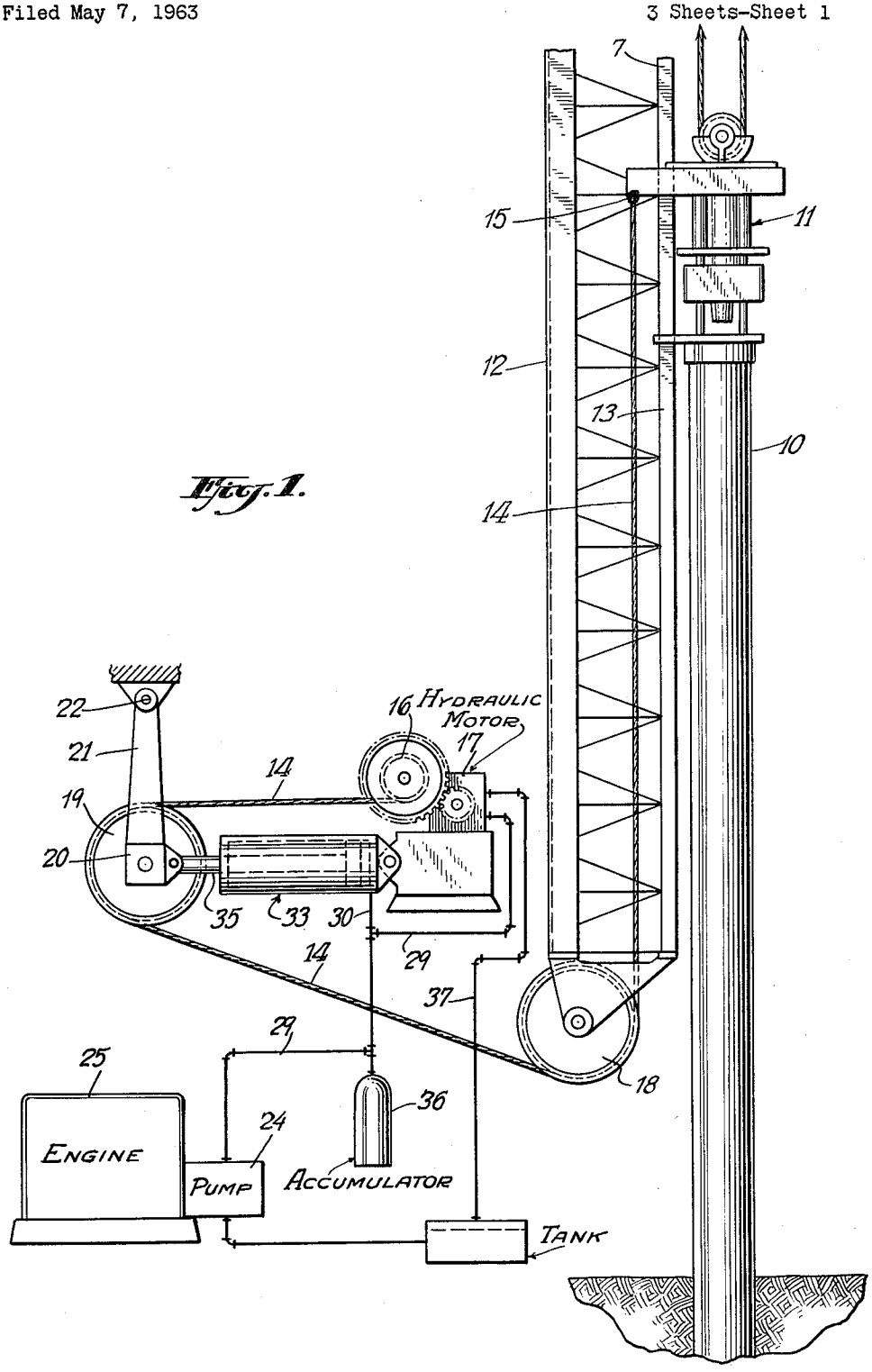
March 9, 1965 E. W. SPANNHAKE ETAL 3,172,485

DOWNCROWDING ARRANGEMENT FOR PILE DRIVING AND THE LIKE

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Fig. 1.



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DOWNCROWDING ARRANGEMENT FOR PILE DRIVING AND THE LIKE

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Fig. 2.

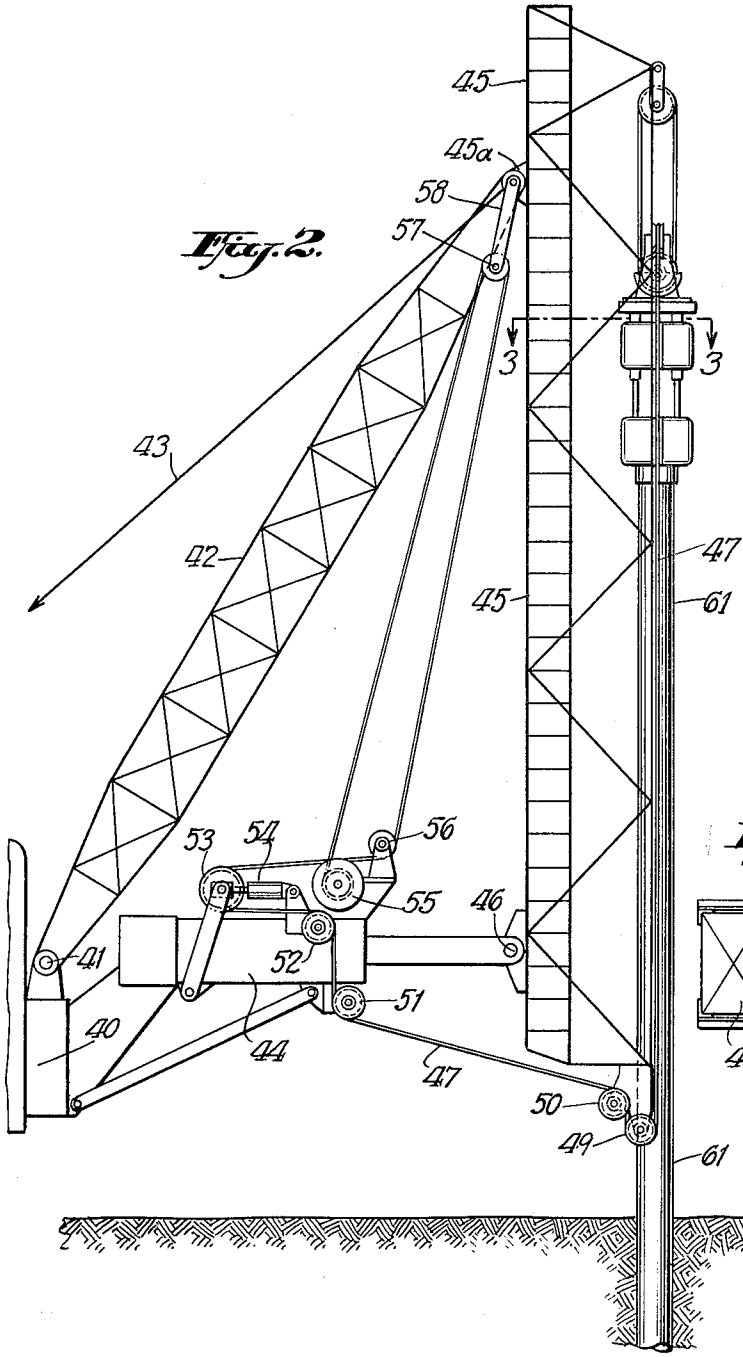


Fig. 4.

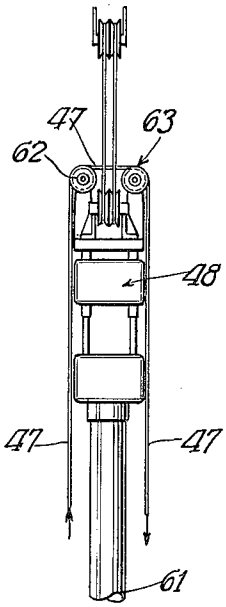
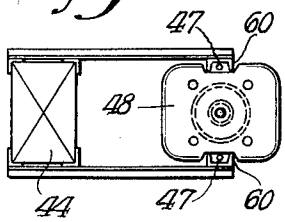


Fig. 3.



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Fig. 6.

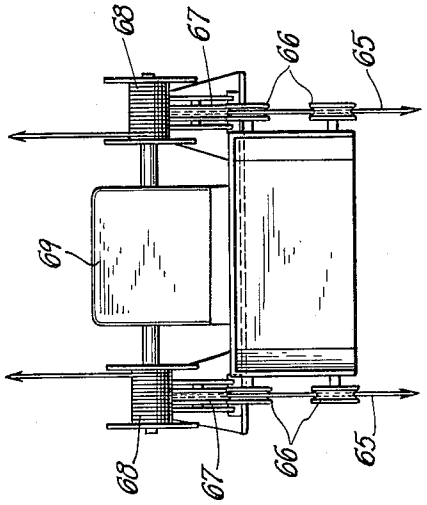
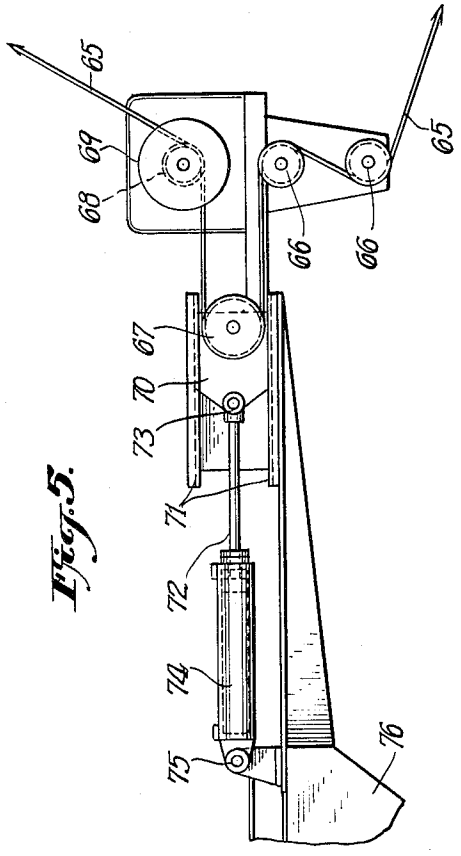


Fig. 5.



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3,172,485

DOWNCROWDING ARRANGEMENT FOR PILE DRIVING AND THE LIKE

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6 Claims. (Cl. 173—147)

This invention relates to arrangements for applying downcrowding forces to equipment for driving piles, caissons or other objects, the invention being particularly adapted for applying such downward forces to pile driving hammers, vibratory equipment or the like as used for driving objects into the earth.

It has long been well known in foundation work that, while driving a pile or vibrating a caisson or the like into the ground, a steady force of considerable magnitude acting in a downward direction on the equipment, is very helpful. While under some circumstances such a force may normally be provided by the weight of the apparatus on the pile driving hammer or vibrator, yet when the height of the object being driven, such as a long pile, becomes very substantial, this necessitates that the weight of the hammer or other driving equipment be suspended high above the ground, and this in turn leads to problems of stability in the handling of such equipment as cranes or pile drivers. In order that such equipment will be sufficiently stable, same will, for this reason, normally have to be made very heavy and bulky and thus too clumsy readily to be maneuvered on and off the site.

It has also been known that, for some applications such as caisson drilling, a hydraulic winch may be attached by a rope or cable to the boring head for exerting a continuous downward pull, as a substitute for excessively weighted equipment. However, attempts to apply such a method for pile driving by the use of pile driving hammers or by the use of vibrating or other discontinuous impact methods of driving, have met with serious difficulties due to the jerky motions in the downward direction which these operations induce on the driven objects. This makes it impractical to handle such a downcrowding rope or cable while keeping same from jumping off its sheaves and fouling, thereby necessitating interruption of operations. Yet efficient methods are highly important for the handling of long piles or caissons by operations which avoid so far as possible any interruptions of the driving process.

The present invention provides a practical way of utilizing a wire rope or cable for accomplishing a constant downward pull against a reciprocating hammer or vibrating equipment, the downward force or bias being capable of being maintained without interruptions during the very substantial distances of travel of long piles or other objects being driven. In accordance with the invention, arrangements are provided which maintain this force bias uninterrupted by the jerky and irregular motions induced in the driven object by the blows of the hammer or the vibrations. The invention further provides for the reeving of such a cable in a manner whereby all other necessary movements or motions of the hammer or vibrator, its handling equipment and the piles or cores driven thereby, may be carried out during the pile driving operations, or at times between driving successive piles, without interference from such cable or rope.

Various further and more specific objects, features and advantages of the invention will appear from the description given below, taken in connection with the accompanying drawings, illustrating by way of example preferred forms of the invention.

In the drawings:

FIG. 1 is a somewhat schematic elevational view showing an arrangement of pile driving apparatus and one form of hydraulically controlled arrangement for reeving a cable for applying the desired uninterrupted downcrowding force in accordance with the invention;

FIG. 2 is another somewhat diagrammatic elevational view of equipment similar to that of FIG. 1, but embodying certain additional and alternative features;

FIG. 3 is a sectional view taken substantially along line 3—3 of FIG. 2;

FIG. 4 is a view of a portion of the upper part of the arrangement of FIG. 2 as viewed at right angles to the view of FIG. 2;

FIG. 5 is a schematic view of certain features of an alternative embodiment of the invention; and

FIG. 6 is an end view of the apparatus of FIG. 5.

Referring now to FIG. 1 in further detail, a pile is shown at 10 being driven into the earth as by a suitable known type of high speed hammer (or some known form of vibrator) indicated generally at 11, and which in a conventional manner is carried along pile driver leads 12 accompanied by sliding ways 13. With this embodiment of the invention, a downward pull is applied to the driving means 11 by a cable 14 connected to the driving means at a point such as indicated at 15. This cable, which should be of considerable length, is wound on a downcrowd drum 16, which drum may be rotated as by a hydraulic winch motor 17. The cable may be guided away from the lower portions of the leads 12 by a sheave 18 and thence to the downcrowd drum 16 by way of a cable-tensioning sheave 19. Tensioning sheave 19 is rotatably carried by bearing means 20 which is movable generally horizontally by reason of the fact that same is suspended on arm means as at 21 pivotally attached at 22 to some fixed object.

The hydraulic motor 17 is driven from a suitable source of hydraulic fluid, such as oil, contained in a tank 23. The oil may be supplied under pressure by a hydraulic pump as at 24, supplied from the tank 23 and driven by a suitable engine schematically indicated at 25. A pressure line 29 runs from such pump to the hydraulic motor 17, and a branch line 30 extends to a hydraulic cylinder and piston means 33, arranged whereby the pressure supplied into the cylinder will move its piston 35 toward the left, as viewed in FIG. 1. This piston is pivotally connected, as shown, to the housing for the bearing 20 of the tensioning sheave 19, so that by introduction of pressure in this cylinder, such sheave is forced toward the left, thereby subjecting the cable 14 to additional tension. Pressure line 29 is also connected to an accumulator as at 36, which should have sufficient volume to supply fluid for the total stroke of piston 35. A line 37 returns hydraulic fluid from the motor 17 to the tank 23.

The operation of this arrangement is as follows. As the hammer or other driving means 11 is lowered onto the pile 10, or other object being driven, the hydraulic circuit is put into operation, and this will create, due to the attempt of the motor 17 to turn drum 16, a tension in the cable 14, which in turn will tend to pull the driving means 11 downwardly upon the pile with a force proportional of the hydraulic pressure.

It is well known that a high speed pile driving hammer or vibrator whose mass is driven down by forces exceeding the effect of the weight alone of its stationary mass, gives rise to upward forces on the housing of the hammer or vibrator, tending to lift same from the pile or other object being driven. These forces are generally greater, the faster the hammer is being operated. With the above-described arrangement, the downward force applied to the cable, therefore, should be made as great, or sufficiently

greater than is necessary to keep the housing from lifting during the downstroke of the hammer or other driving means. Keeping such a force on the cable at all times will be sufficient assurance for keeping the driving means on the pile under all normal conditions. If now the hammer begins to strike, the pile will move downwardly in short jerks. If the cable, as connected to the hammer, should simply be wound around the downcrowd drum 16, or wound around such drum as directed thereon merely by sheaves, it would be found that the whip being created in the cable during the driving impacts would frequently be sufficient to throw it off the sheaves, or otherwise disrupt the arrangement. However, with the present invention, the tensioning sheave 19 and the area of the hydraulic piston 35, are so arranged that, with equal hydraulic pressure in the lines 29 and 30, the torque on the downcrowd drum 16 will at all times overcome the force of the hydraulic cylinder and piston means and thus force the piston to the extreme right. Under such conditions, if the pile and hammer cause a jerking motion in a downward direction, a condition of low tension or slack travels down the cable 14 at an extremely high speed. As this condition reaches the tensioning sheave 19, the inertia of the latter is low enough immediately to permit sheave 19 to be moved by the hydraulic piston toward the left, thus very quickly taking up the slack, before the cable can jump out of position at any point. To this end the sheave 19 and moving parts connected thereto, should have a mass as small as reasonably possible.

It has further been found that the effectiveness of this arrangement depends upon the tension per unit of cross-sectional area of steel in the cable created by the hydraulic tensioning arrangement, apart from the help of the winch means 16, 17. This tension should bear a certain relationship to the striking speed of the hammer and such that it should preferably be made greater than 1700 pounds per square inch for every foot per second of hammer striking speed.

For most satisfactory results with the above-described arrangement, it is also highly desirable that the fluid pressure system be able to supply the fluid, such as oil, quickly enough to the cylinder and piston means and thence to apply force against the tensioning sheave 19 quickly enough to immediately take up the tension variations in the cable. The provision of the accumulator 36 serves to this end, and preferably its accumulated oil volume should be slightly greater than the total displacement volume of cylinder 33 between the two extreme positions of its piston.

FIG. 2 illustrates a further example of the invention in some respects similar to that of FIG. 1, but embodying alternative and additional features. This figure illustrates only the front side of the equipment, although as hereinafter explained, the cable reeving and tensioning arrangements may be duplicated on the reverse side of the equipment. Here the frame for a pile driver, as partially shown at 40, carries on a pivoting means 41, a boom 42, which is held in conventional manner as by a boom pennant 43. The frame 40 also may carry a conventional telescoping "spotter" 44, so-called. Leads 45 are attached to the boom 42 of the pile driving apparatus as by universal joint means as at 45*a*. A further attachment to the leads may also be made at the front end of the spotter as at 46. With this embodiment, a downcrowd cable 47 extends from a pile driving hammer 48 to a terminal sheave 49, thence over a system of guide sheaves as at 50, 51, 52, to a tensioning sheave 53, the position of which is controlled by hydraulic cylinder and piston means as at 54 and having a hydraulic operating circuit like that of FIG. 1. Thence the cable is guided to a winch drum 55, in the following manner, which is one of the important aspects of this embodiment of the invention. That is, instead of running directly from the tensioning sheave to the wind-up or winch drum as in FIG. 1, here the cable is led through a guide sheave 56 to a sheave block 57 which is connected to a downcrowd boom pennant 58. From sheave block 57, the cable is led down to the winch drum 55, the latter being driven by a hydraulic motor as in the system of FIG. 1.

As may be seen in FIG. 3, the hammer 48 may be guided by leader columns 60. These columns are preferably formed of channel sections so that the downcrowd cable 47 may be guided along the cavities provided by such channel sections. As shown in FIG. 4, the hammer 48 is resting on top of a pile 61. In order that the forces and blows will be directed essentially along the neutral axis of the hammer, the downcrowd cable 47 may be arranged to extend along each side of the hammer and pile, as best shown in FIG. 4. This is accomplished by reeving the cable over guide sheaves as at 62, 63 at the top of the hammer, and by using the same cable for both sides. To this end, as above noted, all of the cable reeving and tensioning arrangements as hereinabove described for the cable 47 are duplicated on the opposite side of the equipment from that viewed in FIG. 2.

The operation of the arrangements of FIGS. 2 to 4 is as follows. As the downcrowding force is exerted on the pile 61 by the cable and by winch drums as at 55, and while the pile is at rest, the leaders 45 will tend to be raised by a force (applied by the cable at terminal sheave 49 for example) which force will be equal and opposite to that working on the pile. Should the weight of the leaders be insufficient to withstand this upward force, there exists danger that the boom 42 may tilt backward out of control, while the leaders tend to rise with respect to the pile. However, the reeving of the downcrowd cable 47 through the downcrowd sheave block 57 will cause sufficient downward force to be applied to the boom and leaders to prevent this from happening. A further advantage of this reeving method results from the fact that the relaxation wave effect which tends to occur in the downcrowd cables when blows are struck by the hammer, will arrive at the winch drums 55 substantially later than at the tensioning sheaves 53, thus giving the latter ample opportunity to move before the winch means 55 calls for an accelerated supply of hydraulic fluid. It will be understood that, except as above explained, the parts of FIG. 2, such as the tensioning sheaves 53, hydraulic means 54 and winch means 55 (as duplicated on opposite sides) will operate as with the arrangement of FIG. 1 above described, the hydraulic circuits being the same or similar.

While the arrangement as shown in FIGS. 2–4 inclusive, assures that the forces in the downcrowding cable will be the same at both sides of the hammer, yet sometimes it may not be convenient to use this arrangement for equalizing these forces. In that event, separate cable systems on each side of the hammer may be used, and the winch drums therefor may be driven through suitable differential gearing (of any suitable known type, not shown) to assure an equal pull on both cables.

In fact various forms of linkages and arrangements, different from those hereinabove described, may be used as to the tensioning pistons and tensioning sheaves without departing from the principles of the invention. For example, FIG. 5 shows another arrangement for inducing the desired tension in the cables. Here a cable 65 may run up over the top of the hammer or other driving means, in the manner shown in FIG. 4, and from there extend down along each side of the pile with the cable portions at each side respectively being reeved through duplicates of the equipment as shown in FIG. 5. Here the cable 65 passes over guide sheaves as at 66 onto cable-tensioning sheaves as at 67, and from there onto drums as at 68 of winch 69. Sheaves 67 are carried on slidable blocks as at 70 which may be guided horizontally in tracks as at 71. Pistons as at 72 may be pivotally connected as at 73 to the blocks 70, the pistons sliding in hydraulic cylinders 74, these in turn being hingedly connected as at 75 to a portion of the so-called "spotter" frame 76 of the pile driver. (The hydraulic circuits for this embodiment may be the same or similar to that described in connection with FIG. 1.) FIG. 6 shows an end view of the apparatus as pro-

vided on each side with reeving arrangements as of FIG. 5.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. In apparatus for driving objects into the earth by the use of driving means which applies driving impulses thereto: cable means extending downwardly under tension from the driving means for applying a downcrowding force thereto; winch means for winding the cable means and retaining same under tension; means through which the cable is reeved prior to passing to said winch means; and hydraulic means for controlling the tension of the cable means in said reeving means to take up slack in the cable means when conditions of decreased tension occur therein as the result of the driving impulses.

2. In apparatus for driving objects into the earth by the use of driving means which applies driving impulses thereto: cable means extending downwardly under tension from the driving means for applying a downcrowding force thereto; hydraulic motor operated winch means for winding the cable means and retaining same under tension; means through which the cable is reeved prior to passing to said winch means; hydraulic cylinder and piston means for restoring tension to the cable means in said reeving means when slack impulses tend to occur in the cable means as the result of the driving impulses; and a common source for supplying hydraulic fluid pressure to said winch means and to said cylinder and piston means.

3. In apparatus for driving piles and the like by the use of a pile driving hammer which applies driving impulses: cable means applied to the hammer body and extending downwardly under tension therefrom for applying downcrowding force thereto; winch means for winding the cable means and retaining same under tension; means through which the cable is reeved prior to passing to said winch means; and fluid pressure operated means for pulling the cable means taut in said reeving means and thus maintaining such downcrowding force when slack impulses tend to occur in the cable means as the result of the driving impulses at the driving means.

4. In apparatus for driving objects into the earth by the use of driving means which applies driving impulses thereto: cable means extending downwardly under tension from the driving means for applying a downcrowding force thereto; winch means for winding the cable means and retaining same under tension; means through which the cable is reeved prior to passing to said winch means; a tensioning sheave included in said reeving means; and means for applying pressure to said tensioning sheave to force same against the cable means to restore its tension responsive to slack impulses in the cable means resulting from the driving impulses.

5. In apparatus for driving piles and the like, of the type having upstanding leads along which driving means is arranged to move, said leads being pivotally connected by spotter means at the lower portions thereof to a frame for the apparatus and pivotally connected at the upper portions thereof to the frame by an inclined boom, the combination comprising: cable means extending downwardly under tension from the driving means for applying downcrowding force thereto; winch means for winding the cable means and retaining same under tension; means through which the cable is reeved prior to passing to said winch means; and hydraulic means for restoring tension to the cable means in said reeving means when slack impulses tend to occur in the cable means as the result of driving impulses, said reeving means including sheaves directing the cable from the winch means to the upper part of the boom, thence down to said hydraulic means and thence to a region at the lower portion of the leads and up to the driving means.

6. In apparatus for driving objects into the earth by the use of driving means which applies driving impulses thereto: a cable having one portion extending under tension up along one side of the object being driven and passing around portions at the driving means to apply downcrowding force thereto, another portion of the cable extending thence downwardly along the other side of the object; winch means for winding the ends of the cable and retaining same under tension; means through which both portions of the cable are reeved prior to passing to said winch means; and hydraulic means for controlling the tension of the cable in said reeving means to take up slack in the cable, when conditions of decreased tension occur therein as the result of the driving impulses.

References Cited by the Examiner

UNITED STATES PATENTS

2,588,037	3/52	Orton	254—172 X
2,732,180	1/56	Gratzmuller	254—172
2,990,022	6/61	Muller et al.	173—147 X

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