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(71) Applicant: **Steding, Jerry A.**
**9315 Riverclub Parkway**
**Duluth Georgia 30136(US)**

(72) Inventor: **Steding, Jerry A.**
**9315 Riverclub Parkway**
**Duluth Georgia 30136(US)**

(74) Representative: **Timmers, Cornelis Herman Johannes, Ir. et al**
**EXTERPATENT B.V. Willem Witsenplein 4**
**NL-2596 BK The Hague(NL)**

## (54) Method and apparatus for installing a concrete pile in soil.

(57) A concrete pile installation apparatus and method is disclosed wherein a device penetrates the soil to produce opening for the formation of the pile. Fill material (25), such as grout, is introduced into the opening and a potential vacuum void (26) created in the formation of the pile, is vented to the atmosphere to prevent the pulling of surrounding soil (27) into the opening (26) and thereby causing the formation of a defective pile.

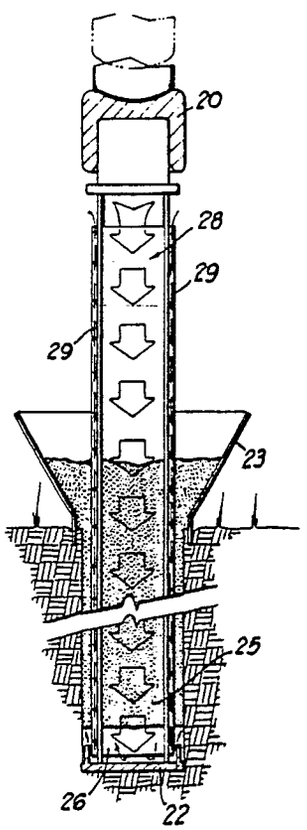


FIG 2

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# Method and apparatus for installing a concrete pile in soil.

The present invention relates to a method and apparatus as described in the preamble of Claims 1 and 5 respectively and known from US-A-3 851 484 and US-A-3 851 485, both issued to Steding on December 3, 1974.

A problem can arise during the installation of concrete piles in accordance with the prior art where soft soil below the water table is encountered and where the rate of penetration of the plow point into the soft soil is not controlled. This problem can result in the formation of imperfect concrete piles, and it is the primary object of the invention to alleviate this difficulty in a simple, effective and economical manner.

More particularly, if the pile driving hammer is allowed to strike the pusher with such force that the resulting penetration of the plow point under each hammer blow is in the order of six inches to one foot, then, at the point of impact of the pile hammer with the pusher, the plow point is temporarily driven from beneath the grout column above it, forming a void between the plow point and grout column. Such void cannot exist in actuality because of a nearly perfect vacuum therein, and therefor the void must be instantly filled either with grout from above or with the surrounding soft soil adjacent to the concrete pile being formed. The vacuum tends to pull the surrounding soft soil into the void in some cases, resulting in decreasing the diameter of the pile..

The invention aims to correct and eliminate said problem and this aim is achieved by the measures as specified in the characterizing clause of Claims 1 and 5 respectively.

The invention provides a vacuum relief passage means in a concrete pile installing apparatus whose presence does not impede the normal mode of use of the apparatus to form concrete piles in accordance with the teachings of the above referenced prior patents.

Preferred and advantageous embodiments are described in the subclaims.

The invention will be elucidated on the hand of the drawing, wherein:

Figure 1 is a partly schematic vertical cross-section through a prior art concrete pile installing apparatus and method;

Figure 2 is a similar view of the improved anti-vacuum apparatus and method for installing concrete piles in accordance with the present invention;

Figure 3 is a side elevation of an assembled pusher and plow point according to one embodiment of the invention;

Figure 4 is a horizontal section taken on line 4-4 of Figure 3;

Figure 5 is a view similar section taken on line 5-5 of Figure 3;

Figure 6 is a view similar to Figure 4 showing a different type of plow point;

Figure 7 is a side elevation of a pusher and plow point according to a second embodiment of the invention;

Figure 8 is a horizontal section taken on line 8-8 of Figure 7;

Figure 9 is an exploded perspective view, partly in section, showing a pusher and plow point according to another embodiment of the invention;

Figure 10 is a fragmentary side elevation of the elements shown in Figure 9 in assembled relationship;

Figure 11 is a horizontal section taken on line 11-11 of Figure 10;

Figure 12 is a similar view taken on line 12-12 of Figure 10;

Figure 13 is a perspective view, partly in section and partly broken away, showing another embodiment of the invention;

Figure 14 is a fragmentary longitudinal vertical section taken through the apparatus in Figure 13;

Figure 15 is a horizontal section taken on line 15-15 of Figure 14;

Figure 16 is a side elevation, partly in section, showing an anti-vacuum auger-type pile installing apparatus according to another embodiment of the invention;

Figure 17 is an end elevation of the apparatus shown in Figure 16.

Referring to the drawings in detail wherein like numerals designate like parts, Figure 1 depicts the prior art substantially in accordance with the above referenced prior art. A drive head 20 is engaged with a drive head adapter 20A and pusher 21 which is in turn engaged at its lower end with a suitable plow point 22. A grout supply hopper 23 on the ground surface surrounds the pusher 21 to deliver grout downwardly by gravity into the bore or cavity 24 of the soil created by the advancing plow point 22 under the influence of a pile driving hammer (not shown).

As explained previously, in soft soil below the water table, unless the rate of penetration of the plow point 22 per hammer blow is controlled, the plow point will be temporarily driven away from the bottom of the grout column 25 tending to create a void 26 between the plow point and the grout column. This void cannot remain empty because of

the high degree of vacuum therein and must be substantially filled with grout or with the soft soil adjacent to the apparatus and the pile being installed.

As indicated by the numeral 27 in Figure 1, the vacuum in the void 26 may pull the surrounding soft soil inwardly, thus effectively decreasing the diameter of the bore immediately behind the plow pointy 22 and correspondingly decreasing the cross-sectional size of the concrete pile, rendering it defective.

Figure 2 depicts the complete solution of the prior art problem described in connection with Figure 1 by means of the present invention. In figure 2, the same drive head 20, grout hopper 23 and plow point 22 may be employed. However, the pusher 28 according to the present invention differs from the prior art pusher 21 in that it is provided with longitudinally extending vacuum-relief passage means 29, whereby the vacuum induced in the temporary void 26 when the plow point 22 moves away from the grout column 25 is vented to atmosphere and thus effectively eliminated, so that the surrounding soft soil cannot be pulled inwardly to diminish the cross-sectional size of the concrete pile as shown in Figure 1.

Figures 3 to 6 depict in greater detail a first embodiment of the invention including a pusher 30 and a plow point 31 telescopically engaged as shown. The drive head 20 and grout hopper 23 shown in Figures 1 and 2 are omitted in Figure 3 for ease of illustration but these latter components are used in the method and apparatus according to Figures 3 to 6.

The plow point 31 is circular, as shown, and the pusher 30 is a H-cross section member. On opposite sides of its center web 32, pusher 32 is provided with shallow channel members 33 welded thereto defining with the web 32 a pair of opposite side vacuum-relief passages 34. Similarly, a pair of channel member 35 welded to the outer faces of the side webs 36 of the pusher define another pair of vacuum-relief passages 37 lengthwise of the pusher. As shown in Figure 3, the channels 33 and 35 at their tops terminate short of a flange 38 near the top of the pusher. Therefore, the tops of the passages 37 are open to atmosphere below the flange 38 as are the tops of the passages 34 since the channels 33 also terminate below the flange 38 at the same elevation as the channels 35. As shown in dotted lines in Figure 3, the lower ends of the channels 33 and 35 also terminate somewhat above the corresponding ends of the webs 36 whereby the vent passages 37 and 34 communicate at their lower ends with the temporary void 26, Figure 2. The construction of the apparatus in Figure 3 to 6 is the same as disclosed in Figure 2, although shown in greater detail. It should be clear that the venting or anti-vacuum passages 37 and 34 of the pusher 30 prevent the objectionable inward drawing of the soft soil surrounding the pusher, as shown in Figure 1, resulting in the formation of defective piles. With the unique anti-vacuum feature of the present invention, there is no necessity for controlling the degree of penetration of the plow point 22 under each hammer blow, and thus this less expensive process can be used in more applications.

Figure 6 depicts the same apparatus structure shown in Figures 3-5 except that the plow point 31 has a square bottom plate 40 instead of a circular one as in Figures 3 to 5.

Figures 7 and 8 show a second embodiment of the invention in which a pusher 41 comprises a cylindrical tubular member having circumferentially spaced and longitudinal staggered side wall grout openings 42 distributed along its length. A plurality of external vacuum-relief passages 43 are formed longitudinally on the pusher 41 by circumferentially equidistantly spaced channel members 44 welded thereto and having their opposite ends open, as shown. The pusher 41 is employed in the process of installing a concrete pile along with a plow point 45, Figure 7.

Figures 9 through 12 show another modified embodiment of the invention in which a cylindrical tubular pusher 46 having side wall openings 47 along its length is equipped with exterior longitudinal channel members 48 welded thereto and defining a corresponding number of vacuum-relief passages 49 longitudinally of the pusher 46.Near and slightly above the lower end of the tubular pusher 46, Figure 10, an enlarged diameter circumferential venting air passage 50 surrounds the pusher 46 and communicates directly with the longitudinal vacuum-relief passages 49, as shown best in Figure 12, near the lower ends of the latter. The channels 48 are open at their top and bottom ends. As in the prior forms of the invention, the vacuum-relief passage means 49 and 50 serve to vent the void 36, Figures 1 and 2, to the atmosphere at all times so as to avoid inward pulling of the soft soil around the pusher, as previously explained.

Figures 13 to 15 show yet another embodiment of the apparatus in which a pusher 51 comprises an inner tube body 52, having circumferentially spaced longitudinally stagger grout inlet openings defined by short sleeve sections 53, connected between the inner tube body 52 and a surrounding concentric outer tube 54. The annular space 55 between the two tubes 52 and 54 is the vacuum-relief or vent passage for the embodiment of the invention shown in Figures 13 to 15. Again, the operation of the apparatus according to Figures 13 to 15 in the practice of the method is identical to the operation of the preceding embodiments.

Figures 16 and 17 show another embodiment of the invention in which an auger 56 is driven in rotation by means 57 to form a hole 58 while soil is elevated to ground level by the auger. As the auger is retracted upwardly from the hole 58, grout 59 to form a concrete pile within the hole 58 from bottom-to-top thereof is delivered downwardly through a central axial tube 60 of the auger 56. To relieve a vacuum which tends to be created beneath the auger as it is withdrawn from the hole 58, causing similar difficulties to those shown in Figure 1, a vacuum-relief passage 61 extending lengthwise of the auger is formed by an open-ended tube 62 coaxially surrounding the tube 60 and being connected therewith by spaced struts 63. The benefits realized as a result of the vacuum-relief passage 61 are essentially the same as those realized by the relief passages described in the prior embodiments.

In the several embodiments of the invention shown in Figures 3 to 15 of the drawings, the pusher is withdrawn from the bore of hole in the soil at the completion of the process, but the plow point remains embedded in concrete at the bottom of the pile, as shown in US-A-3 851 484 and US-A-3 851 485. Each embodiment of the invention involves a soil penetrating device having a vacuum relief passage means as well as a passage means for grout. The H-cross section pusher 30 has grout passages on opposite side of its center web 32 and between its side web 36. The openings 42, 47 and 53 allow grout from the hopper 23 to pass from the exterior to the interior of the pusher 21 and from the interior to the exterior of the pusher 21 during the formation of the concrete pile. Following withdrawal of the pusher or auger, additional grout is delivered into the bore hole or opening to fill the space previously occupied by the pusher or auger, thus assuring the formation of a complete pile up to ground level.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of the invention or scope of the subjoined Claims.

## Claims

1. A method of installing a concrete pile in soil comprising forming a substantially vertical opening in the soil below the surface of the soil and delivering grout into said opening to form the body of a concrete pile therein, **characterized by** the step of venting to the atmosphere the evacuated void which tends to develop in the opening prior to the delivery of grout into the opening.

2. The method of Claim 1, **characterized by** forming said opening in the soil by driving a pusher which is preceded by a plow point downwardly into the soil and simultaneously delivering the grout by gravity into the opening during the formation of the opening, and evacuated the void which is vented to the atmosphere being formed below the grout and between the grout and said plow point.

3. The method of Claim 1-2, **characterized by** forming said opening in the soil by augering the soil, creating said evacuated void in said opening during the withdrawal of the augering means from the opening, and delivering the grout into the opening during such withdrawal.

4. The method of Claim 3, **characterized by** said venting and the delivery of said grout both being carried out through passages of the augering means.

5. An apparatus of installing a concrete pile in soil comprising a device adapted to penetrate the soil to form a substantially vertical bore hole therein, and means to fill the bore hole produced by the penetrating device with grout delivered downwardly into the bore hole, **characterized by** a longitudinal atmospheric venting means on the device extending substantially from end-to-end thereof.

6. An apparatus according to Claim 5, **characterized by** a pusher preceded by a plow point of somewhat greater cross-sectional size than the pusher, while said atmospheric venting means comprises means forming a longitudinal vent passage on the pusher extending substantially from end-to-end thereof.

7. An apparatus according to Claim 5, **characterized by** an auger, while said means to fill said bore hole with grout comprises a longitudinal grout passage means on the auger, and said venting means comprises a longitudinal venting passage on the auger.

8. An apparatus according to Claim 7, **characterized in** the longitudinal grout passage and venting passage comprise concentric passages through the auger axially near its center.

9. An apparatus according to Claim 6, **characterized in** the pusher comprises an H-cross section member, and means forming vent passages on and along the walls of the H-cross-section member.

10. An apparatus according to Claim 6, **characterized in** the pusher comprises a tubular member having spaced side wall grout inlet openings, and said longitudinal vent passage on the pusher comprises at least one channel member fixed to the exterior of the tubular member.

11. An apparatus according to Claim 10, **characterized by** a plurality of circumferentially spaced channel members secured to the exterior of the tubular member, and by means forming an annular venting passage on the exterior of the tubular member which communicates with the interiors of the channels members.

12. An apparatus according to Claim 11, **characterized in** that the means forming said annular venting passage are located near the lower end of the tubular member.

13. An apparatus according to Claim 6, **characterized in** that the pusher comprises a pair of spaced substantially concentric connected tube elements where the space between the tube elements forms said longitudinal vent passage.

14. An apparatus for installing a concrete pile **characterized by** a device adapted to penetrate soil substantially vertically to form a pile receiving opening therein, means to fill said opening with fill material during the formation of the opening by the device, and a vacuum-relief means on the device in the form of a vent passage extending longitudinally of the device.

15. An apparatus according to Claim 14 **characterized in** that said means to fill said opening with fill material includes a fill material passage means in said device.

16. A method of installing a concrete pile comprising the steps of penetrating soil to form a pile receiving opening therein and delivering flowable fill material into said opening to form the body of a pile therein, **characterized by** relieving a vacuum which tends to be formed in said opening during the formation of the opening and the delivery of the fill material into the opening.

17. A method of installing a concrete pile comprising forming an opening in the soil below the surface of the soil by driving a pusher which is preceded by a plow point downwardly into the soil, delivering grout into said opening to form the body of a concrete pile therein, **characterized by** venting to the atmosphere the evacuated void which tends to develop in the opening being formed below the grout and between the grout and said plow point.

18. The method of Claim 17 **characterized by** delivering the grout by gravity into the opening during the formation of the opening.

19. A method of installing a concrete pile in soil **characterized by** forming an opening in the soil below the surface of the soil by augering the soil to form the opening and venting to the atmosphere the evacuated void which tends to develop in the opening during the withdrawal of the augering means from the opening when the grout is being delivered into the opening during such withdrawal.

20. An apparatus for installing a concrete pile in soil **characterized by** a device adapted to penetrate the soil to form a bore hole therein, means to fill the bore hole produced by the penetrating device with grout which flows into the bore hole as it is being formed, and a longitudinal atmospheric venting means on the device extending substantially from end-to-end thereof.

21. An apparatus for installing a concrete pile in soil **characterized by** an auger adapted to penetrate the soil to form a bore hole, a means to fill said bore hole with grout comprising a longitudinal grout passage means on the auger, and a venting means comprising a longitudinal venting passage on the auger for venting the evacuated void which tends to form as the auger is being removed a the grout flows into the hole.

22. An apparatus for installing a concrete pile in soil **characterized by** a device adapted to penetrate the soil to form a pile receiving opening therein, means to fill said opening with fill material simultaneously during the formation of the opening by the device, and a vacuum-relief means on the device in the form of a vent passage extending longitudinally of the device.

23. A method of installing a concrete pile **characterized by** the steps of penetrating soil to form a pile receiving opening therein, delivering simultaneously flowable fill material into said opening to form the body of a pile therein, and relieving a vacuum which tends to be formed in said opening during the simultaneous formation of the opening and the delivery of the fill material into the opening.

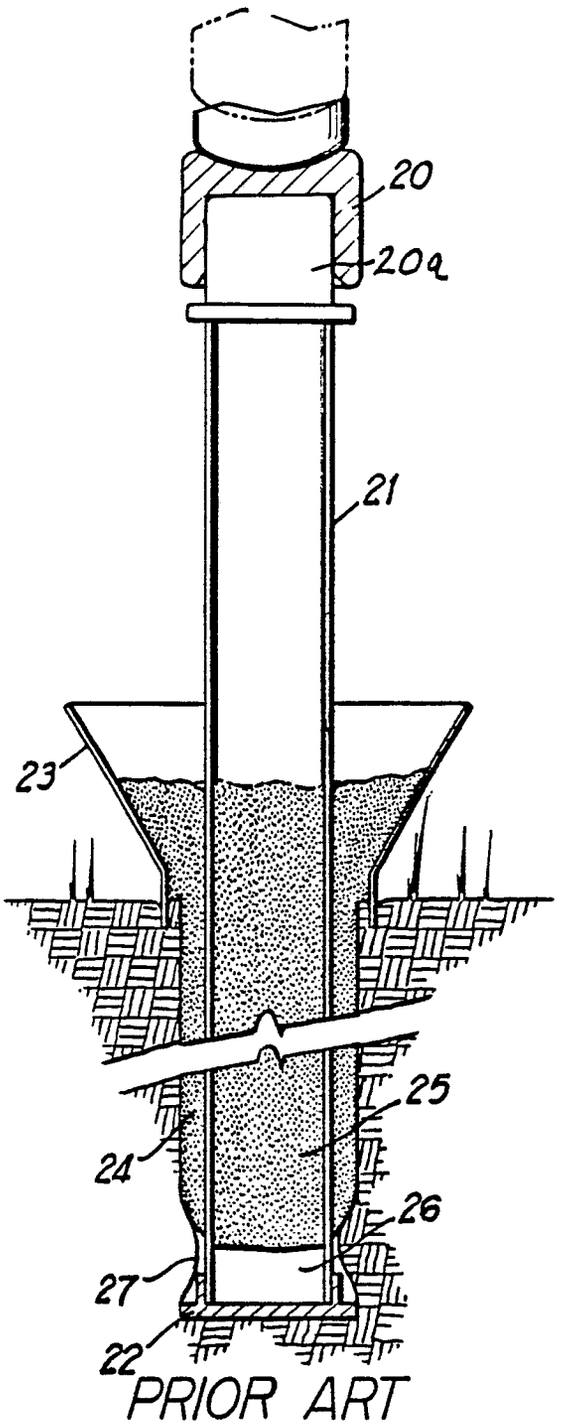


FIG 1

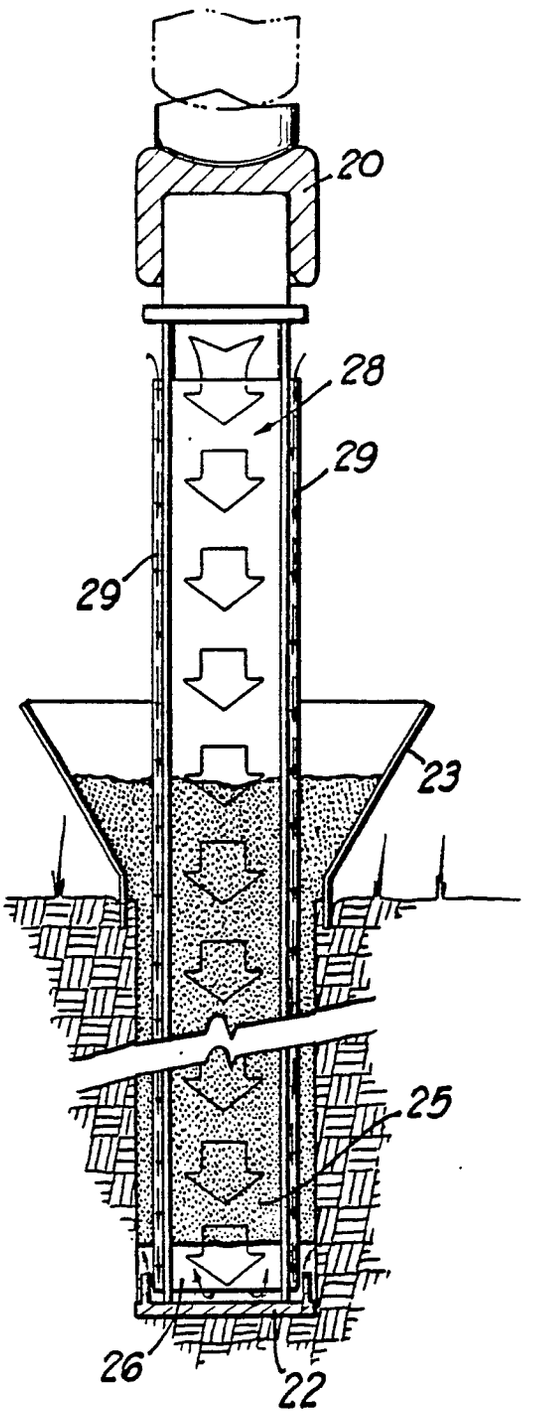


FIG 2

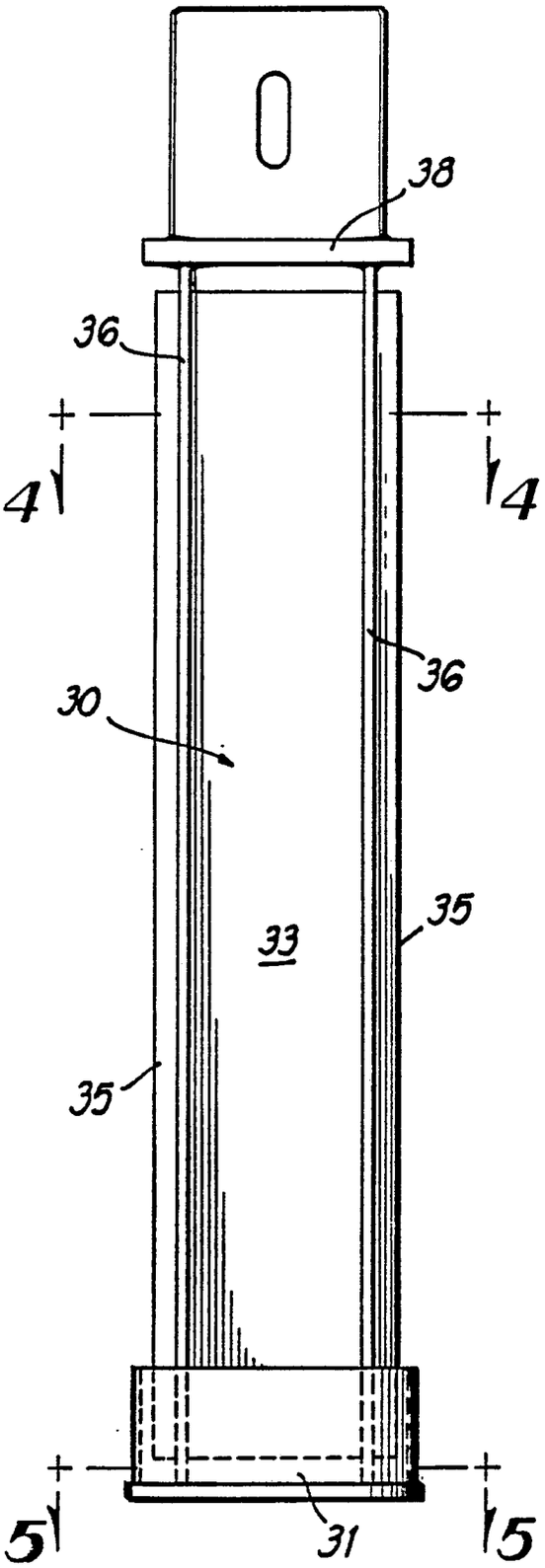


FIG 3

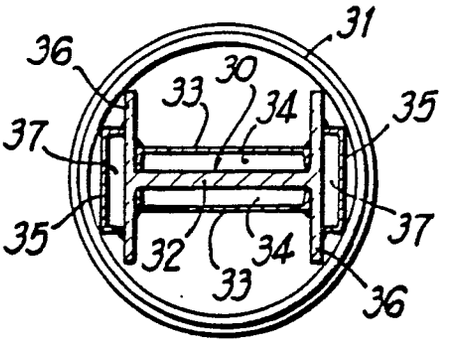


FIG 4

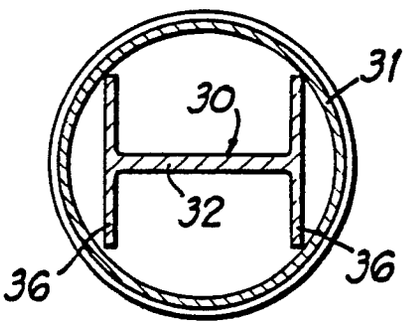


FIG 5

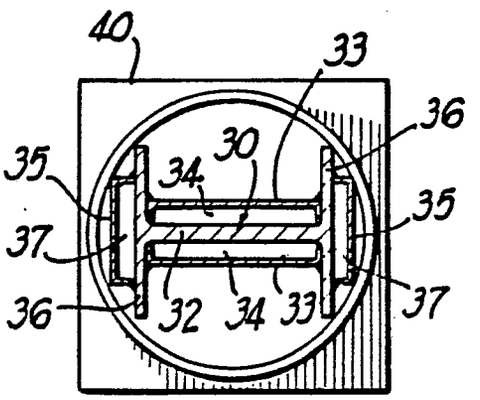


FIG 6

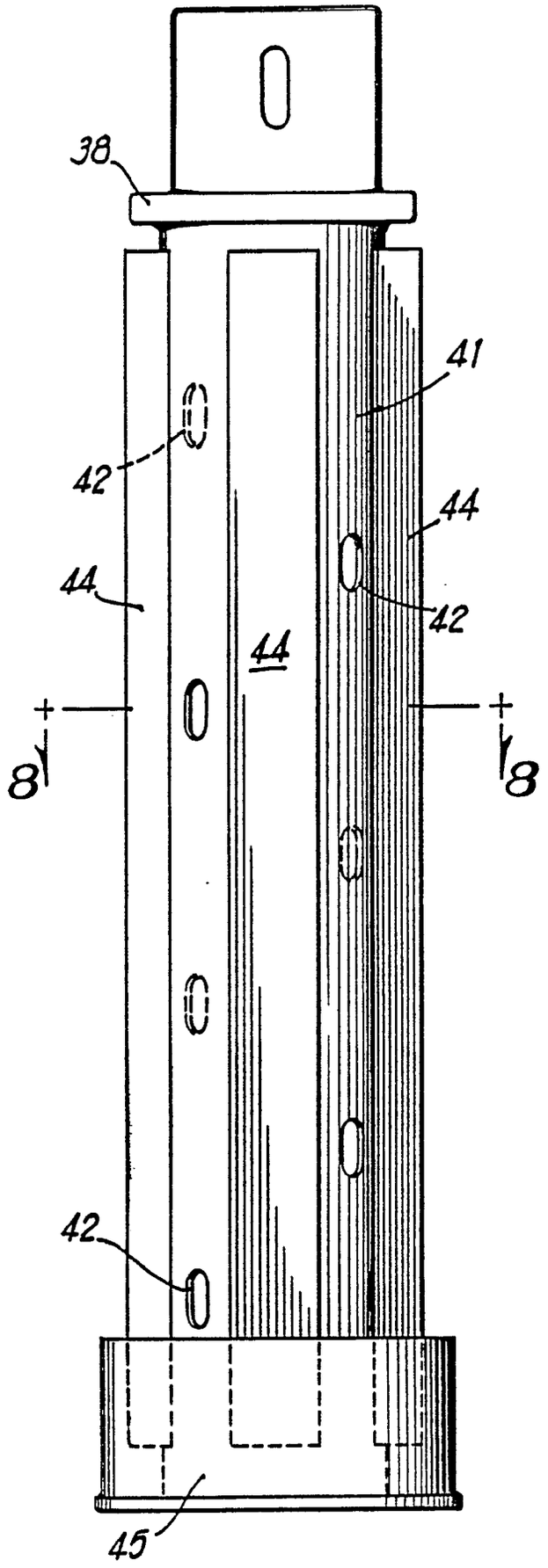


FIG 7

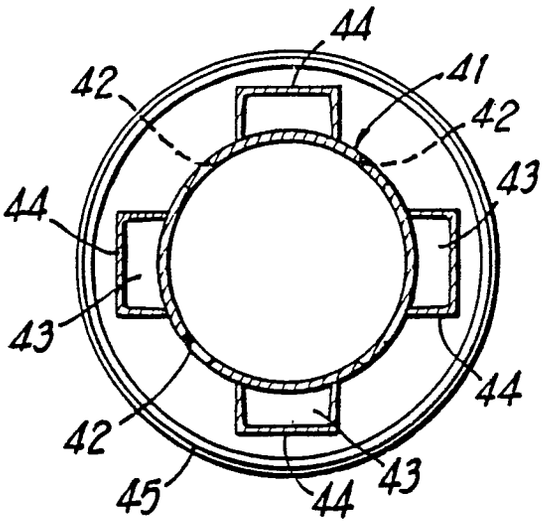


FIG 8

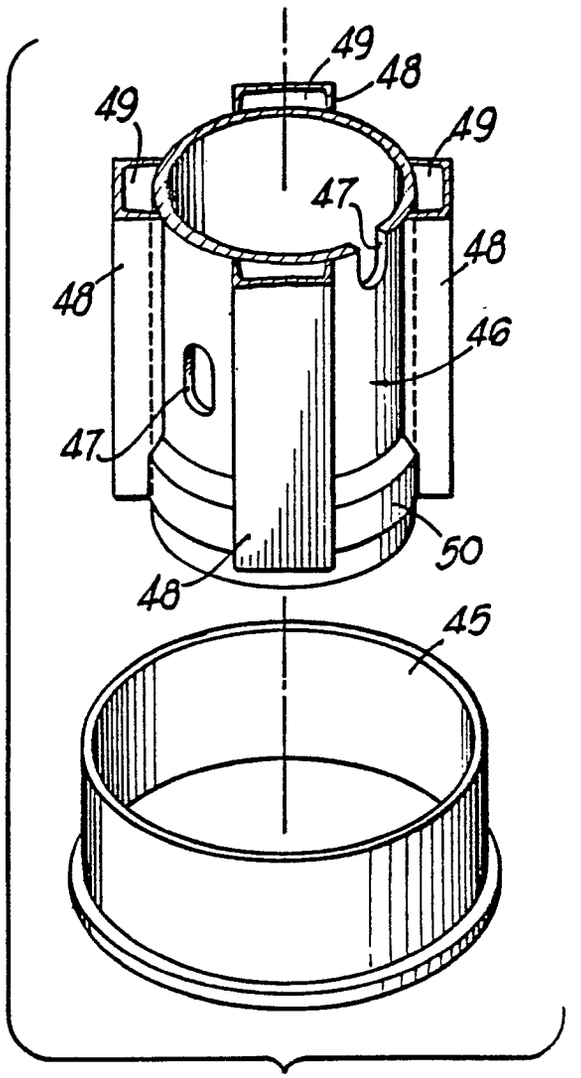


FIG 9

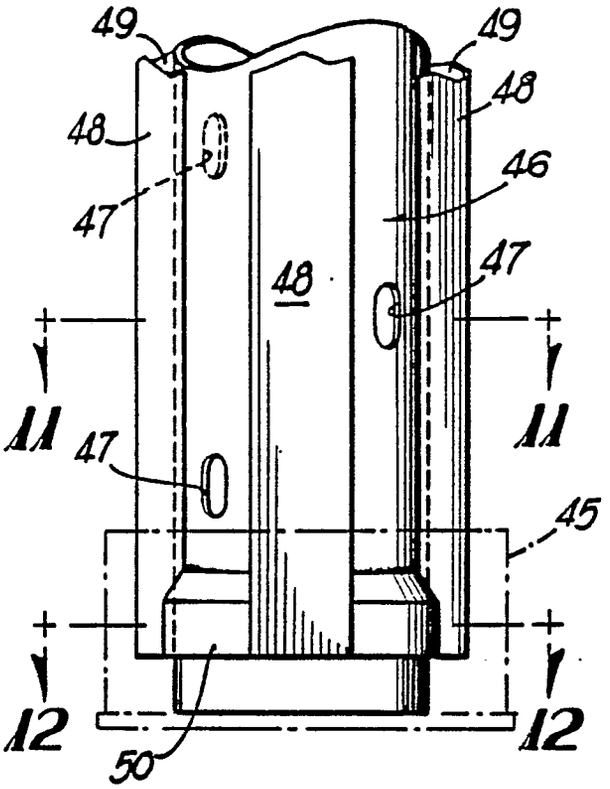


FIG 10

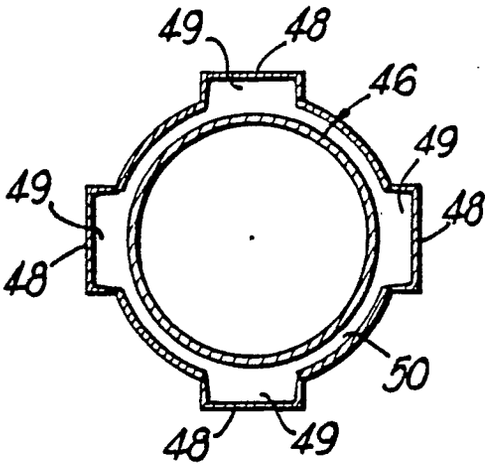


FIG 12

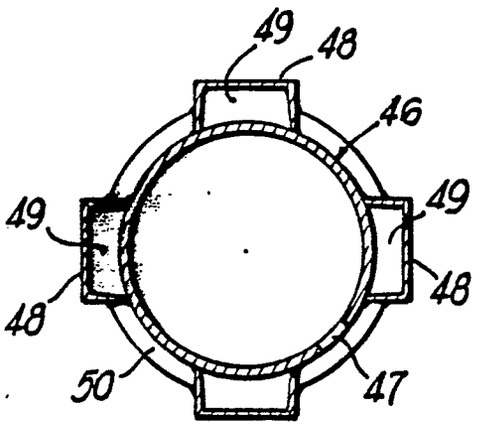


FIG 11

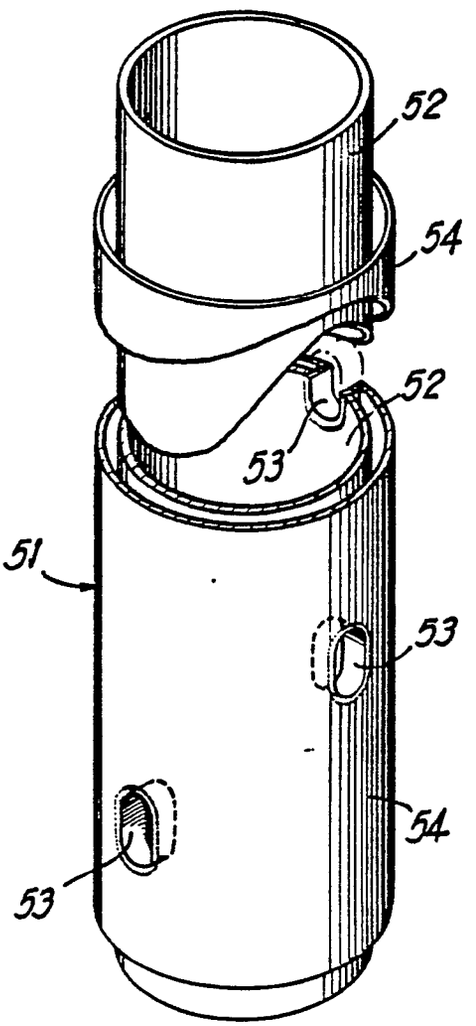


FIG 13

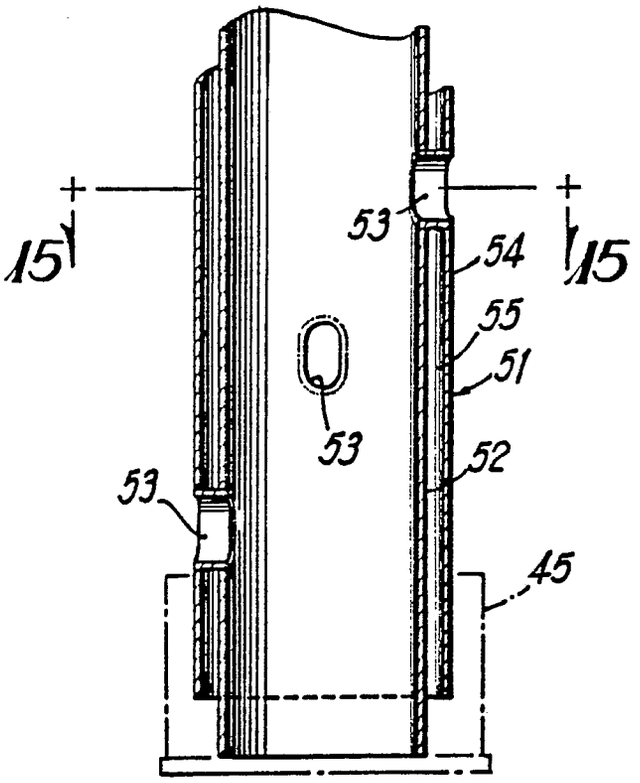


FIG 14

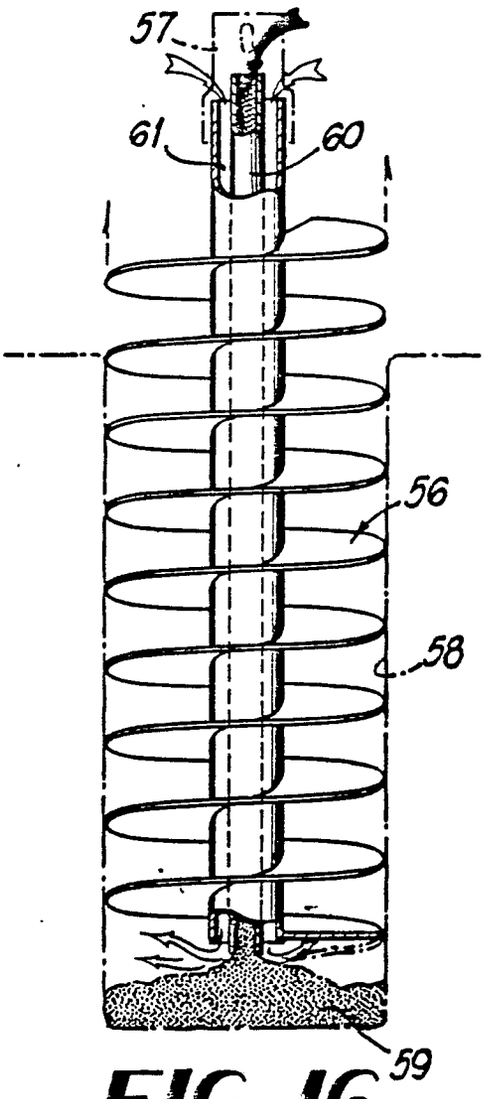


FIG 16

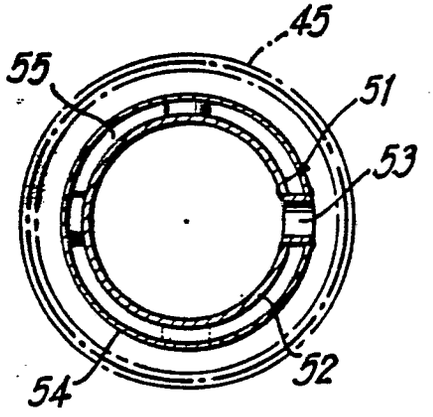


FIG 15

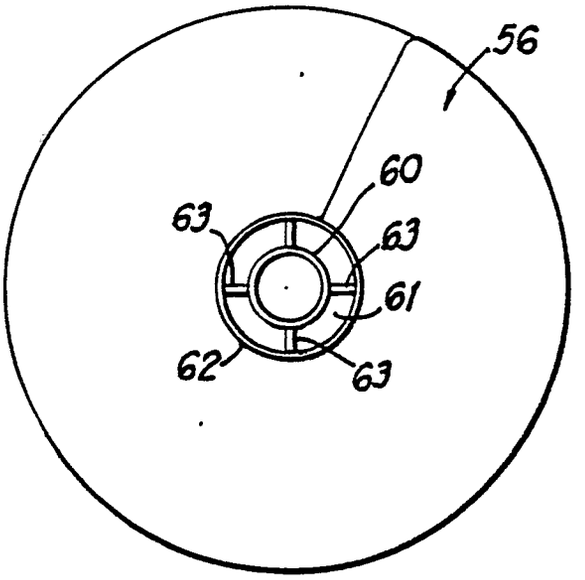


FIG 17

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 88 20 0521

## 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.4) |
|---|---|---|---|
| X | US-A-1 629 947 (BLUMENTHAL)<br>* Page 1, lines 102-108; page 2, lines 1-25,112-130; page 3, lines 9-23,124-128; page 4, lines 4-42; figures 1-9 * | 1,5,14 | E 02 D 5/36<br>E 02 D 15/04 |
| A | | 20,22, 23 | |
| | --- | | |
| A | DE-A-2 613 993 (BILFINGER)<br>* Page 4, lines 21-32; page 5, lines 1-12; figures * | 1,5,6, 14,15 | |
| | --- | | |
| A | US-A-3 638 433 (SHERARD)<br>* Column 19, lines 38-48; column 33, lines 64-75; column 34, lines 1-9,55-65; column 35, lines 21-38; column 37, lines 28-35; figures 1-3,6,7,19-19g * | 1,2,5,6 ,9-12, 17,18, 20-23 | |
| | --- | | |
| A | US-A-3 255 592 (MOOR)<br>* Column 1, lines 29-37; column 2, lines 23-35; column 3, lines 40-44; column 4, lines 12-17,57-72; figure 1 * | 1,2,4,7 ,14-16, 19,21 | TECHNICAL FIELDS SEARCHED (Int. Cl.4)<br>E 02 D |
| | --- | | |
| A | GB-A-2 042 029 (CHUAN PAO CHEN)<br>* Page 1, lines 110-119; figures 5-8 * | 3,4,19 | |
| | --- | | |
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| | --- | | |
| A | US-A-4 018 056 (POMA)<br>* Column 4, lines 29-36; column 5, lines 5-38,59-68; column 11, lines 1-20,45-54; figures 1-8 * | 2,6,10, 11 | |
| | --- -/- | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 17-11-1988 | RUYMBEKE L.G.M. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)

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# EUROPEAN SEARCH REPORT

Application Number

EP 88 20 0521

## 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.4) |
|---|---|---|---|
| A | US-A-3 921 410 (PHILO) | | |
| A | GB-A- 541 509 (HAGRUP) | | |
| A | FR-A-2 148 968 (LANDAU) | | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 17-11-1988 | RUYMBEKE L.G.M. |

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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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