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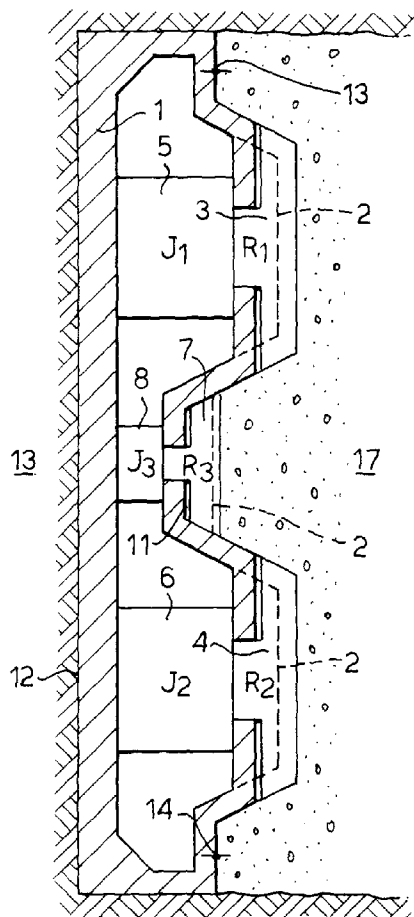
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### (54) Formwork for construction in concrete

(57) Reusable formwork for construction in concrete, especially for defining the "growing" end of a concrete diaphragm wall or other wall being formed below ground level, comprises at least two rigid formwork bodies (1, 3, 4, 7) together forming a containing surface for concrete to be cast. Mechanical means (such as hydraulic jacks  $J_1, J_2, J_3$ ) are provided for producing forces across the containing surface (2) tending to produce relative movement of the rigid bodies and sufficient to release one of them from adhesion to concrete cast on the said containing surface. Preferably there are more than two of the rigid bodies arranged so that by actuating them in appropriate sequence they can all be released.

Fig.1.



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## Description

This invention relates to re-usable formwork for casting concrete bodies and more especially (but not exclusively) for forming the end, for the time being, of a concrete body to be extended in a subsequent casting step (hereinafter for brevity called the "growing" end). An important application is in constructing walls below ground level (either to remain so as a "diaphragm wall" or to be exposed by subsequent excavation of the ground to one side of the wall as a retaining wall).

Diaphragm walls (and retaining walls constructed below ground level) are generally cast in sections short enough to for the excavation to be supported by a drilling fluid (typically bentonite slurry), and thus require large numbers of joints. In some cases the sides of the excavation itself may be sufficient to contain the concrete, but formwork is normally needed at the growing end of the casting (or at both ends, where the wall is to be extended in both directions), so that the end shall be true enough to ensure proper coupling and sealing to the next section; if the end face is true enough, it may be used to guide the machine excavating for the next section.

Conventional formwork is extracted by pulling it vertically upwards. Especially if the wall is deep, the force required to extract it after the concrete has set may be very high.

In some cases, formwork has been extracted sideways after excavation for the next section is complete by manipulation of the excavating tool or an auxiliary tool.

In accordance with the invention, reusable formwork for construction in concrete comprises at least two rigid formwork bodies together forming a containing surface for concrete to be cast and mechanical means for producing forces across the containing surface tending to produce relative movement of the said bodies and sufficient to release one of them from adhesion to concrete cast on the said containing surface.

Preferably one of the two rigid bodies forms the main structural member of the formwork (though it may itself be of modular construction) and the, or each, other rigid body is a plate closing an aperture in that one rigid member. Preferably there is more than one other rigid body, not only to allow forces to be distributed over the area of the formwork but also to allow the associated mechanical means to be actuated successively to release all the parts of the formwork.

Preferably the formwork is of steel, for durability and to allow the dimensional accuracy needed to ensure there is negligible risk of concrete leaking between contacting parts.

The said mechanical means are preferably hydraulic jacks, either direct-acting or using levers, wedges or the like to change the direction of movement. Other suitable mechanisms (including pneumatic motors and screw jacks) can be used if preferred, for instance be-

cause hydraulic power is not readily available on site.

The containing surface may be generally flat, but preferably it incorporates at least one projection or recess (for example a vertical rib or channel) to provide mechanical interlock between the concrete sections.

Where waterproof sealing is required, rubber or other resilient strips may be inserted partly into longitudinal slots in the formwork so that they may become embedded in the concrete cast against it and may subsequently be pulled free from the formwork when it is released from the concrete and in due course be embedded in the concrete of the next section to be cast.

The invention includes a method of casting a concrete wall or other body in successive steps including defining the growing end of the body by reusable formwork comprising at least two rigid formwork bodies together forming a containing surface for the concrete of a first section to be cast and mechanical means for producing forces across the containing surface tending to produce relative movement of the said bodies, casting a first section of the concrete body against the containing surface and after it has set actuating the said mechanical means to produce forces sufficient to release one of the two rigid bodies from adhesion to the concrete and then withdrawing the formwork.

If there are only two said rigid bodies, it may be necessary to apply an impact after the said one rigid body has been released to release the other. Another possibility is for the parts to be coupled in a manner allowing relative movement in both directions (using close-fitting sliding surfaces or a compressible gasket to maintain a seal against leakage of concrete) and to be actuated first in a direction to release one (preferably the smaller) of the two rigid bodies and then in the other direction to release the other.

Preferably, however, there are more than two of the said rigid bodies and the mechanical means associated with them are actuated sequentially so that in a first step at least two of the rigid bodies are released from the concrete and in a second step at least one of them is moved back into contact with the concrete from which it was released in the first step to transmit forces sufficient to release the, or each, rigid body that was not released in the first step.

More especially, we prefer to make the formwork with a main rigid body accounting for a major part of its area and a number (preferably more than one) of groups of other rigid bodies, each group comprising three such bodies arranged in line (preferably either horizontally or vertically); the mechanical means for the outer pair of each (or the) group of three rigid bodies are then intended to be actuated in the first step to release from the concrete the main rigid bodies and the central rigid body of each (or the) group, and then those mechanical means deactivated and the mechanical means for the central rigid body of each (or the) group actuated to release the outer pair(s) of rigid bodies.

The invention will be further described, by way of

example, with reference to the accompanying drawings in which each of Figures 1-4 is a diagrammatic plan view of one design of formwork in accordance with the invention showing successive stages in its preferred mode of operation.

#### *Preferred form of the Invention*

The formwork shown in the drawings is of modular construction and comprises at least two active sections (at top and bottom) spaced apart by plain sections of the same overall plan section. The active sections have a casing 1 (cross-hatched for clear identification) and the plain sections are of the same plan shape except for portions 2 which, for clarity, are shown only in Figure 1. Corresponding to these portions 2, the active sections include a pair of similar rams 3,4 which can be urged outwards by respective hydraulic jacks 5,6 and, in line between them a smaller ram 7 which can be urged outwards by another hydraulic jack 8. Membranes 9, 10, 11 ensure that the rams are leakproof in their unactuated starting positions. Aligned slots are used to hold and position water-stop strips 13, 14.

The formwork is set up in the starting position in an initial excavation, either contacting the earth at its ends as shown or if the nature of the ground demands it in conjunction with other formwork, with its back face 12 in nominal contact with the earth 13 of the next section to be excavated, and concrete 16 (Figure 2) poured to fill the existing excavation 17 and allowed to harden.

A new section of excavation 18 is next formed outside the formwork, and then hydraulic jacks 5 and 6 are actuated, urging their rams 3 and 4 towards the concrete and the remainder of the formwork away from it; since the rams have nowhere to go, this moves the remainder of the formwork and releases both the body 1 and the ram 7 from adhesion to the concrete. This leaves the formwork adhered to the concrete only over the area of the rams 3 and 4 and the waterstops 13 embedded in the concrete.

Now (Figure 3), the hydraulic jack 8 is actuated to bring its ram 7 back into engagement with the concrete 16; unless the stroke of this ram is greater than that of rams 3 and 4, they need to be retracted - this can be done simultaneously, before or after actuation of jack 8, but preferably after as this minimises risk of damage to the water-stops 13, 14. This action breaks the remaining adhesion of rams 3 and 4 to the concrete (Figure 4) and the formwork can be easily withdrawn and repositioned for casting of the next section.

#### *Variant 1*

A first alternative design of formwork simply omits the ram 7 and its jack 8; the procedure is as described to the stage of Figure 2 but the rams 3 and 4 are freed from adhesion to the concrete by applying a few blows to the formwork by swinging the excavating apparatus

or some other adequately massive object.

#### *Variant 2*

5 A second alternative design of formwork also omits the ram 7 and jack 8 but in this case the jacks 5 and 6 are bidirectional and the membranes 9, 10, 11 are replaced by compressible gaskets. In this case the first action for the release of the formwork is to drive the jacks 10 5 and 6 in the direction to compress the gaskets, so freeing the rams 3 and 4 from adhesion; the second and final is to drive them in the other direction to urge the freed rams 3 and 4 into engagement with the concrete and release the main body 1 of the formwork. The gas- 15 kets may be resilient and reusable (e.g. of a foam rubber) or they could be crushable and disposable (e.g. of expanded polystyrene).

#### **20 Claims**

1. Reusable formwork for construction in concrete comprising at least two rigid formwork bodies together forming a containing surface for concrete to be cast and mechanical means for producing forces across the containing surface tending to produce relative movement of the said bodies and sufficient to release one of them from adhesion to concrete cast on the said containing surface.
2. Reusable formwork as claimed in claim 1 in which one of the said two rigid bodies forms the main structural member of the formwork and the, or each, other rigid body is a plate closing an aperture in that one rigid member.
3. Reusable formwork as claimed in claim 2 in which there is more than one other rigid body.
4. Reusable formwork in accordance with claim 3 comprising a main rigid body accounting for a major part of its area and at least one group of other rigid bodies, each group comprising three such bodies arranged in line.
5. Reusable formwork as claimed in claim 4 in which there are at least two such groups of three other rigid bodies.
6. Reusable formwork as claimed in anyone of claims 1-5 in which the mechanical means for producing forces across the containing surface are hydraulic jacks.
7. Reusable formwork as claimed in any one of claims 1-6 in which there are longitudinal slots for insertion of resilient sealing strips.

8. A method of casting a concrete wall or other body in successive steps including defining the growing end of the body by reusable formwork comprising at least two rigid formwork bodies together forming a containing surface for the concrete of a first section to be cast and mechanical means for producing forces across the containing surface tending to produce relative movement of the said bodies, casting a first section of the concrete body against the containing surface and after it has set actuating the said mechanical means to produce forces sufficient to release one of the two rigid bodies from adhesion to the concrete and then withdrawing the formwork. 5 10
9. A method as claimed in claim 8 in which more than two of the said rigid bodies are used and the mechanical means associated with them are actuated sequentially so that in a first step at least two of the rigid bodies are released from the concrete and in a second step at least one of them is moved back into contact with the concrete from which it was released in the first step to transmit forces sufficient to release the, or each, rigid body that was not released in the first step. 15 20 25
10. A method as claimed in claim 9 in which the formwork comprises a main rigid body accounting for a major part of its area and at least one group of other rigid bodies, each group comprising three such bodies arranged in line and in which the mechanical means for the outer pair of each (or the) group of three rigid bodies are actuated in a first step to release from the concrete the main rigid body and the central rigid body of each (or the) group, and then those mechanical means deactivated and the mechanical means for the central rigid body of each (or the) group actuated to release the outer pair(s) of rigid bodies. 30 35 40 45 50 55

Fig.1.

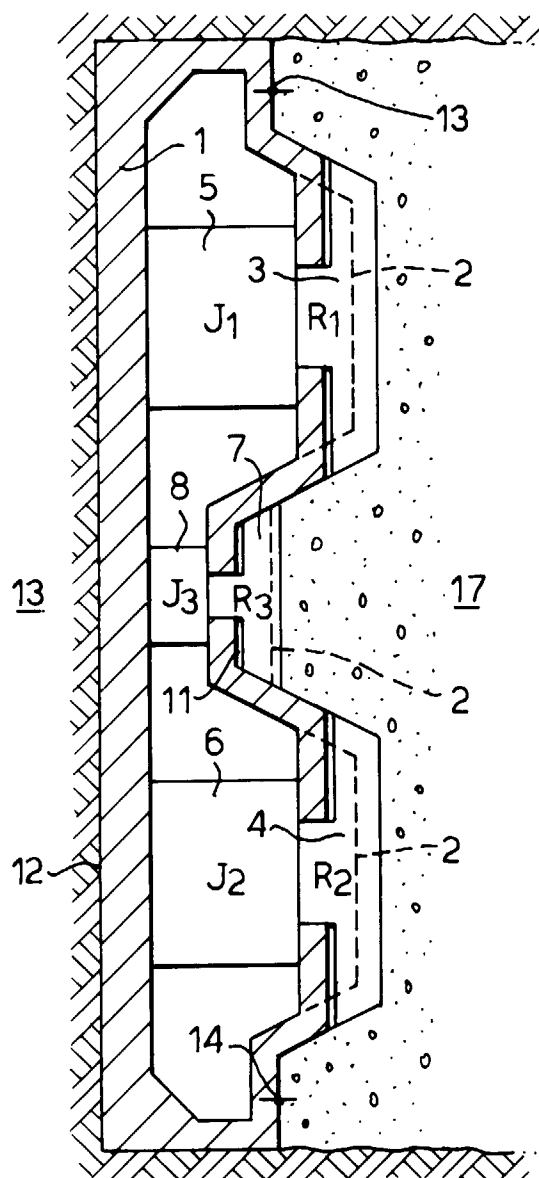


Fig.2.

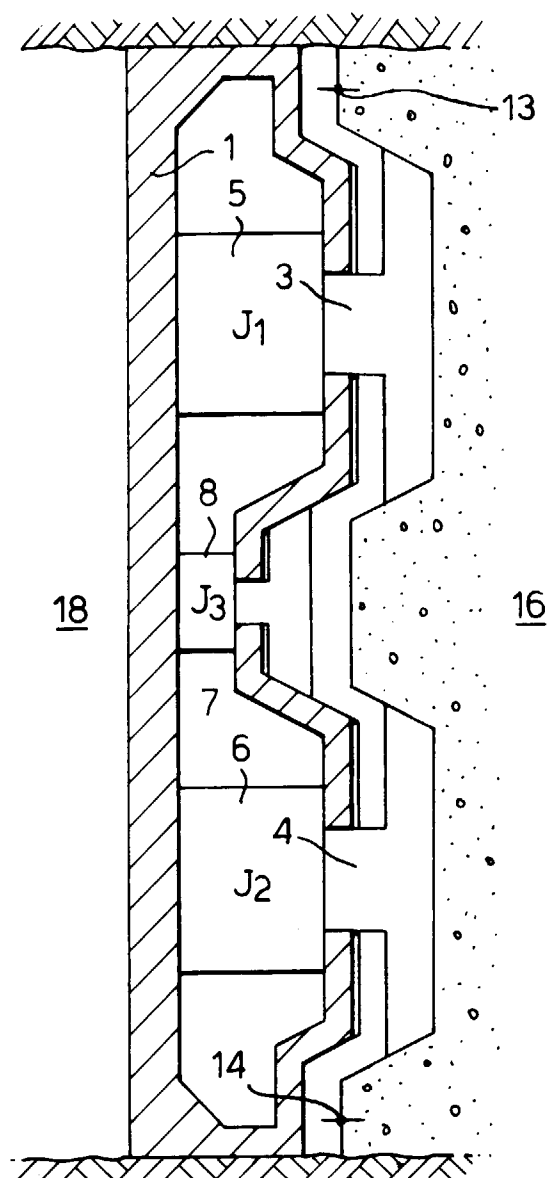


Fig.3.

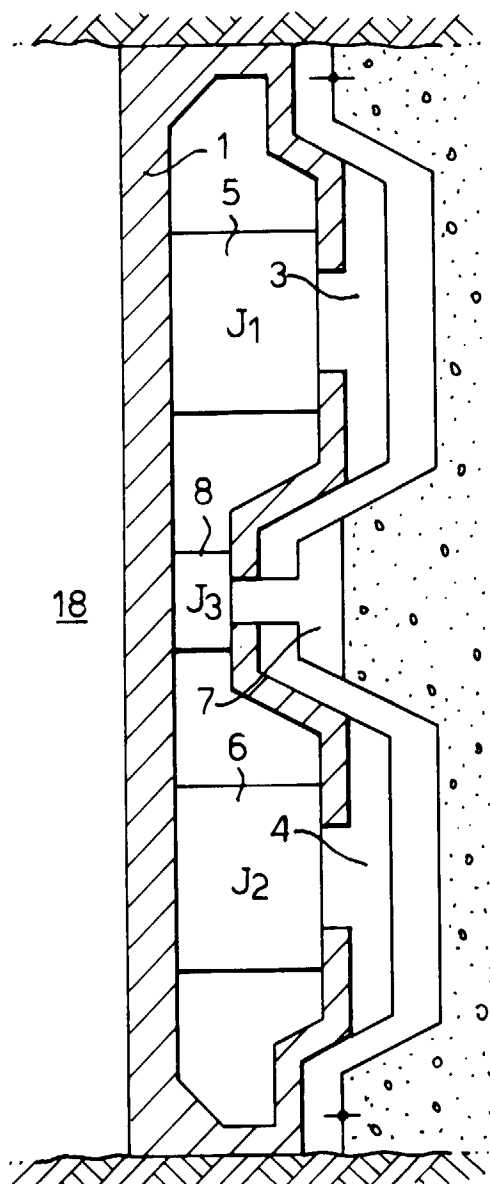
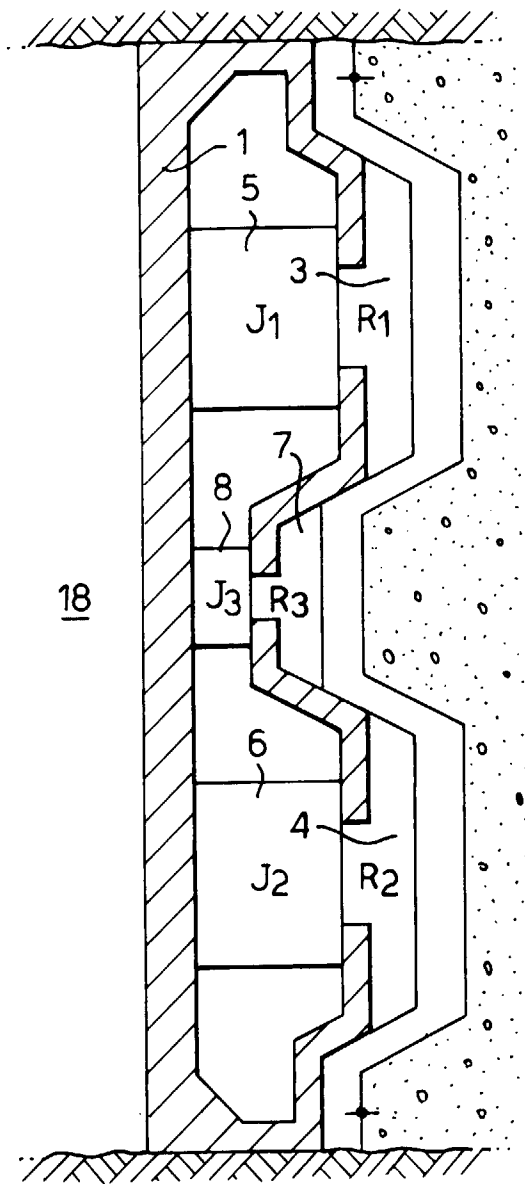


Fig.4.





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## EUROPEAN SEARCH REPORT

Application Number  
EP 96 30 5061

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                         |                                                     |                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Citation of document with indication, where appropriate, of relevant passages                                           | Relevant to claim                                   | CLASSIFICATION OF THE APPLICATION (Int.CL.6)             |
| X<br>Y<br>A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DE-U-90 01 679 (BAUER SPECIALTIEFBAU)<br>* the whole document *                                                         | 1-3,6,8<br>7<br>4,5                                 | E02D5/18<br>E04G11/46<br>E04G19/00                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ---                                                                                                                     |                                                     |                                                          |
| X<br>A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EP-A-0 414 120 (DYCKERHOFF & WIDMANN AG)<br>27 February 1991<br>* column 6, line 7 - column 8, line 2;<br>figures 1-6 * | 1<br>2-10                                           |                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ---                                                                                                                     |                                                     |                                                          |
| X<br>A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EP-A-0 440 584 (BSS INFRAG S A) 7 August 1991<br>* column 3, line 2 - column 5, line 10;<br>figures 1-3F *              | 1<br>2-10                                           |                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ---                                                                                                                     |                                                     |                                                          |
| Y<br>A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DE-A-16 34 445 (LORENZ) 15 October 1970<br>* the whole document *                                                       | 7<br>1,8                                            |                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ---                                                                                                                     |                                                     |                                                          |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FR-A-2 473 091 (SIF ENTREPRISE BACHY) 10 July 1981<br>* page 5, line 23 - page 6, line 34;<br>figures 1-4 *             | 1-10                                                |                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | -----                                                                                                                   |                                                     |                                                          |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                         |                                                     | TECHNICAL FIELDS SEARCHED (Int.CL.6)<br><br>E02D<br>E04G |
| Place of search<br>THE HAGUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                         | Date of completion of the search<br>18 October 1996 | Examiner<br>Tellefsen, J                                 |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>D : document cited in the application<br/>L : document cited for other reasons<br/>.....<br/>&amp; : member of the same patent family, corresponding document</p> |                                                                                                                         |                                                     |                                                          |

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