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(54) **PILE DRIVING**

PFAHLRAMME

PROCEDE ET DISPOSITIF SERVANT A ENFONCER DES PIEUX

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(73) Proprietor: **Fast Frames (UK) Limited**
Dorchester DT2 7NY (GB)

(72) Inventor: **JONES, Clive,**
c/o Fast Frames (UK) Limited
Dorchester, Dorset DT2 7NY (GB)

(74) Representative: **Evens, Paul Jonathan**
Maguire Boss,
5 Crown Street
St. Ives, Cambridge PE27 5EB (GB)

(56) References cited:
WO-A-99/11872 DE-C- 202 814
FR-A- 2 678 011 US-A- 1 359 956
US-A- 5 104 264

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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The invention relates to pile driving, and more particularly, but not exclusively, to underwater pile driving, e.g. for stabbing piles directly into the seabed.

DESCRIPTION OF THE BACKGROUND ART

[0002] It is known to provide a guide for aligning a pile with the surface of a substrate into which the pile is to be driven and to provide stability for a piling hammer. Particularly when piling underwater there is the problem that after the pile has been introduced into the seabed or the like, the guide must be removed to allow the pile to be driven into its final position. This guide removal is time consuming and thus expensive. Accordingly, the present applicant proposed in International patent publication WO99/11872 a pile guide which allows pile driving to continue from start to finish without any need to interrupt driving to remove the guide.

[0003] The pile driving apparatus described in WO99/11872 is supported on a base frame, a plan view of which is reproduced in Figure 1. The base frame 10 has a substantially rectangular footprint (made up of a welded framework of girders and mudmats) with a centrally-placed aperture (12) through which a pile (14) is guided. The base frame 10 thus surrounds the pile (14). It will be seen however, that the base frame is formed with an aperture or slot (16) extending through the frame from its exterior to the central aperture (12) and through which a tether or rigging (18) fixed to the pile (14) can be passed.

[0004] The present applicant has appreciated certain problems associated with transporting a pile guide of the kind shown in WO99/11872. The rectangular footprint of the base frame may have an area exceeding 100m², effectively ruling out all forms of transport other than by sea. The present applicant has sought to obviate or at least alleviate such problems.

SUMMARY OF THE INVENTION

[0005] In accordance with the present invention, there is provided a pile guide according to claim 1.

[0006] Advantageously, the base frame comprises a rigid member, preferably substantially U-shaped and at least one ground-engaging panel releasably coupled to the rigid member. The releasable coupling between the U-shaped member and the at least one ground engaging panel enables the pile guide to be transported in more than one piece to the site where it will be used. This fact overcomes dependence on transport by sea alone, since each piece may be moved, for example, by road, albeit with a police escort if required. Such im-

proved transportability is important since it is in the very nature of pile driving that the pile guide must be moved from site to site if it is to be reused.

[0007] The substantially U-shaped rigid member may support the pile guide member. The rigid member has a central aperture through which a pile guided by the pile guide member may be driven. Being substantially U-shaped, there is a channel, communicating with the central aperture, through which a tether or rigging fixed to a pile may pass in order to disengage the pile guide from the pile once driven into the substrate. The present applicant has appreciated that the U-shaped rigid member is the backbone of the pile guide, having to withstand the stresses of supporting the pile guide member even during pile driving. The pile guide member may be of conventional form (e.g. an immobile channel adapted to receive slidably a pile to be driven into the substrate) or of improved form (e.g. of two part and pivotable construction, each part being adapted to pivot away from the pile once partially driven into the seabed, see WO99/11872).

[0008] The at least one ground-engaging panel, or mudmat, may extend laterally of the substantially U-shaped rigid member. The at least one ground-engaging panel may be releasably coupled to the rigid member by a plurality of bolts.

[0009] The base frame may include a pair of ground-engaging panels, releasably coupled one per opposing side of the substantially U-shaped rigid member. Each ground-engaging panel may extend laterally of the respective side of the U-shaped rigid member to which it is releasably coupled.

[0010] The at least one substrate-engaging panel or the substantially U-shaped rigid member may comprise receptors for engagement by fork means of a fork-lift truck. The receptors may comprise a pair of flanges which project laterally such that their undersides are contactable by the fork means of a fork-lift truck. Each flange may form part of a channel, either of open- or closed-box construction. The pile guide may further comprise means for attaching lifting lines (e.g. ropes or cables) to the base frame. The attaching means may be selected from the group consisting of hooks, rings and apertures.

[0011] The substantially U-shaped rigid member and the at least one substrate-engaging panel may include location means for secure stacking of one on top of the other. The location means may comprise complementary profiles which enable one to nest against the other.

[0012] In accordance with another aspect of the present invention, there is provided a pile guide for supporting a finned pile as it is driven into a substrate, comprising a base frame and a guide member mounted on the base frame, characterised in that the guide member comprises a pair of upright guide channels for receiving and guiding a pair of stabilising fins associated with a finned pile during pile driving.

[0013] The present applicant has appreciated that the

use of such a pile guide with finned piles has a number of significant advantages. Firstly, there may be sufficient clearance space between the pair of guide channels to enable finned piles to be driven fully into the seabed in one operation. With conventional pile guides and conventional piles, the pile driving operation needed to be interrupted to remove the pile guide before the pile could be driven all the way into the seabed. Secondly, for a given size of pile, the finned piles are anchored more securely to the seabed than conventional piles because of the lateral resistance to movement offered by the fins in silty layers above underlying hard layers. Thus, in order to achieve an anchorage with specific lateral loading resistance against tip rotation, finned piles of a smaller diameter than conventional piles may be used. The use of more lightweight finned piles enables a consequential reduction in the build specification of the corresponding pile guide; leading to cost savings in terms of both materials and transportation considerations.

[0014] A third and potentially more significant advantage arises from the flexibility of using a pile guide which guides fins associated with a pile, rather than the main body of the pile. Provided the fins achieve a given "wing span", variable diameter piles may be supported by the same pile guide. This in turn has a knock-on benefit of speeding up pile driving a set of finned piles of different sizes, since the same guide may be used for each.

[0015] In one embodiment, the pair of upright guide channels may be positioned opposite each other, with channel openings facing each other. In this way, the guide channels are configured to receive a finned pile having a pair of diametrically opposed stabilising fins extending in an axial direction along the curved periphery of the pile. The upright guide channels may be supported by inclined struts extending from an outer periphery of the base frame.

[0016] In accordance with yet another aspect of the present invention, there is provided apparatus for driving a pile into a substrate, comprising a pile follower for transmitting impact from a pile driver to a pile being driven into a substrate, wherein the pile follower has a pair of fins for engaging corresponding guide channels of a pile guide.

[0017] When pile driving below water level, a pile may be part-driven into a substrate (e.g. seabed) with the aid of a pile guide. Once one end of the pile is embedded in the sea floor, a follower can be fitted to the exposed end of the pile. In order to transmit pile hammer impacts squarely to the pile in such a way as to drive the pile vertically, the follower has traditionally been machined to very tight tolerances which is expensive with such a large object. However, by providing a pair of fins, the follower can be guided in the same way as a finned pile. In this way, the need for accurate machinery is substantially reduced.

[0018] The pair of fins may extend in a common plane to engage diametrically opposed guide channels of the pile guide. The pile follower may have an end profile

comprising a driving face and an alignment member projecting axially beyond the driving face. The alignment member aids registration of the driving face with the exposed end of the pile by providing a positive locating action therewith. The alignment member may be configured to engage the radially inner periphery of a tubular pile. The alignment member may comprise a plurality of plates arranged around the radially inner or outer periphery of the pile follower.

[0019] The apparatus may further comprise a pile guide in accordance with earlier aspects and embodiments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a plane view of a prior art base frame;
Figure 2 is a plane view of a pile guide embodying one aspect of the present invention;
Figure 3 is a front view of the pile guide of Figure 2;
Figure 4 is a perspective exploded view showing base frame detail of the pile guide of Figure 2;
Figure 5 is a schematic front view of a finned follower embodying another aspect of the present invention; and
Figure 6 is a partial cross-sectional view along A-A in Figure 5 showing detail of the finned follower.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0021] Figures 2 and 3 show plan and front view respectively of a pile guide (20) embodying the present invention. The pile guide (20) comprises a base frame (22) and a pile guide member (24) mounted on the base frame (22). The base frame (22) comprises a generally U-shaped rigid member (26) and a pair of substrate-engaging panels or mudmats (28) which are releasably coupled to the rigid member (26). The pile guide member (24) comprises a pair of upright guide channels (30) mounted on the rigid member (26) and supported by inclined struts (32) extending from the peripheral corners of the base frame (22). The pile guide (20) may be dismantled to improve ease of transportation, and, in particular, the base frame (22) constituents may be decoupled into three more manageable pieces, namely two mudmats (28) and the rigid member (26).

[0022] Figure 4 illustrates the construction of the base frame (22) in more detail. The generally U-shaped rigid member (26) forms the backbone of the structure and is also fundamental to the operation of the pile guide (20). The rigid member not only provides the points of anchorage for the pile guiding member (24) and mudmats (28), but also defines a central aperture (40) through which a pile is driven into the substrate. There-

after, the base frame (22) may be disengaged from around the pile by moving the base frame (22) to pass the pile through channel or peripheral opening (42); the peripheral opening having a span which exceeds the diameter of the pile. The mudmats (28) are bolted to, and extend laterally of the sides (44) of the rigid member. Thus, in use, the base frame (22) may have a footprint covering something in excess of 100m². However, when being stored or in transit to the pile driving site, the mudmats (28) may be detached from the rigid member (26) to reduce the overall area which must be made available to accommodate the pile guide.

[0023] As shown in Figure 4, the sides of the rigid member (26) and mudmats (28) are provided with receptors (50) for receiving the forks of fork-lift trucks. The receptors (50) comprise a pair of flanges (52) forming an open channel into which the prongs of a fork-lift may be inserted. The uppermost flange in each pair then bears the weight of the component during lifting. Padeyes (60) are also provided at the corners of the rigid member (26) for attaching lifting lines (e.g. cables) and thereby lifting the base frame (22).

[0024] The pile guide member (24) is adapted to guide a pile having a pair of diametrically opposed stabilising fins extending in an axial direction along the curved periphery of the pile. The pair of upright guide channels (30) are positioned opposite each other with channel openings facing each other. In this way, the channels receive and guide the stabilising fins during pile driving. Once the pile has been driven into the substrate (e.g. seabed) the pile guide (20) may be lifted over the protuberant part of the pile to disengage the stabilising fins from the pile guide member. Of course, if the stabilising fins have been driven into the substrate, the upright guide channels (30) no longer engage the pile, and the pile guide (20) may disengage the pile by sliding the pile guide (20) to pass the pile through the opening (42).

[0025] Figures 5 and 6 show a pile follower (100) embodying another aspect of the present invention. The pile follower (100) is illustrated in use between a pile driving hammer (102) and a finned pile (104), both of which are shown in phantom lines. The pile follower (100) has a pair of diametrically opposed fins (106) which are configured to be a sliding fit inside the guide channels (30) of pile guide (20). The pile follower (100) has an end profile (110) comprising a driving face (112) and an alignment ring (114). The alignment ring (114) comprises a plurality of members (116) which extend axially beyond the driving face (112). The alignment ring (114) is a snug fit inside the bore (118) of the finned pile (104) to achieve registration between the driving face (112) and the exposed end of the finned pile (104).

[0026] The operation of the pile guide (20), the finned pile (104) and the pile follower (100) will now be described to illustrate the interaction therebetween. The pile guide (20) is positioned on a substrate (e.g. seabed) and finned pile (104) is loaded into the pile guide (20) with its fins slidably received in the upright guide chan-

nels (30). The finned pile (104) is driven into the seabed as far as the reciprocating motion of the drive hammer (102) will allow. The drive hammer (102) is then raised clear of the exposed end of the finned pile (104) so that follower (100) may be fitted to it. The fins (106) of the follower (100) are aligned with those of the pile (104) so that the fins (106) are slidably received in the guide channels (30). The alignment ring (114) engages the bore of the finned pile (104) as the latter is lowered into position, ensuring that the driving face (112) of the follower (100) registers with and abuts the end of the finned pile. The hammer (102) is then re-engaged, with the follower (100) now transmitting impact to the finned pile (104).

Claims

1. A pile guide (20) for supporting a pile as it is driven into a substrate by a pile driver, comprising a base frame (22) and a guide member (24) mounted on the base frame (22) and configured to guide a pile as it is driven into the substrate, **characterised in that** the guide member (24) comprises a pair of upright, spaced apart guide channels (30), each configured to receiver slidably and guide a respective one of a pair of stabilising fins of a finned pile, with resulting engagement between fins and channels providing alignment with the substrate during pile driving.
2. A pile guide (20) according to claim 1, **characterised in that** the upright guide channels (30) are positioned opposite each other, with channel openings facing each other.
3. A pile guide (20) according to claim 1 or claim 2, **characterised in that** the upright guide channels (30) are supported by inclined struts (32) extending from an outer periphery of the base frame (22).
4. Apparatus for driving a pile into a substrate, comprising a pile guide (20) according to any one of claims 1 to 3, **characterised in that** the apparatus further comprises a pile follower (100) for transmitting impact from a pile driver to a pile being driven into a substrate, the pile follower (100) having a pair of fins (106) configured to slidably engage the pair of upright guide channels (30) of the pile guide (20).
5. Apparatus according to claim 4, **characterised in that** the pair of fins (106) extend in a common plane.
6. Apparatus according to claim 4 or claim 5, **characterised in that** the pile follower (100) has an end profile (110) comprising a driving face (112) for engaging a pile and an alignment member (114) projecting axially beyond the driving face (112) for

aligning the driving face (112) with a pile.

7. Apparatus according to claim 6, **characterised in that** the alignment member (114) is annular.

8. Apparatus according to claim 7, **characterised in that** the alignment member (114) comprises a plurality of plates (116) arranged in a ring.

9. A method of driving a finned pile into a substrate, providing a pile guide (20) comprising a base frame (22) and a guide member (24) mounted on the base frame (22) and configured to guide a pile as it is driven into the substrate, **characterised by** providing a guide member (24) having a pair of upright, spaced apart guide channels (30), each configured to receive slidably and guide a respective one of a pair of stabilising fins of a finned pile, with resulting engagement between fins and channels providing alignment with the substrate during pile driving; positioning a finned pile (104) in the pile guide (20) with the fins slidably engaging the upright guide channels (30); and pile driving the finned pile (104) into the substrate.

10. A method according to claim 9, **characterised by** interrupting pile driving; fitting a pile follower (100) to an exposed end of the finned pile, the pile follower (100) having a pair of fins (106) which slidably engage the upright guide channels (30) of the pile guide (20); and further pile driving the finned pile (104) into the substrate, using the pile follower (100) to transmit impact to the finned pile.

Patentansprüche

1. Eine Pfahlführungsvorrichtung (20) zur Stützung eines Pfahls, während er durch eine Pfahlramme in den Untergrund eingerammt wird, die aus einem Grundrahmen (22) und einem Führungselement (24) besteht, das am Grundrahmen (22) befestigt ist und dafür ausgelegt ist, einen Pfahl zu führen, während er in den Untergrund eingerammt wird, **dadurch gekennzeichnet, dass** das Führungselement (24) ein Paar senkrecht verlaufender, in bestimmten Abständen zueinander angeordneter Führungskanäle (30) aufweist, von denen jeder dafür ausgelegt ist, die jeweilige Flosse eines Stabilisierungsflossenpaares eines mit Flossen versehenen Pfahls gleitend aufzunehmen und zu führen, wobei das sich dabei ergebende Ineinandergreifen zwischen Flossen und Kanälen die Ausrichtung auf den Untergrund während des Einrammens des Pfahles gewährleistet.

2. Pfahlführungsvorrichtung (20) nach Anspruch 1, **dadurch gekennzeichnet, dass** die senkrecht verlaufenden Führungskanäle (30) einander gegenüberliegend positioniert werden, wobei die offenen Seiten der Kanäle einander zugewandt sind.

3. Pfahlführungsvorrichtung (20) nach Anspruch 1 oder Anspruch 2, **dadurch gekennzeichnet, dass** die senkrecht verlaufenden Führungskanäle (30) von Schrägstreben (32) gestützt werden, die von einer äußeren Begrenzungsfläche des Grundrahmens (22) ausgehen.

4. Vorrichtung für das Einrammen eines Pfahls in einen Untergrund, die eine Pfahlführungsvorrichtung (20) aufweist, nach einem der vorangehenden Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die Vorrichtung außerdem einen Pfahlaufsetzer (100) für die Übertragung der Stoßkraft von einer Pfahlramme auf einen Pfahl aufweist, der in einen Untergrund eingerammt wird, wobei der Pfahlaufsetzer (100) ein Flossenpaar (106) besitzt, das so ausgelegt ist, dass es in das Paar der aufrecht verlaufenden Führungskanäle (30) der Pfahlführungsvorrichtung (20) gleitend einrastet.

5. Vorrichtung nach Anspruch 4, **dadurch gekennzeichnet, dass** das Flossenpaar (106) sich auf einer gemeinsamen Ebene befindet.

6. Vorrichtung nach Anspruch 4 oder Anspruch 5, **dadurch gekennzeichnet, dass** der Pfahlaufsetzer (100) ein Stirnseitenprofil (110) hat, das eine Rammfläche (112) aufweist, damit ein Pfahl und ein Ausrichtungselement (114) ineinander greifen können, das axial über die Rammfläche (112) hinausragt, um die Rammfläche (112) auf einen Pfahl auszurichten.

7. Vorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** das Ausrichtungselement (114) ringförmig ist.

8. Vorrichtung nach Anspruch 7, **dadurch gekennzeichnet, dass** das Ausrichtungselement (114) eine Vielzahl von Platten (Lamellen) (116) aufweist, die zu einem Ring angeordnet sind.

9. Verfahren für das Einrammen eines mit Flossen versehenen Pfahls in einen Untergrund, das eine Pfahlführungsvorrichtung (20) vorsieht, die einen Grundrahmen (22) und ein Führungselement (24) aufweist, das auf dem Grundrahmen (22) angebracht ist und dafür ausgelegt ist, einen Pfahl zu führen, wenn er in den Untergrund eingerammt wird, **dadurch gekennzeichnet, dass** ein Führungselement (24) vorgesehen ist, das ein Paar senkrecht verlaufender, in bestimmten Abständen

zueinander angeordneter Führungskanäle (30) enthält, von denen jeder dafür ausgelegt ist, die jeweilige Flosse eines Paares stabilisierender Flossen des mit Flossen versehenen Pfahls gleitend aufzunehmen und zu führen, wobei das sich dabei ergebende Ineinandergreifen zwischen Flossen und Kanälen eine Ausrichtung auf den Untergrund während des Pfahlrammvorgangs gewährleistet; das einen mit Flossen versehenen Pfahl (104) in der Pfahlführungsvorrichtung (20) in die richtige Stellung bringt, wobei die Flossen gleitend in die senkrecht verlaufenden Führungskanäle (30) eingreifen; und für das Einrammen des mit Flossen versehenen Pfahls (104) in den Untergrund.

10. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** das Pfahleinrammen unterbrochen wird; ein Pfahlaufsetzer (100) auf eine freiliegende Stirnseite des mit Flossen versehenen Pfahls aufgesetzt wird, wobei der Pfahlaufsetzer (100) ein Flossenpaar (106) aufweist, das gleitend in die senkrecht verlaufenden Führungskanäle (30) der Pfahlführungsvorrichtung (20) eingreift; und der mit Flossen versehene Pfahl (104) weiter in den Untergrund eingerammt wird, wozu der Pfahlaufsetzer (100) für die Übertragung der Stoßkraft auf den mit Flossen versehenen Pfahl genutzt wird.

Revendications

1. Guide pour pieu (20) pour supporter un pieu lorsqu'il est battu dans un substrat par un appareil de battage, comprenant un châssis (22) et un élément de guidage (24) monté sur le châssis (22) et configuré pour guider un pieu lorsqu'il est battu dans le substrat, **caractérisé en ce que** l'élément de guidage (24) comprend une paire de canaux de guidage (30) verticaux et espacés, chacun d'eux étant configuré pour recevoir par glissement et guider une des ailettes respectives de la paire d'ailettes de stabilisation d'un pieu à ailettes, ce qui entraîne un engagement entre les ailettes et les canaux proposant un alignement avec le substrat lors du battage du pieu.
2. Guide pour pieu (20) selon la revendication 1, **caractérisé en ce que** les canaux de guidage verticaux (30) sont placés à l'opposé l'un de l'autre, avec les ouvertures des canaux se faisant face.
3. Guide pour pieu (20) selon la revendication 1 ou 2, **caractérisé en ce que** les canaux de guidage verticaux (30) sont supportés par des traverses inclinées (32) s'étendant d'une périphérie externe du châssis (22).
4. Dispositif pour effectuer le battage d'un pieu dans un substrat, comprenant un guide pour pieu (20) selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** le dispositif comprend en outre un faux pieu (100) pour transmettre l'impact d'un appareil de battage à un pieu battu dans un substrat, le faux pieu (100) ayant une paire d'ailettes (106) configurées pour engager par glissement la paire de canaux de guidage verticaux (30) du guide pour pieu (20).
5. Dispositif selon la revendication 4, **caractérisé en ce que** la paire d'ailettes (106) s'étend dans un plan commun.
6. Dispositif selon la revendication 4 ou 5, **caractérisé en ce que** le faux pieu (100) a un profil d'extrémité (110) comprenant une face de battage (112) pour engager un pieu et un élément d'alignement (114) se projetant de façon axiale au-delà de la face de battage (112) pour aligner la face de battage (112) avec un pieu.
7. Dispositif selon la revendication 6, **caractérisé en ce que** l'élément d'alignement (114) est annulaire.
8. Dispositif selon la revendication 7, **caractérisé en ce que** l'élément d'alignement (114) comprend une pluralité de plaques (116) disposées dans un anneau.
9. Méthode de battage d'un pieu à ailettes dans un substrat, proposant un guide pour pieu (20) comprenant un châssis (22) et un élément de guidage (24) monté sur le châssis (22) et configuré pour guider un pieu lorsqu'il est battu dans le substrat, **caractérisé en ce qu'il** propose un élément de guidage (24) ayant une paire de canaux de guidage (30) verticaux espacés, chacun d'eux étant configuré pour recevoir par glissement et guider une des ailettes respectives d'une paire d'ailettes de stabilisation d'un pieu à ailettes, ce qui entraîne un engagement entre les ailettes et les canaux proposant un alignement avec le substrat pendant le battage du pieu ; plaçant un pieu à ailettes (104) dans le guide pour pieu (20) avec les ailettes engageant par glissement les canaux de guidage verticaux (30) ; et battant le pieu à ailettes (104) dans le substrat.
10. Méthode selon la revendication 9, **caractérisée par** l'interruption du battage du pieu; l'adaptation du faux pieu (100) à une extrémité exposée du pieu à ailettes, le faux pieu (100) ayant une paire d'ailettes (106) qui engage par glissement les canaux de guidage verticaux (30) du guide pour pieu (20) ; et

le battage ultérieur du pieu à ailettes (104)
dans le substrat, à l'aide du faux pieu (100) pour
transmettre l'impact au pieu à ailettes.

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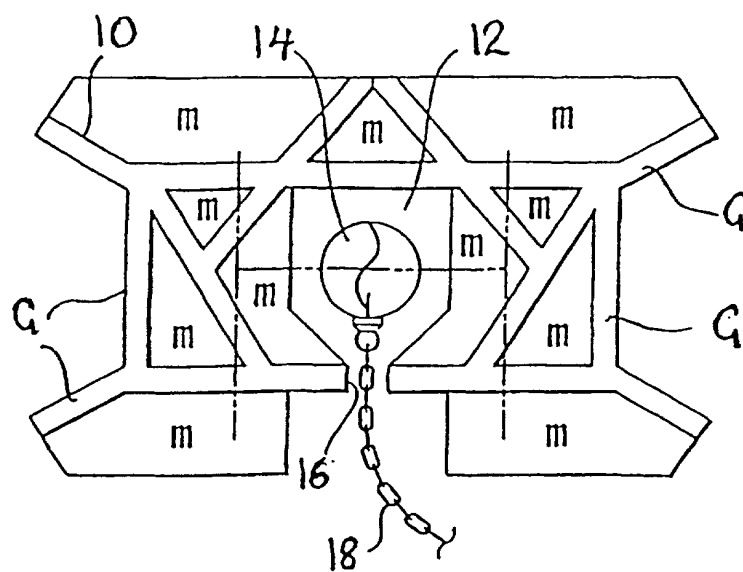


Fig. 1
(Prior Art)

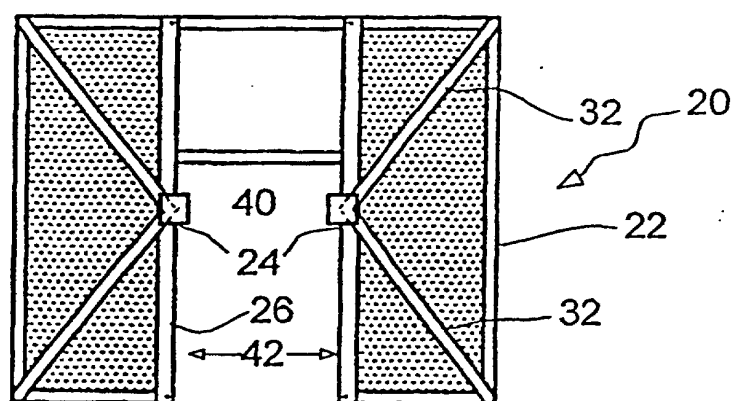


FIG 2

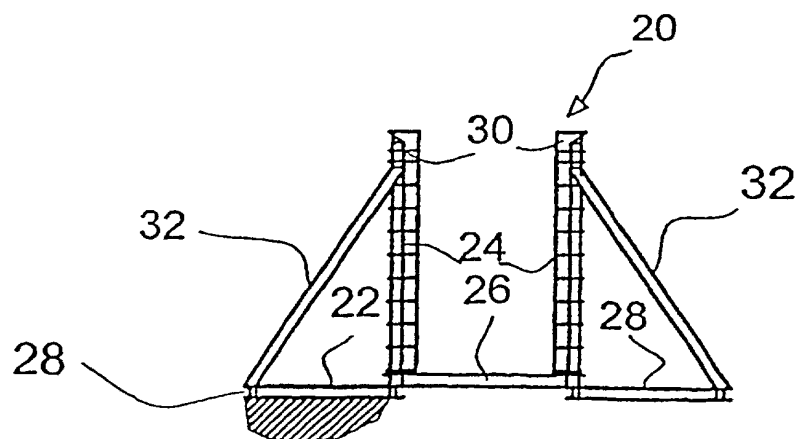


FIG 3

