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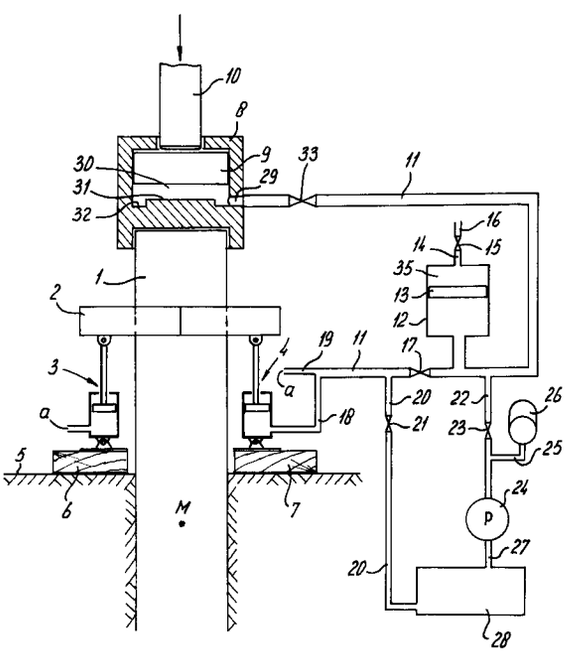
(54) Method and apparatus for removing a driven-in object

(57) A method for the removal of a driven-in slender object (1), such as a pipe, a pile or a sheet pile wall plank, comprises the application of an upwardly directed tractive force to the object, and also the exertion of an impact load on the object while maintaining the tractive force. The impact load can be directed either upwards or downwards. The apparatus used for this method comprises an impact plate (9) and/or a piling cap (8) which has a ram element (10) and a hauling means (2) which can be fastened to the object and has a hydraulic press element (3,4) for the application of an upwardly directed tractive force to the object.

Fig-1



EP 0 692 578 A1

Description

The invention relates to the removal of an object which has been driven into the ground, particularly a steel pipe which is used to construct a foundation pile in the ground. In the construction of a cast-in-situ foundation pile of this type, the pipe, which carries a cover at its bottom end, is first driven into the ground. A reinforcement is then placed in the pipe, whereupon concrete is poured in and compacted by vibration.

As the level of concrete rises, the pipe must be gradually extracted. According to a known technique a hauling means is then fastened to the part of the pipe projecting above ground level and is supported on the surface of the ground surrounding the pipe. By means of a hydraulic press system an upwardly directed tractive force can be exerted on the pipe via the hauling means, such that the pipe can be gradually moved upwards.

A hauling means of this kind is known from DE-A-3031027. In practice it appears that this known hauling means does not always function in the desired manner. The object of the invention is therefore to provide a method by means of which better removal of a driven-in object is possible. In this context the invention relates to a method for the removal of a driven-in slender object, such as a pipe, a pile or a sheet pile wall plank, comprising the application of an upwardly directed tractive force to the object, and also the exertion of an impact load on the object while maintaining the tractive force.

The exertion of an impact load on the object has the consequence that the friction between said object and the ground is temporarily reduced because of the shock load. In combination therewith the constant tractive load gives rise to the desired upwardly directed movement of the object.

A shock load of this kind can be applied not only when the impact load is directed upwards, but also when the impact load is directed downwards. This means that the method according to the invention can also be applied when use is made of a standard impact pile driving hammer, which of course produces a downward impact load.

Provision is preferably made for the tractive force produced by the hauling means to change in magnitude at the beginning of the impact load. When a blow is struck, the tractive force can thus temporarily increase, so that optimum use can be made of the periods in which friction between the ground and the object is temporarily reduced.

This magnitude of the variation of the tractive force is for example dependent on the strength of the blow and the spring stiffness of the transmission mechanism.

The invention likewise relates to an apparatus by means of which this method can be applied. A first variant of this apparatus comprises a piling cap which has a ram element and a reservoir containing hydraulic liquid, which is controlled by the ram element, a hauling means which can be fastened to the object and has a hydraulic press element for the application of an upwardly directed tractive force to the object, together with hydraulic means for coupling between the reservoir in the piling cap and the press element.

The pressure pulses produced in the hydraulic liquid by means of the ram element can be transmitted to the press element, so that during the periods in which friction between the ground and the object is relatively low, such as result from the shock load, a relatively high tractive force can be applied to the object.

The reservoir in the piling cap is preferably cylindrical and closed by a floating impact plate which cooperates with the ram element. The reservoir is connected via a hydraulic line to the press element of the hauling means.

In order to achieve the desired stiffness in the hydraulic system a pressure vessel may be provided to maintain a presettable hydraulic pressure.

In a practical embodiment the press element comprises two hydraulic cylinder and piston devices, of each of which one end is connected to a support foot and the other end is connected to a clamp gripper which can be fastened to the object.

The cylinders can in addition be selectively brought by means of a valve system into communication with the reservoir in the piling cap, or with an operating system by means of which the cylinder and piston devices can be moved up and down in order to bring the clamp gripper into the desired position on the object.

As soon as the object has been moved upwards over the maximum stroke length of the cylinder and piston devices, the clamp gripper must be released and reattached in a lower position. The valve system then ensures that the cylinder and piston devices are temporarily uncoupled from the reservoir in the piling cap and are connected to the operating system which can bring about these movements.

A second variant of the apparatus is one in which the weight which makes the blow in the upward direction strikes against an impact plate or impact shoes. The impact plate in question, as a component of a casing, can be connected with the aid of this casing to connection means, such as traction links, which transmit the traction stroke from the casing to the object driven into the ground. In the case of impact shoes, these shoes are connected to the object by means of cables or rods. The traction stroke transmission means referred to, such as a casing, traction links, cables or rods, ensure that the blow produced by the ram element is transmitted as a traction stroke to the object driven into the ground.

In addition, as in the previous embodiment of the apparatus, a fastenable hauling means having a hydraulic press element is attached to the object and exerts thereon an upwardly directed tractive force.

The hauling means is adjusted to a constant tractive force. By means of the traction stroke the friction produced by the soil on the object is substantially reduced. The displacement brought about as the result of the traction stroke (lasting about 4 to 15 milliseconds depending on the type of ram element in combination with the trac-

tion stroke transmission means) is continued by the hauling means until such time as the friction of the ground on the object is restored to such an extent that equilibrium of forces is obtained again. In this connection it may be observed that the restoration of the friction applied by the ground to the object is rather sluggish in relation to the duration of a blow. Restoration times of 300 to 600 ms are observed for heavy types of soil.

In addition to a continuously acting pump, in this embodiment a pressure vessel is installed in the hydraulic system and serves as an accumulator, ensuring that the upwardly directed tractive force of the hauling means remains constant as far as possible.

In a third variant of the apparatus the ram element exerts on the object, via an impact plate, pressure blows in the same way as in the driving of the object into the ground. Here also, in the hauling of the object the fastenable clamp gripper is clamped around the object and exerts an upwardly directed tractive force. Through the pressure blow the object is driven into the ground in the first instance, but, because of the greatly reduced friction applied by the soil to the object, the object is pulled a greater distance out of the ground until such time as this friction is restored to a value at which equilibrium of forces is achieved and no further movement occurs. The displacement pulling out of the ground is many times greater than the displacement driving into the ground.

In a fourth variant of the apparatus the blow is converted mechanically from a pressure blow into a traction blow on the object driven into the ground. The ram element here strikes against an impact plate or impact cap, which strikes against an external construction, such as a tube, which is placed around the driven-in object. This external construction stands on the outer end of a number of levers (preferably three) which are installed around the driven-in object. The pivot points of the levers are connected to feet which are supported on the ground around the object. The inner ends of the levers rest under a hauling means fastenable to the object.

By means of the levers and the hauling means the pressure stroke on the external construction is converted into a traction stroke on the object.

If, as in the previous variants, the fastenable hauling means is in addition constructed with a hydraulic press element, a practically constant tractive force is also exerted on the object, so that efficiency is considerably improved.

As soon as the maximum displacement distance of the levers or of the cylinder and piston devices has been reached, the ram element is stopped and the fastenable hauling means is detached. Thereupon said hauling means is brought to the lowest position and coupled again or clamped again to the object, and the striking of the ram element is resumed. In order to lower the hauling means, the inner ends of the levers are pushed down or these inner ends are pushed down together with the hauling means through the falling of said hauling means.

In all the above-described variants use is usually made of a hoisting tool. Through the attachment of the necessary means of connection to the driven-in object, this hoisting tool can exert a further tractive force on said object in addition to the hauling means fastenable to the object.

In case the driven-in object should be pulled by means of a high tractive force, it may occur that the fastenable hauling means slips in case the friction resistance between the object and said hauling means is too low. Moreover, as a result of a high clamping force the object may become damaged by the fastenable hauling means.

In order to be able to exert a high pulling force, while preventing slip and damages, one or more collars may be provided on the object against the underside of which, or around which the fastenable hauling means may be provided. In case more than one collar is available, the maximal mutual distance thereof is somewhat smaller than the maximum stroke length of the piston rods of the cylinder-piston devices. Thereby, the hauling means can be connected to the next lower collar as soon as the maximum stroke length of the cylinder-piston device has been reached.

It is not necessary for the collar to surround the complete circumference of the slender object. A collar may consist of parts, which are regularly distributed around the circumference. For instance, the collar may consist of two protrusions.

The method and apparatus according to the invention will now be explained more fully with reference to an exemplary embodiment, which is illustrated in the drawings.

Figure 1 shows the apparatus according to the invention.

Figures 2 and 3 show curves of the force produced on a driven-in object with the apparatus according to Figure 1, plotted against time.

Figure 3 shows the apparatus in which traction strokes are applied to the driven-in object by means of a ram element making traction strokes.

Figure 4 shows the apparatus in which pressure strokes are applied to the driven-in object.

Figure 5 shows the apparatus in which traction strokes are applied to the driven-in object. The pressure strokes of the ram element are here converted via levers or tilting mechanisms and via the fastenable hauling means on the object into traction strokes. The press element part is not shown here.

Figure 6 shows the curve of the force produced by the apparatus, plotted against time, such as can occur at point M of the object in Figures 3 and 5.

In Figure 1 is shown a driven-in pipe 1 which has to be removed on or after the casting of a concrete pile in the ground. The installations needed for adding the concrete and the like are not shown. Clamped fast to the pile 1 is a clamp gripper 2, which is fastened to the pile 1 in a manner known per se. Reference is made to the clamp gripper as known from DE-A-3031027. Other clamp grippers can of course also be used.

The clamp gripper 2 is connected to the piston rods of the hydraulic cylinder and piston devices 3 and 4 respectively. The casings of these cylinder and piston devices are supported on the feet 6 and 7 respectively, which are arranged on the surface 5 of the ground into which the pipe 1 has been driven.

Mounted on the pipe 1 is the piling cap 8, which has a cylindrical reservoir 30 in which is housed the floating impact plate 9 in the form of a floating piston. When a hammer blow is struck the floating impact plate 9 moves downwards and thus forces the hydraulic liquid out of the reservoir 30. This liquid flows via the opening 29 through the line 11 to the hydraulic cylinder and piston devices 3 and 4 respectively, which in turn press the clamp gripper 2 upwards. In spite of the fact that the impact plate 9 is a floating plate, when the hammer blow is struck a shock load is produced in the pipe 1, as a result of which the friction on the pipe in relation to the soil is temporarily reduced. Just at that moment the hydraulic cylinder and piston devices 3 and 4 respectively also receive a hydraulic pulse, as a result of which the clamp gripper 2 is pushed upwards. Thanks to these two additional effects supplementing the constant pressure which is to be maintained in the cylinder and piston devices, the pipe 1 can be pulled out of the ground in an appropriate manner.

A vessel 12, in which a floating piston 13 is contained, is connected to the line 11. Above this floating piston 13 is situated a gas chamber 35 containing gas under pressure, which serves as spring stiffness for the hydraulic system. A line 14 provided with a shut-off valve 15 is connected to the chamber 35, such that the gas can be supplied or discharged via the line 16 in order to enable the stiffness of the hydraulic system to be adjusted while the pipe 1 is pulled upwards.

Depending on the stiffness of the hydraulic system and the magnitude and duration of the hammer blow, the floating impact plate 9 can move so far downwards that it lies on the impact seat 31. The residue or end part of the hammer blow, remaining after the floating impact plate has delivered a hydraulic pulse in the line 11, is thus transmitted by metal contact instead of liquid contact to the pile. In the situation in which the floating impact plate 9 rests on the impact seat 31, the volume of liquid contained in the chamber 32 is zero. On completion of the hammer blow, the force delivered via the part 10 then becomes so slight or non-existent that the floating impact plate 9 is pressed upwards because of the hydraulic pressure in the reservoir 30.

Depending on the size of the opening 29, the passage opening of the line 11 and the length of the line 11, a valve 33 can be installed in the line 11 in order to prevent the floating impact plate 9 from moving upwards prematurely, which would result in a premature pressure drop in the line 11 and thereafter in the vessel 12. The valve 33 makes it possible to allow the practically unhindered flow of liquid from the chamber 30 in the direction of the vessel 12. In the reverse direction the flow of liquid is prevented in such a manner that the floating impact plate moves upwards only after the hammer blow and preferably after completion of the extraction movement of the pipe 1. Before the next hammer blow is struck, the floating impact plate is in its uppermost position. The valve 33 is for example equipped with a non-return valve and a bypass, the passage opening of which can be controlled with the aid of mechanical and/or electrical control means during and/or before the pile driving process.

In order as far as possible to be independent of the influence of the upwardly moving floating impact plate 9, it is preferable for the vessel 12 to be situated as close as possible to the cylinder and piston devices.

The line 11 is connected via feed lines 18 and 19 to the hydraulic cylinder and piston devices 4 and 3 respectively. During the upward pulling of the pile by means of the cylinder and piston devices 3 and 4 respectively the shut-off valve 17 in the line 11 is opened and the shut-off valve 21 in the line 20 is closed. The shut-off valve 23 has a construction such that the liquid delivered by the pump 24 can flow only in the direction of the line 11. Consequently, no pressure pulses can reach the pump 24 or the accumulator 26 via the line 11. Said accumulator 26 serves to maintain the static pressure in the hydraulic system. The pump 24 receives liquid from the storage tank 28, specifically via the line 27.

If during the upward movement of the pipe 1 the hydraulic cylinder and piston devices reach their maximum height of lift, the clamp gripper 2 must be released, and the hydraulic cylinder and piston devices must thereupon be retracted again. For this purpose the valve 17 in the line 11 is closed and, if necessary, the gas pressure in the chamber 35 in the vessel 12 is raised in order to prevent the floating impact plate 9 from striking against the seat 31 of the piling cap 8.

The clamp gripper 2 is then released from the pipe 1 and the shut-off valve 21 in the line 20 is opened. The hydraulic liquid flows via the lines 18, 19, the line 11 and the line 20 back to the storage tank 28. As soon as the hydraulic cylinder and piston devices 3 and 4 respectively are in the retracted state, the clamp gripper 2 is clamped fast again on the pipe 1. The shut-off valve 21 is then closed and the shut-off valve 17 opened, and, if necessary, the gas pressure in the chamber 35 is brought back to its original value. Thereupon the further upward movement of the pipe 1 can be started.

Figure 2a shows a possible curve of force plotted against time in a position of the pipe 1 just under the surface 5 of the ground. The solid line 100 relates to the situation in which the floating impact plate 9 does not reach the impact seat 31 of the piling cap 8 during a hammer blow. In this figure two successive hammer blows are indicated schematically. The line 101 relates to the situation in which the floating impact plate 9 does reach the impact seat 31.

Figure 2b shows the curve of force in the pipe 1 if the piling cap 8 is not standing on the pipe 1 but on a dummy pile. The additional tractive force is transmitted in this case via the hydraulic system, the lifting cylinders and the clamp gripper to the pipe 1. The pipe 1 is thus

pulled by the additional increase of the tractive force. In this case the reduction of frictional force exerted by the ground on the pipe is not so great during the piling blow as in the case where the piling cap is situated on the pipe 1 together with the ram.

Figure 3 shows the second variant of the apparatus, wherein the vessel 12 and the connection by the line 11 between the line 22 and the piling cap 8, as provided in the hydraulic system described for Figure 1, are omitted. Through an upward movement the striking weight 55 produces against an impact element 53 a blow which is transmitted by connection means 52 and traction lugs 51, which are fastened on the pipe 1, as a traction stroke to the pipe 1.

The impact element 53 and the connection means 52 may form a component part of a casing of the striking weight 55. It is also possible for the impact element 53 to be made in the form of separate impact shoes and for the connection means 52 to be in the form of steel cables or draw rods. By means of the impact shoes the blow is transmitted uniformly to the steel cables or draw rods.

If the connection means 52 are made in the form of steel cables or draw rods, they are held under tension by hoisting means 54, as a result of which the striking weight 55 also always strikes the impact element 53 in the correct manner.

In case the impact element 53 is partly carried out as a plate which is exposed to the striking action, a piling cap may be integrated therein or connected to its lower side, which piling cap 8 is upside down in comparison to the situation shown in Figure 1. Striking weight 55 strikes upon such inverted piling cap 8.

In that case, piling cap 8 can be connected to line 11 and vessel 12 as also described with reference to Figure 1.

In Figure 4 the third variant of the apparatus is shown, wherein the striking weight 55 delivers a pressure blow via the impact plate or cap 56 to the pipe 11. The hydraulic system is the same as that described for Figure 3. The efficiency of this variant is lower than that of the second variant shown in Figure 3.

Figure 5 shows a fourth variant of a downwardly striking striking weight, but this striking weight strikes against the pipe 1 not directly but indirectly.

By means of a reversing device the striking weight 55 applies a traction stroke to the pipe 1. In similar manner to that described in connection with the previous figures, a clamp gripper 2 having an appertaining hydraulic system is mounted on the pipe 1. The cylinder and piston devices are not shown in this figure.

The clamp gripper 2 now rests on levers 61, which act as tilting mechanisms. Via the pivot point or pivot pin 64 these levers 61 are connected to feet 6 and 7, which are supported on the ground surface 5. An external construction 62, which is arranged around the pipe 1, rests on the outer ends of the levers 61. This external construction 62 could be a tube having the necessary openings to enable it, inter alia, to follow the extraction process.

On the top of the external construction 62 is mounted an impact plate or piling cap 63, for example in the form of an adaptor. The striking weight 55 strikes on the impact plate 63 and thus produces a traction stroke on the pipe 1.

With the aid of the lever action the traction stroke can be made greater, as a force, with a long and a short arm, than would be the case with lever arms of equal length.

The external construction 62 may have a height such that the pipe 1 cannot encounter the impact plate 63 during the extraction. It is naturally also possible for the external construction 62, if it is not high enough, to be replaced by a higher external construction 62 after stopping the process of extracting the pipe 1, whereupon the extraction process can be continued.

If the outer ends of the levers 61 have reached their lowest positions or the cylinder and piston devices have reached their highest position, the piling process is stopped. The external construction 62 together with the impact plate 63 is then raised, for example with the aid of a hoisting device or a jack device, whereupon the levers 61 are tilted mechanically or hydraulically into a position in which the outer ends of the levers 61 have reached their highest position. The levers 61, the external construction 62 and the impact plate 63 are all held fast just as they are.

The clamp gripper 2 is thereupon released and is allowed to fall onto the inner ends of the levers 61. The clamp gripper 2 is clamped around the pipe 1 again. The levers 61 are now free to move and the impact plate 63 together with the external construction 62 is lowered onto the outer ends of the levers 61. The traction process can then be continued.

Figure 6 shows a schematic example of the curve of force, plotted against time for two successive blows, which occurs in the pipe 1 with apparatus in accordance with Figures 3 and 5, specifically at a point M which is situated just under the ground surface 5.

In most of the cases described above the hoisting crane with its hoisting apparatus will help in pulling the pile out of the ground, a connection being made for this purpose between the hoisting apparatus and the pile.

Mention is made above of a clamp gripper with an appertaining cylinder and piston device. It is of course also possible for two clamp grippers, each with its own cylinder and piston device, to be used. In this case identical partly separated hydraulic systems can be used, specifically in such a manner that on the release and the dropping of the one clamp gripper the other clamp gripper continues with the extraction of the pipe, without the other clamp gripper being troubled by a pressure drop in its portion of the hydraulic system.

With two clamp grippers arranged one above the other and allowed to fall alternately in order to bring the cylinder and piston device into the retracted position, it is also possible to restrict to a minimum the driving-in of the pipe which is to be extracted.

Claims

1. Method for the removal of a driven-in slender oject, such as a pipe, a pile or a sheet pile wall plank, comprising the application of an upwardly directed tractive force to the object, and also the exertion of an impact load on the object while maintaining the tractive force.

2. Method according to Claim 1, wherein the impact load is directed upwards.

3. Method according to Claim 1, wherein the impact load is directed downwards.

4. Method according to Claim 1, 2 or 3, wherein the tractive force changes in magnitude at the beginning of the impact load, and returns to a constant preset value before the next impact load.

5. Method for the removal of a driven-in slender object, such as a pipe, a pile or a sheet pile wall plank, comprising the application of an upwardly directed tractive force to the object, whereby for exerting the tractive force connections are provided between the upper side of the object and a hausting device for exerting one part of said traction force, as well as of a connection element present on the object or releasably connected thereto for exerting the other part of the traction force by means of the pressure force exerted by a pressure device, which pressure device is situated between said connection element and the ground near the slender object, and exerting an impact load on the object while maintaining the traction force.

6. Method according to claim 1, in which, around the slender object, at least two releasable and displaceable connection elements (2) are provided above each other, which elements are each connected to a pressure device (3, 4), which pressure device is situated between a connection element and the ground near the slender object, wherein the connection elements convert the pressure forces exerted by the pressure device in traction forces in the slender object, and wherein, for maintaining said other part of the traction force, during the time that one of said connection pieces (2) is not loaded, in order to displace said connection piece to another part of the slender object, a pressure force is exerted on the other connecting piece by means of the corresponding pressure device.

7. Apparatus for applying the method according to Claims 3 and 4, comprising an impact plate and/or a piling cap together with a ram element and hauling means which can be fastened to the object and has a hydraulic press element for the application of an upwardly directed tractive force to the object.

8. Apparatus according to Claim 7, comprising a piling cap together with a ram element and a reservoir containing hydraulic liquid, which is controlled by the striker element, a hauling means which can be fastened to the object and has a hydraulic press element for the application of an upwardly directed tractive force to the object, together with hydraulic means for coupling between the reservoir in the piling cap and the press element.

9. Apparatus according to Claim 8, wherein the reservoir in the piling cap is cylindrical and is closed by a floating impact plate which cooperates with the ram element.

10. Apparatus according to Claim 9, wherein the reservoir is connected via a hydraulic line to the press element of the hauling means.

11. Apparatus for applying the method according to Claims 2 and 4, comprising an impact plate and/or piling cap together with a ram element, a tilting mechanism for reversing the downwardly directed impact force into an upwardly directed impact force, said tilting mechanism being connected on the one hand to the impact plate and/or the piling cap and on the other hand to a hauling means which can be fastened to the object.

12. Apparatus for applying the method according to Claims 2 and 4, comprising an impact plate or impact shoes together with a ram element, stroke transmission means which make a connection between the impact plate or the impact shoes and the driven-in object, together with a hauling means which can be fastened to the object in order to apply an upwardly directed tractive force to the object.

13. Apparatus according to any of Claims 8-12, wherein a pressure vessel is provided to maintain a pre- settable hydraulic pressure.

14. Apparatus according to any of Claims 7-13, wherein the press element comprises two or more hydraulic cylinder and piston devices, of each of which one end is connected to a support foot and the other end is connected to a clamp gripper which can be fastened to the object.

15. Apparatus according to Claim 14, wherein the cylinders can be selectively brought by means of a valve system into communication with the reservoir in the piling cap or with an operating system by means of which the cylinder and piston devices can be moved up and down in order to bring the clamp gripper into the desired position on the object.

16. Apparatus according to any of claims 5-15, wherein the slender object comprises one or more external

collars, onto which or around which a connectable traction element (2) can be applied for applying an upwardly directed tractive force in the slender object.

17. Apparatus according to claim 16, wherein the collar consists of collar parts or protrusions which are regularly spaced over the circumference of the slender object.

Fig-1

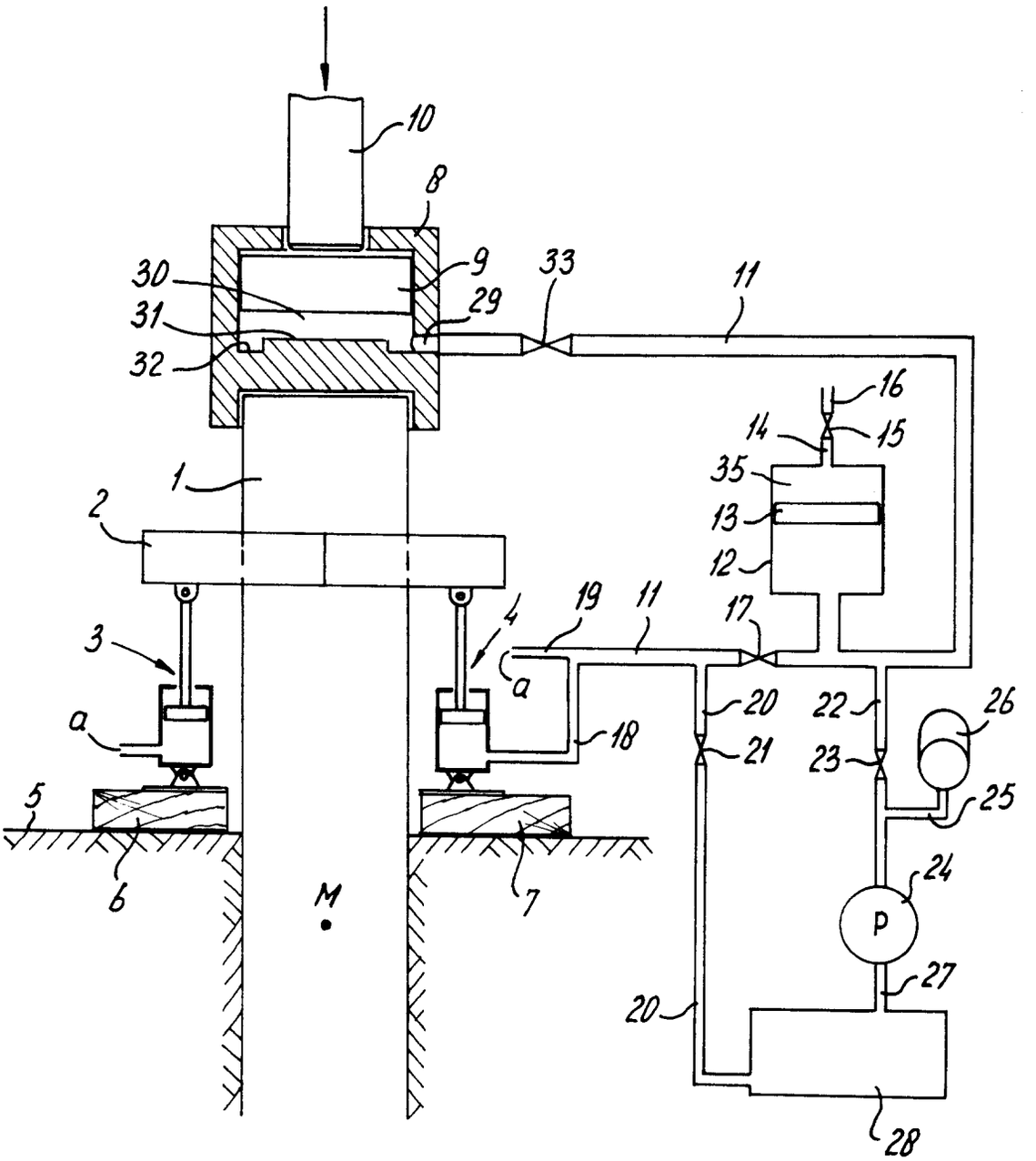

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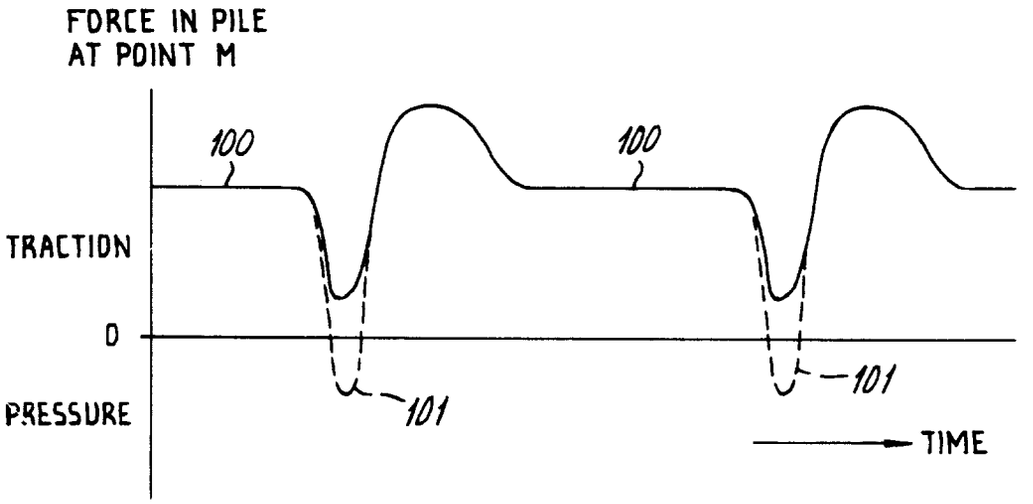
fig-2a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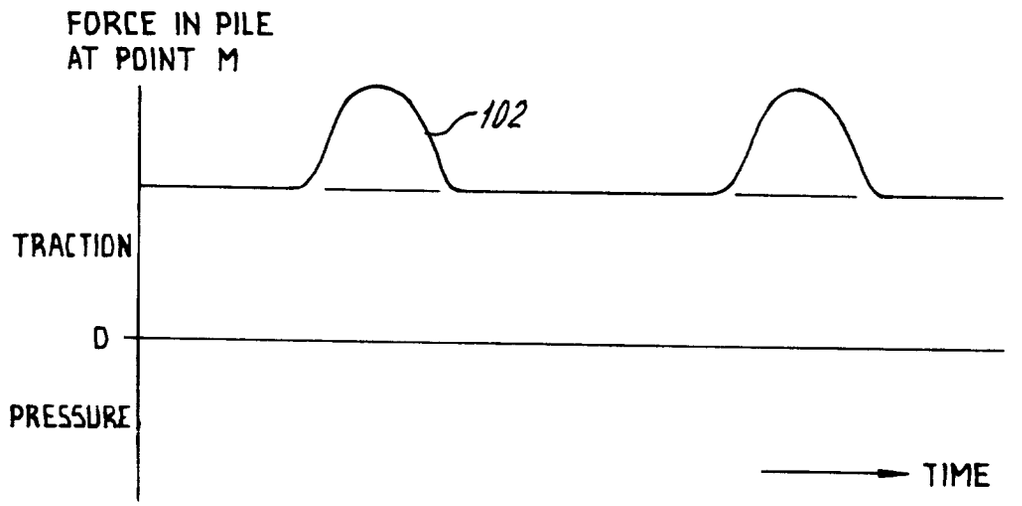
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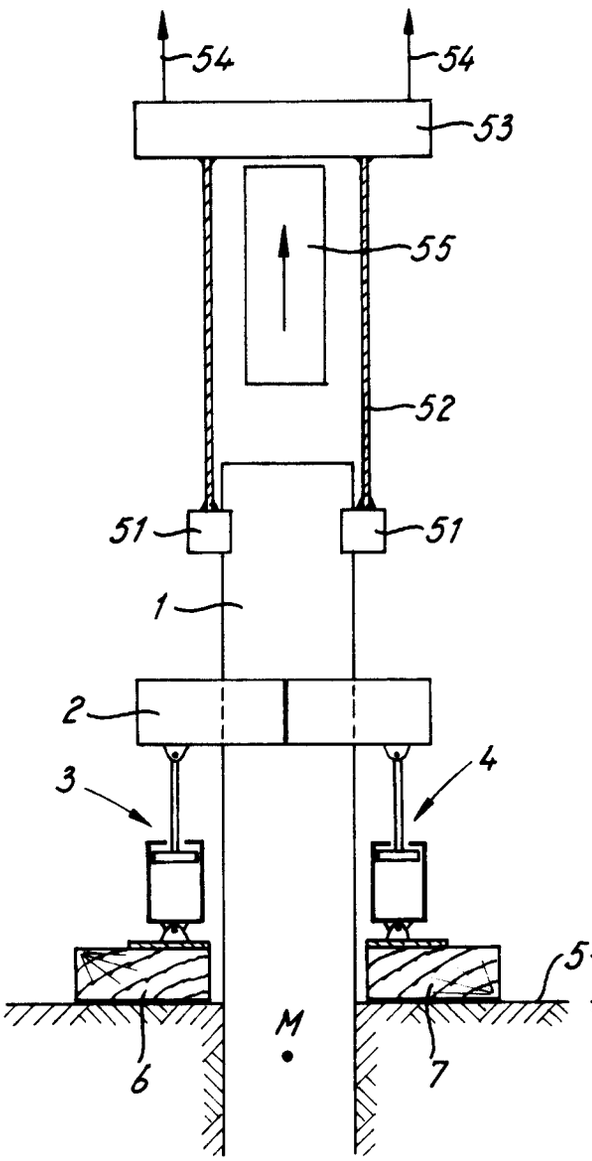

Fig - 4

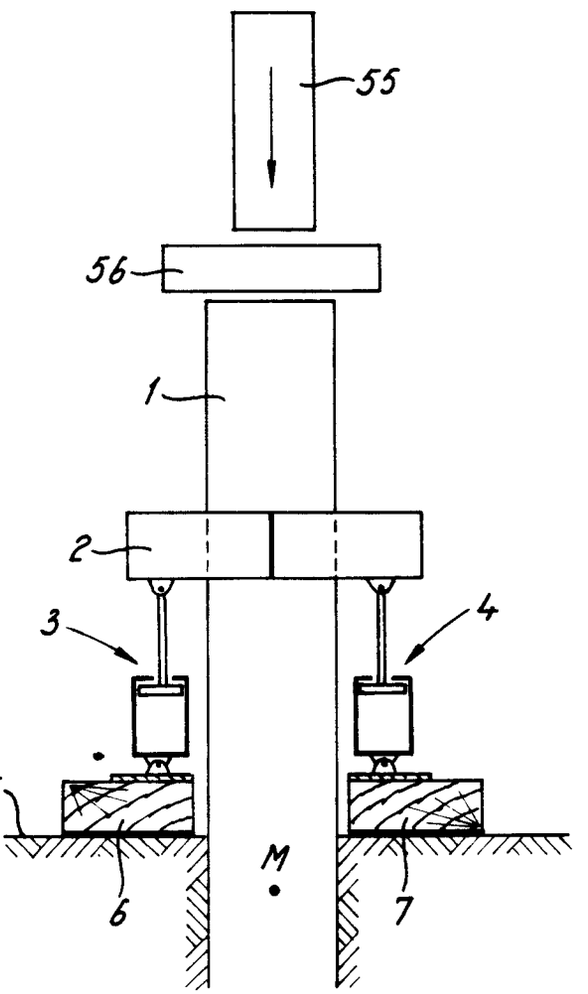

Fig-5

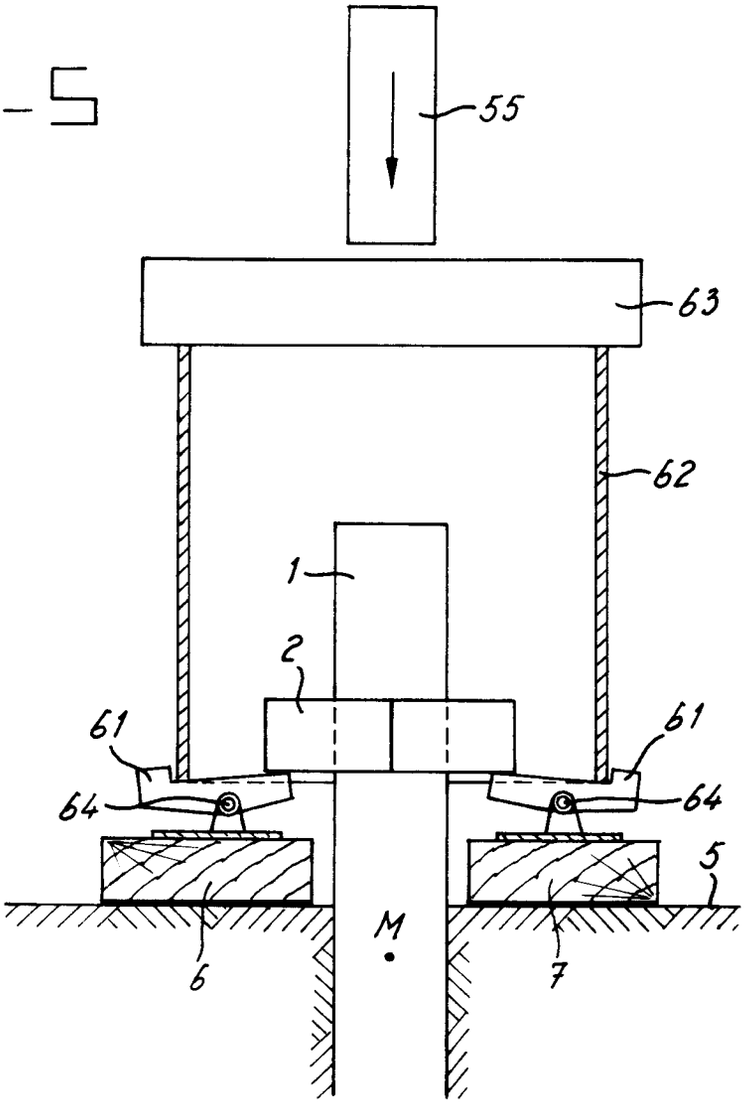
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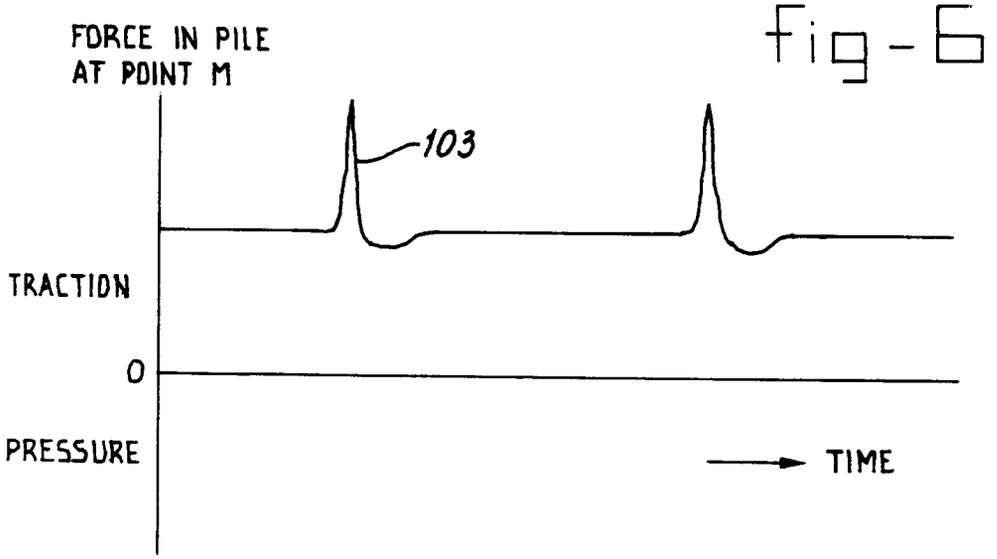
Fig-6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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 20 1906

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y A	GB-A-804 430 (DORNFELD & DORNFELD) 12 November 1958 * the whole document * ---	1-3 5 4,6,9, 11,16,17	E02D9/02
X A	WO-A-84 00571 (RAYMOND INT BUILDERS) 16 February 1984 * page 7, line 25 - page 10, line 25; figure 1 * ---	1,2 4,8,9	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 October 1995	Blommaert, S

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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