

[54] **BULLDOZER FRAME WITH STRUT STRESS LIMITER**[75] Inventor: **Bernard L. Winker**, Chicago, Ill.[73] Assignee: **International Harvester Company**, Chicago, Ill.[22] Filed: **Apr. 30, 1973**[21] Appl. No.: **355,824**[52] U.S. Cl. **172/803, 267/162**[51] Int. Cl. **E02f 3/76**[58] Field of Search **172/801-809; 267/162; 37/42 R**[56] **References Cited****UNITED STATES PATENTS**

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[57]

ABSTRACT

Diagonal strut between bulldozer blade and push arm incorporating prestressed Belleville washers. The Belleville washers allow the strut to shorten when, during tilting of the bulldozer, side loads cause the push arm to assume an angle of somewhat less than 90° to the bulldozer. Great strain would otherwise occur in the push arm, particularly at the region to which the diagonal strut is connected. The Belleville washers are prestressed so that deflection thereof under compression loading and the resultant shortening of the diagonal strut can occur without an increase in the loading of the diagonal strut.

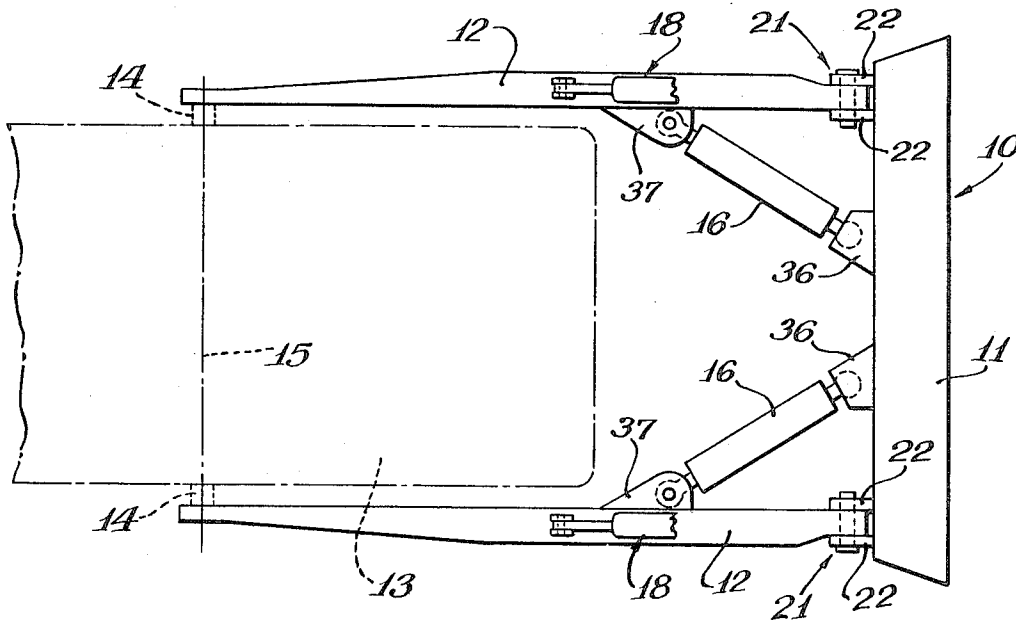
14 Claims, 5 Drawing Figures

FIG. 1.

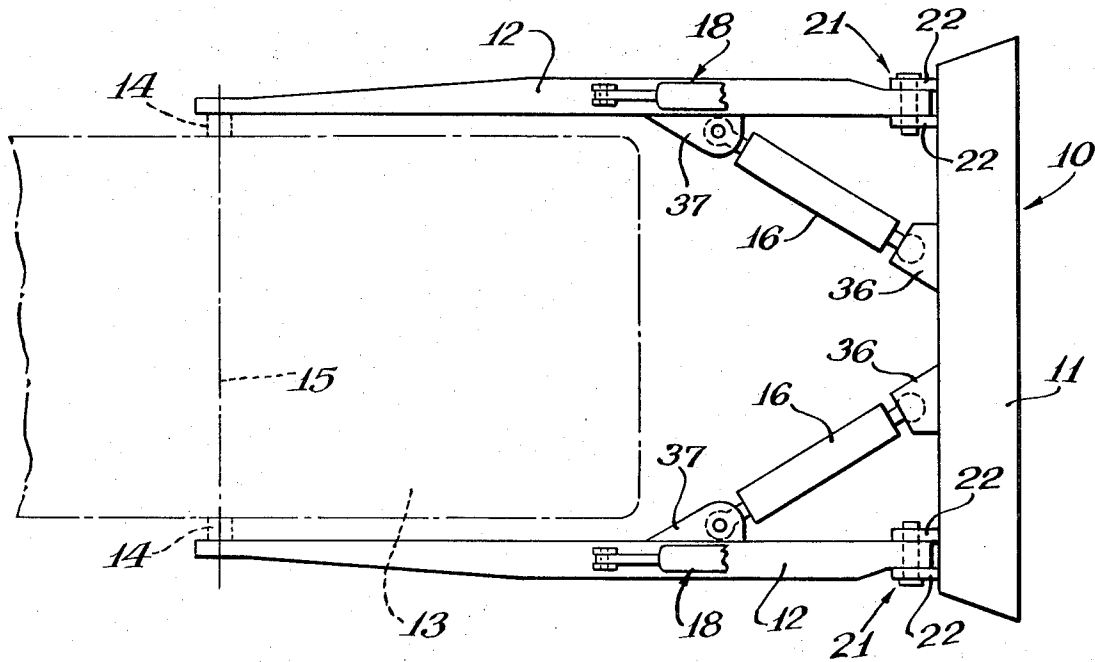


FIG. 2.

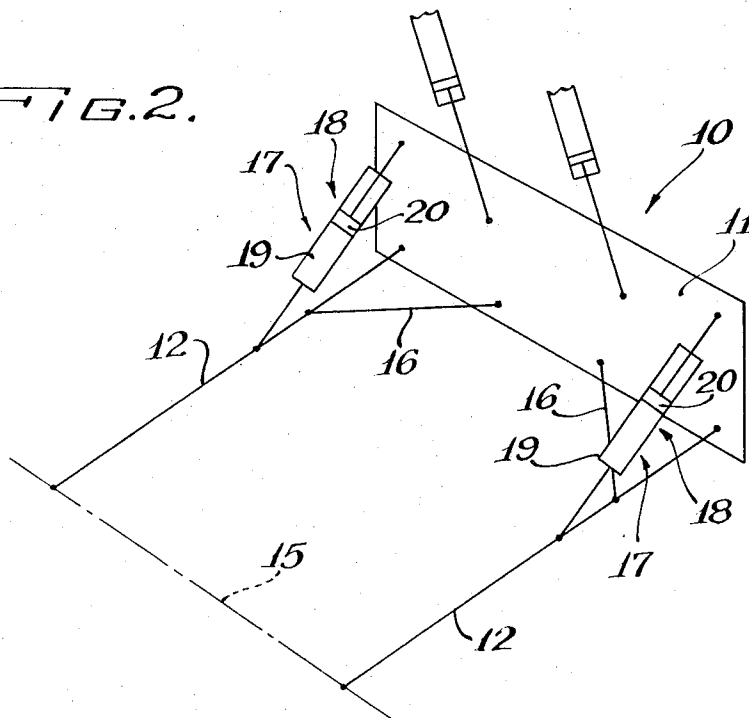


FIG. 3.

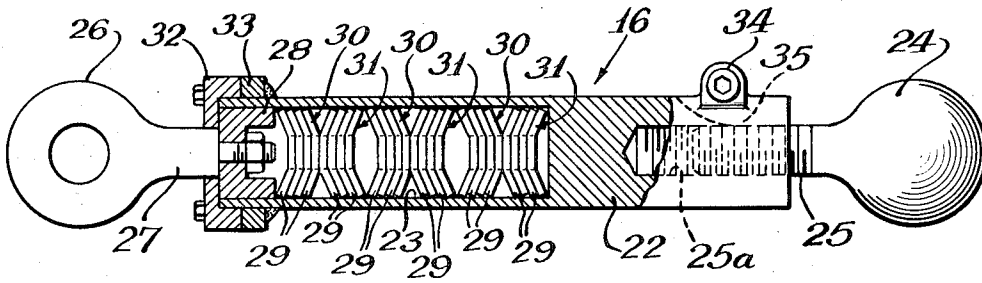


FIG. 4.

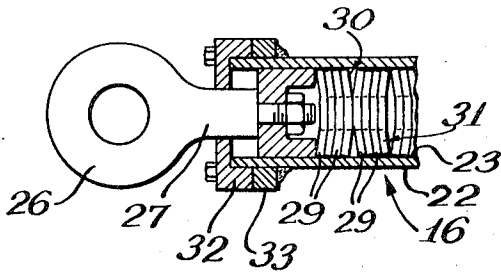
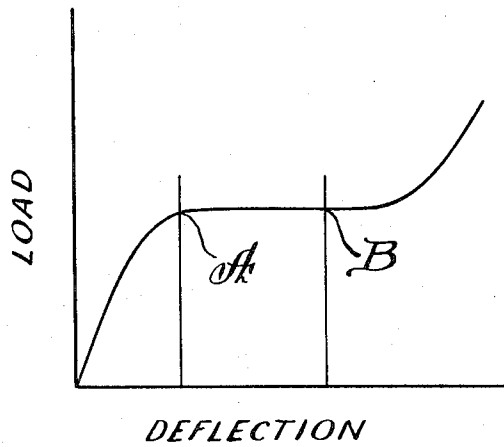


FIG. 5.



BULLDOZER FRAME WITH STRUT STRESS LIMITER

This invention relates to a diagonal strut for use between a bulldozer blade and a push arm. More particularly, the invention relates to a diagonal mechanical strut that will shorten under certain conditions.

During much of its operation, a bulldozer blade should stay at a constant angle, e.g., at 90°, to each push arm connected thereto, and the diagonal strut maintains this angle. Under certain conditions such as when a blade receives a side load while in a tilted attitude, however, it is desirable for the angle between the bulldozer blade and one push arm to decrease slightly. During these conditions, an unyielding strut places undue stress upon the push arm. If the diagonal strut is made to yield in an ordinary way by the inclusion of springs, the strut may be insufficiently stiff to hold the push arm at right angles to the bulldozer as is required during normal use of the bulldozer. If the springs in the diagonal strut are made quite stiff to compensate for this, then the increase in the spring force occasioned by shortening of the strut can be great enough to cause undue stressing of the push arm.

According to the present invention, the nature of spring means incorporated in the diagonal strut and the manner of incorporating the spring means are such that the load required to deflect the spring means in compression is relatively great, but does not appreciably increase as the deflection takes place. Novel interaction is achieved because of characteristics of the several interacting components involved.

More particularly, my invention provides a spring loaded, constant force means, the constant force means characterized by serving as a diagonal resilient strut, disposed between respective end attachment points therefor on a supported, side loadable bulldozer blade and on push arm means tiltably supporting same; the push arm means characterized by reacting to blade tilt, by bowing outwardly against the tilt caused load in the constant force means in resisting change of distance between its end attachment points; the constant force means further characterized by having a mechanical spring preload offering a resisting force with no more than minor difference in magnitude between it and the tilt caused load; the change of distance between the constant force means end attachment points due to a superimposed side-load-caused load, characterized by being attended by change in length of the constant force means with no appreciable change in the resisting force offered by the constant force means; the constant force means further characterized by a ball joint on an end of the diagonal resilient strut forming the end attachment point at that end; the mechanical spring preload characterized by a preloaded stack of frusto conical springs, pluralities of adjacent ones of which springs are, respectively, in parallel nested arrangement and in conical spring series opposing arrangement; and the spring preload further characterized by a full resisting force available from preload being slightly in excess of the tilt caused load.

It will be apparent from the foregoing that two such spring loaded struts when connected in the conventional diagonal way in a bulldozer parallelogram frame will in no way impair the normal rigidity present with the blade in the tilted attitude and in the untilted attitude. And yet when a blade receives a superimposed

side load while in the tilted attitude, one spring loaded strut automatically reacts by foreshortening. Such foreshortening is attended by limited sidewise shift of the bulldozer frame giving way to and relieving the side load, with no appreciable increase at any stress point in the frame such as interior joints, corner joints, and the like.

The significance is two-fold or two-stage in nature. The affected strut in two contrasting stages affords predetermined initial resistance at constant length, and affords ultimate resistance at constant force. The objectives in this method of applying my invention are to insure that the stage or step of maintaining frame rigidity up to predetermined stress in the strut, can always be followed if necessary by an automatic step of providing strut-stress-limiting. If so, the push arms undergo parallelogram movement.

In the drawings:

FIG. 1 is a plan view of an assembly of bulldozer blade and push arms, with parts removed;

FIG. 2 is a diagrammatic perspective view of the assembly;

FIG. 3 is a view, partially in longitudinal section, of the novel diagonal strut of the present invention;

FIG. 4 is a fragmentary longitudinal sectional view of the diagonal strut, when shortened; and

FIG. 5 is a graph illustrating the load-deflection curve of the diagonal strut.

As shown in FIGS. 1 and 2, a frame assembly 10 comprising a bulldozer blade 11 and two push arms 12 is mounted on a tractor 13. The front ends of the push arms 12 are connected to end portions of the bulldozer 11, and rear ends of the push arms are connected to trunnions 14 carried at the sides of the tractor 13, for purpose of pivotal movement of the bulldozer and push arms 12 about a horizontal axis 15. Conventional hydraulic lift cylinders are provided for the latter purpose.

Diagonal struts 16, which are the subject of the present invention, have their ends connected to regions of the push arms 12 and bulldozer 11 spaced from the connections of the bulldozer 11 with the front ends of the push arms 12.

Adjustable links 17, which incorporate power cylinder units 18, connect upper regions of the end portions of the bulldozer 11 with mid regions of the push arms 12 and serve to control the angle of the plane of the bulldozer blade 11 with that of the push arms 12. Each power unit 18 comprises a cylinder 19 and a piston 20 slidably mounted therein. One end of each link, or more particularly a rod attached to the piston 20 and protruding from the cylinder 19, is connected to the bulldozer 11. The other end of the link 17, or more particularly a rod-like extension of the cylinder 19, is connected to the associated push arm 12. When the bulldozer blade 11 is to be pitched, both links 17 are lengthened or shortened by adjustment of the pistons 20 in the same direction in the cylinders 19. When the bulldozer blade 11 is tilted, one link 17 is lengthened, and the other link 17 is shortened, by shifting of one piston 20 in one direction in its cylinder 19, and of the other piston 20 in the opposite direction in its cylinder 19.

During normal operation of the bulldozer blade 11, when the tractor 13 is acting through the push arms 12 to move the bulldozer blade 11 forward, the push arms 12 are preferably at right angles to the bulldozer 11.

Such angular relationship is maintained by the diagonal struts 16. Connections 21 between the front ends of the push arms 12 and the end portions of the bulldozer blade 11 permit the right-angle relationships between the push arms and bulldozer blade but they do not require it and, in fact, they swivel with the action of a ball type joint. More specifically, each connection 21 is formed by a pair of spaced ears 22 secured to the bulldozer 11 and by a spherical connection between the ears 22 and the front end of the associated push arm 12. Each swivelling connection 21 permits a deviation in the right angle between the bulldozer 11 and each push arm 12.

The diagonal struts 16 must maintain the right-angle relationship between the push arms 12 and the bulldozer blade 11 during normal forward movement of the bulldozer blade 11 through the push arms 12 and during pitching of the bulldozer blade. Yet, the diagonal struts 16 must yield in compression to a limited extent to accommodate side loads causing angular shifting of the push arms 12 sidewise, especially while the bulldozer blade has a tilted attitude. To this end, the diagonal struts have the novel and inventive construction to be described.

Beforehand, however, the geometry of blade tilt will lend background interest to the reader. Tilting the blade bends push arms 12, both of which bow outwardly at the midportion under the strain. The geometry is explained in another specification, U.S. Pat. No. 3,452,828 owned by the same assignee. Various reasons exist for tilting the bulldozer blade 11. For one, lowering the blade at one corner enables that corner to get under a large boulder. Dislodging the boulder induces side load in the tilted blade, especially if the bulldozer is being turned as it moves the blade ahead to work the boulder loose.

As shown in FIGS. 3 and 4, each strut 16 comprises a rod 22 having a deep axial recess 23 extending from one end thereof, a ball member 24 having a threaded shank 25 in threaded engagement with an opening 25a formed in the end of the rod 22 opposite that from which the axial recess 23 extends, and an eye member 26 having a shank 27, an enlarged head 28 secured to the shank 27, and a stack of Belleville springs 29 positioned in the axial recess 23 in the rod 22. Each spring washer 29 is a nonplanar ring or annular disk shaped like the frustum of a cone. The stack of springs 29 is composed of two sets of alternate pluralities 30 and 31 of springs 29. Each of the pluralities 30 is composed of several nested Belleville springs 29 angled in one direction when considered from the small end of the conical frustum to the large end, and each of the pluralities 31 is composed of several nested Belleville springs 29 angled in the opposite direction. The one end of the stack of springs 29 engages the bottom of the recess 23 in the rod 22, and the other end of the stack is engaged by the enlarged head 28 on the eye member 26.

The enlarged head 28 is retained in the open end of the axial recess 23 and the rod 22 by a retaining collar 32 which is secured to the end of the rod 22 by being bolted to a ring 33 welded to the exterior of the rod 22. The overall length of the diagonal strut 16 may be adjusted by turning of the ball member 24 with respect to the rod 22 so that the extent to which the threaded shank 25 lies in the end of the rod 22 is adjusted. The overall length of the diagonal strut 16 is fixed by a locking or holding means 34 which is secured to the exte-

rior of the rod 22 at opposite sides of a longitudinal slot 35 which extends radially of the rod 22 between its exterior and the opening 25a therein as well as longitudinally of the rod from the end thereof adjacent the ball member 24. The locking or holding means 34 narrows the longitudinal slot 35 and thus causes the rod 22 so tightly to grip the threaded shank 25 as to prevent turning and sliding of the shank of the ball member 24 with respect to the rod 22.

The height or length of the stack of pluralities 30 and 31 of Belleville springs 29, by the simple expedient of adding one or more of these Belleville washers to the stack, or removing a like number from the stack, is selected so as to be somewhat greater than the distance between the base of the axial recess 23 in the rod 22 and the end of the enlarged head 28 on the eye member 26 when the enlarged head engages the retaining collar 32. Thus, the Belleville springs 29 are preloaded. When as shown in FIG. 4, the eye member 26 and enlarged head 28 thereon is moved to the right as viewed in this figure with respect to the rod 22, the springs 27 become flatter, and the diagonal strut 16 shortens.

The deflection of the dished springs 29 arranged in oppositely directed alternate pluralities 30 and 31 takes place with a loading as illustrated by the graph of FIG. 5. From zero deflection to a certain deflection indicated by point A, the deflection or overall shortening of the plurality of springs 29 is proportional to load, fairly much in the expected way according to Hooke's law. But the characteristic of properly stacked Belleville washers is such that from point A to point B additional deflection occurs without increase in load. That characteristic readily manifests itself and it both has been, and can be, readily observed.

The preloading of the stack of springs 29 is chosen so that they are at point A of the graph of FIG. 5 when the diagonal strut 16 is in its fully expanded position in which the enlarged head 28 engages the retaining collar 32 as shown in FIG. 3. During its entire service life, each strut has its stack of springs always deflected somewhere in the range between points A and B. Thus when either diagonal strut 16 is shortened to the maximum extent caused when the tilted blade is side-loaded, the point B or a point slightly to the left thereof on the curve of FIG. 5 will have been reached. Whatever shortening of a diagonal strut 16 occurs with switch from normal tilted operation of the bulldozer blade 11, to the side-loaded operation thereof while so tilted, occurs at constant loading of that diagonal strut which is on a side of the bulldozer frame opposite to the side which is being side-loaded.

Resistance to shortening of the stack of springs 29 comes from the tendency of each spring 29 to resist flattening as well as from friction between engaging conical surfaces of adjacent springs 29 of each of the pluralities 30 and 31, which friction arises from sliding of the conical surfaces on one another due to straightening of the springs 29. Under loads causing deflection greater than at point B, the consequent variation in deflection is more or less according to Hooke's law, once again.

The diameter of the recess 23 in the rod 22 must be a little greater than the outer diameter of the springs 29 when they are flattened to the maximum so that the springs 29 will not become jammed in the recess 23. The function of the recess 23 is to contain the springs and keep them in a stack.

Each diagonal strut 16 has its ball member 24 received in a ball-shaped socket formed in a bracket 36 secured to the bulldozer 11, as shown in FIG. 1. The eye member 26 of each strut 16 is pinned to a bracket 37 attached to the associated push arm 12.

When tilting of the bulldozer blade 11 occurs, there is a tendency for the angle of each push arm 12 with respect to the bulldozer 11 to decrease somewhat below 90°. Such decrease must be resisted during normal operation of the bulldozer blade 11, and the stress due to tilting manifests itself not by shortening of the diagonal strut 16, but rather by a bending strain in the associated push arm which accommodates to the stress by bowing slightly outwardly. The load at preload point A of the curve of FIG. 5 is slightly larger than and readily resists against the tilting load. Now when the additional load over and above the tilting load is added, the shank 27 of the eye member 26 will move deeper into the rod 22 as shown in FIG. 4, and the diagonal strut 16 is shortened to accommodate the decrease in angle of the associated push arm 12 with respect to the bulldozer blade 11. As this occurs, no additional load that is perceptible will be carried and so the strut will now be at point B on the curve of FIG. 5.

The particular additional load being referred to is a horizontal side load introduced endwise into the tilted blade. The particular strut being referred to which provides the sought for "give" to the mechanism is the opposite strut, that is, the strut adjacent that end of the blade which is opposite to the end into which the side load is being introduced. In short, when a side load is applied with the blade in a tilted attitude, the mechanism accommodates with a simple sidewise-give movement, without overstress of the mechanism at the joints or corners.

What is claimed is:

1. In an assembly comprising a bulldozer blade, a push arm having its front end connected to one end portion of the bulldozer blade, and a power unit connecting the push arm with the said one end portion of the bulldozer blade for tilting the same, an improved arrangement of the bulldozer blade and the push arm, in combination with a diagonal strut connecting regions of the push arm and the bulldozer blade spaced from said end of the push arm and said one end portion of the bulldozer blade and having spring means incorporated therein that deflects under compression loading so as to shorten the diagonal strut, the deflection being in proportion to load up to a certain point, thence occurring in amount about at constant load to another point, and thence occurring in still further amount in proportion to load, the spring means being preloaded up to about the said certain point even with the diagonal strut disconnected from the push arm and the bulldozer blade, shortening of the strut by decrease of the angle between the push arm and the bulldozer blade due to tilting of the bulldozer blade being accompanied by compressive deflection of the spring means without increase in loading between the said certain point and the said other point, and a similar arrangement at the other end portion of the bulldozer blade.

2. A combination as specified in claim 1, the spring means comprising nested Belleville springs.

3. In an assembly comprising a bulldozer blade, a push arm having its front end connected to one end portion of the bulldozer blade, and a power unit connecting the push arm with the end portion of the bull-

dozer blade for tilting the same, an improved arrangement of the bulldozer blade and the push arm, in combination with a diagonal strut connecting regions of the push arm and the bulldozer spaced from said end of the push arm and said one end portion of the bulldozer blade and comprising a first part having at one end a connecting portion and at the other end an axial recess and a retaining collar, a stack of Belleville springs in the axial recess, and a second part having at one end a connecting portion and at the other end an enlarged head positioned in the axial recess within the retaining collar against the stack of Belleville springs, the retaining collar keeping the enlarged head within the axial recess, the springs being under compression even with the enlarged head and the retaining collar engaged, the springs being further compressible by movement of the enlarged head thereagainst away from the retaining collar, such movement involving shortening of the diagonal strut, and a similar arrangement at the other end portion of the bulldozer blade.

4. A combination as recited in claim 3, the stack comprising a first plurality of nested Belleville springs angled in one direction and a second plurality of nested Belleville springs angled in the opposite direction.

5. A combination as specified in claim 3, the stack comprising several pluralities of nested Belleville springs, the springs of one set of alternate pluralities being angled in one direction and the springs of the other set of alternate pluralities being angled in the opposite direction.

6. A combination as specified in claim 3, the stack of Belleville washers deflecting under compression loading so as to shorten the diagonal strut, the deflection being in proportion to load up to a certain point, thence occurring in still further amount in proportion to load, the stack of Belleville washers being preloaded up to about the said certain point even with the diagonal strut disconnected from the push arm and the bulldozer, shortening of the strut by decrease of the angle between the push arm and the bulldozer due to tilting of the bulldozer being accompanied by compressive deflection of the stack of Belleville washers without increase in loading between the said certain point and the said other point.

7. In an assembly comprising a bulldozer, push arms having their front ends connected to end portions of the bulldozer, and power units connecting the push arms with the end portions of the bulldozer for tilting the same, the combination with the bulldozer and the push arms of two diagonal struts, one being connected to the bulldozer and one push arm in spaced relation to the connection therebetween, the other being connected to the bulldozer and the other push arm in spaced relation to the connection therebetween, each diagonal strut comprising a first part having at one end a connecting portion and at the other end an axial recess and a retaining collar, a stack of Belleville springs in the axial recess, and a second part having at one end a connecting portion and at the other end an enlarged head positioned in the axial recess within the retaining collar against the stack of Belleville springs, the retaining collar keeping the enlarged head within the axial recess, the springs being under compression even with the enlarged head and the retaining collar engaged, the springs being further compressible by movement of the enlarged head thereagainst away from the retaining

collar, such movement involving shortening of the diagonal strut.

8. A combination as specified in claim 7, the connecting portion of the first part of each diagonal strut being connected to the bulldozer, the connecting portion of the second part of each diagonal strut being connected to the associated push arm.

9. A combination as specified in claim 8, the connecting portion of each diagonal strut connected to the bulldozer being in the form of a spherical ball, the connecting portion of each diagonal strut connected to the associated push arm being in the form of an eye.

10. A combination as specified in claim 9, said ball having a threaded shank in threaded engagement with the balance of the first part of the diagonal strut for adjustment of the length of the diagonal strut, each diagonal strut further comprising holding means preventing adjustment of the connecting portion with respect to the balance of the first part by turning of the connecting portion.

11. In a bulldozer, having a blade and push arm means, the improvement comprising constant force means for serving as diagonal resilient strut, disposed between respective end attachment points therefor on a supported side loadable bulldozer blade and on push arm means tiltably supporting same, said push arm means reacting to blade tilt, by bowing outwardly against the tilt-caused-load of compression in said means in resisting change of distance between its end attachment points;

said constant force means having a mechanical spring preload offering a resisting force with no more than minor difference in magnitude between it and the tilt-caused-load;

the change of distance between said means end attachment points due to a superimposed side-load-

caused load attended by change in length of said constant force means with no appreciable change in the resisting force offered by said means, said constant force means having a preload stack of cone spring means comprising frusto conical springs, pluralities of adjacent ones of which are, respectively in parallel nested arrangement and in conical-spring series opposing arrangement.

12. The invention of claim 11, the constant force means characterized by:

a ball joint on an end of the diagonal resilient strut forming the end attachment point at that end.

13. The invention of claim 11, the spring preload characterized by the full resisting force available from preload being slightly in excess of the tilt-caused-load.

14. Method of maintaining rigidity up to a predetermined stress and thereafter providing automatic strut-stress-limiting in a bulldozer parallelogram frame comprising a supported blade push arm means tiltably supporting the blade, and a diagonal, constant force, long strut interconnecting the blade and push arm means to reinforce the frame across a corner angle, said method including the steps of:

applying load to the frame by tilt loading which is compressively resisted by the long strut;

affording predetermined initial resistance at constant length, at said corner by maintaining the angularity by means of the resisting long strut;

applying load to the frame by a superimposed side loading, which also is compressively resisted by the long strut; and

affording ultimate resistance at constant ultimate force, at said corner by foreshortening the resisting long strut.

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