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Jansz

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[45] **Aug. 13, 1974**

[54] **IMPULSE DRIVING APPARATUS**

[75] Inventor: **Joost Werner Jansz,** The Hague, Netherlands

[73] Assignee: **Hollandsche Beton Groep N.V.,** Rijswijk Z.h., Netherlands

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **173/101,** 173/1, 173/DIG. 1

[51] **Int. Cl.** **E02d 7/10**

[58] **Field of Search** .. 173/1, 101, 102, 103, DIG. 1, 173/127, 118

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Primary Examiner—Ernest R. Purser

Attorney, Agent, or Firm—Brisebois & Kruger

[57] **ABSTRACT**

An impulse driving apparatus, for use for example in pile driving, in which a plurality of striker members are released from a given height above an object to which impulses are to be given in such a way that the stricker members deliver impulses to the object either simultaneously or at pre-determined intervals of time.

7 Claims, 12 Drawing Figures

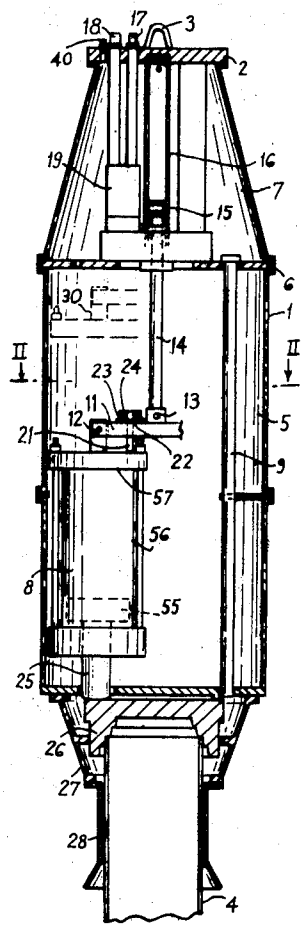
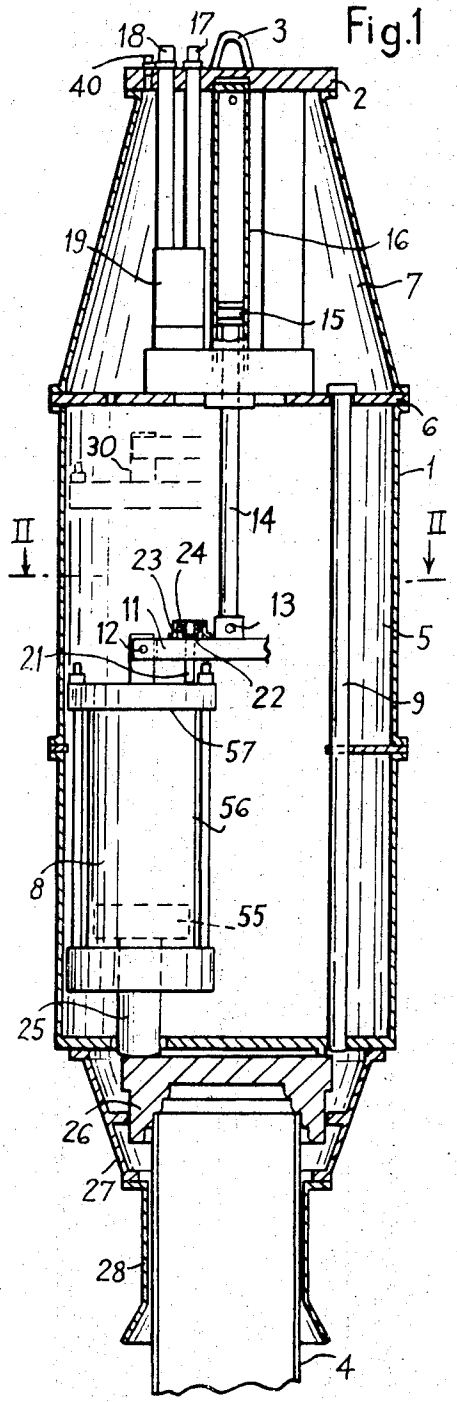


Fig.1



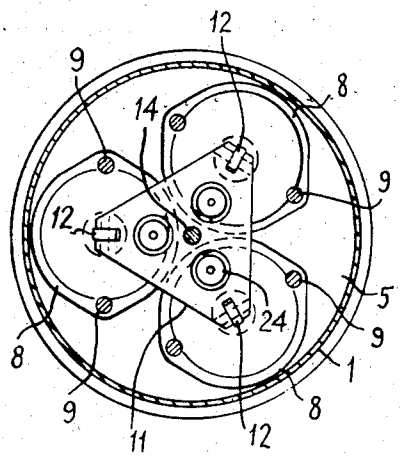
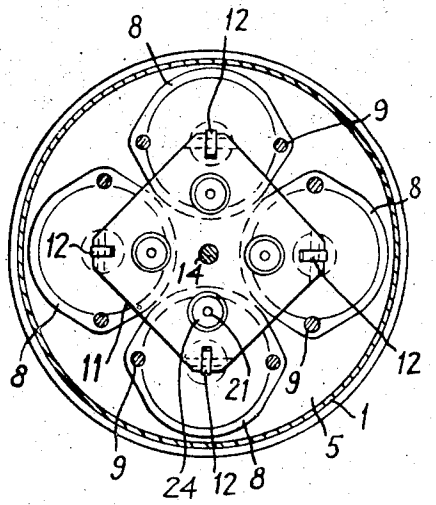


Fig.2

Fig.3



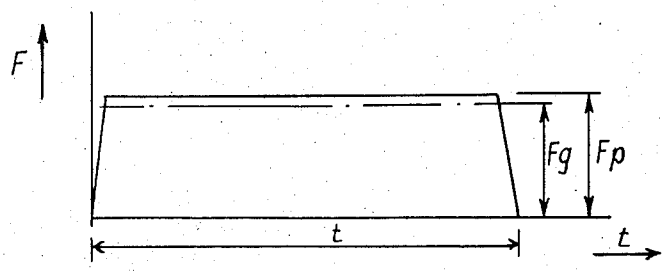


Fig.4a

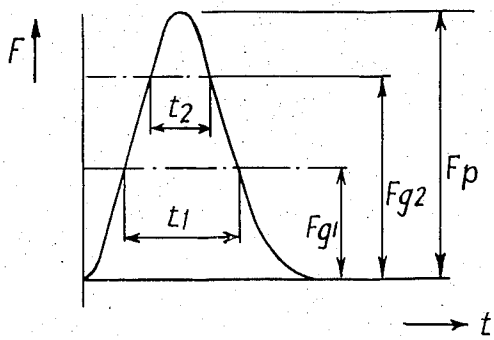


Fig.4b

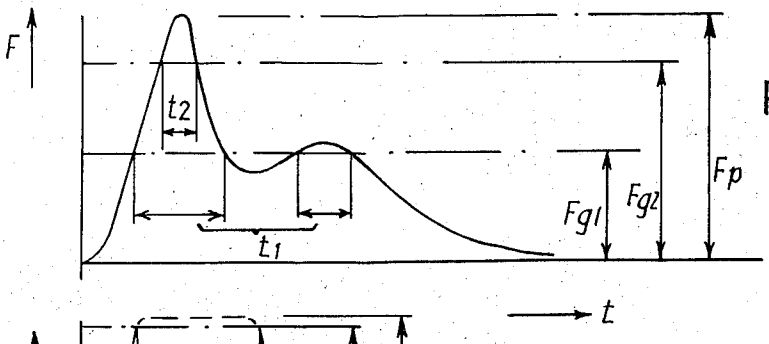


Fig.4c

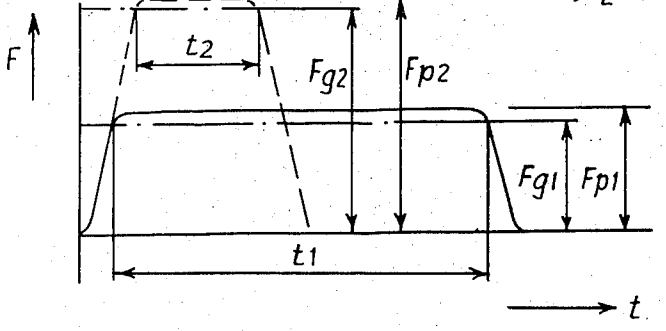


Fig.4d

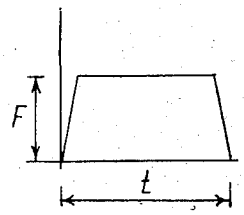


Fig.5a

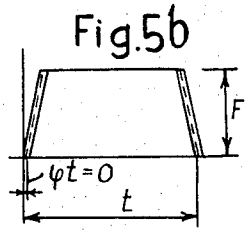


Fig.5b

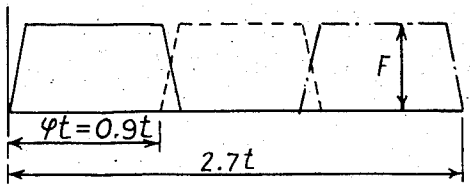


Fig.5d

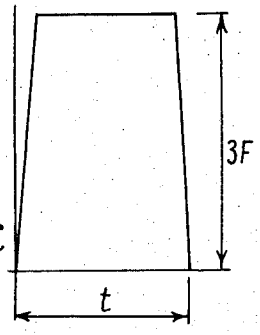


Fig.5c

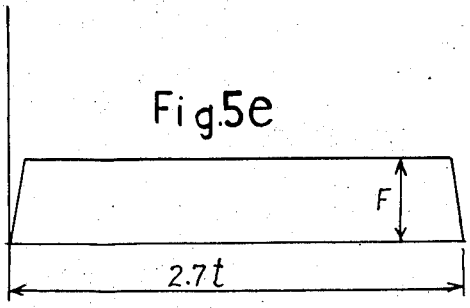


Fig.5e

IMPULSE DRIVING APPARATUS

This invention relates to impulse driving apparatus and methods which have particular, though not exclusive, application in driving objects, for example piles, into the ground.

The apparatus of the present invention enables larger amounts of energy to be available in one unit, for driving an object, such as a pile, into the ground, than have previously been obtainable.

It is not possible simply to increase the size of known apparatus in order to make available larger amounts of energy due, inter alia, to manufacturing difficulties in heat treating and handling large parts.

According to one aspect of the present invention there is provided an impulse driving apparatus including a plurality of hammer members each arranged to deliver an impulse to an object in response to a signal, a cylinder, a piston in the cylinder carrying a rod coupled to the hammer members, means whereby the piston and a face of each of the hammer members can each be raised to a respective height above an object to which impulses are to be given and means to release the piston in response to the said signal thereby to allow each hammer member to fall and to deliver an impulse to an object.

According to another aspect of the invention there is provided a method of operating an impulse driving apparatus as described above wherein the hammer members impact upon the object substantially simultaneously.

According to yet another aspect of the present invention there is provided a method of operating an impulse driving apparatus as described above wherein the hammer members impact upon the object at successive predetermined intervals of time.

Embodiments of the invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a partially cut-away longitudinal section through a pile driving apparatus,

FIG. 2 is a cross-section on the line II—II of FIG. 1,

FIG. 3 is a cross-section at a similar point on another embodiment of a pile driving apparatus,

FIG. 4 represents at (*a*)(*b*)(*c*) and (*d*) the force-time diagrams of different pile driving apparatus,

FIG. 5 represents at (*a*)(*b*)(*c*)(*d*) and (*e*) respectively the force-time diagrams of further pile driving apparatus.

Referring to FIGS. 1 and 2 there is shown an apparatus which has an outer casing 1 having an end member 2 with a loop 3 from which the apparatus can be suspended above a pile 4 which is to be driven into the ground. The apparatus includes a main part 5 which is separated by a bulkhead 6 from an upper part 7. The main part 5 houses three impulse driving or hammer units 8, of which only one is shown in FIG. 1. The units 8 are of the type described in our British Pat. Specification No. 1,168,547 and U.S. Pat. No. 3,431,986, in which a chamber containing a precompressed gas is arranged in the path of a hammer, the gas being precompressed to such an extent that the minimum force exceeding the ground resistance is directly available under the impact of the hammer.

The units 8 are guided by rods 9 and are each pivotally coupled to a plate 11 at respective points 12. The plate 11 is pivotally attached at 13 to a piston rod 14, which extends from a piston 15 housed in a cylinder 16 in the upper part 7 of the casing through the bulkhead 6. The movement of the piston 15 in the cylinder 16 is determined by oil passing through inlet and outlet pipes 17, 18 under the control of a unit 19.

Pins 21 having collars 22 pass through the plate 11 to engage the upper end of each of the units 8 and are restrained against movement upwards by pre-loaded springs 23 acting between the respective collars 22 and housings 24.

A striker member 25 attached to a piston 55 within the chamber 56 of the unit 8 extends from the lower end of each of the units 8 and engages with its lower or striker face a cap 26 for a pile. The precompressed gas in the chamber acts between the head of this piston 55 and the head 57 of the chamber. The cap 26 is located in a cover 27. A guiding member 28 extends from the cover 27 to guide the apparatus on to a pile.

The embodiment shown in FIG. 3 differs from that of FIG. 2 in that it has four units 8 suspended from a plate 11 instead of three units, but it is operated in a similar manner to the embodiment of FIG. 2.

In operation, oil enters the lower part of the cylinder 16 and raises the piston 15 and the assembly including the plate 11 and the units 8 to the chain dotted position 30. The control unit 19 then operates to cause the piston 15 to fall and allow the plate 11 and the units 8 to fall either under the influence of gravity alone or together with an additional driving force causing the striker members 25 to hit the cap 26 and impact forces to be imparted to the pile 4 from each of the units 8 substantially simultaneously. Since the members 25 are arranged substantially on the circumferential arc of the tubular pile 4, the force is transmitted substantially directly to the pile. The pins 21 act upon their respective units 8 to maintain the units at a common level when they are in the position 30. The springs 23 are of such a strength and so compressed that when the units are lifted the springs 23 appear to be rigid, the weight acting upon the plate 11 in this condition being, in one particular embodiment, of the order of 10 tons per unit 8. However, the strength and compression of the springs 23 are such that when the respective striker members 25 hit the cap 26 the springs 23 are able to deform without breaking, even though in one particular embodiment the impact force resulting from each of the units 8 is of the order of 800 tons.

The pins 21 ensure that each of the units 8 is raised to the same level before it is released by tending to correct any tilting of the plate 11 about the pivot point 13 of the plate 11 on the piston rod 14, thereby making more certain that the energy delivered by each unit 8 is the same and that the time of impact of its striker member 25 on the cap 26 is substantially the same.

During the operation of the apparatus compressed air can be pumped into the casing 1 through an inlet nozzle 40 at sufficient pressure to exclude water from the apparatus at whatever level underwater the apparatus is being operated. By operating the apparatus in this pressure equalised condition it is possible to construct the casing 1 less strongly than would otherwise be necessary.

In one particular embodiment the duration of the impact force delivered to the pile by each of the units 8 is five hundredths of a second and the impacts are de-

livered within one thousandth of a second of one another.

Instead of using a spring **23** to provide the resilient device other known resilient members can be used.

An idealised diagram of the impact force F against time *t* for one of the units **8** is shown in FIG. **4** at (*a*), where the level of force F*g* indicates the reaction force of the ground which it is necessary to overcome, and the level of force F*p*, imparted by a particular unit, is the minimum slightly higher force which it is necessary to exert upon the pile in order to overcome the ground reaction force.

In FIG. **4**(*b*) the force-time diagram of a known steam hammer apparatus shows that to overcome a ground force F*g***1** the necessary energy is only available for a time t_1, while to overcome a higher ground force F*g***2** the necessary force is only available for an even shorter time t_2. The peak force F*p* which is produced by the steam hammer is considerably higher than that required and could be damaging to the pile.

The diagram of FIG. **4**(*c*) shows the distribution with time of the force available from a diesel operated hammer. This curve also shows a high peak force F*p* which could be damaging to a pile. The first peak, which is due to the stored energy of the hammer, provides sufficient energy to overcome a ground reaction force F*g***2** over a very short time period t_2, while the time t_1, during which energy is available to overcome a lower ground reaction force F*g***1**, extends over a longer time period comprising a part of the period of this first peak and a part of the period of a second peak resulting from the energy obtained from the combustion of fuel in the diesel unit.

In the diagram of FIG. **4**(*d*) there is shown in solid lines the distribution of energy for a unit according to the embodiment described with reference to FIGS. **1** and **2**, in which the precompression of the gas in the units **8** is such that the minimum force F*p***1**, available upon impact for a time t_1, is just sufficient to overcome a ground resistance force F*g***1**. To overcome a ground resistance force F*g***2**, using the same units **8**, it is necessary to precompress the gas in the units **8** to a higher level. Since the total amount of energy available is the same, the required level is reached in this latter arrangement, as may be seen by the dotted lines, over a shorter time period t_2.

Furthermore, as will be seen with reference to FIG. **5**, it is possible to apply the impacts from the units **8** or from hammers successively and at time intervals which are determined by a particular desired distribution with time of the stored energy and to use either units **8** of the type described in our above mentioned patent specifications or hammers of a type commonly known and used.

In FIG. **5** there is shown in an idealised form at (*a*) a diagram of the force available from a single unit **8**, and at (*b*) the forces available from three of the units **8** providing impact forces substantially simultaneously with a phase difference $\phi t = 0$. The sum of these simultaneous impacts is shown in FIG. **5** at (*c*) to provide an acceptable distribution of impact force.

It is possible, in accordance with one aspect of the invention employing units **8**, to delay the times of impact of the individual units **8**. The result of such a method of operation is shown in FIG. **5** at (*d*) where a delay $\phi t = 0.9t$ is provided between the successive times of impact. The resultant of these successive impacts is shown in FIG. **5** at (*e*) to provide an impact force which is at a desirable level and extends over a lengthened time period of $2.7t$.

The invention is not limited to the particular embodiments described and modifications and variations within the scope of the invention may be made. For example other methods of raising the plate **11** and the units **8** than the hydraulic method employing the piston and cylinder may be used. Where units **8** employing precompressed gas in the path of a hammer are used, the gas can be precompressed under the control of oil pressure applied via a line which is common to each of the units **8**, thereby ensuring that the gas in each unit is precompressed to a common value.

I claim:

1. An impulse driving apparatus for driving piles and other objects including a plurality of hammer members mounted for movement in the same direction and each having a striker face, the striker faces of the respective hammer members being located sideways relative to each other in the direction perpendicular to the direction of the movement of the hammer members whereby each striker face can independently deliver an impulse to the object to be driven, fluid-operated piston means, means coupling said piston means to said hammer members, said coupling means including a plate pivotally connected to the piston means, the hammer members being respectively connected to said plate at substantially equal distances from and at substantially equally spaced positions around said pivotal connection of the plate to the piston means, control means for controlling the supply of operating fluid to said piston means to cause said hammer members to move away from the object to which impulses are to be delivered and thereafter towards said object whereby each hammer member delivers an independent impulse to the object by its respective striker face.

2. An impulse driving apparatus as claimed in claim **1** having pivotal connections between the hammer members and the plate.

3. An impulse driving apparatus as claimed in claim **2** including resilient stop means arranged between the plate and each hammer member respectively to maintain each hammer member in a predetermined pivotal position relative to the plate when it is away from the object.

4. An impulse driving apparatus as claimed in claim **1** including wherein each hammer member comprises a cylinder, a piston within the cylinder attached to a striker member projecting from the cylinder and having a striker face, and a gas under pressure in the cylinder between the piston attached to the striker member and the end of the said cylinder remote from the striker member.

5. An impulse driving apparatus as claimed in claim **1** for sub-aqueous use, including a housing within which the apparatus is contained, the housing having means whereby compressed air can be introduced therein to exclude water from the apparatus.

6. An impulse driving apparatus for driving piles and the like under sub-aqueous conditions, comprising a substantially air-tight housing having at its lower end a vertical tubular guide portion which is open at its bottom and serves to guide the apparatus onto and to receive the top of a pile to be driven, hammer means mounted on guides for vertical movement within said housing and having a striker face at its lower end,

hydraulically-operated piston means coupled to said hammer means for moving said hammer means between a lower position in which said striker face is above said guide portion and a raised position, control means for controlling the supply of operating fluid to said piston means, and means for introducing compressed air into said housing to exclude water therefrom when the apparatus is submerged.

7. Apparatus as claimed in claim 6, and including a pile cap captively mounted in said housing for limited vertical movement and positioned to rest on the top of a pile inserted in said guide portion and to be struck by the striker face of said hammer means when in its lower position.

* * * * *