

PROCESS AND ARRANGEMENT FOR SINKING A DEEP BORE-HOLE

The invention relates to a process for sinking a deep bore-hole according to the rotary flushing drilling process, wherein a drill string hanging on a hook and comprising a multiplicity of coupled, drill pipes is sunk into the bore-hole, wherein the deepest drill pipe carries a rotary drilling tool at its free end, which is driven by the drill string or indirectly, wherein the lower part of the drill string is fitted with at least one heavy element, by means of which the cutting pressure of the rotary drilling tool is produced, and the drill string is displaced according to the progress of the drilling by coupling further drill pipes to its upper end, wherein a drilling fluid is fed through the hollow drill pipes to the rotary drilling tool, where it emerges into the bore-hole, wherein the drilling fluid in the bore-hole is fed to the surface together with the drillings, and wherein the drilling fluid in the drill string only communicates with the drilling fluid in the bore-hole in the region of the rotary drilling tool.

The invention further relates to an arrangement for carrying out such a process - within the context of the invention a deep bore-hole denotes bore-holes which are customary in oilfields or in connection with exploration work. The depth of these can reach 5000 m or even 10,000 m. The drilling fluid is mainly composed of water and chemicals. It produces a considerable hydrostatic pressure in the bore-hole, which for a 10 m depth of bore-hole increases by about 1 to 2 bar from the top to the bottom of the bore-hole. The rotary

drilling tool is caused to rotate by a rotary drill drive unit. The rotary drill drive unit can be disposed on the surface and can drive the rotary drilling tool via the drill string. However it can also be disposed in the drill string in the vicinity of the base of the bore-hole, wherein the part of the drill string located above it is not normally also driven. The drill pipes from which the drill string is assembled can vary in terms of their spatial extent.

In the context of the known measures which the invention takes as its starting point (Encyclopedia of Natural Science and Technology, published by Modern Industry, Munich, 1980, Pages 1233 and 1234), the drill string comprises one unit with respect to the hydrostatic effects which the drilling fluid exerts on it. The hydrostatic pressure of the drilling fluid acts on the rotary drilling tool within the framework of a state of hydrostatic stress, with an axial component with respect to the drill string, which at the upper end of the drill string merely acts in opposition to the atmospheric pressure. The radial components of the upwardly decreasing hydrostatic pressure of the drilling fluid, which are distributed over the length of the drill string, cancel each other out. In this way the hydrostatic pressure of the drilling fluid acts outwards from the rotary drilling tool, with a component of pressure acting on the drill string. This exerts a lifting force on the drill string which opposes the weight of the drill string acting in the axial direction. The lifting force and weight are superimposed and lead to the elastic deformations which result from the state of stress.

The so-called neutral cross-section is located between a lower section of the drill string with a compressive stress which decreases upwards and an upper section of the drill string with a tensile stress which decreases downwards. It is understood that the conditions and the position of the neutral cross-section are altered if the drill string rests on the base of the bore-hole with a supporting force which is more or less greater according to the conditions imposed on the hook on which the drill string hangs. It is further understood that, for a constant supporting force, the neutral cross-section moves upwards within the drill string corresponding to the progress of the drilling and thus corresponding to the increasing hydrostatic pressure with respect to the base of the bore-hole.

If a drill string or a drill string section is placed under a compressive stress, its progress in a straight line is a metastable state. As soon as it is acted upon by lateral forces, the drill string can bow or bend. Since the diameter of a bore-hole is, as a rule, larger than the outside diameter of the drill pipes, that part of the drill string which extends from the base of the bore-hole to the neutral cross-section is in danger of bowing when drilling takes place. The direction of drilling of the rotary drilling tool can depart from the vertical if bowing takes place. Undesirable deviations in the bore-hole can then occur. Moreover, due to bowing, there is an increased danger of the drill pipes breaking in the region of compressive stress.

Within the framework of the known measures, drilling

is effected using heavy elements, which are constructed as drill pipes of heavy wall thickness and therefore great weight. They are also termed heavy rods. These heavy rods are formed in such a way and arranged in such a number that the drill string in the region between the rotary drilling tool and the neutral cross-section exhibits a reduced tendency to bow under the influence of the above-mentioned hydrostatic compressive stresses and, if applicable, the compressive stresses determined by the supporting force. For a deep bore-hole the part of the drill string which consists of heavy rods can be several hundred metres long.

With the known measures for sinking a deep bore-hole, bore-hole deviations are not eliminated, but are merely reduced. Moreover, the bore-hole deviations increase with increasing depth of the bore-hole. The use of an increasing number of heavy rods as drilling progresses, due to the increasing hydrostatic pressure, leads to an increase in the load on the hook as the depth of the bore-hole increases. The cost of manufacturing and assembly for a large number of special heavy rods is high.

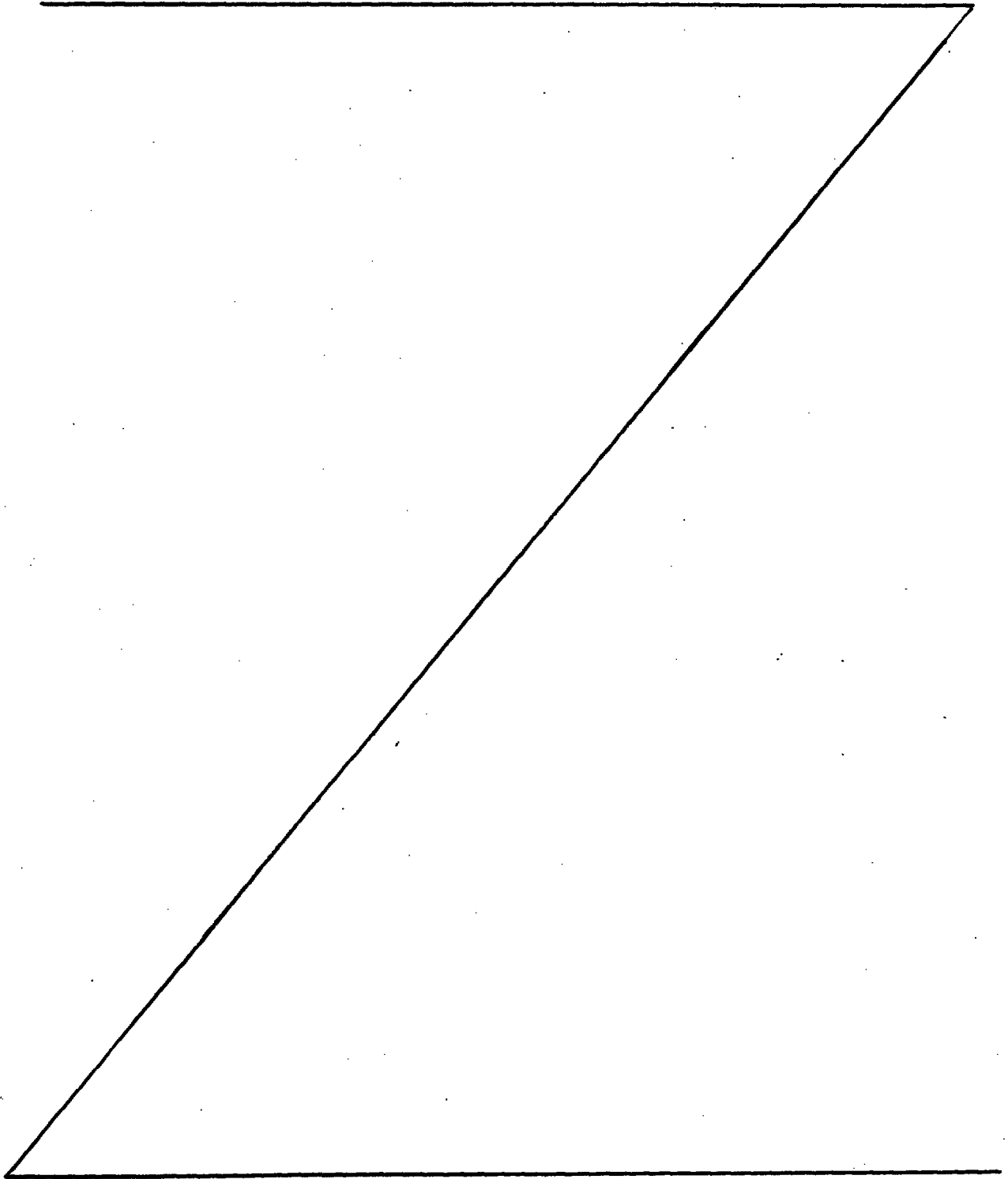
A basic object of the invention is to carry out a rotary flushing drilling process in such a way that straight bore-holes can be drilled without expensive measures. For this a lesser number of heavy elements is used compared with the known processes, which number is independent of the depth of the bore-hole. Furthermore, the load on the hook is reduced compared with the known processes.

According to a first aspect of the present invention

there is provided a process for sinking a deep bore-hole according to the rotary flushing drilling process, wherein a drill string hanging on a hook, and comprising a multiplicity of coupled, drill pipes is sunk into the bore-hole, wherein the drill string carries a rotary drilling tool at its lower end, which is driven by the drill string or down-hole driving means, wherein the lower part of the drill string is fitted with at least one heavy element, by means of which the cutting pressure of the rotary drilling tool is produced, and the drill string is displaced according to the progress of the drilling by coupling further drill pipes to its upper end, wherein a drilling fluid is fed through the drill pipes to the rotary drilling tool, where it emerges into the bore-hole, wherein the drilling fluid in the bore-hole is fed to the surface together with the drillings, and wherein the drilling fluid in the drill string only communicates with the drilling fluid in the bore-hole in the region of the rotary drilling tool, the drill string divided by means of at least one hydrostatic separation element into drill string sections which are hydrostatically independent, and which are acted upon at their lower ends and at their upper ends by the hydrostatic pressure of the drilling fluid in the bore-hole, with the heavy element(s) supported near the rotary drilling tool, and with the drill string kept under tensile stress down to the immediate vicinity of the rotary drilling tool by using sliding joints, with a sliding travel restricted to a maximum length of 5 mm, as said hydrostatic separation elements and by operation of the hydrostatic separation elements under tensile

force conditions.

It follows from the definition of the hydrostatically independent drill string section in the teaching of the invention that the hydrostatically determined axial stress



merely results from the difference in hydrostatic pressure between the upper and lower ends of the hydrostatically independent drill string section. Thus this stress is proportional to the length of the drill string section. The latter is selected so that a hydrostatically induced risk of bowing does not arise for the drill string section, even under the possible effect of the supporting force. A hydrostatically independent drill string section, which is hung in the drilling fluid, and which is acted upon at its upper end and at its lower end by the hydrostatic pressure of the drilling fluid in the bore-hole, has a compressive stress zone, a neutral cross-section without compressive stress or tensile stress, and a tensile stress zone. The position of this neutral cross-section is thus substantially independent of the depth to which the drill string section is submerged, since it is only the difference in hydrostatic pressure between the upper and lower ends which determines the length of the compressive stress zone. If a second drill string section is hung from such a submerged drill string section, the first drill string section is placed completely under a tensile stress, since the second section exerts a tensile force which exceeds the compressive force on the first section resulting from the hydrostatic pressure difference (a prerequisite for this is that the sections have the same dimensions). The same applies if further sections are hung on. A drill string of this type behaves physically like a chain which is hung in a liquid. A zone of compressive stress only exists in the lower region of the lowest section.

If a drill string comprising hydrostatically independent sections is fitted at its lower end with a rotating drilling tool, and is lowered far enough so that the rotary drilling tool is located on the base of the bore-hole, a compressive load is exerted according to the invention on the rotary drilling tool by a heavy element of constant weight, which is supported near the rotary drilling tool. On drilling, a compressive load acts on the rotary drilling tool, which is independent of the hydrostatic pressure at the base of the bore-hole. The compressive load on the rotary drilling tool is determined by the weight of the heavy element minus the hydrostatic pressure difference at the lowest drill string section. In contrast to this, the hydrostatic pressure difference for known processes is determined by the complete drill string. In order to produce a definite compressive load on the rotary drilling tool, only one heavy element is required for the process according to the invention, the weight of which element is less than the total weight of the heavy rods in the known processes. Furthermore, the load on the hook is reduced.

In the process according to the invention, and due to the support of the heavy element in the immediate vicinity of the rotary drilling tool, the entire drill string located above the support is under a tensile stress, and the drill string cannot bow. As a consequence of this, bore-hole deviations are substantially prevented, and drilling progresses along a straight line in the vertical direction.

According to a second aspect of the invention there

is provided an arrangement for carrying out the process. The characteristics of the arrangement are given independent protection. An arrangement according to the invention starts from the known arrangement comprising a drilling rig with hook, draw works, manipulating device for the drill string, and flushing unit, with a drill string comprising a multiplicity of drill pipes coupled so that they rotate together, wherein the lower part of the drill string is equipped with heavy elements, with a rotary drilling tool at the lower end of the drill string and with a rotary drill drive unit, with one or more hydrostatic separation elements enclosed within the drill string so that they rotate with it whereby the hydrostatic separation elements are sliding joints with a sliding travel restricted to a maximum length of 5 mm and whereby the heavy element is supported near the rotary drilling tool.

A hydrostatic separation element according to the invention consists of two sealed hollow parts which slide against each other and which can move axially in relation to the drill string, the degree of axial movement of which is restricted in both axial directions, which are coupled to each other so that they rotate together, and the free ends of which can be coupled to drill pipes so that they rotate together with the latter. The two-piece construction of the element and its ability to move axially lead to a hydrostatic separation of the two parts, since the drilling fluid can penetrate between the two parts, and both parts are acted upon at their respective ends by the hydrostatic pressure. The restriction

of axial movement means that tensile stresses can be transmitted, in order to pull the drill string out of the bore-hole, for example. The two parts are coupled to each other so that they rotate together, in order to transmit rotational motion from the rotary table at the surface to the rotary drilling tool at the base of the bore-hole. The sealing of the two parts against each other ensures that the drilling fluid in the drill string only communicates with the drilling fluid in the bore-hole in the region of the rotary drilling tool.

A preferred form of a hydrostatic separation element is characterised in that it comprises two coaxial tubular pieces which can move into each other, sliding with their axes parallel on sliding surfaces, that at least one seal is disposed between the tubular pieces, and that both sliding surfaces have toothed wheel rims which engage within each other and which can move axially and transmit the rotational force, that one tubular piece has a threaded stem at its free end and that the other tubular piece has a threaded socket at its free end. The threaded stem and the threaded socket ensure that this preferred form of hydrostatic separation element can be enclosed between two drill pipes so that it rotates with the latter without further measures.

Arranging that the capacity for axial movement is as small as possible within the context of the structural possibilities obviously falls within the scope of the invention.

A further preferred form of hydrostatic separation

element is characterised in that it is equipped with one or more spring elements between the two coaxial tubular pieces, which spring elements press the two tubular pieces apart under spring pressure up to the maximum axial extension. The spring elements cushion any shocks which may occur and which act in the axial direction.

An example of an embodiment of the heavy element according to the invention is characterised in that the heavy element comprises a tube arranged coaxially with respect to the drill string, the inside diameter of which tube is larger than the outside diameter of the drill string, at least in the lower region of the drill string, that the heavy element is supported with its lower end near the rotary drilling tool, and that the heavy element is otherwise free of the drill string. Supporting the heavy element at the lower end of the drill string (in association with the hydrostatic separation) ensures that the entire drill string is placed under tensile stress. A compressive stress only exists in the heavy element.

A further example of an embodiment of the heavy element according to the invention is characterised in that the heavy element comprises a tube which is arranged coaxially with respect to the drill string, the outside diameter of which tube is smaller than the inside diameter of the drill string, at least in the lower region of the drill string, that the heavy element is supported with its lower end near the rotary drilling tool, and that the heavy element is otherwise free of the drill string.

The heavy element according to the invention can also

comprise several tubular pieces connected to each other.

An arrangement according to the invention is explained below in more detail by means of the schematic drawings, which merely represent examples of embodiments, and
5 where:

Figure 1 shows a rotary flushing drilling device with hydrostatic separation elements and a heavy element,

Figure 2 is a detailed view of a hydrostatic separation element,

10 Figure 3 is a detailed view of a heavy element with an inside diameter which is larger than the outside diameter of the drill string, at least in the lower region of the drill string, and

15 Figure 4 is a detailed view of a heavy element with an outside diameter which is smaller than the inside diameter of the drill string, at least in the lower region of the drill string.

In the example of an embodiment shown in Figure 1, the arrangement for carrying out the process according to the
20 invention comprises a drilling rig 1 with a hook, draw works, device for manipulating the drill string, rotary drill drive unit and flushing unit, a drill string 2 comprising a multiplicity of drill pipes 3 which are coupled so that they rotate together and in which hydrostatic separation elements 4
25 are enclosed so that they rotate with the drill pipes, a rotary drilling tool 5, and a heavy element 6. It is understood that a number of hydrostatic separation elements 4 which departs from that shown in Figure 1 can also be used for

the arrangement.

Figure 2 is a schematic representation of a detailed view of a preferred embodiment of a hydrostatic separation element, partly sectioned and partly as an external view. The hydrostatic separation element 4 preferably comprises two coaxial tubular pieces 401 and 402, which are pushed into each other and which also slide against each other. The outer surface of the inner piece 403 slides on the inner surface of the outer piece 404. Further, sealing elements 405 are fitted between the two sliding surfaces, so that the drilling fluid inside the drill string cannot escape into the borehole. Varying the number of sealing elements falls within the scope of the invention. The sliding travel 406 is restricted to a maximum length of 5 mm, for example, by means of ring surfaces 407. Adjusting the sliding travel 406, by fitting washers on the ring surface 407 or by another means of adjusting the distance of axial movement, falls within the scope of the invention. For the transmission of rotational forces, the outer surfaces of the inner piece 403 and the inner surfaces of the outer piece 404 have toothed segments 408 which engage with each other and which are not restricted by the sliding travel. The inner tubular piece 401 and the outer tubular piece 402 can be screwed to the drill pipes 3 above and below the hydrostatic separation element by means of threads 409 and 410. The inner tubular piece is provided with a threaded socket 409, and the outer tubular piece is provided with a threaded stem 410 (the threads are not shown). It is understood that interchanging threaded stem 410 and threaded

socket 409 falls within the scope of the invention. In order to cushion any possible shocks which occur in the axial direction, one or more spring elements 411 can be disposed between the ring surfaces 407. Assembly of the hydrostatic separation element is possible in the manner shown if the outer tubular piece 402 consists of two shells which are screwed together, for example. Assembly of a hydrostatic separation element according to Figure 2 can be also effected by employing other mechanical means, however.

Figure 3 shows by way of example an embodiment of a heavy element 6. The inside diameter of the heavy element 6, which is arranged coaxially to the drill string 2, is larger than the outside diameter of the drill pipes 3. The heavy element 6 is supported with its lower end 601 near the rotary drilling tool 5. The lower end 601 of the heavy element 6 can be supported by various known mechanical means, such as a threaded joint.

Figure 4 shows by way of example a further embodiment of a heavy element 6. The outside diameter of the heavy element 6, which is arranged coaxially to the drill string 2, is smaller than the inside diameter of the drill pipes 3. The heavy element 6 is supported with its lower end 601 near the rotary drilling tool 5. The lower end 601 of the heavy element 6 can be supported by various known mechanical means, such as a threaded joint.

In the examples shown in Figures 3 and 4, the heavy element 6 consists of several tubular pieces 602. The heavy element 6 can obviously also be constructed as a structural

unit.

The heavy element 6 according to the invention can be developed further by various known mechanical means. In Figure 3, for example, a so-called stabiliser 603 is mounted on the external periphery of the heavy element 6; this supports the heavy element 6 laterally in relation to the wall of the borehole. Supporting the heavy element 6 at its upper end 605 in relation to the drill pipe 2 also falls within the scope of the invention. In the example shown in Figure 3 a tubular sleeve 604 is mounted on the drill pipe 2 in the region of the upper end 605 of the heavy element, the outside diameter of which tubular sleeve is adapted to the inside diameter of the heavy element at its upper end 605. Furthermore, constructing the support at the upper end 605 so that the upper region of the heavy element 6 cannot rotate against the drill string 2 in the upper region also falls within the scope of the invention. This can be achieved, for example, by a hexagonal guide to take the axial displacement.

Independently of which mechanical means may be used to provide lateral stabilisation of the heavy element 6, it must be ensured that a capacity for axial movement persists between heavy element 6 and drill string 2, apart from at the lower end 601 of the heavy element.



CLAIMS

1. A process for sinking a deep bore-hole according to the rotary flushing drilling process, wherein a drill string hanging on a hook, and comprising a multiplicity of coupled, drill pipes is sunk into the bore-hole, wherein the
5 drill string carries a rotary drilling tool at its lower end, which is driven by the drill string or down-hole driving means, wherein the lower part of the drill string is fitted with at least one heavy element, by means of which the cutting pressure of the rotary drilling tool is produced, and the
10 drill string is displaced according to the progress of the drilling by coupling further drill pipes to its upper end, wherein a drilling fluid is fed through the drill pipes to the rotary drilling tool, where it emerges into the bore-hole, wherein the drilling fluid in the bore-hole is fed to the
15 surface together with the drillings, and wherein the drilling fluid in the drill string only communicates with the drilling fluid in the bore-hole in the region of the rotary drilling tool, the drill string divided by means of at least one hydrostatic separation element into drill string sections
20 which are hydrostatically independent, and which are acted upon at their lower ends and at their upper ends by the hydrostatic pressure of the drilling fluid in the bore-hole, with the heavy element(s) supported near the rotary drilling tool, and with the drill string kept under tensile stress down
25 to the immediate vicinity of the rotary drilling tool by using sliding joints, with a sliding travel restricted to a maximum length of 5 mm, as said hydrostatic separation elements and by



operation of the hydrostatic separation elements under tensile force conditions.

2. An arrangement for carrying out the process according to Claim 1, comprising a drilling rig with hook,
5 draw works, manipulating device for the drill string, and flushing unit, with a drill string comprising a multiplicity of drill pipes coupled so that they rotate together, wherein the lower part of the drill string is equipped with heavy elements, with a rotary drilling tool at the lower end of the
10 drill string and with a rotary drill drive unit, with one or more hydrostatic separation elements enclosed within the drill string so that they rotate with it whereby the hydrostatic separation elements are sliding joints with a sliding travel restricted to a maximum length of 5 mm and whereby the heavy
15 element is supported near the rotary drilling tool.

3. An arrangement according to Claim 2, wherein the hydrostatic separation elements comprise two sealed hollow parts which slide against each other, which can move axially in relation to the drill string, the axial movement of which
20 sealed hollow parts is restricted in both axial directions, which are coupled so that they rotate together, and which can be coupled at their free ends with drill pipes so that they rotate together with the latter.

4. An arrangement according to one of Claims 2 or 3,
25 wherein the hydrostatic separation elements comprise two coaxial tubular pieces which can move into each other on sliding surfaces, that at least one seal is disposed between the tubular pieces, that the two sliding surfaces have toothed

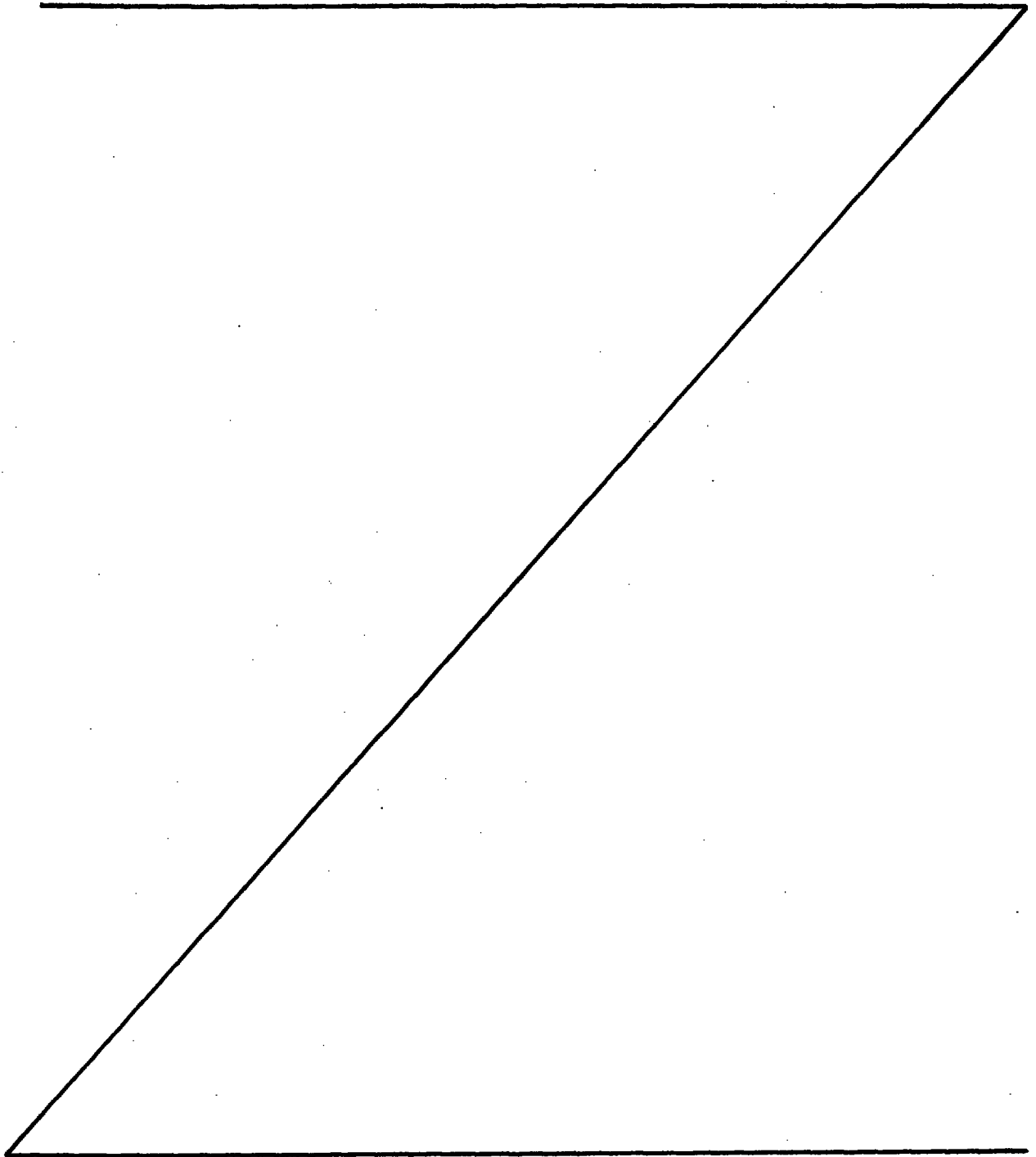


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segments which engage with each other, which can move axially and which transmit rotational forces, that one tubular piece has a threaded stem at its free end, and that the other tubular piece has a threaded socket at its free end.

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5. An arrangement according to any one of Claims 2





to 4, wherein the hydrostatic separation elements are equipped with one or more spring elements between the two coaxial tubular pieces which spring elements press the two tubular pieces apart by spring pressure in the axial direction up to the maximum axial extent.

6. An arrangement according to any one of Claims 2 to 5, wherein the heavy element comprises a tube arranged coaxially with respect to the drill string, the inside diameter of which tube is larger than the outside diameter of the drill string, at least in the lower region of the drill string, that the heavy element is supported with its lower end near the rotary drilling tool, and that the heavy element is otherwise free from the drill string.

7. An arrangement according to any one of Claims 2 to 5, wherein the heavy element comprises a tube arranged coaxially with respect to the drill string, the outside diameter of which tube is smaller than the inside diameter of the drill string, at least in the lower region of the drill string, that the heavy element is supported with its lower end near the rotary drilling tool, and that the heavy element is otherwise free from the drill string.

8. An arrangement according to any one of Claims 2 to 7, wherein the heavy element comprises several tubular pieces which are attached to each other.

9. A process for sinking a deep bore-hole, substantially as hereinbefore described with reference to the accompanying drawings.

10. An arrangement for sinking a deep bore-hole,



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substantially as hereinbefore described with reference to the accompanying drawings.