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(54) Tractor pipelaying unit

(57) Improvements are made to prior tractors supported and driven by a rubber track (62) having bogie wheels (61) to increase the boom lifting capacity. The improvements include a main subframe having a loop-like structure which has a center section (74) extending under the tractor frame (70,72) midway between the front idler wheels (63) and rear drive wheels (65), two end sections (76,80) extending outwardly, one end section (76) supporting the drawworks (78) and the other end (80) supporting the tairlead (82). A rigid cross member extends from the fairlead (82) to the drawworks (78) and is positioned above the tractor frame (70,72) beneath the cab (106).

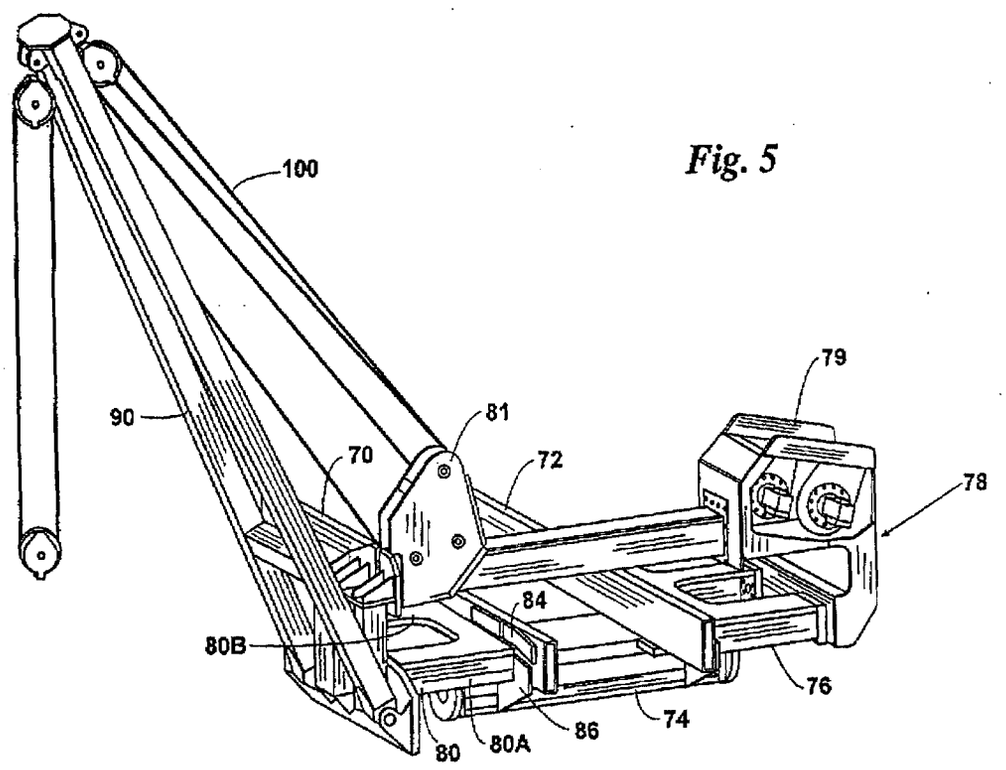

Fig. 5

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Description

BACKGROUND OF THE INVENTION

[0001] This invention relates mainly to a pipelayer and tractor for use in laying pipe in a previously dug trench. It relates especially to modifications of commercially available tractors to obtain a new and useful tractor with pipe laying attachments which improve load lifting capacities.

[0002] Pipelines are used throughout the country as a means of conveying products such as gasoline, gas, fuel, water and so forth from one location to a selected destination. A trench of selected size, width and depth is dug usually by use of ditching machines. After the trench has been dug a pipelaying apparatus follows which is usually self-propelled and is driven along the path of the trench. The apparatus has a pipe laying attachment attached to the tractor for lifting the pipe from the ground and lowering it into the trench. After the pipe is lowered and desired tests are made, the trench is then filled. As set forth in U.S. Patent 5,392,936 issued February 28. 1995 to Solomon et al, it is now a recent practice to use a tractor with a rubber track. One such tractor is a Caterpillar model CHALLENGER CH 65 factor manufactured and sold by Caterpillar incorporated of Peoria, III. This tractor can be driven down hard surfaced roads without damaging the road surface. A pipelayer apparatus is attached to this tractor. One such attachment that has been used is a Model M-20RT available from Midwestern Manufacturing Company of Tulsa, OK and is sometimes referred to herein as SL20RT.

[0003] In the type tractor just mentioned each side has a rear wheel which is the power wheel and a front idler wheel. A rubber track extends around these two and a bogie assembly holds the rubber track between the wheels to the ground. In this system the attachment which includes a drawworks assembly and a fairlead assembly are connected directly to the frame. On one side is the fairlead assembly and on the other side is a drawworks. These are aligned essentially with the front wheels. The boom is supported from the fairlead assembly. For an assembly such as the one just described there is a maximum load which is determinable for a particular boom and associated drawworks and fairlead assembly. I may call this a specific load limit. If this specific load limit is exceeded then the tractor may tip over or too much load might be placed on the front wheels and cause them to fail. Thus, it is quite obvious that the operators will take great care to see that the specific load limit is not exceeded.

[0004] It is an object of this present invention to modify a particular pipe laying tractor type unit to be an improved pipe laying tractor unit that has a boom load limit greatly increased over the prior pipelaying tractor unit for a basic tractor.

SUMMARY OF THE INVENTION:

[0005] I have made improvements to an existing Caterpillar CHALLENGER CH Model 70 tractor that greatly increases the load lifting capacity of the boom. In some cases the load limit for the boom has been calculated to be nearly doubled or more over the lifting capacity of the boom before our improvements were made.

[0006] I have a method of modifying a tractor unit to improve the boom lifting capacity over previous units in which that tractor has a tractor frame, a drive means on each side of the tractor frame, each drive means has a front and a rear wheel, a rubber track supported by the wheels and a bogie assembly inside the rubber track with bogie wheels riding against the inside of the rubber track when that part of the track is adjacent the ground.

[0007] I provide a special subframe including a center section and two end sections, one end section on each end of the center section. The center section is beneath the tractor main frame. The subframe is welded or otherwise rigidly supported from the tractor frame with the middle of the center section being aligned with a line drawn between the midpoints between the front wheel and the rear wheel on each side of the frame. A drawworks assembly is supported from and above one end section and a fairlead assembly is supported on the other end section. A boom is supported from the fairlead assembly. A rigid member is attached between the drawworks assembly and the fairlead assembly. Thus, the subframe ideally forms a more or less rectangular box, loop-like structure. This loop includes the center section which is under the tractor frame and the two end sections, the drawworks assembly, the fairlead assembly and the rigid member which are all connected into a rigid loop. Thus in our preferred embodiment them is a strudural loop through which the tractor frame extends. One benefit of this structure is that the tractor main frame is relieved of most of the torsional strain.

[0008] The boom hoist line extends beneath the cab from the drawworks along the rigid member to the fairlead assembly end around necessary pulleys to raise and lower the boom.

[0009] I also lock out the air springs of the bogie assemblies. More specifically, I remove the air spring and replace it with a rigid metal thus the bogie wheels are always held against the lower part of the rubber track. Thus the bogie wheels are always supporting a part of the load. I also lock the axle on the front wheel on each side of the tractor to the tractor frame so that the tractor front axle is prevented from oscillating.

[0010] One object is that by using our improvements I greatly improve the lifting capacity of a given tractor.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0011] Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in

which:

FIGURE 1 illustrates a front end view of a prior tractor pipelaying apparatus;
FIGURE 2 illustrates the right hand side of the prior tractor pipelaying equipment shown in Figure 1.
FIGURE 3 shows subframe structure of this invention with a loop-like structure;
FIGURE 4 illustrates the structure of Figure 3 in isometric form;
FIGURE 5 is an isometric view of the device of Figure 4 with the boom added;
FIGURE 6 is an isometric view of a pipelaying tractor showing the boom connected using the structure of Figure 3;
FIGURE 7 is similar to Figure 6 in that it shows the structure of Figure 5 mounted on a inventional tractor;
FIGURE 8 illustrates a bogie support arm with a lock out block to prevent wheel oscillation;
FIGURE 9 is similar to Figure 8 except that it shows an air spring instead of the lock out block;
FIGURE 10 is a view showing a block welded between the tractor frame and axle to prevent axle oscillation;

DETAILED DESCRIPTION :

[0012] Attention is first directed briefly to Figures 1 and 2 which illustrate in general the prior art and shows a typical pipelaying tractor on which applicant's improvements of this invention may be made. This explanation is brief, but is considered helpful in explaining the improvements and modifications which have been made.

[0013] Attention is first directed to Figure 1 which illustrates a front view of a representative conventional farm tractor such a Caterpillar® CH-65 which was originally designed primarily for use on large farms in the raising of agricultural products. As shown, this tractor has been equipped with a commercially available pipelayer such as Model M-30RT from Midwestern Manufacturing Company of Tulsa, Oklahoma for use in laying pipelines in trenches. Also shown in Figure 1 is a drawworks frame 10 and a boom 52. A boom line 12 is connected to boom winch 30 which is used to raise and lower the boom to and from the upright position to an extended position in which the boom is forced by gravity to rotate about pivot 54 which is supported from the frame of a tractor. The boom hoist line 12 extends over the boom block 24 and the tether line is connected back to the frame 13 in a normal manner. The boom 52 is provided with the top load line block 22 and a traveling block 26. A load line 20 extends from top load line winch 30 through a pulley 56 over the top load line block 22 and down to support the traveling block 26.

[0014] Figure 2 is a side view of the prior art devices of Figure 1 except that the boom, the boom line and the load line extension is not shown. This side view is of the side of the tractor opposite the boom support. Shown thereon is a drawworks frame 10, drawworks base frame 44, a boom winch 30, a boom line support 58 and a fuel tank 60 which extends horizontally coextensive with the length of rubber track 62. The conventional tractor shown in Figure 2 is also provided with a rear counterweight 64. There is also shown a front idler wheel 63 and a rear drive wheel 65 about which track 62 extends. These are aligned with similar wheels on the opposite side of the tractor. The drawworks frame 10 is supported from the tractor frame directly above front wheel 63. The fairlead assembly is likewise supported by the tractor frame above the front wheel on the opposite side of the tractor from that of the drawworks frame. Also shown is a bogie assembly 69 including air spring 67. A bogie assembly 69 with air spring 67 is provided to force the bogie wheels 61 downwardly against track 62.

[0015] Attention is now directed toward Figures 3 and 4 which show a subframe assembly, of this invention, which is attached to the frame 70 and 72 of a tractor. The main subframe assembly includes a center section 74 which has a first end section 76 and a second end section 80, all welded together. End section 76 is used to support the drawworks frame 78. Other end section 80 is secured to center section 74 such as by welding and supports fairlead frame 82. The center section 74 is supported from main tractor frame 70 and 72. Reinforcing blocks 84, 86 and blocks 84A and 86A are provided on the outside of tractor frame 70 and 72. A plate 88 is a part of center section 74 and is welded to each block 84, 86 and blocks 84A and 86A for each tractor frame 70 and 72, respectively. Boom 90 is supported from fairlead frame 82 at block 91.

[0016] Center section 74 has plates 92 and 92A which are placed adjacent the lower side of frame 70 and 72, respectively. Another plate 94 and 94A is on each end of the lower portion of the center section 74. Element 94 and 94A serves as a nut plate to which the bogie assembly is attached. Elements 96 and 96A are a plate welded to the end of the center section. The outer end of frames 80 and 76 are provided with bolt plate 98 and 98A which are welded to the sections 80 and 76, respectively. It is to this plate 98 and 98A that fairlead frame 82 and drawworks frame 78 are supported normally by bolting.

[0017] A rigid cross member 102 connects the fairlead frame 82 to the drawworks frame 78. As will be seen, cross member 102 is above tractor frame 70 and 72 and below the tractor cab.

[0018] Figures 3 and 4 show the subframe assembly of this invention which permits a given tractor to have a greatly increased boom load capacity. This design permits the weight distribution toward the center of the tractor, i.e., over the track assemblies. The tractor, in its prior state was nose (or front) heavy. This system, disclosed herein, can handle higher boom loads than before without tipping of the tractor toward the nose. As can be seen

this subframe assembly can be considered a loop-like boom load raising structure. This structural loop includes a main subframe which includes center section 74, one end section 80 and a second end section 76. End section 80 supports fairlead frame 82 and end section 76 supports the drawworks frame 78. A cross member 102 rigidly connects the drawworks frame 78 and the fairlead frame 82. Thus, there is a rigid subframe assembly. Center section 74 is supported from tractor frames 70 and 72. Support plates 84 and 86 are welded to the outer side of tractor frame 70. Likewise, support plates 84A and 86A are welded to the outside of tractor frame 72. Vertical plates 88 and 88A are welded at the lower end to center section 74 and at the upper end are welded respectively to plates 84 and 86 and 84A and 86A. Horizontal spacer plates 92 and 92A are on the top towards the end of center section 74 and are in direct contact with the lower side of frame 70 and 72, respectively. Plate 92 is the top plate of the center section and is welded to plate 84 and 84A which anchor the center section to tractor frame 70 and 72, Also provided are spacer bars 96 and 96A.

[0019] Center section 74 has a first end plate 94 and a second end plate 94A. End sections 76 and 80 are welded to center section 74. Other sound engineering methods may be used for rigidly securing center section 74 to end sections 76 and 80 to form the main subframe which is rigidly attached to the tractor frame member 70 and 72. As can be seen in Figures 3 and 4, this main subframe extends undemeath the tractor frame and is rigidly attached thereto. It can further be seen that end sections 76 and 80 are a part of the main subframe assembly.

[0020] On the left side of the structures of Figures 3 and 4 there is a fairlead frame assembly 82 which includes a fairlead 81 and a lower structure member 91 from which the boom 90 is supported. A bolting plate 98 is secured to the end of end section 80. The structure 91 is bolted to bolting pads 98.

[0021] The right side of the drawing shows a drawworks frame 78 and means for supporting it. This includes a bolting pad 98A which is similar to 98 and is secured to end section 76. The drawworks frame 78 is bolted to bolting pad 98A and the drawworks frame 78 supports winch box 79.

[0022] In order to complete the loop a rigid cross member 102 is bolted, or may be welded at one end to winch box 79 and at the other end to fairlead 81. As can be seen in Figure 7, cross member 102 is just beneath the cab 106. As can be seen in Figure 4, a boom hoist line 100 extends from winch box 78 in a channel (or cable tray) within cross member 102 up over fairlead 81 to the boom.

[0023] Center section includes center section 74 and a similar spaced apart section 74A as shown in Figure 4. Also seen in Figure 4, the end sections 80 and 76 in this embodiment shown are symmetrical shaped members.

[0024] The structural loop of Figures 3 and 4 is typically made of A36 steel suitable for the environment in which it is to operate. The sizes of the different components are such as to maintain a substantially rigid loop and strength for the design load using good engineering practices.

[0025] The cable tray (for boom hoist line 100) on the boom frame together with the structural loop of Figures 3 and 4 creates a "full circle" to carry the moment Stresses.

[0026] Attention is next directed to Figures 6 and 7 to illustrate the placing of the subframe assembly as shown especially in Figures 3, 4 and 5 on a tractor such as the aforesaid Challenger 65B. Figure 6 is an isometric view from the rear and boom side and Figure 7 is an isometric view from the front and drawworks assembly side. Idler wheel 110 and drive wheel 104 support rubber track 108. Arm 80A of end section 80 (is illustrated just under the rubber track 108) and connects end section 80 to fairlead frame 82. A boom 90 is supported from section 82 of the fairlead assembly. Boom hoist line 100 shown in Figure 5. Bogie wheels 116 are shown under the fairlead assembly area and this connection to the frame will be described later. A fender or stepping member 116 is supported from the tractor and is above the rubber track 108. Welding equipment 112 and 114 are generally supported on the front of a tractor in a normal manner. Drawworks assembly 78 and winch box 79 are also shown on the side of the tractor opposite the fairlead assembly.

[0027] Attention is now directed to Figure 7 which shows a bogie wheel assembly 120 as provided and indudes four bogie wheels 124 to 124N and this assembly has been provided with a lock out block 122 which now holds the bogie wheels 124 against the rubber track 108 to obtain more uniform load support by these wheels. As can be seen in these drawings, the subframe assembly is centered, and supported by the tractor frame, at about the midpoint between the drive wheel and the front idler wheel. As indicated in Figure 7 the center of the longitudinal axis of the cross member 102 is spaced at about the midpoint between the axis of the rear wheels 110 and 111 and the axis of the front wheels 104, 117. Stated differently, one end of cross member 102 is preferably at the midpoint between the axle of wheels 104 and 110 on one side of the tractor and the other end of cross member 102 is at the midpoint between the axle of wheels 111 and 117 on the other side of the tractor.

[0028] Attention is next directed to Figure 9 which shows a part of the main bogle support system for holding the bogie wheels against the drive belt 108 as the original equipment of the aforesaid Challenger 65B. This old system includes air spring tension arm 124 which is pivotally supported about pivot 126. Pivot 126 is supported from the tractor frame. A bogie support arm 128 is connected to the cradle or frame which holds the bogie wheels against the rubber track. An air spring 130 is positioned between the ends of tension arm 124 and

support arms 128. This system of Figure 9 was originally provided to the tractor to obtain an improved operator ride while providing some traction efficiency. However, when loading the boom to its upper limits in the system of Figure 9 a sufficient amount of track support was lost in the cushion effect of the air spring.

[0029] In order to require that the bogie wheels provide positive load support during the operation of the tractor such as that shown in Figures 6 and 7, the device of Figure 9 is modified to that of Figure 8. There are two major changes. One, the pivot 126 of the device in Figure 9 was rigidly supported from the tractor frame. Now pivot 127 is supported from a bogie frame which in turn is supported from a frame center section which includes center section 74, end section 76 and end section 80. The reason this change was made is the original or prior bogie wheel assembly axle was not sufficient to carry the load now imposed by the sideboom attachment and tractor. The other change in Figure 8 from Figure 9 is that the air spring 130 of Figure 9 has been removed and replaced by a lockout block 122. This lockout block 122 is typically a steel block welded between the arms 124 and 128. This prevents flexing. This results in a nearly positive loading in the original bogie wheels 124 to 124N. There are normally eight such bogie wheels on each side of the tractor.

[0030] Attention is next directed to Figure 10. Shown thereon is a portion of the tractor frame 144, the wheel axle 140 and track 142. In accordance with my invention, I normally lock the axis 140 to the frame 144 by use of lock 146. This lock is preferably in the shape of an angle iron or ninety degrees. This block 146 is welded to the axle 140 and to the tractor frame 144. This gives greater stability when upper loads are placed on the boom. This locking of the axle on the front wheel on each side of the tractor is to prevent oscillation. This adds stability.

[0031] Calculations have indicated that by use of my invention, such as the various features described above, on a type tractor such as the CH65 and CH70, I can nearly double or more the load limits on a given pipelaying tractor unit of the prior art such as the tractor Caterpillar Model Challenger CH 65 and the pipelayer apparatus attachment described as Model M20RT described above.

[0032] Thus, it is apparent that there has been provided, in accordance with the invention. an improved tractor pipelaying unit that fully satisfies the objects, aims and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art and in light of the foregoing description. Accordingly, it is intended to embrace all such altematives, modifications and variations as fall within the spirit of the appended claims.

[0033] Tipping calculations are shown below.

Tipping Capacity Calculation Results

[0034] This Challenger Series of Agricultural tractors includes the previously mentioned models, Challenger CH65 and CH70 (which are rubber track Crawler tractors) and which have similar designs. The CH70, modified in accordance with my invention including locking out the bogies and use of the sub-frame assembly, may be labeled SL40RT. Calculations for the tipping capacity of the SL40RT are shown on the Tipping Calculations Exhibit. Dimensional values are explained here as well.

[0035] In order to understand the calculations and assumptions that must be made, it is necessary to understand the definitions that govern the ratings of side booms. SAE J743b contains the recommended definitions for tipping that govern the load ratings given to side booms and pipe layers. SAE is the Society of Automotive Engineers. In looking at paragraph 2.12 of the above mentioned recommended definitions, it is found that the definition for tipping of a Crawler tractor is

The load on the hook that the machine will lift at a given load overhang distance without causing any track roller of the track opposite the boom side to lift more than 1/4 in from the track link at point G.

[0036] Point G is indicated in a figure included in SAE J743b.

[0037] In paragraph 2.13, we find the definition for tipping for a wheel tractor.

The load on the hook that the machine will lift at a given load overhang distance without causing a tire on the side opposite the boom to lift more than 1/16 in from the test surface.

[0038] The Challenger is neither a steel track Crawler tractor, nor is it a wheel tractor, but in keeping with the spirit of the intent of these definitions,the tipping definition of the Challenger rubber track type tractors should be:

The load on the hook that the machine will lift at a given load overhang distance without causing a tire, wheel, or roller on the side opposite the boom to lift more than 1/4 in from the inside of the rubber track, or without causing the rubber track to lift more than 1/4 in from the test surface.

[0039] This definition is a self-imposed definition, as the SAE definition does not specifically cover this type of tractor.

[0040] The following are the assumptions that are made in order to arrive at the tipping value that is shown in the Exhibit.

- The full counterweight side of the tractor rises at the same time.
- As pad of the previous assumption, the bogies must be locked out (locking out the bogies is taught above in my invention disclosure).
- The values placed on the weights and locations on the exhibit are assumed.

Summary of Calculations

[0041] In actual practice, these assumptions are not entirely correct, and the actual tipping capacity of the SL40RT will be a fraction of that value that is shown in the Exhibit. However, with appropriate modifications, that fraction will closely match the value given in this Exhibit. The tipping capacity is shown at over 47,000 pounds. This assumes capacity is based on proven formulas that have been developed and used throughout the industry to calculate the potential lift of a given tractor equipped with a specific pipelayer attachment.

[0042] In the case of the previously produced models of the SL20RT, physical tests were conducted on the units. These units did not lock out the bogies. The tests showed that the condition of tipping (lifting of any wheel) of the SL20RT was accomplished at approximately 20,000 lbs.

[0043] The new SL40RT (using the invention disclosed herein) will have the bogies locked out.

Claims

1. A subframe assembly for supporting a boom on a tractor which has a tractor frame, a driver cab, a support means on each side of said tractor frame for supporting said tractor from the ground;
said subframe assembly comprising:
a main subframe having

(i) a center section positioned under said tractor main frame and supplied therefrom;
(ii) two end sections, one on each end of said center section;
(iii) a draw works assembly supported from one end section; and
(iv) a fairlead assembly supported from the other end section.

2. A subframe assembly as defined in claim 1 including a cross member connecting said drawworks assembly and said fairlead assembly, and positioned below the cab and above the tractor frame.

3. A subframe assembly as defined in claim 1 including a boom hoist line under said cab and above said tractor frame.

4. A subframe assembly as defined in claim 1 in which said tractor has a drive means on each side of said tractor frame, each drive means having a front and a rear wheel, a rubber track supported by said wheels, a bogie assembly within said rubber track for holding the bogie wheels down, said bogie assembly rigidly supported from said tractor frame.

5. A subframe assembly as defined in claim 1 including a boom arm supported from said fairlead assembly.

6. A subframe assembly as defined in claim 1 in which the tractor has front wheels including means to lock the axle in a fixed position to prevent oscillations.

7. A subframe assembly as defined in claim 1 in which said center section is positioned directly under said cab.

8. A subframe assembly as defined in claim 1 for use with a tractor in which the tractor has drive means on each side of said tractor frame, each drive means having a front and a rear wheel, a rubber-like track supported by said wheels and in which the middle of said center section is aligned between the approximate midpoints between said wheels on each side of said tractor frame.

9. A method of modifying a tractor to improve its boom lifting capability in which the tractor has a tractor frame, a drive means on each side of said tractor frame, each drive means having a front and a rear wheel, a rubber track supported by said wheels, a bogie assembly inside said rubber track and having bogie wheels riding against the inside of said rubber track when that part of the track is adjacent the ground, said bogie assembly further including a subassembly having an air spring for urging the bogie wheels downwardly toward the track, the modification comprising the following steps

providing a subframe including a center section and two end sections, one end section on each end of the center section,
attaching the center section to the tractor frame and positioned on the under side thereof with one end section extending outwardly from said center section on one side of said tractor frame and the other end section extending outwardly from the other side of said tractor frame;
supporting a drawworks assembly on one end section and a fairlead assembly on the other end section;
supporting a boom from the fair lead assembly.

10. A method as defined in claim 9 including the step of locking out the air springs so that they are ineffective.

11. A method as defined in claim 9 in which each front wheel is an idler wheel including the step of locking the axle of the front idler wheel on each side to the tractor frame so that the axle of the idler wheel is prevented from oscillating.

12. A method of modifying a tractor to improve its boom

lifting capability in which the tractor has a tractor frame, the modification comprising the following steps:

providing a subframe having a center section and two end sections, one end section on each end of the center section;
rigidly attaching the center section to the underside of the tractor frame with one end section extending outwardly from said center section on one side of said tractor frame and the other end section extending outwardly from the other side of said tractor frame and extending outwardly therefrom;
rigidly attaching said one end section with the other end section by means including a rigid member extending above said tractor frame from one side to the other thereof.

13. A method as defined in claim 12 including the steps of:

supporting a drawworks assembly on one end section and supporting a fairlead assembly on the other end section.

14. A subframe assembly for supporting the boom of a tractor which has a tractor frame and a driver cab supported by said frame
said subframe assembly including
a main subframe having

(i) a center section positioned under said tractor main frame and secured thereto;
(ii) two end sections, one on each end of said center section and extending upwardly and outwardly therefrom.

15. A subframe assembly as defined in claim 14 including means connecting the upper ends of said two end sections, including at least a rigid member extending across the top of said tractor frame
said center section, said two end sections and said connecting means to form a complete loop.

16. A subframe assembly as defined in claim 15 wherein said connecting means includes a drawwork supported from one end of said one end section and a fairlead supported on the end of the other end section.

17. A subframe assembly as defined in claim 16 including a boom supported from said fairlead section.

18. A subframe assembly as defined in claim 16 including a boom hoist line extending under said cab and above said tractor frame.

19. A subcombination for use with a tractor having a frame, a driver cab, a drive means on each side of said tractor frame, each drive means having a front and a rear wheel, a rubber track supported by said wheel and a bogie assembly within said rubber tracks for holding bogie wheels down against said rubber track, the combination which comprises:

a fairlead assembly supported on one side of said frame at about the midpoint between the front and rear wheel on that side;
a boom supported from said fairlead assembly;
a drawworks supported on the other side of said frame from said fairlead assembly at about the midpoint between said front and rear wheels on that side;
a boom hoist line running above said tractor frame and below said cab.

20. A combination as defined in claim 19 including a cross member connecting said drawworks assembly and including said fairlead assembly and positioned below the cab and above the tractor frame.

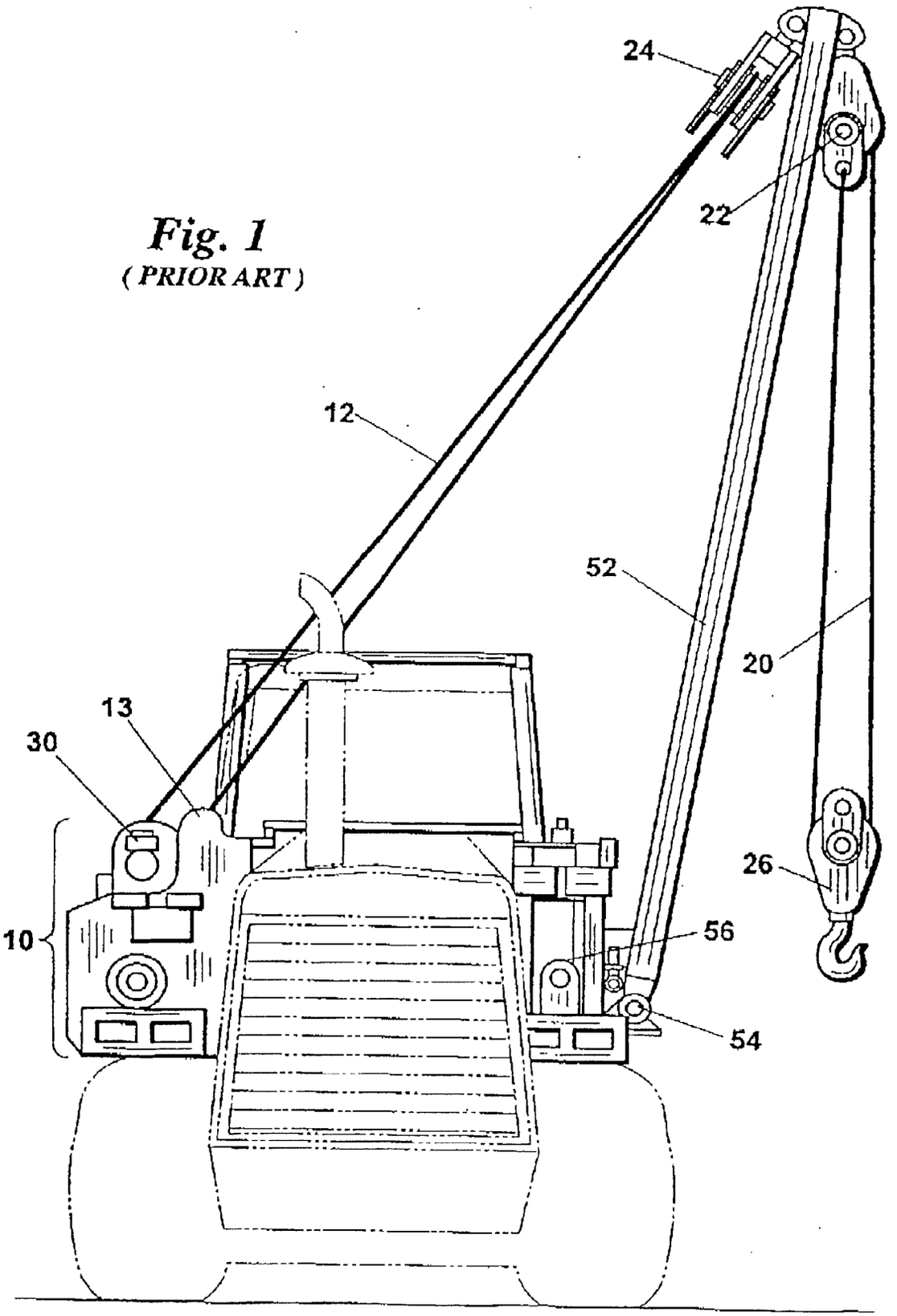

Fig. 1
(PRIOR ART)

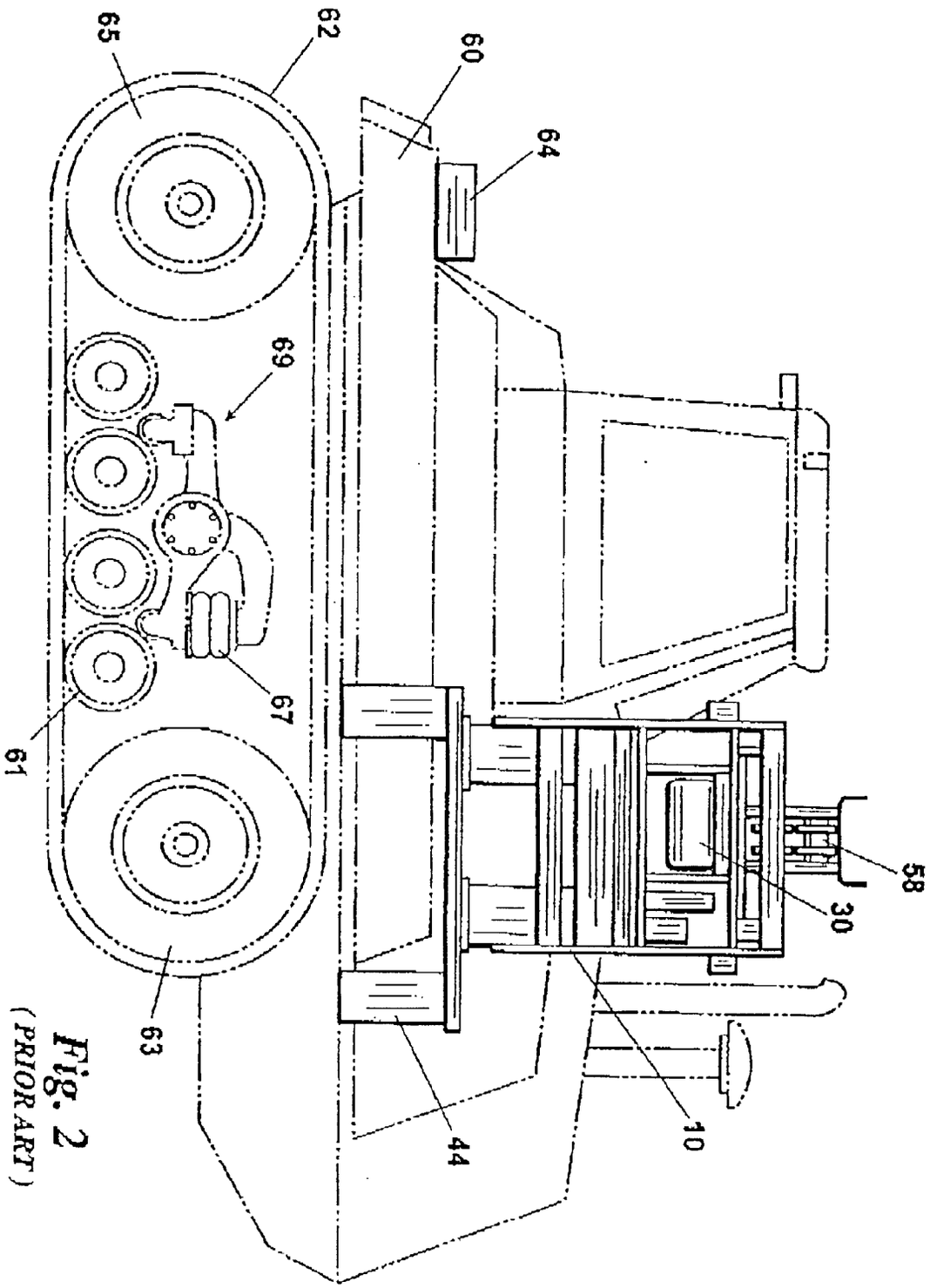

Fig. 2
(PRIOR ART)

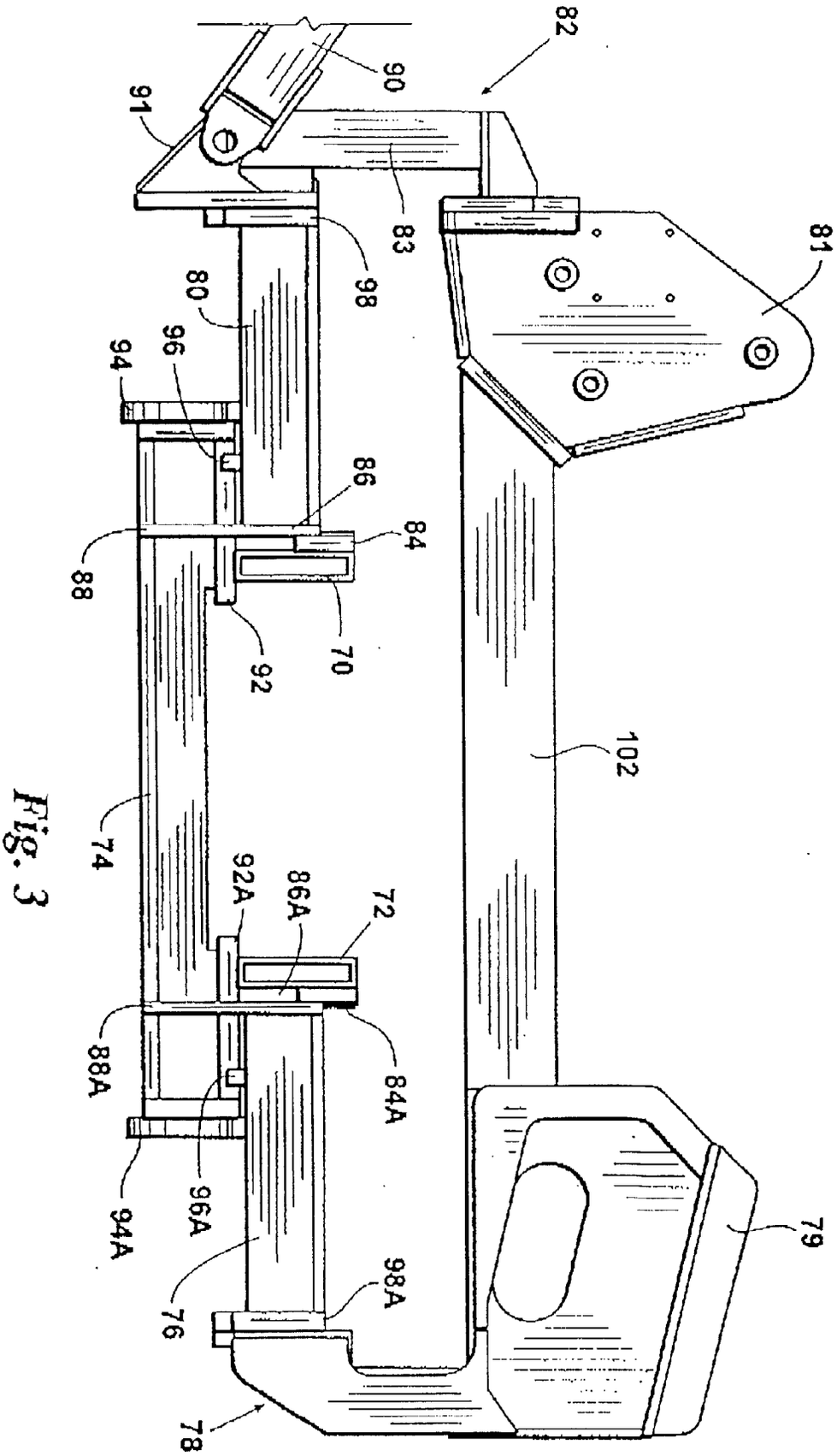
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Fig. 3

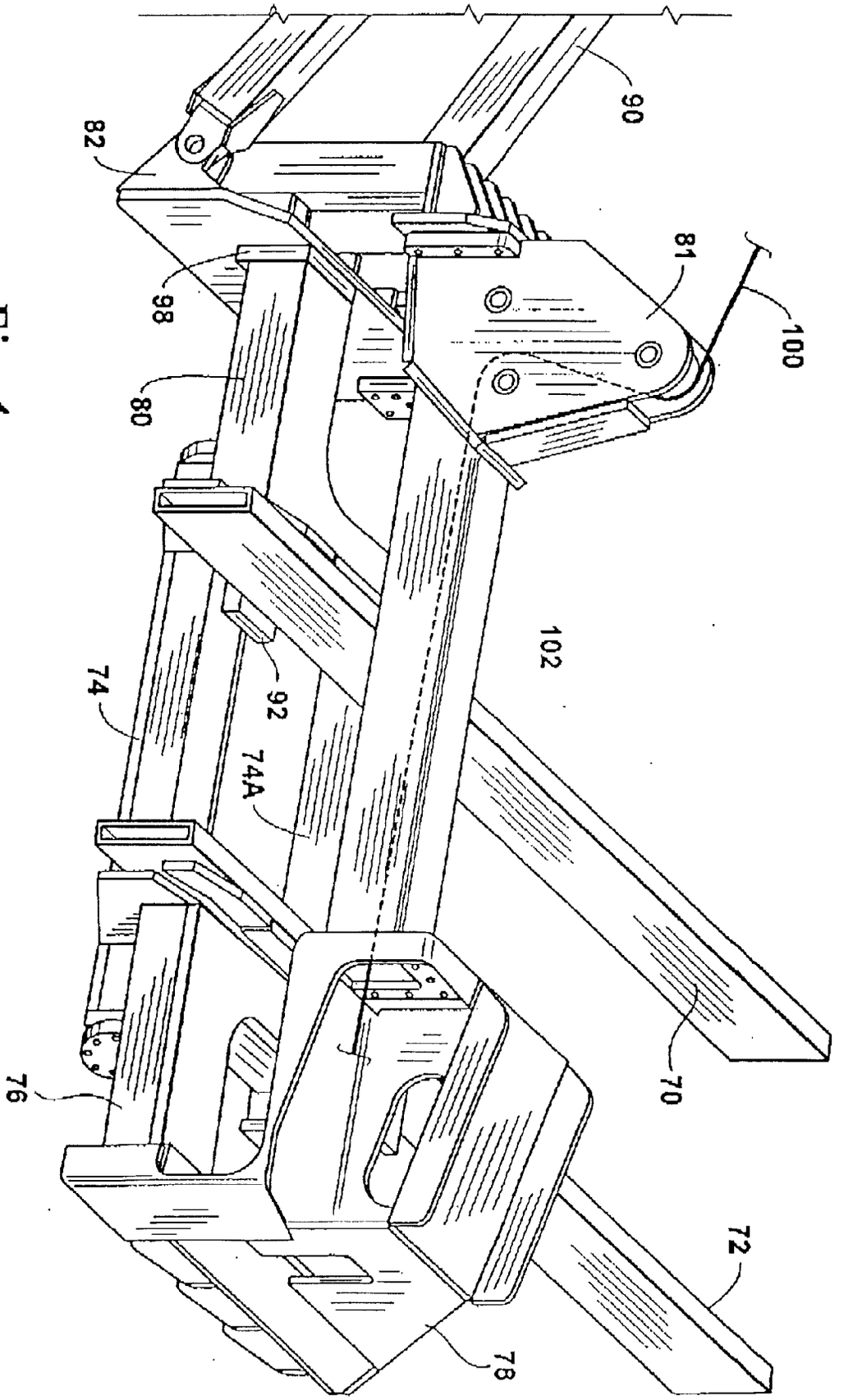


Fig. 4

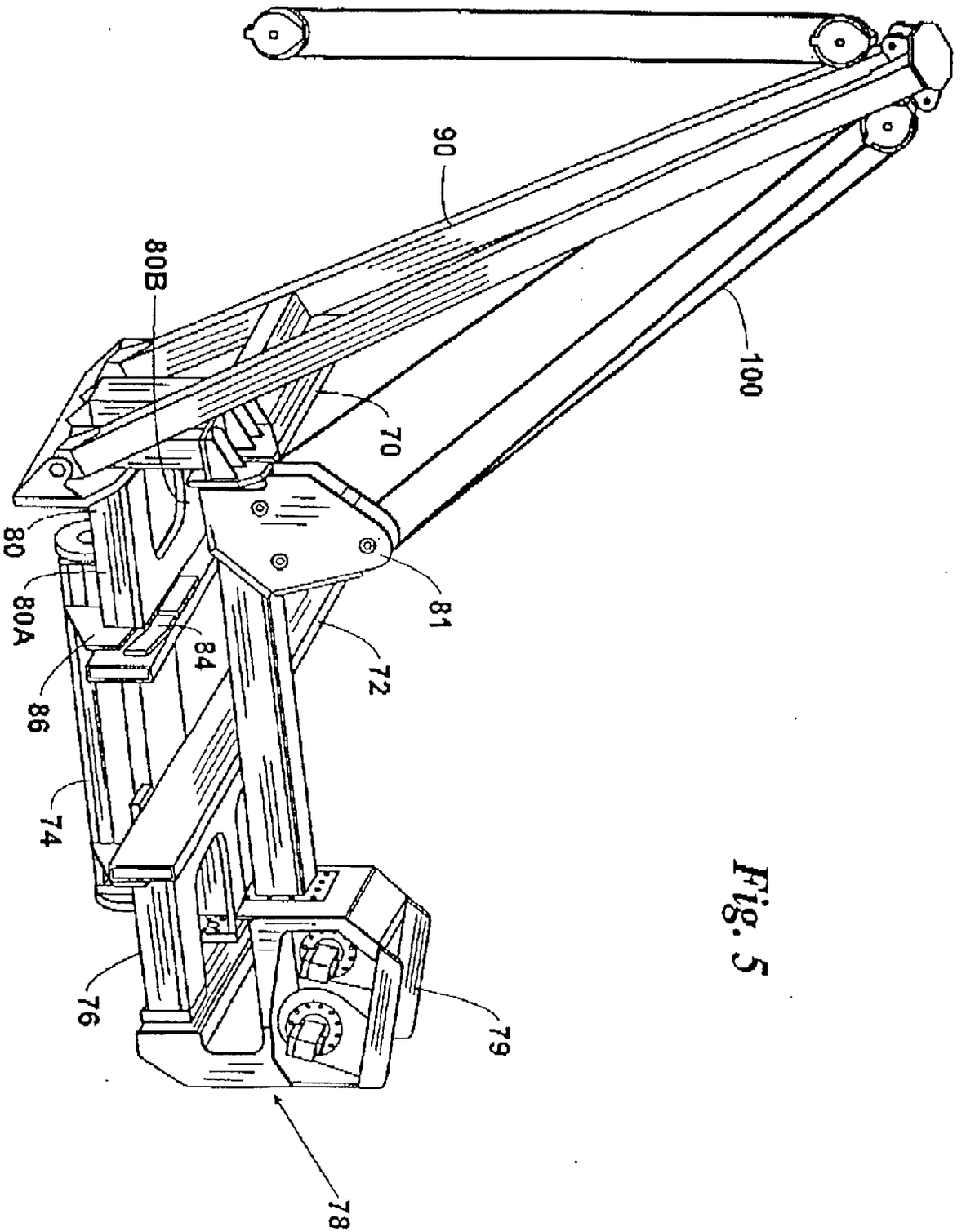


Fig. 5

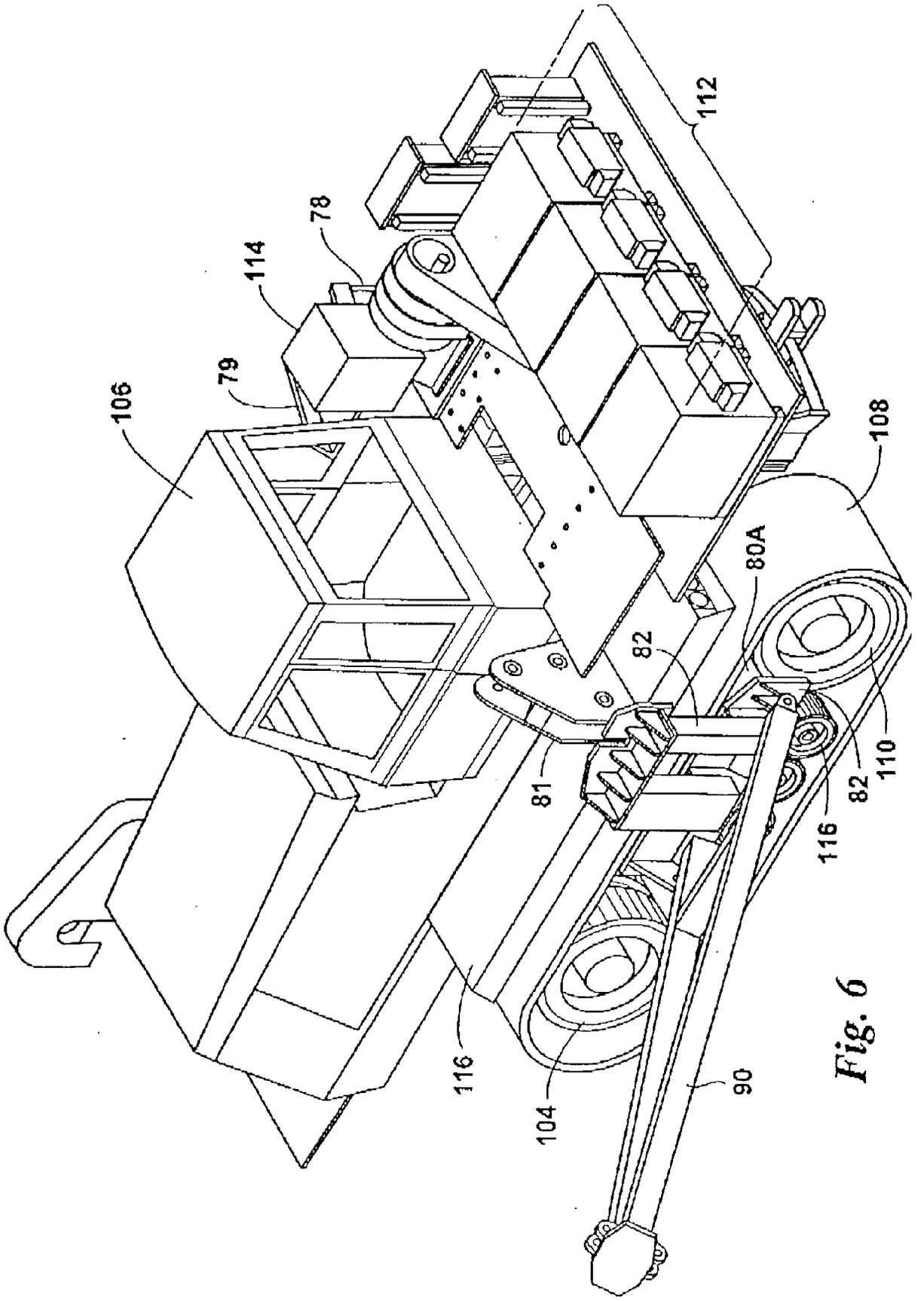
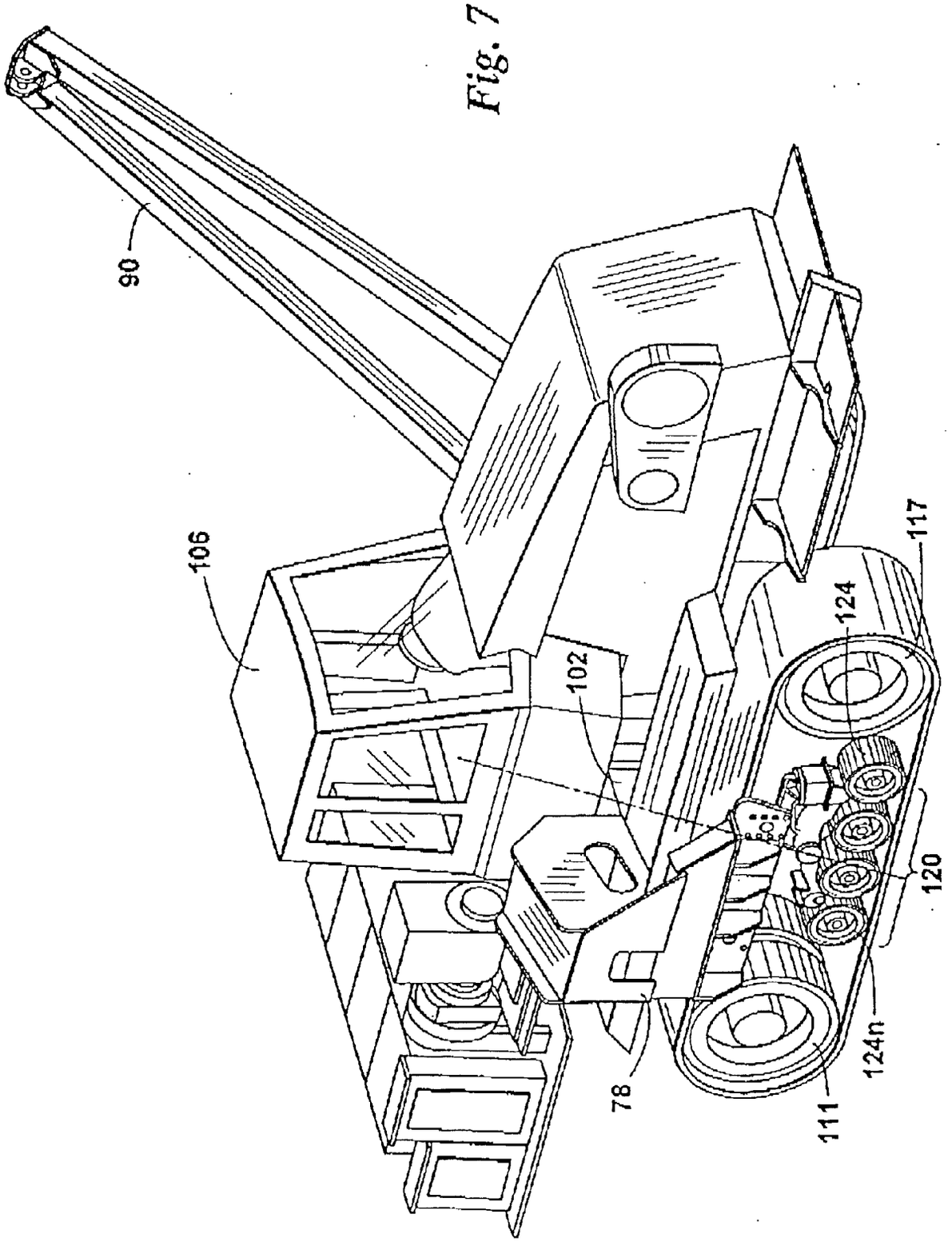


Fig. 6

Fig. 7



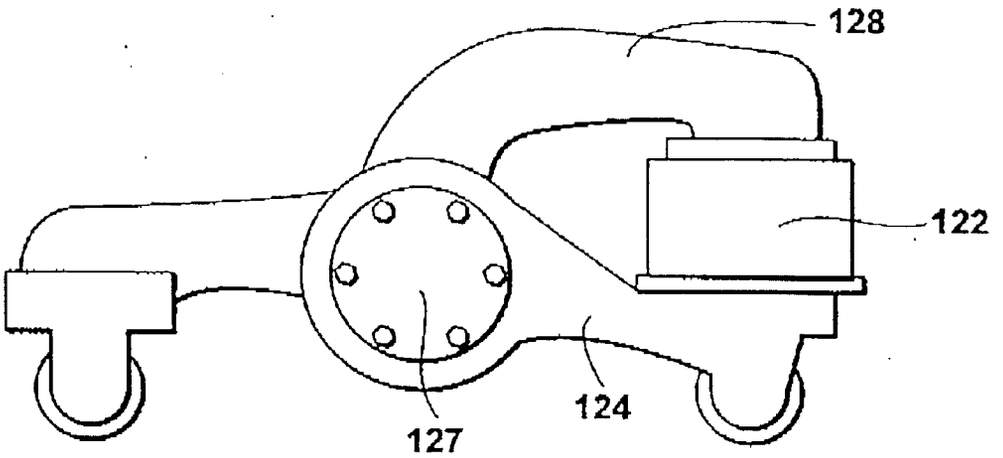


Fig. 8

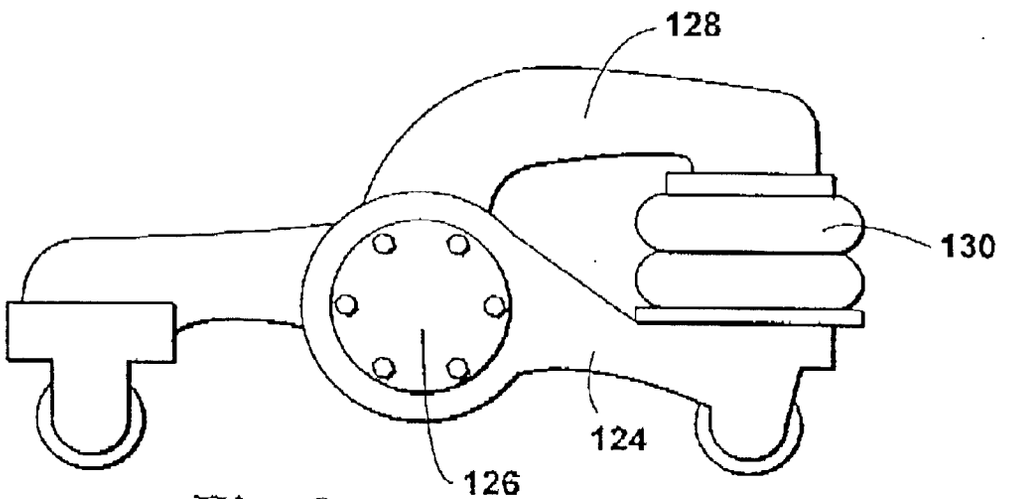


Fig. 9
(PRIOR ART)

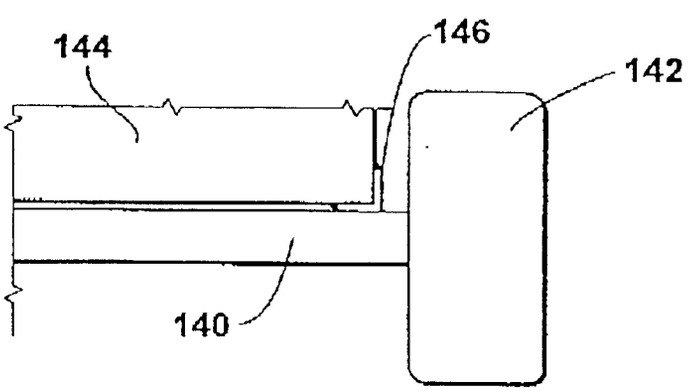


Fig. 10