United States Patent

Peterson et al.

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[54] SIDE-BY-SIDE TRACTOR COMBINATION

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[63] Continuation of Ser. No. 635,803, May 31, 1971, abandoned.

[52] **U.S. Cl.** **172/801,** 180/6.48, 172/809

[51] **Int. Cl.** **E02f 3/76**

[58] **Field of Search** 172/801, 803, 809; 180/6.48, 180/14

[56] **References Cited**

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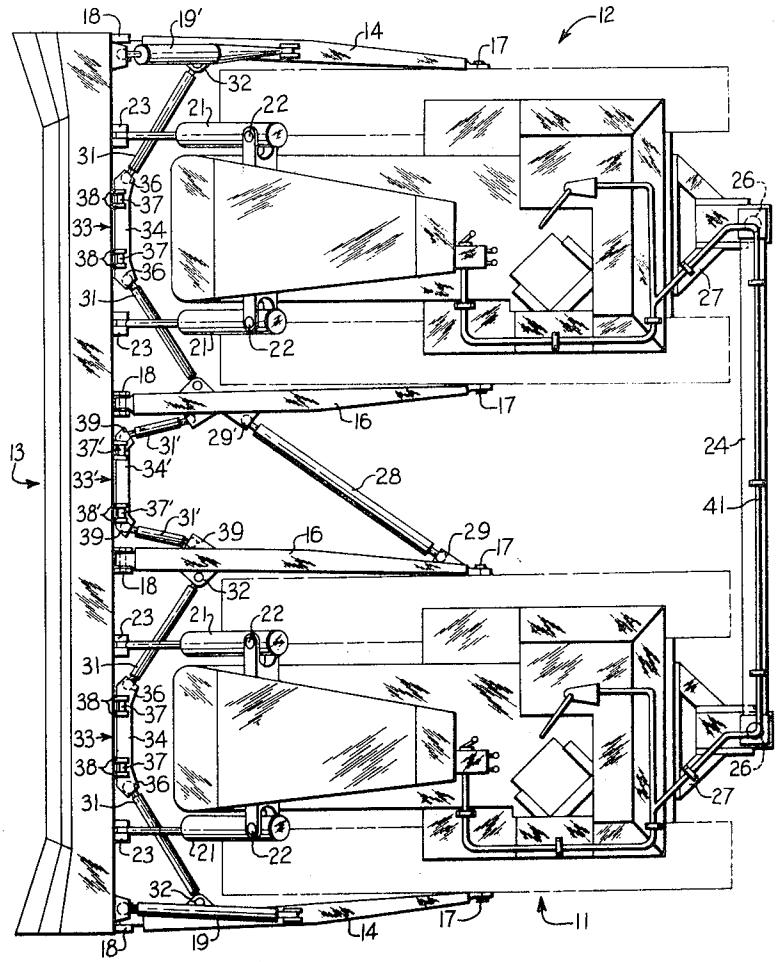
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[57] **ABSTRACT**

Two or more tractor vehicles are disposed in a highly stable unitized side-by-side relationship to apply increased tractive effort to a single working implement such as a bulldozer blade. Disengageable bracing structure couples the adjacent tractors to maintain parallelism and a pre-determined longitudinal relationship without subjecting localized regions of the assembly to excessive stress. In a preferred form, the bracing maintains these relationships while providing for independent oscillations of the tractors in response to terrain irregularities.

9 Claims, 6 Drawing Figures



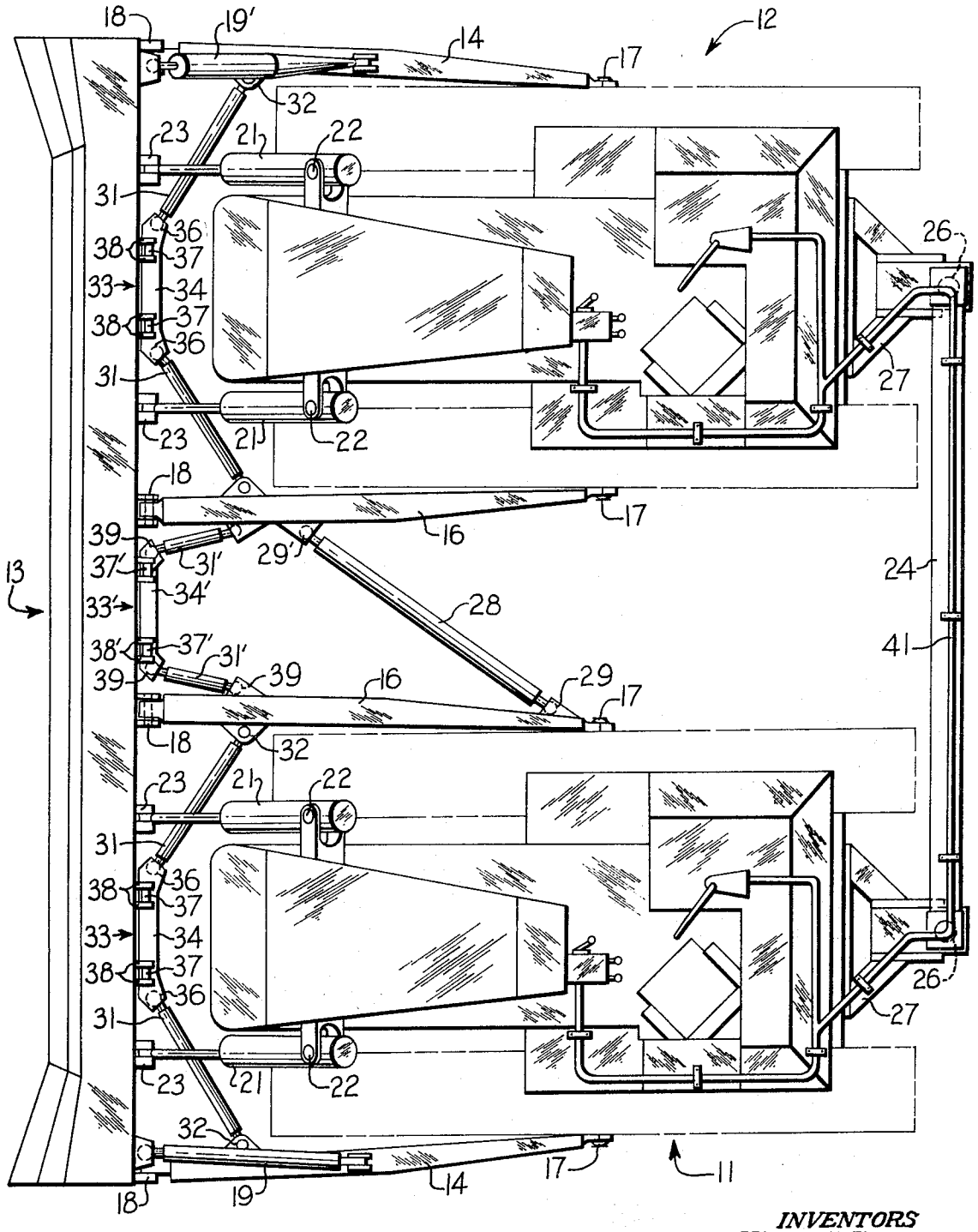


Fig. 1

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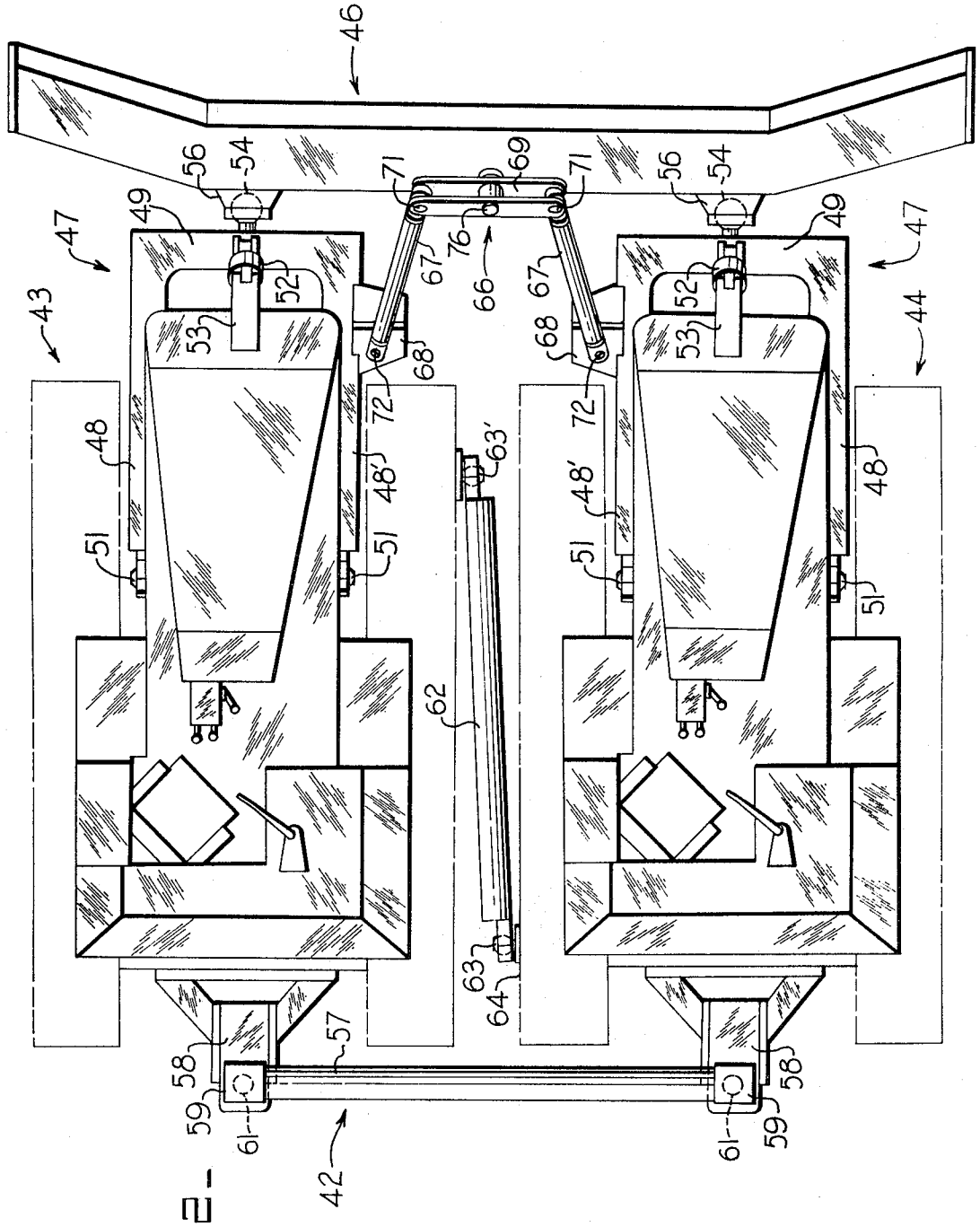


FIG. 2

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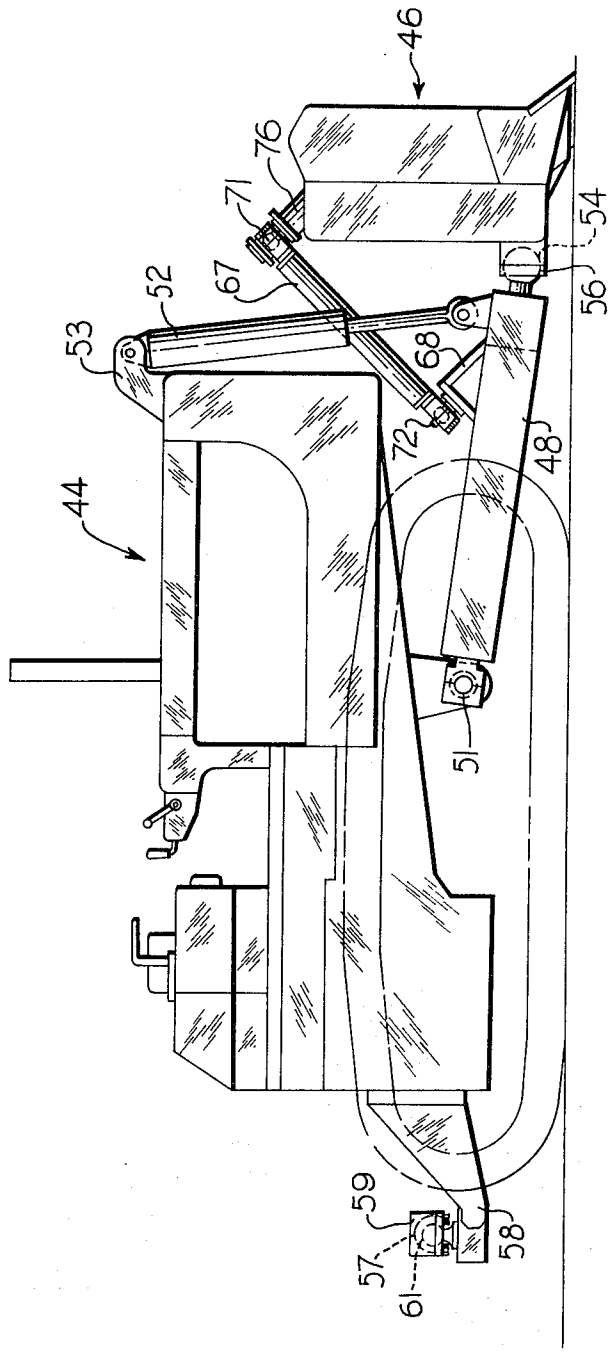


FIG. 3

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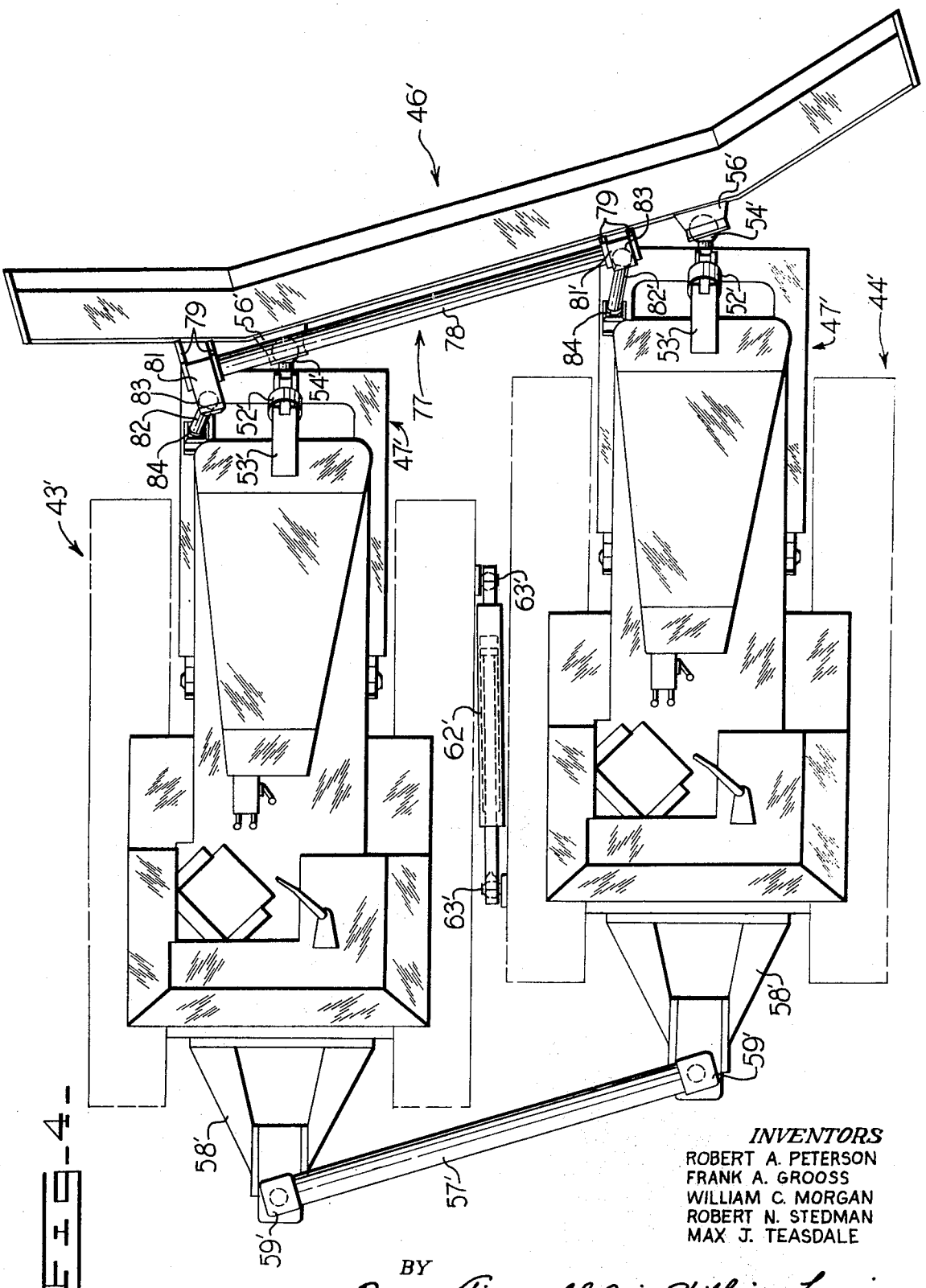


FIG-4-

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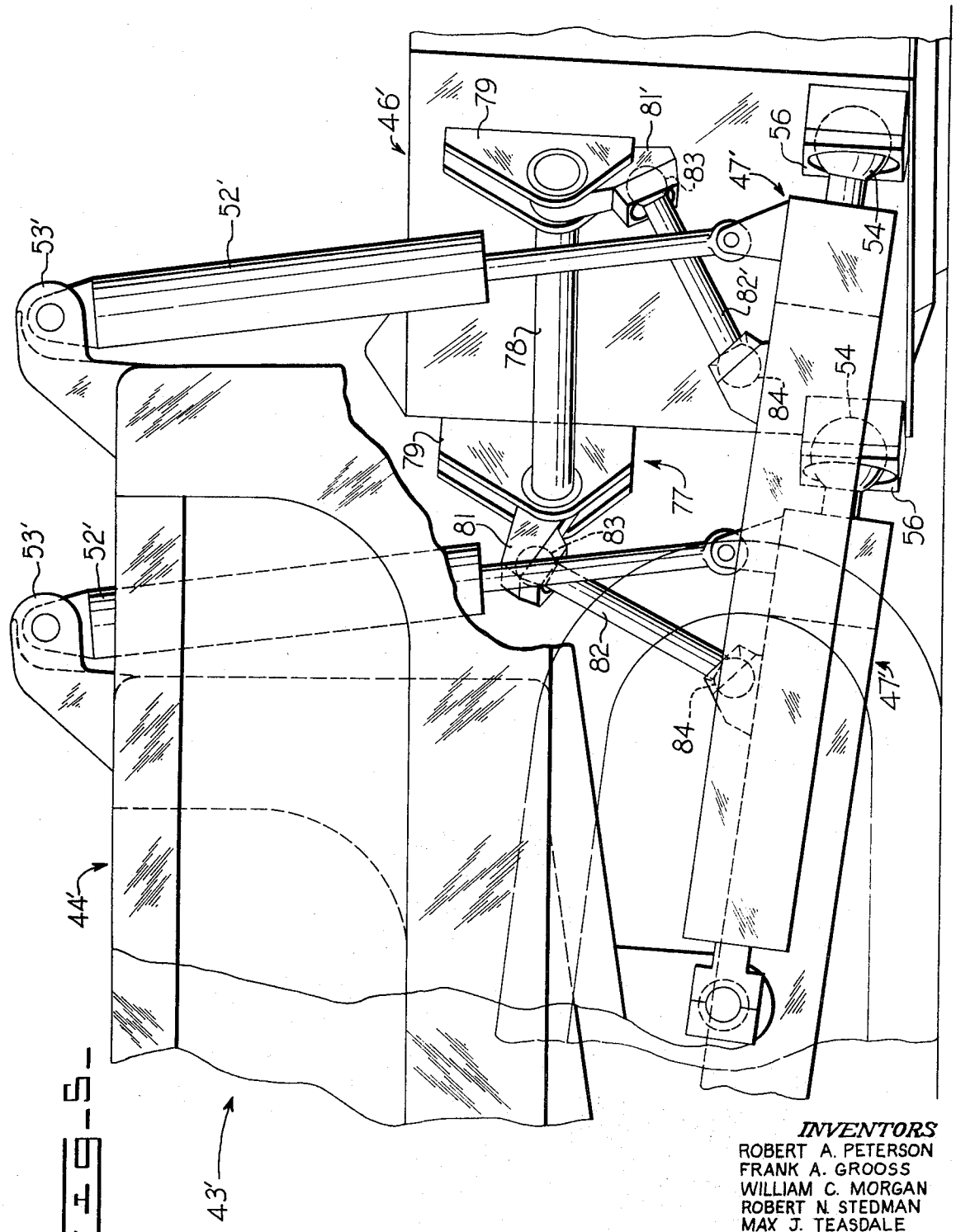


FIG-5-

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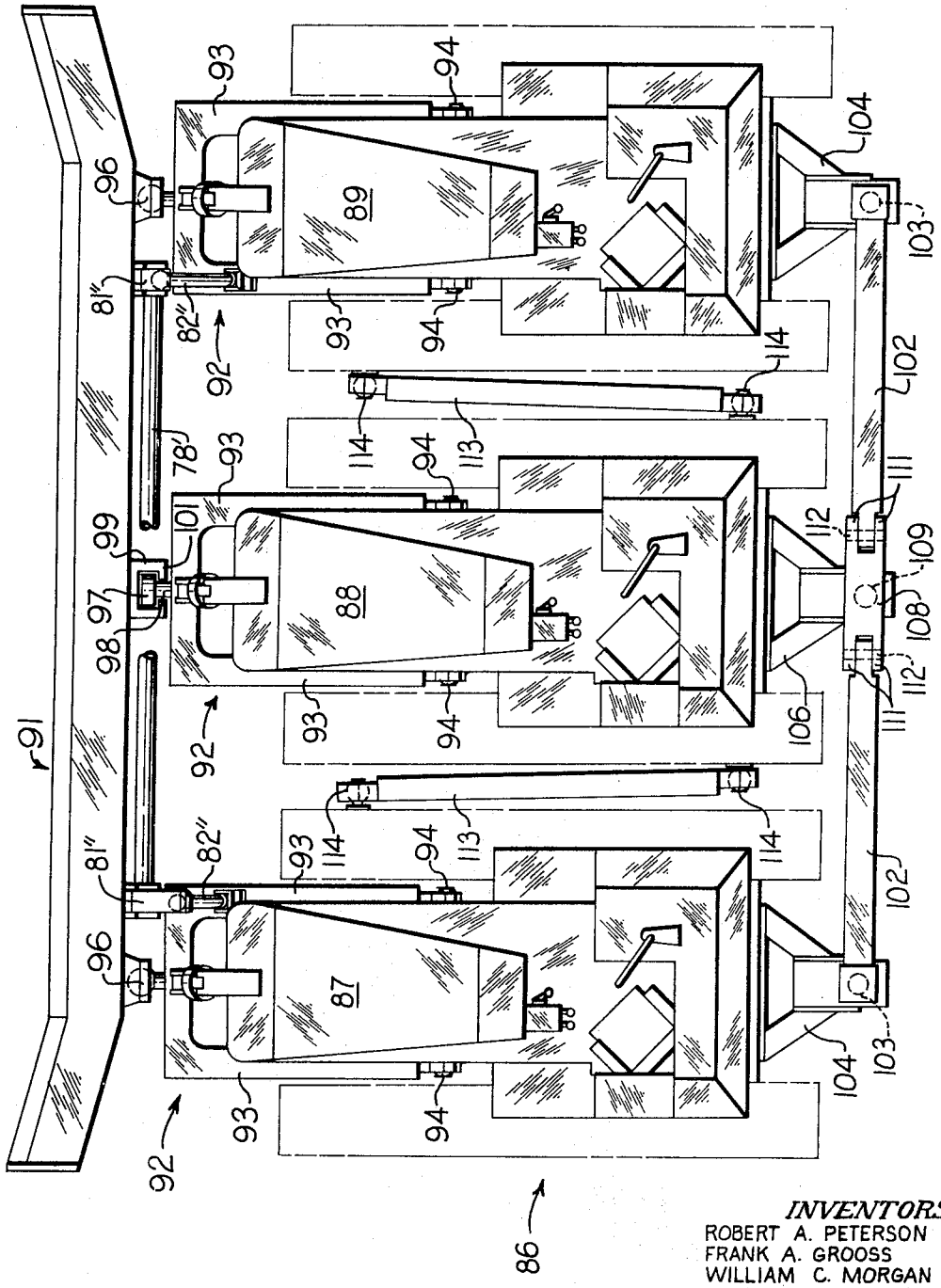


FIG-6-

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SIDE-BY-SIDE TRACTOR COMBINATION

This is a continuation of application Ser. No. 635,803, filed 5-31-71, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to tractors and more particularly to the combining of a plurality of separable tractor vehicles for operation as a unitary traction device for powering a common load.

In earthworking projects and other operations of the type in which tractors are employed there is a continuing demand for increased tractive effort to power larger working implements or to apply more force to existing equipment. Strip mining, for example, requires the removal of large volumes of overburden and can be greatly facilitated through the use of larger bulldozers and related equipment. Similar needs are often present in connection with highway construction, land reclamation and in many other situations.

In theory, greater tractive effort can be provided for by scaling up the size of existing tractor designs. In practice, several serious difficulties may be encountered in using this approach to the problem. Very large tractors are extremely expensive to construct and operate and are therefore limited to certain specialized applications in which high costs can be justified. A user cannot economically employ such a tractor for a variety of general purpose operations, many of which may not require extremely high tractive force. Further, serious problems arise in connection with transporting a very large tractor from one job site to another. Such tractors may exceed the load carrying capacity of many trucks, aircraft, highway bridges, road beds and the like and may have dimensions which also create problems in transporting the tractor by ordinary means.

For these reasons, it is frequently preferable to combine two or more smaller tractors into a unitized assembly for powering a single large load. The component tractors of such a unit may be disengaged from each other when necessary for separate use, maintenance, and for shipping purposes. Thus, such a unit is much more adaptable and efficient from the standpoint of the general purpose user in that extremely high tractive effort is available when needed with the unit being readily divisible into two or more separately usable units of smaller capacity.

In combining separately usable tractors to function as a unitized traction device for a common load, it has heretofore been the practice to arrange the tractors in tandem. One tractor is situated behind the other and the two are coupled through a pivotable hitch, with the controls of the two tractors being coordinated for operation by a single individual. U.S. Pat. No. 3,245,488 to R. A. Peterson, issued Apr. 14, 1966, and entitled "CONTROL ARRANGEMENT AND STEERING OF TRACTORS IN TANDEM" discloses a multiple tractor unit of this general type.

These tandem coupled tractor units are available commercially and have proven to be very useful in many working situations. However, the tractive base of such a unit is not appreciably broader than that of a single tractor and there is no substantial gain in stability with respect to lateral forces. Where a very broad bulldozer blade or other implement is to be carried by the unit, very high off-center stresses may be present and substantial design complications are required to strengthen the assembly and to prevent unwanted pivoting of one tractor relative to the other about the coupling therebetween. Still another characteristic of the tandem arrangement is that the implement is supported by only one of the tractors with the other functioning principally to provide tractive force.

For these and other reasons, the tandem coupled multiple tractor units lack certain operational characteristics which would be highly desirable for some applications, particularly where very broad working implements are to be powered by the unit.

Some gain in the breadth of the tractive base may be realized by utilizing the "Siamese" type of tractor, an example of which is described in U.S. (Reissue) Pat. No. Re. 24,175 to R. A. Peterson, issued July 3, 1956, for "TRACTOR WITH TWIN POWER PLANTS." In these systems, two crawler tractor bodies each carrying a separate engine but only one track are coupled together in a parallel relationship. This provides for increased tractive effort and much more efficient steering in an arrangement which can be divided into two parts for shipping purposes. However, the components are not complete tractors and cannot readily be adapted for separate use and thus the system is not a multiple tractor unit in the sense that the term is used herein.

SUMMARY OF THE INVENTION

The present invention is a unitized multiple tractor assembly providing for increased tractive effort with a broader, more stable, tractive base and reduced stress concentrations. The component tractors do not require complex modifications to adapt to the unitized assembly and may readily be separated for shipping, servicing, or individual use. Each component tractor may contribute directly to the support of a common working implement such as a bulldozer blade and each may apply tractive force directly thereto.

In accordance with the invention, the component tractors are disposed in an essentially side by side relationship and are coupled together by bracing structure which maintains a forced parallelism and a pre-determined longitudinal relationship in the presence of high loading forces of variable magnitude and direction and without requiring massive structure at any localized region of the assembly. In general, elements of the bracing extend transversely relative to the tractors at both forward and rearward locations to maintain parallelism and extend diagonally to maintain the longitudinal relationship. Where appropriate, a bulldozer blade or other implement carried by the unit may be a component element of the bracing while still being adjustable in any of several ways. In some preferred embodiments of the invention, the bracing maintains the above described relationships and stress distribution while providing for independent oscillation of each component tractor in response to terrain irregularities and the like.

Accordingly, it is an object of this invention to provide a multiple tractor combination in which component tractors may perform parallel functions and are more completely unitized for applying tractive effort to a common load while being readily separable for independent use and for shipping, maintenance, and the like.

It is another object of the invention to provide a multiple tractor unit which is more stable in the presence of large load forces of variable directions and magnitude and which is relatively free of localized stress concentrations.

It is still another object of the invention to provide a multiple tractor unit in which the tractors are held in a pre-determined side-by-side relationship while being capable of independent oscillations.

The invention, together with further objects and advantages thereof, will be better understood by reference to the following description of preferred embodiments in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a plan view of a first embodiment of the invention in which two tractor vehicles are unitized with a single large bulldozer blade;

FIG. 2 is a plan view of a second embodiment of the invention in which a pair of tractors are unitized for carrying and operating a single bulldozer blade and in which the tractors are independently oscillatable in response to ground irregularities;

FIG. 3 is a side elevation view of the unitized dual-tractor and bulldozer embodiment of FIG. 2;

FIG. 4 is a plan view of still another embodiment of the invention in which a pair of independently oscillatable tractors are coupled together as a unit with a single bulldozer and in

which the bulldozer blade may be angled relative to the direction of travel of the tractor unit;

FIG. 5 is a side elevation view of the unitized multiple tractor embodiment of FIG. 4; and

FIG. 6 is a plan view of still another embodiment of the invention in which three tractors form a unitary traction device with each being independently oscillatable relative to the others.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawing and more particularly to FIG. 1 thereof, there is shown a left-hand tractor vehicle 11 and a second or right-hand tractor vehicle 12 which are coupled together for unitized operation in conjunction with a single very large bulldozer blade 13. The tractors 11 and 12 may be crawler tractors of essentially conventional design except insofar as couplings and control coordinating elements are added for the purpose of unitization as will hereinafter be described. In accordance with the invention, the two tractors 11 and 12 are disposed in a spaced apart side-by-side relationship, with the bulldozer blade 13 being situated forward from the tractors and in transverse relation thereto.

In accordance with an important advantage of the invention, the blade 13 is carried by both tractors 11 and 12 and both apply tractive force directly thereto. For this purpose, each tractor 11 and 12 has a pair of push-arms including outer push-arms 14 and inner push-arms 16 having rearward ends coupled to opposite sides of the associated tractor by ball and socket joints 17 so that the arms may pivot in vertical planes. The forward end of each push-arm 14 and 16 is coupled to the back of blade 13 at one of a series of spaced apart pivot joints 18. To hold the blade 13 in an upright position, one of a pair of tilt braces 19 and 19' extends from the central portion of each outer push-arm 14 to the top of the back of the blade 13 and is pivotably connected to each such element. To provide for adjusting the tilt of the blade 13, one of the braces 19' may be a double acting fluid jack, with the other brace 19 being of fixed length. Operation of the jack 19' thus acts to change the tilt of the blade 13 in the manner described in U.S. Pat. No. 3,049,820 to R. W. Lichti, issued Aug. 21, 1962, and entitled "DIAGONAL BRACE MOUNTING FOR BULLDOZER BLADES." The elevation of blade 13 is controlled by a pair of lift jacks 21 at each tractor 11 and 12 extending from pivot connections 22 at the sides of the associated tractor body to the back of the blade at pivot couplings 23. Thus, contraction of the jacks 21 raises the blade 13 and push-arms 14 and 16 through a pivoting motion about joints 17 while extension of the jacks 21 lowers the blade.

The construction as described to this point ties together the two tractors 11 and 12 and the blade 13 to form a unit in which the blade 13 is carried by both tractors and in which both tractors directly supply tractive effort thereto. Although the blade 13 may be of unusually great breadth, it is not subjected to extreme bending forces inasmuch as it is supported at points distributed along substantially its entire length by the spaced apart push-arms 14 and 16. However, in the absence of further provisions, extremely precise coordination of the movement of the two tractors 11 and 12 is needed to avoid concentrated stresses at several points such as the center portion of the blade between the two tractors or the joints 17 and 18 at each end of the push-arms. Under certain conditions, such as in turning and where localized ground irregularities are encountered, these exceedingly high stresses cannot be avoided even by the most precise coordination of the two tractors. Accordingly, the unitized multiple tractor assembly is provided with additional bracing members to avoid these stress concentrations and thus to avoid the need for very massive construction of several components. To be effective for this purpose, such means must aid in holding the tractors 11 and 12 in the parallel relationship and in the pre-determined longitudinal relationship which in this embodiment includes co-planarity of the front and rearward ends of both tractors.

To hold the two tractors 11 and 12 in forced parallelism, a rear cross-brace 24 extends transversely therebetween in spaced relationship from the blade 13 and preferably at the back of the tractors. To provide for separate use of the two tractors 11 and 12 when desired, the cross-brace 24 is attached to each thereof by a disengageable connection such as a pair of ball and socket joints 26 each coupling one end of the cross-brace to the drawbar structure 27 of the adjacent tractor. Thus, the cross-brace 24 acting in conjunction with the blade 13 and tractors 11 and 12 forms a rectangular structure which locks the two tractors into the desired parallel relationship without subjecting the blade 13 and push-arms 14 and 16 to excessive stresses.

To hold the two tractors 11 and 12 in the side-by-side longitudinal relationship without excessive stress on the components which support the blade 13, a diagonally directed brace 28 extends between the two inner push-arms 16 and is coupled to each thereof by a ball and socket joint 29. Since the joint 29 which couples brace 28 to one push-arm 16 is situated well to the rear of the joint 29' at the other push-arm, the brace effectively resists any tendency of the rectangle defined by the blade 13, cross-brace 24, and the two tractors 11 and 12 to distort into a parallelogram and thereby severely stress the several connections between these elements. In the absence of the diagonal brace 28, such concentrated stresses could easily arise from a slight difference in the speeds or effective traction of the two tractors. Inasmuch as the unitized multiple tractor assembly is generally steered by changing the relative speeds of the two tractors, such stresses would necessarily arise during turns.

To further strengthen the structure against distortion in the presence of stress, a diagonal brace 31 extends from each of the push-arms 14 and 16 to connect with the back of blade 13 at the region forward from the center of the associated one of the tractors 11 and 12. To avoid concentrating stress at localized regions of the push-arms 14 and 16, braces 31 connect thereto through pivot joints 32, having pivot axes normal to the plane defined by the push-arms, and are connected to the back of the blade 13 through torsion bar assemblies 33. The torsion bar assemblies 33 relieve the stress which might otherwise develop from tilting of the blade 13 and from lateral loading forces thereon and may be of the general type described in the hereinbefore identified U.S. Pat. No. 3,049,820. Each such assembly 33 is comprised of a horizontal torsion bar 34 disposed parallel to the back of the blade 13 and having ball and socket connections 36 at each end to one of the diagonal braces 31. Each such torsion bar 34 is coupled to the back of the blade 13 through a pair of upwardly projecting ears 37 which are pivoted to brackets 38 projecting rearwardly from the blade with the pivot axis being parallel to that of the torsion bar. As described in U.S. Pat. No. 3,049,820, the slight freedom of movement of torsion bar 34 about the pivot formed by ears 37 and brackets 38 provides for resisting distortion of the right angle relationship of the push-arms 14 and 16 and blade 13, but does not concentrate stress in a single one of the diagonal braces during tilting of the blade.

To further strengthen the assembly, an essentially similar torsion bar assembly 33' is attached to the back of the blade 13 between the two inner push-arms 16 by ears 37' and brackets 38'. One of an additional pair of diagonal braces 31' extends from each end of a torsion bar 34' to the push-arms and ball and socket joints 39 connect the braces with both the torsion bar and the push-arms.

Suitable techniques for coordinating the movements of two tractors for control by a single operator are known to the art. Such systems require signal lines between the two tractors which may variously be hydraulic or electrical conduits according to the type of system employed. In the present invention, the necessary control connection conduits 41 preferably extend along the rear cross-brace 24.

In the above described embodiment of FIG. 1, the two tractors 11 and 12 are forcibly held in the preferred relationship relative to each other and relative to the blade 13 without ex-

cessive structural complication and without creating localized regions of extreme stress. However, in many instances, it is desirable that the two tractors be able to undergo several forms of movement independently of each other while being forcibly held in the parallel side-by-side relationship. It is advantageous, for example, if each tractor may oscillate about a longitudinal axis, rock relative to a transverse axis, and rise or drop without forcing a corresponding motion of the other tractor. This limited freedom of movement is desirable in that it further reduces potential stress concentrations, particularly where there are localized irregularities in the ground or other surface over which the multiple tractor unit must travel. Referring now to FIGS. 2 and 3 in conjunction, a second embodiment of the invention is shown in which the component tractors are capable of this kind of limited independent movement.

As in the previous instance, the multiple tractor unit 42 has side-by-side left-hand and right-hand tractors 43 and 44 respectively. To support a bulldozer blade 46, which is situated forward from the tractors 43 and 44 and transverse thereto, each tractor has a C-frame 47. Each such C-frame 47 includes arms 48, connected by an integral cross member section 49 at the front ends, which extend rearwardly on opposite sides of the tractor and which are coupled thereto at ball and socket joints 51 so that the C-frames may be pivoted about an axis transverse to the associated tractor. Pivoting of the C-frames 47 is effected by a pair of hydraulic lift jacks 52 each of which is carried at the forward end of a separate one of the tractors 43 and 44. Each jack 52 has a lower end pivotably coupled to the center of the C-frame cross member 49 and an upper end pivotably coupled to a bracket 53 at the top forward end of the associated tractor.

A forwardly projecting ball 54 is mounted at the center of each C-frame cross member section 49 and is received in one of a pair of sockets 56 on the back of the blade 46 thereby providing a flexible coupling between the blade and each of the two tractors 43 and 44.

The universal type of coupling between the blade 46 and tractors 43 and 44 formed by the balls 54 and sockets 56 provides for the support of the blade and the application of tractive force thereto while providing for the limited independent movements of either tractor in response to ground irregularities as discussed above. To lock the two tractors 43 and 44 into the desired parallel relationship without interfering with this freedom of movement, a rear cross-brace 57 again extends between the two tractors in parallel relationship to the blade and at a position rearwardly spaced therefrom. The cross-brace 57 may again be connected between the drawbar structures 58 of the two tractors and is coupled thereto by ball and socket joints 59 wherein the balls 61 are part of the tractor drawbars and project upwardly therefrom.

The bracing between the two tractors 43 and 44 formed by the blade 46 and rear cross-brace 57 defines a rectangle which, in the absence of further bracing, would be capable of distorting into a parallelogram inasmuch as the joints 54 and 59 are all pivotable. Thus, the blade 46 and cross-brace 57 maintain the tractors parallel but do not by themselves force the desired longitudinal relationship therebetween. This is accomplished by an additional brace 62 which extends diagonally between the two tractors 43 and 44. Brace 62 is coupled to the inside track roller frame 64 of each tractor by a ball and socket joint 63 with the joint 63' at one of the tractors 43 being situated well forwardly of the joint at the other of the tractors 44. Thus, the brace 62 in conjunction with blade 46 and cross brace 57 locks the two tractors 43 and 44 into the desired unitary system while providing for the above described independent movements of each tractor.

When the forward cross-brace is a working implement, such as the bulldozer blade 46, which must be held upright, an additional connection to the tractors is needed for this purpose. A highly advantageous means is a single-tree assembly 66 which extends from the upper center portion of the blade 46 to the inside arm 48' of each C-frame 47 to hold the blade erect without restricting the above described freedom of movement of the two tractors.

Assembly 66 has a pair of braces 67 each extending upwardly and forwardly from a bracket 68 at the forward portion of a separate one of the inside arms 48' of the C-frames 47. Each brace 67 inclines towards blade 46 at an angle of about 45° and is inclined at a smaller angle, 15° in this instance, towards the center of the blade 46 to connect with one end of a single-tree member 69 at a pivot joint 71. The opposite end of each brace 67 is connected to the C-frame bracket 68 through another pivot joint 72 and the pivot axes of both sets of joints 71 and 72 are normal to the plane defined by the two braces 67. Single-tree 69 is itself pivoted, at a point midway between the joints 71, to the top central portion of the blade 46 by a pivot pin 76 which is also aligned normal to the plane defined by the two braces 67.

The single-tree assembly 66 functions to hold the blade 46 erect, with only minor changes in pitch, while the tractors undergo sizable oscillations. In a representative embodiment of the invention, one of the tractors may turn approximately 20° about a longitudinal axis extending through ball joints 54 and 59 while the other tractor oscillates a similar amount in a reverse rotational sense. While at this extreme position, one tractor is still capable of rising approximately 4 feet relative to he other. Thus, the system is well able to accommodate to severe terrain irregularities without creating extreme stresses in any of the structural components.

Variations may be made in the structure for holding the blade 46 upright while still providing for separate oscillation and independent lifting of the tractors and still other modifications are possible to provide for greater adjustability of the blade or other implement. FIGS. 4 and 5 illustrate a construction in which the above described single-tree assembly is replaced with a torsion bar assembly 77 and in which one tractor may be advanced relative to the other to angle the blade. In this modification of the invention, the two tractors 43' and 44' carry a bulldozer blade 46' on C-frames 47', with the blade being joined to the C-frame through universal joints formed by balls 54' and sockets 56' in an arrangement which may be essentially similar to that hereinbefore described with reference to the embodiment of FIGS. 2 and 3. Referring again to FIGS. 4 and 5, the side-by-side relationship of the two tractors 43' and 44' is again stabilized by a rear cross-brace 57' extending between the drawbars 48' of the two tractors and coupled thereto through ball and socket joints 59', and by a diagonal brace 62' extending between ball and socket joints 63' at the adjacent sides of the two tractors. To control the elevation of the blade 46', one of a pair of synchronized hydraulic lift jacks 52' is coupled between each C-frame 47' and a bracket 53' at the top front of the associated one of the tractors 43' and 44'.

In any of the several embodiments of the invention described herein, certain elements described as rigid braces may be made adjustable in length by any of various means to provide desired forms of adjustability to the multiple tractor unit as a whole. In the embodiment of FIGS. 4 and 5 for example, the diagonal brace 62' which extends between the two tractors 43' and 44' is a hydraulic jack which may be extended or contracted to provide for moving one tractor slightly ahead of the other and for holding the two tractors in this relationship. This provides for angling the blade 46' relative to the direction of travel of the tractors 43' and 44'. The ball and socket connections at the several joints 54' and 59' between the tractors 43' and 44', the blade 46', and the supplementary bracing structures 57' and 62' as described above readily provide for this operation.

Assembly 77, which holds the blade 46' upright in this embodiment of the invention, is comprised of a torsion bar rod 78 disposed parallel to the blade and which has ends extending through a pair of spaced apart brackets 79 at the back of the blade so that the torsion bar is held thereon while being rotatable. One of a pair of short levers 81 and 81' extends radially from each end of the torsion bar 78 at the brackets 79, the two

levers forming an angle of approximately 90° with respect to each other relative to the axis of the torsion bar. Links **82** and **82'** extend from the ends of levers **81** and **81'** respectively to the top of the adjacent one of the C-frames **47'**, the links being coupled to the levers and to the C-frames by ball and socket joints **83** and **84** respectively. Thus, while some minor change of pitch may occur, the blade **46'** is held in an essentially upright position irrespective of lateral or longitudinal oscillations of one tractor relative to the other.

If the two levers **81** and **81'** are situated directly over the balls **56'** which couple the blade **46'** to C-frames **47'**, then angling of the blade by advancing one tractor has a minimal effect on the ability of the torsion bar assembly to adjust to independent oscillations of the tractors. However, this positioning of the levers may not always be practical due to the presence of other elements such as the lift cylinders **52'**. If both levers **81** and **81'** are located either inside or outside the span between sockets **56'**, the blade angling will reduce the ability of the torsion bar assembly **77** to accommodate to tractor oscillation. This is avoided in the embodiment of FIGS. **4** and **5** by situating one lever **81'** inside the span between the sockets **56'** and situating the other lever outside the span. In particular, lever **81'** connects to the inside arm of C-frame **47'** of tractor **44'** while lever **81** connects to the outside arm of the C-frame of tractor **43'**.

The structure for joining tractors to form a unitary traction device as hereinbefore described may be adapted to units having more than a pair of component tractors. Referring now to FIG. **6**, there is shown a unitized assembly **86** having three component tractors including a left-hand tractor **87**, center tractor **88** and right-hand tractor **89**. The three tractors **87**, **88** and **89** are again shown in a combination which includes blade **91**, it being understood that the blade may be replaced with another form of working implement. If the unitized tractor assembly **86** is to push, or draw, a separately supported load, a simpler structural member may be substituted for the blade to provide the cross-bracing at the forward portions of the three tractors.

To couple each of the three tractors **87**, **88** and **89** to the blade **91**, each tractor has a C-frame **92** with a pair of arms **93** which extend rearwardly along opposite sides of the tractor and which are coupled thereto at pivot joints **94**. The two outermost tractors **87** and **89** are coupled to the blade **91** by ball and socket couplings **96** at the center of the associated C-frame **92**. As will hereinafter be discussed in more detail, the center tractor **88** is free to move vertically relative to the blade **91** as well as the other two tractors; and accordingly, the coupling between the center tractor and the blade **91** is by means of a roller **97** mounted at the center of the associated C-frame **92** on a shaft **98** which projects forward therefrom into a vertically aligned guide channel member **99**. Guide **99** is secured to the back of blade **91** and has inwardly angled edges **101** that lock the roller **97** into the guide channel. Thus, the forward end of the center tractor **88** is constrained against lateral movement to maintain parallelism with the outer tractors **87** and **89** while being free to move vertically independently of the other tractors and independently of the bulldozer blade **91**.

The bracing structure for maintaining the three tractors in a parallel relationship is completed by a pair of rear cross-braces **102** each of which extends transversely between the center tractor **88** and a separate one of the outer tractors **87** and **89**. Each rear cross-brace **102** is coupled to the associated one of the outer tractors **87** and **89** by a ball and socket joint **103** at the tractor drawbar structure **104**. To provide for independent vertical movement of any one tractor, the rear cross-braces **102** connect to the drawbar **106** of the center tractor **88** through a compound pivot and ball and socket joint assembly **107**.

Assembly **107** may have a connector member **108** forming a socket which engages with an upright ball stud **109** on the center tractor drawbar **106** and which has a pair of spaced apart parallel wings **111** at each side between which the adjacent end of a cross-brace **102** is received. Pins **112** pivotably couple each cross-brace **102** to the connector wings **111**.

The rectangular configuration defined by the blade **91**, rear cross-braces **102**, and the tractors **87**, **88** and **89** is braced against unwanted distortion into a parallelogram by a pair of diagonal braces **113** each of which extends between the rearward portion of the center tractor **88** to the forward portion of a separate one of the outer tractors **87** and **89**. Each of the diagonal braces **113** is coupled at each end to the adjacent tractor through a ball and socket joint **114** so that the braces do not restrict the desired independent motions of any one of the tractors.

To hold the blade **91** upright without inhibiting the desired freedom of movement of the three tractors **87**, **88** and **89**, a torsion bar **78'** is journaled to the back of the blade in the manner hereinbefore described with reference to the embodiment of FIGS. **4** and **5** and is coupled to the C-frames **92** of the outermost tractors **87** and **89** in the previously described manner by levers **81''** and diagonal links **82''**. Torsion bar **78'** is situated above the level of the C-frame **92** of the center tractor **88** and has no direct connection thereto.

It will be apparent that many variations and modifications are possible within the scope of the invention.

What is claimed is:

1. A unitized multiple tractor assembly comprising; a plurality of tractors disposed in a substantially parallel and side-by-side relationship, and bracing structure coupling said tractors to maintain said relationship in the presence of unequal forces acting on said tractors, said bracing structure having a component coupling forward portions of adjacent ones of said tractors with a front brace member extending transversely relative to said tractors at the forward ends thereof and being coupled to each of said tractors through flexible joints, said bracing structure having a component coupling more rearward portions of said tractors with a rear brace member extending transversely relative to said tractors at the back ends thereof and being coupled to each of said tractors through flexible joints, said bracing structure further having a diagonal brace member extending between each adjacent pair of said tractors, said diagonal brace member being coupled to one of said tractors at a point forward from the coupling to the other thereof and being coupled to each of said tractors through flexible joints, said flexible joints enabling each of said tractors to undergo a limited amount of lateral and longitudinal oscillation independently of the others of said tractors, wherein said diagonal brace is selectively extensible and contractible whereby one of said adjacent pair of tractors may be advanced relative to the other to angle a working implement carried by said unitized multiple tractor assembly.

2. A unitized multiple tractor assembly having three tractors disposed in a substantially parallel and side-by-side relationship including a right tractor, a left tractor, and a center tractor disposed therebetween, and bracing structure coupling said tractors to maintain said relationship in the presence of unequal forces acting on said tractors, said bracing structure being comprised of:

a rigid front brace member extending transversely relative to said tractors at the forward ends thereof, said front brace being coupled to said right and left tractors by flexible joints and being coupled to said center tractor by guide means providing for vertical movement of said center tractor relative to said front brace,

a pair of rear brace members each extending from said center tractor to a separate one of said right and left tractors and each being coupled to each of said tractors by flexible joints, and

a pair of diagonal braces, each extending from a separate side of said center tractor to a longitudinally spaced point on a separate one of said right and left tractors and being coupled to said tractors through flexible joints.

3. A powered earth working apparatus comprising:

a plurality of tractors disposed in a substantially side-by-side and parallel relationship,

a bulldozer blade disposed forwardly from said tractors and in a substantially transverse relationship thereto,

a push arm coupling said blade to each of said tractors whereby said blade is carried thereby and whereby said blade forms a front cross brace between said tractors,

a rear cross-brace member extending transversely between each adjacent pair of said tractors at a position spaced rearwardly from said blade, and

a diagonal brace member extending between an adjacent pair of said tractors and being coupled to one of said pair of tractors at a point situated forwardly from the coupling to the other of said pair of tractors,

said blade being coupled to said push arms through flexible joints and said rear cross braces and said diagonal brace being coupled to said tractors through flexible joints whereby each of said tractors is capable of a limited amount of independent motion,

bracing extending between said blade and at least one of said push arms independently of said flexible joint therebetween for holding said blade in a substantially erect position, said bracing comprising

a singletree arm having a central portion thereof pivotally coupled to said blade substantially midway between an adjacent pair of said tractors, and a pair of braces each coupling a separate end of said single tree arm with said push arm of a separate one of said tractors, said braces having flexible couplings to said singletree arm and said push arms.

4. The combination defined in claim 3 wherein said singletree arm and said pair of braces are coplanar with the plane defined thereby being inclined relative to said blade and said push arms.

5. A powered earth working apparatus comprising: a plurality of tractors disposed in a substantially side-by-side and parallel relationship,

a bulldozer blade disposed forwardly from said tractors and in a substantially transverse relationship thereto,

a push arm coupling said blade to each of said tractors whereby said blade is carried thereby and whereby said blade forms a front cross brace between said tractors, said blade being coupled to said push arms through flexible joints

a rear cross-brace member extending transversely between each adjacent pair of said tractors at a position spaced rearwardly from said blade, and

a diagonal brace member extending between an adjacent pair of said tractors and being coupled to one of said pair of tractors at a point situated forwardly from the coupling to the other of said pair of tractors,

a torsion bar extending parallel to said blade between said adjacent pair of tractors and being attached to said blade by means providing for rotary movement of said torsion bar,

first and second levers projecting radially from spaced apart portions of said torsion bar, and

a pair of links each coupling a separate one of said levers with said push arm of a separate one of said tractors, said links having a flexible coupling to said levers and to said push arms.

6. The combination defined in claim 5 wherein said levers project from said torsion bar at substantially differing angles relative to the axis thereof.

7. The combination defined in claim 5 wherein a first of said levers and the associated one of said links is situated in the region between a pair of said flexible joints which couple said blade to said push arms and wherein the other of said levers and the other of said links are situated outside said region.

8. Brace structure for unitizing a plurality of tractors disposed in a substantially side-by-side and parallel relationship, and which are capable of traveling in different directions in the absence of said brace structure, said brace structure comprising:

a bulldozer blade disposed forwardly from said tractors and in a substantially transverse relationship thereto,

at least a pair of push arms coupling said blade to each of said tractors to support said blade thereon, said blade and push arms jointly forming a front cross brace between said tractors, for preventing divergence or convergence of the front ends of said tractors,

a rear cross-brace extending transversely and interconnecting each adjacent pair of said tractors at a position spaced rearwardly from said blade, and

a single diagonal brace member means extending diagonally and interconnecting an adjacent pair of said tractors for preventing distortion of the frame defined by said pair of tractors and said front and rear cross braces.

9. The combination defined in claim 8 wherein said blade is coupled to said push arms through flexible joints and wherein said rear cross brace and said diagonal brace member means are coupled to said tractors through flexible joints whereby each of said tractors is capable of a limited amount of independent motion, and further comprising bracing extending between said blade and at least one of said push arms independently of said flexible joint therebetween for holding said blade in a substantially erect position.

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