United States Patent

[11] 3,601,212

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[45] Patented Aug. 24, 1971
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Peoria, Ill.

[54] **CUSHIONED TRACK**
60 Claims, 32 Drawing Figs.

[52] U.S. Cl. **180/9.44,**
37/124, 152/182, 214/130, 305/19
[51] Int. Cl. **B62d 55/08**
[50] Field of Search 305/19, 57,
58, 54; 152/182, 183; 180/9.2

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Primary Examiner—Richard J. Johnson
Attorney—Fryer, Tjensvold, Feix, Phillips & Lempio

ABSTRACT: A machine is supported by four ground-engaging cushioned tracks. Each cushioned track comprises an annular resilient spacer having an endless track assembly mounted therearound. The track assembly comprises a plurality of shoes having flat inner surface portions surrounding and compressing the outer periphery of the spacer to normally define a substantially continuous, polygonal-shaped surface contact therebetween. The shoes extend laterally across the spacer and are connected together by laterally spaced link assemblies each positioned at a respective side of the spacer to form a unitized cushioned track.

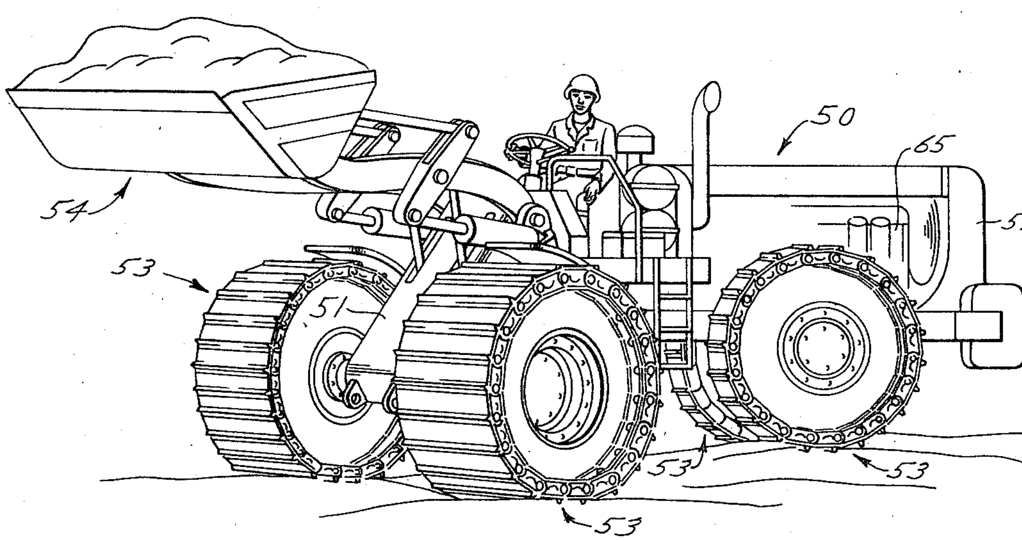

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FIG. 1

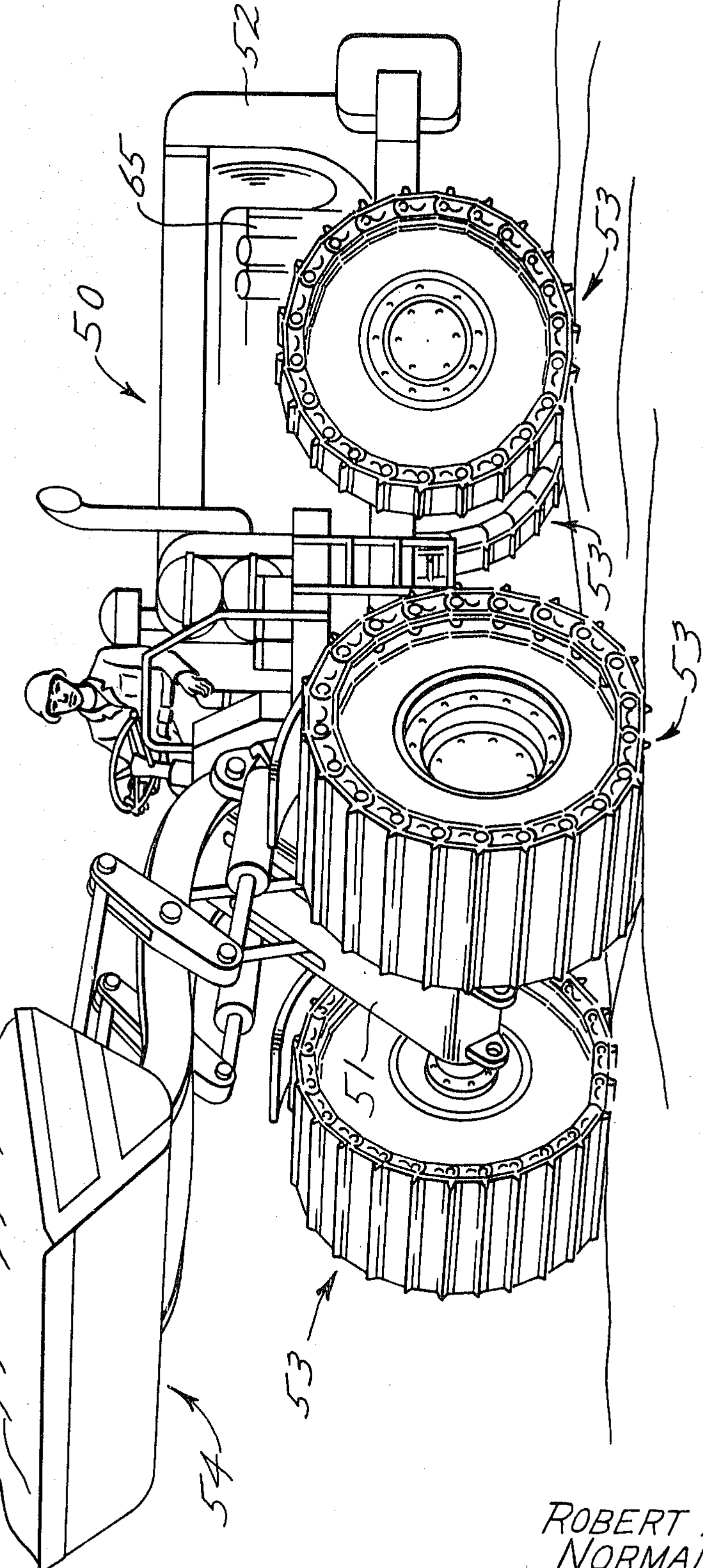

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FIG. 2

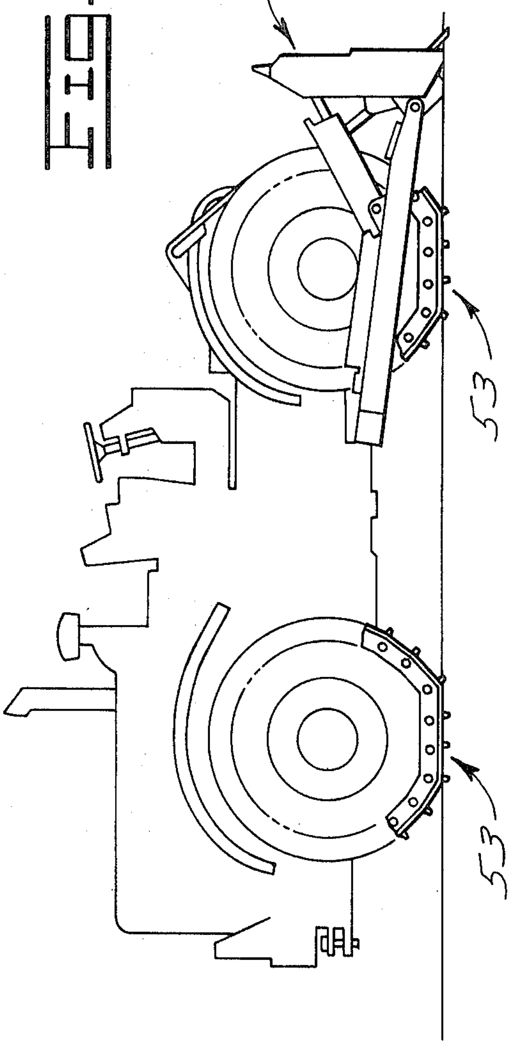
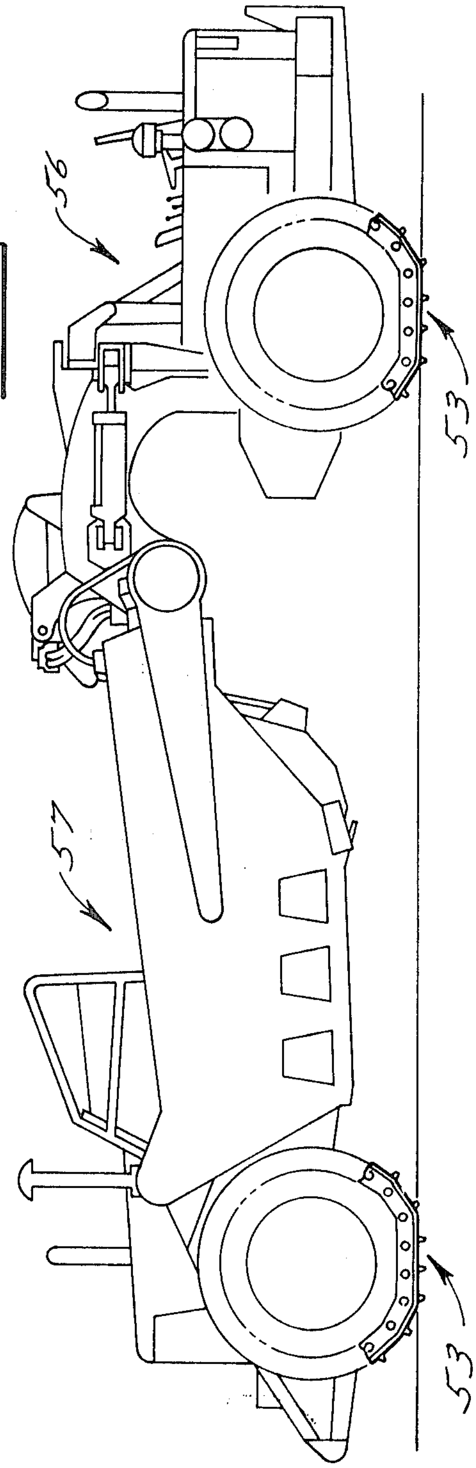


FIG. 3



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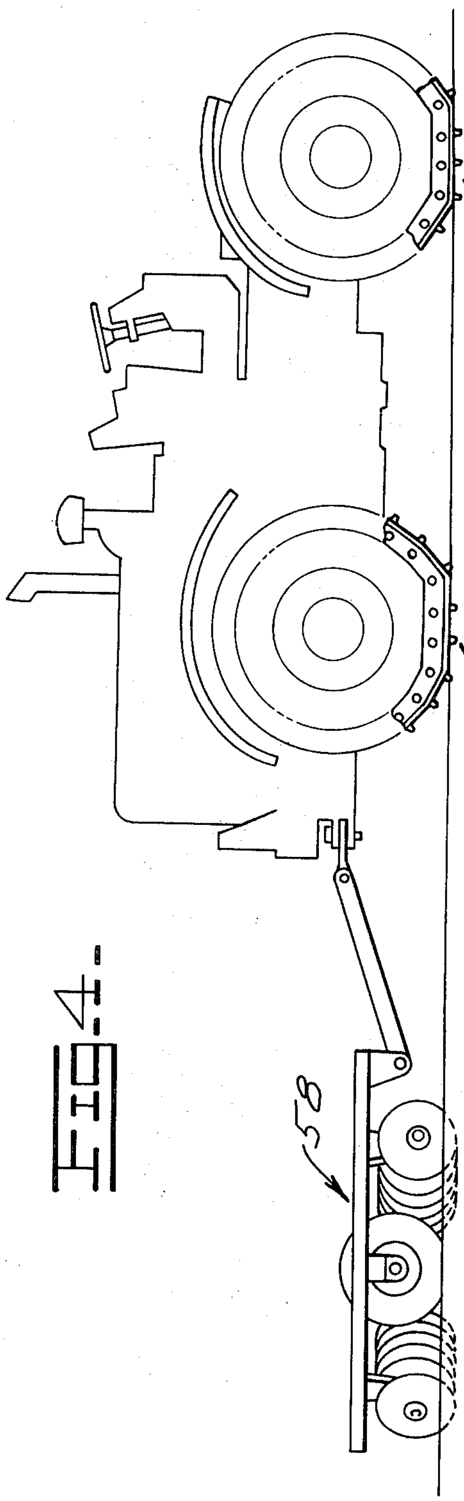

FIG. 4.

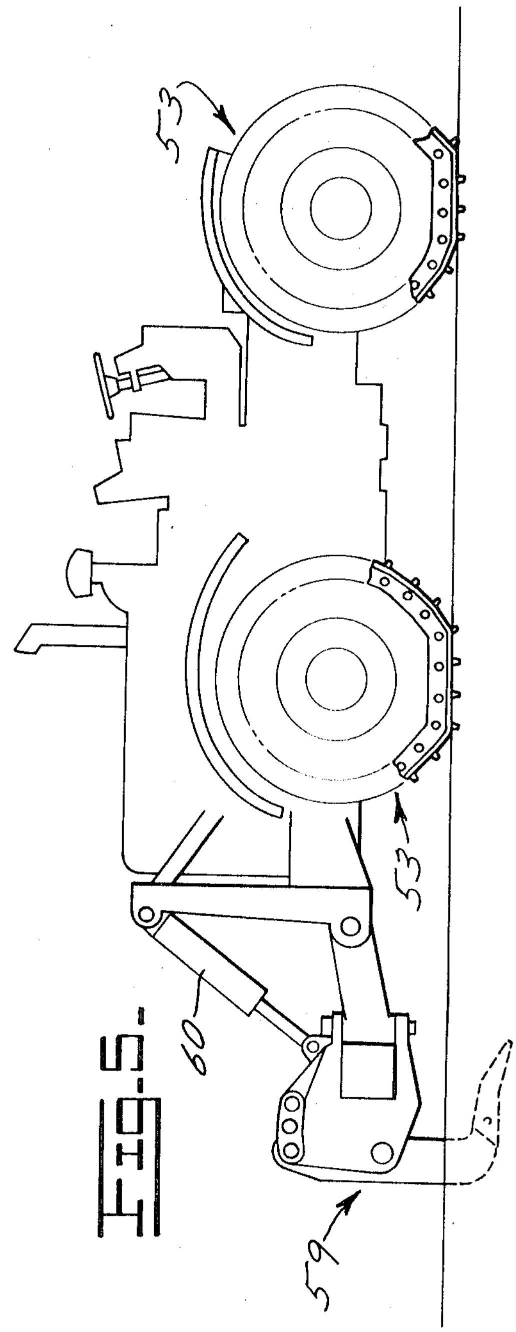

FIG. 5.

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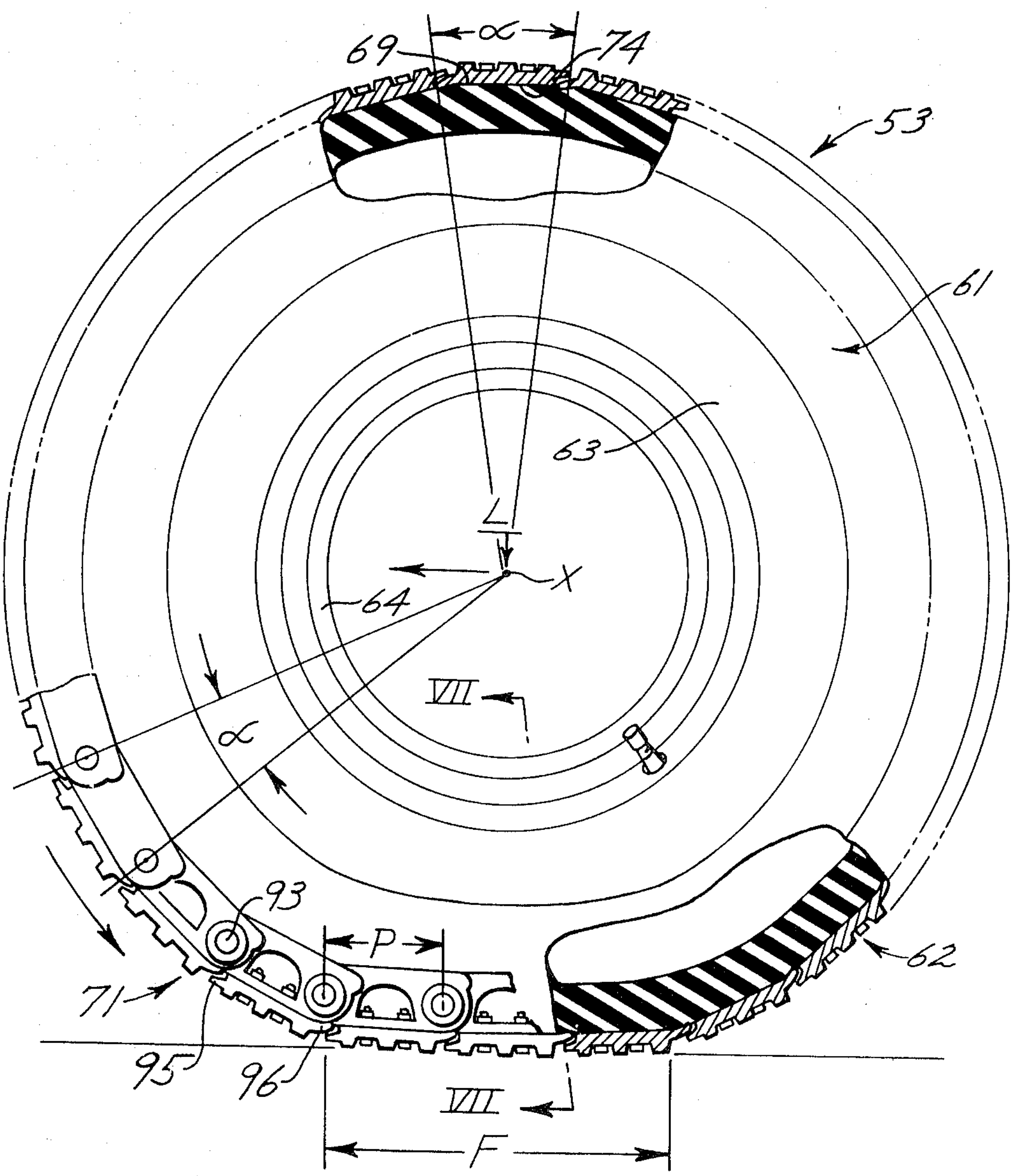
Fig. 6.



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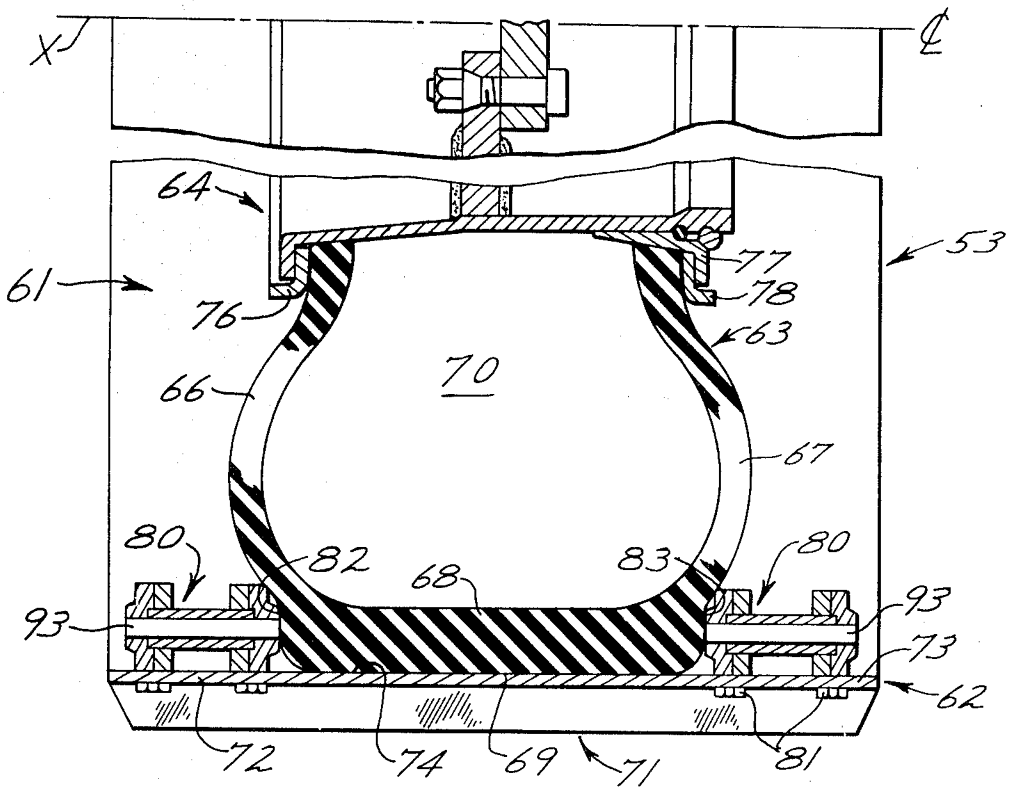

Fig. 7

Fig. 8

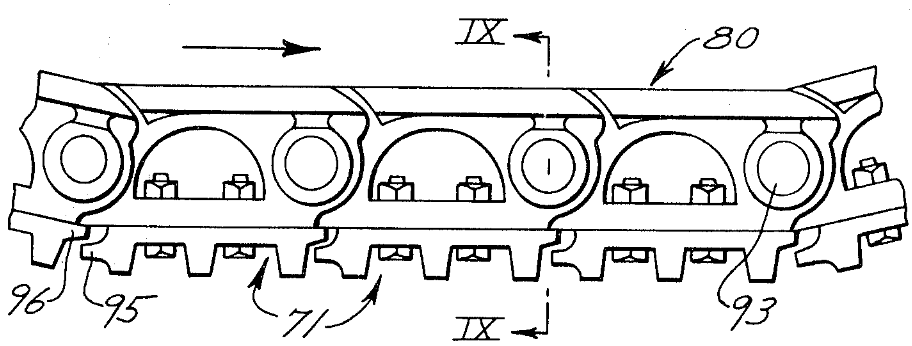

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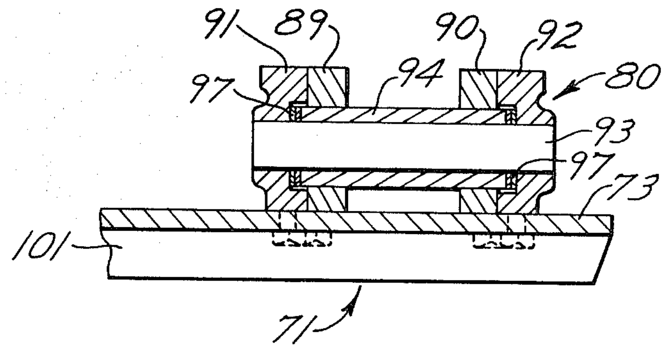
FIG. 9.



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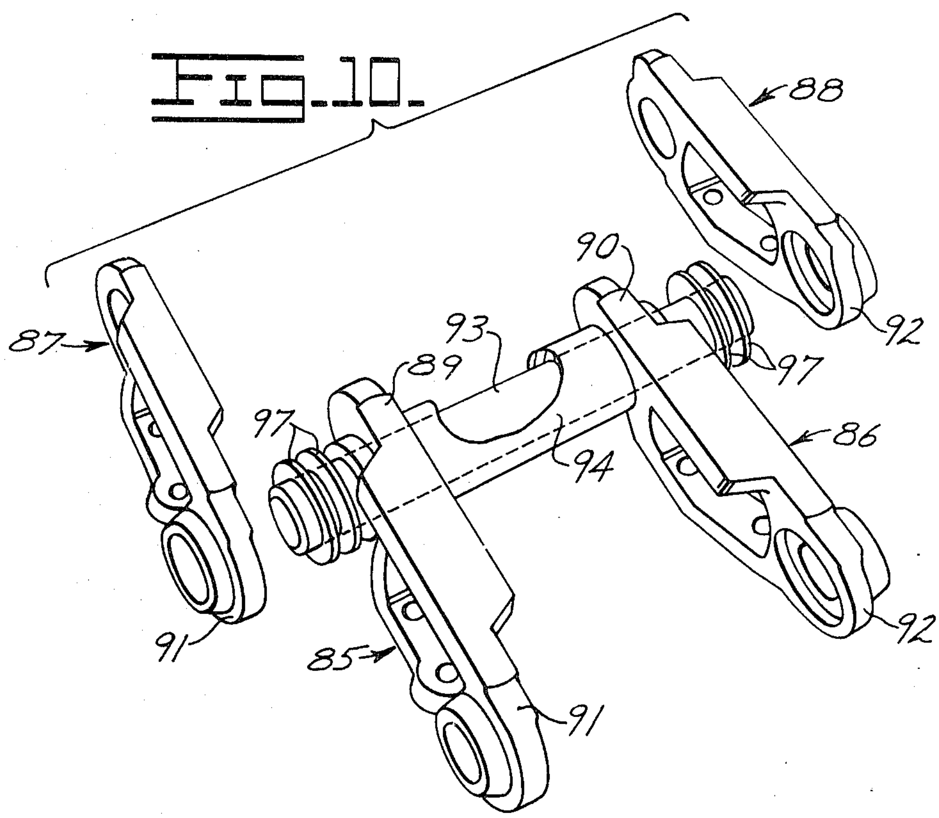

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FIG. 11

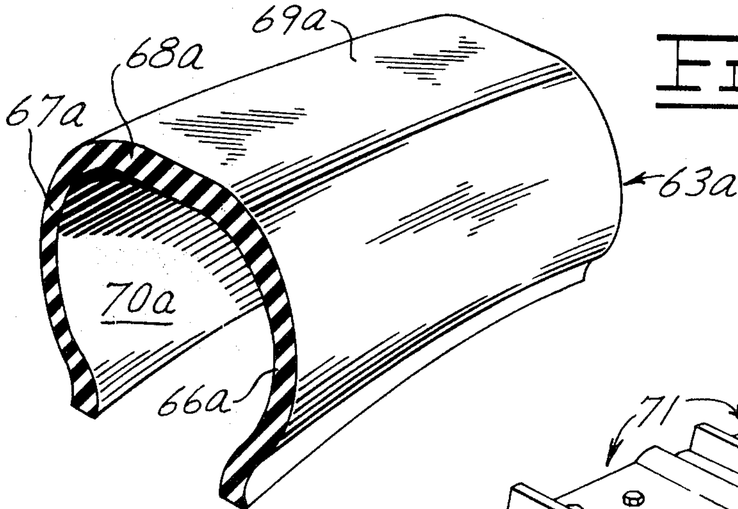


FIG. 12

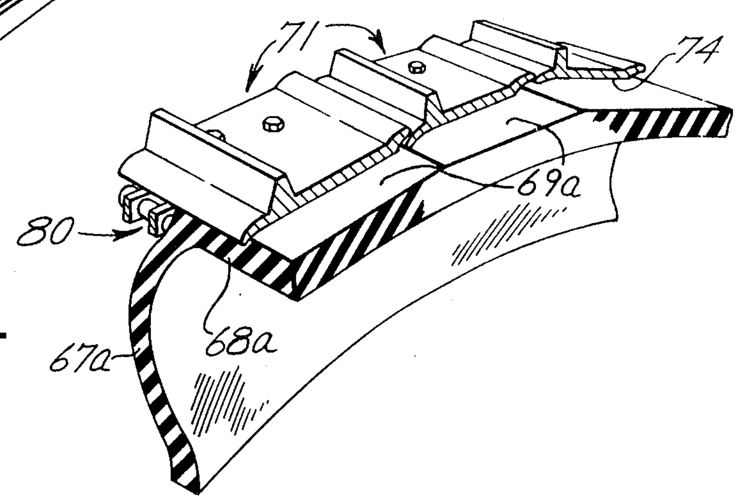


FIG. 13

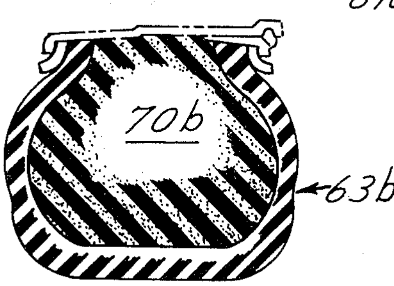


FIG. 15

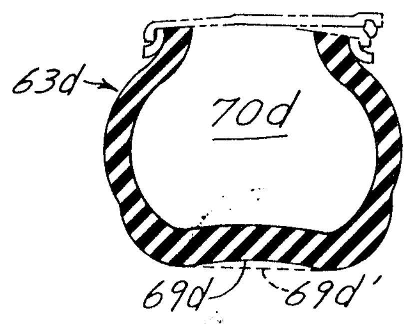
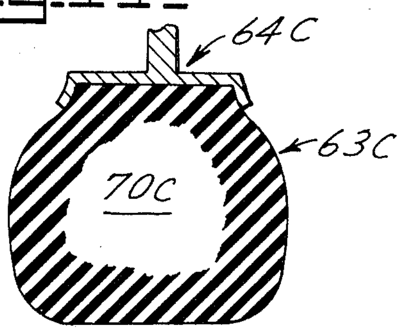


FIG. 14



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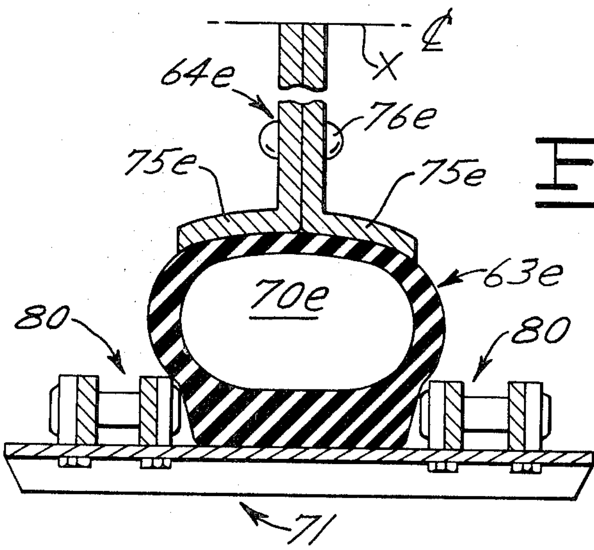
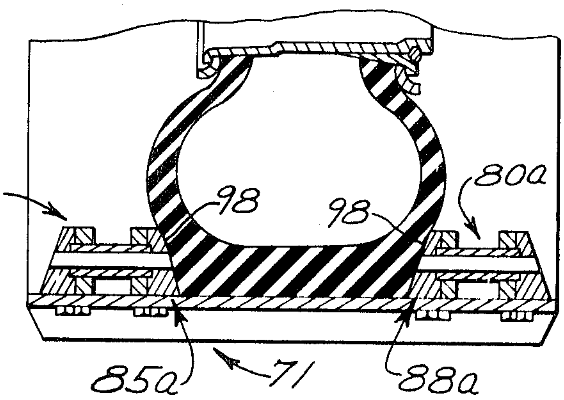


Fig. 16.

Fig. 17.



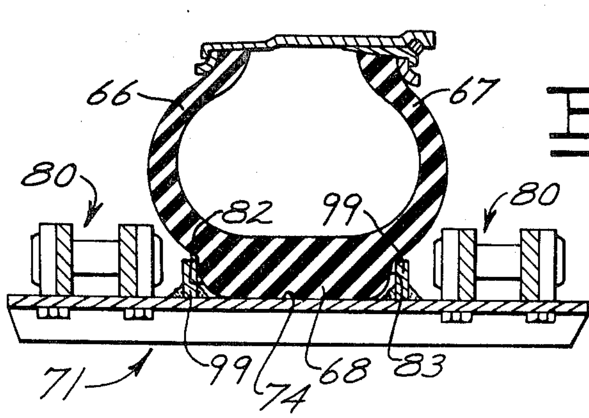


Fig. 18.

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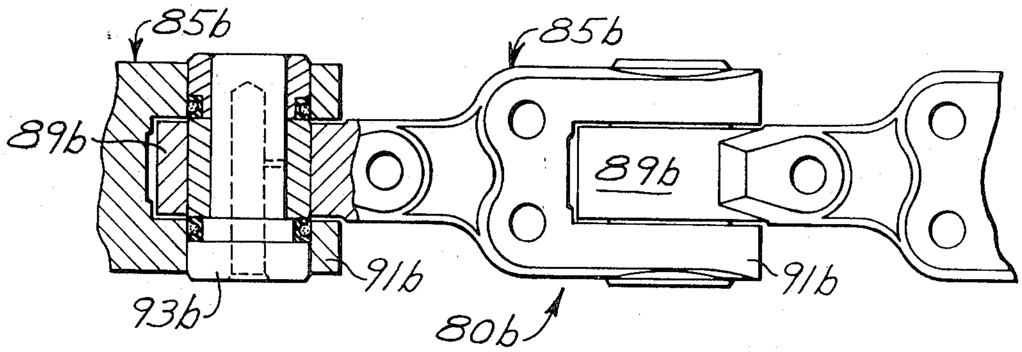
Fig. 19.



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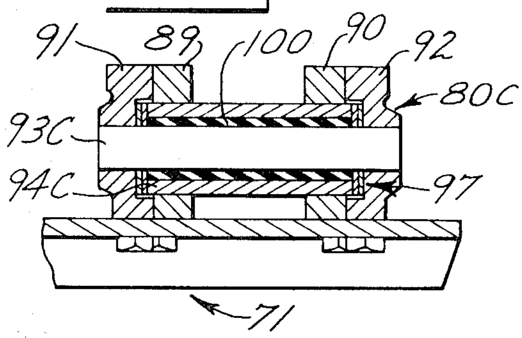
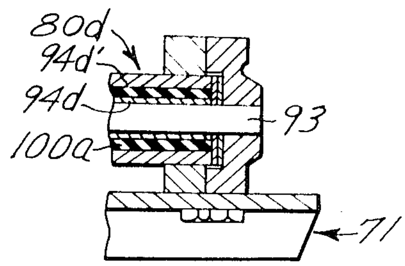


Fig. 20A.



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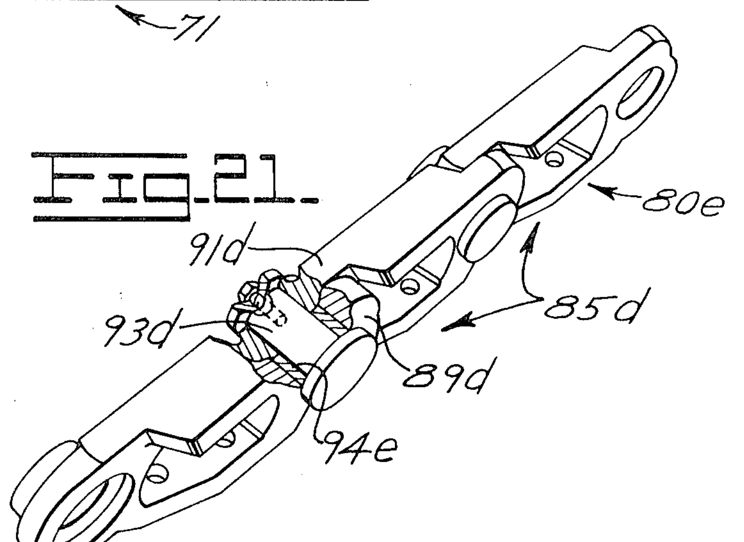

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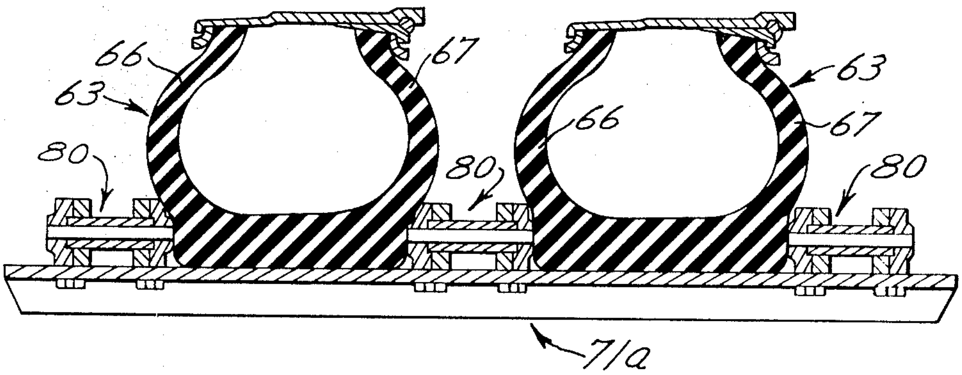
Fig. 22.



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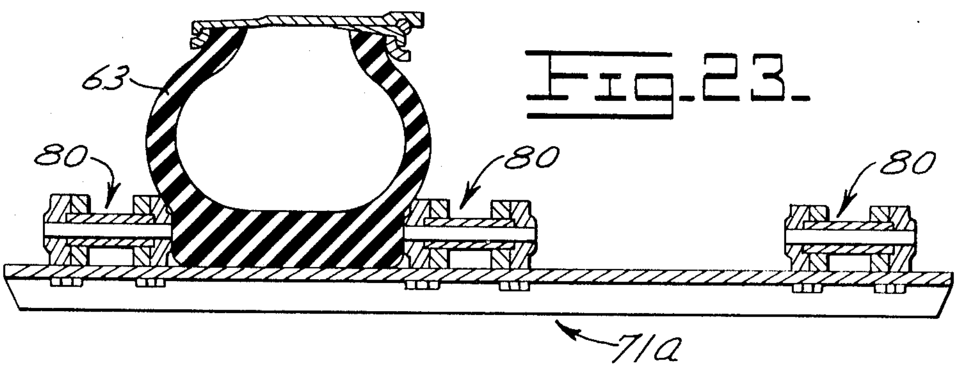

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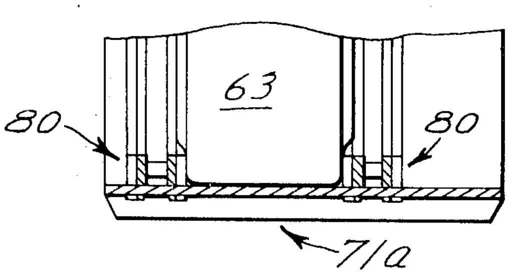

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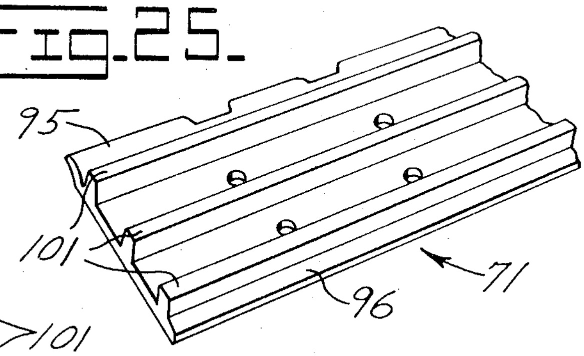
Fig. 25.



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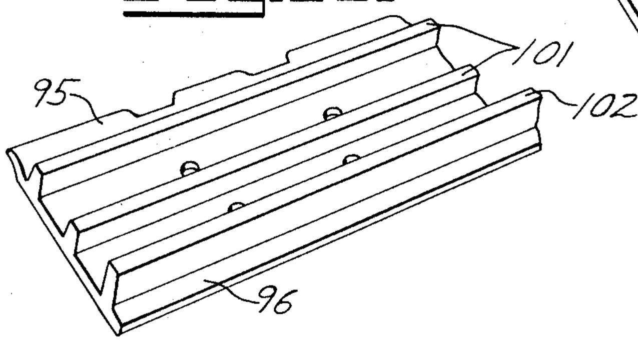

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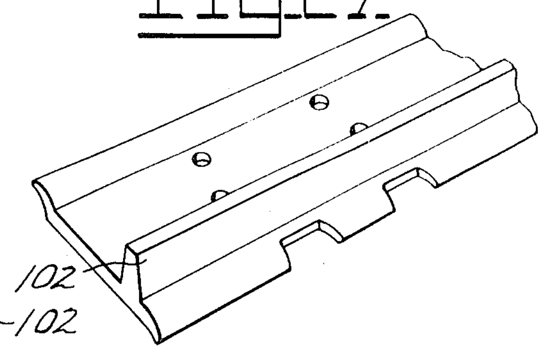

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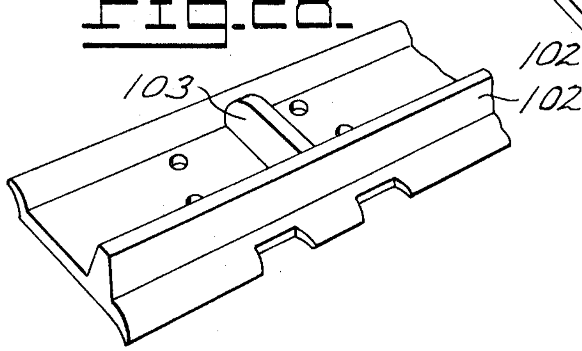

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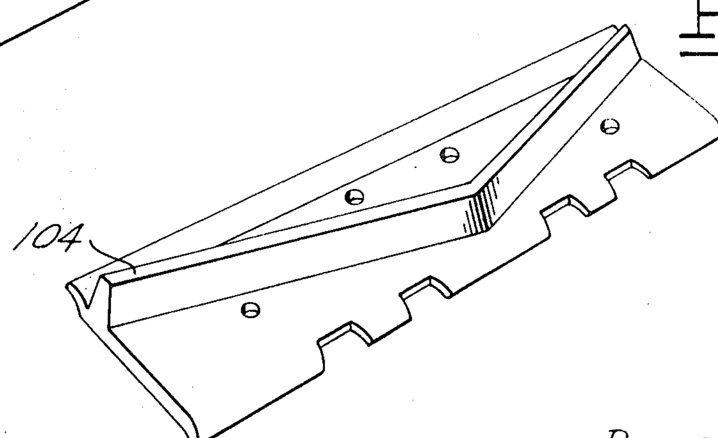

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Fig. 30

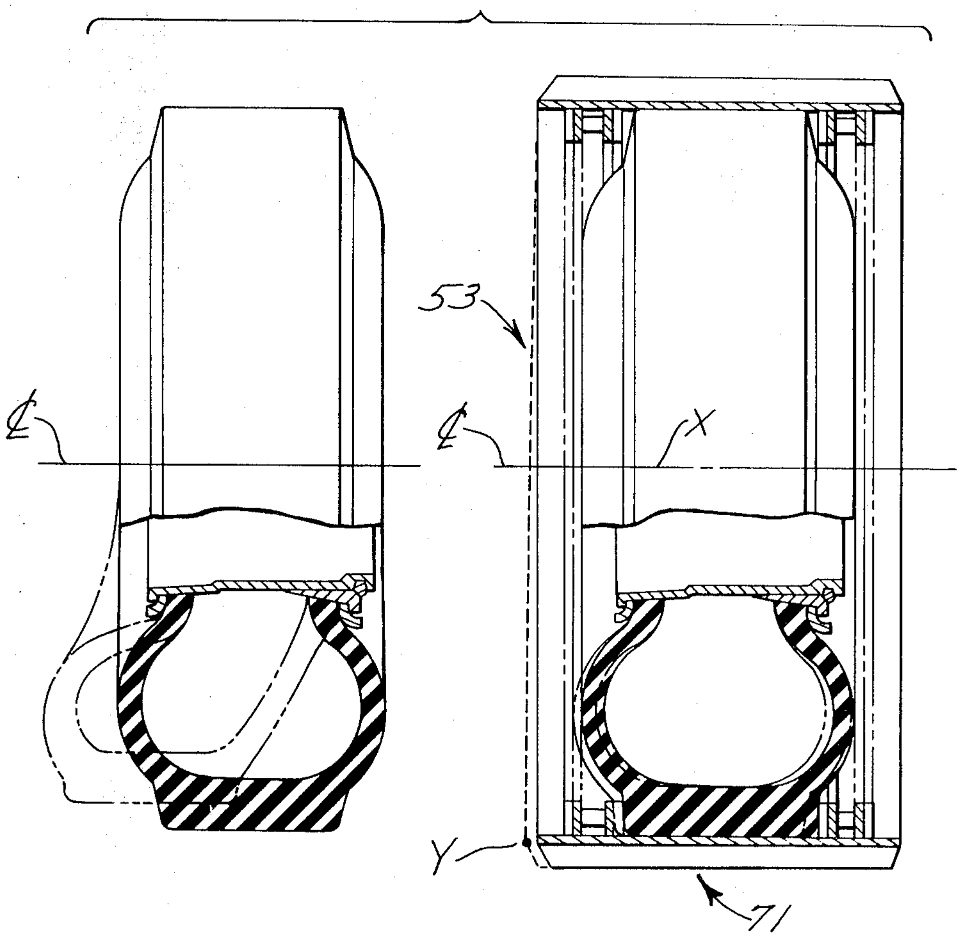

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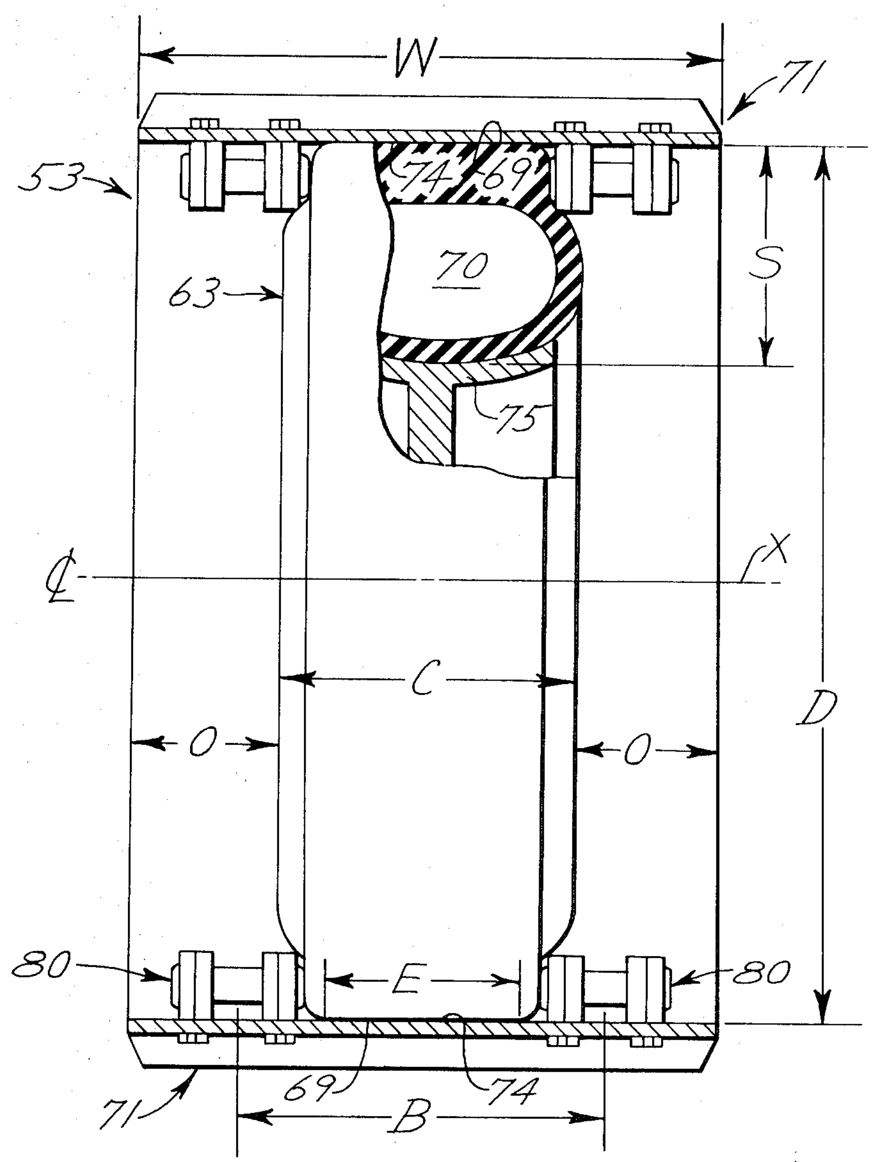
Fig. 31.



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CUSHIONED TRACK

Commercially available earthworking and transport machines are generally mounted on endless tracks or pneumatic tires for locomotion purposes. Track-type machines, such as conventional two-track crawler tractors, presently comprise the most compact, powerful and all-purpose pulling and pushing machines available. However, such machines inherently exhibit certain limitations and operating deficiencies such as speed limitations, vibration and shock-absorbing limitations, numerous, complex and massive components and high-noise level.

Continued improvements made to such crawler tractors, primarily intended for increasing the speed capabilities thereof, have comprised the redesign of existing components or development of various four track-type machines. The former improvements generally relate to the strengthening and geometric redesign of various components, lubrication of wear-prone parts and improvements to the machine's suspension system. The developed four track-type machines are exemplified by the type of machine disclosed in U.S. Pat. No. 3,435,908, assigned to the assignee of this application.

For some purposes, rubber tired tractors are preferred over crawler tractors due to their increased speed capabilities. However, the rubber tired tractor exhibits a number of deficiencies when compared to the crawler-type tractor such as: lower tractive efficiency; poorer flotation characteristics; and less stability. In addition, conventional rubber tires are highly prone to periodic repair or replacement due to their propensity to to wear and damage.

For example, standard rubber tires now comprise a substantial fraction, usually from one-tenth to one-fourth at list prices, of the purchase price of a rubber tired machine. Such tires tend to wear out or damage more rapidly than the remaining components of the machine and are normally repaired or replaced a number of times during the machine's life. Repair and replacement costs are greatly affected by the type of surface over which the tire runs as well as the extent of care and maintenance afforded thereto.

Tire wear largely depends upon the abrasiveness or sharpness of the tire-engaging surface. For example, sharp gravel and crushed or blasted rock greatly accelerate tread wear. Since wet rubber normally tends to cut more easily than dry rubber, tire damage is further increased when the tire operates over wet ground. Also, some operators are inclined to run a machine at unduly high speeds to further increase the rate of tire wear.

Further regarding stability, a conventional rubber tire is induced to "roll-off" its rim when the vehicle is cornered at high speeds or is tilted laterally during side hill earthmoving operations, for example. In the event that such "roll-off" and/or tilting becomes too severe, the vehicle will tip over to thus subject both the machine and its operator to serious damage or injury. Therefore, under such operating conditions machine stability can only be assured by operating the machine at acceptably low-cornering speeds and inclinations to ground level.

Also, conventional earthmoving vehicles of the type herein mentioned primarily depend on the spring and damping characteristics of their rubber tires for vehicle suspension purposes. The inability of such rubber tires to provide adequate damping under certain operating conditions limits vehicle speed due to the poor vehicle ride occasioned thereby.

Numerous prior art attempts have been made to improve the performance and wearability of conventional rubber-tired machines. In addition to reconstructing the tire itself, many unacceptable proposals have been offered to surround or armor the tire with a chain-type arrangement or the like. For example, such prior art solutions have comprised the utilization of bars of lugs formed on a track or link for mechanically engaging and interlocking with mating grooves or indentations formed in the tire.

Many of the prior art devices also place their linking pivot pins on the tire's periphery and oftentimes close to the radial center thereof. Such prior art arrangements generally tend to disadvantageously affect a vehicle's stability, speed capability, load carrying and working capacity and/or structural integrity. For example, the pivot pins and integrated chains are oftentimes unduly wear and damage prone since the vehicle load is primarily supported by the chains which also constitute the drive output to ground.

As will be hereinafter understood, the cushioned track of this invention, particularly when employed on a four-cushioned track vehicle, virtually constitutes a complete departure from the prior art and is a particular contribution to the earthworking and earthmoving industries. Although such cushioned track per se exhibits some incidental similarities to both the above, briefly discussed conventional endless track and rubber tires, it will be seen that this invention when employed on a vehicle exhibits numerous desiderata and features heretofore unrealized by conventional machinery. In particular and as hereinafter more fully discussed, a vehicle employing the cushioned tracks of this invention thereon affords the vehicle numerous desirable dynamic characteristics relating to vehicle ride, stability and handling.

Therefore, an object of this invention is to overcome the above, briefly described problems by providing a cushioned track for ground engaging vehicles capable of yielding high monetary and power utilization savings by combining the high speed, steering and load carrying capabilities of a conventional rubber tired machine with the high torque earthworking capabilities of a conventional track-type machine. The multipurpose and highly durable cushioned track is particularly adapted for use with multiaxled, heavy duty earthworking and/or transport machines to greatly improve the vehicle's dynamic characteristics relating to vehicle ride, stability and handling. In addition, a cushioned track constructed pursuant to the teachings of this invention will exhibit excellent and closely controlled suspension characteristics, including stability, and a high degree of structural integrity heretofore unrealized by conventional support mechanisms.

The cushioned track of this invention, exhibiting the above desiderata, is adapted to be rotated about a central axis thereof and comprises an annular resilient spacer means having an annular, endless track assembly mounted therearound. The track assembly comprises a plurality of closely coupled ground-engaging shoes connected together by laterally spaced link assemblies, positioned outboard of the resilient spacer means, to form a unitized construction. The spacer means outer periphery is normally circular about its central axis and in its relaxed state and is compressed by inner surface portions of the shoes to form a substantially continuous surface contact therebetween. Restraining means are positioned on opposite sides of the spacer means to prevent lateral movement thereof relative to the shoes.

Other and more specific objects of this invention will become apparent from the following description and accompanying drawings wherein:

FIG. 1 is a perspective view of an articulated loader mounted on four cushioned tracks of this invention;

FIG. 2 is a side elevational view of an articulated bulldozer mounted on four cushioned tracks of this invention;

FIG. 3 is a side elevational view of a tractor-scraper mounted on four cushioned tracks of this invention;

FIG. 4 is a side elevational view of a tractor having a drawn implement attached thereto;

FIG. 5 is a side elevational view of a tractor having a ripper attached thereto;

FIG. 6 is a side elevational view of a cushioned track embodiment of this invention comprising a resilient spacer and track assembly, shown as it would appear with a load L imposed thereon;

FIG. 7 is a cross-sectional view taken on line VII—VII in FIG. 6;

FIG. 8 is an enlarged, side elevational view of a portion of an endless track assembly employed in the cushioned track of FIGS. 6 and 7;

FIG. 9 is a cross-sectional view taken on line IX—IX in FIG. 8;

FIG. 10 is an exploded, isometric view of a portion of a link assembly employed in the FIG. 8 track assembly;

FIGS. 11–16 illustrate resilient spacer modifications which may be employed in the cushioned track;

FIGS. 17 and 18 illustrate track assembly modifications which may be employed in the cushioned track;

FIGS. 19–21 illustrate link assembly modifications which may be employed in the track assembly;

FIGS. 22–24 illustrate alternative cushioned track embodiments;

FIGS. 25–29 illustrate various grouser arrangements which may be employed on ground-engaging shoes employed in the track assembly;

FIG. 30 schematically compares a cushioned track embodiment of this invention to a convention pneumatic tire; and

FIG. 31 schematically illustrates design parameters relating to the cushioned track of this invention.

FIG. 1 illustrates an articulated, self-propelled loader 50 of the type manufactured by Caterpillar Tractor Co. and known as its "950 Loader." The loader comprises a tractor having first and second sections 51 and 52, respectively, articulated together for relative pivotal movement in a conventional manner about a vertically disposed axis positioned between the two sections.

This invention, as utilized with such machine, comprises the substitution of two pairs of vertically disposed cushioned tracks 53 in lieu of conventional pneumatic rubber tires. Each pair of the cushioned tracks normally has a horizontally disposed common axis of rotation when positioned on level ground. As shown, a first pair of the cushioned tracks mounted on section 51 may be steered simultaneously relative to the second pair of cushioned tracks mounted on section 52. Standard integrated loader bucket, lift arms and tilt linkage means 54 are pivotally mounted on the forward end of frame section 51 for selective actuation by the operator.

The cushioned track of this invention is particularly useful with such articulated, multiaxled machines to render them capable of exhibiting the above-described desiderata. For example, the cushioned track may also be utilized with many other types of ground-engaging vehicles or machines, such as the "834 Bulldozer" and "657 Scraper" illustrated in FIGS. 2 and 3, respectively. The bulldozer comprises a conventional bulldozer attachment 55 mounted on the front end of the tractor in a conventional manner. The scraper essentially comprises tractor and bowl sections 56 and 57, respectively, connected together in a conventional manner for simultaneous movement.

FIG. 4 illustrates a drawbar-pull application of this invention wherein a ground-engaging implement means 58, shown in the form of an offset disc-type harrow, is operatively connected to the rear end of the FIG. 2 tractor. FIG. 5 illustrates the type of articulated tractor shown in FIGS. 2 and 4, but further comprising a selectively actuated ripper means 59, pivotally mounted on the rear end thereof. A conventional hydraulic cylinder 60 may be utilized to selectively pivot and move the ripping means at least partially below the cushioned tracks and ground level for ripping or scarification purposes.

Although the machines illustrated in FIGS. 1–5 are all of the four wheel type, it should be understood that a greater or lesser number of the cushioned tracks may be employed on a particular machine. Also, the machine may be driven by two or more of the cushioned tracks although the FIGS. 1–5 machines are all of the four-wheel drive type. In addition, each cushioned track may be suspended on its own, individually suspended axle or, alternatively, each pair of laterally spaced cushioned tracks may be constructed and arranged to continuously have the same central axis of Rotation X (FIG. 6).

FIGS. 6–10 illustrate one cushioned track embodiment, subjected to a vertically downwardly imposed load L by the weight of the machine. The cushioned track comprises an annular resilient spacer means 61 having a substantially annular, preferably polygonal-shaped endless track assembly 62 mounted completely therearound. The spacer means comprises a resilient member 63, shown in the form of an air-inflated rubber tire or air bag mounted on a conventional rim means 64. The rim may be suitably connected to the vehicle's drive axle or drive output (not shown) to be driven and rotated about the central axis X thereof by an internal combustion engine 65 (FIG. 1) in a conventional manner.

The spacer means comprises opposed side portions 66 and 67 (FIG. 7) connected together by a substantially annular peripheral portion 68 having a width extending laterally relative to the side portions and in the direction of axis X. The FIG. 6 pneumatic tire spacer means embodiment may be of standard construction comprising suitably integrated inter-liner, body plies and tread plies. For reasons hereinafter more fully explained, the tire embodiment preferably shows an absence of any appreciable amount of ground-engaging treads on outer surface portions 69 of periphery 68 thereof.

The resilient member may be either molded to have smooth and uninterrupted outer surface portions 69 or conventional treads of a particular resilient member may be at least substantially ground-off by a suitable burnishing apparatus, for example. Outer surface portions 69 could be slightly roughened or serrated in certain applications to increase the coefficient of friction thereat. FIG. 11 illustrates one preferred resilient member embodiment 63*a* wherein outer surface portions 69*a*, as well as the intersecting outer surfaces of side portions 66*a* and 67*a*, are preferably molded or otherwise formed to be completely smooth and uninterrupted. As shown, outer surface portions 69*a* may be normally convex with respect to the central rotational axis X (FIG. 6) in their freely relaxed condition.

The FIGS. 6 and 11 resilient member embodiments of the spacer means are each adapted to define a closed, annular chamber 70 (FIG. 7) with the employed rim means 64. A conventional valve stem (FIG. 6) or other suitable inflation means may be utilized to pressurize such chamber with a suitable gas, such as air or nitrogen, preferably to a pressure level selected from the range of from 15 p.s.i. to 100 p.s.i. The selected pressure level will depend on the particular cushioned track application under consideration which will dictate the desired size, strength and related design parameters for the resilient member.

In all spacer means embodiments herein considered the respective peripheral portions of the spacer means must be constructed to afford the strength, support and drive desiderata hereinafter more fully described. Likewise, the connected side portions thereof must exhibit sufficient rigidity and stiffness to transmit driving torque to such peripheral portion without collapsing or otherwise unduly distorting the resilient member during operation and particularly when it is subjected to heavy loads.

If so desired, chamber 70 could be at least partially filled with a liquid (hydroflated) to aid in further increasing the traction and drawbar pull capabilities of a particular machine. Also chamber 70 could be filled with a homogeneous, resilient filling agent or plastic foam 70*b* (FIG. 13), such as certain polyurethane foams, polyvinyl chlorides or polyethylenes. A solid resilient member 63*c* (FIG. 14) could also be used and mounted on a single-piece rim means 64*c* so long as material 70*c* for the resilient member is constructed and arranged to exhibit the required resiliency, durability and related design desiderata.

Referring to FIG. 6, the endless track assembly means is mounted on and completely around the spacer means to form a "boxed-in" and unitized construction therewith. The track assembly comprises a plurality of closely coupled ground-engaging shoes 71 disposed at least substantially parallel and aligned with horizontally disposed central axis X of the cushioned track. The shoes are constructed to have widths defining outboard portions 72 and 73 extending laterally across and beyond the respective side portions of the spacer means (FIG. 7). Inner surface portions 74 of each of the shoes are substantially smooth and uninterrupted and are maintained solely in intimate frictional contact with outer surface portions 69 of the spacer means. The track shoes are preferably suitably alloyed with heavy cross sections to resist bending and deep hardened to exhibit long wear.

Referring to the resilient member embodiment 63*a* illustrated in FIGS. 11 and 12, outer surface portions 69*a* thereof are normally continuous and circular about the central axis *X* of the spacer means in their freely relaxed condition (FIG. 11). When compressed by inner surface portions 74 of shoes 71 at least a substantial portion of outer surface portions 69*a* assume a substantially continuous polygonal-shaped surface contact therewith (FIGS. 6 and 12). The outer peripheral portion of the spacer means is preferably compressed by the shoes to have its outside diameter *D* (FIG. 31) assume less than 99 percent of its normal, freely relaxed and inflated outside diameter (FIG. 11), in most cushioned track applications.

In addition, it is preferred to maintain at least approximately 80 percent of outer surface portions 69*a* in continuous frictional contact with inner surface portions 74 of the shoes and to continuously maintain a coefficient of friction therebetween which is at least 0.3. In most cushioned track applications, such coefficient of friction will approximate 0.8 by continuously assuring a static seal between the spacer means and shoes.

The outer surface portions of the FIGS. 11, 13, 14 and 16 resilient member embodiments are normally substantially flat and parallel to central axis *X* of the cushioned track when in their freely relaxed condition. However, it should be understood that such outer surface portions could be molded to normally assume an arcuate shape (convex or concave) with respect to such central axis in their freely relaxed condition. For example, annular outer surface portions 69*d* of the FIG. 15 spacer means embodiment are concave relative to central axis *X* when chamber 70*d* of resilient member 63*d* is deflated. When the chamber of such spacer means is inflated and surface portions 69*d* are compressed by the constraining track assembly, they will assume the illustrated dotted line, flat position 69*d'*, parallel to central axis *X*. Such arrangement will further aid in counteracting any tendency for the shoes to bend to thus further increase the structural integrity of the unitized spacer means.

FIG. 16 illustrates an excellent type of resilient member embodiment 63*e* for purposes of this invention comprising a closed, completely sealed air inflated chamber 70*e*. These types of resilient members are fully disclosed in U.S. Pat. application Ser. No. 835,499 filed on June 23, 1969 by Charles E. Grawey for "Belted Oval Pneumatic Tube-Tire." Such application is assigned to the assignee of this application. The oval-shaped tube tire disclosed therein comprises radially disposed reinforcement windings about the torus thereof to restrict growth in the direction of the torus' major axis and rotational axis *X* (FIG. 6). The tube tire thus primarily expands radially outwardly in the direction of its minor axis and is capable of containing a widely varied air pressure level in chamber 70*e* thereof.

Various types of rim means may be employed in the spacer means to provide the final drive output from a vehicle's drive train. FIGS. 7, 13 and 15, for example, suggest the use of a conventional rim means comprising an annular rim member 64 having the air-inflated resilient member mounted thereon. Bead flanges 76–78 are mounted on respective ends of the rim member in a conventional manner to abut the bead portion of side portions 66 and 67 to retain the resilient member on the rim member.

FIG. 14 illustrates a rim means 64*c* which is formed as a one-piece casting or stamping, for example, to mount the resilient member thereon. FIG. 16 illustrates a rim means embodiment 64*e* comprising substantially identical L-shaped parts 75*e* having first leg portions extending radially inwardly towards central axis *X* of the spacer means and attached together by conventional rivet means 76*e* or the like. Leg portions 75*e* supporting the resilient member thereon, extend away from each other in the direction of the central axis of the cushioned track.

Referring again to FIGS. 6 and 7, each metallic shoe 71 may comprise a substantially flat plate having a substantially uniform thickness throughout. It should be further noted that the plate is parallel to central axis *X* to continuously maintain inner surface portions 74 thereof also parallel and aligned with such axis. Although inner surface portions 74 are preferably flat, it should be noted that in certain applications such smooth and uninterrupted surface portions could be arcuately shaped in the direction of their circumferential length about central axis *X* and/or in a lateral direction relative to such circumferential length.

For example, such surface portions could be formed slightly concave or convex in the direction of axis *X* depending on the particular match-up with outer surface portions 69 of the spacer means. In addition. although inner surface portions 74 of the shoes are preferably metallic, they may be coated with a resilient rubberlike plastic or rubber-based material, for example. Such material could be in the form of an insert which is vulcanized or otherwise secured to the shoes. Likewise a metallic insert could be secured to inner surface portions 74 and have an arcuate or flat shape formed thereon.

Referring to FIGS. 7–10, the track assembly further comprises an annular link assembly 80 positioned adjacent to each of the side portions 66 and 67 of the spacer means to closely couple the shoes together. The shoes may be attached to the link assemblies by releasable bolt means 81, for example, to facilitate change of one or more of the shoes should such change become necessary. Each link assembly preferably extends radially inwardly a substantial distance toward central axis *X* from inner surface portions 74 of the shoes.

In the FIG. 7 embodiment, opposed inboard surface portions of each of the link assemblies abut outboard portions 82 and 83 of respective side portions 66 and 67 to provide restraining means for preventing lateral movement of the resilient member in the direction of axis *X* and relative to the shoes. In certain applications it may prove desirable to form annular grooves (not shown) at outboard portions 82 and 83 to move the link assemblies toward each other and at least partially within the confines of side portions 66 and 67, respectively. Furthermore, it should be noted that substantially all portions of the side portions, positioned adjacent to and extending radially inwardly toward axis *X* from outboard portions 82 and 83, are shown in FIG. 7 as being normally positioned out of contact with respect to the link assemblies. However, during operation vertical damping movements of the cushioned track in FIG. 6 may cause five shoes, for example, to flatten out at footprint *F* on the ground. Simultaneously therewith, a portion of the above-mentioned radially extending portions of the side portions may tend to "fold over" and at least partially abut over the link assemblies in FIG. 7.

Referring more particularly to FIGS. 8–10, each link assembly comprises a plurality of laterally spaced first and second pairs of links 85–86 and 87–88. The links are preferably heavily strutted to assure uniform loading, minimize stress concentrations and to evenly distribute wear. Each link of each pair of links overlaps an adjacent link of an adjacent pair of links so that inner overlapped first end portions 89 and 90 of the first pair of links 85–86, for example, are positioned within outer, overlapping second end portions 91–92 of the adjacent second pair of links 87–88. The resulting integrated construction of each link assembly presents substantially smooth and circumferentially continuous inboard surface portions or restraining means abutting outboard surface portions 82 and 83 of the spacer means (FIG. 7).

The pivot means for pivotally connecting the first end portions of the first pair of links to the second end portions of the second pair of links may comprise a pin 93 extending through the first pair of links and press-fitted into or otherwise suitably connected to the second end portions **91–92** of the second pair of links. The second pair of links are thus attached together for simultaneous rotation about the longitudinal axis of the pin. A bearing bushing **94** is mounted for limited rotational movement relative to the pin by its press-fit connection to first end portions **89–90** of the first pair of links.

The bushings may be cold-forged and formed with slightly tapered ends internally thereof to aid in resisting undue shocks and stresses. The pins are preferably induction hardened to exhibit high wear-resistant and smoothly finished bearing surfaces over a tough core. The relative hardnesses of the pins and bushings are preferably compatible to minimize wear.

Referring to FIGS. **6** and **8**, the longitudinal axis of each pin **93** is preferably positioned substantially parallel relative to central axis *X* of the cushioned track and further positioned substantially intermediate a respective pair of adjacent shoes connected together thereby. Such an arrangement facilitates a close coupling of the shoes together and also permits them to move into contact with the ground at footprint *F* in a substantially smooth, uninterrupted and continuous manner. For example, such close coupling aids in forming the substantially continuous and uninterrupted polygonal shape of surface portions **74** which completely surround the spacer means.

It should be further noted that first and second lugs or stops **95** and **96** are formed integrally with each shoe, at respective ends thereof. The lugs function in conjunction with the above-described intermediate position of pin **93** to completely mask each other during rotation of the cushioned track. In particular, lug **95** of one shoe will completely cover second lug **96** of a leading shoe to protect the spacer means against damage and dirt infiltration during all phases of machine operation.

If so desired, conventional sealing means, shown in the form of two pairs of back-to-back cone-shaped metal discs or Belleville-type washers **97** of the type disclosed in U.S. Pat. No. 3,050,346, for example, may be utilized in the link assembly. A pair of the washers are mounted on each end of the pin to be compressed between the end of the bushing and one of the links **87** and **88** for sealing purposes. The links have suitable counterbores formed therein (FIG. **9**) to accommodate reception of the washers.

FIG. **17** illustrates a modified track assembly wherein link assemblies **80***a* each comprise annular surface portions **98** formed on inboard surface portions of links **85***a*–**88***a* to diverge relative to each other radially inwardly toward the central axis of the cushioned track. FIG. **18** discloses another track assembly embodiment wherein the link assemblies are positioned laterally and out of abutting contact with respect to outboard surface portions **82** and **83** of the sidewall portions of the resilient member. In such an application two metallic bands or lugs **99** are secured to inner surface portions **74** of each track shoe to abut the outboard surface portions of the resilient member to provide the restraining means preventing lateral movement thereof.

FIGS. **19–21** illustrate additional link assembly embodiments. In the FIG. **19** fork and blade link assembly embodiment **80***b*, identical links **85***b* each comprises blade end **89***b* mounted in a fork end **91***b* of an adjacent link by a track pin cartridge **93***b*. Such cartridge is fully disclosed in U.S. Pat. No. 3,463,560, assigned to the assignee of this invention.

FIG. **20** illustrates a link assembly embodiment and c wherein a resilient and preferably slightly compressed rubber bushing or sleeve **100** is positioned between each pair of pins and bushings **93***c* and **94***c*. The resilient sleeve may be vulcanized or otherwise suitably secured to the pin and bushing to closely control rotational movement therebetween to improve damping and speed capabilities of the cushioned track for certain applications. FIG. **20**A illustrates a link assembly embodiment **80***d* wherein a rubber sleeve **100***a* is vulcanized between metallic bushings **94***d* and **94***d'* to aid in relieving high-"pinch" loads. Rotary frictional contact is occasioned between inner bushing **94***d* and pin **93**.

The FIG. **21** link assembly embodiment **80***e* comprises a single set of links **85***d* comprising a bushing **94***e* pressed into the bushing end **89***d* of the link. A pin **93***d* is inserted through the bushing and press-fitted or otherwise secured to end **91***d* of the connected link. It should be understood that the FIGS. **8–10** double-link assembly embodiment would be preferred over the FIG. **21** single-link embodiment for most cushioned track applications due to its increased "antisnaking," rigidity and damping capabilities, for example.

FIGS. **22–24** illustrate modifications to the cushioned track wherein the widths of shoes **71***a* are elongated so that they extend a substantially greater distance beyond one side portion **67** of the resilient member than the opposite side portion **66**. In addition, a third identical link assembly **80** is attached to the shoe outboard of the other link assemblies and dual spacer means are mounted for simultaneous rotation by a common drive axle (not shown). In the FIG. **23** modification, the second spacer means has been removed to permit the cushioned track to run in the manner illustrated. In the FIG. **24** embodiment, the third link assembly is eliminated to provide uneven overhangs *0* (FIG. **31**) to provide increased flotation capabilities on "soft" ground, for example.

Although in certain application, the outer surface portions of the track shoes may be smooth and uninterrupted, i.e., void of grousers, FIGS. **25–29** illustrate a number of grouser arrangements which exhibit various desirable traction characteristics. The FIGS. **6** and **25** grouser arrangement comprises three identical grousers **101** secured to the outer surface portions of the shoe and substantially equally spaced thereon. The radial height of the grousers are equal and extend laterally in the direction of the central axis of the cushioned track and at least substantially fully across the width of the shoe.

The FIG. **26** grouser arrangement is substantially similar to the one shown in FIGS. **25**, except that leading grouser **102** has a height greater than the height of the other two grousers **101**. Such a grouser **102** would be preferred in certain applications to increase tractive capabilities and to strengthen the shoes when operating over certain soil conditions.

FIG. **27** illustrates a grouser arrangement similar to the one illustrated in FIG. **26**, except that grousers **101** have been eliminated. The FIG. **28** grouser arrangement is similar to the FIG. **27** grouser arrangement, except that an additional cross grouser **103** is secured to the shoe to extend perpendicularly relative to grouser **102**. FIG. **29** illustrates a further grouser arrangement wherein a V-shaped "chevron" grouser **104** is secured to the track shoe.

In the above description it should be noted that similar constructions are depicted by like numerals with certain numerals being accompanied by lower case letters to depict modifications occasioned to certain constructions.

The FIG. **6** track assembly, for example, may be assembled by at least partially deflating spacer means **61** and then wrapping uncoupled track assembly **62** therearound. A suitably sized "master pin" **93** may be employed in each of the link assemblies to facilitate such uncoupling. Alternatively, a breakable link of the type disclosed in U.S. Pat. No. 3,427,079 could be utilized for coupling purposes. The loose ends of the track assembly may be drawn together by a suitable cinch or the like to align the mating "master pin" retaining bores of such ends. Once the "master pin" is press-fitted into place, chamber **70** of the spacer means is pressurized with air to a predetermined level. The magnitude of such level will largely determine the degree to which the spacer means is compressed by the track assembly to provide the above-discussed surface contact and drive means desiderata between surfaces **69** and **74** (FIG. **7**).

Although the circumferential lengths of all sides of the polygonal surface contacts are preferably equal, it should be understood that in certain applications that one or more such sides may be formed to a length different that the remaining sides. For example, the alternate circumferential lengths of each adjacent pair of coupled shoes could be ten inches and20 inches, respectively. Also, as suggested above surfaces **74** could be preformed to be arcuate rather than flat to thus define a substantially circular circumferential length about axis X.

The method for imparting drive to the above-described cushioned track comprises the steps of: Completely surrounding the periphery of vertically disposed spacer means **61**, exhibiting a substantially equal air pressure level in chamber **70** (FIGS. **6** and **7**), with endless track assembly **62**; compressing and deforming the periphery of the spacer means with shoes **71** against the counteracting radial pressure occasioned by the air pressure in chamber **70**, so that it normally assumes a substantially circumferentially continuous surface contact with inner surface portions **74** of the shoes about central axis X (FIG. **6**); imposing a vertical load L on the spacer means and track assembly and simultaneously engaging a stationary surface or ground with the shoes at footprint F; and rotating the spacer means about its central axis to drive the shoes over the ground by means of the continuous surface contact existing between the shoes and spacer means.

In the method suggested by the FIG. **6** cushioned track embodiment, for example, the compressing and deforming steps comprise the steps of compressing and deforming the periphery of the spacer means so that: The circumferential lengths of inner surface portions **74** of each of the shoes are substantially equal; the polygonal-shaped surface contact area is substantially parallel to central axis of rotation X; and the circumferential length of each of the inner surface portions of the shoes normally defines (with load L not imposed on the cushioned track) the base of an isosceles triangle having its apex at the central axis and having its sides or radii defining an included angle α (FIG. **6**) therebetween selected from the range of from 6° to 30°. It should be noted that such a range of angles also substantially applies to the pitch length P between adjacent pivot pins **93**, i.e., wherein an imaginary line between the centers of two adjacent pins forms the base of the isosceles triangle.

Regarding such angle as related to flat surface contacts **69–74**, should the angle fall below 6° the circumferential length thereof will become too short for effective static sealing purposes. Should the angle exceed 30°, difficulty will be encountered in forming the continuous polygonal shape of surfaces **69** which will inhibit effective static sealing and the drive contact between surfaces **69** and **74**, uneven stress distributions will be induced across the shoes and side portions **66** and **67** will undesirably tend to conform to the polygonal shape. For example, a tested cushioned track having an angle α of 28° began to exhibit the above-mentioned undesirable characteristics, particularly in the low-speed range.

Regarding pin pitch, should the angle fall below 6° the strength and section modulus of shoes **71** will normally be insufficient to support loads imposed thereon. When the angle exceeds 30° unduly high vibrations are induced as well as gouging at footprint F.

FIG. **31** schematically illustrates design parameters relating to the cushioned track of this invention and in particular to the tested FIGS. **6–10** embodiment. The dimensional parameters illustrated have the following meanings:

W = Lateral Width of Shoe **71**

D = Compressed Outside Diameter of Inflated, Unloaded (Load L) Spacer Means **61** (percentage range indicates degree of diametrical compression from inflated normal relaxed diameter)

O = Overhand of Shoe **71**

E = Lateral Width of Friction Engagement Between Surfaces **69** and **74**

P = Pitch Between Pins **93** (FIG. **6**)

B = Lateral Distance Between Centers of Link Assemblies **80**

F = Footprint Length of Shoes **71** on Ground With Load L Imposed on Cushioned Track **53** (FIG. **6**)

C = Chord or Maximum Width of Resilient Member **63**

S = Sectional Height of Resilient Member **63**

Lateral distance B is preferably equal to or greater than $0.2D$ to assure a sufficiently large surface contact between surfaces **69** and **74** for driving purposes and for assuring adequate load carrying capabilities. The upper limit of such relationship of B to D will depend upon the particular cushioned track application in question.

Overhang O is preferably equal to or greater than $0.1S$ to fully protect the sectional height of resilient member **63**. The upper limit of S will largely depend upon the accommodating space limitations of a particular machine on which the cushioned track is employed.

Lateral width E, defining the surface contact between surface **69** and **74**, is preferably selected from the range of from $0.5C$ to $1,0C$. Should such surface contact fall below $0.5C$, the desired amount of "dry" frictional contact will be lost to induce slippage and dirt infiltration, an unduly high amount of rubbing contact between link assemblies **80** and side portions **66** and **67** will be induced and uneven stress distributions will be promoted in shoes **71**. Such problems, which may arise depending on the particular cushioned track application, will tend to diminish when E moves toward $1.0C$.

One tested embodiment of the FIGS. **6–10** cushioned track closely approximated the following parameters:

W=34 inches
D=60 inches
O=3 inches
E=16 inches
P=6 inches
B=22 inches
F=24 inches
C=21 inches
S=16 inches
=14° and wherein
B=$0.36D$
O=$0.18S$
E=$0.76C$

The cushioned track and method teachings of this invention afford a number of observed features and benefits, particularly useful for earthworking machines such as scrapers, motor graders, wheel loaders, bulldozers and other types of machines utilizing a work tool and/or utilized for transport purposes. Additional applications may include military hauling and combat units, log skidders and haulers and the like. As suggested in the objects of this applications many such machines are now capable of performing heavy duty and high-speed (e.g., 30 m.p.h.) operations at a working efficiency heretofore unrealized by conventional machines and greatly improve the dynamic characteristics thereof. The observations hereinafter set forth, although particularly drawn to the tested FIGS. **6–10** cushioned track embodiment, also substantially apply to the above described modifications and alternative embodiments.

As suggested above, the dynamic characteristics, i.e., handling, stability and ride of a vehicle mounted on cushioned tracks of this invention such as the 950 Loader illustrated in FIG. 1, are greatly improved over the dynamic characteristics of conventional earthmoving vehicles.

Regarding vehicle handling, testing has shown that the cushioned tracked 950 Loader, for example, exhibits a much higher degree of cornering stiffness than a conventional rubber-tired 950 Loader. Cornering stiffness is an important design consideration which affects vehicle handling or directional control and may be defined as the negative of the derivative of the cornering force with respect to the slip angle of the cushioned track. The slip angle is the angle between the direction of cushioned track heading and the direction of cushioned track travel.

Such high cornering stiffness is important to such vehicle operation since vehicle handling is inherently made highly responsive to steering input without loss of adequate control stability. In addition, an oversteered or understeered vehicle will tend to approach the condition of neutral steer to thus largely render the loader vehicle's handling characteristics insensitive to a change from the empty to the loaded bucket condition, for example. For example, if a vehicle is turning at steady-state with a constant steer angle input and then increases its speed, the vehicle will turn at a smaller radius if oversteered, turn at a larger radius if understeered, and maintain the same turning radius during neutral steer.

Further regarding steering, it should be noted that the four cushioned track vehicle can be steered in automotive fashion. In comparison, a conventional two-track type tractor is normally steered by disengaging one track and by powering the other track to effect a turn. If the tractor is under high load, the powered track may spin out resulting in an inefficient turning cycle.

The dynamic stability of the cushioned track vehicle is also markedly improved over that of conventional vehicles. During a low-speed loading cycle of a loader, for example, the dynamic stability characteristics of the vehicle can be described by several basic modes of vibration. Such modes will largely depend upon the design characteristics of the cushioned track, vehicle design parameters and the vehicle's operational configuration, i.e., bucket-up, bucket-down, bucket loaded or bucket empty. The most predominant mode sensed as "stability" is the mostly lateral mode of vehicle vibration occurring when the lift arms are fully raised which is excited by lateral forces on the vehicle and ground irregularities. This mode of vibration is generally characterized by vehicle motion which oscillates about a nodal-axis near ground level.

The frequency of the mode for one conventional, fully vehicle rubber-tired loader approximates 0.5 c.p.s., which is sufficiently low to afford the operator an insecure feeling during certain phases of loader operation. In contrast thereto, the cushioned track vehicle assures a substantial relative increase in the vertical spring rate of the resilient members, a larger footprint *F* (causing the effective spring rate of the soil to increase), and a larger effective tread width of the vehicle. These characteristics tend to increase the frequency of motion of this mode of vibration and, as a result, to greatly increase the dynamic stability of the cushioned tracked vehicle over that of comparable conventional wheel loaders.

Further regarding dynamic stability, a mostly yaw mode of vibration occurs when the loader bucket is in the carry position, with the cushioned tracks either braked or free to roll fore-aft. This mode influences the operator's sense of vehicle stability and is excited most often when steering corrections are made. This mode of vibrations normally occurs at about 1.0 c.p.s. for a conventional rubber-tired loader. The previously mentioned design parameters exhibited by the cushioned track affect this mode advantageously. In addition, a high lateral spring rate and static aligning spring rate are exhibited which tend to increase the frequency of the mode, thus giving the operator a feeling of improved stability.

In addition, studies have indicated that the substantial increase in the lateral spring rate of the cushioned track alters the modes of vehicle vibration. The mostly yaw mode in conventional wheel loaders has been altered to the extent that in the cushioned track loader, this mode is no longer easily excited by steering corrections. Another mode then becomes predominant but since it has a higher frequency the overall effect is to improve the dynamic stability characteristics of the cushioned track vehicle.

Still further regarding dynamic stability, fore-aft (or longitudinal) stability can be characterized by the mostly fore-aft mode of vehicle vibration, which generally occurs when the vehicle's brakes are applied. This mode is most easily excited when the bucket is raised or dropped abruptly. The fore-aft dynamic stability is improved by increasing the mostly fore-aft mode frequency which is accomplished by increasing the vertical spring rate and effective footprint area of the cushioned track.

The dynamic ride characteristics of a conventional rubber-tired vehicle are primarily influenced by mostly pitch and mostly bounce modes of vibration. In general a smoother ride will be occasioned at the lower frequencies of these modes and visa versa. However, in the case of the cushioned track an increase in such frequencies and a significant increase in damping provide an improved ride for most roading conditions. It should be noted parenthetically that the hereinafter more fully discussed increased damping afforded by the cushioned track greatly improves all modes of dynamic stability. Increased damping causes the vibrations to decay rapidly with little chance for successive vibration inputs to cause conditions bordering on instability.

It should be noted that the cushioned track per se forms a unitized, "boxed-in" construction which is totally integrated to afford it great stability and structural integrity. The degree to which spacer means **61** conforms to the polygon shape of the track assembly (FIG. **6**) is primarily dependent on the amount of radial squeeze imparted to the spacer member by the track assembly and by the spacer means' counteracting stiffness. As suggested above, the spacer means would normally require compression so that it will assume at least 99 percent of its normal, relaxed diameter and circumferential surface area. In the case of radial ply resilient members, for example, such value may be as high as 98° and in relatively soft resilient members as low as 75.

Torque transmitted to the spacer means by the machine's drive axle and rim means **64** is transferred to the track assembly via side portions **66** and **67** which must exhibit sufficient stiffness to prevent excessive "wind-up" and related spacer means distortion. As suggested in FIG. **16**, for example, the sectional height of the resilient member may be quite short (e.g. 10 percent) in relation to the outer radius of the spacer means. In turn, torque is transmitted to shoes **71** primarily through the surface contact between abutting surfaces **69** and **74**. The cushioned track, even though capable of speeds in excess of 30 m.p.h., is able at speeds even as low as 2 m.p.h. to transmit at least 75 percent of the machine's weight *L* (FIG. **6**) through the spacer means and to the tracks in the form of traction.

The FIG. **6** cushioned track embodiment inflated from 30 to 60 p.s.i. when tested for typical vehicle applications and under typical operating conditions normally developed approximately 45 percent frictional drive to the shoes at footprint *F* and approximately 55 percent frictional drive to the shoes around the remaining circumferential length (e.g. 300°) **of the shoes. Although substantially equal for the above typical conditions, the relative percentages of such frictional drives will depend, for example, on soil conditions, the coefficient of friction between the various portions of surface contacts 69–74, inflation pressure, geometric and structural design criteria and related design parameters. The preferred range for each of the above percentages is** 50 percent plus or minus 10 percent.

Another feature of this invention is the inherent ability of the cushioned track to normally, continuously maintain frictional contact between surfaces **69** and **74** during all phases of machine operation. In addition to continuously assuring the above-discussed drive means, the abutting surfaces tend to form a static seal to prevent water, dirt and the like from entering between the spacer means and track shoes. The ability of the resilient spacer means to substantially conform to the polygonal configuration of shoes **71** assures such sealing desideratum even though the shape of the track changes due to external forces, such as the weight *L* of the vehicle and forces occurring as a result of vehicle movement. As suggested above, the construction and arrangement of lugs **95** and **96** and their structural relationship to pin **93** further aid in the sealing and "self-cleaning" functions.

As also noted above, the drive means created between the spacer means and the shoes provides the main (e.g., 75 percent) torque transmitting driving means for a machine. In certain applications the coefficient of friction between such abutting surface portions may be maintained less than 1.0 by suitably reducing the air pressure in chamber **70**, for example, to permit limited relative rotational movement to occur therebetween under extreme conditions of operation to prevent damage to the machine. However, in the majority of cushioned track applications under consideration such surface portions would be firmly maintained together to prevent such slippage during all phases of machine operation.

Referring to FIG. **6**, it can be seen that the "loaded" unitized cushioned track essentially forms a polygonal-shaped semicircle, a chord of which forms a portion of the boundary of the semicircle at footprint *F*. During operation, the machine continuously provides a footprint of varied circumferential length when subjected to varying loads. When subjected to static load *L*, the normal footprint preferably comprises at least two track shoes to assure good traction regardless of the material over which it is worked. The normal footprint can be selectively varied by changing the inflation pressure in chamber **70**, for example. The footprint greatly aids in stabilizing the machine in comparison to conventional rubber tires which do not inherently provide a broad base or footprint of the type continuously developed by the cushioned track. It should be further noted that the rigid shoes, forming footprint *F*, effectively increase the area of the tire thereat as the shoes are presented to the ground. Thus, greater flotation characteristics are achieved than would be true with respect to conventional rubber-tired machines.

The coefficient of friction between the ground-engaging track shoes and the ground is preferably maintained within a range of from 0.3 to 1.0 to correspond to the coefficient of friction developed between surfaces **69** and **74**. Therefore, due to the ability of the cushioned track to achieve such a high coefficient of friction, it becomes apparent that the "self-loading" capabilities of scrapers, loaders and the like are greatly increased over that of conventional rubber tired machines. For example, such increased capability may reduce the need for a conventional tractor-pusher, elevator or hoe to aid in the expeditious loading of material. In addition, such traction capabilities greatly increases the spectrum of materials which may be worked efficiently.

It should be further noted that the cushioned track functions as a "load distributor" in that when a particular shoe is moved into engagement with the ground, that loads transferred to the shoe are distributed and dissipated throughout the cushioned track system and are not concentrated at any particular portion thereof. For example, if a shoe engages a sharp rock or the like to create a point load application, the resulting load will be substantially absorbed over a broad a broad area of the cushioned track to prevent damage to the spacer means and machine. Otherwise stated, the shoes serve to effectively increase the area of such point loads as they are presented to the cushioned track. The inherent rigidity of the cushioned track also facilitates an overall load distribution of the type above-mentioned.

In addition, the cushioned track provides an improved enveloping capability over that of a conventional track-type vehicle. For example, when the cushioned track traverses a rigid obstacle, such as a 6 inch high bump, the mounting axle will be displaced vertically only a portion of the 6 inches. The magnitude of such displacement will primarily depend on the inflation pressure of the FIG. **6** resilient member, for example.

As suggested above in the discussion of improved dynamic characteristics of a cushioned track vehicle, another feature of this invention is the ability of the cushioned track to automatically function, in a favorable manner when needed, as a variable combined spring and damping means. Such means minimizes and/or isolates undue oscillations and vibrations occurring during machine operation. The spring function is primarily due to the resilient nature of the spacer means.

Such damping is primarily occasioned due to the rotational frictional contacts occurring between pins **93** and bushings **94**. The magnitude of such frictional contact is primarily dependent on the amount of track tension, as determined by the radial pressure imposed on the track assembly by the spacer means. As suggested above, the FIG. **16** oval-shaped tube tire, fully disclosed in U.S. Pat. application Ser. No. 835,499, constitutes an excellent resilient member embodiment due to its ability to primarily expand radially in the direction of its minor axis and to contain a widely varied air pressure level therein. The degree of such damping may be closely controlled by selectively changing such radial pressure, varying the size of the pins and bushings and/or lubricating the pins and bushings. Due to the cushioned track's unique construction, it will automatically exhibit a certain degree of variable rate spring desideratum and detuning during vehicle operation.

In the Fig. **7** embodiment, some damping is also inherently developed due to limited "scrubbing" occurring between contacting surface portions **69** and **74**. Such damping is primarily determined by the pressure level maintained in chamber **70** of the spacer means which to some degree controls the amount of spacer means deflection. Additional damping results from relative motions occurring in the cushioned track and the limited "scrubbing" action occurring between the engaging portions of the link assemblies and outboard portions **82** and **83** of the spacer means. The latter damping is influenced by pressure exerted by the spacer means on the track assembly and also by the amount of initial interference, contour and surface conditions of the rubbing outboard surface portion.

It should be further noted that dynamic stress magnification on components in the track assembly are maintained quite low since the spacer means functions as a "soft" spring to cushion impact loads. Also, vehicle weight *L* (FIG. **6**) is transferred to the ground through the broad, flat track shoes at footprint *F* rather than through pins **93**, bushings **94** and the attendant structures. It can thus be seen that wear occurring in the track assembly is substantially lower than wear occuring in conventional track-type machines, for example, since the track assembly of this invention need not engage rollers, idlers, sprockets and the like.

During operation, virtually the only wear area occurs at the contacting surface portions of the pins and bushings. Such wear is substantially low due to the small angle (e.g., 10°) of oscillatory movement occurring therebetween and because each connected pair of links flex only twice per revolution. In comparison, the links of conventional track-type machines, for example, flex four times per revolution. The track shoes of this invention will also exhibit relatively low wear primarily due to the above-discussed absence of high impact or point loading.

Referring to FIGS. **7** and **31**, it should be noted that since the track assembly overhangs at a distance *0* on each side of the spacer means, that the track assembly further functions as a protective guard to prevent damage to side portions **66** and **67** of the spacer means. It should be further noted that the wide spacing of the link assemblies provides a strongly reinforced support for the track shoes in conjunction with the counteracting force imparted to the track shoes by the periphery of the spacer means. In addition, flexing of the track assembly during operation aids in the above-mentioned automatic self-cleaning function which effectively loosens and breaks up compacted materials lodged in the track assembly during operation.

It has been further noted that the noise level of the cushioned track is quite low, particularly when compared with conventional track-type vehicles, even when run at speeds as high as 30 m.p.h., for example. It should be further noted that temperatures prevalent in the components of the cushioned track normally do not exceed an acceptably low level.

Referring to FIG. **30**, another feature of this invention is the ability of cushioned track **53** to resist the illustrated severe lateral thrusts imposed thereon due to its highly unitized construction. In particular, a large portion of the spacer means is used to resist lateral thrusts in contrast to the illustrated conventional rubber tie wherein the corresponding lateral thrusts are resisted primarily due to the inherent stiffness at the lower portion of the tire. For example, it should be noted that the prior art tire construction tends to fold over, thus decreasing vehicle stability and inducing the tire to leave it rim and/or to turn over laterally.

In contrast thereto, the cushioned track will maintain the shoes **71** and axis *X* substantially parallel relative to each other during virtually all high-speed cornering, side hill and other extreme operating conditions wherein a vehicle is induced to tilt laterally relative to ground level. In fact, the entire vehicle will more readily tent to slide laterally, rather than to tip. Such tipping is further resisted since the pivot point *Y* about which tipping tends to occur is disposed substantially outboard of the cushioned track and machine. The cross grouser of chevron grouser arrangement, illustrated in FIGS. **28** and **29**, respectively, will further aid in stabilizing a machine during such extreme operating conditions.

Further regarding lateral stiffness of the track assembly, the cushioned track exhibits extremely high-cornering stiffness. This attribute gives a vehicle very responsive handling characteristics and permits it to "neutral steer," i.e., the vehicle's steady-state handling characteristics will not vary significantly during forward movement.

We claim:

1. A cushioned track comprising

an annular resilient and deformable spacer means rotatable about a central axis thereof and having opposed radial side portions connected together by a generally transversely flat annular peripheral portion having a width extending laterally relative to said side portions and in the same direction as said axis and

an endless track assembly means mounted completely around said spacer means for substantially unitizing said spacer means therewith, said endless track assembly means comprising

an annular articulated link assembly comprising a plurality of links, pivotally connected together about axes which are located radially inwardly from the outer surface of the peripheral portion of said spacer means, positioned adjacent to each of said side portions and projecting radially inwardly along said side portions, and

a plurality of circumferentially closely positioned ground-engaging rigid shoes each being connected to at least one pair of laterally spaced links and having generally transversely flat and uninterrupted inner surface portions maintained in compressed intimate contact with outer surface portions of said peripheral portion to circumferentially surround and substantially completely cover said spacer means forming substantially circumferentially continuous surface contact therewith, and cooperating with said spacer means to form a variable footprint of at least two shoes when engaged with horizontally disposed stationary surface and subjected to a load imposed on said cushioned track vertically downwardly relative to said central axis and said stationary surface to place the inner surface potions of said at least two shoes in substantially coplanar relationship.

2. The invention of claim 1 wherein a closed chamber of said member is at least partially filled with a liquid.

3. The invention of claim 1 wherein a closed chamber of said member is at least substantially filled with a resilient plastic material.

4. The invention of claim 1 wherein said spacer means comprises a substantially solid and homogeneous resilient member mounted on an annular rim.

5. The invention of claim 1 wherein the peripheral portion of said spacer means is compressed by the inner surface portions of said shoes to have the outside diameter thereof assume less than 98 percent of its normal, freely relaxed outside diameter.

6. The invention of claim 1 wherein at least 80 percent of the outer surface portions of said peripheral portion are continuously maintained in contact with inner surface portions of said shoes to form a static seal and the coefficient of friction therebetween continuously approximates at least 0.3.

7. The invention of claim 1 wherein said spacer means comprises a rim means having a resilient member mounted thereon, said rim means comprising substantially identical L-shpaed parts having first portions extending radially inwardly toward said central axis and attached together and second portions extending away from each other in the direction of said central axis, said resilient member mounted on said second portions.

8. The invention of claim 1 wherein said shoes have widths defining outboard portions extending a substantially equal lateral distance beyond a respective one of said side portions, each of said link assemblies connected to a respective one of said shoe's outboard portions closely adjacent to a respective one of said side portions.

9. The invention of claim 1 wherein the lateral distance between centers of said link assemblies is at least 0.2 times the outside diameter of the peripheral portion of said spacer means.

10. The invention of claim 1 wherein the lateral width of each of the outboard portions of each of said shoes is at least 0.1 times the sectional height of an annular resilient member mounted on an annular rim of said spacer means.

11. The invention of claim 1 wherein the lateral width of the contacting inner surface portions of said shoes and the outer surface portions of said peripheral portion is from 0.5 to 1.0 times the maximum lateral width between the side portions of said spacer means.

12. The invention of claim 1 wherein a self-propelling vehicle is mounted for movement on at least two pairs of said cushioned tracks, each of said pairs of cushioned tracks being vertically disposed and normally having a common axis of rotation.

13. The invention of claim 12 further comprising a loader bucket, lift arms and tilt linkage means therefor pivotally mounted on a forward end of said vehicle for selective vertical movement relative to a horizontal plane normally containing the axis of rotation of at least one of said pairs of cushioned tracks for loading and carrying purposes.

14. The invention of claim 12 further comprising bulldozer means, including a normally vertically disposed blade, mounted on a forward end of said vehicle.

15. The invention of claim 12 wherein said vehicle constitutes a scraper, a first pair of said cushioned tracks being simultaneously steerable relative to a second pair of said cushioned tracks.

16. The invention of claim 12 wherein said vehicle constitutes a tractor, a first pair of said cushioned tracks being simultaneously steerable relative to a second pair of said cushioned tracks.

17. The invention of claim 16 wherein said tractor comprises first and second sections articulated together for relative pivotal movement about a vertically disposed axis normally disposed substantially perpendicular relative to the normal rotational axes of said cushioned tracks.

18. The invention of claim 12 further comprising ground-engaging implement means mounted on said vehicle.

19. The invention of claim 18 wherein said implement means comprises ripping means mounted on said vehicle for selective movement at least partially below said cushioned tracks and ground level.

20. The invention of claim 1 wherein said spacer means comprises a resilient member mounted an an annular rim means to define a closed chamber with said rim means exhibiting a pressure against the inner surface portions of said shoes selected from the range of from 15 p.s.i. to 100 p.s.i.

21. The invention of claim 20 wherein said rim means comprises a rim member having said air-inflated resilient member mounted thereon and at least one flange mounted at each end of said rim member to abut portions of said side portions to retain said air-inflated member of said rim member.

22. The invention of claim 20 wherein said chamber is air inflated and the outer surface portions of said peripheral portion are substantially smooth and uninterrupted.

23. The invention of claim 22 wherein the outer surface portions of said side portions are substantially smooth and uninterrupted.

24. The invention of claim 1 wherein said endless track assembly is polygonal-shaped and the outer surface portions of said annular peripheral portion are normally continuous and

circular about said axis in their freely relaxed condition and are compressed by said shoes to substantially assume a polygonal shape.

25. The invention of claim **24** wherein the outer surface portions of said annular peripheral portion are normally substantially flat and parallel relative to said central axis in their freely relaxed condition.

26. The invention of claim **24** wherein the outer surface portions of said annular peripheral portion are normally convex with respect to said central axis in their freely relaxed condition.

27. The invention of claim **24** wherein each side of the outer surface portions of said compressed polygonal-shaped annular peripheral portion is substantially flat and parallel relative to said axis.

28. The invention of claim **27** wherein the circumferential lengths of said sides are substantially equal.

29. The invention of claim **1** wherein each of said shoes comprises a substantially flat plate having a substantially uniform thickness throughout, said plate being substantially parallel to said central axis.

30. The invention of claim **29** wherein said plates are attached to each of said link assemblies by releasable bolt means.

31. The invention of claim **1** wherein each of said link assemblies comprise a plurality of laterally spaced pairs of links, each link of each pair of links overlapping an adjacent link of an adjacent pair of links so that inner overlapped first end portions of a first pair of links are positioned within outer overlapping second end portions of an adjacent second pair of links, and pivot means pivotally connecting the first end portions of said first pair of links and second end portions of said second pair of links together.

32. The invention of claim **27** wherein said pivot means comprises a pin connecting the second end portions of said second pair of links together, and a bushing mounted for limited rotational movement relative to a longitudinal axis of said pin and connecting the first end portions of said first pair of links together, whereby said resilient spacer and said endless track are unitized to rotate as a unit about the central axis thereof.

33. The invention of claim **31** further comprising a sealing means mounted at each end of said pivot means for sealing purposes.

34. The invention of claim **31** wherein the longitudinal axis of each pin is positioned substantially parallel relative to said central axis and further positioned substantially intermediate a pair of adjacent shoes.

35. The invention of claim **34** further comprising a lug means formed on each end of each shoe to be substantially parallel with respect to the longitudinal axis of said pins for continuously and completely overlapping a lug means of an adjacent shoe whereby the entire peripheral portion of said spacer means is completely masked during rotation of said cushioned track.

36. The invention of claim **1** wherein each link of each of said link assemblies is attached to a respective one of said shoes and comprises a blade end and an opposite fork end, the blade end of a first link being positioned in the fork end of a next circumferential adjacent second link and pivot means pivotally connecting the blade and fork ends of said first and second links together.

37. The invention of claim **36** wherein said pivot means comprises a pin disposed substantially parallel relative to said central axis and being positioned substantially intermediate a pair of circumferentially adjacent shoes connected together thereby.

38. The invention of claim **1** wherein restraining means comprises inboard portions of each of said link assemblies abutting outboard portions of said respective side portions to aid in preventing lateral movement of said spacer means.

39. The invention of claim **38** wherein the outboard portions of said side portions diverge relative to each other radially inwardly toward said central axis and the inboard portions of said link assemblies diverge relative to each other radially inwardly toward said central axis to abut respective outboard portions of said side portions.

40. The invention of claim **1** wherein said shoes have widths defining outboard portions, one of said shoe's outboard portions extending a substantially greater lateral distance beyond one of said side portions than the lateral distance the other of said shoe's outboard portions extends beyond the other of said side portions, each of said link assemblies connected to a respective one of said shoe's outboard portions closely adjacent to a respective one of said side portions.

41. The invention of claim **40** further comprising a third annular link assembly attached to said shoes outboard of the other link assemblies.

42. The invention of claim **41** further comprising a second spacer means mounted between said third link assembly and an adjacent one of said other link assemblies.

43. The invention of claim **1** wherein outer surface portions of each of said shoes are flat and uninterrupted.

44. The invention of claim **43** further comprising at least one grouser secured to the outer surface portions of each of said shoes to extend radially outwardly therefrom and away from said central axis.

45. The invention of claim **44** wherein said grouser extends in a circumferential direction and is substantially perpendicular relative to said central axis.

46. The invention of claim **44** wherein said grouser has a V-shaped "chevron" configuration in a circumferential direction about said central axis.

47. The invention of claim **44** wherein said grouser extends laterally in the direction of said central axis and at least substantially fully across the width of said shoe.

48. The invention of claim **47** wherein said grouser is positioned radially outwardly from and closely adjacent to the pivotal connection for each connected, adjacent pair of links.

49. The invention of claim **44** wherein three of said grousers are secured to the outer surface portions of each of said shoes and are substantially equally spaced thereon circumferentially about said central axis.

50. The invention of claim **49** wherein one of said grousers extends radially outwardly relative to said central axis at a greater distance than the other of said grousers.

51. The invention of claim **1** wherein the circumferential length of each of the inner surface portions of each of said shoes defines the base of an isosceles triangle having its apex at said central axis of rotation and having its sides defining an included angle therebetween selected from the range of from 6° to 30°.

52. The invention of claim **51** wherein the circumferential lengths of said inner surface portions are substantially equal.

53. The invention of claim **51** wherein at least two of said inner surface portions are substantially coplanar when subjected to a static load.

54. The invention of claim **1** wherein the circumferential length of each of the inner surface portions of each of said shoes and the linear distance between the pivot axes of each adjacent pair of pivot connections are substantially equal.

55. The invention of claim **54** wherein each of said circumferential lengths and linear distances define the base of an isosceles triangle having its apex at said central axis of rotation and having its sides defining an included angle therebetween selected from the range of from 6° to 30°.

56 A cushioned track comprising

an annular resilient spacer means having a generally transversely extending outer peripheral surface and radially disposed side portions rotatable about a central axis thereof and

a polygonal-shaped endless track assembly means mounted completely around said spacer means for substantially unitizing said spacer means therewith, said endless track assembly means comprising

two annular articulated endless link assemblies positioned along opposite sides of said spacer means, a plurality of closely coupled ground-engaging shoes circumferentially surrounding said spacer means and having substantially smooth and uninterrupted inner surface portions maintained in compressed intimate contact with the spacer means substantially entirely across the width of the outer peripheral surface portion of said spacer means said link assemblies having connected to said shoes to closely couple them together, each link assembly comprising a plurality of links pivotally connected together with each pair of connected links having a longitudinal pivot axis positioned parallel to and extending in the same direction as said central axis and further positioned substantially intermediate each pair of adjacent shoes and radially inwardly of the outer peripheral surface of said spacer means.

57. The invention of claim **56** further comprising a lug means formed on each end of each shoe to be substantially parallel with respect to said longitudinal pivot axes for continuously and completely closely overlapping a lug means of an adjacent shoe whereby the entire peripheral portion of said spacer means is completely masked during rotation of said cushioned track.

58. The invention of claim **56** wherein the circumferential length of the inner surface portions of each of said shoes and a straight line between adjacent pairs of said pivot axes each defines the base of an isosceles triangle having its apex at said central axis of rotation and having its sides defining an included angle therebetween selected from the range of from 6° to 30°.

59. The invention of claim **58** wherein the circumferential lengths of said inner surface portions are substantially equal.

60. The invention of claim **58** wherein the circumferential lengths of said inner surface portions and said straight lines are each substantially equal.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,601,212 Dated August 24, 1971

Inventor(s) ROBERT A. PETERSON and NORMAN E. RISK

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

Col. 7, line 64, "and c" should be --80c--.

Col. 15, Claim 1, line 49, "potions" should be --portions--;

Claim 2, line 2, "member" should be --spacer means--;

Claim 3, line 2, "member" should be --spacer means--;

Claim 7, line 4, "shpaed" should be --shaped--.

Col. 16, Claim 20, line 2, "an" (first occurrence) should be --on--.

Col. 17, Claim 32, line 1, "27" should be --31--.

Col. 19, Claim 56, line 7, "having" should be --being--.

Signed and sealed this 7th day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents