

Depth vibrator with adjustable imbalance

Description

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The invention relates to a depth vibrator for compacting soil by means of a rotating imbalance. The rotating imbalance generates vibrations, with which the depth vibrator compacts the soil and possible additive material.

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Depth vibrators are generally used in three methods for sub improvement, which differ from one another with regard to the mode of functioning and the load transfer. With the vibro-compaction method, coarse-grained soils are compacted in themselves. With the vibro-displacement method, load-transferring columns of grit or gravel are introduced into mixed- and/or fine-grained, non-compactable soils. With the third method, pile-like foundation elements are produced, by means of which relatively high loads can be transferred if a sustainable connection with displacement columns cannot be guaranteed. The different depth vibration methods are also described in the applicant's brochure "Depth Vibration Methods" (Brochure 10-02D).

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All the methods have in common the fact that the vibrator is sunk in the ground to an intended improvement depth and then, depending on the type of method, soil is compacted from the bottom upwards, a displacement column is built up or a pile-like foundation element is produced.

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As an essential element, the vibrator contains a motor-driven imbalance, which sets the vibrator into horizontal vibrations. The depth vibrator is adapted to the intended working depth by

means of attachment pipes and guided by cranes, excavators or specially developed support devices (support caterpillars).

5 A depth vibrator for compacting a soil with a first imbalance weight and a fastening element for the exchangeable mounting of a second imbalance weight is known from DE 10 2014 019 139 A1. The first imbalance weight and the second imbalance weight can be driven in a rotating manner about the longitudinal axis of the depth vibrator. The fastening element is arranged such
10 that the imbalance of the depth vibrator can be reduced by the incorporated second imbalance weight.

A depth vibrator for compacting soils with an elongated housing with a longitudinal axis and a motor-driven rotary
15 axis mounted coaxially in the housing as well as an imbalance mass rotating with the rotary axis is known from DE 199 30 884 A1. Means for changing the radial distance of the centre of gravity of the imbalance mass from the longitudinal axis and a speed-variable drive for the rotary axis are provided. By
20 changing the magnitude of the imbalance mass, the effective impact force during the sinking and/or extraction is changed.

In the case of depth vibrators with which the eccentric is non-adjustable, it has to be established already during the
25 assembly what centrifugal forces and amplitude the vibrator is to have. During operation, there is only very limited scope, by changing the speed, for reacting to different soil properties.

30 Depth vibrators with an adjustable eccentric require a mechanical device for adjusting the imbalance masses. The adjustment mechanism, however, is subjected to high loads on

account of the strong vibrations, which high loads can lead to failure of individual mechanical parts.

5 The problem underlying the present invention, therefore, is to propose a depth vibrator with an adjustable imbalance mass, which is constructed in a simple and robust manner and therefore has a long service life. Furthermore, a corresponding method for compacting soil is to be proposed, which enables a change to the imbalance mass during the
10 operation.

As an solution, a depth vibrator for compacting soil is proposed, comprising: a rotary drive that is rotatingly drivable in two rotation directions, a drive shaft that is
15 drivingly connected to the rotary drive, a primary mass body that is connected to the drive shaft in a rotationally fixed manner and rotates together with the latter about the rotary axis, a secondary mass body that is rotatable to a limited extent relative to the primary mass body and occupies a first
20 rotation position relative to the primary mass body when the drive shaft is rotated in the first rotation direction, in which rotation position a centre of gravity of the secondary mass body is arranged close to the centre of gravity of the primary mass body, and occupies a second rotation position
25 relative to the primary mass body when the drive shaft is rotated in the second rotation direction, in which second rotation position the centre of gravity of the secondary mass body is arranged distant from the centre of gravity of the primary mass body, wherein the centre of mass of the secondary
30 mass body and the centre of mass of the primary mass body have different radial distances from the rotary axis.

An advantage is that the imbalance can be changed between two magnitudes by a simple reversal of the direction of rotation of the rotary drive, wherein, on account of the embodiment of the first and secondary mass body such that the centres of gravity lie on different radii, particularly high imbalances can be achieved and/or a large variability with regard to the adjustable imbalances is provided. The effect of this is that the amplitude of the depth vibrator can be adjusted in particularly large ranges by means of the adjustment of the secondary mass body. Depending on the mass and shape of the secondary mass body, the amplitude in the first rotation position can be more than doubled compared to the second rotation position. For the adjustment of the imbalance, the direction of rotation of the rotary drive merely has to be changed, for which purpose the latter has to be briefly stopped.

With regard to the embodiment of the mass bodies and, accordingly, the position of the respective centres of mass of the primary mass body connected non-rotatably to the drive shaft on the one hand and of the secondary mass body rotatable relative to the drive shaft on the other hand, various possibilities are conceivable. According to a first possibility, the rotatable secondary mass body has a greater radial distance from the rotary axis than the non-rotatable primary mass body. Alternatively, the reverse is also possible, i.e. the primary mass body connected non-rotatably to the shaft has a greater radial distance from the rotary axis than the rotatable secondary mass body in this regard.

The rotary drive can have any embodiment which is suitable for generating for a rotary movement in two rotation directions. For example, the rotary drive can be constituted in the form

of an electric motor or a hydraulic drive. The electric motor can comprise a stator, which is connected non-rotatably to a housing of the depth vibrator, i.e. is supported relative thereto in the sense of rotation, as well as a rotor, which is
5 connected to a motor shaft in order to drive the latter.

The drive shaft, which carries the primary and secondary mass bodies, is drivingly connected to the rotary drive. With the expression "drivingly ", an indirect connection of the
10 aforementioned drive parts is intended to be included in the context of the present disclosure, i.e. the possibility that one or more further components can be interconnected in the power path between the rotary drive and the drive shaft, for example a coupling or a gear unit.

15 The term "primary mass body" is intended in the present disclosure to mean in particular at least one mass body which is connected non-rotatably, i.e. in a rotationally fixed manner to the drive shaft. A "secondary mass body" denotes in
20 the present disclosure in particular a mass body which can be adjusted relative to the primary mass body, so that the centre of gravity of the total mass changes. One or more primary and secondary mass bodies can be provided. Accordingly, it is to be understood that, within the scope of the disclosure, each
25 reference to a primary or secondary mass body can also apply to each further corresponding primary or secondary mass body. The mass bodies can also be referred to as mass members.

The masses of the primary and the secondary mass body can be
30 selected as required and according to the desired amplitude of the depth vibrator. A great variability can in particular be achieved if the primary and secondary mass bodies have masses of different magnitude. The primary mass body compared to the

secondary mass body can have a larger or smaller mass. It is advantageous in terms of a large vibration amplitude if the mass body, the centre of gravity of which has the greater distance from the rotary axis, also has the greater mass. This
5 may be the primary or secondary mass body. It is also possible that the masses of the primary and secondary mass body are of equal magnitude.

It is provided in particular that the centre of mass resulting
10 from the primary mass body and the secondary mass body in the first rotation position has a greater distance from the rotary axis than the centre of mass resulting from the primary mass body and the secondary mass body in the second rotation position. The centres of mass of the primary and secondary
15 mass body in the first rotation position preferably lie on a common side and in the second rotation position on opposite sides relative to the rotary axis of the drive shaft.

According to a preferred embodiment, a first stop is provided,
20 against which the secondary mass body is supported when the rotary drive is rotated in the first rotation direction, and a second stop, against which the secondary mass body is supported when the rotary drive is rotated in the second rotation direction. A particularly straightforward structure
25 is achieved in that first and second stop are formed on a common stop element, for example as two stop faces of the stop element acting in opposite rotation directions. For an or each imbalance assembly, which comprises a primary mass body and a secondary mass body, preferably precisely one stop element is
30 provided per secondary mass body, which forms the first rotation stop and the second rotation stop.

According to a possible embodiment, the stop element can be provided on the primary mass body, in particular can be fixedly connected to the latter. The connection of the stop element to the primary mass body can take place for example by means of a screw connection, wherein other connections such as a weld joint are also possible. The stop element can be constituted for example in the form of a stop bar, which is fixedly connected to the primary mass body and extends parallel to the rotary axis along an outer circumferential surface of the primary mass body.

According to a possible embodiment, the first mass body comprises a cylindrical segment, which preferably extends over approximately 180° about the rotary axis. The mass body can be produced in one piece with the drive shaft. Alternatively, the mass body can also first be produced separately and then connected to the drive shaft in a rotationally fixed and axially fixed manner, for example by means of shaft toothing, i.e. shaft splines or a shaft-hub connection with suitable axial securing means.

The secondary mass body can comprise an annular segment, which is mounted rotatably about the drive shaft. The annular segment can extend for example over more than 160° and/or less than 180° about the rotary axis.

According to a first possibility, the secondary mass body can be arranged with an axial overlap with respect to the primary mass body. The mass bodies are preferably constituted such that a smallest inner radius of an annular segment of the secondary mass body is greater than a greatest outer radius of the primary mass body. In other words, the secondary mass body in the first rotation position lies radially outside the

primary mass body. According to an advantageous development, the secondary mass body in this embodiment comprises an upper cover part, which is fixed to an upper end of the annular segment, and a lower cover part, which is fixed to a lower end
5 of the annular segment, wherein the two cover parts are at least indirectly rotatably mounted radially on the inside on the drive shaft. In this embodiment, the primary mass body in the first rotation position is accommodated spatially in the secondary mass body. As a result that the annular segment of
10 the secondary mass body lies radially outside the primary mass body, a particularly large imbalance and, correspondingly, also a large vibration amplitude are generated.

According to a second possibility, the secondary mass body can
15 also be arranged with an axial offset with respect to the primary mass body, i.e. above and/or below a respective axial end of the primary mass body. This embodiment is particularly suitable for applications in which only a small additional imbalance or increase in amplitude is required.

20 For both possibilities, it applies that the secondary mass body is arranged at least partially radially outside the primary mass body and/or that the centre of mass of the secondary mass body has a greater radial distance from the
25 rotary axis than the centre of mass of the primary mass body. The stop element is configured corresponding to the embodiment of the secondary mass body. Particularly in the case of the first possibility, the stop element can be constituted radially protruding with respect to an outer circumferential
30 surface of the primary mass body, in order to act as a driver for the secondary mass body during rotation of the drive shaft. For a particularly large contact area, the stop element can extend in the axial direction over at least a third of the

height of the primary mass body. In the case of the second possibility, the stop element can in particular protrude axially with respect to an axial end side of the primary mass body.

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In order to generate a particularly large imbalance mass, at least one of the primary and the secondary mass bodies can contain heavy metal. Furthermore, a plurality of primary and/or secondary mass bodies can also be provided.

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An imbalance assembly, which is to be mounted as a unit in a housing of the depth vibrator, can in each case comprise at least one shaft part, a primary and a secondary mass body. The shaft part is mounted rotatably in the housing of the depth vibrator by means of an upper bearing, which is arranged above the primary mass body, and by means of a lower bearing, which is arranged below the primary mass body.

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According to an embodiment for particularly good vibration amplitudes, a plurality of imbalance assemblies can be provided, which are arranged below one another. The individual imbalance assemblies are preferably driven by a single rotary drive. For this purpose, the motor shaft of the rotary drive can be drivingly connected to the drive shaft of a first assembly and the first drive shaft can be drivingly connected to the drive shaft of a second assembly arranged below. An arbitrary number of further imbalance assemblies is possible. The driving connection of the individual shaft parts to one another can be implemented for example by means of a flange connection, shaft toothing, i.e. shaft splines or other shaft-hub connection. Each individual assembly preferably has separate bearings for mounting the respective shaft part in the housing, in order that the bearing load overall is small.

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It is thus guaranteed that the depth vibrator durably withstands forces and vibrations also in the case of an embodiment with a plurality of imbalance assemblies.

5 A method for compacting the soil by such a depth vibrator can comprise the steps: vibro-driving of the depth vibrator into the soil up to a desired depth by rotating the rotary drive in a first or second rotation direction and compacting the soil by rotating the rotary drive in the second rotation direction.
10 By rotating the rotary drive in the second rotation direction, large vibration amplitudes and therefore a high level of compaction are generated. The vibro-driving down to the desired depth can take place with a small or large amplitude.

15 Preferred embodiments are explained below with the aid of the figures in the drawing. In the figures:

Figure 1 shows a depth vibrator in a first embodiment in a longitudinal cross-section;

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Figure 2 shows the depth vibrator from figure 1 in cross-section according to intersecting line II-II from figure 1;

25 Figure 3 shows a depth vibrator in a second embodiment in a longitudinal cross-section;

Figure 4 shows the depth vibrator from figure 3 in cross-section according to intersecting line IV-IV from
30 figure 3;

Figure 5 shows a depth vibrator in a third embodiment in a longitudinal cross-section;

Figure 6 shows a depth vibrator in a further embodiment in a longitudinal cross-section; and

5 Figure 7 shows the depth vibrator from figure 6 in cross-section according to intersecting line II-II from figure 6.

Figures 1 to 7 are first described below jointly with regard
10 to their common features.

A portion of a depth vibrator 2 is shown. A depth vibrator serves to compact soil by means of an imbalance. An imbalance is understood to mean a rotating body, the mass whereof is not
15 distributed rotation-symmetrically. The mass inertia axis of the mass body is offset relative to the rotation axis, so that the imbalance generates vibrations during rotation, with which the soil and possible additive material is compacted.

20 The depth vibrator 2 accordingly comprises a rotary drive 3, a drive shaft 4 driven in a rotating manner by the latter, a first mass body 5, which is connected non-rotatably to the drive shaft 4, as well as a second mass body 6, which can be adjusted in the sense of rotation with respect to first mass
25 body 5. The aforementioned components are accommodated in a housing 7 of depth vibrator 2, respectively mounted rotatably in the latter. It is provided that first and second mass bodies 5, 6 differ from one another with regard to their shape and/or mass and/or their respective distance of the centre of
30 gravity from drive shaft 4.

Rotary drive 3 is constituted in the present case in the form of an electric motor, which comprises a stator 8 supported in

the sense of rotation with respect to housing 7 and a rotor 9 rotatable with respect thereto. It goes without saying, however, that other motors can also be used, for example a hydraulic drive. Rotor 9 of electric motor 3 is connected to a motor shaft 10, in order to drive the latter in a rotating manner. The motor shaft 10 is mounted rotatably about a rotary axis A in the housing 7 by means of a first bearing 12, which is arranged above the rotary drive 3, and a second bearing 13, which is arranged below the rotary drive 3. The rotary drive 3 is configured such that it can drive the motor shaft 10 in two rotation directions, i.e. in the clockwise direction and in the anticlockwise direction.

The motor shaft 10 is connected by suitable connection means 14 to the drive shaft 4 lying there beneath in a rotationally fixed manner for the transmission of a torque. The connection means 14 are constituted in the present case in the form of a flange connection, wherein it is to be understood that other shaft couplings for the non-rotatable connection are just as possible.

The drive shaft 4 is mounted rotatably in housing 7 by suitable bearing means 15, 16, for example by means of roller bearings or sliding bearings. The first mass body 5, which can also be referred to as the primary mass body, is connected non-rotatably, i.e. on a rotationally manner to the drive shaft 4. The non-rotatable connection can be implemented by known means, for example in a form-fit manner by means of a shaft-hub connection and/or in a firmly bonded manner by means of a weld joint. It is also possible for the drive shaft 4 to be produced in one piece with first mass body 5.

The second mass body 6, which can also be referred to as the secondary mass body, is rotatable to a limited extent relative to first mass body 5. Provision is made such that secondary mass body 6 takes up a first rotation position P1 when the drive shaft 4 is rotated in first rotation direction R1 and a second rotation position P2 relative to first mass body 5 when the drive shaft 4 is rotated in opposite second rotation direction R2. In first rotation position P1, which can be seen in figures 1 to 5 in each case in the left-hand half of the image, the secondary mass body 6 is moved closer to primary mass body 5, i.e. the two mass bodies 5, 6 are located on the same half side relative to rotary axis A. In the second rotation position P2 of the swivellable, i.e. pivotable mass body 6, which is represented dashed in each case in the right-hand half of the image in figures 1 to 5 (reference number 6'), the secondary mass body 6 is arranged spaced apart from primary mass body 5, i.e. the two mass bodies 5, 6 are located on opposite half-sides relative to rotary axis A. It emerges from this embodiment that resultant centre of mass Sres1 formed from the first and the second mass bodies 5, 6 in the first position P1 of mass body 6 has a greater radial distance from the rotary axis A than resultant centre of mass Sres2, which emerges from the first and the second mass bodies 5, 6 when the secondary mass body (6') is located in the second position P2. It follows from this that the magnitude of the imbalance can be changed between two magnitudes by a simple rotation direction reversal (R1, R2) of the rotary drive 3. For the displacement of the imbalance, the direction of rotation R1, R2 of the rotary drive 3 merely has to be changed, for which purpose the latter briefly has to be stopped.

A particular feature of the present invention is that the centre of mass S6 of the swivellable mass body 6 has a greater radial distance from rotary axis A than the centre of mass S5 of the mass body 5 rotationally fixedly connected to the shaft 4, and/or that the swivellable mass body 6 protrudes at least partially radially with respect to the rotationally fixed mass body 5. As a result of this embodiment, particularly high imbalances can be achieved in the first rotation position P1, and respectively the amplitude of the depth vibrator 2 can be adjusted in particularly large ranges. Depending on the mass and shape of the secondary mass body 6, the amplitude in the first rotation position P1 can be more than doubled compared to the second rotation position P2.

In the embodiment shown in figures 1 and 2, the primary mass body 5 comprises a cylindrical segment, which extends over 180° about rotary axis A. In this embodiment, the secondary mass body 6 is arranged with an axial overlap with respect to primary mass body 5 and comprises an annular segment 17 with an upper cover part 18 and a lower cover part 19. Upper cover part 18, annular segment 17 and lower cover part 19 form a half-shell, which is dimensioned such that the first mass body 5 can be accommodated therein when the second mass body 6 is in the first rotation position P1. For this purpose, a smallest inner radius of annular segment 17 of the secondary mass body 6 is greater than a greatest outer radius of the primary mass body 6. In the first rotation position P1, the secondary mass body 6 lies radially outside relative to the primary mass body 5 and surrounds the latter. As a result of that the annular segment 17 of the secondary mass body 6 lies radially outside the primary mass body 5, a particularly great imbalance and, correspondingly, also a great vibration amplitude are generated.

Supporting of the half shell-shaped mass body 5 on the drive shaft 4 is effected by means of two bearings 20, 21. Upper cover part 18 is mounted rotatably on the shaft 4 by means of
5 a first bearing 20, which is arranged axially above first mass body 5, and lower cover part 19 by means of a second bearing 21, which is arranged axially beneath the first mass body 5. It can be seen in particular in figure 2 that the annular segment 17 extends over an angular region of somewhat less
10 than 180° about rotary axis A.

Relative rotation positions P1, P2 are each defined by a stop element 22, against which the secondary mass body 6 strikes when the rotary drive 3 rotates and is thus arranged in a
15 defined rotation position relative to primary mass body 5. In the present case, precisely one stop the element 22 is provided, which forms both a stop in the first rotation direction R1 and also a stop in the second rotation direction R2. The stop element 22 is constituted in the present case in
20 the form of a strip or bar, which is fixedly connected to the primary mass body 5, for example in a form-fit manner by means of screw connections or firmly bonded by means of welding. Stop element 22 protrudes radially above an outer circumferential surface of the primary mass body 5 and extends
25 in the axial direction, as can be seen in particular in figure 1, over at least half the axial length of the primary mass body 5, so that the most uniform possible force introduction and, respectively support of the secondary mass body 6 is provided. A first lateral face 23 of the strip 22 forms a
30 first stop in the first rotation direction R1 of the swivellable mass body 6, whilst an opposite second lateral face 24 of the strip 22 forms a second stop in the opposite rotation direction R1 of mass body 6.

In the embodiments according to figures 1 and 3, optional additional masses 25, 26 are also provided, which are connected fixedly to drive shaft 4. In the present case, a
5 first additional mass 25 is arranged above the first bearing 15 and a second additional mass 26 is arranged below the second bearing 16. The rotationally fixed connection to the shaft 4 can be effected for example by means of a form-fit shaft-hub connection. Provision can be made such that at least
10 one of the mass bodies 5, 6, 25, 26 contains heavy metal. Apart from that, the mass bodies can be produced from a metallic material, such as steel.

Figures 3 and 4 show a depth vibrator 2 in a somewhat modified
15 second embodiment. The latter largely corresponds to the embodiment according to figures 1 and 2, so that reference is made to the above description with regard to the common features. Identical, respectively modified details are provided with the same reference numbers as in figures 1 and
20 2.

In contrast with the above embodiment, two swivellable secondary mass bodies 6₁, 6₂ as provided in the present embodiment according to figure 3 and 4, which in each case are
25 mounted rotatably on the drive shaft 4. A first swivellable mass body 6₁ is arranged above the primary mass body 5 and is mounted on the shaft 4 by means of a connecting web 27 and the upper bearing 20. A second swivellable mass body 6₂ is arranged below the primary mass body 5 and is connected in a
30 swivellable manner to the shaft 4 by means of a connecting web 28 and a lower bearing 21. The two secondary mass bodies 6₁, 6₂ are constituted in the form of annular segments, which extend over approximately 180° about rotary axis A. It can be

seen in particular in figure 3 that an outer circumferential surface of the secondary mass bodies 6_1 , 6_2 protrude radially with respect to an outer circumferential surface of primary mass body 5. It follows from this that centres of mass S_{6_1} , S_{6_2} of the secondary mass bodies 6_1 , 6_2 have a greater radial distance from the rotary axis A than the centre of mass S5 of primary mass body 5.

In the present embodiment, two stops 22_1 , 22_2 are also provided corresponding to the number of swivellable masses 6_1 , 6_2 , which stops are each connected to the primary mass body 5. Stops 22_1 , 22_2 in each case project axially beyond an end front face and protrude radially beyond an outer circumferential surface 29 of the primary mass body 5. They are constituted in the form of fairly short bars, which moreover, can be connected to the mass body 5 as in the embodiment described above. The present embodiment is constructed radially somewhat smaller, since a radial overlap between swivellable mass bodies 6_1 , 6_2 and rotationally fixed mass body 5 is provided. As for the rest, the structure and mode of functioning correspond to the above embodiment, to the description whereof reference is made in this regard to avoid repetition.

Figure 5 shows a depth vibrator 2 in a further embodiment. The latter for the most part corresponds to the embodiment according to figures 1 and 2, so that reference is made to the above description with regard to the common features. Identical, respectively modified details are provided with the same reference numbers as in figures 1 and 2 and/or in figures 3 and 4.

A particular feature of the present embodiment is that the depth vibrator 2 comprises a plurality of imbalance assemblies 11₁, 11₂, which are each accommodated as a unit in the housing 7. Each imbalance assembly 11₁, 11₂ comprises respectively a
5 shaft part 4₁, 4₂, which in each case is mounted rotatably in the housing 7 by means of two bearings 12₁, 13₁; 12₂, 13₂ and can be driven in a rotating manner by the rotary drive 3, as well as a primary and a secondary mass body 5, 6. In each case, a first bearing 12₁, 12₂ is arranged above and a second
10 bearing 13₁, 13₂ below the respective mass bodies 5, 6, in order to ensure a secure radial bearing over the entire length of the shaft. The individual shaft parts 4₁, 4₂ are connected to one another by suitable shaft connections 14₁, 14₂, such as flange connections, wherein other connecting means are also
15 conceivable. In the present case, two imbalance assemblies 11₁, 11₂ are provided, which are driven by a single rotary drive. It is understood that three or more imbalance assemblies can also be used in order to generate still greater vibration amplitudes. The latter are drivingly connected to
20 one another by further shaft connections (14).

Figures 6 and 7 show a depth vibrator 2 in a further embodiment. The latter largely corresponds to the embodiment according figure 1 and 2, so that reference is made to the
25 above description with regard to the common features. Identical, respectively modified details are provided with the same reference numbers as in figures 1 and 2.

A difference with the present embodiment compared to those
30 according to figures 1 and 2 lies in the assignment of the two mass bodies 5, 6, which are interchanged in the present case. It can be seen that, in the present embodiment according to figures 6 and 7, the primary mass body 5, which is connected

to drive the shaft 4, in a rotationally fixed manner is the one with a greater distance of the centre of mass S5, whereas the mass body 6 swivellable about the rotary shaft 4 is the one, the centre of mass S6 whereof lies on a smaller radius.

5 The rotationally fixed connected mass body 5 comprises an annular segment 17, an upper cover 18 and a lower cover 19, which are connected fixedly to one another. For the rotationally fixed connection, a shaft toothing 30, 30' or another common shaft-hub connection can be provided between
10 the upper and the lower covers 18, 19 on the one hand and drive shaft 4 on the other hand. An axial support can be effected by means of an axial bearing. The swivellable mass body 6 can be mounted rotatably on the drive shaft 4, for example by means of a slide bearing 20 or a slide bush,
15 respectively.

Relative rotation positions P1, P2 of the swivellable mass body 6 are defined by a stop element 22, against which the mass body 6 strikes when the rotary drive 3 rotates and is
20 thus arranged in a defined rotation position relative to the rotationally fixed mass body 5. Rotation stop 22 is constituted as a strip or bar, which is connected to the primary mass body 5 and protrudes radially inwards from an inner circumferential surface. As for the rest, the embodiment
25 according to figure 6 corresponds, with respect to structure and mode of functioning, to those according to figures 1 and 2, to the description whereof reference is made in this regard.

30 It is to be understood that further embodiments are also conceivable, which in the present case are not all disclosed. In particular, it is possible for the embodiment according to figures 3 to 5 to be constituted with a reversed assignment of

the first and the second mass bodies 5, 6, i.e. outer mass body connected to drive shaft 4 in a rotationally fixed manner and inner mass body mounted swivellable about the drive shaft 4.

List of reference numbers

	2	depth vibrator
	3	rotary drive
5	4	drive shaft
	5	mass body
	6	mass body
	7	housing
	8	stator
10	9	rotor
	10	motor shaft
	11	imbalance assembly
	12, 13	bearing
	14	connecting means
15	15, 16	bearing
	17	annular segment
	18	cover part
	19	cover part
	20, 21	bearing
20	22	stop element
	23	lateral face
	24	lateral face
	25	additional mass
	26	additional mass
25	27	connecting web
	28	connecting web
	29	circumferential surface
	30	connection
	A	rotary axis
30	P	position
	R	direction
	S	centre of gravity/centre of mass

Claim:

1. A depth vibrator for compacting soil, comprising:

a rotary drive having an axis of rotation;
a drive shaft rotatable about the axis of rotation of the rotary drive in a first rotation direction R1 and in second rotation direction R2 opposite R1;
a primary mass body fixed to the drive shaft and rotatable therewith about the axis of rotation;
a stop member fixed to the drive shaft;
and a secondary mass body orbital about the drive shaft between a first rotation position P1 relative to the primary mass body by rotation of drive shaft in said first rotation direction R1 until said secondary mass body abuts one side of said stop member, and a second rotation position P2 relative to the primary mass body by rotation of the drive shaft in the second rotation direction until said secondary mass body abuts an opposing side of said stop member.

2. The depth vibrator for compacting soil according to claim 1,
wherein when said secondary mass body is moved into said first rotation position P1 the secondary mass body and primary mass body have substantially the same center of gravity relative to said axis of rotation.

3. The depth vibrator for compacting soil according to claim 2, wherein when said secondary mass body is moved into said second rotation position P2 the secondary mass body and primary mass body have substantially different centers of gravity relative to said axis of rotation.

4. The depth vibrator for compacting soil according to claim 1, wherein a center of gravity of said secondary mass body and of the primary mass body are located at different radial distances from the rotary axis.

5. The depth vibrator for compacting soil according to claim 4, wherein a center of gravity of said secondary mass body is located at a greater radial distance from the rotary axis as a center of gravity of said primary mass body.

6. The depth vibrator for compacting soil according to claim 1, wherein said stop member is connected to the primary mass body.
7. The depth vibrator for compacting soil according to claim 1, wherein said primary mass body comprises a partial-cylindrical segment.
8. The depth vibrator for compacting soil according to claim 7, wherein said primary mass body extends 180° about the rotary axis.
9. The depth vibrator for compacting soil according to claim 1, wherein said secondary mass body comprises an annular cylindrical segment mounted rotatably about both the primary mass body and drive shaft.
10. The depth vibrator for compacting soil according to claim 9, wherein said secondary mass body extends between 160° to 180° about the rotary axis.
11. The depth vibrator for compacting soil according to claim 9, wherein said primary mass body and said secondary mass body axially overlap.
12. The depth vibrator for compacting soil according to claim 9, wherein said secondary mass body is outside the primary mass body.
13. The depth vibrator for compacting soil according to claim 1, wherein said primary mass body and the secondary mass body are mounted on a shaft rotatably seated in bearings.
14. The depth vibrator for compacting soil according to claim 13, wherein said bearings comprise an upper bearing located above the primary mass body and a lower bearing located below the primary mass body.
15. The depth vibrator for compacting soil according to claim 1, wherein the secondary mass body is movable relative to the primary mass body by reversal of the rotation direction of the rotary drive.
16. The depth vibrator for compacting soil according to claim 9, wherein said stop member

comprises a bar fixedly connected to the primary mass body.

17. The depth vibrator for compacting soil according to claim 16, wherein said stop member protrudes radially relative to the primary mass body and extends axially along at least one third of the primary mass body.

18. A depth vibrator for compacting soil, comprising: a rotary drive having an axis of rotation;
a drive shaft rotatable about the axis of rotation of the rotary drive in a first rotation direction R1 and in second rotation direction R2 opposite R1;
a primary mass body fixed to the drive shaft and rotatable therewith about the axis of rotation;
a stop member fixed to the drive shaft;
and a secondary mass body comprising a cylindrical segment orbital about the drive shaft and the primary mass body between a first rotation position P1 relative to the primary mass body by rotation of drive shaft in said first rotation direction R1 until said secondary mass body abuts one side of said stop member, and a second rotation position P2 relative to the primary mass body by rotation of the drive shaft in the second rotation direction until said secondary mass body abuts an opposing side of said stop member.