(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 339 785 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **89302723.5**

(51) Int. Cl.[4]: **F17C 13/00**

(22) Date of filing: **20.03.89**

(30) Priority: **26.03.88 GB 8807276**

(43) Date of publication of application:
02.11.89 Bulletin 89/44

(84) Designated Contracting States:
AT BE DE ES FR GR IT NL SE

(71) Applicant: **CHEMROCK CRYOGENIC CORPORATION**
1101 Kermit Drive Suite 503
Nashville Tennessee 37217(US)

(72) Inventor: **Currie, Neil**
Stepping Stones Thistle Hill
Knaresborough N. Yorks. HG5 8JW(GB)

(74) Representative: **Rushton, Ronald et al**
SOMMERVILLE & RUSHTON 11 Holywell Hill
St. Albans Hertfordshire AL1 1EZ(GB)

(54) Settling or compacting granular material.

(57) A method of compacting granular insulating material in an enclosed space particularly in the annular space between an inner shell and an outer wall of a storage tank utilises an apparatus comprising a carrier (15), means (19) for moving the carrier (15) around the space and for varying the height of the carrier (15) within the space, and a plurality of elongated pokers (22) supported by and depending from the carrier (15). The method comprises periodically lowering the carrier to immerse the pokers into the granular material and then raising the carrier to withdraw the pokers from the granular material and periodically moving the carrier to different positions with the pokers withdrawn from the granular material.

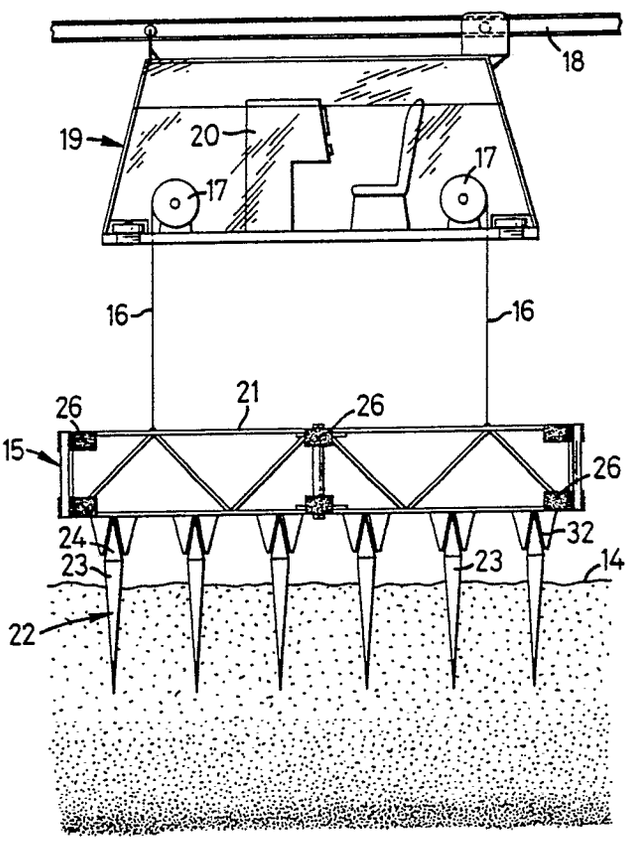

FIG.1

EP 0 339 785 A1

Settling or Compacting Granular Material

This invention relates to apparatus and methods for settling or compacting granular material contained in an enclosed space. More particularly, but not exclusively, the invention is concerned with settling or compacting granular insulating material in the annular space between the inner and outer walls of large storage tanks such as are used for the storage of liquified natural gas (LNG) and other liquified gases.

The trend in the storage of liquified gases has moved increasingly towards the use of tanks with concrete outer shells. In those tanks using perilte insulation in the annular space the ability to compact the perlite during placing is considered to be imperative because:-

a) the design detail between the wall and roof of the tanks leaves little height for a reservoir of perlite to be provided and which moves down into the annular space to allow for natural compaction and filling of the void left after cool down of the inner tank. In existing tank designs the total drop in insulation level in the annular space from these two factors can be more than 3.5 metres.

b) due to the potential hazards in topping up tanks in service great care has to be taken with regard to the use of an inert gas as a propellant, and also to avoid build up of static electrical charge; the work is comparatively slow and also more expensive per cubic metre filled than the cost of the initial filing.

In Australian Patent Application AU-A-32591/84 the desirability of settling the granular insulating material is discussed and also the problems associated with satisfactorily carrying out the settling process.

Where the outer wall of the tank is metal the conventional system for settling the insulating material is to apply vibrators to the outside of the outer shell. Conventional vibrator systems can not be used on concrete outer shells 0.5-1.0 metres thick, neither can they be used effectively on the inner tanks, due to the vibration damping effect of the resilient blanket which normally surrounds the inner shell and separates the granular insulating material from the inner shell.

The solution to these problems proposed in the aforesaid Australian Application is to position a vertical metal plate so that it is at least partially immersed in the granular material in the space and then to vibrate the plate to effect settling.

In present day methods the expanded perlite is produced on site from perlite ore and ideally the filling and compaction operations should at least keep pace with the expanded perlite production rate. Also at the end of the operation the apparatus should be reasonably easily removable from the annular space between the inner shell and outer wall. It is the object of the present invention to provide such a method and apparatus.

According to the aspect of the invention an apparatus for settling or compacting granular material contained in an enclosed space comprises a carrier, means for moving the carrier so that it can be located at different positions in the enclosed space, a plurality of elongated pokers supported by and depending from the carrier so that they can be inserted into the granular material, for producing a settling or compacting effect on the granular material, by positioning of the carrier above the granular material.

The material from which the pokers are formed is not important providing that the pokers have the necessary strength to perform their task.

The pokers are advantageously arranged to be vibrated relatively to the carrier by one or more vibrators. Thus the pokers may be arranged in groups each ganged with a vibrator. Alternatively each of the pokers has a respective vibrator associated with it for causing bodily vibration of the poker relative to the carrier. Advantageously the vibrator is housed within the associated poker. The vibrators may be electrically, pneumatically or even accoustically operated. The advantage of using the plurality of vibrating pokers in an annular space is that the pokers can be disposed widthwise as well as circumferentially so that there is a large vibrating area within the granular material and all the granular material is closer to a vibrating surface as compared with a vibrating plate.

The pokers may be of any cross-sectional shape. Advantageously however they are selected to produce a wedging effect when inserted into the granular material.

Preferably, at least a lower part of each poker, i.e. the part designed to extend into the granular material is tapered for example conically so that it is of decreasing cross-section as one proceeds downwardly over said lower part to its lower end in order to minimise the drag resistance as the poker is pulled out of the granular material. Thus the poker may taper downwardly over its whole length or only over a lower part of its length. In the latter case the poker may also taper over an upper part of its length so that its cross-section also decreases upwardly from said junction with said lower part. Should the poker then sink too deeply into the material so that the upper part becomes partly immersed in the granular material, the drag resistance when pulling the poker out of the granular

material is reduced as compared with a poker having one continuous taper over its whole length. Thus each of the pokers may be of double conical form with the bases of the cones conjoined.

The pokers may be arranged in a plurality of adjacent rows with the pokers in one row staggered in position along the row with respect to the pokers in another row.

According to another aspect of the invention, there is provided a method of compacting granular insulating material in the annular space between an inner shell and an outer wall of a storage tank utilising an apparatus comprising a carrier, means for moving the carrier around the annular space and for varying the height of the carrier within the annular space, and a plurality of elongated pokers supported by and depending from the carrier, the method comprising carrying out a cycle of operations consisting of lowering the carrier to immerse the pokers into the granular material for effecting a settling or compacting of the granular material, raising the carrier to withdraw the pokers from the granular material and moving the carrier around the annular space with the pokers withdrawn from the granular material and then repeating the cycle a plurality of times.

Thus granular material is fed into the annular space, a plurality of said cycles of operation carried out at a first level of the carrier, further granular material added in stages and a plurality of said cycles of operation carried out at increasingly higher levels between additions of granular material.

Preferably the pokers are individually vibrated at least when they are immersed in the granular material.

Preferably the pokers are disposed on the carrier so that they extend in at least two rows spaced from each other across the width of the annular space the pokers in each row extending around the annular space.

The invention will now be described by way of example with reference to the accompanying drawing, in which:

Figure 1 shows a front elevational view of one form of apparatus for carrying the invention into effect,

Figure 2 shows a cross-section through the upper wall structure of a storage tank with the apparatus in position.

Figure 3 shows a plan view of the apparatus,

Figure 4 shows an elevational view of a detail, and

Figure 5 shows a section on the line V-V of Figure 4.

Referring now to the drawings, the tank is of conventional design and has an inner cylindrical shell of metal whose outer surface is shown at 10 (Fig.2) and an outer cylindrical concrete wall whose inner surface is shown at 11 (Fig.2) and which may be up to 1 metre thick. The surfaces 10 and 11 define between them an annular space 12. The inner shell is surrounded by a resilient blanket 13 of, for example, resilient glassfibre and the internal surface 11 of the outer wall may be lined with an insulation layer 27 of, for example, polyurethane. The remainder of the annular space is filled with compacted perlite. In the drawing the perlite is shown as having been placed up to level 14. Such a blanket 13 is necessary because perlite when compacted is virtually non-compressible. The blanket 13 acts as a cushion to absorb relative movement of the tank walls and thereby substantially eliminate crushing of the perlite after the placing and compacting of the perlite has been completed.

The insulating perlite material is supplied to the annular space 12 between the walls 10 and 11 through a series of filling ports (not shown) distributed around the top of the tank.

In order to settle and compact the perlite an apparatus 15 is provided which is suspended on cables or chains 16 from hoists 17. The hoists 17 form part of a cab structure 19 which is mounted on crane beam 18 secured in the annular space 12. The beam 18 extends about the annular space 12 over the complete circular extent of the annular space 12. The cab structure 19 can be driven along the crane beam 18 in the manner of a gantry crane so that it can do a complete journey around the annular space 12. The cab structure 19 also has an operator's control console 20.

The apparatus 15 comprises a framework 21 from which depend a series of pokers 22. The framework 21 which is generally rectangular in plan view is in two parts 21a and 21b which can be angularly adjusted relatively to each other so that, within limits, the apparatus 15 can be accommodated in annular spaces of different curvatures from each other.

The pokers 22 are of double conical form comprising lower cone 23 and upper cone 24 conjoined at their bases. In this example as can be seen in Fig.3 two pokers 22 are disposed across the width of the annular space 12 and there may be, for example, six pokers in all disposed in two rows of three with the pokers 22 in one row staggered with respect to the pokers 22 in the other row.

The lower cone 23 of each poker 22 carries within it a vibrator 31 of the rotating eccentric weight type. The lower cone 23 is typically 6" in diameter at its base and is about 4 feet in length base to apex. The base of the upper cone 24 extends upwardly from the base of the lower cone 23 and is secured to gusset plates 25 through resilient suspension means in the form of rubber pads 32. The gusset plates are themselves se-

cured to the framework 21.

To constrain and guide the framework 21 around the annular space 12, soft brushes 26 are provided on its inner and outer sides and which engage the insulating blanket 12 and the outer wall surface 11 and any insulation layer 27 respectively. Alternatively other devices may be used instead of soft brushes, for example a rubber bumper.

In order to place and compact perlite in the annular space 12 using the apparatus 15, initially a first layer of perlite is provided at the bottom of annular space 12 and the pokers are inserted into it at a first position to a depth of say 3-4 feet. The perlite is compacted by the vibration of the pokers 22. After a predetermined time the pokers 22 are hoisted out of the perlite and moved a predetermined distance around the annular space 12 and then re-inserted into the insulating material at a second position. This is repeated until a complete travel of the annular space has been effected by the apparatus 15. Then the apparatus 15 is raised to a higher level and the sequence of operation is repeated on a fresh layer of perlite material. The apparatus 15 is successively raised to higher levels in this way until the annular space 12 has been filled to the desired height with compacted perlite. The aggregate volume of the lower cones 23 should advantageously approximate to the anticipated decrease in volume of the perlite resulting from the induced settlement.

If it is assumed by way of a typical example that in order to keep pace with the on-site production of expanded perlite, the distance round the annular space to be covered is 60 metres per hour, then assuming each vibrating operation lasts 6 minutes, there are ten moves per hour so that each move around the annular space between each vibration operation would be 6 metres. Consequently in order to cover the whole of the annular space without significant spaces the pokers 22 should extend over an arc of the order of 6 metres.

Alternatively, there may be more than one of the apparatus 15 disposed around the annular space and working simultaneously either to reduce the extent of the arc over which the pokers 22 of each apparatus 15 extend or to keep up with perlite production.

After completion of the compaction up to the desired height and apparatus 15 is sufficiently small that it can be readily removed through one of the manhole openings in the roof of the tank.

The advantage of the above described design of apparatus over the use of apparatus using flat or curved plates, is that it does not have a tendency to "plane" in the perlite and change direction like the latter, possibly causing damage to the blanket 12 and the liner 27.

Claims

1. Apparatus for settling or compacting granular material contained in an enclosed space characterised in that it comprises a carrier (15), means (19) for moving the carrier (15) so that it can be located at different positions in the enclosed space, a plurality of elongated pokers (22) supported by and depending from the carrier (15) so that they can be inserted into the granular material, for producing a settling or compacting effect on the granular material, by positioning of the carrier (15) above the granular material.

2. Apparatus according to claim 1, wherein the pokers (22) are arranged to be vibrated relatively to the carrier (15) by one or more vibrators (31).

3. Apparatus as claimed in claim 1, wherein the pokers (22) are arranged in groups, each group being arranged to be vibrated by a respective vibrator (31).

4. Apparatus according to claim 2 wherein each of the pokers (22) has a respective vibrator (31) associated with it for causing bodily vibration of the poker (22) relative to the carrier (15).

5. Apparatus according to claim 4, wherein each of the pokers (22) houses the associated vibrator (31) within it.

6. Apparatus according to any preceding claim, wherein each of the pokers (22) is tapered at least over a lower part of its lenght so that it has a decreasing cross-section proceeding downwardly over said lower part to its lower end.

7. Apparatus according to claim 6, wherein each of said pokers (22) is conical over at least said lower part.

8. Apparatus according to any one of claims 1 to 5, wherein each of said pokers is tapered over a lower part (23) of its length so that it has a decreasing cross-section proceeding downwardly over said lower part to its lower end and is also tapered over an upper part (24) of its length from the junction with said lower part so that its cross-section also decreases upwardly from said junction.

9. Apparatus according to claim 8, wherein each of the pokers is of double conical form with the bases of the cones conjoined.

10. Apparatus according to any preceding claim, wherein the pokers (22) are arranged in a plurality of side-by-side rows with the pokers (22) in one row staggered in position along the row with respect to the pokers in another row. (Fig. 3)

11. A method of compacting granular insulating material in the annular space between an inner shell and an outer wall of a storage tank utilising an apparatus comprising a carrier, means for moving the carrier around the annular space and for varying the height of the carrier within the annular space, and a plurality of elongated pokers sup-

ported by and depending from the carrier, the method comprising carrying out a cycle of operations consisting of lowering the carrier to immerse the pokers into the granular material for effecting a settling or compacting of the granular material, raising the carrier to withdraw the pokers from the granular material and moving the carrier around the annular space with the pokers withdrawn from the granular material and then repeating the cycle a plurality of times.

12. A method according to claim 11, wherein in a cycle of operation of the apparatus granular material is fed into the annular space, a plurality of said cycles of operation carried out at a first level of the carrier, further granular material added in stages and a plurality of said cycles of operation carried out at increasingly higher levels between additions of granular material.

13. A method according to claim 11 or 12 wherein the pokers are individually vibrated at least when they are immersed in the granular material.

14. A method according to any one of claims 11 to 13, wherein the pokers are disposed on the carrier so that they extend in at least two rows spaced from each other across the width of the annular space the pokers in each row extending around the annular space.

15. A method according to any one of claims 11 to 14, wherein each poker is tapered at least over a lower part so that it has a decreasing cross-section proceeding downwardly over said lower part to its lower end, and the height of said carrier is so controlled that the pokers normally only become immersed in the granular material over their tapered part.

16. A method according to any one of claims 11 to 14, wherein each poker is tapered over a lower part so that it has a decreasing cross-section proceeding downwardly over said lower part to its lower end and is also tapered over an upper part of its length from the junction with said lower part so that its cross-section also decreases upwardly from said junction, and the height of said carrier is so controlled that the pokers normally only become immersed in the granular material over their lower tapered part.

17. A method according to any of claims 11 to 16, wherein the carrier is suspended by cables from a hoist which runs around the annular space and the movement of the carrier around the annular space is guided by brushes which are mounted on the carrier and engage the external surface of the inner shell and the inner surface of the outer wall of the storage tank.

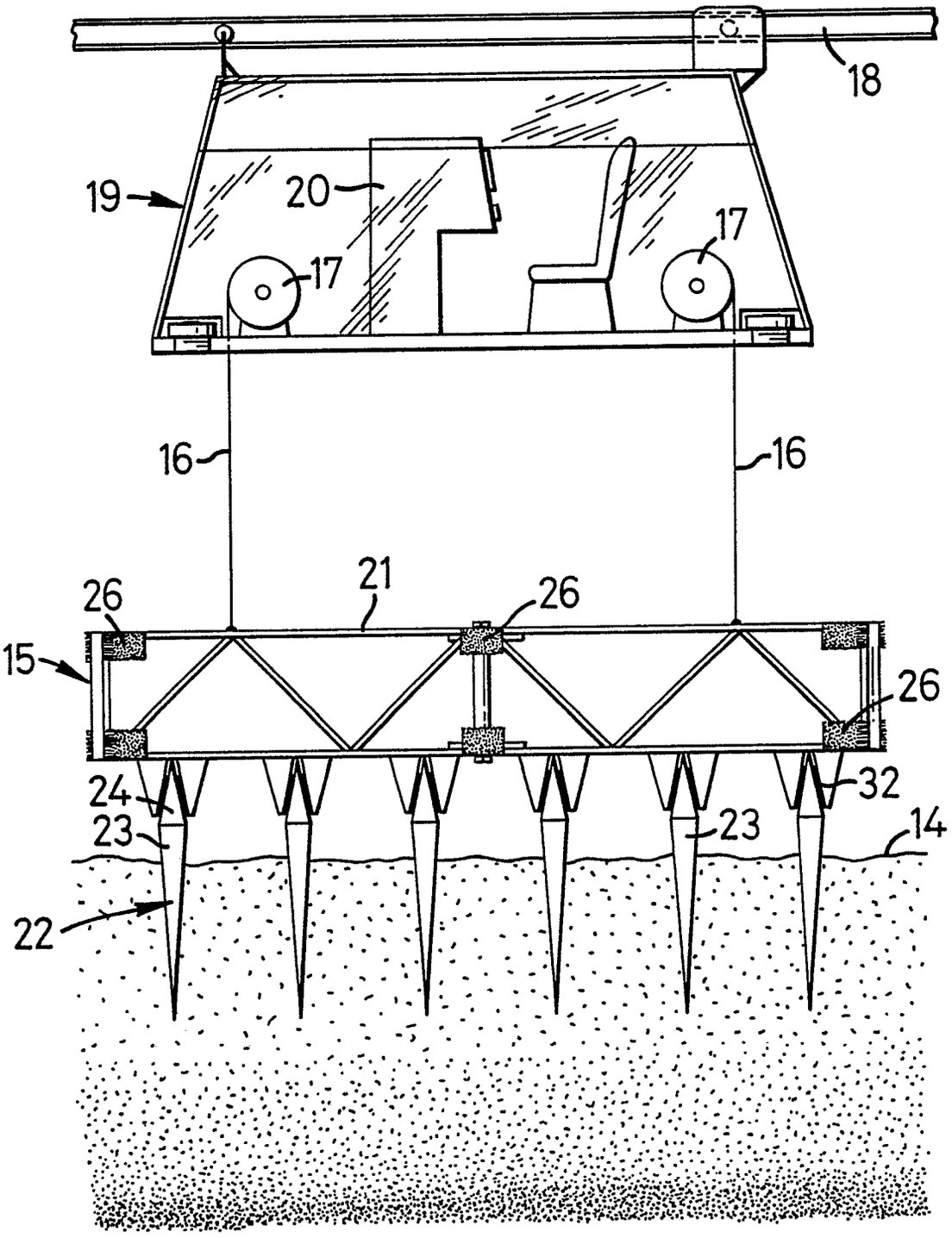

FIG.1

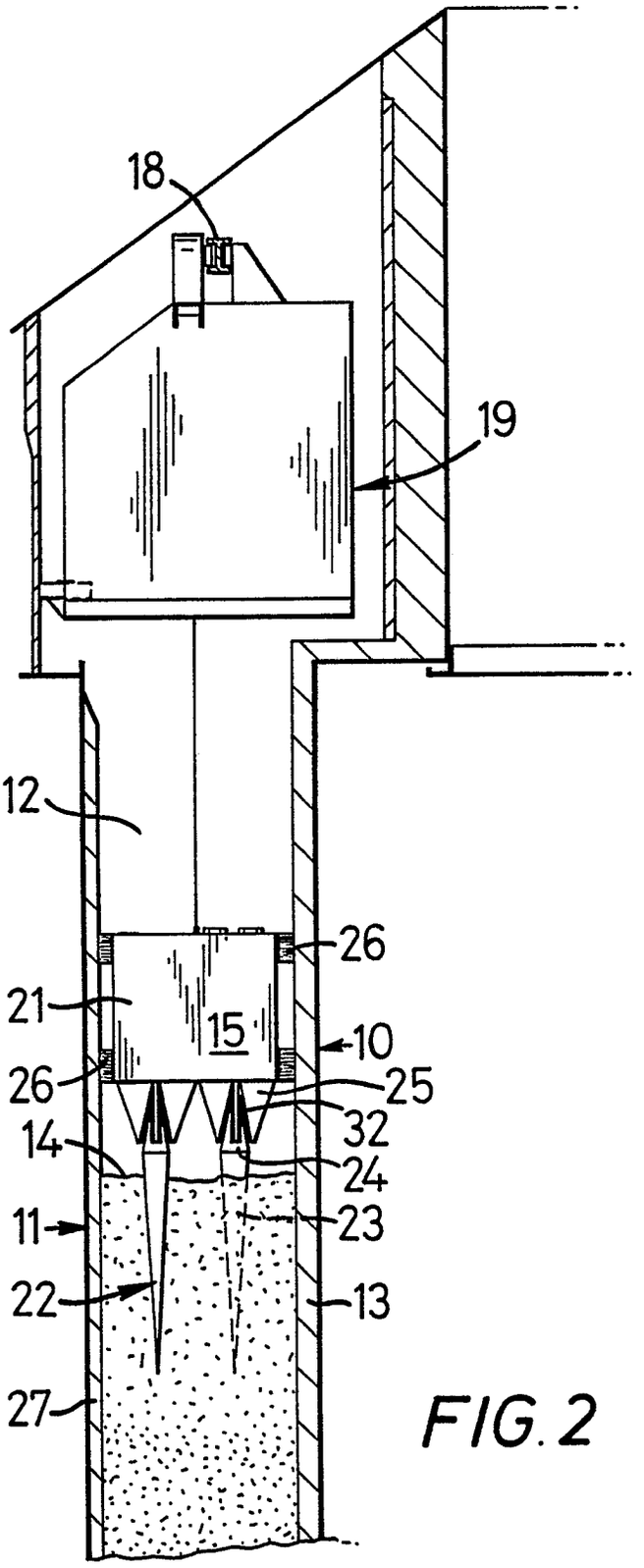

FIG. 2

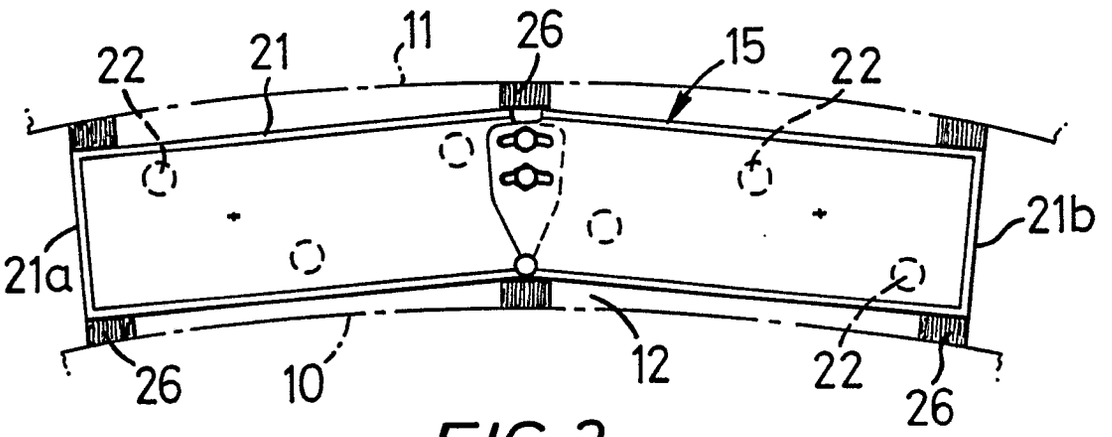

FIG. 3

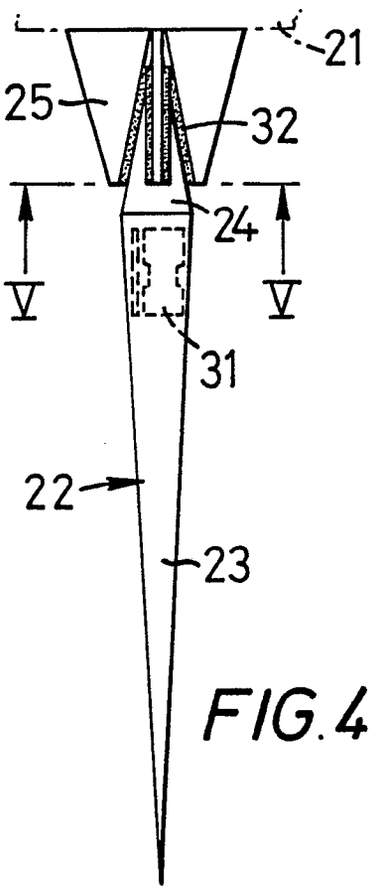

FIG. 4

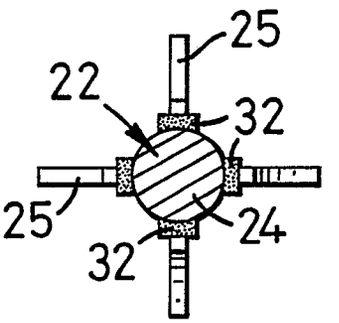

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 30 2723

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	FR-A-2 065 776 (CARBONISATION ET CHARBONS ACTIFS) * Page 1, lines 10-16,35-38; page 2, lines 1-23; page 4, lines 1-2; page 4, line 21 - page 5, line 24; page 7, line 23 - page 8, line 10; claim 1; figure 2 *	1,2,4, 11,12	F 17 C 13/00
A	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 20 (M-188)[1165], 26th January 1983; & JP-A-57 173 697 (TOOYOO KANETSU K.K.) 26-10-1982	1,2,4, 11-14, 17	
A	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 20 (M-188)[1165], 26th January 1983; & JP-A-57 173 698 (TOOYOO KANETSU K.K.) 26-10-1982	1,2,4, 11-14, 17	
A	PATENT ABSTRACTS OF JAPAN, vol. 11, no. 54 (M-563)[2501], 19th February 1987; & JP-A-61 215 899 (TOYO KANETSU K.K.) 25-09-1986	1,2,4, 11-14, 17	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 42 (M-359)[1765], 22nd February 1985; & JP-A-59 183 194 (MITSUI KENSETSU K.K.) 18-10-1984	1,2,4, 11-14, 17	F 17 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14-08-1989	MARZENKE J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

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)