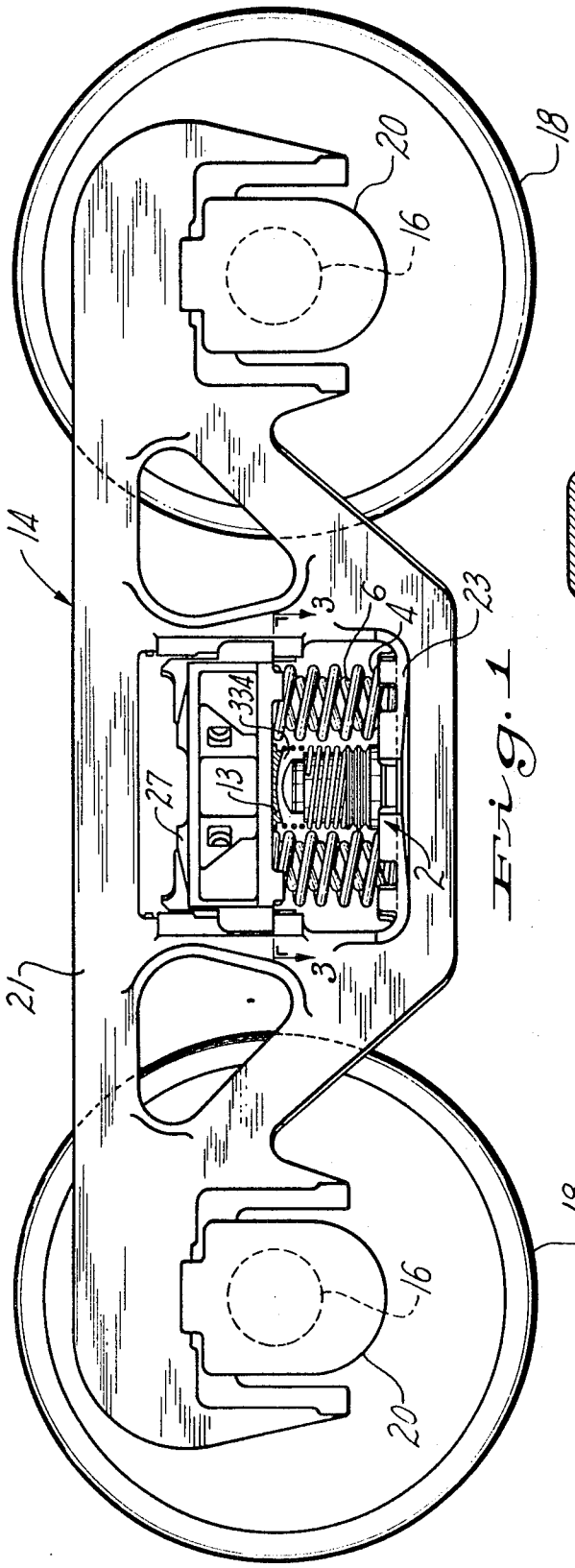


Fig. 1

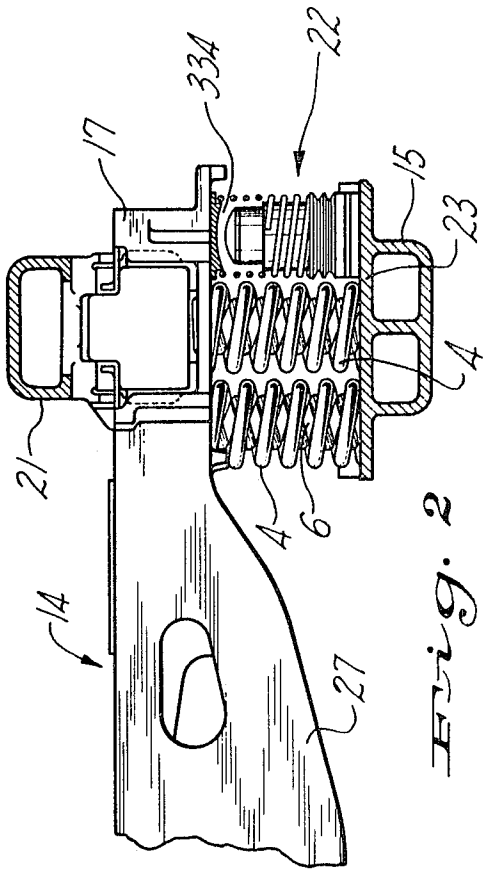


Fig. 2

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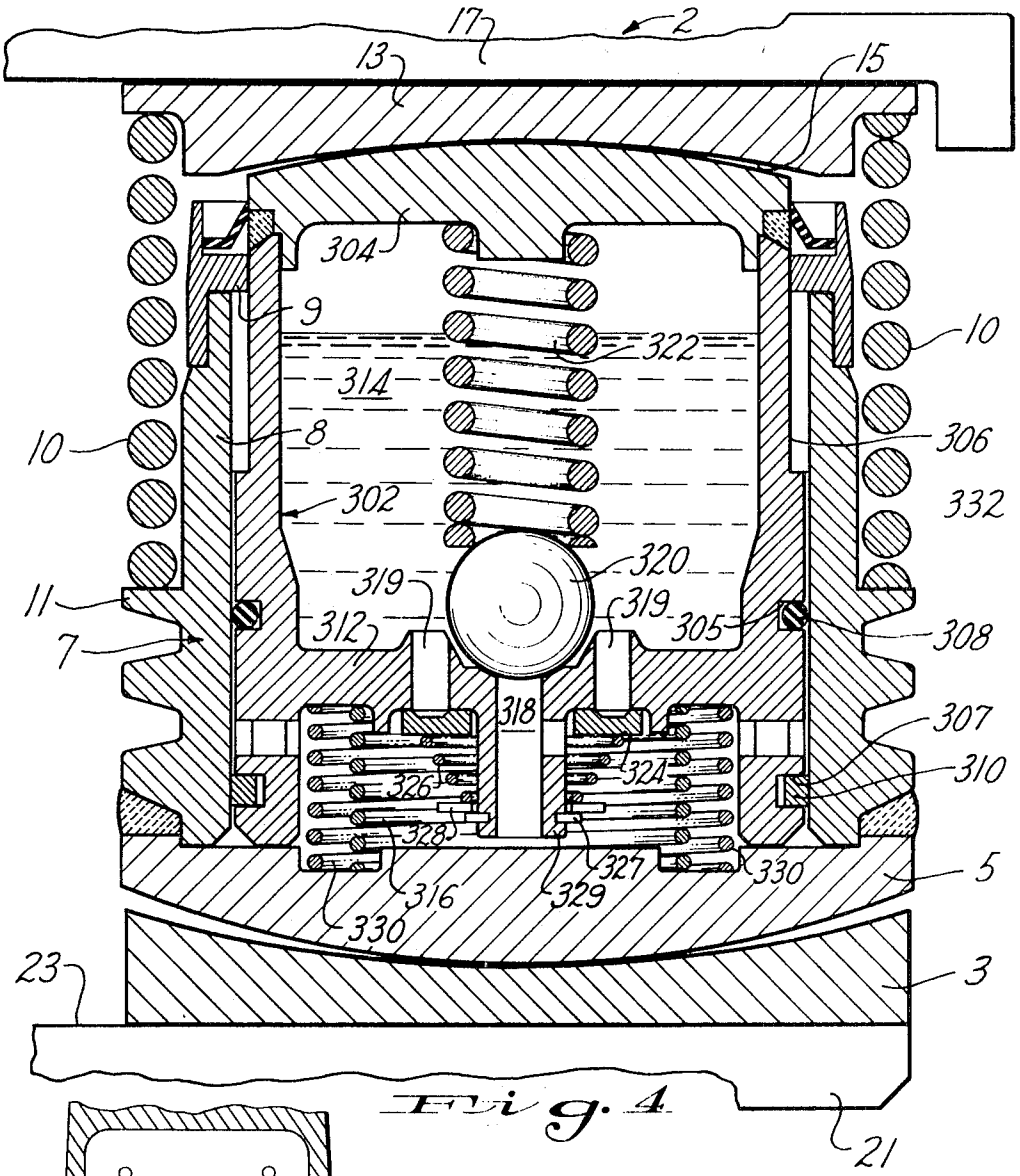

Fig. 4

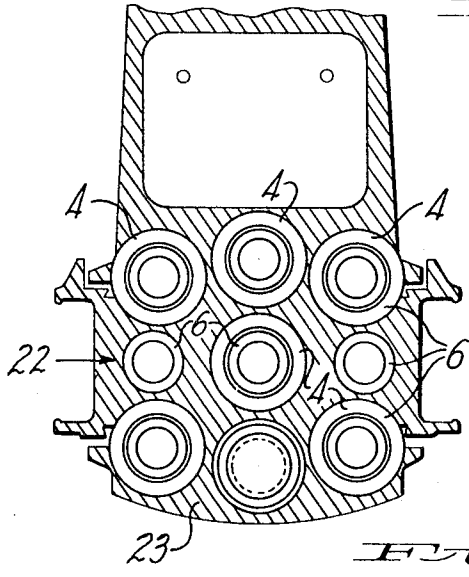

Fig. 3

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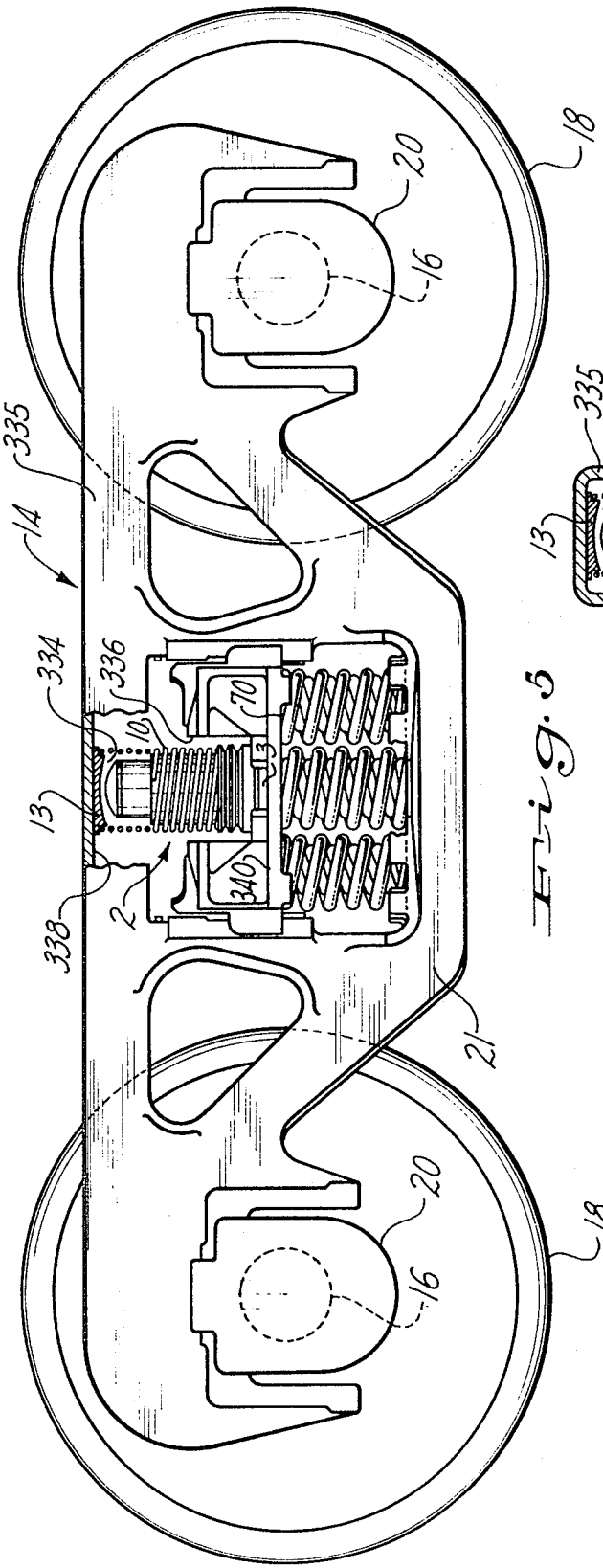

Fig. 5

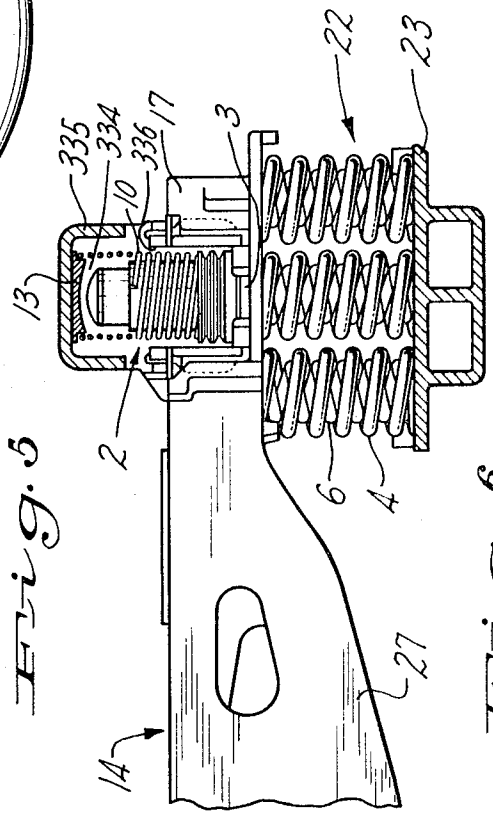

Fig. 6

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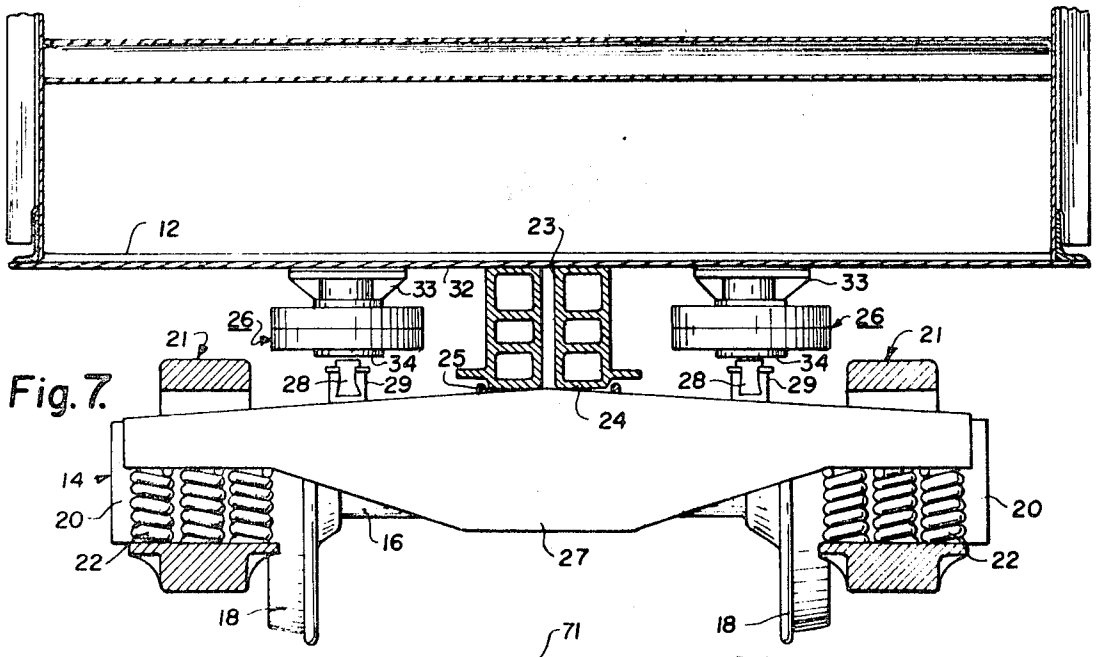

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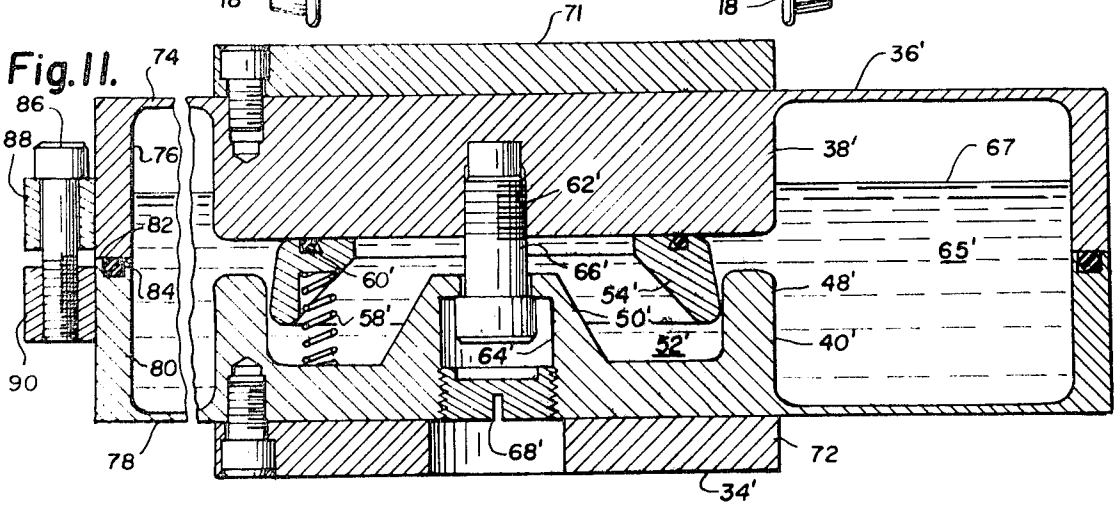

Fig. 11.

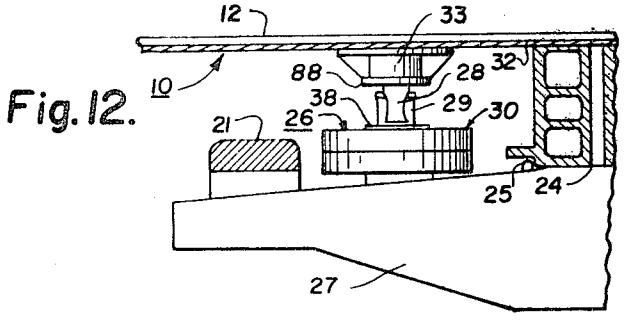

Fig. 12.

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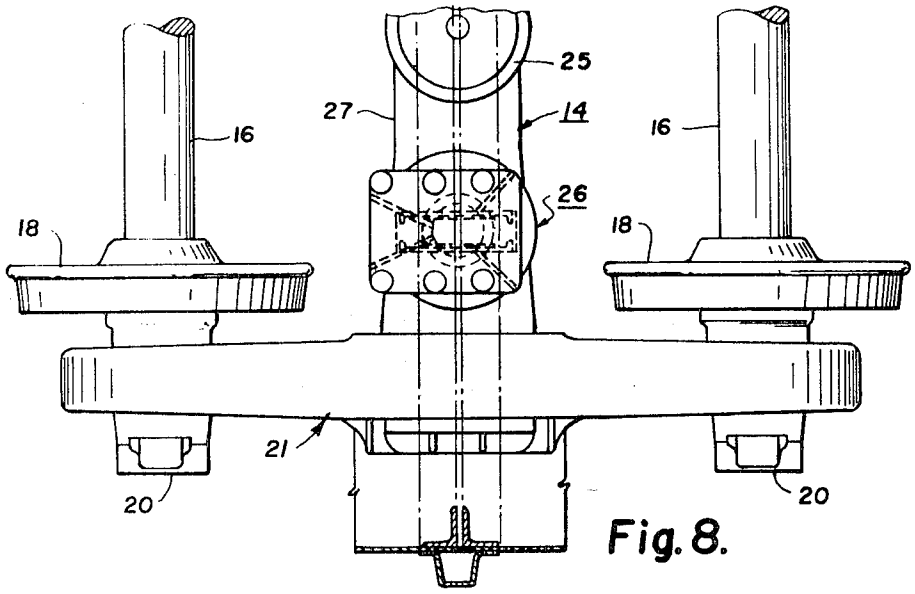

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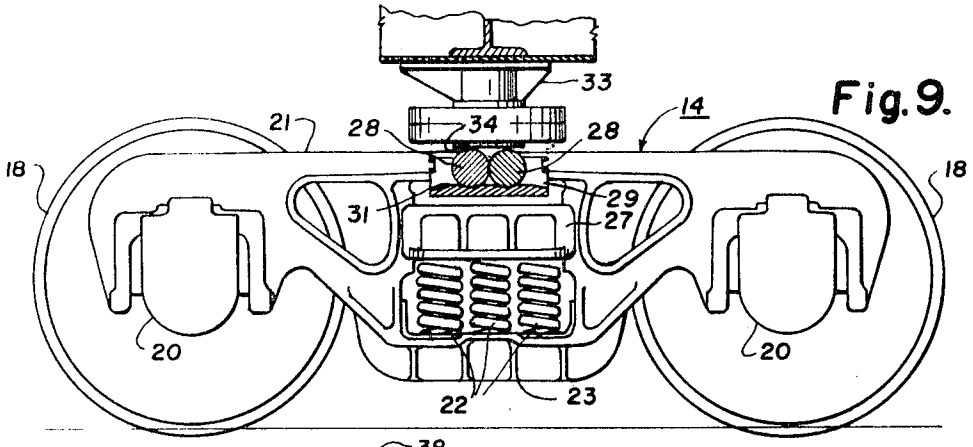

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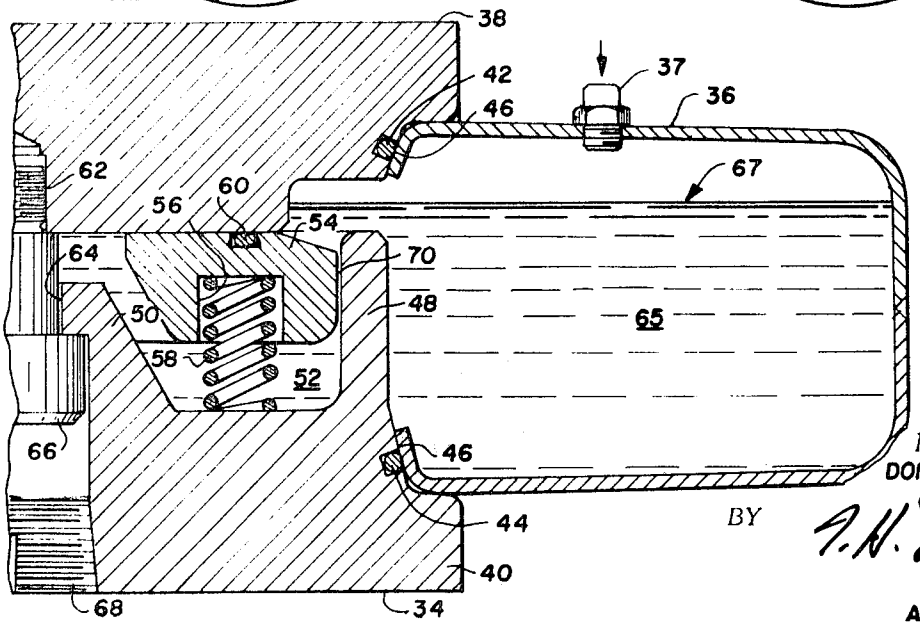

Fig. 10.

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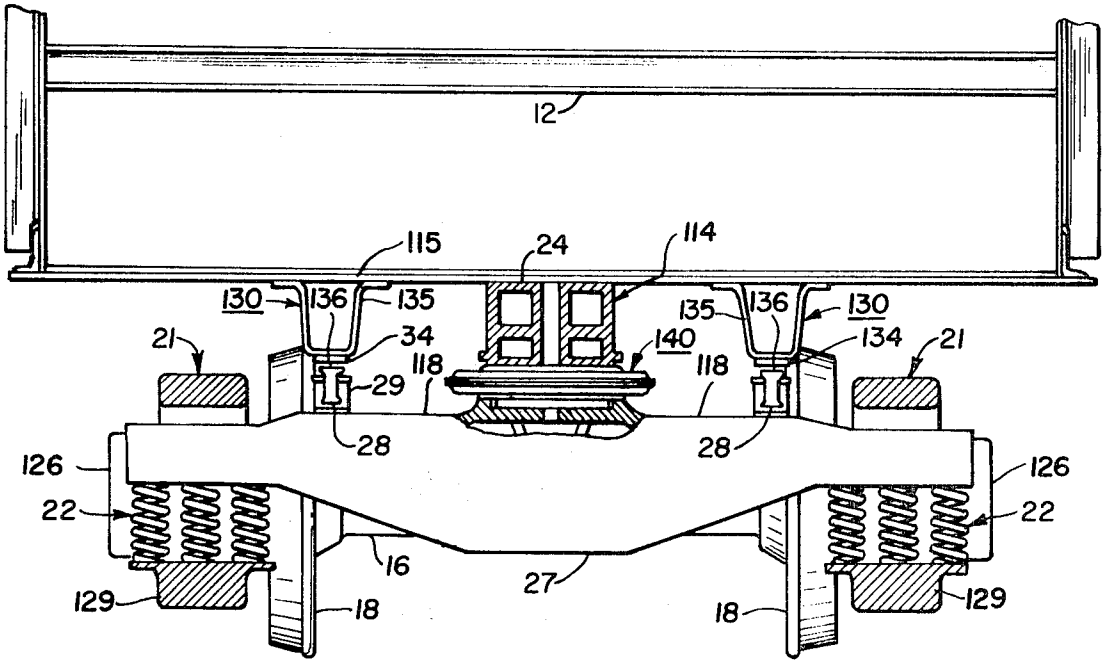

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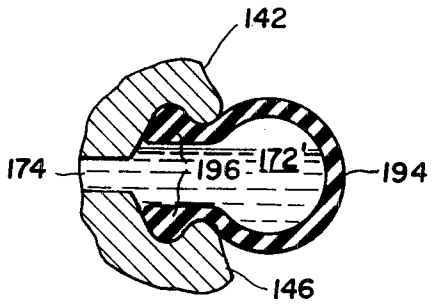

Fig. 13.

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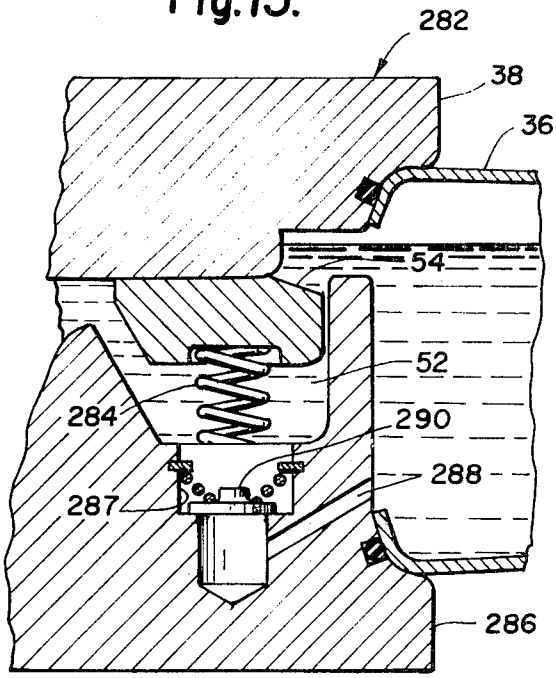
Fig. 15.



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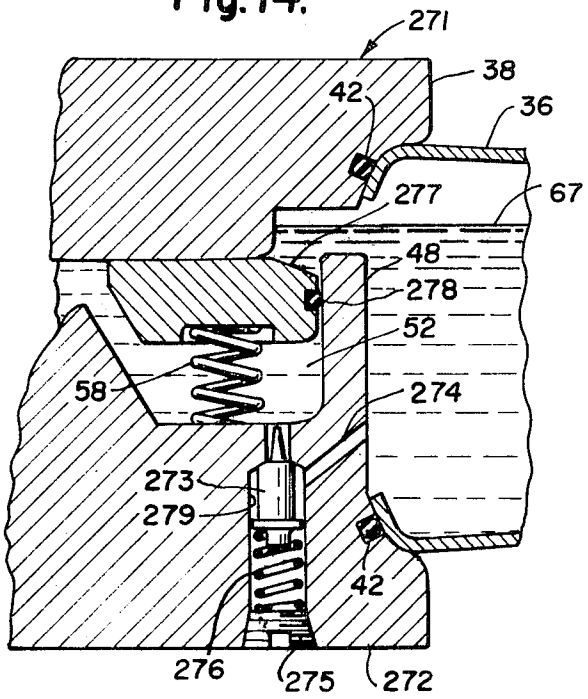

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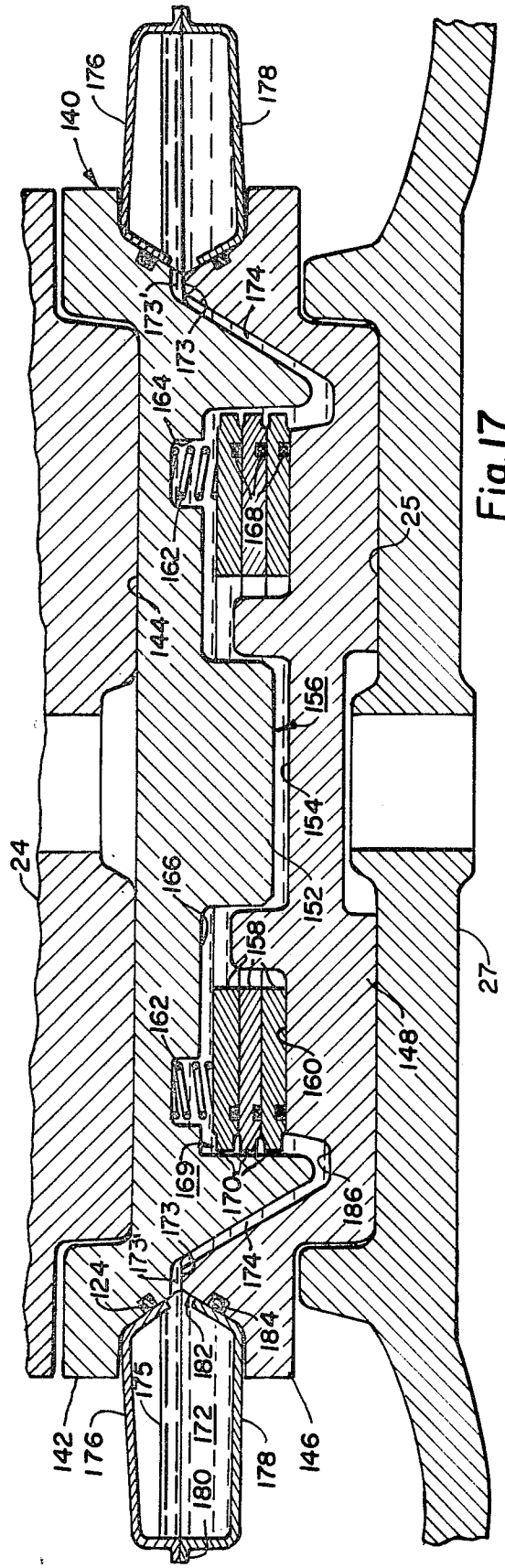

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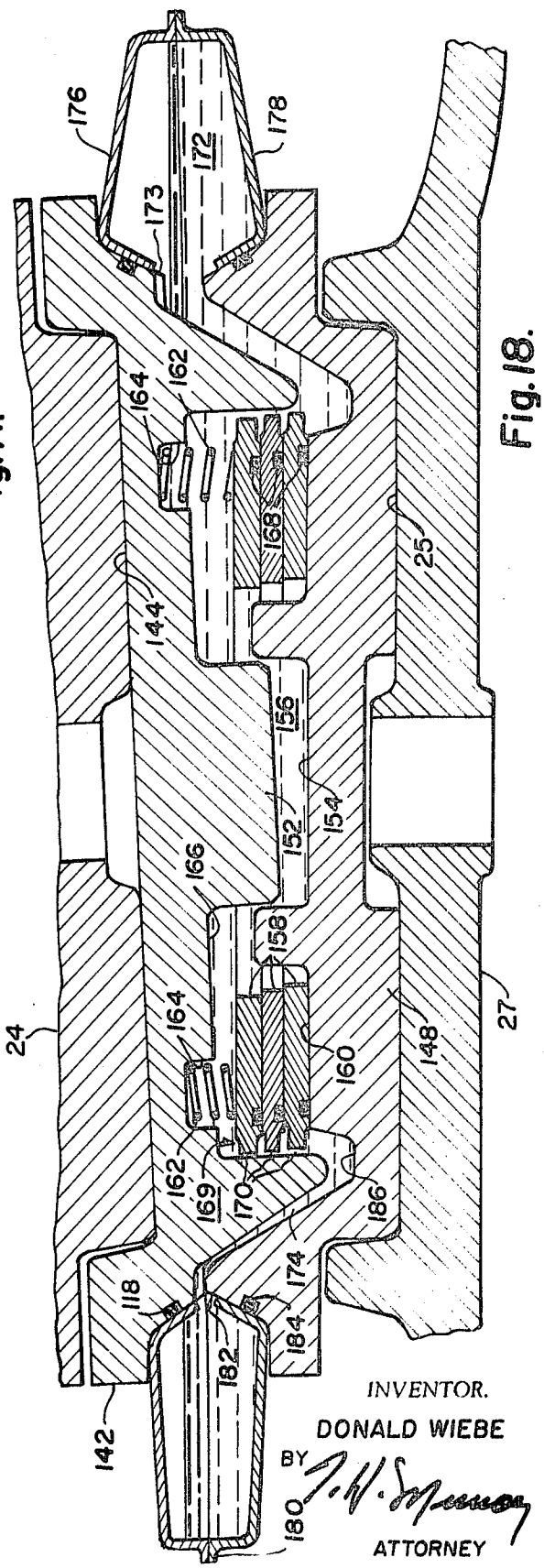

Fig. 18.

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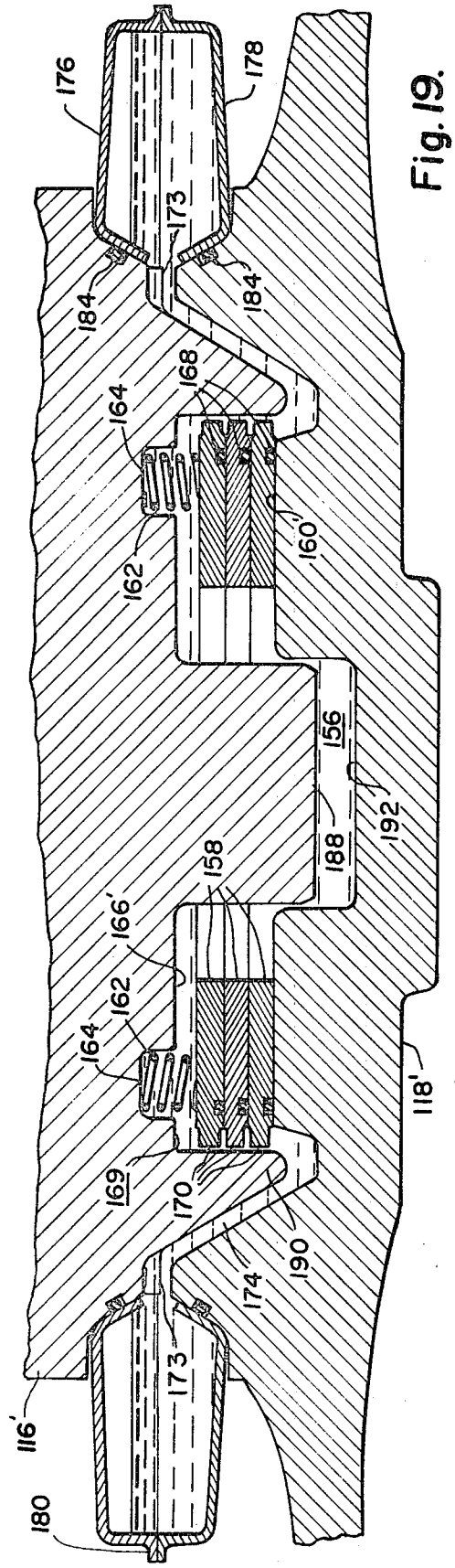

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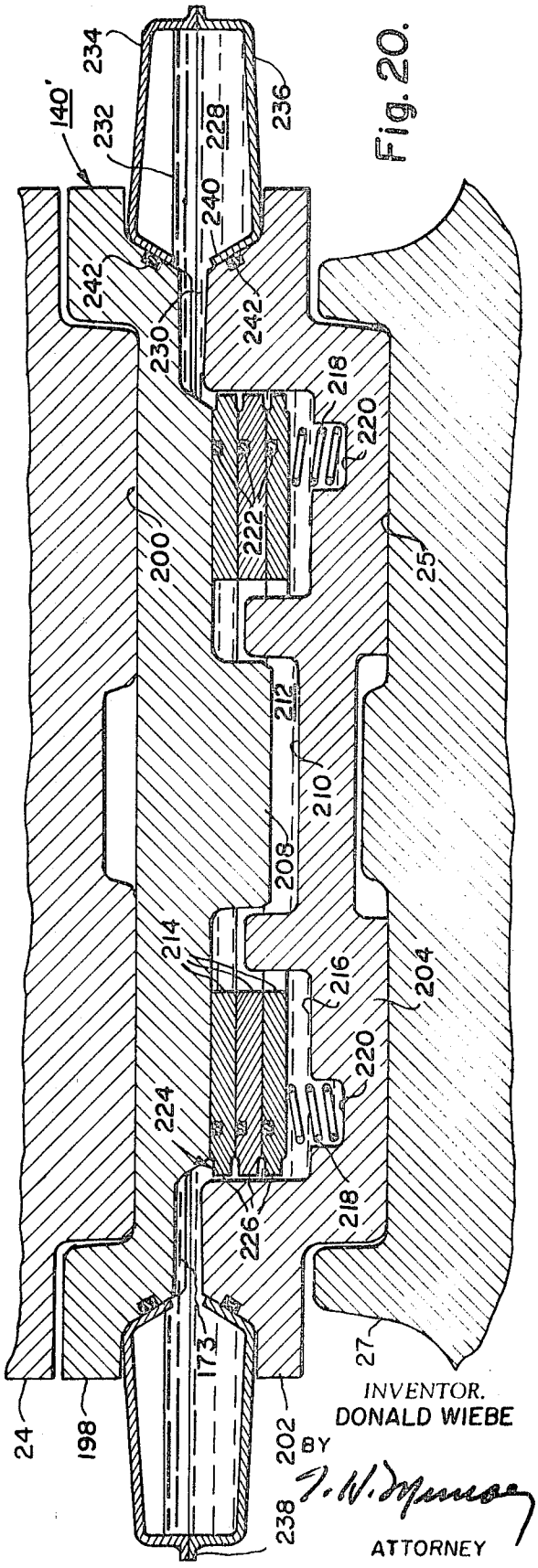

Fig. 20.

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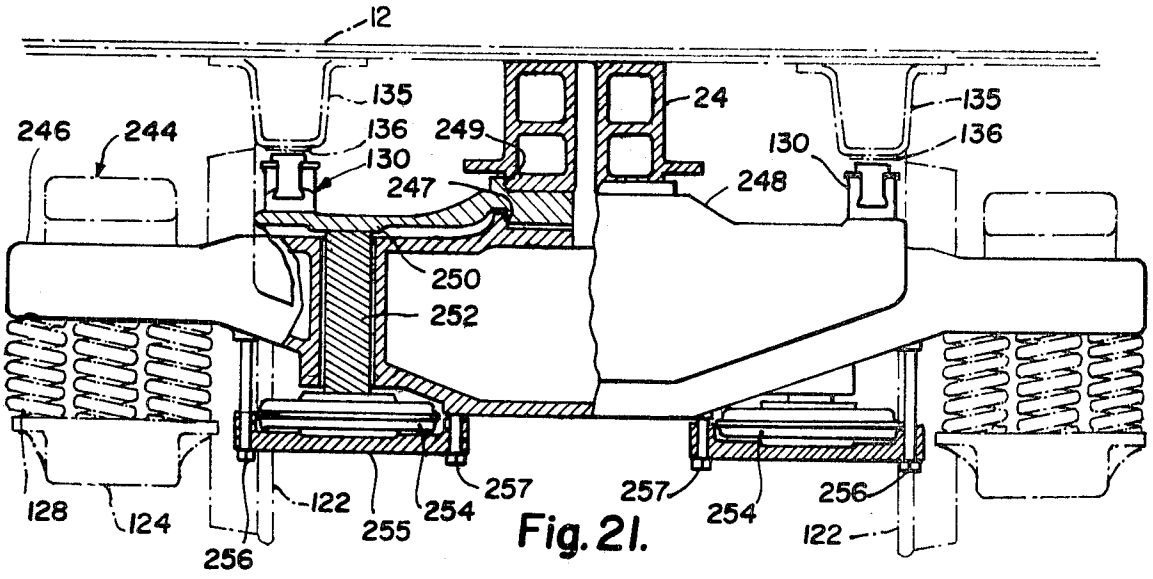

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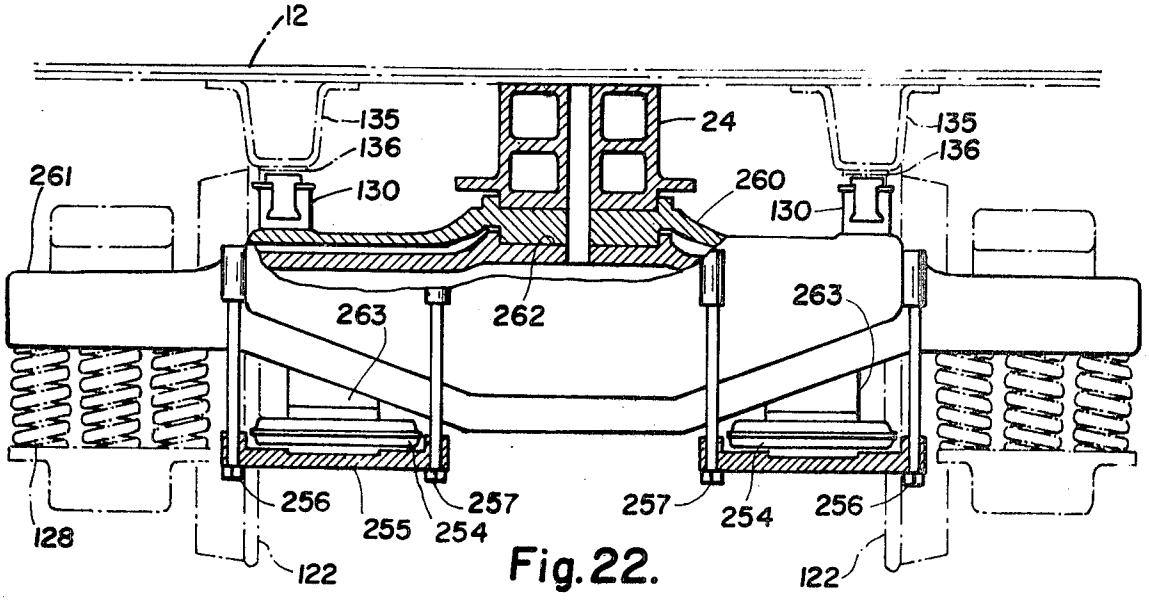

Fig. 22.

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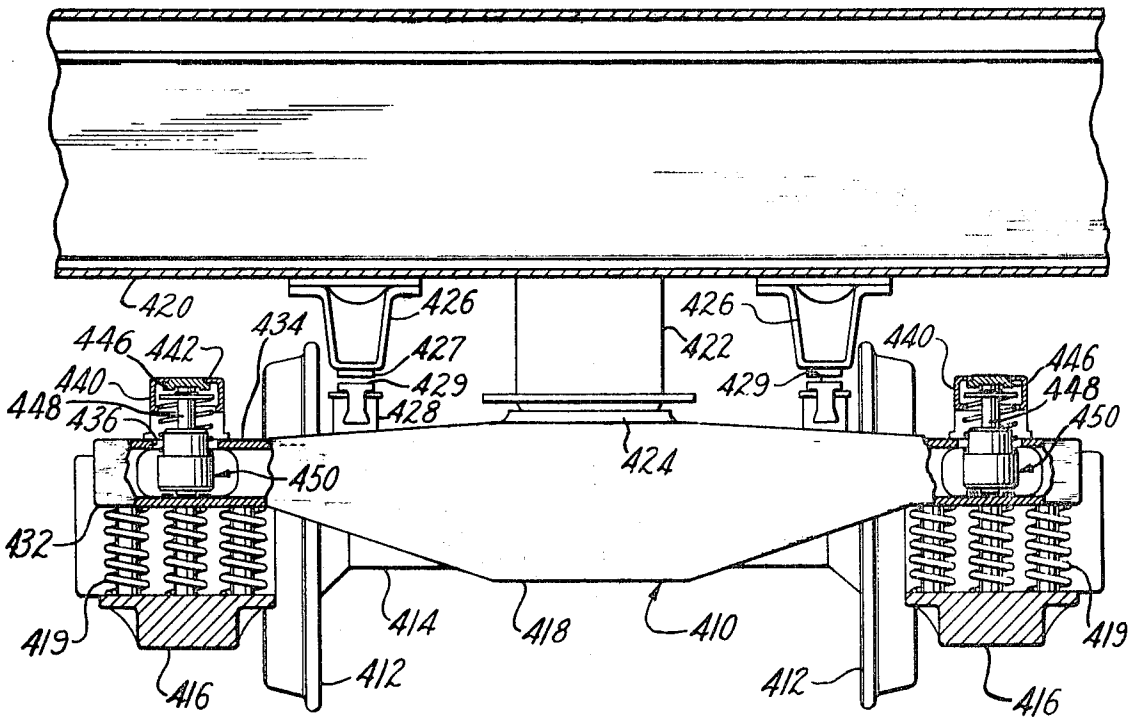

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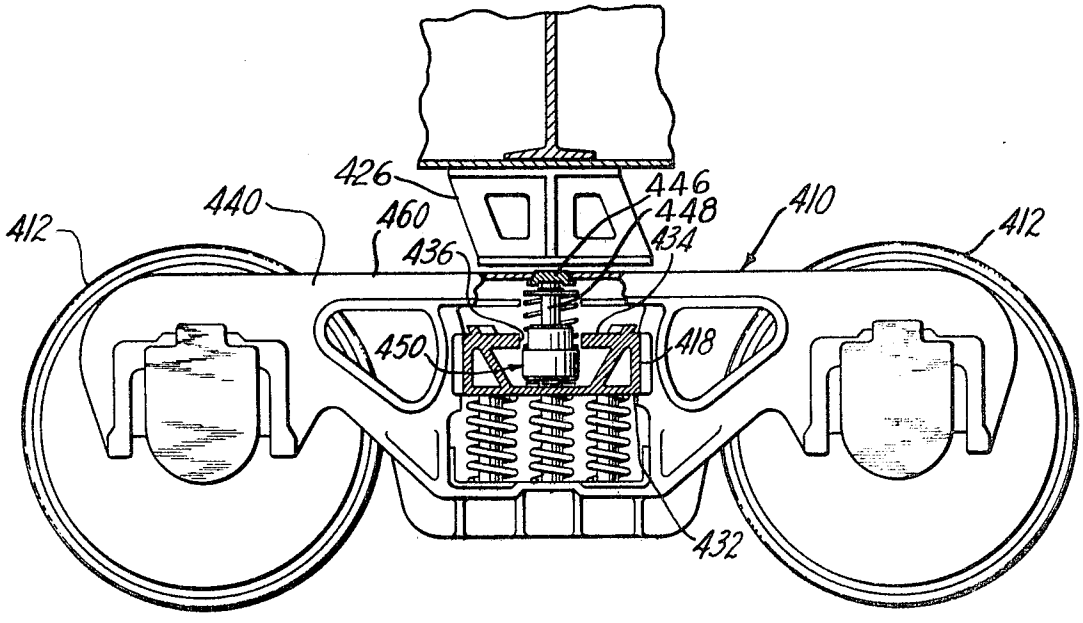

Fig. 24.

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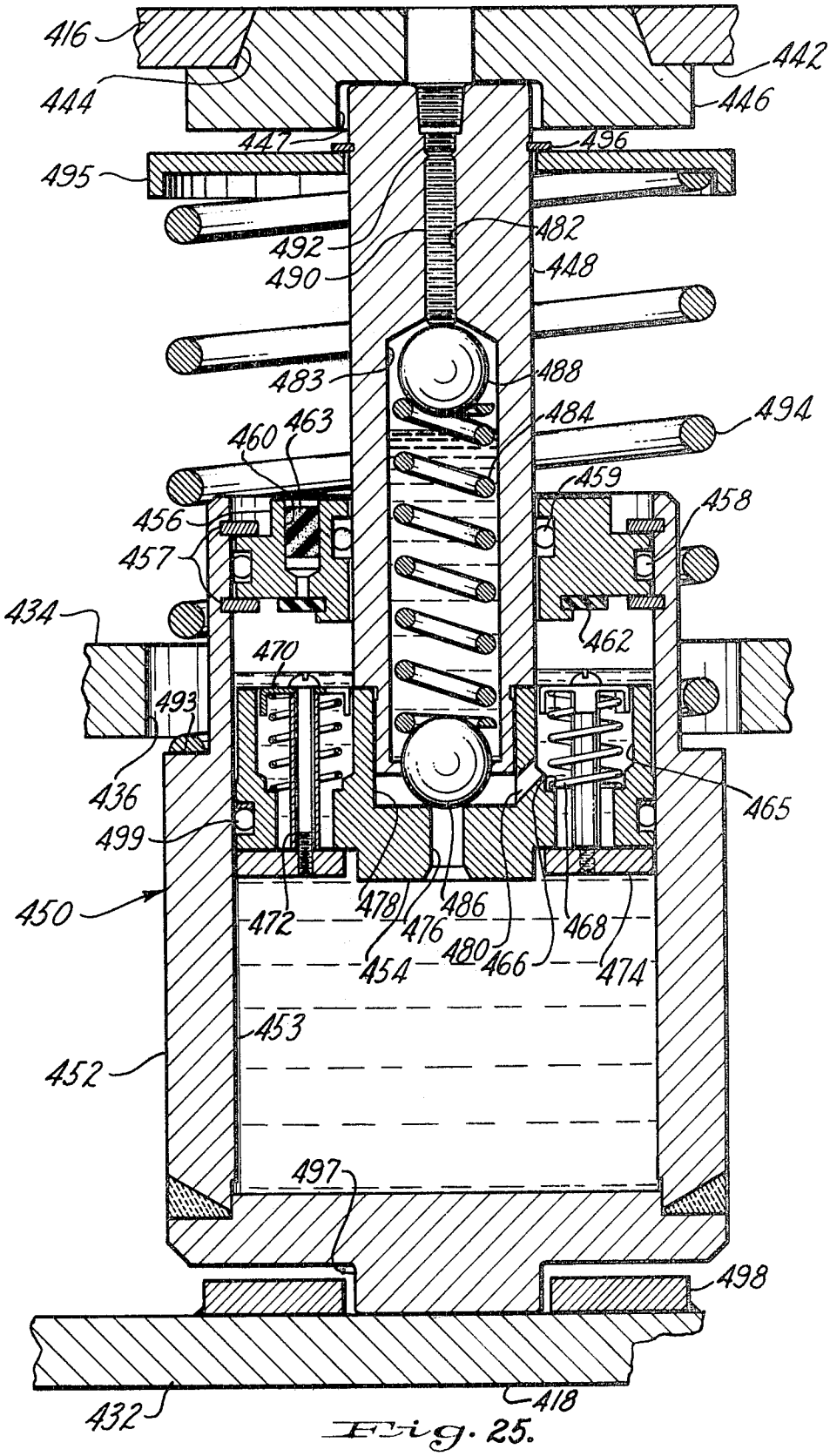
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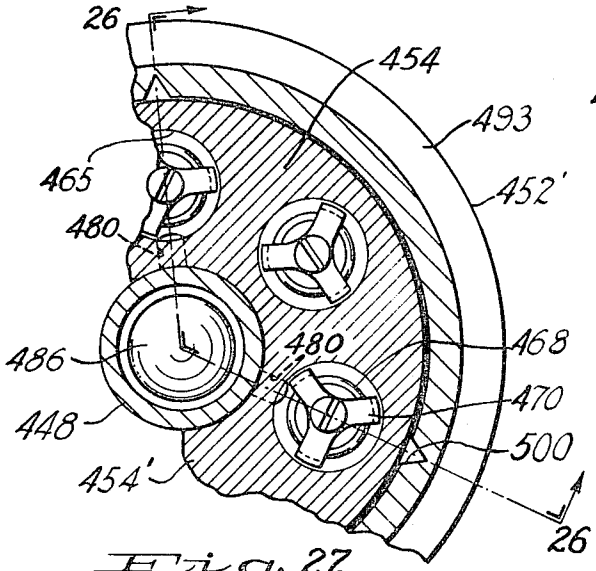
Fig. 25.



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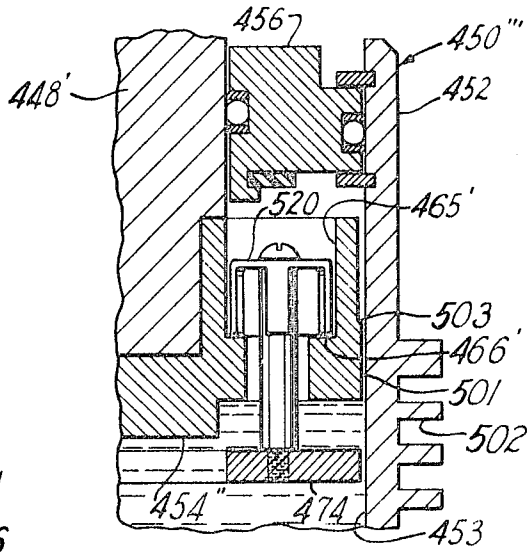

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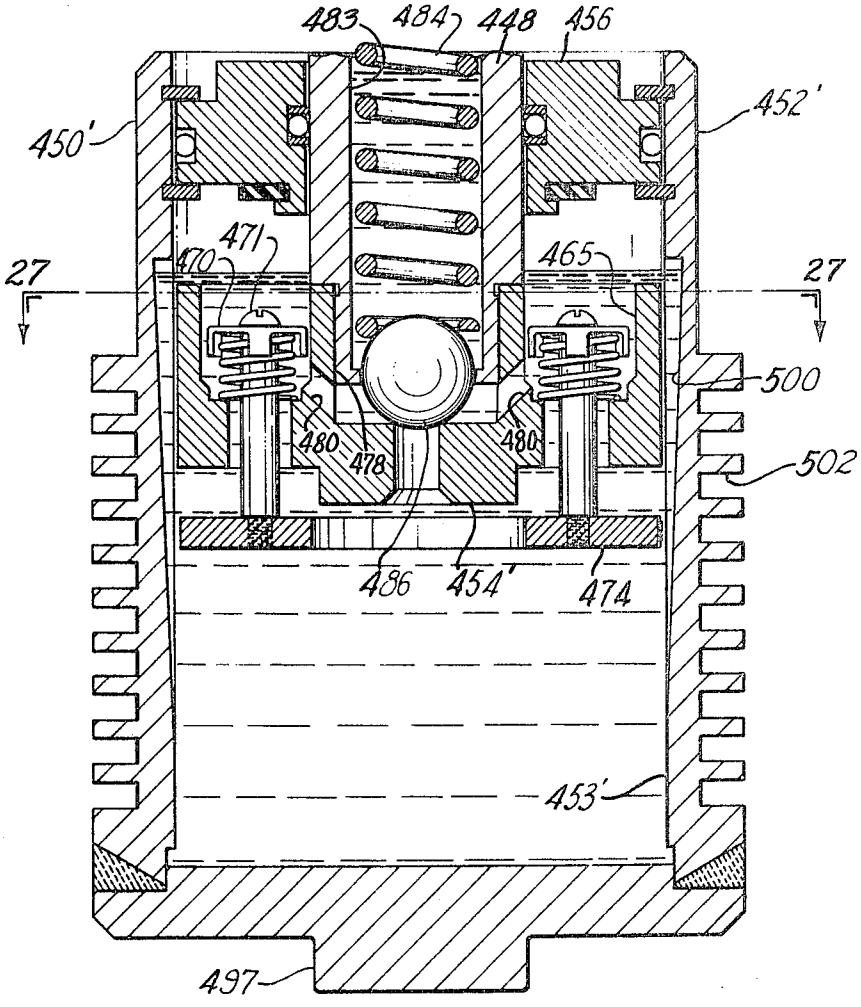

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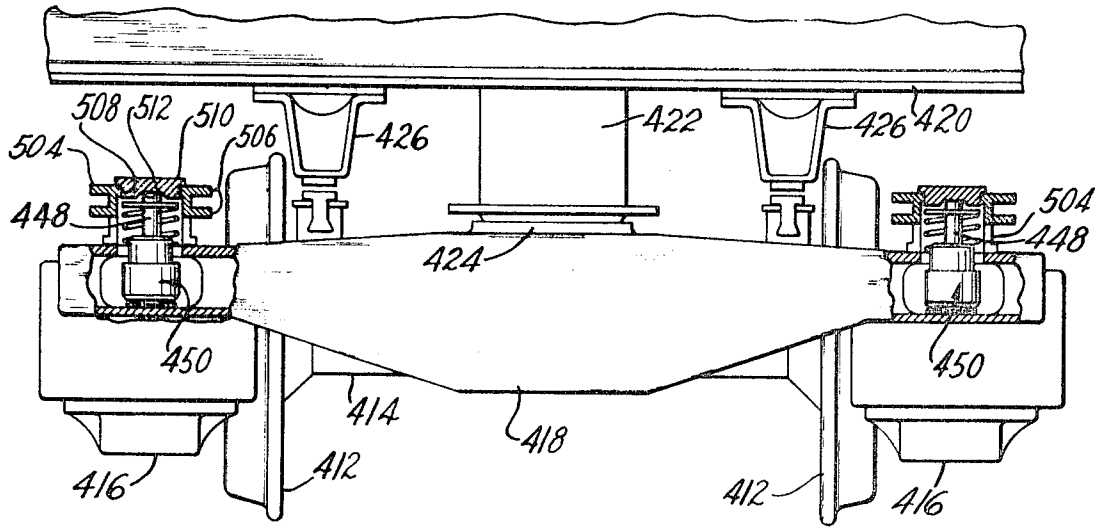
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Fig. 28.

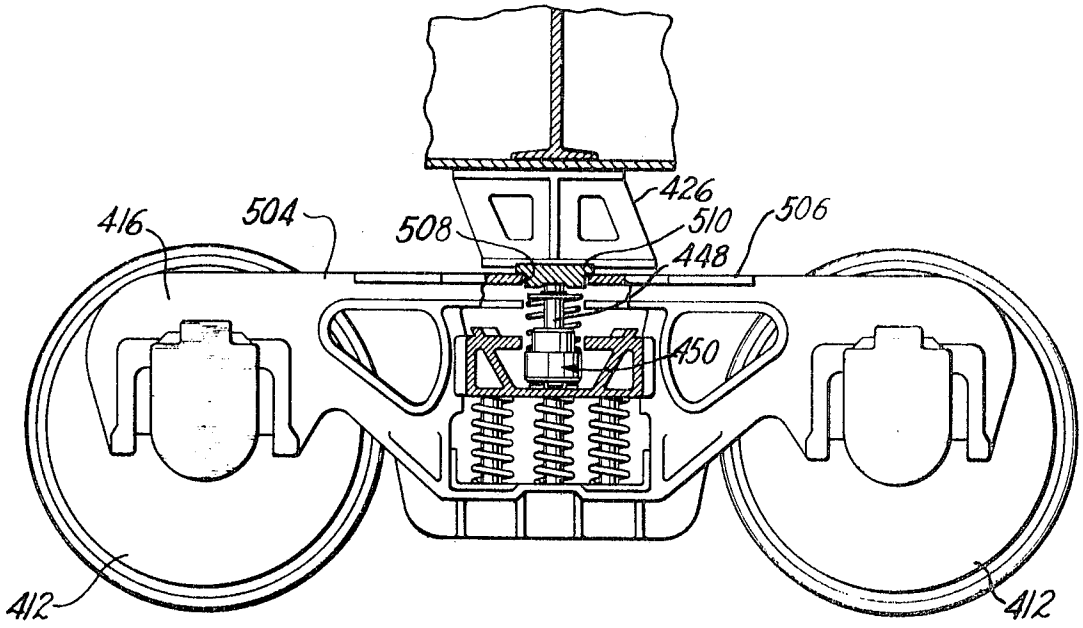
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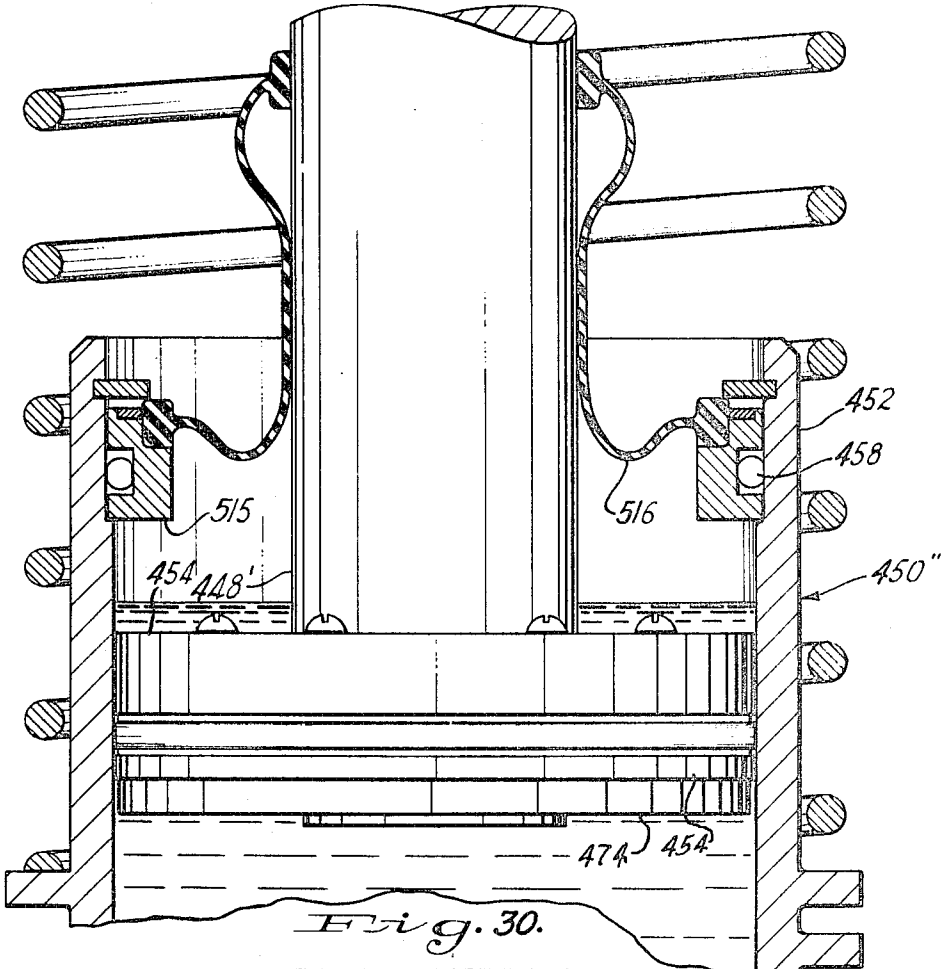
Fig. 29.



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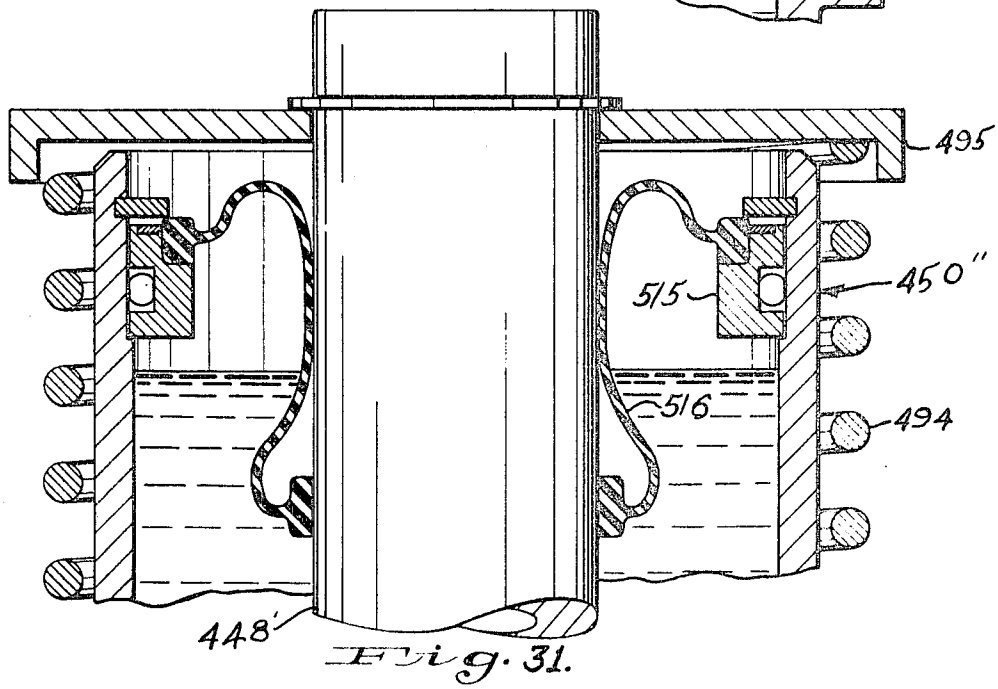

Fig. 31.

FLUID TRUCK SNUBBER

This application is a continuation-in-part of application Ser. No. 534,220 filed Mar. 14, 1966 (now abandoned) which application was a continuation-in-part of application Ser. No. 468,850 filed July 1, 1965 (now abandoned) and this application is also a continuation-in-part of Ser. No. 579,709 filed Sept. 15, 1966 (now abandoned).

The lateral instability of freight cars and the derailments caused thereby are well known in the art and the resonance environment that results when freight cars, including the newer types known as high center of gravity cars, traverse track with cross level differences changes are set forth in the paper entitled "The Effects of the Lateral Instability of High Center Gravity Freight Cars" presented Mar. 27, 1968 to the 1968 Joint ASME–IEEE Railroad Conference on Mar. 27, 1968 in Chicago, Ill. and which has been published under the same title by the American Society of Mechanical Engineering, Journal of Engineering for Industry, Nov. 1968 issue. In addition to the references in said paper the above-identified prior applications identify some of the prior art relevant to this invention.

The various objects and advantages of this invention will become more readily apparent upon consideration of the following description and drawings, in which

FIG. 1 is a side elevational view of a railway car truck having snubber therein which is constructed, located and operable in accordance with the principles of this invention;

FIG. 2 is a cross-sectional view of the end of a bolster, the supporting spring group, and the side frame as shown in FIG. 3;

FIG. 3 is a partial sectional view taken substantially along line 3—3 of FIG. 1;

FIG. 4 is an enlarged cross-sectional view of the snubber shown in FIG. 1;

FIG. 5 is a view similar to FIG. 1 having a snubber of this invention located above a bolster-supporting spring group;

FIG. 6 is a view similar to FIG. 2 showing the snubber shown in FIG. 5;

FIG. 7 is an end elevational view of a portion of a railway car and truck support therefor having a snubber of this invention located therebetween;

FIG. 8 is a top plan view of one end of the truck support as shown in FIG. 7;

FIG. 9 is a side elevational view of the structure shown in FIG. 8;

FIG. 10 is an enlarged sectional view of the snubber shown in FIG. 7;

FIG. 11 is a sectional view similar to that of FIG. 10 of another embodiment of this invention;

FIG. 12 illustrates an arrangement wherein a snubber of this invention is mounted on the truck bolster;

FIG. 13 is a cross-sectional view of a modified reservoir for a snubber of this invention;

FIG. 14 is a fragmentary cross-sectional view of another snubber of this invention;

FIG. 15 is a fragmentary cross-sectional view of another snubber of this invention;

FIG. 16 is a view, partly in elevation and partly in section, of a portion of a railway car body and truck support therefore having a snubber of this invention located therebetween;

FIG. 17 is a sectional view of another embodiment of a snubber of the invention located between the car center plate and the truck bolster;

FIG. 18 is an enlarged view, in section, of the snubber of FIG. 17 when fully angularly displaced;

FIG. 19 is a view, similar to FIG. 17, of a modified form of snubber of this invention incorporated directly into a car center plate and truck bolster;

FIG. 20 is an enlarged view, in section, of still another modified form of a snubber of this invention;

FIG. 21 is a view similar to FIG. 7 of a modified application of the snubber as shown in FIG. 7;

FIG. 22 is a view similar to FIG. 21 of still another modified application of the snubber as shown in FIG. 7;

FIG. 23 is a fragmentary partially sectional end elevational view of a car body underframe and the supporting truck therefor incorporating the side frame of this invention;

FIG. 24 is a side elevational partially sectional view of the structure of FIG. 23;

FIG. 25 is a sectional view of a portion of the structure of FIG. 23 on an enlarged scale showing a snubber constructed according to the principles of this invention;

FIG. 26 is a fragmentary sectional view similar to a portion of FIG. 25 taken substantially on the line 26—26 of FIG. 27 and showing another embodiment of the principles of this invention;

FIG. 27 is a fragmentary sectional view taken substantially on line 27—27 of FIG. 26;

FIG. 28 is a view similar to FIG. 23 showing another embodiment of the principles of this invention;

FIG. 29 is a side elevational partially sectional view of the structure of FIG. 28;

FIG. 30 is a fragmentary sectional view of another embodiment of the principles of this invention;

FIG. 31 is a fragmentary sectional view of the embodiment of FIG. 30 with elements in different relative positions; and

FIG. 32 is a fragmentary sectional view of another embodiment.

As illustrated best in FIGS. 7 to 9 the conventional railway freight car comprises an elongated car body 12 supported upon four-wheel truck assemblies 14 (only one of which is shown) adjacent the ends of the car body 12. Each truck assembly has a pair of parallel axles 16 extending transversely of the body 12 with spaced journal wheels 18 being carried by each axle 16 to properly engage railroad tracks of a known gage. The outer ends of the axles 16 are suitably rotatably supported in known journal boxes 20 and each pair of adjacent boxes 20 at opposite sides of each truck assembly 14 is connected by known truck side frames 21. Each side frame 21 has a formed opening intermediate the axles 16 which provides a lower support portion 23 for supporting the lower ends of a suitable spring group 22 comprised of a plurality of vertically extending springs. A bolster 27 extends between each pair of opposed side frames 21 with the undersurface of the opposite ends thereof being supported by engagement with the upper ends of opposed spring groups 22. Longitudinally spaced portions of the body 12 adjacent the ends thereof are supported by the longitudinally spaced bolsters 27 by means of suitable center sill assemblies which illustratively comprise circular center plates 24 extending downwardly of the body 12 which are received within upwardly open cup-shaped bearings 25 rigidly carried centrally by the bolsters 27, respectively. Inasmuch as the structure of truck assemblies for railway freight cars and their structural cooperation with components of freight car bodies are well known in the art the description herein of such structures is of a general nature as a detailed description is not essential to the understanding of this invention by one skilled in the art to which it pertains.

With such known suspension the weight of the body 12 is supported by the abutting engagement of the center plates 24 with the surfaces of bearings 25 and the truck assemblies 14 are capable of rotating with respect to the center plates 24 when negotiating a curve in the track. The body 12 is thus normally supported upon a narrow area as compared to the width of the body 12 and accommodates for small differences in track profile, raising or lowering one end or the other of the bolsters 27 without severe or undue twisting the body 12. To prevent the body 12 from tilting too far in either direction, suitable known side bearing assemblies are provided such as those wherein a pair of rollers 28 is mounted on the top surfaces of the bolsters 27 at some distance on either side of the center plate 24 and wear plates (not shown) are fixed to the bottom of the body 12 above the rollers 28, respectively, with a space of one-quarter to three-eighths of an inch between the bottom surface of the wear plate and the top surface of the rollers 28. When the body 12 is tilted or rocked to one side or the other, one of the wear plates contacts a side bearing assembly

or pair of rollers 28 to arrest further relative motion between the bolsters 27 and the body 12 while maintaining the ability of the truck to rotate about the center plate 24 as needed.

When a body 12 is traveling over track the normal rocking of the body 12 is readily arrested by the side bearing assemblies with perhaps slight compression of the spring groups 22 supporting that end of the bolster 27 toward which the body 12 is swaying. Due to the yielding of the spring groups 22, the body 12 rebounds from the extreme tilted position and under certain conditions will swing over to tilt in the opposite direction and strike the side bearing assembly on the other side of the truck assembly 14 to produce a series of oscillations between the extreme positions of the body 12. As is known, a resiliently mounted body has a natural period of vibration associated with its mass, the position of its center of gravity, the resilient characteristics of the mounting member and the geometry of the whole system. In many instances the energy of the first tilting motion is absorbed in the internal and external friction of the various members involved, but when a body 12 is traveling along a track the energy of the first impulse provided by the rising of a pair of wheels on one side of the truck assembly 14 will initiate a rocking motion to the body 12 and such rocking motion is often augmented by a second impulse produced by the opposite pair of wheels 18 passing over a high portion of track at or near the time of the rebound from the first oscillation. Since such augmentation may well be much greater than the energy absorbed during the first swing, the second swing may well be more violent that the first. In an extreme case, a number of impulses occurring at intervals of time almost exactly equal to the period of oscillation of the body 12 will be added together to produce extreme and dangerous rocking of the body 12.

One preferred form of this invention as presently contemplated is shown in FIGS. 1–4 wherein a snubber is located in the position of one of the springs of the prior art spring groups 22. A typical prior art arrangement of the springs in a spring group 22 is shown in FIG. 3 with the snubber 2 replacing one of the springs and comprises seven large springs 4 and nine smaller springs 6 with each of the large springs 4 having a smaller spring 6 internally coaxial therewith to provide a maximum of spring force for the space available. In such conventional spring groups 22 three of the large springs 4 are located in a slightly outwardly curved row at the extreme outer end of the bolster 27 (only two being shown) and three other large springs 4 are located in a similar slightly oppositely curved row at the portion of the bolster 27 in juxtaposition with the inner side of the side frame 21. A single large spring 4 is located between the center springs 4 of the inner and outer rows and a pair of small springs 6 are located between the ends of the inner and outer rows of springs. As shown the center spring 4 and the spring 6 encompassed thereby of the outer row of springs 4 has been replaced by a spring group snubber 2. Although one typical prior art arrangement of springs 22 has been shown other prior art spring group arrangements are modifiable to incorporate the snubbers of this invention.

Snubber 2 (FIG. 4) extends vertically in use and comprises a bottom platen 3 having a substantially flat bottom surface supported upon a central area of the bottom portion 23 of side frame 21. The upper surface of the platen 3 is substantially spherically concave on a large spherical radius and supports thereon a bottom end portion 5 of a lower member 7. Member 7 has a tubular cylinder portion 8 extending upwardly from the end 5 with the upper end thereof terminating in a ring-shaped stop element having an inwardly extending stop portion 9. The bottom surface of end 5 is convexly spherical with a spherical radius substantially shorter than the radius of the upper surface of the platen 3, and cooperates with the upper surface of the platen 3 in a manner very similar to that described in my previously copending application Ser. No. 709,142 filed Feb. 28, 1968. The upper portion of cylinder 8 is encompassed by the lower portion of a compression-type helical spring 10 with the lower end of spring 10 being supported on an outwardly extending flange portion 11 of cylinder 8 having a suitable upwardly facing supporting surface engaged by the lower end of spring 10.

A top platen 13 having a substantially spherical concave bottom surface 15 of generally the same spherical radius as the spherical radius of platen 3 is biased into engagement with a downwardly facing outer area of the bolster 27 by the spring 10. Spring 10 has a free length such that when installed, by separating one end of the bolster 27 from the adjacent bottom portion 23 of the side frame 21 the maximum amount permitted by the interfitting of such parts, the compression of spring 10 will bias platens 3 and 13 into firm engagement with the opposed upwardly facing surface on the bottom portion 23 and the undersurface of the end portion of the bolster 27, respectively. The outer periphery of platen 13 provides an outwardly and downwardly open notch 19 for receiving the upper end of spring 10 such that the spring 10 is retained coaxially with the central axis of the snubber 2.

Slidably received within the cylinder 8 is a formed hollow piston 302 having an upper end portion 304 which has a spherical convex upper surface of shorter radius than the bottom surface of the top platen 13 and related to that surface in the same manner as the two aforementioned spherical surfaces. End 304 is rigidly secured to a downwardly extending tubular side portion 306 which for the major axial extent thereof from the location thereof is closely telescopically received within the cylinder 8. With the snubber 2 in the collapsed position the lower end of side 306 engages an upper flat inner surface of the platen 5. The piston 302 is provided with axially spaced external circumferential grooves 305 and 307 upwardly adjacent the lower end thereof which grooves 305 and 307 are respectively suitably dimensioned to receive suitable sealing elements such as an O-ring 308 and a metallic piston ring 310 of a type well known in the art of hydraulic cylinder construction. Piston 302 has an integral partition portion 312 extending across the interior of the piston 302 axially inward from the lower end thereof which divides the interior of the piston 302 into an upper closed chamber portion or reservoir 314 and a lower open chamber portion 316.

Hydraulic communication between the reservoir 314 and the lower chamber 316 is through a central bore or passageway 318 centrally coaxial with the piston 302 and a plurality of smaller bores or passageways 319 circumferentially spaced on a common diameter of piston 302 and radially spaced from and parallel to passageway 318. Chambers 314 and 136 are substantially filled with a suitable hydraulic fluid and passage of fluid from the lower chamber 316 to the reservoir 314 is controlled by a ball valve 320 seated on a suitable seat at the upper end of passageway 318 which valve 320 is biased into engagement with the seat therefor by a compression-type helical spring 322 interposed between the underside of the upper end 304 and the upper surface of the valve 320 to provide a high-pressure check valve structure. Extending over and slightly beyond the bottom ends of the passageways 319 is a ring-shaped flat valve 324 which is biased lightly against the area of the partition 312 adjacent the bottom ends of the passageways 319 by a slightly compressed helical compression spring 326. Spring 326 is supported by a suitable snapring 327 and washer 328 mounted on a downward extension or center post 329 of the central portion of the partition 312 in a suitable snapring groove or by other suitable removable connections. Passageway 318 extends upwardly through the post 329.

Radially outwardly of the ring valve 324 and interposed between the bottom surface of the partition 312 and the upper surface of the bottom end 5 is a pair of springs 330 applying a moderate upwardly biasing force on the piston 302 to cause the piston 302 to be extended from the cylinder 8 whenever the cooperable bolster end moves upwardly in a direction away from the portion 23 of the side frame 21. The amount of extension of the piston 302 from the cylinder 8 is limited by an external circumferential shoulder 332 extending outwardly of the side 306 which is engageable with the underside of the stop 9. After shoulder 332 engages the stop 9 further separa-

tion of the bolster 27 from the bottom portion 23 causes a gap, clearance or space 334 to occur (FIG. 1) between the top member 304 and the top platen 13 since spring 10 maintains the upper and lower platens in engagement with the opposed surfaces on the bolster 27 and the portion 23.

The vertical extent of the clearance 334 is such that the distance the spring groups 22 are compressed when supporting a loaded body 12 during travel over typical track profile which does not cause or result in severe or dangerous rocking is somewhat less than the vertical extent of the clearance 334 and the snubbers 2 are not activated during such travel. A typical clearance 334 dimension of 3/16 inch is sufficient to accommodate approximately 90 percent of all the permissible spring movements with a loaded body 12. Consequently the snubbing action of the embodiment is limited to cycles of spring movement where the motion of a loaded body 12 causes compression of a spring group 22 greater than the extent of clearance 334.

During the movement of a body 12 over railway tracks the top platens 13 move upwardly and downwardly with extension and compression of spring groups 22 and increase and decrease the vertical dimension of the clearances 334 without moving the pistons 302 within the cylinders 8 as long as the distance the spring groups 22 are axially compressed is not greater than the vertical extent of clearances 334. When either spring group 22 is axially compressed a distance greater than the clearance 334 the associated top platen 13 contacts the top member 304 of the associated piston 302 and forces the piston 302 downwardly into the cylinder 8. As the piston 302 begins to move downwardly within the cylinder 8 compression of the hydraulic fluid within the lower chamber 316 is initiated and, as the piston 302 continues its descent increases the pressure within the hydraulic fluid until a sufficient hydraulic force is effective upon the lower hydraulically effective area of valve 320 to overcome the bias of spring 322. When such hydraulic force is obtained in the lower chamber 316 the spring 322 is compressed and the valve 320 moved upwardly off the seat therefor at the upper end of passageway 318 and the pressurized hydraulic fluid flows from the lower chamber 316 through the passageway 318 into the reservoir 314. The given, specific or constant pressure of the hydraulic fluid at which the valve 320 moves upwardly is dependent upon the downward biasing force of the force of the spring 322 and the area of the valve 320 to which the hydraulic fluid is applied. At any time the pressure of the hydraulic fluid in chamber 316 falls below such constant pressure value the valve 320 is biased into engagement with the seat therefor.

Passageway 318 is preferably of a cross section to permit flow of pressurized hydraulic fluid therethrough from lower chamber 316 at a rate that the pressure of the hydraulic fluid remaining in the chamber 316 remains substantially constant during continued descent of the piston 302. Thus, this preferred embodiment is directed to a snubber for a railway car which is located in a spring group and is only operable when a given pressure is developed within a hydraulic fluid in a chamber of decreasing volume and, thereafter the hydraulic fluid within such chamber as the volume continues to decrease remains substantially at such specific or constant pressure. Accordingly, the cross-sectional area of passageway 318 is determined by the relative velocity of the piston 302 with relation to the cylinder 8 which occurs during movement of a loaded body 12 over a generally encountered or normal section of track. Further in such a constant pressure snubber the cross-sectional area of passageway 318 is of a magnitude to permit free flow of hydraulic fluid therethrough without incurring any viscous drop to any substantial degree and permit substantially all the pressure drop in the hydraulic fluid to occur in the passageway defined by the displaced valve 320. In practice a passageway 318 of 3/16 inch to 1/2 inch diameter has been satisfactory.

During the flow of pressurized hydraulic fluid into the reservoir 314 the passageway 318 functions as a submerged orifice and such flow causes a large portion of the energy required to pressurize the hydraulic fluid to be converted into heat. In order to obtain the desired flow of hydraulic fluid the fluid contained within the snubber 2 is of a quantity to provide a submerged orifice at the upper end of passageway 318 for all relative axial positions of the lower member 7 and the piston 302.

After the completion of any downward motion of the piston 314 and the end portion of the bolster 27 thereafter moves upwardly with respect to the top platen 13, the piston 314 thereafter moves upwardly due to the bias of springs 330. As the piston 314 moves upwardly the volume of the open chamber 316 increases and a slight decrease in pressure of the hydraulic fluid therein occurs so that passageway 318 is closed by valve 320. As the piston 314 continues to move upwardly the pressure of the hydraulic fluid within the lower chamber 316 becomes lower than the pressure of the hydraulic fluid within reservoir 314 and the pressure of the hydraulic fluid within the reservoir 314 is effective upon the top surface of the valve 324 to move the valve 324 downwardly away from the bottom ends of the passageways 319 and hydraulic fluid from the reservoir 314 flows into the lower chamber 316 to maintain the open chamber 316 full of hydraulic fluid for all relative positions of the lower member 7 and the piston 302 whereby the snubber 2 is in a position to again be operational as described upon any downward movement of the piston 302 occurring after the gap 334 has been traversed.

Snubbers 2 have a collapsed height which includes the height of the platens 3 and 13 equal to or preferably slightly less than the collapsed height of spring groups 22 so that the spring groups become solid before the snubbers 2 are fully collapsed whereby no further forces are applied to the snubbers 2, thus preventing damage from possible overstressing.

The use of snubbers 2 as described results in snubber force being additive with the closing force being applied to the spring group 22 in which the snubber 22 is located. Although the platens 3 and 13 are preferred either or both may be omitted in which event the end of the top member 304 engages the undersurfaces of the end portions 17 of the bolsters 27 and the bottom surfaces of the bottom ends 5 engage the upper facing surfaces of support portions 23. With such modification the springs 10 of the snubbers are of a length to hold the ends of the snubbers firmly in engagement with such surfaces throughout the greatest separation of the end portions 17 from the bottom portions 23 and the surfaces engaged are preferably provided with spherical surfaces corresponding to the spherical surfaces or platens 3 and 13.

As indicated the typical clearance 334 of a loaded car is approximately three-sixteenths of an inch however when a car is unloaded the clearance 334 increases to about 1 11/16 inches due to the unloaded condition of the spring groups 22. With such unloaded condition clearance snubbing action does not occur until the end portions 17 of the bolster 27 move a distance greater than increased clearance. Such limiting of the snubbing action to potentially damaging cycles of spring excursion is a highly desirable feature since it greatly reduces wear and heat production of the snubber of this invention as compared to continuously acting snubbers. If desired, snubbers 2 can be utilized as described without a clearance 334 and in such event a snubbing force would be obtained upon all movements of the ends of the bolsters 27 towards the support portions 23. Although a standard truck assembly 14 has been shown and described a modified truck assembly 14 having longer springs 4 and 6 in the spring groups 22 is a desired alternate structure. In such alternate structure larger snubbers 3 are utilized and larger clearances 334 are obtainable.

FIGS. 5 and 6 illustrate another preferred embodiment in which like parts have been identified by like reference numerals. In this embodiment the spring groups 22 of the prior art described are utilized and snubbers 2 are located between the outer end portions 17 of the bolsters 27 and the upper portions 23 of the side frame 21. Bolster 27 is of any conventional structure and a known bolster 27 having a hollow rectangular end portion 17 with suitable internal bracing and external

guide or retaining means is illustrated. The upper cross-extending portion of the bolster **27** at each end portion **17** is provided with an opening **336** in alignment with the central spring **4** of the spring group **22** therebelow. The upper portion **335** of the side frame **21** is of known construction such as the inverted U-shaped member shown with the opening between the downwardly extending side portions thereof being vertically aligned with the opening **336**. A snubber **2** extends vertically between an inner downwardly facing surface **338** on the upper bight portion of the upper portion **335** and the inner upwardly facing surface **340** of the lower crossmember of the outer end portion **17** of the bolster **27** each each side of each truck assembly **14**. As installed the upper surface of the top platens **13** engage the inner downwardly facing surfaces of the upper portions **335** and the lower surfaces of the lower platens **3** engage the inner upwardly facing surfaces of the lower crossmembers of the end portion **17**. Snubbers **2** are of the structure previously described; however, snubbers **2** in this embodiment are of an overall length to function upon movement in the same manner as previously described. In order to so function the length of the snubbers **2** can vary dependent upon the distance existing between the surfaces between which the ends of the snubbers **2** operates. Such distances are known for various prior art structures of side frames **21** and bolsters **27**. As before, spring **10** has a free length such that when snubbers **2** are installed by separating the bolsters **27** from the upper portions **335**, and the bolster **27** thereafter moves upwardly due to the force of the spring groups **22** and the bolster **27** is supported with the body **12** at rest, the patens **3** and **13** are biased into firm engagement with the surfaces **338** and **340**, respectively, a clearance **334**, typically of three-sixteenth inch, is provided between the upper surface of top member **304** and the lower surface of the top platen **13** which clearance **334** is sufficient to accommodate approximately 90 percent of the spring movements of a loaded railway car. The operation of the snubbers **2** located above the spring groups **22** is the same as previously described; however, the energy input to the snubbers **2** is different due to locating the snubbers **2** above the spring groups **22**. In this embodiment the snubbers **2** operate in series with the spring groups **22**, respectively, during the periods the spring groups **22** are extending, that is, the period any one spring group **22** is rebounding and releasing the energy stored therein during the prior period of compression thereof due to the movement of the bolster end portion **17** towards the bottom portion **23** causing compression of the spring group **22** therebetween. For the same reasons previously stated the clearance **334** when a body **12** is fully loaded permits the spring groups **22** to extend a distance equal to that of the clearance **334** without causing the snubbers **2** to operate to absorb the rebound energy. When the spring groups **22** move the end portions **17** of the bolster **27** upwardly a distance greater than the clearance **334** the snubbers **2** are subjected to a compression force whereby energy is absorbed as previously described. In such operation the extending spring groups **22** remain in engagement with the lower surface of the end portion **17** of the bolster **27** and the movement of the bolster **27** towards the upper cross portion **335** after the clearance **334** has been traversed causes compression of the snubbers **2**.

In this embodiment the snubbers **2** result in the snubber force being applied to dissipate the rebound or extension energy of a spring group **22**; that is, the snubbing force is a constant pressure force which retards the extension of a spring group **22** and which snubbing force is opposed to the extension force. Further the modifications previously mentioned regarding snubbers **2** are applicable to this embodiment. In this embodiment the increase in clearance **334** for unloaded bodies **12**, as previously described, is not obtained and when bodies are unloaded the snubbers **2** are effective at all times.

Although preferred embodiments have been heretofore described the principles of this invention can also be employed in other types of snubbers or at other locations of a railway car at which snubbing action is desired. Further although the previously described embodiments have been designated as preferred embodiments it is quite possible that some of the hereinafter-described embodiments will in fact be the preferred embodiments dependent upon experience gained over periods of actual use.

FIGS. **7** to **10** illustrate another type of snubber **26** of this invention. In this embodiment prior art spring groups such as spring groups **22** are utilized and the snubbers **26** are cooperable with the spaced roller bearings **28** mounted in channel sections **29** secured to the truck bolster **27** intermediate the spring groups **22** and the center plate **24**, respectively, in each truck assembly **14**. Snubbers **26** are secured to suitable structural supports **33** depending downwardly in alignment with the bearings **28**, respectively, with the lower surface **34** of each snubber **26** constituting a bearing plate. A clearance space is preferably provided between the bearing plates and the roller bearings **28** cooperable therewith, respectively, and roller bearings **28** are adapted to roll on cam surfaces **31** formed on the lower surfaces of channel sections **29**, as best shown in FIG. **9**. THe clearance between the lower surfaces **34** and the rollers **28** permits the truck assembles **14** to negotiate small profile differences between the two supporting rails therefor with only minor motion influence on the body **12**.

Each snubber **26** (FIG. **10**) includes an upper body member **38** suitable rigidly secured to a support **33** which is normally upwardly spaced from a lower body member **40** having the lower surface **34** previously identified. The upper member **38** has a centrally located upwardly extending threaded bore **62** and the lower member **40** has a central through bore vertically aligned with the bore **62**. Suitable fastening means such as a capscrew **66** extends through the central bore **64** and is threadedly engaged with the threaded bore **62** to provide means to limit the upper and lower members **38** and **40** from separating from each other but which allows members **38** and **40** to move together under compressive forces. A cap **68** is threaded into the outer threaded end of the bore **64** to prevent fluid from escaping from a chamber **52** through the bore **64**.

Opposed surfaces of members **38** and **40** define opposite vertically located ends of a chamber **52** therebetween with the lower member **40** having an inwardly extending annular upwardly open portion formed therein outwardly adjacent the central portion thereof through which screw **66** extends. The outer peripheral portion of chamber **52** is formed by the inner surface of an integral upwardly extending annular flange portion **48** on the outer portion of member **40**. An annular ring **54** is located within chamber **52** which has a vertically extending outer surface located throughout the length thereof closely adjacent the inner surface of flange **48** to form an elongated open-ended passageway **70** therebetween. The central opening of ring **54** is located to permit the central upwardly extending portion of member **40** to travel therewithin during movement of the members **38** and **40** towards each other as hereinafter described. As shown, the upper edge of flange **48** is generally horizontally aligned with the central portion of the lower surface of the upper member **38** when the snubber **26** is not subjected to compressive forces. Ring **54** has a downwardly facing surface of a configuration to be freely received within the annular portion of cavity **52** and an upper flat surface which is biased towards or into engagement with the lower surface of member **38** by a plurality of suitable biasing means such as springs **58**. As shown, a plurality of circumferentially spaced downwardly open blind bores **56** extend upwardly in the annular ring **54**, with the upper ends of springs **58** being received therein, respectively. Springs **58** extend downwardly beyond bores **56** with their lower ends engaging the upwardly facing inner surface of the annular portion of cavity **52** of lower body member **40**. An O-ring **60** is desirably employed on the upper portion of ring **54** to provide a seal between the annular ring **54** and the lower surface of the upper member **38** when such members are engaged.

A fluid casing or reservoir **36** is provided which encompasses the annular opening between the upper end of flange **48** and the portion of member **38** opposed therefrom in all relative positions of the members **38** and **40**. As shown, reser-

voir 36 is of U-shaped cross section with the sidewalls or arms thereof extending generally horizontally with the outer ends thereof being received in suitable vertically spaced cooperable portions on the members 38 and 40. The upper and lower inwardly extending sidewalls of the reservoir 36 extend along slightly convergent lines outwardly from the center of the snubber 26 such that the sidewalls, combined with a given radial dimension and a particular wall thickness, control the stress magnitude and establishes the proper spring constant to separate the members 38 and 40 at a desired rate with the approximate size and geometry of the unit shown in FIG. 10. A slope of approximately 5° to the horizontal has been found to be satisfactory. For such purposes reservoir 36 is formed of a suitable flexible material such as steel and the outer ends of the arms are preferably sealed to the members 38 and 40 by suitable sealing means, such as O-rings 42 and 44 respectively. Prior to use each snubber 26 is substantially filled with a suitable liquid, hydraulic fluid or oil 65 such that the oil level 67 in the reservoir is above the upper end of passageway 70 in all relative positions of the members 38 and 40.

With snubbers 26 supported on supports 33 at each end of each bolster 27, as a car body 12 travels over supporting tracks as are generally encountered the rocking motion of the body 12 does not cause any operations of the snubbers 26 inasmuch as the surfaces 34 do not contact the rollers 28. Under more severe conditions which cause a body 12 to rock the snubbers 26 are effective to damp such rocking movement after the snubbers 26 have traversed the clearance distance between the surfaces 34 and the rollers 28 and engage the rollers 28. When surface 34 of any snubber 26 engages a roller 28 the member 40 is restrained by the roller 28 in engagement therewith and further movement of such snubber 26 towards such engaged roller 28 forces the upper member 38 with ring 54 in engagement therewith towards the lower member 40 and the ring 54 descends further downwardly into cavity 52. Inasmuch as the rollers 28 are supported by bolsters 27 which are supported by spring groups 22 the movement of ring 54 into cavity 52 is dependent upon the relative motion of the bolster 27 with respect to the body 12. Such movement of the ring 54 into the cavity 52 exerts a compressive force upon the fluid contained within cavity 52 and, since liquids are incompressible and passageway 70 is open ended, forces pressurized fluid from the cavity 52 through passageway 70 into reservoir 36. Thus, the application of a compressive force to a snubber 26 dissipates the energy input thereto by flow of hydraulic fluid through a restricted passageway. During such restricted flow of pressurized fluid a large amount of energy applied to a snubber 26 is converted to heat and dissipated to the surrounding ambient air or the heat-conducting means to which the snubbers 26 are connected and in particular to the lower portion of the body 12 which constitutes a heat sink. In addition, in order to obtain large energy dissipation, the passageway 70 is of a length and cross section to obtain a large pressure drop during low of pressurized fluid therethrough at a given rate. Under extreme conditions of rocking motion such a pressure drop is of a magnitude varying between 3,000 to 5,000 pounds per square inch; however, other pressure drops can be obtained as desired. Since heat energy is dissipated during operation of a snubber 26 the components of snubbers 26 are subjected to thermal expansion and it is preferable that the pressure drop obtained in a snubber 26 be substantially constant regardless of the operating temperature thereof or the viscosity of the hydraulic fluid. Consequently ring 54 is preferably formed of a material, such as brass and aluminum, having a higher coefficient of thermal expansion than that of member 40 to maintain the flow of fluid through passageway 70 to obtain the same pressure drop notwithstanding the decrease in viscosity of the fluid due to the heating thereof occurring during operation of a snubber 26. Also since the viscosity of a hydraulic fluid decreases with increased temperature a slight decrease of the cross section of passageway 70 is desirable to compensate for such decreased viscosity.

With a lower member 40 engaged by a roller 28 relative movement of upper member 38 with respect to member 40 will continue as long as the body 12 continues to have relative movement towards the engaged roller 28. Under full compression of members 38 and 40 the upper end of flange 48 engages the upwardly adjacent downwardly facing surface of the upper member 40 at which time snubbers 26 no longer are effective to absorb energy. Consequently, snubbers 26 are designed with relation to the maximum loads which are applied thereto to absorb a maximum amount of energy during their compression stroke which is less than the force which causes fatiguing or structural failure of the components of the snubbers 26 of side frames.

After the completion of a compression stroke of a snubber 26 and regardless of the extent thereof, relative movement of the body 12 subsequently occurs away from the previously engaged roller 28 such that the member 38 moves relatively upwardly with the body 12 away from the lower member 40. When the body 12 initially has relative motion away from a roller 28 engaged by a member 40, the sidewalls of the reservoir 36 bias the members 38 and 40 away from each other until there has been sufficient relative movement of the body 12 to permit the members 38 and 40 to be fully extended from each other. Thus, the lower member 40 can remain in engagement with a roller 28 for a period even though the body 12 has relative movement away from such roller 28. Also, during the prior compression stroke of a snubber 26 the springs 58 are compressed and capable of reextending upon upward movement of member 38. During upward movement of member 38 relative to member 40 the pressure of the fluid within the cavity 52 decreases constantly and the fluid within reservoir 36 is effective upon the upwardly facing outer peripheral portion of ring 54, which is at a relatively higher pressure, to bias the ring 54 downwardly. In order to provide a sufficient area of ring 54 for the hydraulic fluid in reservoir 36 to be hydraulically effective thereon, a downwardly and outwardly open circumferential recess is provided at the lower outer portion of member 38 to permit flow of fluid from the reservoir 36 over the upwardly facing outer peripheral portion of ring 54. The downwardly facing portion of such recess is spaced upwardly from the upper end of flange 48 and limits the movement of the members 38 and 40 toward each other. Thus, when there is no relative movement between member 38 and 40 or during upward movement of member 38 relative to member 40 opposed forces are effective upon ring 54, and for this invention the springs 58 provide an upward bias on ring 54 which is less than the hydraulic force biasing ring 54 downwardly. Consequently, when member 38 starts upward movement relative to member 40 the ring 54 is biased away from the upper member 38 and hydraulic fluid flows from the reservoir 36 over the top of ring 54 through the center thereof into the cavity 52 to maintain the cavity 52 full of fluid during such upward movement of member 38. Separation of the ring 54 from member 38 establishes communication of the entire periphery of cavity 52 to reservoir 36 to obtain rapid return flow of fluid into cavity 52. In addition, during relative movement of member 38 away from member 40 a certain viscous drag is developed between the ring 54 and flange 48 due to fluid in passageway 70 which also retards the upward movement of ring 54.

In filling the snubber 26 with fluid a quantity of air exists above the level 67 which is retained at atmospheric or slightly higher pressure to provide a positive pressure within the reservoir 36. When ring 54 separates from member 38, as heretofore described, a faster rate of return flow of fluid is obtained when a pressure greater than atmospheric pressure exists above level 67 than when atmospheric pressure exists above the level 67. In order to prevent a pressure less than atmospheric from existing above level 67 a suitable check valve 37 is located in the upper sidewall of reservoir 36 which permits air to pass therethrough into the reservoir 36 above the level 67 and which prevents reverse flow of air out of reservoir 36. If desired, suitable valve means can be provided in the

upper sidewall of reservoir 36 to limit the pressure of the above level 67.

Annular flange 48 preferably has a strength such that pressures higher than desired in chamber 52 are prevented by expansion of the flange 48, under pressure, slightly increasing the size of the passage 70 to prevent increase in the pressure drop therethrough. Such construction permits the snubber to respond at a more or less constant force.

Thus, snubbers 26 are of a structure to provide a unidirectional resistance to motion which absorb energy throughout their entire compression stroke. Further, although a clearance between the wear plates 34 and rollers 28 is preferred, the snubbers 26 bare equally suited to absorb energy upon initial movement of members 37 and 40 towards each other. Thus, if desired, the wear plates 34 can be located in engagement with rollers 28 such that any movement of the bolsters 27 towards the body 12 will cause the members 38 and 40 to move towards each other and be effective immediately to absorb energy. If further desired the snubbers 26 can be preloaded by compressing the snubbers 26 a distance such that the wear plates 34 engage the rollers 28 and the members 40 are displaced, with respect to the spacing of members 40 from members 38 previously described, towards the members 38. For such purposes rings 54 can be displaced up to one-half of the distance through which they travel. With such preloading the snubbers 26 are effective throughout the entire relative motion between the body 12 and the bolster 27 and immediately effective to absorb energy when members 38 and 40 are moved towards each other.

FIG. 14 illustrates a snubber 271 which is a modification of the embodiment of FIG. 10 having constant pressure operation as described with references to the embodiments shown in FIGS. 1–4 and 6, 7. The structure of snubber 271 is quite similar to snubber 26 and the like parts are identified by the same reference numerals and snubbers 271 are supported by the body 12 (not shown) in the same manner as snubbers 26. In this embodiment a lower body member 272 is similar to member 40 and additionally has a spring-biased valve 273 communicating on its lower pressure side with the reservoir 36 through a fluid-conducting passageway 274. Valve 273 is located in a stepped cylindrical bore 279 extending from the bottom surface of the lower body member 272 with the upper end thereof communicating with the annular portion of cavity 52. Valve 273 is of a type suitable for blocking communication between the reservoir 36 and the cavity 52 until a preselected pressure has been attained in cavity 52.

A ring member 277 is the same as ring 54 but further includes on the outer periphery thereof a suitable sealing member such as an "O" ring 278 which engages the inner surface of flange 48 throughout the movement of ring 277 to prevent flow of liquid out of cavity 52 between the flange 48 and the ring 277 when the body members 38 and 272 move toward each other. It is to be noted that the "O" ring 60 of FIG. 10 has here been omitted from ring 277 in favor of a close mating fit between the ring 277 and the member 38 but either sealing method can be used in either modification.

As shown, valve 273 comprises a body portion which extends coaxially within bore 279 with an upwardly facing annular surface thereon engaging the downwardly facing surface or seat of the stepped bore 279. The annular surface of valve 273 is biased upwardly in engagement with such seat in the bore 279 by engagement of the lower end of valve 273 with the upper end of a suitable compression spring 276 located in the lower portion of the bore 279; the lower end of which spring 276 is adjustably positioned within the bore 279 by suitable means such as a plug 275 threadedly received at the outer end of the bore 279. Although the upper portion of the bore 279 is of a reduced diameter compared to the portions thereof in which the body portion of the valve 273 is received the cross-sectional area thereof is of a magnitude to provide for fluid flow as described hereinafter.

In operation, when the members 38 and 272 move towards each other the fluid within cavity 52 is pressurized due to the engagement of the upper portion of the ring 277 with the lower surface of member 38 and the engagement of the "O" ring 278 with the inner surface of the flange 48. As movement of members 38 and 272 toward each other continues the pressure of the fluid within cavity 52 increases until a pressure is obtained which when applied to the upper hydrostatically effective area of the valve 273 exposed to such pressurized fluid is sufficient to overcome the bias of spring 276 whereby the valve 273 moves out of engagement with the stepped bore seat in bore 279 and hydraulic communication is established between the cavity 52 and the reservoir 36 through bore 279 and passageway 274. With such structure the snubber 271 functions as a constant pressure device as previously described.

Upon movement of the members 38 and 272 away from each other the ring 277 separates from member 38 as previously described to provide for rapid return flow of fluid to cavity 52 from the reservoir 36; it being noted that the engagement of the "O" ring 278 with flange 48 aids such separation. At the same time the simultaneously occurring slight decrease in fluid pressure within cavity 52 results in the valve 273 being biased upwardly by spring 276 so that the annular surface of the valve 273 engages the seat within bore 279 cooperable therewith to close the communication of cavity 52 to reservoir 36 through bore 279 and passageway 274. Although not shown any suitable sealing means can be provided for "O" ring 278 such as a suitable piston ring structure.

With the modification shown in FIG. 14 the necessity for closely controlled spacing between the ring 277 and the flange 48 is eliminated due to the use of sealing ring 278. Further the biasing force on relief valve 273 is adjustable so that the pressure at which snubber 271 operates can be matched to various car weights and designs after installation.

As indicated rapid refill of cavity 52 is obtained with the embodiments of FIG. 10 and FIG. 14. If desired such rapid refill can be obtained by the modification shown in FIG. 15 wherein a snubber 282 (like components being identified by the same reference numerals has the ring member 54 thereof mounted upon a plurality of springs 284 which apply a much greater biasing force on the ring 54 than the springs 58 of FIG. 10. A lower body member 286 differs from lower body member 40 of FIG. 10 in that body member 286 is provided with at least one stepped cylindrical bore 287 extending downwardly from the bottom of an annular portion of cavity 52 which bore 287 communicates with the casing 36 by way of a passageway 288. Located in each bore 287 is a suitable check valve 290 of a well-known type to allow substantially free flow of liquid from the casing 36 into the cavity 52 with a minimum pressure drop while being effective to prevent liquid flow in the opposite direction.

By using several such check valves 290 rapid refill of the cavity 52 is accomplished even though no separation between the ring member 54 and the upper body member 38 takes place, making it possible to greatly increase the spring constant of the springs 284 over that of springs 58 as may be desirable under some conditions.

With reference now to FIG. 11, an alternative embodiment of the invention is shown in which a reservoir 36′ similar to reservoir 36 is formed from upper and lower halves, the upper half being an integral part of the upper member 38′ and the lower half being an integral part of the lower member 40′. (Like parts having the same reference numerals and similar parts having the same number primed,) In this embodiment the lower body member 40′ has an annular flange 48′ and a raised center section 50′ defining the lower surface a fluid cavity 52′. Likewise, an annular ring 54′ having a higher thermal coefficient of expansion than the surrounding parts projects into the fluid cavity 52′ and is biased upwardly into engagement with the underside of member 38′ by coil springs 58′. O-ring 60′ seals the annular rings 54′ against the upper body member 38′ and the member 38′ has a centrally located threaded bore 62′ which receives the threaded end of a cap-screw 66′ extending through a central bore 64′ in the lower

member 40'. Cap 68' is threaded into the lower end of bore 64'.

Secured to the upper surface of member 38' is a plate 71 which, for example, is connected to support 33 shown in FIG. 7. A second plate 72 is secured to the lower member 40' and has a lower bearing surface 34' adapted to contact the bearings 28.

Annular casing 36' is formed from upper and lower halves formed integrally with the members 38' and 40', respectively. Thus, the upper half of the annular casing 36' comprises a circular plate 74 formed integrally with the member 38' and extending outwardly therefrom in cantilever beam relationship. Depending downwardly from the edge of the circular plate 74, and formed integrally therewith, is a cylindrical flange 76. In a similar manner, a circular plate 78 is formed integrally with the lower member 40' and is provided with an upwardly projecting cylindrical flange 80 arranged to abut the edge of flange 76 as at 82. An O-ring seal 84 is interposed between the mating surfaces of the flanges 78 and 80. The entire upper assembly comprising member 38', plate 74 and flange 76 is secured to the entire lower assembly comprising member 40', plate 78 and flange 80 by suitable means such as bolts 86. As shown, each bolt 86 passes through an opening in a boss 88 which is welded or otherwise securely fastened to the upper flange 76, and is threaded into a cooperating boss 90 welded or otherwise securely fastened to the lower annular flange 80.

The device shown in FIG. 11 operates as before described however the ring 54' has a tapered outer surface ending in portion of a spherical surface on the lower edge thereof which is of a curvature to maintain the annular dimension of the passage between the ring 54' and the flange 48' substantially unchanged even though the ring 54' is tipped about a diameter thereof in relation to the annular flange 48'.

FIG. 12 illustrates an alternative arrangement wherein the snubbers 26 are mounted on, and carried by, the truck bolsters 27. The channel sections 29 and roller bearings 28 are, in turn, carried on the upper members 38, the bearings 28 being arranged to contact bearing plates 88 mounted on the lower surface of supports 33 in alignment therewith. The operation of the invention in this case is, of course, similar to that previously described with the exception that the snubbers 26 are carried by the bolsters 27. Also, if desired a clearance space between the rollers 28 and the bearing plates 88 can be provided to obtain other operation of the snubbers 26 as previously described.

FIG. 16 illustrates utilization of a snubber 140 between a center plate 24 and a bolster 27 of a truck assembly 14. FIG. 16 is similar to FIG. 7 and like parts have been identified by the same reference numerals. Inasmuch as a snubbers 140 are utilized, snubbers 26 of FIG. 7 are omitted and suitable prior art brackets 135 are shown having wear plates 34 secured thereto which wear plates 134 cooperate with the rollers 28 as well known. As shown more clearly in FIGS. 17 and 18, snubber 140 comprises an upper platelike member 142 having a flanged circular recess 144 therein for receiving the lower end of the car center plate 24 and a lower platelike member 146 having a circular downwardly depending portion 148 for mounting on the flanged bearing surface 25 of the truck bolster 27. Lateral movement between the plate members 142 and 146 is limited such as by a downwardly extending projection or pin 152 on the plate 142 which extends into a central recess 154 in the plate 146 or by conformation of the conical surfaces of the members 142 and 146 which define an annular passage 174 therebetween. A clearance space 156 is provided between the projection 152 and the bottom of the recess 154 which space 156 increases upon vertical movement between members 142 and 146 (see FIGS. 18 and 19). Weight-bearing members or lugs 173 with channels 173' therebetween extend downwardly from upper plate member 142 to engage the bottom plate member 146 to support the weight of the car body 12. The inner ends of channels 173' communicate with the upper ends of annular passage 174.

Between the two platelike members 142 and 146 there is provided a plurality of stacked washers 158 which rest on an annular shoulder 160 formed on the lower member 146. The washers 158 are held in snug-abutting relationship with the annular shoulder 160 by coil springs 162 disposed in bores 164 circumferentially spaced along an extending upwardly of an annular groove 166 formed in upper member 142. O-ring seals 168 are desirable provided between the washers 158 and between the bottom washer and the shoulder 160 to provide seals therebetween.

In practice, the washers 158 are 6½ to 12 inches outside diameter by ¼—¼ inch thick but are shown much thicker relative to their diameters for easier comprehension of their operation.

The annular groove 166 and the space 165 contain a liquid, such as hydraulic fluid or oil, which is forced through an annular orifice 169 composed of the small clearance spaces 170 between the edges of the washers 158 and the outer wall of the groove 166 when the members 142 and 146 are moved toward each other. An annular reservoir 172 surrounds the opening at the end of channels 173' between the members 142 and 146 to receive the displaced liquid which is returned to the groove 166 and space 156 when the members 142 and 146 move away from each other. The normal liquid level within reservoir 172 is indicated by liquid level line 175. The reservoir 172 is of any suitable form such as the form of reservoir 36.

As shown in FIG. 17 with the car body 12 in normal upright position and the weight of the body 12 being supported on lugs 173 snubbers 140 function and operate generally in the same manner as the center plate 24 of car bodies of the prior art, but as soon as swaying motion begins an entirely different function and operation is obtained. When a body 12 sways to the left as shown in FIG. 18 the lugs 173 on the left-hand portion of the upper plate member 142 function as a pivot while the lugs 173 on the right-hand side of the upper plate member 142 are elevated a substantial distance above the lower plate member 146. During such movement the annular surface of the outer wall of the groove 166 is elevated from the washers 158 and together with the space 156 provides an increasing volume to be filled with fluid from the reservoir 172 through the channels 173' and the passage 174. As plate 142 separates from plate 146 and the body 12 rocks on the bolster 27, the viscous drag between washers 158 and the outer wall of the groove 166 as well as the immediate pressure difference in the fluid between reservoir 172 and the space 156 and groove 166, at the onset of separation between members 142 and 146, exerts an upward force on the washers 158 against the downward biasing force of the springs 162 with the result that the washers 158 are lifted off the shoulder 160 and fluid flows freely into the groove 166 and the space 156 with no tendency to produce cavitation. Should the swaying or rocking motion continue far enough, the wear plate 34 and roller 28 come into contact and form a new pivot point further removed from the center of the bolster 27 and the plate 142 lifts free from its corner pivot lugs 173, with still further increase in the fluid demand volume of the groove 166 and the space 156 to be filled by further inflowing of fluid from the reservoir 172 along the same path as earlier described. All of the above action is essentially the same as that of prior art center plate and side bearing assemblies including a rebound caused by the action of the spring groups 22 which are compressed after the initial contact of the rollers 28 and the wear plate 34 and which will expand to return the body 12 to its original upright position. As the body 12 begins this return motion, the fluid space within the groove 166 and the space 156 begins to decrease in volume with consequent displacement of the fluid then within such space. The first effect of such return motion is to close the washers 158 upon each other and upon the surface 160 thus forcing the fluid from such space to travel through the annular orifice 169 composed of the clearances 170 about the individual washers 158. The orifice 169 is carefully calculated and is of a length and cross section to produce a large energy-absorbing pressure drop whenever fluid at high pressure is

forced to flow therethrough and since the pressures developed in a typical snubber **140** are of the order of 1,000 to 5,000 pounds per square inch, a large amount of energy is absorbed as the fluid is forced to flow through the orifice **169**. This mechanical flow energy is transformed into heat which is readily absorbed by the upper and lower plate members and conducted away to the body **12** and the bolster **27**, respectively, both of which are massive metallic bodies quite suitable to act as heat sinks.

As the body **12** returns to the upright position this absorption of energy is sufficient to reduce the rebound from each cycle and to limit the extreme motion amplitude for a given track profile difference.

Snubber **140** includes the following:

1. The use of a plurality of washers **158** to produce a relatively long orifice **169** from a plurality of short openings **170** makes it possible to maintain a longer length and an approximately constant annular clearance orifice **169** even though the members **142** and **146** are rotated into nonparallel positions by pivoting about some of the lugs **173** as shown in FIG. **18**.
2. The thickness of the washers **158** is calculated by geometry so that in no position of rotation about any diameter thereof will there by any binding of the washers **158** on the shoulder of groove **166**. A typical result of such computation shows that for a washer diameter of 12 inches and a 0.004-inch annular dimension of the space **170**, the washer **158** can be approximately one-half inch thick or less without any possibility of binding in the groove **166** due to rotation about any diameter of the washer **158**.
3. The design of the walls of the groove **166** is such that as the pressure within the groove **166** increases the metal surrounding the groove **166** will expand to open the space **170** allowing a more rapid outflow through the orifice **169** so that a more or less consistent pressure is produced regardless of the rate at which the car body may be rocked back into the upright position.
4. Washers **158** are in many instances desirably made of a metal having a higher coefficient of expansion than that of plate member **142** so that at lower than normal temperatures the orifice path **169** will have an increased cross-sectional area to compensate for increased viscosity of the hydraulic fluid at such temperatures, thus tending to maintain a constant rate of energy absorption at various temperatures.

It is to be noted that elements similar to the washers **158** as seen in FIG. **17** can be substituted for the annular ring **54**, or equivalent described herein, to provide, in such other embodiments the advantages of the multiple element piston assembly hereinabove set forth.

Another type of operation highly valuable in the prevention of damage to the trucks occurs when, as often happens in a switching operation, particularly in classification yards, a car standing still is struck by a moving car or vice versa. This blow, applied to the coupling of the car at some distance below the center of gravity of the car body, has a tendency to rotate the car body about its center of gravity so that the end of the car, opposite from that which is struck, is raised a substantial distance off the truck supporting that end of the car body. After the coupling blow has occurred the car body descends by the action of gravity and strikes a heavy blow on the top of the bolster, often damaging the truck center plate or some of the support members of the car. The damping device of this invention is well suited to soften the blow downward against the bolster, since, when the car body is raised from the bolster (as shown in FIG. **19**) fluid flows into the fluid demand space within the groove **166** and the space **156** so that when the car body begins to descend, the damping action now becomes a shock-absorbing action with the energy of the falling body being absorbed over a relatively long period of time.

An important feature of the embodiment of the snubber **140** shown in FIGS. **17** and **18** is that the opening between the members **142** and **146** terminates in an annular groove **186** which communicates with the lower end of the annular space **170** and the lower end of passage **174**. The annular groove **186** comprises the lowermost point of the space between the members **142** and **146** containing fluid. In the use of a snubber **140**, the repeated passage of the fluid back and forth between reservoir **172** and space **156** will tend to trap air bubbles within the fluid, thereby creating what can be compared to an emulsification of air and fluid. This emulsification will be more predominant adjacent the level **175** of the liquid within cavity **172**, which level is beneath an airspace in reservoir **172**. If the entrapped air bubbles pass into the annular space **156** and annular chamber **166** as the member **142** tilts back and forth, the damping action of the device will, of course, be impeded. By providing the annular space **186** leading to orifice **169** at the lowermost level of the fluid the entrapment of air bubbles at this area will be at a minimum as any bubbles entrapped within the fluid will rise over a period of time to the surface at level **175**, which is far above the groove **186**.

In the modification of the invention shown in FIG. **19**, a snubber is incorporated in the structures of a center plate **116'** and a truck bolster **118'** which are modifications of a standard center plate **24** and bolster **27** to form a snubber similar to snubber **140**. As shown in FIG. **19**, the center plate **116'** has a downwardly depending circular center portion **188** and a downwardly depending flange **190** surrounding the center portion **188** to form an annular cavity **166'**. The truck bolster **118'** has a central recess **192** therein for receiving the center portion **188** of the center plate **116'** and a laterally extending shoulder **160'** surrounding the recess **192** and spaced below the groove or cavity **166'** on the center plate **116'**. The remaining elements of this modification are the same as those shown in FIGS. **17** and **18** and are identified by the same reference numerals.

An annular reservoir **172'**, which is a modification of reservoir **172**, is shown in FIG. **13** and comprises a ring member **194**, composed of a reinforced elastomer, and similar in shape to an automobile tire. The member **194** may be installed between the members **142** and **146** of FIGS. **17** and **18**, for example, to encompass and communicate with the outer ends of channels **173'** between these members. The member **194** retains the liquid in a manner similar to the sidewalls of the reservoirs hereinbefore described. It is not necessary to provide O-ring seals as of the prior-discussed reservoirs as beads **196** at the free ends of member **194** cooperate with grooves in members **142** and **146** to prevent liquid from escaping.

In FIG. **20**, a further modification of the invention is shown which is similar in construction and operation to that of FIGS. **17** and **18**. In this embodiment a snubber **140'** similar to snubber **140** has fluid from an annular reservoir **228** (similar to prior-discussed reservoir) enter an annular damping orifice **224** from above rather than below as in the embodiments of FIGS. **17** and **18**. It comprises an upper annular platelike member **198** having a flanged circular recess **200** therein for receiving the car center plate **24**, and a lower platelike member **202** having a circular downwardly depending portion **204** for mounting on flanged bearing surface **25** of the truck bolster **27**. As in the embodiment of FIGS. **17** and **18**, limited lateral movement between the plate members **198** and **202** is permitted by a projection or pin **208** on the plate **198** which extends into a recess **210**, in the plate **202**. Sufficient clearance space **212** is provided between the projection **208** and the bottom of recess **210** to permit peripheral contact between lugs **173** and member **202**.

Between the two platelike members **198** and **202** there is provided a plurality of stacked washers **214**, corresponding to washers **158** shown in FIGS. **17** and **18**. The washers **214**, in this embodiment, are disposed within an annular groove **216** formed in the lower member **202**. The washers **214** are resiliently supported by coil springs **218** disposed in blind bores **220** spaced around the bottom of the annular groove **216**. O-ring seals **222** are desirable provided between the washers **214** and between the top washer and the bottom sur-

face of an upper platelike member **198**. Springs **218** apply an upward force to the washers **214** to maintain sealing contact between the individual washers **214** and between the topmost washer **214** and the upper plate **198**.

Liquid within space **212** and annular groove **216** is forced through an annular orifice **224** formed by small clearance spaces **226** between the edges of the washers **214** and the outer wall of the groove **216** when the members **198** and **202** are moved toward each other. Reservoir **228** surrounds the opening **230** between the upper member **198** and the lower member **202** to receive such displaced liquid which returns to groove **216** and space **212** when the members **198** and **202** separate from each other. Numeral **232** indicates the normal level of the liquid within the reservoir **228**, the space above the level **232** being filled with air.

Reservoir **228** is formed from two generally ring-shaped channel members **234** and **236** having flanges which are welded together as at **238** to form a generally toroidal member of U-shaped cross section with the legs of the U disposed in a widened portion **240** of the opening **230** between members **198** and **202** at the outer periphery thereof. O-ring seals **242** are provided between the members **234** and **236** to prevent the escape of fluid from the reservoir **228**.

An advantage inherent in the embodiment shown in FIG. **20** resides in the positioning of the washers **214** above the springs **218** so that when the upper plate **198** begins to move away from the lower plate **202** the inertia of the washers **214** provides assistance to the liquid pressure differential in overcoming the biasing force of the springs **218** to open a space between the washers **214** and the upper plate **198** and provide for rapidly filling of the groove **216** during initial rocking of the car body relative to the bolster. The embodiment of FIG. **20** also makes it possible to reduce the distance between the upper and lower plate member surfaces **200** and **206**, respectively, since there is better conformation of the female lower plate member to the female upper surface of the bolster.

In the embodiment of this invention shown in FIG. **21**, a car body **12** with side bearing brackets **135** and a downwardly extending center plate **24** is supported upon a truck **244** very similar to that described with relation to FIG. **16** and illustrated therein. The truck **244** is provided with axles (not shown) wheels **122**, side frames **124**, springs **128** and side bearing assemblies **130** all as are well known. A bolster **246** extends transversely under the car body and is supported at the end portions thereof by springs **128** in a well-known manner. In the central top surface of the bolster **246**, a recess **247** is provided for a saddle member **248** which, in turn, has upon its upper central surface a wide shallow circular recess **249** within which the circular bottom portion of the center plate **24** is positioned and supported for rotation relative to the truck **244** to allow the car to negotiate curves in the railroad track as previously described. The saddle member **248** is suitable shaped to encompass the upper portion of the bolster **246** and extends outwardly from its central portion to provide support for the side bearing assembles **130** rigidly secured to the upper surface of the saddle member **248**. Inwardly spaced from the side bearing assemblies **130** on the inside surface of the saddle member **248** are integral weight-bearing pads **250** the undersurface of which are engaged by vertically extending column members **252** having their lower ends vertically extending column members **252** having their lower ends supported by snubbers **254** very similar to those shown and described in FIGS. **10** and **11** excepting only that the reservoir **36** of FIG. **11** has, in FIGS. **21** and **22**, been replaced by a reservoir very similar to that described for reservoir **228** of FIG. **20**. The snubbers **254** on each side of the center plate **24** are suitably supported from the bottom part of the bolster **246** by a suitable bearing plate **255** rigidly removably secured to the bolster **246** as by threaded retaining member such as bolts **256** and **257** strong enough to carry the full weight of one end of the car in rocking motion as hereinafter described.

The operation of the embodiment shown in FIG. **21** is very similar to that described with the relation to the embodiment of FIGS. **17–19** since the saddle member carrying the load of the car body will in normal attitude fully compress the snubbers **254** and when rocking of the car body with respect to the bolster takes place the clearance spaces **136** will allow a slight amount of rocking which, if exceeded, will bring a bracket **135** into contact with the cooperable side bearing assembly **130**. If the rocking motion is large enough a bearing assembly **130** will depress the adjacent end of the saddle member **248** which, assuming rocking of the body **12** to the left, rocking about the upper end of the left-hand column member **252** acting as a supporting pivot will raise the right-hand end of the saddle member **248** allowing the opposite or right snubber **254** to expand with an inflow of liquid into the damping chamber **52** as hereinbefore described with relation to the earlier embodiment. The restoring spring constant as between channel member **176** and **178** (see FIG. **17**) is designed to expand the snubber at the extreme car body position for any given amplitude of motion. Rocking of the car body to this extent will undoubtedly compress the springs **128** and cause rebound of the car body toward the right-hand side with a force acting through the right-hand side bearing assembly **130** and the right-hand column **252** to force oil out of the damping chamber **52** as hereinabove described. The energy-absorbing action of the right-hand damping assembly **254** will remove a significant portion of the rebound rocking energy of the car body **110** to prevent buildup of rocking motion and provide the damping action as heretofore described.

It is to be noted that the snubbing of the embodiment of FIG. **21** is applied only on the rebound and not on the original swaying motion.

The embodiment of the invention shown in FIG. **22** is very similar to that of FIG. **21** excepting only that the saddle member **260** of this embodiment rests directly on a bolster **261** in a center flat portion **262**. Similar damping assemblies **254** resting on weight-bearing plates **255** are in this embodiment suspended from the saddle **260** with a column member **263** extending downwardly from the bolster **261** to a central portion of each damping assembly **254**. In the embodiment shown in FIG. **22** the normal weight of the car body is supported directly on the bolster **261** and the damping assemblies **264** are in expanded condition such as that shown in FIG. **10** with the damping recess filled with liquid. When, illustratively, the car body rocks over to the left, the left-hand bracket **135** acting on the left-hand side bearing **130** will apply a downward force to the saddle **260** which through the portion resting on the left-hand edge of the bolster center flat portion **262** will apply a force tending to pivot the saddle **260** about the left-hand edge of portion **262**. This pivoting motion will be opposed at the right-hand end of the saddle **260** by the right-hand damping assembly **254** which will yield with an energy-absorbing action to allow the saddle member **260** to pivot about left-hand edge of portion **262** in following the rocking motion of the car body **110**. The energy-absorbing action in this case is very similar to that previously described and takes place on the initial rocking motion rather than on the rebound action.

Although various embodiments of this invention have been described herein various modifications and alterations to such embodiments can, in view of such description, be readily made by one skilled in the art to which this invention pertains and although not enumerated such modifications and alterations are within the scope of this invention. In particular it will be noted that I have disclosed and described constant pressure snubbers as shown in FIGS. **1** to **6** and **14**, a viscous snubber as shown in **10** which is also a substantially constant pressure snubber when expansion of flange **48** under pressure occurs, viscous snubbers as shown in FIGS. **11**, **17** to **22**. The various structural features described herein such as the quick fluid return by auxiliary means as shown in FIG. **13** of an equivalent structure, and the various manners in which the snubbers described herein operate such as the difference described without a clearance can be employed in the various snubbers as desired. Also, although the constant pressure and viscous

snubbers have been shown and described in particular locations, either type of snubber can be used as desired in the various locations. Further it is to be realized that since bolsters are spring supported, and the truck wheels run over uneven track, and the car bodies sway that no uniform or specific motion between the various elements of a freight car that necessarily exists when one or two of these three elements have a particular motion resulting from a particular force or forces being applied thereto. Accordingly, the description herein has in the interests of clarity referred to particular movement which results from various relative movements of the elements of a freight car and it is to be recognized that is is the relative movement of the components of the snubbers described which result in the operation as described.

As heretofore described some snubbers of this invention include clearance spaces to permit limited movement of the members with which they are cooperable without absorption of energy. As also described, some snubbers of this invention are preloaded to be immediately effective to absorb energy upon relative movement of the members with which such snubbers are cooperable. In addition other embodiments of this invention are located between members having relative movement in the manner as such preloaded snubbers and in addition are provided with integral means to permit limited movement of the members in the manner as such clearance spares. Thus other preferred embodiments of this invention are shown in additional FIGS. 23 to 32 (which correspond to FIGS. 1 to 10 of my previously copending application Ser. No. 579,709) and the following description is identical to that in application Ser. No. 579,709 and the portions of the structures in FIGS. 23 to 32 which are identical to those previously described will be obvious to those skilled in the art. FIGS. 23 and 24 illustrate a freight car truck having four wheels 412 adapted to rest upon rails (not shown) and mounted in pairs on two car axles 414 rotatably mounted in and supporting a pair of side frame 416 in a manner well known in the art. A set of truck springs 419 in each side frame, respectively, support one end of an elongated bolster extending from the interior of one side frame 416 to the interior of the other side frame 416. A freight car body 420, partially shown in section, has a centrally located downwardly depending center plate 422 mounted for limited rotation and rocking motion on a suitable flat center portion 424 of the bolster 418 to support the weight of the car body and load therein. A pair of brackets 426 downwardly depending from portions of the car frame, equally transversely spaced on either side of the center plate 422, carry on their bottom surfaces wear plates 427 slightly upwardly spaced from a pair of side bearing assemblies 428 with a side bearing clearance 429 provided between the bearing assemblies 428 and the wear plates 427 to provide for slight amount of rocking motion between the car body 420 and the bolster 418 without activating the springs 419 as is well known. Located above and resting upon the spring set 419 are flattened end portions of the bolster 418 of a generally rectangular shaped having a solid bottom element 432 and a top element 434 upwardly spaced therefrom and having therein a centrally located recess or bore 436.

Each side frame 416 comprises a pair of formed vertically extending horizontally spaced side elements 440 usually made integral with and joined together by a top element 442 which extends over and is spaced upwardly from the respective end portion of the bolster 418 supported by a particular side frame 416. Centrally located in the top element 442 is a bore 444 (best seen in FIG. 25) in which is rigidly secured as by welding a flanged mounting element 446 having its flange located within and contacting the bottom surface of the top element 442 for a purpose to be described. Centrally located in its bottom surface the mounting element 446 is provided with a shallow blind bore 447 within which is received the end portion of an elongated cylindrical piston rod 448 of a snubber assembly 450 constructed according to the principles of this invention. The snubber assembly 450 further comprises a solid bottom elongated, hollow cylindrical body member 452 having a cylindrical inner surface 453 and slidably mounted therein a cylindrical piston element 454 completely surrounding and rigidly secured to the bottom end of the piston rod 448 which extends upwardly through and is slidably received in a disklike closure element 456 suitable removably mounted in the top end of the cylinder 453 as by suitable snaprings 457 and maintained in fluidtight relationship with the cylinder 453 and the piston rod 448 by resilient members such as O-rings 458 and 459, respectively. In a radially intermediate portion of the closure element 456 there is a plurality of stepped bores 460 (only one of which is shown) extending downwardly through the closure element 456 with its larger portion beginning at the upper surface of the element 456 and continuing downwardly for nearly the whole thickness of the element 456 with a shorter small portion extending through the bottom surface of the closure element 456. A flattened ring-shaped resilient valve element 462 suitably mounted in a groove in a downwardly extending central portion of the closure element 456 covers the bottom ends of the bores 460 to provide check valve action between the ambient atmosphere and the interior of the cylinder 453 so that ambient pressure higher than the pressure between elements 456 and 454 can cause air to flow through the bores 460 into the interior of the cylinder 453. Within the bores 460 in the enlarged portion there are suitable porous filter elements 463 through which air entering the cylinder 453 must pass, thereby preventing the introduction of dust or other solid particles into the cylinder 453.

In a radially intermediate portion of the piston element 454 there is provided a plurality of stepped cylindrical bores 465 extending downwardly through the piston element 454 and having a shoulder 466 in an axially intermediate portion of the bores 465 marking the transition between the enlarged upper portion and the smaller lower portion of the bore 465 while providing a seat for a valve spring 468 which is slightly compressed between the shoulders 466 and a three-legged spider-type spring retainer 470 which is in turn rigidly removably secured by a bolt or capscrew 471 to the upper end of a hollow cylindrical spacer 472 extending downwardly through the bore 465 to a ring-type valve element 474 rigidly removably secured to the bottom ends of the capscrews 471 extending through spacers 472 similarly mounted in all of the bores 465. It is to be noted that the springs 468 are of suitable design to provide a total amount of upward bias on the valve element 474 only slightly greater than the weight of the element 474 for a purpose more readily apparent upon consideration of the description of the operation of this device as hereinafter set forth.

The piston element 454 also contains a central bore 476 extending upwardly therethrough in communication with an enlarged central bore portion 478 in which is rigidly secured the bottom end of the piston rod 448. Smaller substantially radial bores 480 communicate between the enlarged portion 478 and some of the radially intermediate bores 465 to allow the passage of fluid from the bottom portion of the cylinder 453 upwardly through the bore 476, the enlarged bore portion 478, the radial bores 480, and the radially intermediate bores 465 to the upper side of the piston element 454 under conditions to be described.

The piston rod 448 has a stepped axial bore with variously sized portions extending downwardly from its upper surface through the lower end of the piston rod 448 and having in an enlarged portion 483 of the bore 482, a pair of metal balls spaced apart and biased in opposite directions by a valve spring 484 applying a downward force to the lower ball 486 acting as a check valve in conjunction with the central bore 476 by maintaining the bore 476 in a closed condition until a predetermined amount of pressure has been developed in the lower portion of the cylinder 453 which is enough to compress the spring 484 and develop an orifice between the lower ball 486 and the edges of central bore 476. The upper ball 488 forms a seat for the upper end of the spring 484 and is adjustably maintained in position by two locking setscrews, 490, 492 in the small upper portion of the bore 482 and adjustably

threadedly positioned in bore 482 so that adjusting screw 490 downwardly increases the force of the spring 484 and upwardly decreases the same spring force if desired.

Since the upper portion of the cylinder 453 will never be subjected to high pressure in contradistinction to the high pressures which will be developed in the lower portion of the cylinder 453 the wall thickness of the body 452 is reduced in its upper portion by an amount substantially equal to the wire diameter of the snubber return spring 494 surrounding the small diameter portion of the body member 452, seated upon the shoulder 493 formed by the transition from the large diameter portion of the body member 452 to its smaller diameter portion. The spring 494 extends upwardly from the shoulder 493 to a seating surface within an inverted cup-shaped piston rod cap 495 mounted about a portion of the piston rod 448 downwardly adjacent its upper end and maintained in this position as by a suitable snapring 496.

The bottom end of the body member is formed with a downwardly extending cylindrical center portion 497 freely received within the central bore of a ring-shaped bolster mounting element 498 suitably secured in the central portion of the bottom element 432 of the bolster 418 so that the snubber assembly 450 extends between the bottom element 432 of the bolster 418 and the top element 442 of the side frame 416. The snubber assembly 450 is maintained in constant contact with the bolster 418 and the snubber 416 by action of the snubber return spring 494 which is designed to provide enough force to move the piston 454 rapidly upwardly even against slight pressure differential as hereinafter described. It is to be noted that in this embodiment the piston element 454 is maintained in fluidtight contact with the cylindrical surface 453 by resilient piston ring structure such as the O-ring 499.

Operation of the snubber assembly 450 is as follows:

When the car body 420 rocks over to the right, as seen in FIG. 23, the right-hand side bearing bracket 426 will strike the side bearing 428 on the right-hand end of the bolster 418 forcing that end of the bolster 418 downward, compressing the right-hand truck springs 419. Since the side frame 416 is solidly supported by the wheels it will be maintained at a fixed height above the rails and the snubber 450 will lengthen to maintain contact between the bolster 418 and the side frame 416. Lengthening of the snubber 450 is caused by the snubber spring 494 pushing upward on the piston rod cap 495 and lifting the piston 454 relative to the cylinder 453. As the piston 454 begins to rise, the pressure in the upper portion of the cylinder 453 is increased while pressure in the lower portion is decreased. The pressure differential acting on the piston valve ring 474 compresses the valve springs 468, lowers the valve ring 474 and opens the piston passageways 465 (as shown in FIG. 26) allowing fluid to be displaced from the upper cylinder portion to the lower portion.

Suitable dimensions have been chosen for piston rod 448 and cylinder 452 so that the truck springs 419 will bottom out (become solid) before the top of the piston 454 comes in contact with the cylinder closure element 456.

The relative amounts of air and liquid in the cylinder are such that when the piston is at maximum operating extension or height the level of liquid in the cylinder 452 is above the bottom of piston 454 so that the space below the piston is always completely filled with liquid during operation.

When the car body 420 rebounds toward the left, the right-hand bolster end will begin to rise exerting pressure to shorten the right-hand snubber 450. Shortening the snubber 450 results in increased pressure in the lower cylinder portion and decreased pressure in the upper cylinder portion. This pressure differential added to the force of the piston valve springs 468 holds the piston valve ring 474 tightly closed (as seen in FIG. 25) while the piston O-ring 498 prevents fluid flow between the periphery of the piston 454 and the cylinder wall 453. The fluid in the lower cylinder portion can only flow upward through the central piston bore 476 at a pressure high enough to compress the valve spring 484 and open the valve 486 whereupon fluid is forced through the opening between the valve 486 and seat under high pressure with consequent energy absorption and slowing of the bolster rebound rate. The snubber assembly 450 is of the constant pressure (or pressure relief) type and is purely motion sensitive as distinct from the velocity-sensitive viscous type hereinafter described.

As in conventional snubber action large amounts of energy are absorbed in hydraulic friction and, with such action available at the two ends of the bolster alternately or simultaneously, damping the rythmic swaying of the car body 420 at slow speeds is effected.

When a railway car is traveling along a track at higher speeds the wheels respond vertically to uneven track and move up and down at a rate too rapid for the car body to follow, causing rapid compression and expansion of the truck springs 419 and concomitant rapid lengthening and shortening of the snubber 450 on both bolster ends. If large pressures were allowed to develop in the snubber 450 with repeated squirts of fluid through the orifices formed by the valves 486, a large amount of energy would be absorbed with consequent undesirable heating of the fluid and snubber parts resulting in possible early snubber failure, breakdown of the fluid with foaming and other deleterious effects. To avoid such effects the design of the snubber of this invention provides "dead band" operation according to the following description. In this regard valve ring 474 and valve springs 468 can be viewed as a "dead band valve means."

When at high car speed a high point in the rail causes the side frame 416 to rise allowing the snubber 450 to lengthen rapidly the piston 454 starts to move in an upward direction very suddenly, the sudden upward acceleration of the piston 454, inertia of the piston valve 474 and viscous drag between the valve 474 and the cylinder wall 453, acting upon the low-bias valve springs 468, cause the valve 474 to lag behind the piston motion (assuming the position shown in FIG. 26). The piston passageways 465 are momentarily open for fluid flow therethrough in either direction. When the piston 454 moves downward immediately after having suddenly moved upward, the piston passageways 465 will be open and fluid will flow freely therethrough with little energy absorption. In this manner "dead band" operation provides for extremely low energy absorption during rapid relative piston-cylinder motion with a minimum amount of heating and other deleterious effects. However, as soon as the car speed is reduced, the snubbers 450 are in condition to resume the energy-absorbing mode of operation earlier described.

FIGS. 26 and 27 of the drawings illustrate a second embodiment of the principles of this invention wherein structural elements which are the same as those shown in FIGS. 1 through 3 are designated by the same reference numerals, respectively, as heretofore applied while structural elements similar to, but differing slightly from those of the earlier description are indicated by the same reference numerals primed. The embodiment of FIGS. 26 and 27 is generally indicated as the snubber assembly 450' comprising a cylindrical body member 452' having an inner cylindrical surface 453' in which is mounted for upward or downward motion a piston element 454' which is the same as that piston element 454 best seen in FIG. 25 excepting only that the O-ring 498 and the groove therefor have been eliminated in the piston element 454'. The cylindrical surface 453' slidably receiving the piston element 454' is the same as the cylindrical surface 453 except for the provision of one or more tapered grooves 500 in the cylindrical surface 453' and shown in FIG. 5 to be of triangular cross section with the apex of the triangle directed radially outwardly from the surface 453' and the large end of the groove spaced downwardly from the closure element 456 but upwardly from the top of the piston 454' at normal static height, while the remainder of the groove tapers downwardly to a point spaced upwardly from the bottom of the cylinder 452' at which point the groove 500 runs out to zero dimension and the cylindrical surface 453' becomes smooth.

It is to be noted that the larger diameter portion of the cylinder **452'** is formed with circumferential grooves **502** in its outer surface to provide more heat transfer area exposed to the ambient air. If desired, such grooves can be applied to any of the embodiments of this invention herein described.

The operation of the embodiment of FIGS. **26** and **27** is quite similar to that described for the embodiment of FIGS. **23** through **25**, with the following differences. With the snubber assembly **450'** having the grooves **500** in the cylindrical surface **453'** the orifice between the central bore **476** and the lower ball **486** is supplemented by an orifice between the peripheries of the piston **454'** and the cylindrical surface **453'** to aid in the energy-absorbing action of high-pressure hydraulic fluid flow. Furthermore, the snubber assembly **450'** is position sensitive in that, when the truck springs **419** are in their normal static position or compressed from that position, the piston **454'** will be in the position shown in FIG. **26** with the piston **454'** surrounded by the grooves **500**, extending above the piston **454'** and producing an enlarged orifice with little opportunity for energy absorption. However, when the truck springs **419** expand upwardly in rebound action the rising of the bolster end **418** will shorten the snubber assembly **450'** so that piston **454'** is active in the lower portion of the cylinder **453'** where the grooves **500** are very small or nonexistent and, in this position, which represents the upper portion of the rebound action by the truck spring **419**, the snubber assembly will have almost the same energy absorption characteristics as the earlier described snubber assembly **450**. However, in this case the damping force retarding the motion is of the viscous type (velocity sensitive) until pressures in **453** are developed sufficiently to raise check valve ball **486** and permit additional flow through bore **476**.

It can be shown that the bolster and side frame relative velocities are considerably higher for purely vertical oscillations than for rocking motion. Since rapid vertical motion at high car speeds takes place almost entirely with the springs **419** in normal static loading position or only slightly compressed, the action of the snubber assembly **450'** during this mode of operation will almost entirely take place with the piston **454'** at or near the position shown in FIG. **26** with maximum effect of the grooves **500** still further reducing the energy absorption characteristics of the snubber assembly **450'** beyond that provided by the dead band operation associated with sudden motions of the piston **454'** as described with relation to the piston **454**. The advantage of the grooved cylindrical surface design of the piston assembly **450'** thus resides in the addition of position sensitivity to the motion sensitivity of the originally described snubber assembly **450**. While the elimination of the O-ring **498** and formation of an orifice between the piston **452'** and the cylinder wall **453'** adds a portion of velocity-sensitive operation to the original constant pressure type of operation.

FIGS. **28** and **29** of the drawings illustrate another embodiment of the principles of this invention wherein those parts or structural elements which are the same as those shown in earlier figures carry the same reference numeral designation, respectively, as that used in the FIGS. **1** through **5**. The bolster **418** is supported by a side frame **584** especially designed for the installation of the snubber assembly **450** or **450'** hereinabove described, with no change in the bolster but with the upper portion of the side frames **504** being provided with horizontally extending strengthening ribs **506** and having a central bore **508** in the top element large enough to accept the body portion of the snubber assembly **450** or **450'** so that the snubber assembly can be installed through the bore **508** after the truck elements, bolster, side frames and springs have been assembled in a conventional manner. The bore **508** is covered by a flanged cap element **510** having a shallow blind axial bore **512** in its under side and a flanged portion larger than the bore **508** abutting the upper surface of the top element of the side frame **504** and provided with means for removably securing the cap element **510** in the bore **508** such as a bolt circle of bores with threaded retaining elements such as capscrews (not shown) threadedly received in the top element of the side frames **504** to removably retain the cap element **510** against the upward biasing forces generated in the snubber assembly **450** during operation thereof as hereinbefore described.

The advantage of the embodiment of FIGS. **28** and **29** with the special side frames **504** resides in the ease of installation of the snubber assemblies **450** or **450'** and the readiness with which the snubber assemblies can be removed for inspection and/or repair and replacement without disassembling the truck as would be necessary with the side frames of the earlier described embodiments.

FIGS. **30** and **31** illustrate another embodiment of the principles of this invention in a snubber assembly **450''** wherein the closure element **456** of the earlier embodiments is eliminated and replaced by a ring element **515** rigidly secured in the upper inner portion of the body member **450** and maintained in fluidtight relationship therewith by the O-ring **458** as formerly described. Bonded or otherwise secured to the upper inner surface of the ring member **515** is a reinforced edge portion of a fluidtight flexible boot element **516** which extends from the ring element **515** to an intermediate portion of the piston rod **448'** which is externally similar to the earlier described piston rod **448** but in this embodiment is a solid cylindrical member without the central bores **482, 483** or **476** so that the orifice effect provided by the ball **486** of the other embodiments must in the case of the embodiment of FIGS. **30** and **31** be supplied by other means hereinafter described. The boot element **516** has a reinforced edge portion bonded or otherwise sealingly secured to the outer surface of the piston rod **448'** so that this latter described edge travels upwardly and downwardly with the piston rod **448'** and in the extreme collapsed position of the snubber assembly **450''** assumes a shape such as that shown in FIG. **31**.

It is to be noted that in the snubber **450''**, the guidance function of the closure element **456** can be assumed by the axial dimension of piston **454** which can be increased to provide piston guidance for axial motion thereof.

With the solid piston rod **448'** of the embodiment of FIGS. **30** and **31** the relief valve effect of the ball **486** acting in conjunction with the bore **476** of the first embodiment will be assumed by conventional high-pressure check valves (not shown) in any suitable passageways communicating between the upper and lower portions of the cylinder body **452**.

The use of the boot element **516** in the snubber assembly **450''** provides a flexible closure for displaced hydraulic liquid, reducing pressure buildup in the cavity above the piston **454** due to the volume of liquid displaced by the piston rod and also provides for flooded operation of the piston in all positions.

The solid piston rod **448'** of the fourth embodiment can also be used in a snubber assembly **450'''** as shown in FIG. **32** wherein an orifice **501** having a length determined by an annular shoulder **503** on the periphery of a piston **454''** is provided between the exterior of the piston **454''** and the interior surface **453** of the cylinder member **452** so that all of the flow between the lower portion of the cylinder **452** and the portion above the piston **454''** is forced to take place through the orifice **501**, while the upstroke of the piston **454''** causes liquid to flow down through the stepped bores **465** as earlier described. Thus the snubber assembly **450'''** is of the viscous (velocity-sensitive) type.

It is to be noted that at the beginning of truck spring extension after the first rocking motion has compressed the truck springs **419**, where it would be preferable to extract large quantities of energy immediately, velocities are very low so that viscous type (velocity-dependent) devices are less effective than the constant pressure type in the early stages of spring extension. The greater effectiveness of the constant pressure type of device for certain modes of operation can be readily shown.

FIG. **32** also illustrates the elimination of the spring **468** which is, in this embodiment, replaced by elongated leg portions of a spider-type spacer element **520** very similar to the

spring retainer **470** of the earlier described embodiment excepting only that the spacer element **520** has elongated leg portions extending downwardly therefrom to engage a shoulder **466'** intermediate the length of bores **465'** to limit the amount of free motion between the valve **474** and the piston **454''**.

With the elimination of the springs **468** as shown in FIG. **32** the valve **474** will, of course, remain open at all times except when the piston **454''** is moving downwardly. When the piston **454''** moves downwardly for a substantial distance the movement of hydraulic liquid through the space between the ring **474** and the lowest portion of the piston **454'** will produce viscous drag to cause the ring **474** to close and provide the snubbing action desired. However, such closing of the valve **474** will not take place when very small motions of the piston take place so that in the above-described high-speed operation of the car the small rapid motions of the piston will not close the valve **474** on the bores **465** and the required dead band operation will thus be produced as occurred with the springs **468** in place as in the earlier embodiments.

It is to be noted that various modes of operation suitable for various conditions of car weight, train speed, track profile and ambient temperatures can be met by the use of valve springs **468** of different stiffness than those described for the first embodiment. Under some conditions the springs **468** being much stiffer than those described while under other conditions the springs **468** will be so light that they approach the effect of no spring at all as described for the embodiment of FIG. **32**.

It is to be realized that although the structures for obtaining dead band operation, hereinabove described, all incorporate passageways through the piston, and a piston-mounted valve, such structures are not necessary to the application of the principles of this invention. Any suitable structure allowing free flow through, around or bypassing, the piston for the first half inch of piston motion in either direction followed by forcibly restricted flow for further downward piston motion and unrestricted or nearly free flow for upward motion will apply the principles of dead band operation hereinabove set forth.

Such arrangements may be position sensitive, acceleration sensitive, rate of motion sensitive, or responsive to the duration of motion in a particular direction and can physically include time delay valves and external reservoirs or passageways.

Preferred embodiments of this invention having hereinbefore been described and shown it is to be realized that variations in these embodiments can be introduced without departing from the principle of this invention. It is therefore respectfully requested that this invention be interpreted as broadly as possible and limited only by the claims appended hereto.

What is claimed is:

1. A snubbing device comprising, a pair of body members having opposed portions operably movable towards and away from each other to define a variable volume chamber therebetween, a hydraulic fluid reservoir located to maintain said chamber full of hydraulic fluid in all relative operating positions of said body members, a ring member located in said chamber intermediate said opposed portions and axially movable relative to each of said body members, said ring member upon relative movement of said body members towards each other being in substantially sealing engagement with one of said body members and cooperable with the other of said body members to define a passageway therebetween for the restricted flow of hydraulic fluid from said chamber to said reservoir.

2. A snubber as defined in claim **1** in which said ring member comprise a plurality of disks.

3. A snubbing device as defined in claim **1** in which said reservoir is formed by readily deformable estomeric material.

4. A snubbing device as specified in claim **1** wherein said passageway for restricted flow is defined by the radial outer periphery of said ring member and an adjacent encompassing portion of the other of said body members.

5. A snubbing device as specified in claim **1** additionally including passageway means communicating between said reservoir and said chamber, and valve means cooperable with said passageway means and being operable to open said passageway means when the hydraulic fluid in said chamber is above a predetermined pressure.

6. A snubbing device as specified in claim **1** wherein an upper surface of said ring member faces said one of said body members and is submerged below the operating level of the hydraulic fluid in said chamber.

7. A snubbing device as specified in claim **1** having portions of said reservoir formed integral with said body members, respectively, and movable therewith.

8. A snubbing device as specified in claim **1** additionally comprising valve means operative only during the reciprocable movement of at least one of said body members towards the other of said body members to damp relative movement of said body members by restrictive flow of hydraulic fluid from said chamber, and said valve means maintaining said restrictive flow of hydraulic fluid at substantially constant pressure.

9. A snubbing device comprising, a pair of body members having opposed portions operably movable towards and away from each other to define a variable volume chamber therebetween, a hydraulic fluid reservoir located to maintain said chamber full of hydraulic fluid in all relative operation positions of said body members, a ring member in said chamber intermediate said opposed portions and axially movable relative to each of said body members, said ring member upon relative movement of said body members towards each other being in substantially sealing engagement with one of said body members and cooperable with the other of said body members to define a passageway therebetween for the restricted flow of hydraulic fluid from said chamber to said reservoir, and means biasing said ring member towards said one of said body members.

10. A snubbing device as specified in claim **9** wherein a surface of said ring member faces said one body member and is submerged below the operating level of the hydraulic fluid in said chamber.

11. A snubbing device comprising a first member, a second member normally spaced from and reciprocably movable with respect to said first member to define a variable volume chamber therebetween, a reservoir defining a closed hydraulic system in conjunction with said chamber, said hydraulic system having a hydraulic fluid therein with an upper level thereof movable between upper and lower positions during respective reciprocable movement of said members, said first and second members having cooperable portions defining a passageway means therebetween, said passageway means having a first portion cooperable with one of said members to restrict flow of said fluid between said chamber and said reservoir upon relative movement of said members towards each other, said first portion of said passageway being continuously located below the normal liquid level of said fluid in said system, and said passageway means having a second portion cooperable with the other of said members to provide hydraulic communication between said reservoir and said chamber substantially only upon relative movement of said members away from each other.

12. A snubbing device as specified in claim **1** wherein said second portion of said passageway means is in open hydraulic communication between said reservoir and said chamber only upon relative movement of said members away from each other.

13. A snubbing device as specified in claim **11** additionally including valve means operative only during the reciprocable movement of at least one of said members toward the other of said members to damp relative movement of said body members by restrictive flow of hydraulic fluid from said chamber, and said valve means maintaining said restrictive flow of hydraulic fluid at substantially constant pressure.

14. A snubbing device comprising: a pair of body members defining variable volume chambers therebetween; said body

members being relatively movable in opposite directions; passageway means communicating between said chambers; valve means in communication with said passageway means and operative only during movement of at least one of said body members in one of said directions to damp relative movement of said body members by restrictive flow of hydraulic fluid through said passageway means and between said chambers; and said valve means and said passageway means cooperating to maintain said restrictive flow of hydraulic fluid at substantially constant operating pressure.

15. A snubbing device as specified in claim 14 wherein said chambers are upper and lower chambers and said restrictive flow of hydraulic fluid is from said lower chamber to said upper chamber.

16. A snubbing device as specified in claim 15 wherein said chambers are substantially coaxial.

17. A snubbing device as specified in claim 14 in which one of said members carries dead band valve means operable to permit relatively free flow of hydraulic fluid between said chambers during the initial relative movement in said one of said directions from a given relative position.

18. A snubbing device as specified in claim 14 wherein reservoir means for said hydraulic fluid are located laterally of said body members.

19. In a support configuration for a railway car having a section of a bolster member supported in spaced relationship to a section of a side frame member by spring means, said sections being relatively movable in opposite directions as the railway car traverses a supporting track therefor and a hydraulic snubber assembly located between oppositely facing portions of said sections, the improvement comprising: said snubber assembly including a pair of body members defining variable volume chambers therebetween and said body members being relatively movable in said opposite directions; passageway means communicating between said chambers; and said snubber assembly including valve means in communication with said passageway means and operative only during movement of at least one of said body members in one of said directions to damp said relative movement of said body members by restrictive flow of hydraulic fluid through said passageway means and between said chambers; and said valve means and said passageway means cooperating to maintain said restrictive flow of hydraulic fluid at substantially constant operating pressure.

20. In a support configuration as defined in claim 19 in which said relatively movable members are movable through a distance greater than the closed height of said spring means.

21. A support configuration as defined in claim 19 in which said snubber assembly has end portions thereof which engage said oppositely facing portions only after initial movement in said one of said directions occurs.

22. A snubbing device comprising: a pair of body members defining a variable volume chamber therebetween; said body members being relatively movable in opposite directions; passageway means communicating between said chamber and the exterior thereof; valve means in communication with said passageway means and operative only during movement of at least one of said body members in one of said directions to damp relative movement of said body members by restrictive flow of hydraulic fluid from said chamber through said passageway means; and said valve means and said passageway means cooperating to maintain said restrictive flow of hydraulic fluid at substantially constant operating pressure.

23. A snubbing device as specified in claim 22 wherein reservoir means for said hydraulic fluid are located laterally of said body members.

24. In a support configuration for a railway car having a section of a bolster member supported in spaced relationship to a section of a side frame member by spring means, said sections being relatively movable in opposite directions as the railway car traverses a supporting track therefor and a hydraulic snubber assembly located between oppositely facing portions of said sections, the improvement comprising: said snubber assembly including a pair of body members defining a variable volume chamber therebetween and said body members being relatively movable in said opposite directions; passageway means communicating between said chamber and the interior thereof; and said snubber assembly including valve means in communication with said passageway means and operative only during movement of at least one of said body members in one of said directions to damp said relative movement of said body members by restrictive flow of hydraulic fluid from said chamber through said passageway means; and said valve means and said passageway means cooperating to maintain said restrictive flow of hydraulic fluid of substantially constant operating pressure.

25. In a support configuration as defined in claim 24 in which said relatively movable body members are movable through a distance greater than the closed height of said spring means.

26. A snubbing device comprising, a body member having an elongated bore therein, a piston member axially reciprocal within said bore and defining variable volume chamber portions within said body member adjacent opposite axial ends thereof, said body member having hydraulic fluid within the bore thereof, dead band valve means in at least one of said members connecting said chamber portions to maintain full of hydraulic fluid the one of said chamber portions which increases in volume upon axial movement in one direction of said body member from a given relative position with respect to said piston member, means in at least one of said members operable to restrict flow of pressurized hydraulic fluid between said chamber portions upon movement of said members in a direction opposite said one direction occurring immediately subsequent to each movement in said one direction, and said dead band valve means being operable to maintain said one chamber portion full of hydraulic fluid by relatively free flow of hydraulic fluid between said chamber portions upon axial movement of said piston member in said opposite direction without having any substantial pressurization of said hydraulic fluid in said one chamber portion and said dead band valve means being initially responsive to hydraulic pressure in said one chamber portion to maintain said relatively free flow for an initial period and being further responsive to discontinue said relatively free flow subsequent to said initial period.

27. A snubbing device as set forth in claim 26 in which said dead band valve means is at least in part open-sided grooves extending between said chamber portions and axially beyond said piston member when said piston member is in said given relative position.

28. A snubbing device as set forth in claim 27 in which said grooves have a decreasing cross-sectional area along the length thereof in said one direction.

29. A snubbing device as set forth in claim 26 in which said dead band valve means has lost motion with respect to movement of said piston member in said opposite direction.

30. In a side bearing assembly for a railroad car wherein a side bearing means cooperates with a bearing plate means to limit relative rocking movement between a car truck member and a car body member, the improvement which comprises, a hydraulic damping device supported by one of said members and supporting one of said means, the other of said members supporting the other of said means, and said damping device including means maintaining a normal clearance between said bearing plate means and said side bearing means.

31. In a railway truck assembly of the type in which a laterally extending bolster pivotally supports the underside of a car body and wherein a side bearing is mounted on the truck bolster and arranged to contact a bearing plate, the improvement comprising, a hydraulic damping device interposed between said bearing plate and said body and supported with respect to said body and arranged to cushion the impact between said side bearings and said bearing plate as said car body sways, and said damping device including means maintaining a normally separable relationship between said bearing plate and said bearing.

32. In a railway truck assembly of the type in which a laterally extending bolster pivotally supports the underside of a car body and wherein a bearing plate is mounted on the car body and arranged to contact a side bearing, the improvement comprising, a hydraulic damping device interposed between said side bearing and said truck bolster and supported with respect to said truck bolster and arranged to cushion the impact between said side bearing and said bearing plate as said car body sways, and said damping device including means maintaining a normally separable relationship between said bearing plate and said bearing.

33. In a railway truck assembly of the type in which a laterally extending bolster member pivotally supports the underside of a car body member and wherein a side bearing means cooperates with a bearing plate means to limit relative rocking movement between said car body member and said bolster member, the improvement comprising, a hydraulic damping device supported by one of said members and supporting one of said means, the other of said members supporting the other of said means, said damping device being arranged to cushion the impact between said side bearing means and said bearing plate means as said car sways and said damping device including means maintaining a normally separable relationship between said bearing plate means and said bearing means.

34. In a railway truck assembly, a laterally extending bolster provided with a central bearing surface, a laterally extending saddle member overlying and spaced above said bolster and having a downwardly depending central bearing surface adapted to engage the bearing surface on said bolster, and upper bearing surface on the saddle member for supporting the downwardly depending center plate on a car body, the saddle member being adapted to rock from side to side on the central bearing surface of the bolster as the car body above it rocks from side to side, a pair of compressible and expandable fluid-damping devices carried beneath said bolster on opposite sides of said central bearing surface, and means connecting the saddle member to the damping devices such that when one damping device compresses the other expands and vice versa.

35. The truck assembly of claim 34 wherein each damping device is operatively connected to an end of the saddle member through a reciprocable column which extends through said bolster.

36. The truck assembly of claim 33 wherein the weight of the car body is normally carried by the damping devices with the damping devices compressed, and wherein the saddle member normally does not rest on the central bearing surface of the bolster.

37. The truck assembly of claim 34 wherein the damping devices are carried on bearing plates depending downwardly from said saddle member and movable therewith as a unit, the damping devices being sandwiched between the bearing plates and the bolster such that when the saddle member rocks to one side, only one damping device will be compressed while the other expands and vice versa.

38. The truck assembly of claim 37 wherein the downwardly depending bearing surface on the saddle member normally rests on said central bearing surface such that the weight of the car body is normally carried by said truck.

39. The truck assembly of claim 34 and including side bearings carried on opposite ends of said saddle member, and wear plates on said car body adapted to engage the side bearings as the car body rocks from side to side, the wear plates being normally spaced from the side bearings when the car body is not rocking.

40. In a railway vehicle, in combination, a car body having a center plate thereon, a truck having a bolster for pivotally supporting said center plate, a hydraulic damping device interposed between said center plate and said bolster for dissipating energy by restricted flow of hydraulic fluid through a passageway, said damping device comprising upper and lower relatively movable members defining a fluid cavity of variable volume therebetween and said passageway upon at least a portion of the relative movement between said members being of a variable volume.

41. The combination of claim 40 wherein said upper and lower members form integral parts of said center plate and said truck bolster, respectively.

42. The combination of claim 40 including a plurality of stacked washers disposed in said fluid cavity between said upper and lower members.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,626,864 Dated December 14, 1971

Inventor(s) Donald Wiebe

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 46, delete "136" and substitute -- 316 --;
Column 6, line 36, after "snubber," delete "22" and substitute -- 2 --;
Column 6, line 66, delete "3" and substitute -- 2 --;
Column 7, line 12, delete the first "each";
Column 7, line 30, delete "patens" and substitute -- platens --;
Column 18, line 71, delete "of" and substitute -- or --;
Column 19, line 12, after "that" delete "is" and substitute -- it --;
Column 19, line 37, delete "frame" and substitute -- frames --;
Column 20, line 5, delete "suitable" and substitute --suitably--;
Column 22, line 51, delete "1 through 3" and substitute -- 23 through 25 --;

Claim 3, line 2 after "by" insert -- a --;
line 2, delete "estomeric" and substitute --elastomeric--

Claim 9, line 5 delete "operation" and substitute -- operating --;

Claim 12, line 1, delete "1" and substitute -- 11 --;

Claim 36, line 1, delete "33" and substitute -- 35 --;

Signed and sealed this 20th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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