March 18, 1969 J. L. LEBELLE 3,433,311

PILE DRIVER AND EXTRACTOR WITH ROTATING ECCENTRIC MASSES OF VARIABLE WEIGHTS

Filed May 31, 1967 Sheet 1 of 4

FIG. 1

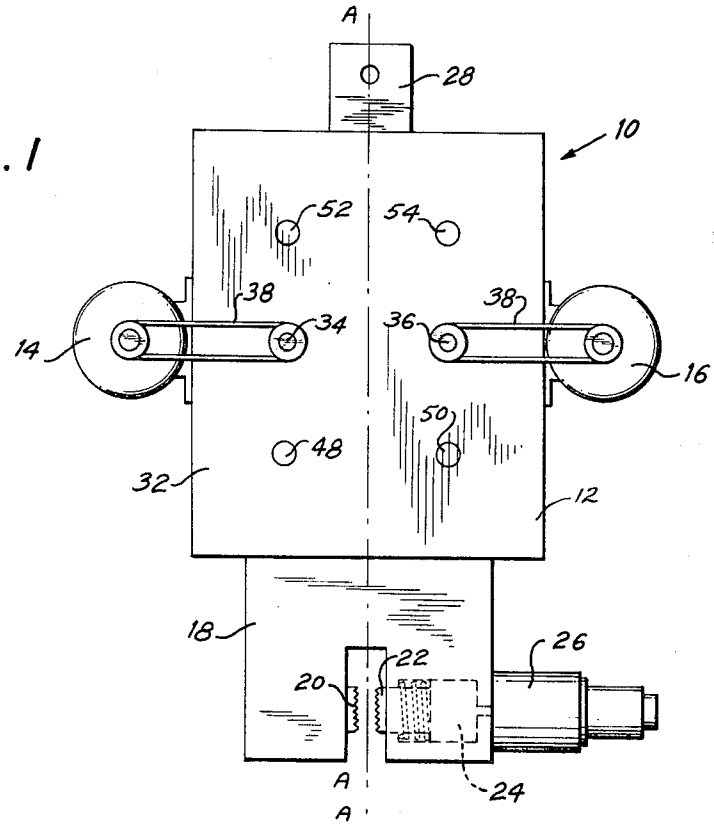
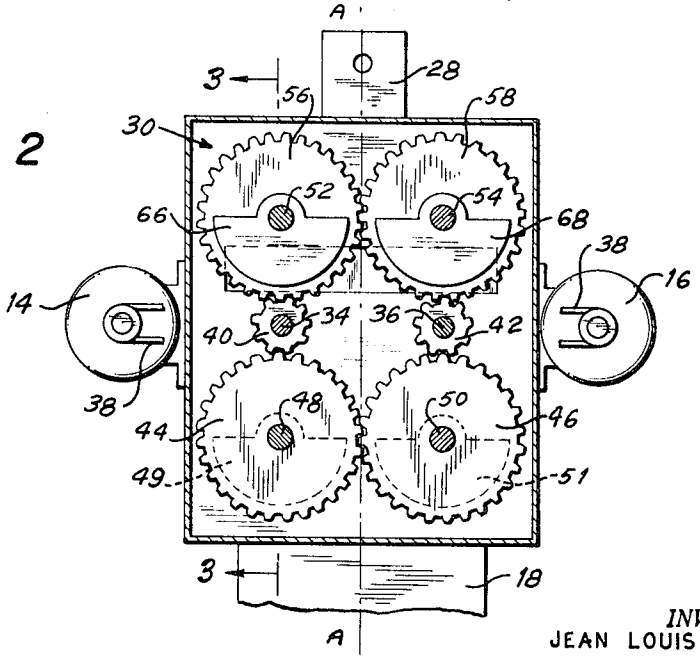


FIG. 2



INVENTOR.
JEAN LOUIS LEBELLE

BY

Kirschstein, Kirschstein & Ottinger

ATTORNEYS

March 18, 1969 J. L. LEBELLE 3,433,311

PILE DRIVER AND EXTRACTOR WITH ROTATING ECCENTRIC MASSES OF VARIABLE WEIGHTS

Filed May 31, 1967 Sheet 2 of 4

FIG. 3

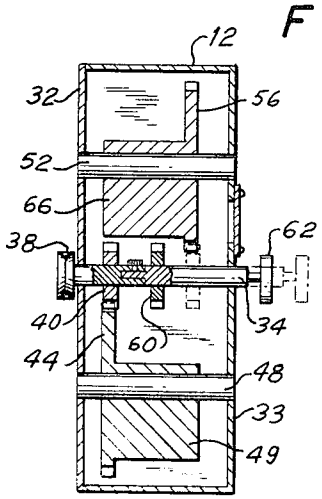


FIG. 3A

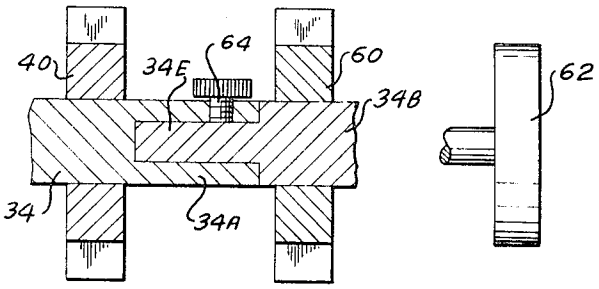
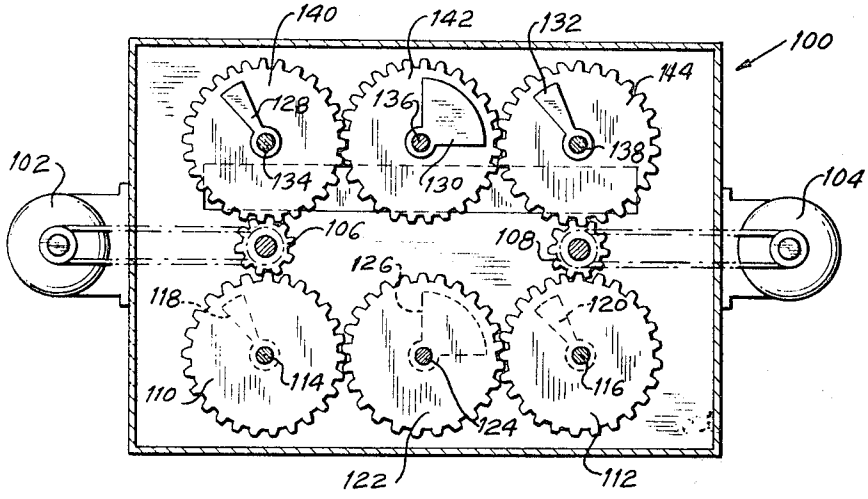


FIG. 6



INVENTOR.
JEAN LOUIS LEBELLE

BY
Kirschstein, Kirschstein & Ottinger

ATTORNEYS

March 18, 1969 J. L. LEBELLE 3,433,311

PILE DRIVER AND EXTRACTOR WITH ROTATING ECCENTRIC MASSES OF VARIABLE WEIGHTS

Filed May 31, 1967 Sheet 3 of 4

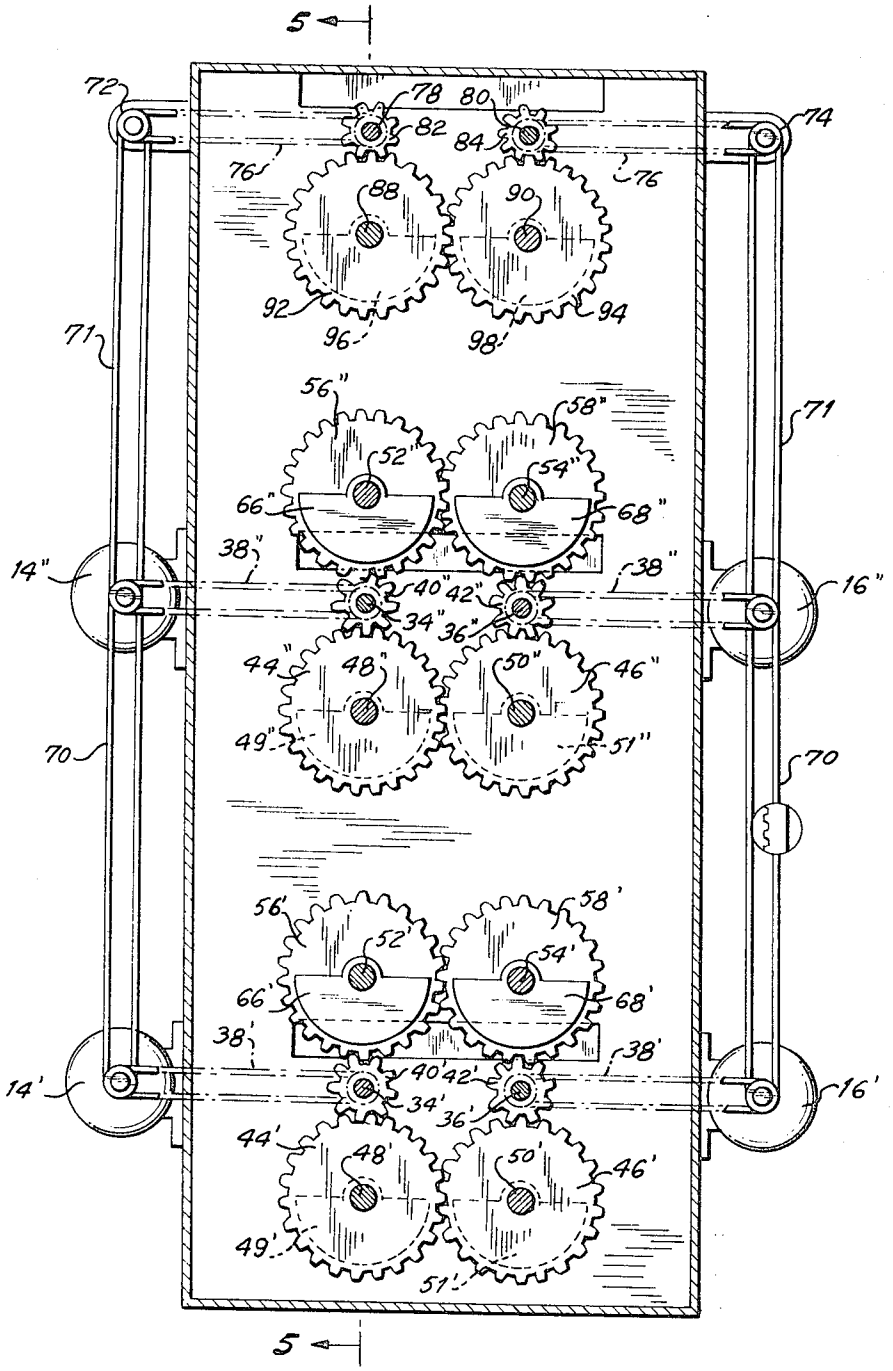


FIG. 4

INVENTOR.
JEAN LOUIS LEBELLE

BY
Kirschstein, Kirschstein & Ottinger

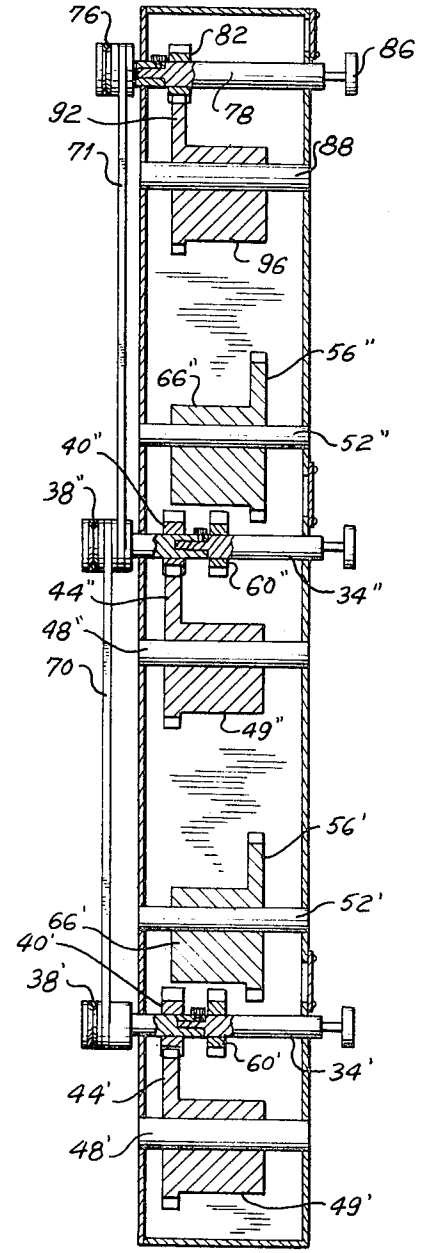
ATTORNEYS

March 18, 1969 J. L. LEBELLE 3,433,311

PILE DRIVER AND EXTRACTOR WITH ROTATING ECCENTRIC MASSES OF VARIABLE WEIGHTS

Filed May 31, 1967 Sheet 4 of 4

FIG. 5



INVENTOR.
JEAN LOUIS LEBELLE

BY
Kirschstein, Kirschstein & Ottinger
ATTORNEYS

United States Patent Office 3,433,311
Patented Mar. 18, 1969

3,433,311

PILE DRIVER AND EXTRACTOR WITH ROTATING ECCENTRIC MASSES OF VARIABLE WEIGHTS

Jean Louis Lebelle, 35 Rue Gounod,
Saint-Cloud, France

Filed May 31, 1967, Ser. No. 642,487
U.S. Cl. 173—49 10 Claims
Int. Cl. E02d 7/18; F16h 33/14; E21c 3/02

ABSTRACT OF THE DISCLOSURE

A pile driver and extractor in which sets of balanced counter rotating eccentric masses are rigidly connected to an elongated ground engaging element in such fashion that the masses develop a vibratory force along the axis of the element with forces at right angles thereto being cancelled. Clutches are provided to vary the number of operating sets of such masses and the masses when driven turn in cadence (as hereinafter defined) so that the vibratory effect is equivalent to that of masses of variable weight.

BACKGROUND OF THE INVENTION

Field of the invention

A vibrodriver for sinking into the ground or extracting from the ground elongated elements such as piles and piling, wherein the vibration is created by balanced sets of counter rotating eccentric weights which are selectively energized individually or in multiple as desired, the weights, when plural sets of weights are turned, rotating in cadence.

Description of the prior art

A vibrodriver, to which the present invention generally relates, is a known type of apparatus. Essentially, it comprises a set of counter rotating balanced eccentric weights which is fixed rigidly to the elongated ground engaging element to be moved. Where two eccentric weights are used, they are turned in opposite directions and at the same speed and the weights are of identical mass and shape. They are interconnected in such a way that the centers of gravities of the weights reach their high points and low points along the longitudinal axis of the element at the same time and thereby reinforce the components of their centrifugal force developed along said longitudinal axis which thereby constitutes an axis of vibration. The components of the centrifugal force along the direction perpendicular to said axis of vibration cancel each other out. Specifically, where, by way of example, the longitudinal axis is vertical, the horizontal components of the centrifugal force are cancelled out. Obviously, this result can be obtained only if the two eccentric weights turn in perfect synchronism, this customarily being accomplished by gearing. The two weights considered as a unit constitute one set of weights.

Another type of set of weights comprises two identical eccentric weights driven in the same direction by two motors and a third eccentric weigh between the other two, each of said weights having an affiliated gear, the gear for the third weight being located between the gears for the first two weights and meshing therewith. Thus, the center gear turns in a direction opposite to that of the two outer gears and the two outer gears turn in the same direction as one another. The center eccentric weight has a mass which equals the sum of the two outer eccentric masses, the latter two being equal to one another. The axes of rotation of the three gears are aligned along a horizontal plane where the axis of vibration is vertical. The horizontal component of the centrifugal force of the central weight balances the sum of the horizontal components of the exterior weights, so that all horizontal components are cancelled out. However, the vertical components of the centrifugal forces are additive and will provide the desired vibratory force. This last described set of weights similarly is rigidly fixed to the element to be driven or extracted.

Both of the described systems operate with eccentric weights of fixed value.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel and improved vibrodriver in which the effective values of the eccentric weights can be varied at will.

It is an ancillary object of the present invention to provide a vibrodriver including different sets of counter rotating balanced eccentric weights wherein the sets can be selectively operated singly or in groups, the operation, when plural, being such that all the weights turn in cadence.

By turning in cadence is meant that when the weights are turning at the same speed they are in phase, i.e., in synchronism, and that when they turn at different speeds the faster rotating sets of weights turn at speeds which are integral multiples of the speed of the slower moving set of weights and the slower moving sets of weights pass through their high or low points on the axis of vibration at the instant that the faster moving weights pass through their corresponding points.

It is another object of the present invention to provide a vibrodriver wherein there are plural sets of counter rotating balanced eccentric weights of which at least one is energized during operation of the vibrodriver and in which selectively at least one other can be energized during operation of the vibrodriver either at the same speed and in synchronism with the first set of weights or at a higher speed or lower speed than the first set of weights and in cadence therewith.

It is another object of the present invention to provide a vibrodriver in which one or more than one sets of counter rotating balanced eccentric weights can be rotated as desired and in cadence where plural sets are rotated, and wherein by adding additional sets of weights the base frequency, which is the frequency of the slowest of the rotating sets of weights, is varied because an effectively larger mass of the weights must be spun.

Other objects of this invention in part will be obvious and in part will be pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements and arrangements of parts which will be exemplified in the vibrodrivers hereinafter described and of which the scope of application will be indicated in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings in which are shown various possible embodiments of the invention,

FIG. 1 is an exterior front elevational view of a vibrodriver according to one embodiment of the present invention;

FIG. 2 is a fragmentary elevational view of the interior of the vibrodriver shown in FIG. 1;

FIG. 3 is a vertical cross-sectional view taken substantially along the line 3—3 of FIG. 2;

FIG. 3A is a fragmentary cross-sectional view of the means for shifting a pinion gear, said means acting as a clutch to selectively engage or disengage a second set of counter rotating balanced eccentric masses with a first set of counter rotating balanced eccentric masses;

FIGS. 4 and 5 are, respectively, schematic front elevational and longitudinal cross-sectional views of a second vibrodriver embodying the present invention; and

FIG. 6 is a view similar to FIG. 4 of a third vibrodriver embodying the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In general, the present invention is carried out by providing a vibrodriver including at least two groups of counter rotating balanced eccentric weights, each group being so constructed as to provide a unidirectional vibration, which is to say, a cyclical reversing force exerted along an axis of vibration which is parallel to and preferably coincident with the longitudinal axis of the elongated element to be driven into or extracted from the ground. Further there is provided motor means with couplings connecting the motor means to the sundry groups, at least one of the couplings being disengageable so that different numbers of groups can be rendered effective, the groups when rendered effective operating in cadence. It should be mentioned that the vibrodriver is effective in various soils, e.g., non-cohesive soils such as sand, silt and gravel, water-saturated adhesive soils, mixed soils and other soils.

Referring now in detail to the drawings, the reference numeral **10** denotes a vibrodriver constructed in accordance with the present invention, the same being illustrated in exterior front elevation in FIG. 1, in interior front elevation in FIG. 2, and in longitudinal cross-section in FIG. 3. The vibrodriver, as is conventional, is employed either for sinking or extracting an elongated element into or from the ground.

The vibrodriver includes a hollow casing **12**, means for vertically vibrating the casing, said means including a pair of drive motors **14**, **16** carried by the casing, and a head **18** fixed to the lower portion of the casing.

The head **18** is entirely conventional and comprises a pair of jaws for selectively gripping an elongated element, e.g., a pile or piling (a sheet). The jaws include a fixed jaw **20** and a movable jaw **22**. Furthermore, means is provided on the head to selectively move the jaws relatively toward and away from one another. Said means, by way of example, incorporates a hydraulic cylinder and piston **24**, the piston being secured to the movable jaw **22**. A hydraulic feed means **26** including a pump and a motor for driving the pump operates hydraulic piston. The remote side of the piston is connected either to a source of hydraulic fluid under pressure or to a sump and the opposite side is reversely connected. Obviously, when the jaws are moved towards one another under hydraulic pressure with a pile or piling therebetween, the head **18** will be rigidly secured to the piling. Desirably, the longitudinal axis of the pile or piling is in alignment with the vertical central axis A—A of the casing. When the jaws are moved apart, the pile or piling will be released.

An apertured lug **28** is fixed to the top of the casing **18** to receive a cable or hook for the purpose of supporting the apparatus. The lug is pulled upwardly when it is desired to extract the pile or piling from the ground and the weight of the casing and the components contained therein will usually suffice to sink the pile or piling into the ground, both such actions being effective upon the application of comparatively mild forces (mild compared to a pile driver) generated by the vibratory means inside the casing.

The means for uniaxially vibrating the casing along the axis A—A, the vertical axis as shown, further includes a gear train generally designated by the reference numeral **30** and plural groups (sets) of eccentric weights. These are seen in FIGS. 2 and 3 wherein a cover plate **32** and the casing **12** have been removed to expose the interior. The gear train includes a pair of parallel transversely spaced coextensive drive shafts **34**, **36** both of which are journalled for rotation in the cover plate **32** and the rear wall **33** of the casing **12**.

The motors **14**, **16** are situated externally of the casing on opposite sides thereof. Each of these motors drives a different one of the shafts **34**, **36** as by means of drive belts **38** (see FIG. 2). Specifically, the motor **14** drives the shaft **34** and the motor **16** drives the shaft **36**. The motors operate at approximately the same speed. However, these speeds will be synchronized by elements of the vibrating means soon to be described. A pinion gear **40** is fast on the shaft **34** and a pinion gear **42** is fast on the shaft **36**. The gear train **30** further includes a pair of gear wheels **44**, **46** each of which is fast to and rotates with a different shaft **48**, **50**. The shafts **48**, **50** are parallel, transversely spaced, coextensive and journalled for rotation in the cover plate **32** and the rear wall **33** of the casing **12**. The pinion gear **40** permanently meshes with the gear wheel **44** and the pinion gear **42** permanently meshes with the gear wheel **46**. Hence, the motor **14** directly drives the gear wheel **44** and the motor **16** directly drives the gear wheel **46**. The gear wheels **44**, **46** turn about horizontal axes lying in the same horizontal plane and are permanently meshed with one another, thereby assuring that said gear wheels turn at the same rate of rotation, that is to say, in synchronism and in phase, as well as rotating in opposite directions, i.e., counter rotating. Each gear wheel has fixed to it a different like one of two identical eccentric weights, the gear wheel **44** having fixed to it an eccentric weight **49** and the gear wheel **46** having fixed to it an eccentric weight **51**.

As shown, each of said gear wheels is integral with its affiliated eccentric weight. The eccentric weights are each mounted for rotation on a different one of said shafts **48**, **50** and are so mutually oriented that they pass through the tops and bottoms of their circular orbits at identical moments, that is to say, they are in synchronism with one another. Phrased differently, the eccentric weights **49**, **51** are angularly arranged on the shafts **34**, **36** and are synchronized in phase by the gear train so that when the motors **14**, **16** are energized and said motors drive the gear wheels **44**, **46** and in turn counter rotate the eccentric weights **49**, **51**, a cyclic uniaxial vibratory force is applied to the casing **12** along the axis A—A and to any pile or piling to which the head **18** is rigidly secured. It will be appreciated that the gear wheels **44**, **46** along with the pinion gears **40**, **42** maintain the motors **14**, **16** in synchronism and prevents their mutual phasing from drifting apart.

As thus far described, the vibrating means is conventional. However, pursuant to the present invention, the vibrating means includes further elements, i.e., means, to vary the effective mass of the counter rotating eccentric weights. This is done not by varying the mass of the weights **49**, **51** just described in the specific group, i.e., set, of weights, but rather by adding an additional group of weights which are driven in cadence with the weights **49**, **51**. To this end, another, i.e., second, pair of parallel transversely spaced co-extensive shafts **52**, **54** are journalled in the casing **12** between the front and rear walls thereof. The shaft **52** is vertically registered above the vertically registered shafts **34**, **48**, and the shaft **54** is vertically registered above the vertically registered shafts **36**, **50**. A pair of gear wheels **56**, **58** are provided, each of these being fast to a different one of the shafts **52**, **54**. Specifically, the gear wheel **56** is fast to the shaft **52** and the gear wheel **58** is fast to the shaft **54**. The shafts **52**, **54** lie in a common horizontal plane. The gear wheels **56**, **58** are permanently intermeshed so as to turn in opposite directions at the same speed.

On each of the shafts **52**, **54** there is permanently mounted a different one or two like eccentric weights, the shaft **52** carrying the eccentric weight **66** and the shaft **54** carrying the eccentric weight **68**. Hence, the eccentric weight **66** turns with the gear wheel **56** and the eccentric weight **68** turns with the gear wheel **58**. As shown, each of the eccentric weights is integral with its associated gear wheel. The eccentric weights **66**, **68** are oriented with respect to the shafts **52**, **54** on which they are mounted in the same manner as the orientation of the eccentric

weights 49, 51 with respect to the shafts 48, 50 on which these latter weights are mounted, so that, when rotated, all the weights are phased and synchronized to exert a uniaxial vibratory force along the axis A—A. It will be observed that the weights 66, 68 will pass through the tops and bottoms of their respective orbits at the same instant.

The pinion gears 40, 42 and the gear wheels 44, 46 constitute couplings permanently connecting the motors 14, 16 via the belt 38 to the first group of eccentric weights 49, 51.

The means varying the driven eccentric mass of the vibrodriver further includes means to selectively engage and disengage the drive shafts 34, 36 to the gear wheels 56, 58 and their associated eccentric weights 66, 68 thus constituting a selectively engagable coupling that connects motors 14, 16 to the second group of eccentric weights 66, 68. Said selective engaging and disengaging means includes a pair of secondary pinion gears, each of which is carried and turned by a different one of the drive shafts 34, 36. The shaft 34 carries one secondary pinion gear 60. The shaft 36 carries another secondary pinion gear (not shown) hereinafter likewise denoted by the reference numeral 60.

Furthermore, said means for selectively engaging and disengaging the drive shafts 34, 36 to the gear wheels 56, 58 comprises (see FIG. 3A) an arrangement for shifting the secondary pinion gears 60 between a position (shown in solid lines in FIG. 3) in which they are clear of the gear wheels 56, 58 to a position (shown in dotted lines in FIG. 3) in which the secondary pinion gears 60 engage their associated gear wheels 56, 58. For this purpose, each drive shaft 34, 36 has a section 34A with an interior axially elongated non-circular well and each shaft has a section 34B with an extension 34E of non-circular cross-section slidably matingly non-rotatably received in the well of the section 34A. For simplicity, only this aspect of the drive shaft 34 is shown in FIG. 3A. The secondary pinion gear 60 is fast to the section 34B. When the section 34B has its extension 34E fully inserted into the bore of the section 34A, the secondary pinion 60 is in a position that is clear of its associated gear wheel 56. When the section 34B has its extension 34A only partially inserted into the associated bore, the secondary pinion gear 60 is in mesh with its associated gear wheel 56. Said section 34B can be manually reciprocated between such two positions with the aid of a handle 62 fast thereto. The extension is lockable in either of its positions by set screw 64 in the section 34A. The aforesaid shiftable position of the pinion gear 60 functions as a clutch to connect or disconnect the second group of eccentric weights 66, 68 to the motors 14, 16 and is merely exemplificative of one type of clutch; any other standard clutch can be substituted therefor.

The second group of eccentric weights 66, 68 are matched in phase with the first group of eccentric weights 49, 51 before being motor driven. By way of example, this can be accomplished by stopping operation of the vibrodriver 10 before engaging the coupling (clutch) for the second group of eccentric weights, since, when idle, all of the eccentric weights will assume identical positions at the bottoms of their orbits as shown in FIG. 2.

The vibrodriver, 10, as described and shown, permits a variation in the effective, i.e., overall, mass of the rotating eccentric weights by continuously driving one set of counter rotating identical eccentric weights and by selectively, which is to say optionally, driving a second set of such weights concurrently with the first, in the given vibrodriver, 10, synchronously with the first. The weights of the second set are identical with one another and symmetrical about the axis of vibrations but do not have to be identical with the weights of the first set. That is to say, the ratio between the masses of the continuously driven eccentric weights and the masses of the selectively driven weights can be varied by choosing any desired ratio between the masses of the groups of eccentric weights. Once selected, the ratio is fixed for any given vibrodriver unless new weights are substituted.

It is desirable not to increase the horizontal (side-to-side) dimensions of the vibrodriver, this being accomplished, as shown by having the second (or third or fourth or more) sets of eccentric weights stacked, that is to say situated, above or below the first group of continously driven eccentric weights. However, the invention is broad enough to embrace groups of eccentrics situated at the same horizontal level as the first group or disaligned horizontally and vertically with the first group, providing that the weights of each subsequent group are symmetrically disposed with respect to the unidirectional vibratory axis.

It is further pointed out that the gear ratio between the pinions 40, 42 and the gear wheels 44, 46 is the same as the gear ratios between the pinions 60 and the gear wheels 56, 58 so that both groups of eccentric weights are driven at equal speeds. Nevertheless, it is within the ambit of the instant invention to drive either set of weights at a speed different from the other set of weights. In such event, all of the weights must be spun in cadence, which is to say the rate of rotation of the faster turning weights must be an integral multiple, e.g., two or four, times the rate of rotation of the slower turning weights and each time that the slower turning weights reach the top or bottom of their orbits, the fast rotating weights likewise must pass through their corresponding points.

Mention previously has been made of a vibrodriver having more than two groups of eccentric weights. Such a vibrodriver in which five groups of eccentric weights are disposed in vertical registration, is shown in FIGS. 4 and 5. Two of the groups (one a continuously driven one and the other a selectively driven one) and the means by which they are driven are identical to those described in connection with the first embodiment of the invention shown in FIGS. 1, 2, 3 and 3A, and for simplicity these two groups have been given the same reference numerals, although they have been primed to distinguish them from the first embodiment of the invention. These two groups are the lowest two groups in FIGS. 4 and 5.

Of the remaining three groups, the lower two (the third and fourth groups), and the manner in which they are driven again is identical to that described in connection with the first embodiment of FIGS. 1, 2, 3 and 3A, and for simplicity have been given the same reference numerals, which, however, have been double primed for distinctiveness. The third and fourth groups of eccentric weights are located vertically above the first and second groups of weights.

It is necessary to synchronize the rotation and positions of the eccentric weights of the first and second groups with those of the eccentric weights of the third and fourth groups, and suitable means is provided for this purpose. Motors 14', 16' drive the eccentric weights 49', 51', 66' and 68' in synchronism, such synchronism originally being obtained by setting the pinions 60' which drive the gear wheels 56', 58' and thereafter being maintained through the gearing. The third and fourth groups of eccentric weights are driven by motors 14'', 16''. To insure synchronism of the motors 14', 16', 14'', 16'', suitable means is included. Such means includes synchronizing notched drive belts 70 turned about sprockets on the shafts of the motors 14', 16' and the motors 14'', 16''. Moreover, to carry the synchronization from the motors 14'', 16'', to the eccentric weights driven thereby, the belts 38'' likewise are notched and engage sprockets on the shafts of the motors 14'', 16''. The belts 38'' similarly are notched and engage sprockets on the shafts of the motors 14', 16'. Hence, the shafts 34'', 36'' will turn at the same speed as and in phase with the shafts 34', 36'. The sprockets on the motors 14'', 16'', which sprockets are driven by the notched drive belts 70 from the motors 14', 16' are connected by clutches (not shown)

to the shafts of the motors 14", 16". Each such motor shaft is fixedly connected to the sprockets that engage the belts 38". These clutches include manual means to engage or disengage them. If it is desired to energize the weights 49", 51", the vibrodriver is stopped and the clutches for the belts 70 are idled, allowing the weights 49', 51', 66', 68' and 49", 51" to swing to the bottoms of their orbits. Then the clutches for the belts 70 are rendered effective to lock the motors 14", 16" to the motors 14', 16'. At this time, the pinions 60" driving the gear wheels 56", 58" are disengaged. Now, when all of the motors are started up, all three mentioned sets of eccentric weights will spin in synchronism.

To set the fourth set of weights in synchronized motion, the gear wheels 56", 68" are connected to be driven by the shafts 34", 36" in the manner already described with respect to the first embodiment of the invention.

It is not necessary that all of the four groups of weights spin at the same speed. For instance, the lower two groups of weights can spin at one-half the speed of the upper two groups of weights. To achieve this, the motors 14', 16' are run at half the speed of the motors 14", 16", and to insure cadence between all four groups of weights the sprockets on the shafts of the motors 14', 16' which engage the belts 70 are twice the size of the sprockets on the shafts of the motors 14", 16" that engage said belts.

The uppermost, i.e., fifth, group of eccentric counter rotating weights is also driven by motors 14", 16", this drive being through a pair of notched drive belts 71 which drive intermediate idler sprockets 72, 74 that, in turn, through another pair of notched belts 76 drive a pair of parallel co-extensive drive shafts 78, 80. The drive shafts 78, 80 have shiftable pinion gears 82, 84 which are moved by a handle 86. This arrangement is similar to that set forth in the first described embodiment of the invention.

The fifth and uppermost group further includes another pair of shafts 88, 90 on which are mounted a pair of gear wheels 92, 94 that mesh with the pinion gears 82, 84 when said gears are in their engaging position.

Also fixed on the shafts 88, 90 are a pair of eccentric weights 96, 98 that may be integral with the gear wheels 92, 94.

From the foregoing, it will be seen that the motors 14', 16', are always engaged to the eccentric weights 49', 51' and can be selectively engaged to drive the eccentric weights 66', 68' in matching phase. Moreover, the motors 14", 16", when energized and locked by the clutches to the motors 14', 16', will drive the eccentric weights 49" and 51" in cadence with the weights 49', 51', 66' and 68'. Said motors 14", 16" also can, by manipulation of the pinions 60" on the shafts 34", 36", be arranged to drive the weights 66", 68" in synchronism with the weights 49", 51", and in cadence with the weights 49' 51', 66', 68'. Finally, by manipulation of the handles 86, the motors 14", 16" can be arranged to drive the eccentric weights 96, 98 in cadence with the four lower sets of eccentric weights. Accordingly, one set of eccentric weights is continuously driven, and, selectively, two, three, four or five sets may be continuously driven, but always where plural sets are driven, they are in cadence, although not necessarily at the same speed.

In the foregoing embodiment, the engagement and disengagement of supplementary groups of eccentric weights, as shown, has been effectuated through the use of sets of shiftable pinion gears; alternately, and as has been mentioned in passing above, conventional clutches may be interposed between driving and driven members, e.g., pinions and gear wheels and sprockets, and all of the driving gears may be permitted to remain in mesh.

As many supplementary groups of selectively energizable counter rotating eccentric weights may be used as is desired, as by simply extending the arrangement shown in FIGS. 1, 2, 3 and 3A, and also in FIGS. 4 and 5. The various groups can be of the same or different weights, and can be driven at the same or different speeds, providing that they are driven in cadence.

FIG. 6 shows schematically another embodiment 100 of the present invention, this being one in which each set of weights includes three weights rather than the two weight sets such as have been described heretofore. The vibrodriver 100 includes two motors 102, 104 which, through sheaves and pulleys, drive parallel pinion gears 106, 108. The pinion gears 106, 108 are permanently in mesh with gear wheels 110, 112 mounted on a pair of parallel coextensive shafts 114, 116 on which eccentric weights 118, 120 are fixed. The weights 118, 120 are in identical angular positions on the shafts 114, 116. A third gear wheel 122 is mounted on a shaft 124 parallel to and coextensive with the shafts 114, 116. The gear wheel 122 is located between and is permanently in mesh with the gear wheels 110, 112. The shafts 124 has fixed thereto another eccentric weight 126. The sum of the masses of the eccentric weights 118 and 120 is equal to the mass of the eccentric weight 126. The centers of gravities of the three weights are at equal distances from their respective shafts. The eccentric weights 118 and 120 jointly turn in a direction opposite to that in which the eccentric weight 126 turns. The eccentric weight 126 is in an angular position on its shaft 124 which is the mirror image of the position of either of the eccentric weights 118, 120 on its respective shaft. Accordingly, when the gear wheels 110, 112 and 122 turn, the horizontal components of the centrifugal forces generated by the respective eccentric weights 118, 120 and 126 are counter balanced. A more detailed disclosure of the foregoing will be found in French Patent No. 1,131,102, published Feb. 18, 1957 and entitled "Improvements in Apparatus for Pile Driving by Vibration."

Pursuant to the present invention, this first set of triple weights is accompanied in the vibrodriver 100 by a second group of eccentric weights 128, 130 and 132 which are fixed on parallel transversely aligned coextensive shafts 134, 136, 138, respectively, the weights 128, 130, 132 and the shafts 134, 136, 138 corresponding, respectively, to the weights 118, 126 and 120 and the shafts 114, 124 and 116. The shafts 134, 136, 138 are vertically above the shafts 114, 124 and 116.

Also fixed on each of the shafts 134, 136, 138 are gear wheels 140, 142, and 144 which are arranged in the same manner as the gear wheels 110, 122, 112, i.e., with the gear wheel 142 between and meshing with the gear wheels 140 and 144. The gear wheels 140 and 144 are selectively engageable with secondary pinions (not shown) such as the pinion 60 previously described, carried by the shafts on which the pinion gears 106, 108 are mounted. Thereby, if the selectively movable pinion gears are disengaged from the gear wheels 140, 144, only the lower set of triple weights will be spun to develop a vibratory force. However, if the pinion gears are brought into mesh with the gear wheels 140, 144 both the upper and lower sets of triple weights will be spun in synchronism to provide a greater vibratory force which is increased by the components along the vibratory axis of the centrifugal force developed by the weights 128, 130 and 132.

It will be obvious that the driving arrangements for the two sets of weights can be varied, as for example, by using a single motor that rotates a pinion gear which is permanently in mesh with the gear wheel 122 and another pinion gear which can be shifted into or out of engagement with the gear wheel 142.

It thus will be seen that there has been provided a vibrodriver which achieves the several objects of the present invention and which is well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention and as various changes might be made of the embodiments above set forth, it is to be understood that all matter herein described or shown in

the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described the invention, there is claimed as new and desired to be secured by Letters Patent:

1. A vibrodriver comprising a support, selectively operable means to rigidly secure said support to a ground engaging elongated element, at least two groups of counter rotating balanced eccentric weights carried by said support, each group when energized providing a unidirectional cyclically reversing vibratory force along an axis of vibration parallel to the longitudinal axis of the element, the axes of vibration of all of said groups being parallel, means to energize at least a first one of said groups while leaving the remainder of the groups unenergized, and selectively operable means to energize at least another of said groups in cadence with the first group while the first group remains energized.

2. A vibrodriver as set forth in claim 1 wherein the selectively operable means when rendered effective energizes the said another of said groups in synchronism with the first group.

3. A vibrodriver as set forth in claim 1 which comprises at least three groups of counter rotating eccentric weights and wherein the selectively operable means is arranged to energize any desired other number of the groups in addition to the first one of the groups, the additional groups when energized being energized in cadence with the first group.

4. A vibrodriver as set forth in claim 1 wherein the means to energize the groups comprises motor means and couplings connecting the motor means to the groups, the couplings for the motor means and the groups other than the first group being selectively engageable or disengageable.

5. A vibrodriver as set forth in claim 1 wherein each of the groups includes two counter rotating balanced eccentric weights turning in synchronism.

6. A vibrodriver as set forth in claim 1 wherein each of the groups includes a central eccentric weight and a pair of outer eccentric weights turning in a direction opposite to the central weight, the outer weights jointly having a mass equal to the mass of the central weight.

7. A vibrodriver as set forth in claim 1 wherein the selectively operable means includes motor means and at least one clutch between the motor means and the said another of the group of weights.

8. A vibrodriver as set forth in claim 7 wherein the clutch comprises a pair of gears and means to selectively engage and disengage the gears.

9. A vibrodriver as set forth in claim 1 wherein the means to energize the groups rotates the first one of said group at a given speed and the said another of said groups at a speed which is a whole multiple of the first group.

10. In an apparatus for driving elongated piling into or extracting elongated piling from soil by uniaxial vibratory force, said apparatus including a casing, means selectively securing a piling to the casing, and means vibrating the casing along an axis parallel to the longitudinal axis of the piling, the vibration means including first spaced shafts, means mounting the first shafts for rotation about parallel axes, said axes lying in a plane perpendicular to the longitudinal axis of the piling, first eccentric weights each fixed to a different first shaft for rotation therewith, said first weights being synchronized and phased to exert a uniaxial vibratory force on the piling in a direction parallel to the longitudinal axis of the piling, and motor means driving the first shafts in opposed directions at the same angular velocity:

that improvement comprising means varying the eccentric mass of the apparatus, said means including second spaced shafts, means mounting the second shafts for rotation about parallel axes, said axes lying in a plane perpendicular to the longitudinal axis of the piling, second identical eccentric weights each fixed to a different second shaft for rotation therewith, said second weights being synchronized and phased to exert a uniaxial vibratory force on the piling in a direction parallel to the longitudinal axis of the piling, and means selectively driving the second shafts in opposed directions at the same angular velocity.

References Cited

UNITED STATES PATENTS

2,743,585	5/1956	Berthet	173—49 X
3,054,463	9/1962	Bodine	173—49 X
3,224,514	12/1965	Hornstein	173—49 X
3,280,924	10/1966	Pavlovich	173—49 X
3,332,293	7/1967	Austin	173—49 X
3,362,485	1/1968	Dyer	173—49

CHARLES E. O'CONNELL, *Primary Examiner.*

U.S. Cl. X.R.

74—61; 175—55