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(54) VIBRATORY PLOUGHS

(71) We, J. I. CASE COMPANY, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 700 State Street, Racine, Wisconsin 53404, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to vibratory ploughs and more particularly to a vibrator assembly for a plough blade.

Ploughs having an elongated vertical blade have been used for several years to lay elongate elements such as cable or flexible pipe. Cable or pipe may be either pulled through the cut of the plough blade, or a cable chute may be provided on the trailing edge of the blade which guides the cable into the ground from a drum mounted on the prime mover. More recently, various types of vibrators have been mounted on the plough blade or the supporting frame which effectively reduces the drawbar pull or force required to pull the blade through the ground. Such a vibrator disclosed in United States Patent Specification No. 3,363,423. Vibration has been utilized in other plough applications, including rippers. Vibration of the blade of cable laying ploughs has also resulted in other advantages, including less ground disturbance and faster cable laying installation.

Following the development of vibratory cable laying ploughs, several improvements have been made, particularly to isolate vibrations to the plough blade. For example, United States Patent Specification No. 3, 618, 237 discloses a frame support for a cable laying blade having a torque cushioning elements which absorb the reciprocable motion of the support and substantially isolate the frame from the supporting structure. Initially, it was considered necessary to rigidly mount the vibrator either directly over the blade or perpendicular to the blade to produce substantially vertical vibrations in the blade.

According to the present invention, the vibrator is partially suspended from the frame which supports the plough blade, thus assisting in isolating the vibrations from the supporting structure. The invention provides a vibrator assembly for a plough blade comprising a frame assembly for attachment to a vehicle and including means for supporting a plough blade thereon; a yoke pivotally mounted at either end thereof on the frame; and a vibrator supported on the yoke; the assembly including means for connecting the yoke to a said plough blade for transmitting pivotal vibrations of the yoke about the ends thereof to a said plough blade.

A plough blade is normally pivotally supported on the frame assembly and thus the vibrations will normally result in an arcuate, clearing motion of the blade. This blade motion has been found particularly suitable for laying cable, flexible pipe and the like. The vibrator is preferably suspended at an angle to the plane of the blade, which enhances the isolation effect. The frame assembly may include elastomeric torque cushioning element which further isolate the vibrations in the frame assembly from the supporting structure, as disclosed in United States Patent Specification No. 3,618,237.

In the preferred embodiment of the present invention, a U-shaped yoke is pivotally mounted at opposite ends to the frame assembly and the vibrator is supported on the yoke generally in the plane of the blade. A plough blade is pivotally mounted on the trailing end of the frame support, with the pivotal connection preferably including elastomeric torque cushioning ele-

ments permitting limited pivotal motion of the plough blade. The yoke is pivotally connected to the blade, thereby transmitting vibrations from the vibrator to the blade and resulting in the preferred orbital or arcuate cleaving motion of the plough blade, particularly at the blade tip or distal end.

The means for connecting the yoke to a plough blade normally comprises a link which is pivotally connected at one end to the yoke adjacent, and preferably beneath the vibrator, means for making a pivotal connection to the blade being provided at the opposite end. The preferred pivotal connections also include resilient elastomeric bearing elements permitting limited pivotal motion of the blade. The vibrator is suspended from the frame support, allowing the vibrator to pivot with respect to the frame assembly. The yoke is attached by means of a mechanical linkage to the plough blade. The motion of the vibrator is therefore resisted primarily through the plough blade, which in turn is suspended from the frame assembly at only one point.

The invention will now be described by way of example and with reference to the accompanying drawings wherein:

Figure 1 is a side elevation of one embodiment of a vibratory cable laying unit which includes the vibrator assembly of the present invention;

Figure 2 is an enlarged side elevation showing the mast assembly of the unit of Figure 1;

Figure 3 is a rear elevation of the mast assembly shown in Figures 1 and 2;

Figure 4 is a partial plan view of the plough blade support assembly of Figures 1 and 2;

Figure 5 is a partial side view of Figure 4 in the direction of view arrows 5-5;

Figure 6 is an enlarged side elevation of the plough blade and the supporting frame shown in Figure 1;

Figure 7 is a partial plan view of the blade and support frame shown in Figure 6;

Figure 8 is a cross-sectional side view of the plough blade and support frame shown in Figure 7, in the direction of view arrows 8-8;

Figure 9 is a partial cross-sectional bottom view of the linkage shown in Figure 8, in the direction of view arrows 9-9; and

Figure 10 is a top partially cross-sectioned view of the connection between the plough blade and the frame assembly shown in Figure 8, in the direction of view arrows 10-10.

The embodiment of the cable-laying plough shown in Figure 1 includes a prime mover 22 and a vibratory plough assembly 24. It will be understood that the prime mover may be any suitable vehicle, including bulldozers, tractors and the like. The disclosed embodiment of the prime mover is a conventional bulldozer having a continuous track 23. Generally, the vibratory plough assembly includes a mast assembly 26, an adjustment mechanism 28, a blade support or frame 30 and an elongated blade 32. As described, the mast assembly 26 is adapted to raise and lower, and adjust the angle of the blade 32 in the vertical longitudinal plane relative to true vertical. The control mechanism 28 is adapted to adjust the lateral position and the angle between the vertical plane of the blade 32 and the longitudinal vertical plane of the prime mover 22 and the blade support or frame 30 is adapted to vibrate the bulldozer blade and transmit an arcuate or orbital motion to the blade tip or toe 33. Reference is directed to our copending Application No. 53543/76 (Serial No. 1559490) which describes the same plough as is illustrated herein and is directed specifically to the mast assembly thereof.

As described above, the cable-laying plough of this invention may be utilized to lay cable, flexible pipe or hose underground. It will be understood that the term cable is used herein as a generic term. In the disclosed embodiment of the cable-laying plough, the cable 34 is received from a drum 36 rotatably supported on a suitable boom 38 of the prime mover 22. The cable is then received on reels 38, over the prime mover and the cable is then fed through a guide or cable shute 40 into the cut made by the plough blade 32. The reels 38 in the disclosed embodiment are supported on a forward mast 42, the bulldozer canopy 44 and a rearward mast assembly 46. The mast assembly 26, control 28 and blade support or frame 30 will now be described in detail.

The mast assembly 26 is shown in detail principally in Figures 2 and 3. As shown, the mast assembly 26 generally includes a support frame 50 and a slide frame 52. The support frame includes a pair of generally vertical laterally spaced, cylindrical rails 54, top and bottom plates 56 and 58, respectively, which secure the rails 54, side plates 56 and 58, respectively, which secure the rails 54, side plates 60, a reinforcing horizontal plate 62 and a support plate 64. As will be noted, the support and slide frames are formed of a plurality of vertical and horizontal plates, which are preferably steel plates welded together to form a solid supporting structure for the blade. The support frame is pivotally mounted on the prime mover as shown in Figure 2. The bulldozer includes a plate 66 secured to the bulldozer frame between the tracks 23. A lug 68 is secured to the plate 66 and a mat-

ing lug 70 is secured to the support plate 64 of the support frame 50. A suitable bearing or pin is provided between the lugs 68 and 70 to pivotally support the support frame on the prime mover.

The slide frame 52 includes opposed end plates 74, top and bottom collar plates 76 and 78, respectively, having suitable recesses 80 as shown in Figure 4 and top and bottom box supports 82 and 84, as shown in Figure 3. The box supports in the disclosed embodiments are bolted by suitable bolts 86 to the end plates 74 and the collar plates 76 and 78 may be welded to the box supports.

The tilting, raising and lowering of the mast assembly is accomplished in the disclosed embodiment by remotely controlled double-acting hydraulic cylinders or pistons. It will be understood, however, that various means may be utilized. For example, the slide frame 52 may be raised and lowered by a rack and pinion assembly, however, the preferred embodiment includes hydraulic cylinders because of the ease of control and durability of pistons in field applications. In the disclosed embodiment, the tilt adjustment is accomplished by hydraulic rams 90 which are pivotally mounted on the prime mover by pin 92 on boss 94, as shown in Figure 2. The extensible piston rods 96 are pivotally secured to the support frame as shown in Figures 3 and 4. A pin 98 extends through the upright or vertical plates 60 and clamp plates 100 are provided between the piston rod and the vertical plates. Extension and retraction of rams 90 thereby adjusts the tilt angle of the mast assembly 26 and thereby the tilt angle of the plow blade, as further described hereinbelow.

The hydraulic rams 102 are supported on plates 104 welded to top plate 56. The opposed end of the rams 102 are pivotally connected to plates 105 of slidable frame 52. The slide frame member 52 may thus be raised and lowered by retraction and extension of rams 102. As described hereinbelow, raising and lowering of slide frame 52 also raises and lowers the plough blade 32.

As described above, the angular and lateral adjustment of blade 32 is accomplished by control mechanism 28. This control is best shown in Figures 2, 4 and 5. The control mechanism is supported on the end plates 74 of slide frame 52. Vertical support plates 110 are bolted by bolts 112 to end plates 74 as shown in Figure 2. The support plates 110 are welded to support channel 114, which structure supports the control mechanism 28 and hence the blade assembly. The top and bottom edges of vertical plate 116, which is welded to channel 114, form horizontal rails for lateral shifting of the blade assembly. Plates 110 and 116 and channel 114 are referred to herein as the relatively fixed frame assembly and 118 are referred to the slide frame assembly.

The slide frame assembly includes a main support channel 122 which is supported on a central cylindrical pivot 124. Plates 126 are bolted to the top and bottom of channel 122, for supporting hook-shaped elements 128 which are slidably received on the top and bottom edges of plate 116. In the disclosed embodiment, bearing strips 130 are disposed between the hook-shaped elements 128 and the plate 116. Plates 132 are welded to support plates 126, adding lateral strength to hook-shaped elements 128. End plates 134 are welded to the top surface of plates 132, providing a box-shaped support structure. Rearwardly extending channels 136 and 138 support the blade frame assembly 30 as described hereinbelow.

In the disclosed embodiment, the blade assembly is shifted laterally by a fluid actuated hydraulic ram 144 having a cylinder 146 and piston rod 148. The ram 144 is connected by a rod to pin 150 of the relatively fixed frame assembly and the piston rod is connected to pin 152 of the slide frame assembly. Support plate or standard 154 retains the rod 150 to channel 114 of the fixed frame assembly and bracket 156 retains the pin 152 to the slide frame assembly, as shown in Figure 5. In the disclosed embodiment, the bracket is secured to the slide frame assembly by bolts 158 and bearing strips 160 are provided between the support plate 116 and channel 122.

The blade assembly may be angularly adjusted about pivot 124 by actuation of hydraulic rams 162 having cylinders 164 and piston rods 166 as shown in Figure 4. Cylinders 164 are pivotally supported within main channel 122 by opposed plates 168, which may be welded to the channel as shown in Figure 2. The cylinders are received in collars 170 which are supported by pins 172 between the plates 168 as shown in Figure 4. The piston rods are pivotally connected by pins 174 to horizontal plate 176, which plate forms a part of the frame assembly 30 and which is pivotally supported on vertical pivot 124 as shown in Figure 4. Reference is directed to our copending Application No. 53541/76 (Serial No. 1559488) which is directed to the provision of angular adjustment for a plough blade in a plough of the type described herein.

Actuation of the rams 162, by extension of one piston rod and retraction of the opposed piston rod, will therefore result in rotation of the blade frame assem-

bly 30 about vertical pivot 124, providing angle adjustment for the blade assembly.

The improved frame assembly 30 is shown in Figures 6 to 10. As shown in Figure 6, the frame assembly is supported on channel 138. The frame assembly includes a parallelogram linkage having elastomeric support cushioning elements as described in United States Patent Specification No. 3,618,237.

The parallelogram linkage includes four vertical columns 180, upper side plates 182, lower side plates 184 and a support beam 188 shown in Figures 7 and 8. End plates 186 are secured to the side plates by elastomeric torque cushioning elements 190, which elements are rectangular as shown in Figure 6. The side plates 182 are secured to vertical columns 180 adjacent control mechanism 128 by pine 192 having resilient bushings 194, as shown in Figure 4. Opposed plates 196 may be welded to vertical columns 180, which plates are secured to torque cushioning elements 190, as shown in Figure 4 and described in the above referenced patent. Similarly, support plates 200 may be welded to the rearward vertical columns 180, which plates are supported on torque cushioning elements 190, as shown in Figure 7. Other details of the parallelogram linkage of the blade support frame may be found in the United States Patent Specification referred to above. However, the support for the vibrator and plough blade disclosed herein provides for results in orbital or arcuate vibratory motion of the blade, as described below.

The vibrator 220 in the preferred embodiment is mounted on a pivotally supported yoke 222. The yoke is supported on plates 200, which in turn are supported on vertical columns 180 as by welding the plates to the columns, as shown in Figure 7. The opposed ends of the yoke are pivotally supported on pins 224 which may include resilient elastomeric bearing elements. The blade in the preferred embodimnt is also pivotally supported on frame 30, as best shown in Figures 8 and 10. The blade assembly 32 includes a vertical rigid blade 226, cover plates 228 and toe 33, as shown in Figures 6 and 10. The blade is pivotally supported on plates 232 by transverse pivot pin 234. Resilient elastomeric bearing elements 236 are received in plates 232. Alternatively, the bushing between the plates 228 may include a resilient centre bushing. The cover plates 228 are welded to the blade 226. The yoke 222 is pivotally connected to the blade assembly by link 242, as shown in Figures 8 and 9. Link 242 is pivotally connected to the blade by pin 244 which extends between cover plates 228. Internal lugs 248 are connected to the yoke 222, generally in the axis of the vibrator. The integral lugs are pivotally connected to link 242 by pin 250.

The vibrator 220 is therefore supported on a four-bar linkage, including link 242, yoke 222, the frame assembly and the blade 32. Vibrations are thus transmitted from the yoke 222, through link 242, to the blade, and the blade is resiliently and pivotally supported on plate 232. The resilient elastomeric bearing 236 permits limited longitudinal movement of the blade and pivotal movement about pin 234, resulting in arcuate or orbital motion of the blade in the ground. This motion may be modified for soil conditions by moving the pivotal connection of the link to the blade. In the disclosed embodiment, pivot pin 244 may be moved to the lower blade aperture 230. The blade may also be shifted downwardly for deep soil penetration using blade aperture 231.

The vibrator or shaker 220 is driven by a suitable motor 256 which is mounted on bracket 260. The bracket may be welded or otherwise secured to plates 232, which plate is welded or otherwise secured on plate 258 and beam 188. The disclosed bracket includes support plates 262 and 264 and the shaft 265 of the motor is connected through universal coupling 266 to the shaker or vibrator. The vibrator 220 may be secured by any suitable means to the yoke 222. In the disclosed embodiment, a suitable mounting plate 268 is provided on the vibrator which is mounted to the yoke.

The disclosed vibrator or shaker 220 is a conventional double-weight vibrator having eccentric weights mounted on a central shaft. The weights are timed to produce vibrations in any preferred axis or plane. The vibrator will normally be timed to produce vibrations perpendicular to the plane of the plate 268, producing the desired orbital motion in the blade 32. One suitable vibrator is disclosed in United States Patent Specifications Nos. 1,999,213; 2,097,347 and 2,178,813. The motor may be a conventional hydrostatic fixed displacement motor available from various sources. As disclosed, the general assembly of the various frame elements is composed of a plurality of plates, channels and the like, which may be formed of any suitable material, including conventional structural steel.

The operation of the disclosed vibratory cable-laying plough may be fully understood from the above description of the various figures, however, the following is a brief description of the overall operation. First, the blade assembly 32 may be raised, lowered and tilted by operation of the mast assembly 26, best shown in Figures 2 and 3. As will be understood from the description

above, the support frame 50 is pivotally supported on plate 66 of the prime mover or vehicle 22. The slide frame assembly 52 is slidably supported on rails 54 which are part of the support frame assembly. The blade assembly 32 is supported on the slide frame assembly as best shown in Figure 1. Actuation of pistons 102 raises and lowers the slide frame assembly 52 and therefore the blade assembly 32. Actuation of pistons 90 adjust the tilt angle of the mast assembly 26 relative to true vertical, thereby adjusting the tilt angle of the blade assembly. The piston rod 96 of 90 may be extended to increases the downward thrust at the rear of the plough blade; forward tilting, resulting from retraction of the piston rod, provides additional lift height of the blade and additional clearance during transport of the vibratory plough. Rearward tilt of the mast assembly also causes the blade to travel slightly to rearward if the plough is raised through use of the vertical lift mechanism. This action is advantageous in that there is less tendency for additional cable to be drawn through the chute or guide 40 as the plough blade is raised, thereby reducing cable damage. Similarly, reverse bending of the cable may be held to a minimum by adjusting the tilt angle of the blade. Forward tilt of the vertical mast may also be used when lowering the plough blade into the ground to protect the cable chute from damage, whereby the chute is tilted away from the ground during entry of the blade. Further, the attack angle of the blade may be varied to compensate for varying soil conditions. And, the depth of the cut of the blade may be varied by lift cylinders 102, without requiring repositioning of the blade with respect to the plough support assembly.

The blade may be caused to track laterally by operation of control mechanism 28. As described, a cable-laying plough is normally rigidly mounted in the longitudinal axis of the prime mover or vehicle 22, however it may be most desirable to move the plough laterally, at times during operation of the cable-laying plough. The disclosed embodiment permits remote operation and control of the lateral position of the blade. The blade may be turned by actuation of pistons 162, best shown in Figures 2 and 4.

Extension of one piston rod 166 and retraction of the other causes the frame assembly 30 to pivot about vertical pivot 124, turning the blade 32 relative to the longitudinal axis of the prime mover. The blade may thereby be caused to track the prime mover or follow a separate path by simultaneous action of cylinder 144. As described above, slide frame assembly 118 is slidably supported on plate 116, which plate forms part of the relatively fixed frame assembly supported on the mast assembly 26. Actuation of piston 144 results in lateral motion of slide frame assembly 118 and therefore blade 32. The blade may be shifted laterally, relative to the longitudinal axis of the prime mover 22, prior to entry of the blade in the soil or the blade may be caused to track laterally by simultaneous operation of pistons 162 and 144 while the plough is in the soil and during continuous operation.

As described above, the suspension of the blade 32 and vibrator 220 results in an arcuate motion of the blade toe 33, as shows in Figures 6 to 10. The vibrator 220 is suspended on a U-shaped yoke 222 which is pivotally supported on the blade support assembly 30. The blade 32 is pivotally and resiliently supported on the frame assembly and the yoke 22 is pivotally supported to the blade by link 242. This four-bar assembly results in orbital motion of the blade upon actuation of the vibrator or shaker 222.

WHAT WE CLAIM IS:

1. A vibrator assembly for a plough blade comprising a frame assembly for attachment to a vehicle and including means for supporting a plough blade thereon; a yoke pivotally mounted at either end thereof on the frame; and a vibrator supported on the yoke; the assembly including means for connecting the yoke to a said plough blade for transmitting pivotal vibrations of the yoke about the ends thereof to a said plough blade.

2. An assembly according to Claim 1 wherein the means for supporting a plough blade on the frame assembly includes a resilient elastomeric bearing element permitting limited pivotal movement.

3. An assembly according to Claim 1 or Claim 2 wherein the means for connecting the yoke to a said plough blade comprises a link pivotally connected at one end to the yoke and having means for making a pivotal connection at the other end to a said plough blade.

4. An assembly according to Claim 3 wherein an elastomeric resilient element is located at either end of the link to provide resilient connections between the link, and the yoke and a said plough blade respectively.

5. An assembly according to Claim 4 including a pivot pin, wherein the elastomeric element encircles a pivot pin at either end of the link.

6. An assembly according to any preceding claim wherein the yoke includes a planar central portion supporting the vibrator.

7. An assembly according to Claim 6 wherein the means for connecting the yoke

to a said plough blade are attached to the yoke adjacent the central portion thereof.

8. An assembly according to any preceding claim including a plough blade supported on the frame assembly.

9. An assembly according to Claim 8 wherein the vibrator is operable substantially in the plane of the blade.

10. An assembly according to any preceding claim wherein the frame assembly includes a horizontal beam, a motor being mounted on the beam for driving the vibrator.

11. An assembly according to Claim 10 wherein the beam provides the means for supporting a said plough blade thereon.

12. A vibrator assembly for a plough blade substantially as described herein with reference to the accompanying drawings.

13. A vibratory plough including an assembly according to any proceding claim.

14. The combination of a plough according to Claim 13 and a vehicle for driving same.

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1559489 COMPLETE SPECIFICATION

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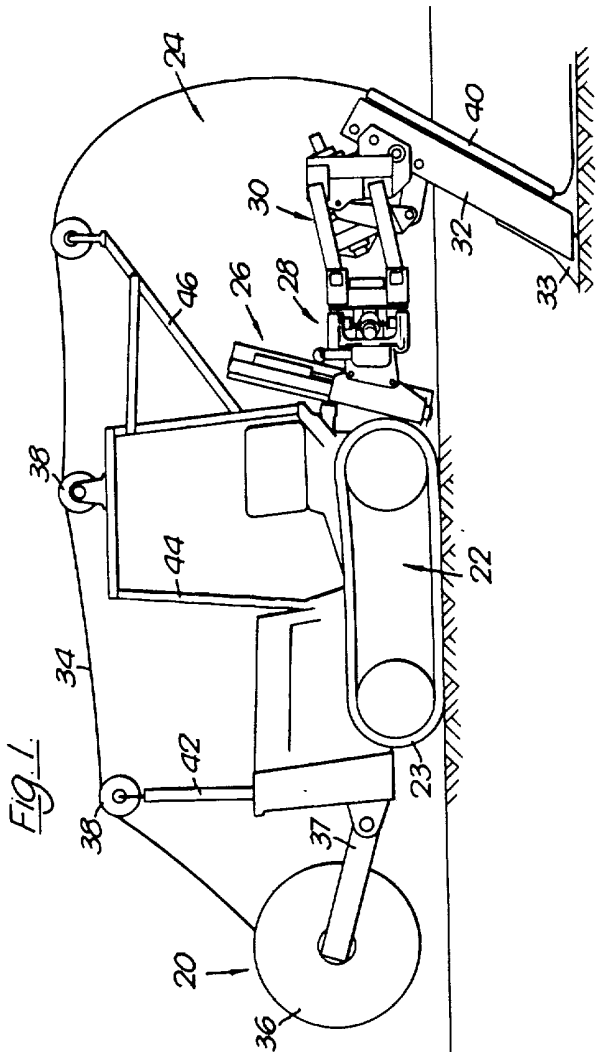

Fig. 1.

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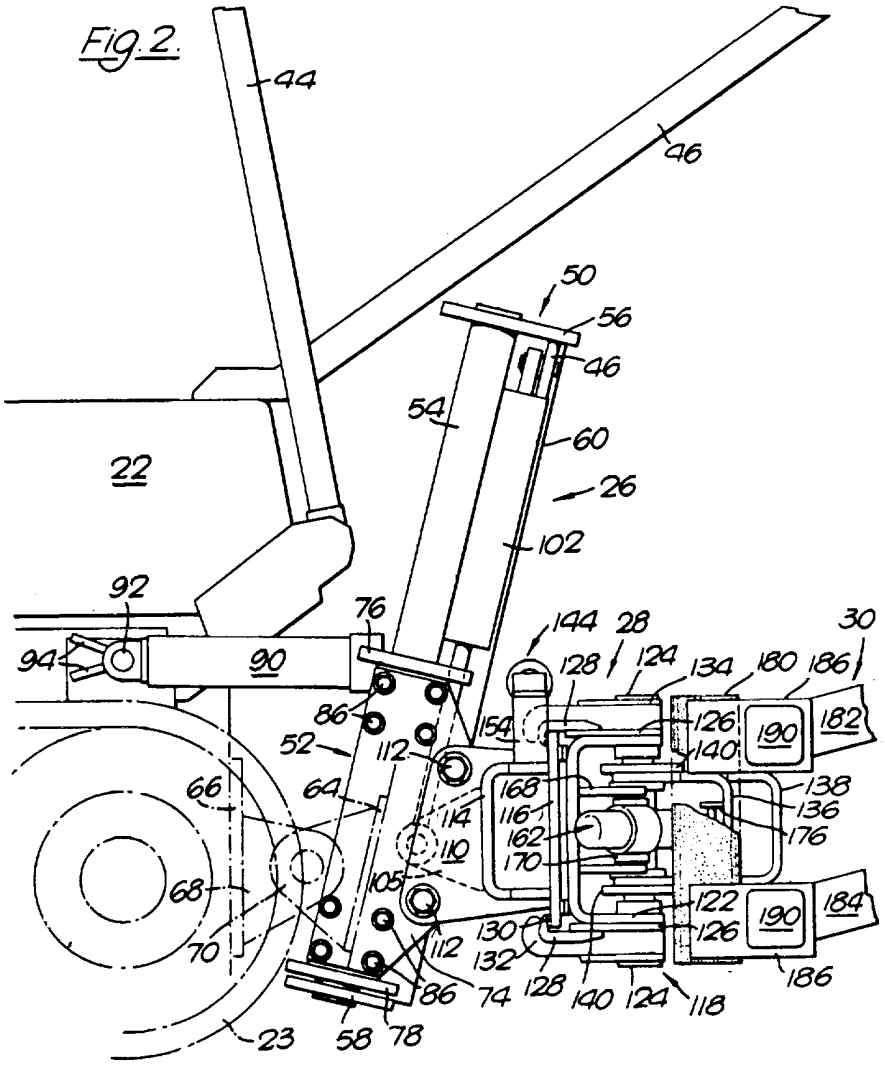
Fig.2.



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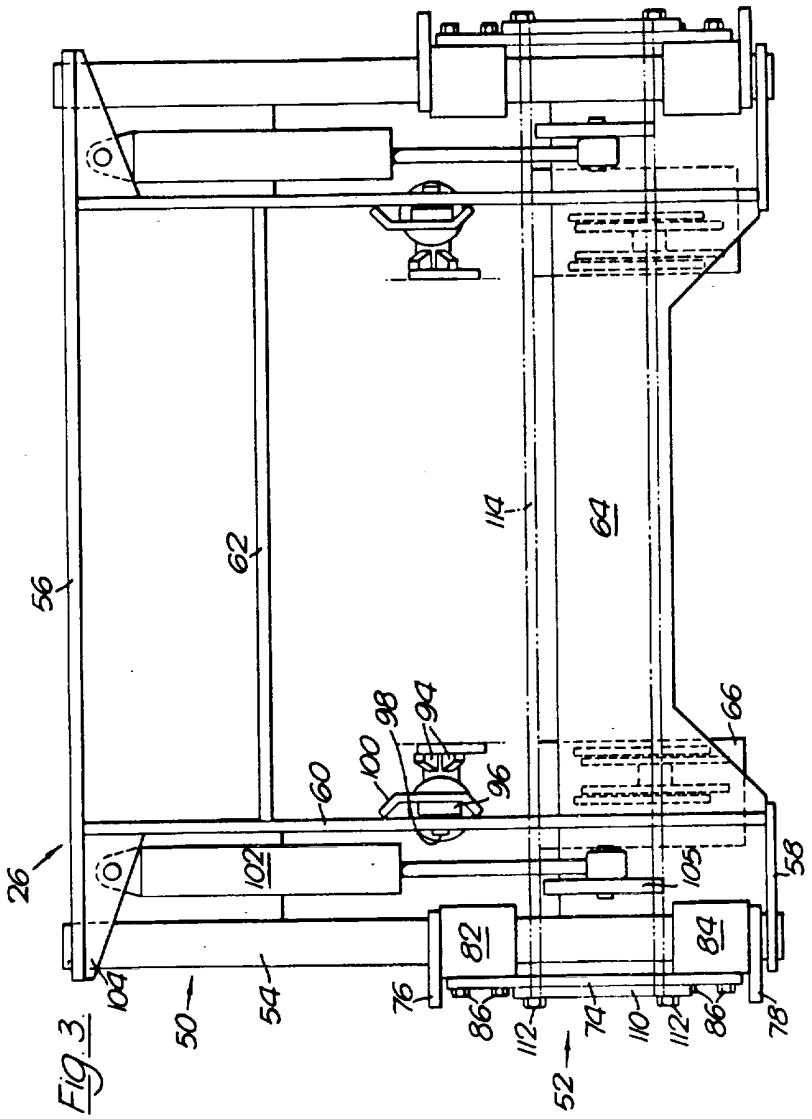

Fig 3

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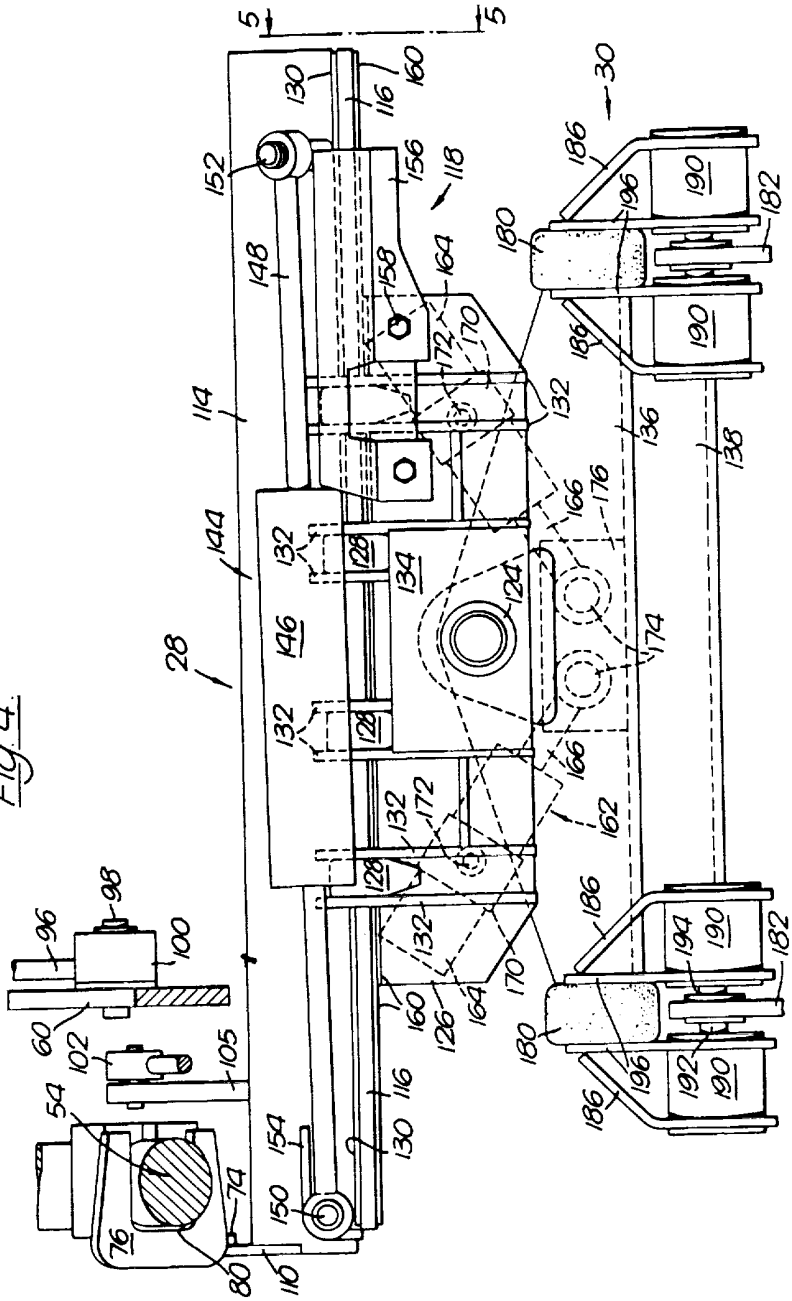

Fig 4.

Fig. 5.

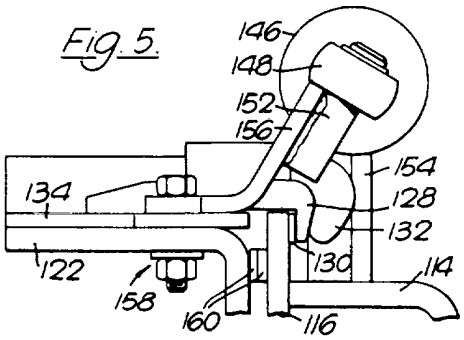
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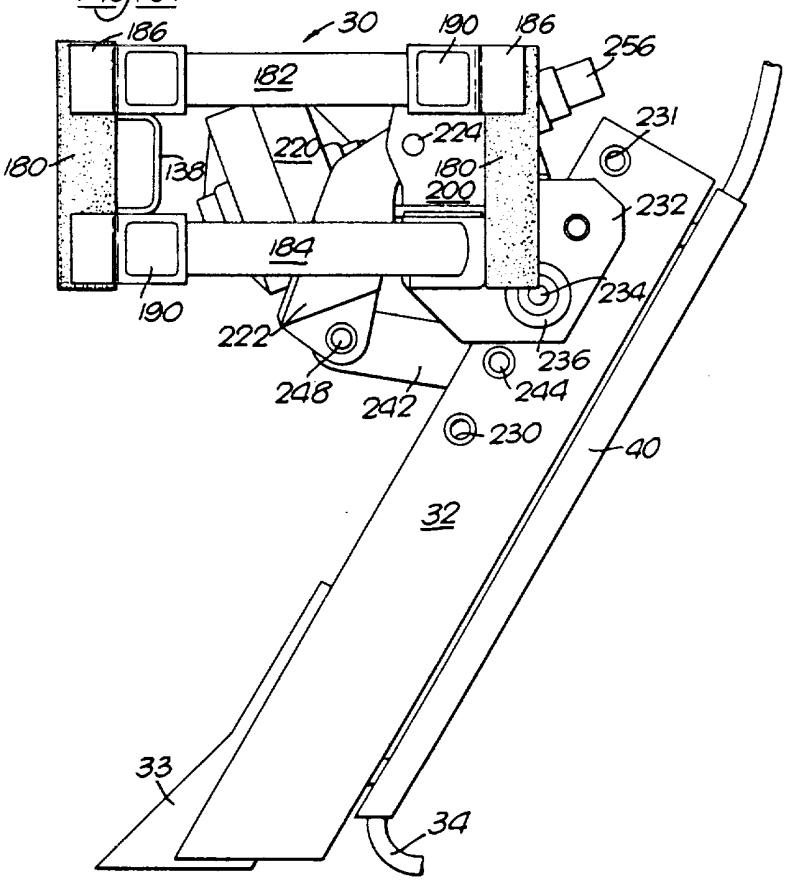
Fig. 6.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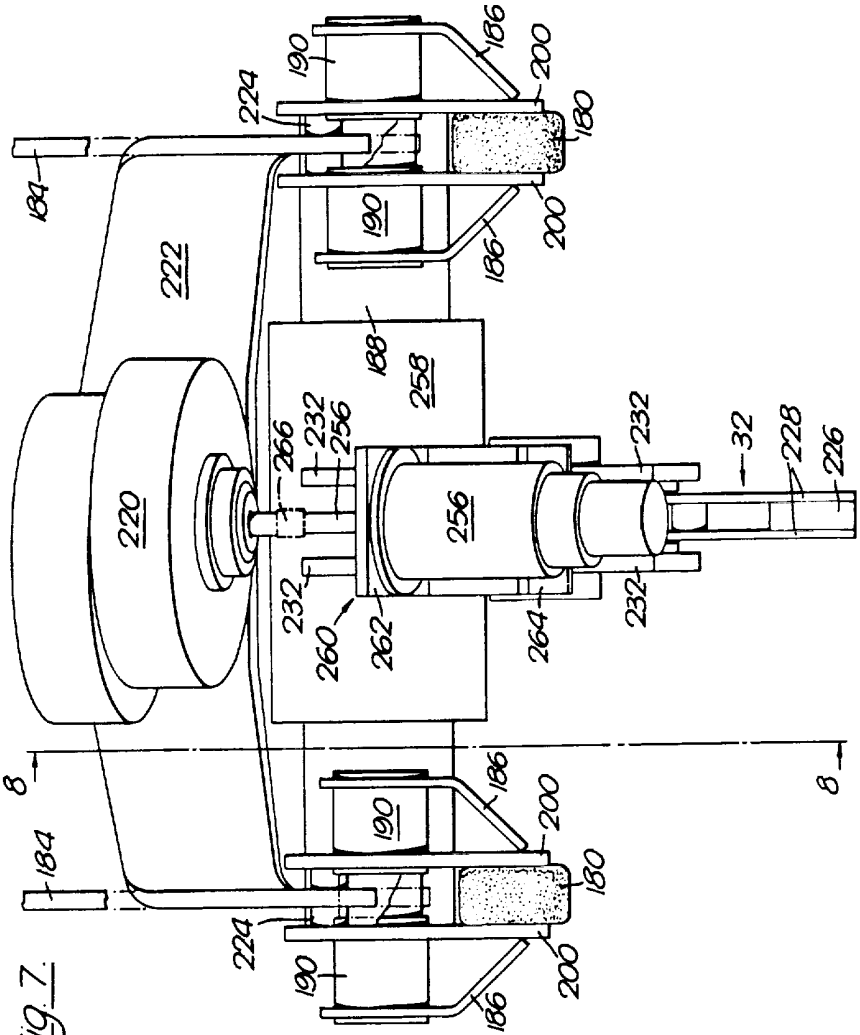

Fig. 7.

Fig. 8.

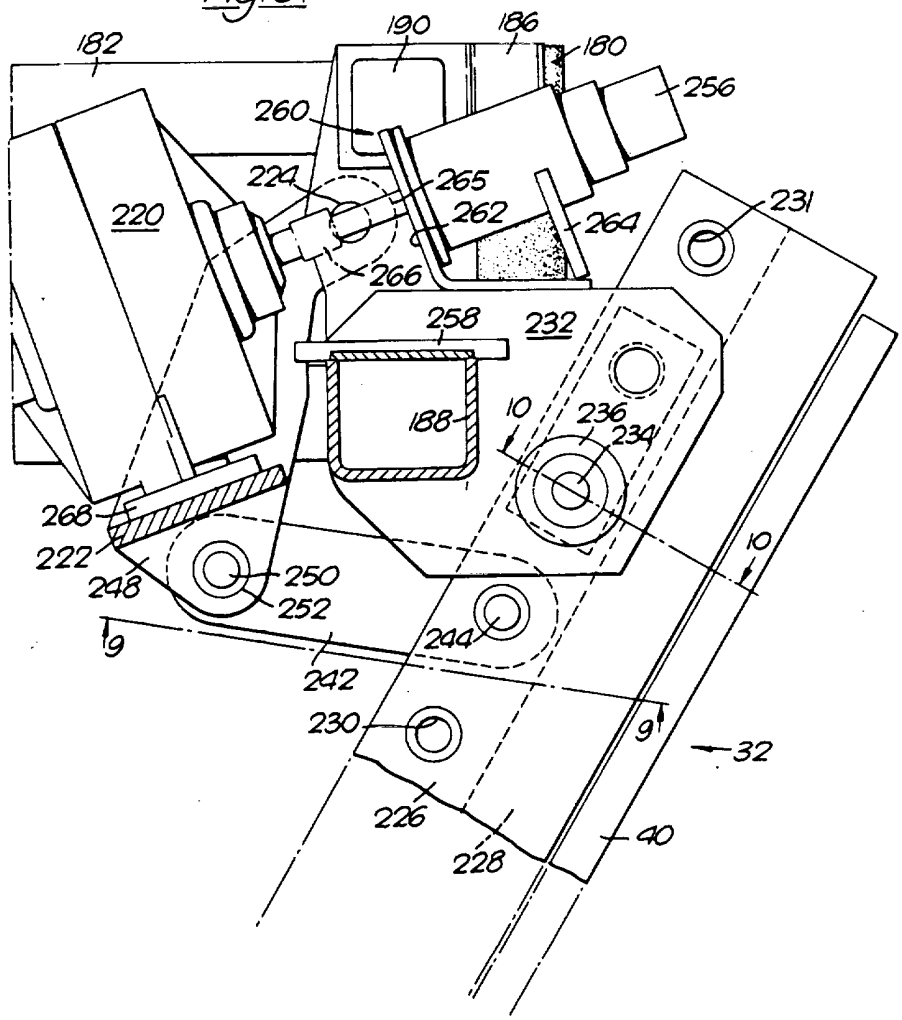
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Fig. 10.

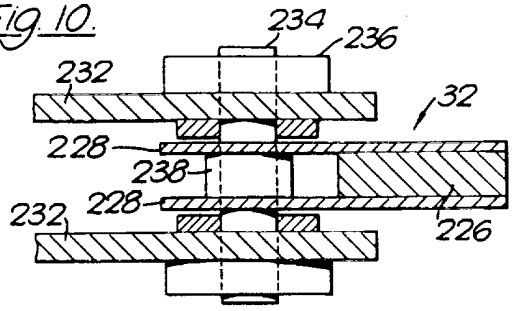
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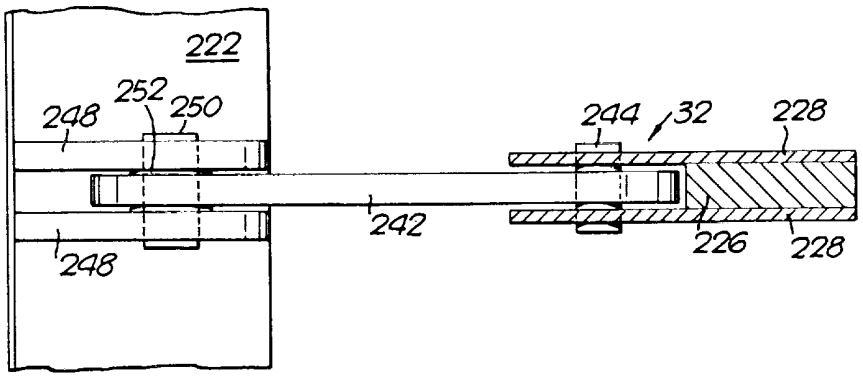
Fig. 9.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