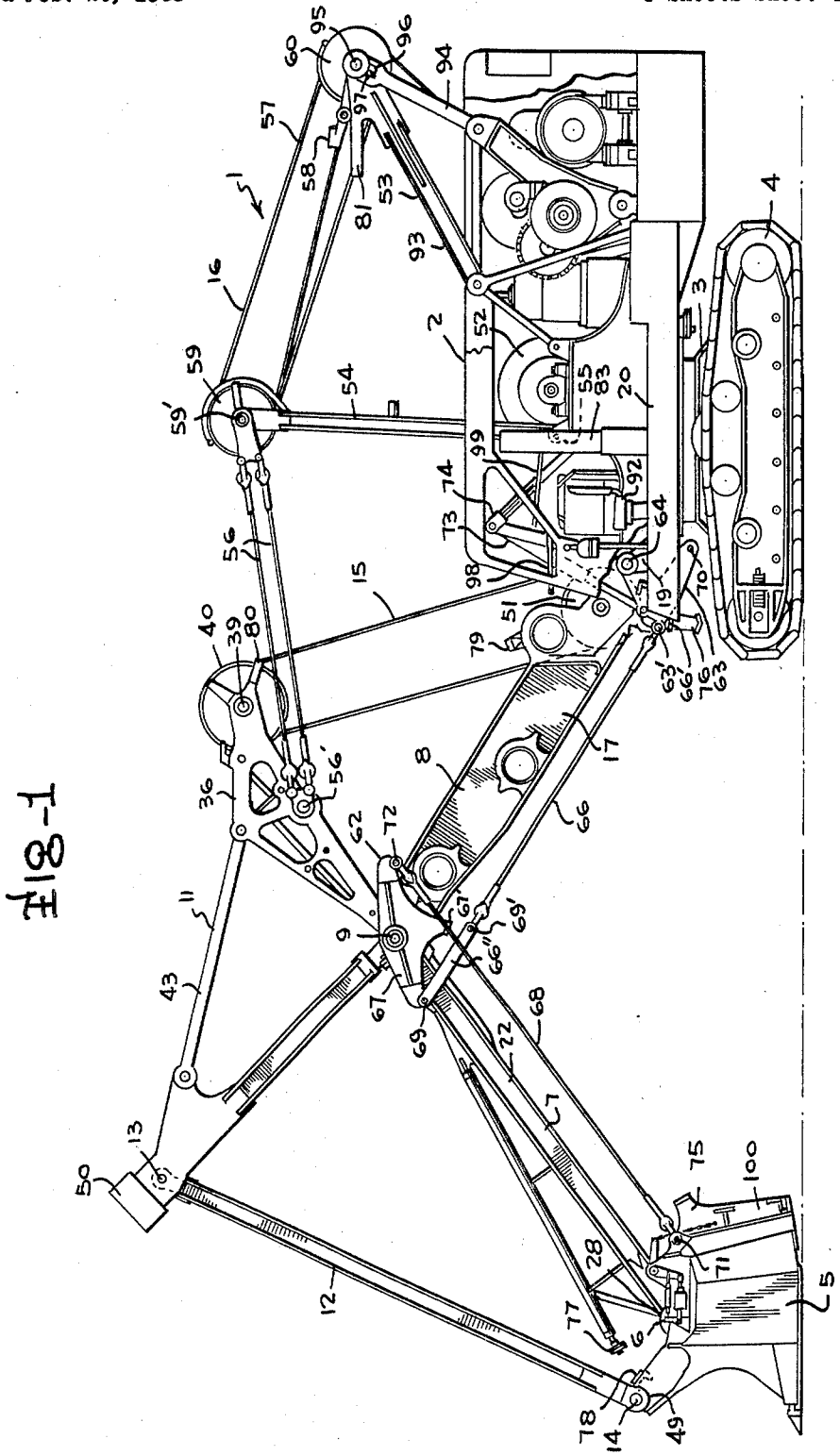
March 17, 1970 G. B. BARON 3,501,034

POWER SHOVEL

Filed Feb. 29, 1968 5 Sheets-Sheet 1



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POWER SHOVEL

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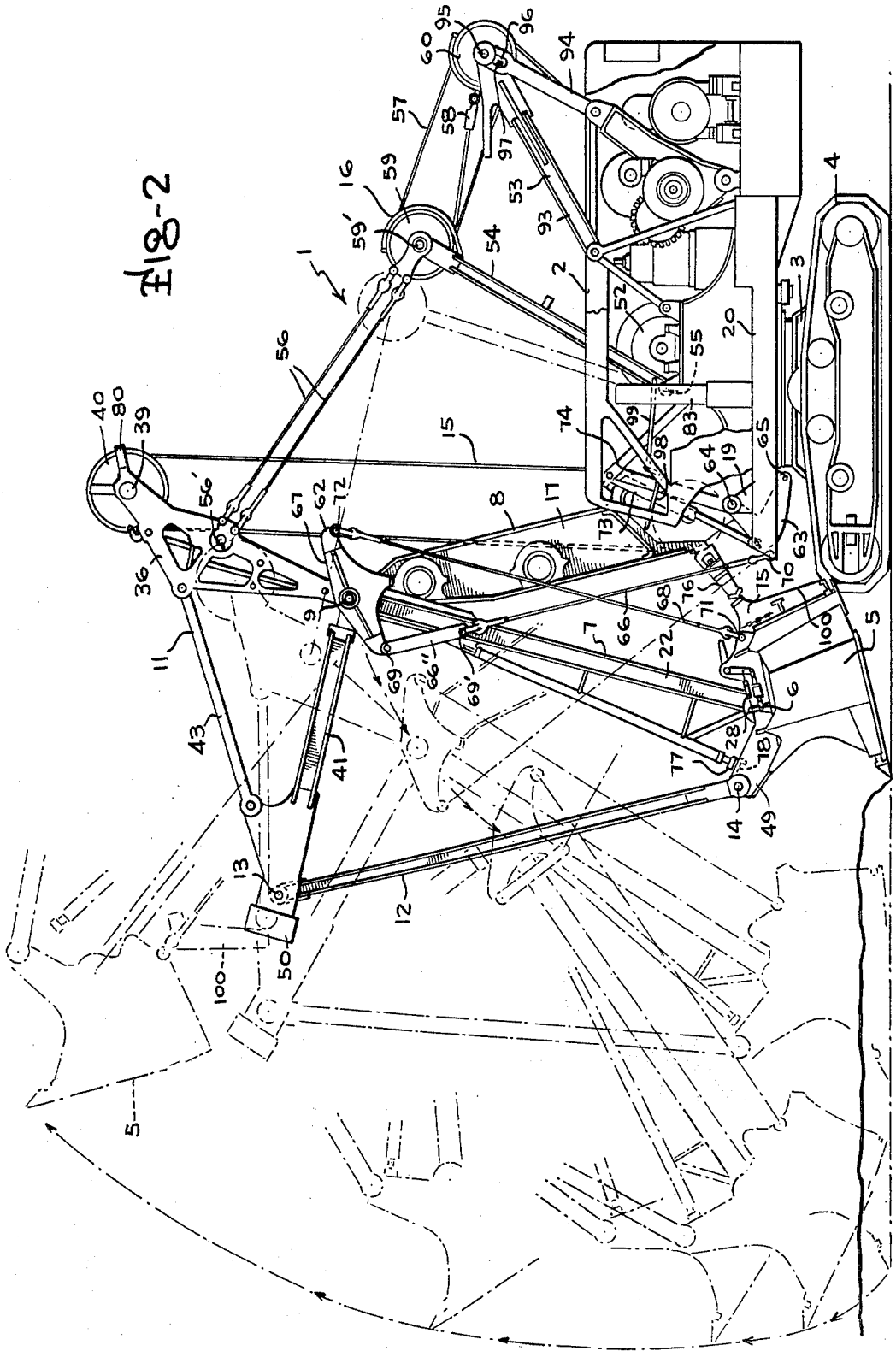

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POWER SHOVEL

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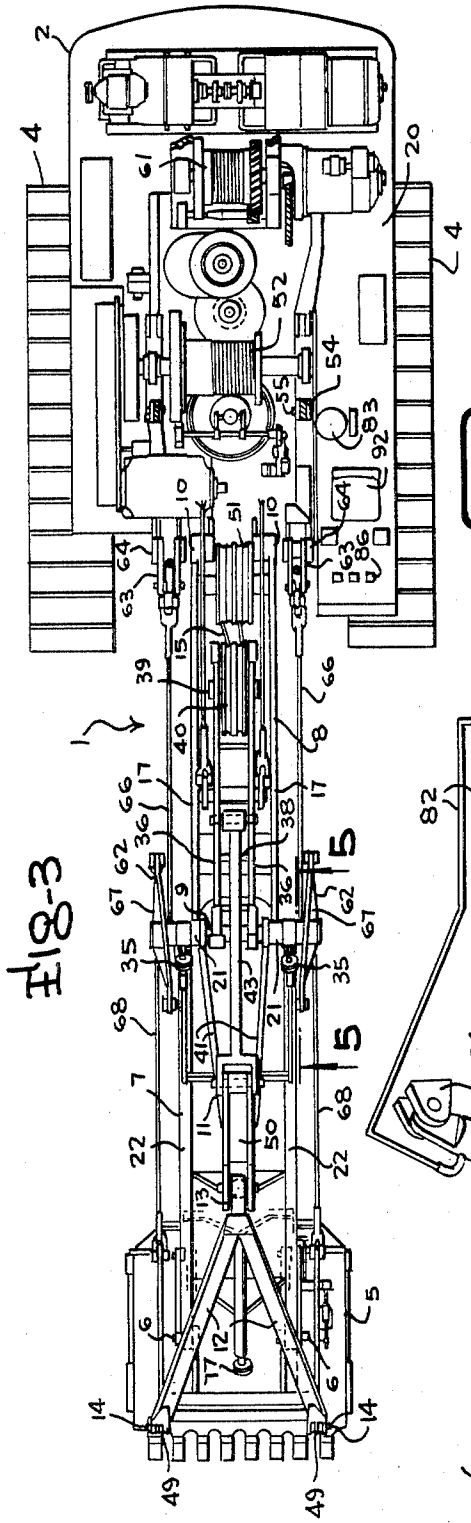

FIG 3

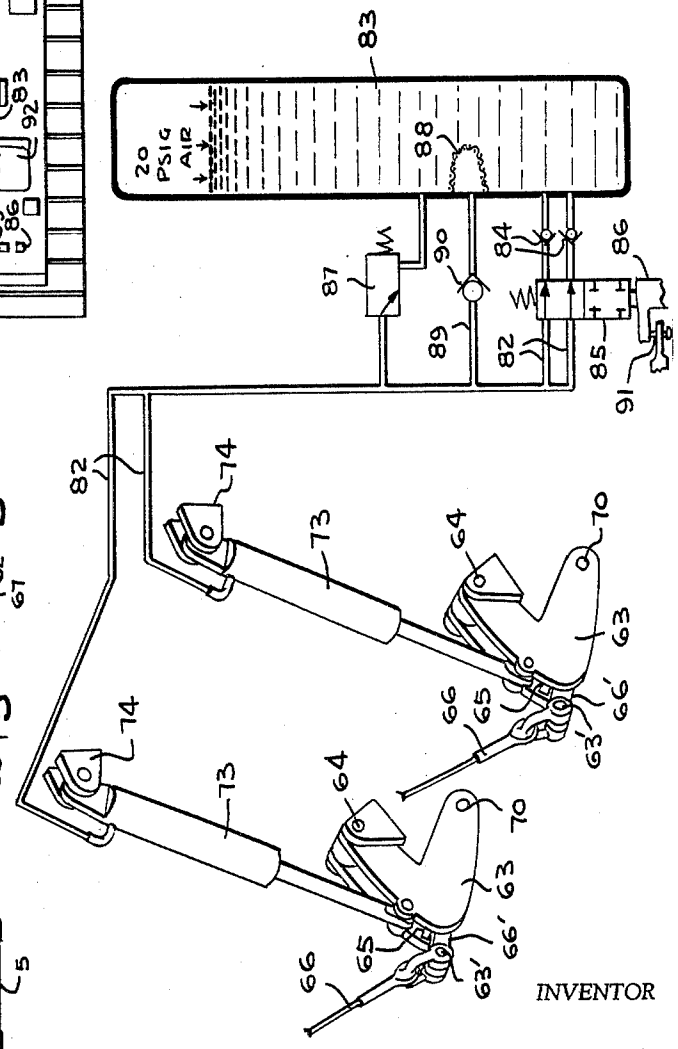

FIG 4

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Fig-5

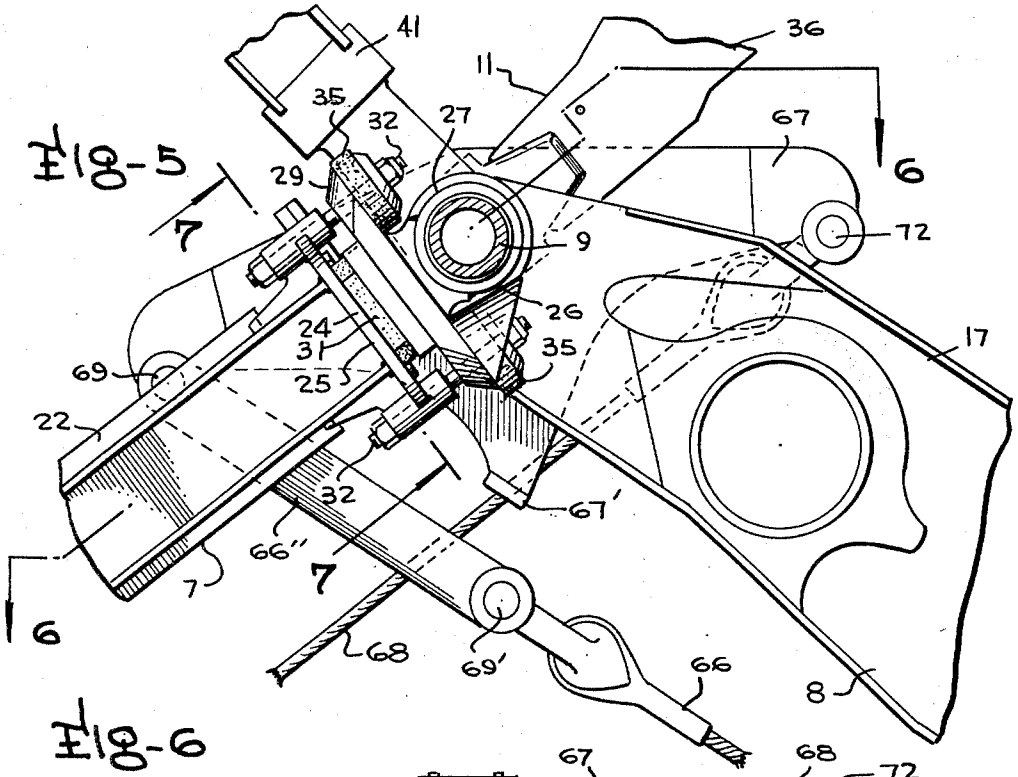
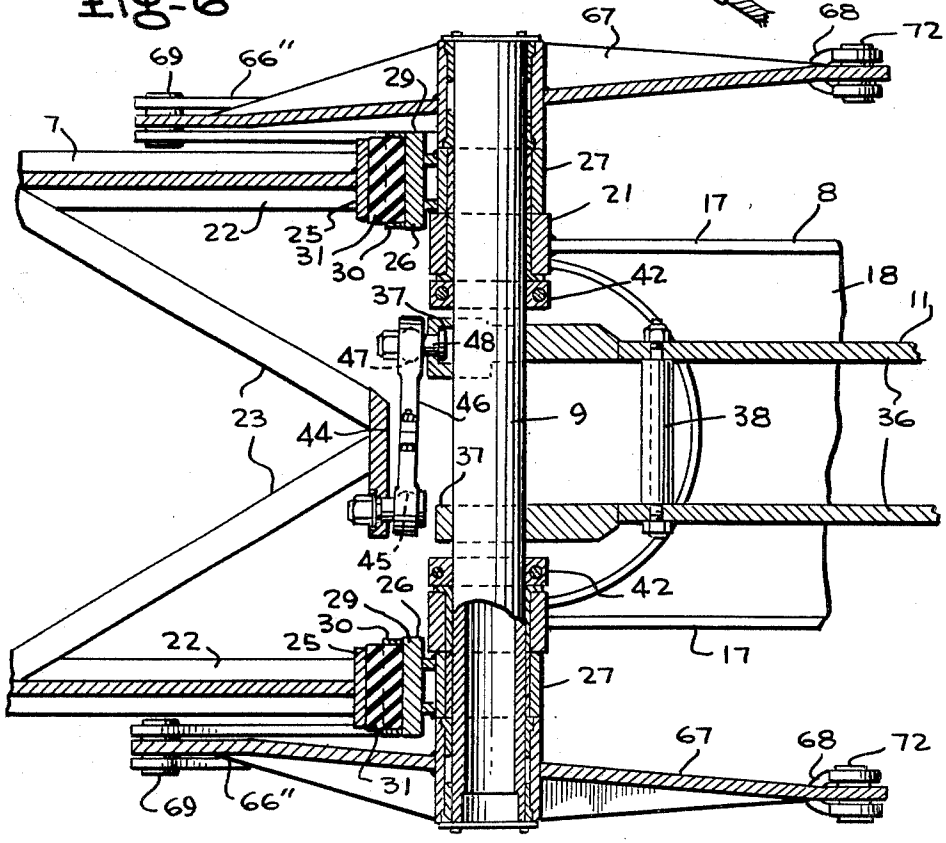


Fig-6



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POWER SHOVEL

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Fig-7

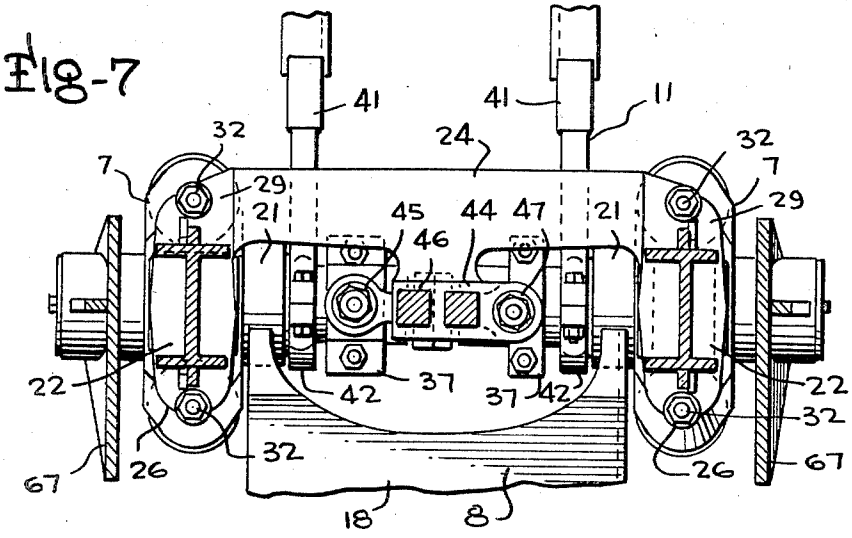
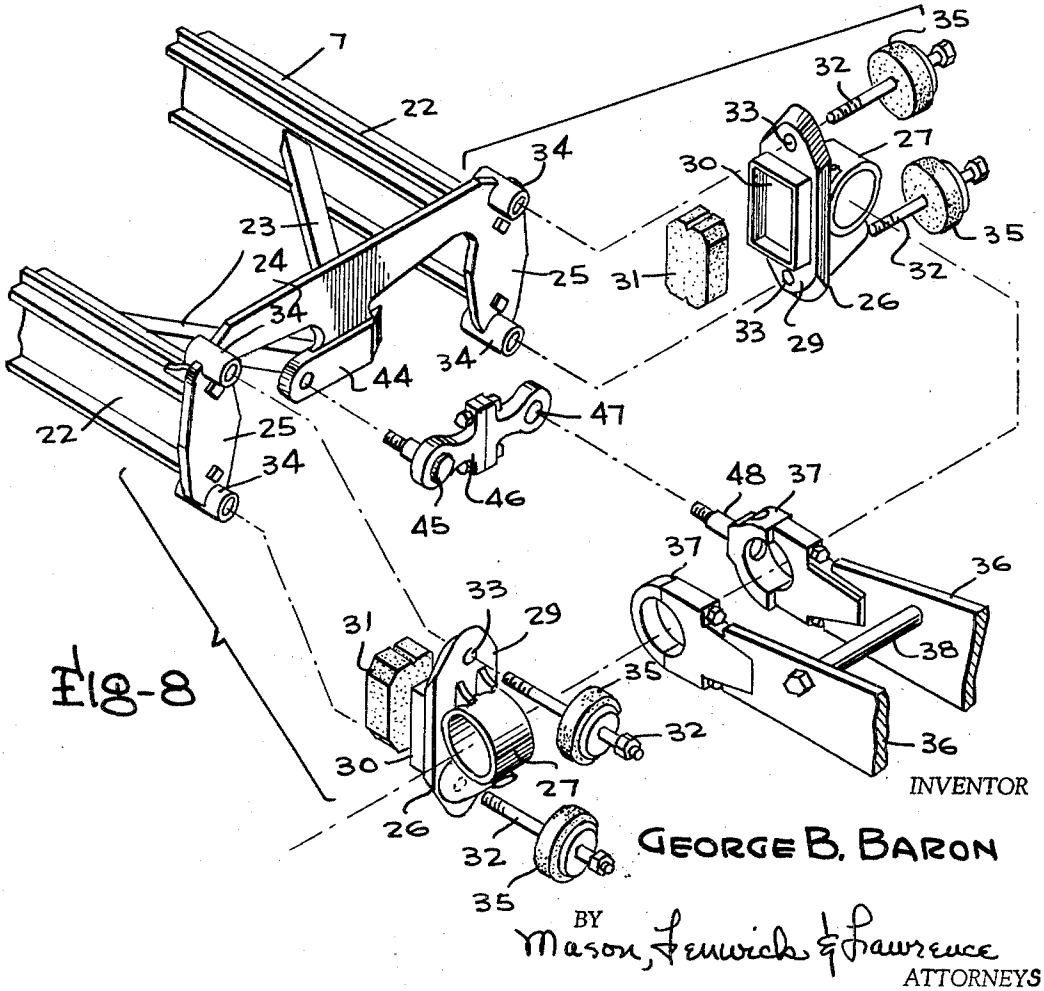


Fig-8



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3,501,034

POWER SHOVEL

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Int. Cl. E02f 3/62, 3/30, 3/38
U.S. Cl. 214—138 14 Claims

ABSTRACT OF THE DISCLOSURE

A revolvable power shovel for low bank digging, wherein the dipper can follow a long horizontal path during a digging stroke by reason of being mounted on a handle pivotally connected at its top to stiffleg which, in turn, is pivotally mounted at its base to the machine. Means permit simultaneous outward pivotal movement of the stiffleg and forward pivotal movement of the handle to give a straight-line movement to the dipper. A control pantograph linkage permits holding the dipper pitch during a digging pass. A pivoted mast is included as part of the crowd mechanism.

BACKGROUND OF THE INVENTION

This invention relates to revolvable power shovels which are particularly adapted to digging horizontally in low banks of material.

It is frequently necessary to excavate material which is only a foot or two high. This is true particularly in strip-mining of thin seams of coal. This condition is also found at times in quarrying, or other open-pit loading operations, as well as in stock piling and other similar jobs.

Efficient operation of a conventonal power shovel is not possible in the above mentioned situations. The conventional shovel carries its bucket, or dipper, on a pivoted handle, and the bucket moves through a prescribed arc in digging. Consequently, the bucket enters the ground on a down swing, reaches horizontal position, and begins its upswing almost as soon as a horizontal position is reached. Normally, the actual effective horizontal stroke of the dipper is of the order of one bucket length when digging material which is one foot thick. This results in only partial filling of the bucket and a very inefficient use of the shovel. The only way in which a full bucket can be obtained is to dig deep into the earth to take the benefit of the full arcuate swing.

The so-called knee-action machine gives a little longer effective horizontal digging operation in practice. The advantages are gained by being able to start the operation with the dipper teeth pitched down at a small angle, and by having a slower bucket pitch-up after the maximum clean-up is reached, since the upper end of the handle is moving out. This, in effect, gives a longer stroke, and results in greater loads in low bank digging.

The use of variable pitch dippers with conventional shovels was an attempt to increase the horizontal digging stroke. These, however, had two problems, the transmission of power out to the handle just behind the dipper, and the requirement that the operator devote much of his time and attention to precise pitch control.

Other attempts to solve this problem have been made by using front end loaders, and similar machines, but these have disadvantages of small size and compulsory use of double acting operating mechanisms with their attendant maintenance problems. In addition, most have used a downward pitching action of the dipper to dump, thus limiting the dumping speed.

SUMMARY OF THE INVENTION

The general object of the present invention is to provide a revolvable power shovel for use in low bank operations with means of mounting the dipper to permit long horizontal digging movements.

A more specific object is to provide a shovel of this kind wherein power for both digging and lifting comes mainly from the hoist, which continues to take up more or less constantly from the starting to the dumping positions.

An important object of the invention is the provision of a shovel which is capable of a long horizontal dipper stroke and has only single-acting primary motions, such as simple wire rope drives for hoist and crowd.

Another object is the provision of a machine of this type wherein the elements mounting the dipper are so arranged that their weight assists the digging action to produce a self-crowding effect.

A further object is to provide such a shovel with almost the entire moment of the weight of the front end equipment available to assist in applying downward force to the dipper teeth so they will penetrate hard material.

Yet another object is the provision of dipper mounting elements which will provide for almost constant speed ratio between the hoist and crowd throughout the horizontal digging stroke, after the dipper attains its final digging attitude, for ease of operation.

It is also an object to provide a dipper mount wherein there is no heavy fixed boom, and the structural elements can be made strong and heavy without placing an undue weight problem on the machine as a whole.

A further object is to provide such a machine with a movable mast to help reduce crowd power requirements, and to relieve the hoist frame of the weight of extra sheaves in the crowd drive.

Yet another object is the provision of means to indicate to the operator when fouling of the crowd reeving is imminent and to indicate at all times the position of the mast.

Other objects of the invention will appear from the following description of one practical embodiment thereof, when taken in conjunction with the drawings which accompany and form part of, this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a side elevation of a revolvable power shovel embodying the principle of the present invention, the dipper being shown at approximately the end of its horizontal stroke;

FIGURE 2 is also a side elevation of the power shovel, the dipper being shown in full lines in fully retracted position ready to start a digging stroke, and in dotted lines in several of its positions during digging, hoisting, and dumping;

FIGURE 3 is a top plan view of the machine shown in FIGURES 1 and 2;

FIGURE 4 is a diagrammatic view showing portions of the pitch control systems and their control cylinders, and the fluid mechanism which operates the cylinders;

FIGURE 5 is a greatly enlarged view of the structure in the region of the head shaft, and is taken substantially on the line 5—5 of FIGURE 3;

FIGURE 6 is a horizontal section through the structure shown in FIGURE 5, and is taken on line 6–6 of FIGURE 5;

FIGURE 7 is a transverse section taken on the line 7–7 of FIGURE 5, and

FIGURE 8 is an exploded perspective view of adjacent portions of the handle and hoist frame, and their means for mounting on the head shaft.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in detail, there is shown a low bank shovel **1** having a body **2** supported for rotation on a base **3** which is mounted upon crawlers **4**. The shovel can be moved from place to place by operation of the crawlers, and the body can be rotatably moved to swing from side to side by suitable power means mounted within the housing of the body **2**. The body, base and crawlers can be of conventional construction.

A bucket, or dipper **5** is pivotally connected at **6** to a handle **7**, in turn pivotally connected to a stiffleg **8** by a head shaft **9**. The stiffleg is pivotally connected to the machine body by foot pins **10**. A hoist frame **11** is also connected to the head shaft **9**, and a hoist link **12** ties the hoist frame to dipper **5** by pivots **13** and **14**. The hoist frame, hoist link, handle and dipper move as a unit about the head shaft, and there is no relative movement among these parts except when the dipper moves about its pivotal connection **6** with the handle in changing pitch. A hoist line **15** controls movement of the hoist frame about the head shaft, and a crowd mechanism **16** controls movement of the hoist frame and stiffleg about its foot pins.

The stiffleg **8** is a heavy member, having a pair of spaced side beams **17** and a center web **18**. At the bottom, the side beams terminate in bearings journalled on foot pins **10**, which are held in ears **19** fixed to the platform **20** of the machine body **2**. At the top, the side beams carry laterally spaced bearings **21** in which the head shaft **9** is rotatably mounted.

Handle **7** consists mainly of two beams **22** spaced a considerable distance apart laterally, with suitable bracing members **23** disposed between them. The rear ends of the beams are joined by a bridge **24**, parts of which, at the ends of the beams, form flat bearing plates **25**. Bearing caps **26**, carrying journals **27**, are bolted to the bearing plates, and the journals are rotatably mounted on the head shaft **9** to provide the pivotal mounting for the handle. The forward ends of the handle carry the pins **6** connecting the handle to the mounting ears **28** of dipper **5**.

The connections of bearing caps **26** to the beam ends of the handle include rubber joints, which reduce the tendency of the dipper teeth to gouge below grade when they encounter sudden resistance during a horizontal pass, and allow the handle to deflect laterally when the side of the dipper is swung into solid material, and thus absorb the energy of such an impact and reduce the twisting and bending loads throughout the structure. To this end, the caps have face plates **29**, of similar shape to the bearing plate sections **25** of bridge **24**, which carry the journals **27**. A receptacle **30** is formed on the back of each face plate, to seat a rubber pad **31**. The receptacles are of less depth than the pads, so that the pads project some distance beyond the receptacle edges. The projecting faces of the pad seat on the bearing plates **25**, and bolts **32** passing through openings **33** in the face plates **29**, and bosses **34** carried by the bridge **24**, secure the caps to the handle and the pads seated against the bearing plates with the proper pressure. Bolts **32** carry smaller rubber pads **35** arranged to transmit tensile loads on the handle. Bolts **32** pass through the pads **35**, and are drawn up to pre-load the pads **31** and **35** against each other, so that if one is fully compressed, the other does not become loose.

Hoist frame **11** includes laterally spaced, triangular frame members **36**, extending generally in the direction of handle **7**, but oppositely from the head shaft **9**, having split journals **37** on their ends to surround the head shaft **9**. The members **36** are held in spaced, parallel relation by cross struts **38**. At their upper ends, the members **36** carry a shaft **39** mounting hoist sheaves **40**. A second pair of hoist frame members **41** have their inner

ends **42** mounted on head shaft **9**, and extend outwardly from the shaft at approximately right angles to the members **36**. Links **43** connect the members **36** and **41** to complete a rigid hoist frame.

In order to protect the rubber pads **31** in handle **7** from severe shear strains, bridge **24** carries an arm **44** which has a ball joint connection **45** with one end of a cross link **46**, in turn connected at the other end by a ball joint **47** with a pin **48** projecting from one of the split journals **37** of members **36** of the hoist frame. This will prevent lateral movement of the handle relative to the head shaft and other parts of the assembly.

The outer end of the hoist frame carries the pivot **13**, which is a ball joint, and the upper end of the hoist link **12** is connected to it. The lower end of the link is pivotally connected at **14**, to ears **49** at the front sides of dipper **5**. This provides a structure in which the hoist link converges upwardly from the pivots **14** at the dipper to the common ball joint **13**. Thus, there is a rigid triangular construction, whereby twisting of the handle due to off-center load on the dipper lip is avoided. Any torsional moment about the center line of the handle can be resolved into a lateral force, exerted at the top of the hoist link through the ball joint, and a lateral shear load in the handle, which is taken by the cross link **46**. The upright members of the hoist frame are spread apart on the head shaft to resist lateral loads at the top. By having the hoist link connected to the dipper rather than the dipper handle, the force exerted by the link is always sufficient to pitch the dipper up.

It has been found that the digging action of the dipper can be improved by mounting a counterweight **50** at the outer end of the hoist frame. This helps return the dipper to the starting position, and reduces the power needed to operate the crowd mechanism, as will be described.

The hoist frame, handle and dipper are moved about the head shaft by means of the hoist line **15**. The line is reeved about the sheaves **40** at the top of the hoist frame, sheaves **51** on the stiffleg **8**, and is wound upon a hoist drum **52**. Its action will be described in detail later.

The movement of the stiffleg **8** about the foot pins **10** is accomplished by the crowd mechanism **16**. This includes a gantry **53**, at the rear of the body, and a movable mast **54** pivotally mounted in the body at **55**. Mast **54** is connected to shaft **56'** on members **36** of the hoist frame by crowd pendants **56**, and to the gantry by crowd ropes **57**. The crowd rope **57** is anchored to the gantry at **58**, passes around sheaves **59** on a shaft **59'** at the top of the mast, sheaves **60** at the top of the gantry, and is wound upon a crowd drum **61** in the machine body.

As mentioned above, dipper **5** is pivotally attached to the end of handle **7** and to the hoist link **12**. This enables the dipper to change its angular relationship to the handle and to the bank in which it is digging. There are times when it is desirable to hold the angular relationship of the bucket with respect to the earth, so as to bring about a long horizontal pass of the dipper. The dipper angular relationship with the earth is either maintained, or changed, under the control of a pantograph linkage **62**. The linkage is duplicated on opposite sides of the bucket and the front end mechanism, so only one will be described.

The linkage **62** consists of a control lever **63**, which is in the form of a bellcrank pivotally connected at one end to a pivot pin **64** axially aligned with the foot pins **10**. The opposite end of the lever is pivotally connected to a pitch link **66** which has its opposite end pivotally connected to one end of an equalizing lever **67** pivotally mounted midway between its ends on the head shaft **9**. Actually, link **66** is pivotally connected at **63'** to a chain link **66'** which, in turn is connected to the free end of lever **63** by pivot **70**. Link **66** has its opposite end pivotally connected, at **69'** to a chain link **66''** having its opposite end pivotally connected to equalizing lever **67** at **69**. Control lever **63** carries a stop **65** for abutment by chain link

66', and the equalizing lever 67 carries a stop 67' for abutment by chain link 66''. The arrangement is such that one chain link or the other is in contact with its abutment, and, when the linkage moves, one chain link will contact its stop as the other chain link moves from its stop. The opposite end of the lever 67 is connected to a second pitch link, which has its opposite end coupled to the dipper 5. Thus, a parallelogram is formed including head shaft 9, pivot 6 between the handle and dipper, pivot 71 between the dipper and pitch link 68, and pivot 72 between pitch link 68 and the equalizing lever 67. The equalizing lever 67, pitch link 66 and control lever 63 and their mountings form two parallelograms, one when chain link 66' is in contact with stop 65 and the other when chain link 66'' is in contact with stop 67'. In the first instance, the parallelogram includes pivot 69, head shaft 9, pivot 64 and pivot 63'. When the chain link 66'' is in contact with stop 67', the parallelogram includes pivot 69', head shaft 9, pivot 64 and pivot 70. Thus, if the control lever 63 is held immovable, the attitude of the bucket relative to the earth will remain unchanged for all movement of the stiffleg and handle. In order to hold the lever 63 against movement, a pitch cylinder 73 is mounted on a support 74 at the front of the machine body 2, and has its piston rod connected to the control lever 63 intermediate the ends of the control lever.

The movements of the dipper are controlled within certain fixed limits. The dipper carries an abutment 75 for contact with a limit stop 76 which projects from the stiffleg 8 near its bottom, to establish a limit of movement of the dipper in a rearward direction for starting a digging pass. The bucket is so weighted with respect to the position of its pivot 6 with the handle that it will assume an upwardly tilted position if not otherwise controlled. The limit of upward pitch is determined by a pitch stop 77, mounted on the handle 7, which cooperates with a pad 78 fixed to the bucket ears 49. Other movement-limiting stops are provided on the stiffleg, at 79, and on the hoist frame members 36, as at 80, which cooperate to limit the hoist movement. Similarly, the upper part of the mast 54 and a stop 81 on the gantry 53 cooperate to limit the crowd take-up movement.

The dipper pitch is controlled by an operator by means of a fluid system, such as that shown in FIGURE 4. This includes lines 82 from the tops of pitch cylinders 73 to a fluid tank 83. Check valves 84 are in the lines 82, adjacent the tank 83, to prevent flow from the tank to the lines. A control valve 85 bridges the lines 82, and is operated by movement of a pitch pedal 86. Normally the valve occupies an open position, so that fluid can flow from the cylinders to the tank. When the operator depresses the pitch pedal, the valve closes, holding the fluid within the cylinders and locking the control levers 63 against movement. A relief valve 87 is interposed between lines 82 and the tank to prevent excessive pressure. All oil flow from the tank to the cylinders is through a strainer 88 in the tank, and line 89, which line includes a check valve 90 to prevent backflow from the lines 82 into the tank. A small amount of air pressure in the tank, assisted by the weight of the rams and other parts, returns them to the extended position when the dipper is returned to the starting position, and keeps slack out of the pitch linkage. Pitch pedal 86 has an adjustable stop 91 so that the stroke of the valve can be limited to prevent it from reaching a fully open position when the pedal is released, thus creating a restriction which prevents the dipper pitching up too fast and slamming against the stops 77 on the end of the handle.

In order to prevent undue slack and fouling of the crowd lines, two indicators are provided, one on the gantry and the other adjacent the operator's seat 92. The gantry includes two upper links 93 and 94, each of which is pivotally connected at its bottom to the base section of the gantry, and each of which supports shaft 95 carrying crowd sheaves 60. Link 94 has a slot 96 in its upper end through which the shaft 95 passes. When the crowd ropes are under tension, shaft 95 is held up against the top of slots 96, but when the crowd ropes become slack, the shaft can drop in slot 96, due to the pivotal connections of the links 93 and 94. There will be a suitable limit switch 97 mounted on link 94 which the shaft 95 will strike and operate when the shaft moves downwardly in slot 96. Operation of switch 97 will cause a warning signal adjacent the operator's seat to sound and the operator can take appropriate action to take the slack out of the crowd ropes. The second indicator includes a pivoted lever 98 adjacent the operator's seat having an arm movable over a mast indicator scale to show the angular position of the mast. The lever 98 is connected by a link 99 to the mast adjacent its pivotal connection to the machine body. Therefore, whenever the mast moves, the lever 98 will move over the scale and provide the operator with a visual indication of the mast position at all times.

In operating the device, the dipper will be brought to starting position near minimum rise, with the dipper teeth on grade level and the pitch up against stop 76 on stiffleg 8. This is the position shown in full lines on FIGURE 2. To begin the normal horizontal digging cycle, the operator will start to take up hoist and pay out crowd. At this time the dipper pitch control is released, and the dipper is free to move about its pivotal connection with the handle. As the dipper moves forward away from stop 76, it begins to assume a horizontal postion. When the dipper front is nearly horizontal, the operator depresses the pitch pedal 86, locking the fluid in the cylinders 73 and holding the dipper against change in angular movement relative to grade level. As the operator continues to pick up hoist and pay out crowd, the bucket advances in a horizontal direction at a given depth in the material, until the operator decides that the dipper is full. The extent of the horizontal forward movement can be seen in the dotted line positions in FIGURE 2. When the dipper is full, the operator releases the pitch and reverses the crowd simultaneously, but continues to hoist. The dipper then pries itself out of the material and rises almost vertically, due to the fact that the operator is taking up both hoist and crowd so that the stiffleg will be rising while the dipper handle lifts. As soon as the bucket is free of the material, it will swing about its pivot on the handle until the pad 78 on the dipper strikes the pitch stop 77 on the handle. The bucket remains with the pitch up against this stop for the rest of the cycle. The operator continues to hoist, take up crowd, and swing the machine until the dumping position is reached. The dumping radius at a given height can be varied by taking up more crowd and less hoist, or reversing the operation to take up more hoist and less crowd. When the dumping position is reached, the dipper door 100 will be opened to drop the load. After dumping, the operator begins to swing back to the pit and to lower the hoist. In most cases he will take up a little more crowd, so that the dipper teeth will clear the unexcavated material as they return to a new staring position. When the teeth are just above the new starting position, the crowd is paid out as fast as possible until the teeth reach grade level, ready to begin another cycle.

It will be understood that there may be some overlapping of the operations described above and that the whole cycle is carried out in as smooth a manner as possible. The pitch control, for instance, is released gradually so that the heel of the dipper does not slam down against the grade level, nor does the dipper hit the pitch stops with any appreciable impact.

It is to be noted that the particular arrangement of the front end mechanism of the present shovel is such that power for both digging and lifting comes mainly from the hoist, which continues to take up more or less constantly from starting to the dumping positions.

The power requirement for crowd is held to a practical minimum. The weight of the stiffleg, hoist frame, handle

and dipper are all forward of the foot pins, so that their weight is applied to the digging operation, and the distance from the top of the mast to the top of the stiffleg is increased automatically as the hoist is taken up. Thus, the required movement of the mast is reduced, and a self-crowding effect is attained. In fact, with the particular arrangement shown, the self-crowding effect can be increased by changing the location of the crowd pendant shaft **56'** on the hoist frame to the point that it will become quite difficult to return the dipper to the starting position. If this hitch **56'** is too far from the head shaft, the instant center of the free body comprising the dipper, handle and hoist frame will move out beyond its own center of gravity as the dipper nears the starting position, thus causing the hoist lines to become slack. The counterweight **50** changes the location of this center of gravity so that more self-crowding effect can be used without danger of incurring such an unstable condition. The use of a movable mast also helps to keep the required crowd power to a minimum, since it gives the crowd drive a much more uniform moment arm. The use of the mast also relieves the hoist frame of the weight of extra sheaves, or other components, of the crowd drive.

Another feature of importance is the fact that, after the dipper attains its final digging attitude, the ratio between hoist and crowd speeds remains almost constant throughout the horizontal digging stroke. This adds greatly to the ease of operation of the machine.

While in the above one practical embodiment of the invention has been disclosed, it will be understood that the specific details of structure shown and described are merely by way of illustration, and the invention may take other forms within the scope of the appended claims.

What is claimed is:

1. A power shovel comprising a body, a stiffleg pivotally connected at its bottom to the body, a dipper handle pivotally connected at its upper end to the top of the stiffleg, a dipper pivotally connected at the lower end of the dipper handle, the pivotal connection between the dipper and the dipper handle being such that the dipper tends to pitch upwardly due to its own weight, means to limit upward pitching movement of the dipper, means to lower and raise the stiffleg about its pivotal connection to the body, means to swing the dipper handle about its pivotal connection to the stiffleg, and releasable holding means to maintain the dipper at fixed angles relative to the body during swinging movement of the stiffleg and dipper handle and bodily movement of the dipper.

2. A power shovel as claimed in claim **1**, wherein the means to raise and lower the stiffleg includes a mast pivotally connected at its base to the body, means interconnecting the mast top and the stiffleg, and means to move the mast about its pivotal connection.

3. A power shovel as claimed in claim **2**, wherein the means to move the mast includes a gantry fixed to the body, a reeved cable connection between the gantry and the mast, and means to reel and unreel the cable.

4. A power shovel as claimed in claim **1**, wherein the releasable holding means includes a pantograph.

5. A power shovel as claimed in claim **4**, wherein the pantograph has a control lever mounted on the body in pivotal alignment with the pivot connection of the stiffleg to the body, an equalizing lever pivotally mounted coaxially with the pivotal connection between the stiffleg and dipper handle, links interconnecting the control lever and the equalizing lever and the equalizing lever and the dipper, and means selectively operable to hold the control lever against movement and release the control lever for movement.

6. A power shovel as claimed in claim **5**, wherein the means to hold the control lever is a fluid cylinder assembly connected to the control lever, and a fluid circuit with means to selectively prevent and permit flow of fluid from the fluid cylinder.

7. A power shovel comprising a body, a stiffleg pivotally connected at its bottom to the body and having a head shaft mounted at its top, a dipper handle pivotally connected at its upper end to the head shaft, a dipper pivotally connected at the lower end of the handle, a hoist frame pivotally mounted on the head shaft, connecting means pivotally attached to the hoist frame and to the dipper, at a point removed from the dipper connection to the handle, means coupled to the hoist frame to swing the hoist frame and dipper handle about the head shaft, means coupled to the hoist frame to lower and raise the stiffleg about its pivotal connection to the body, and releasable holding means to maintain the dipper at fixed angles relative to the body during swinging movement of the dipper handle and stiffleg and bodily movement of the dipper.

8. A power shovel as claimed in claim **7**, wherein the means to swing the dipper handle is a hoist mechanism including sheaves on the hoist frame, a hoist cable drum on the body and a hoist cable reeved over the sheaves and wound in the cable drum.

9. A power shovel as claimed in claim **7**, wherein the means to raise and lower the stiffleg is a crowd mechanism including sheaves, means to couple the sheaves to the hoist frame, a crowd drum on the body, and a crowd cable reeved over the sheaves and wound on the crowd cable drum.

10. A power shovel as claimed in claim **7**, wherein the means to raise and lower the stiffleg includes a mast pivoted at its base to the body, means coupling the hoist frame to the top of the mast, a gantry fixed to the body, a crowd cable drum on the body, sheaves on the mast top and gantry, and a crowd cable reeved about the mast sheaves and gantry sheaves and wound on the crowd cable drum.

11. A power shovel as claimed in claim **10**, wherein the means to swing the dipper handle is a hoist mechanism including sheaves on the hoist frame, a hoist cable reeved over the sheaves and wound on the cable drum.

12. A power shovel as claimed in claim **11**, wherein the hoist frame is triangular having a vertical side in substantial continuation of the dipper handle, a forwardly extending side and a hypotenuse, the hoist cable sheaves being connected to the vertical side adjacent the juncture of the vertical side and hypotenuse and the means connecting the hoist frame to the mast being connected to the vertical side of the hoist frame intermediate the connection of the hoist sheaves and the head shaft.

13. A power shovel as claimed in claim **12**, wherein there is means in the gantry operable upon the crowd cable becoming slack to warn the operator.

14. A power shovel as claimed in claim **12**, wherein there is an indicator coupled to the mast and movable with the mast to indicate mast position.

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HUGO O. SCHULZ, Primary Examiner

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