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

(11) EP 3 112 585 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.01.2017 Bulletin 2017/01

(51) Int Cl.:
E21D 11/00 *(2006.01)* ***E21D 11/10*** *(2006.01)*

(21) Application number: **15174809.2**

(22) Date of filing: **01.07.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(71) Applicant: **Great Ocean Constructions Ltd**
London N1 6TX (GB)

(72) Inventors:
- **HUME, Luke**
  London E8 4DW (GB)
- **HUME, David**
  Melbourne, Victoria 3124 (AU)

(74) Representative: **Persson, Albin**
Hansson Thyresson Patentbyra AB
Box 73
201 20 Malmö (SE)

(54) A TUNNELING MACHINERY AND A METHOD OF PROVIDING A CONCRETE TUNNEL BASE

(57) A device for pouring concrete in a bottom section of a tunnel enclosed in a tunnel lining, comprising a pouring platform , a concrete receiving and pumping platform (18), a plurality of trailers (40) arranged in a row between said placing platform and said concrete receiving and pumping platform (18). Each trailer (40) comprises a support (46) for a concrete pipeline (22) extending from the concrete receiving, pumping platform (18) to the pouring platform, wherein said concrete receiving and pumping platform (18), said trailers (40) and said placing platform are connected to each other to form a train (10) and are supported by wheels engaging said tunnel lining. Propelling means are arranged to propel said train with said placing platform leading.

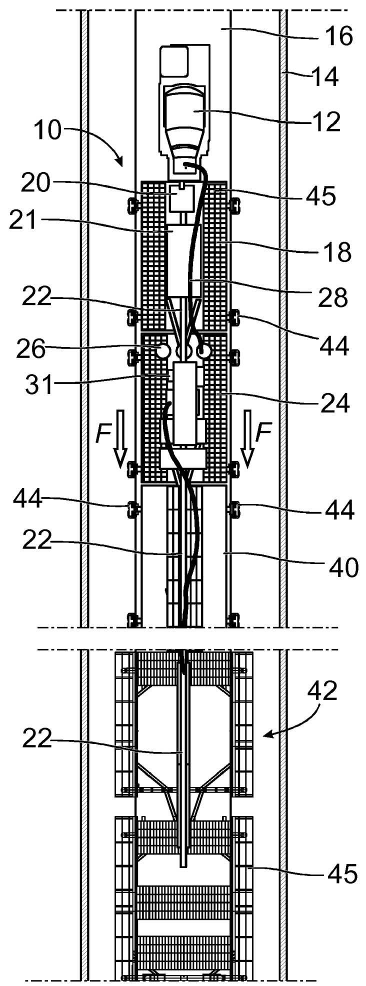

Fig. 1

EP 3 112 585 A1

Description

TECHNICAL FIELD

[0001] The invention relates to a method and a device for placing concrete in a bottom section of a tunnel enclosed in a tunnel lining, comprising a placement and finishing platform.

PRIOR ART

[0002] Different methods and machines are used for the construction of tunnels. A commonly used type of machine is a tunnel boring machine (TBM). A TBM normally has a circular cutting head that is used to excavate material, which is then transported away from the cutting head on conveyors. After excavating the tunnel profile for a given length of tunnel (an advance) a ring comprising of several segments is installed, thus creating a permanent tunnel lining. The tunnel lining is required to retain ground and water pressure and to provide an internal surface appropriate to the function of the tunnel. In many tunnels, the bottom (invert) is then filled with concrete to provide a base. This may be to form a roadway, or support rail for a train. Concrete is delivered to the workface using several different methods including; concrete truck or remixer, pipeline, skips, conveyors and dump trucks. The direction of placement is usually towards the source of supply. This may be a tunnel portal, shaft or cross passage. In other words, if concrete is being supplied from one end of the tunnel, the concrete placement and thus invert forming would commence at the opposite end of the tunnel and the pour(s) would progress towards the end where the concrete is being supplied.

[0003] In long tunnels there are numerous problems relating to transporting the concrete to the location of placement. Normally, concrete trucks travel through in the invert yet to be set up. Such traveling prevents complete preparation of the pour area .This includes but is not limited to -segment cleaning, crack repairs, invert drainage, catch pit, crack inducer and UTX installation, and the installation of any other cast-in items.

SUMMARY OF THE INVENTION

[0004] In accordance with the invention, concrete is delivered by re-mixer (agitator) to a pump mounted on a platform. It is then pumped along a pipeline supported on a plurality of platforms and trailers to a placement platform where it is discharged into the invert through a flexible hose and processed by a finishing platform to form a finished base. This series of platforms and trailers forms a train which has an overall length great enough for the concrete to gain sufficient strength to allow transit of the agitator. The pump platform, trailers and the placement and finishing platforms are supported on primary beams which have wheels mounted at an inclined angle (radially) to run on the tunnel lining.

[0005] The primary beams span across the invert, parallel to the plane of the finished base allowing the train to move above the freshly placed concrete. Given that all elements of this train move together, there is no need to alter the length of pipe line as the pour progresses. By continuously moving the system towards the front, forward placement is achieved and the tunnel invert can be placed in the direction away from the source of supply.

[0006] The pouring process can be continuous because the length of the train is sufficient for the concrete to cure before any piece of equipment imparts load on it. The required length of the system is dependent on thestrength gains of the concrete, which is a function of temperature, time and mix design. This strength gain is a limiting factor on a maximum placement speed, however, changes to the mix design can offset these limits. The combination of platforms and trailers is flexible depending on the task required. Given the direction of placement, the invert preparation works can proceed unaffected by the placement operation. The entire invert can be set up prior to placement commencing or in parallel with the placement operation.

[0007] In accordance with the invention concrete is received at a first end of the train (the rear), pumped along different platforms and trailers of the train and then placed and compacted at a second end of the train (the front). The front platform (placement platform) is used to pour and compact the concrete received through the concrete delivery pipeline and to screed the concrete to the correct elevation. A finishing platform behind this, can be used to accurately finish the concrete and apply a retarder and other surface additives. The placement platform comprises a front screed that is able to travel back and forward along a guide rail, independently of the train. This front screed or primary screed is lowered to a starting position and then moved forward a predetermined distance thus completing a first pass. Then the front screed is raised off the concrete and if required, moved back to the starting position and the above step is repeated. Depending on the circumstances, there could be a requirement to do multiple passes until the level is correctly set. However one pass usually is sufficient.

[0008] Depending on the nature of the task, the finishing platform may contain a second screed (re-screed) which is there to make sure the concrete is cast to the exact position. Given that finishing platform is some distance from where the concrete is being discharged, this concrete has stiffened up a little bit by the time the second screed reaches it, and thus a re-screed is effective at correcting any concrete settlement post initial screeding, especially where wet mixes and steep cant's are encountered. This screed can cut and fill the concrete to the exact elevation. As the concrete is a little stiffer here, it will not tend to slump after re-screeding. In various embodiments first and second screed can be moved independently of the train. As a result it is possible to accurately control the screeding speed and the number of passes.

[0009] In various embodiments the elevation of the screeds can be controlled by adjustable screed rails previously installed in the tunnel lining to mark the correct concrete level. The screed may comprise a first screed element and a second screed element. A first screed element is used to smooth the concrete while a second screed element further adjusts the concrete level to near perfection. An alternative to this is a mechanically operated, electronically guided screed which eliminates the need for screed rails and aids to reduce labour requirements. The finishing platform is also used to accurately finish and treat the freshly screeded concrete surface. Operations such as floating and towelling can be undertaken either remotely by using pole or rope operated equipment, or using hand tools working off access platforms suspended above the concrete. Once the required finish is obtained, surface additives such as retarder or curing compounds can be applied using a pressure spray unit connected to a storage tank toward the rear of the train. This retarder is used where an exposed aggregate finish is required. Other alternatives may be dry shake additives and toppings.

[0010] At the rear of the train are platforms containing the necessary equipment and power sources required to operate the system. Included in this is a jet wash, vacuum unit and retarder storage tank needed to achieve a green cut, exposed aggregate finish.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In order that the manner in which the above recited and other advantages and objects of the invention are obtained will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings.

[0012] Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

- Fig. 1 is a schematic plan view of parts of a train for pouring concrete in accordance with the invention,
- Fig. 2 is a schematic side view of the parts shown in Fig. 1,
- Fig. 3 is a schematic side view showing a pouring and screed platform,
- Fig. 4 is a schematic front view of the pouring and screed platform shown in Fig. 3 without concrete pouring means, and;
- Fig. 5 shows schematically a cross beam assembly with wheels that supports platforms and trailers.

DETAILED DESCRIPTION

[0013] In the embodiment shown in Fig. 1 and Fig. 2, a train 10 is located in a tunnel indicated by a tunnel lining 14. The train 10 comprises different platforms and trailers extending through the tunnel from a first outer endto a second inner end. A pump platform 18 is arranged at said first end to receive concrete from a truck 12. The truck 12 can be a dump truck or an agitator and runs on a concrete tunnel base 16 already placed. The truck normally also comprises an agitator for the concrete. Alternatively it can be a dump truck. In various embodiments a separate agitator is arranged on the pump platform 18. The pump platform 18 comprises a concrete receptacle or hopper 20 and pump 21 and a first section of a concrete pipeline 22. The concrete pipeline 22 extends over the complete train 10 and has enough articulation within its joints to facilitate cornering. The pump platform 18 also serves as a work platform for operators and access passage for various operatives.

[0014] In the train 10, the pump platform 18 is followed by at least one machinery deck 24. The machinery deck(s) 24 contains slurry tanks 26 for wastewater and solids generated by jet washing. Slurry from the slurry tanks 26 is pumped through a slurry return hose 28 back to an empty dump truck 12 tanker or an agitator. The machinery deck 24 further contains a heavy duty vacuum unit 30 and a jet wash unit 31 used for concrete green cutting. The heavy duty vacuum unit 30 is used for recovering waste water and solids from the green cutting process. The jet wash unit is used to provide an exposed aggregate finish and also to keep the machinery clean. Tanks 32 supply fluids to the second end of the train through pipelines running along platforms and trailers. These fluids may include curing compounds and retarders

[0015] In the embodiment shown in Fig. 1 and Fig. 2 the machinery deck 24 also is provided with a compressor 34 to run pneumatic equipment on the train and a generator 36 for power supply. In various embodiments power and air is supplied via tunnel mains system. A jet fan 38 can be arranged to provide on board ventilation. This can be used to supply additional ventilation should fumes accumulate. The machinery decks also provide for storage of tools, spare parts and workshop equipment. In various embodiments, a work bench and welding gear can be provided to enable on site fitting and repairs to take place to ensure the trains operation is continuous

[0016] In the train 10 the machinery deck 24 is followed by at least one trailer 40. The necessary length required for the concrete to gain sufficient strength to allow transit of the agitator and other such equipment, determines the number of trailers 40. The trailers 40 support the concrete pipeline 22 and also other pipelines and lines for compressed air, power, retarder, curing compound, and water.

[0017] The second inner end (the front) of the train 10 comprises a finishing platform 42A and a placement platform 42B. The placement platform 42B provides access for placement and compaction of the fresh concrete to fill a tunnel invert 17. Concrete is discharged through a flexible hose suspended from an overhead boom and compacted with immersion vibrators. The working decks also enable the primary screed to be operated to give an initial concrete elevation. In various embodiments the placement platform 42B and the finishing platform 42A are combined to a placement platform 42. All platforms and trailers are provided with wheels 44 arranged on cross beam assemblies, c.f. Fig. 5. It should be noted that wheels 44 are excluded in Fig. 2 for clarity reasons. The train 10 normally moves in the direction of arrow F during placement. It can however, be reversed at any time. This is often done after completion of pours, but may be needed if a problem is encountered during a pour.

[0018] Each platform has a length of 3-7 meters and each trailer 40 has a length of 8-12 meters. Using five trailers 40 the total length of the train 10 would be 80-100 meters. The train is driven forward at a typical speed of 5 meters per hour. As a result more than 120 meters of tunnel invert slab can be produced each 24 hours. The total length of the train and the speed of the train will ensure that the concrete is sufficiently cured when any equipment imparts load on the newly placed concrete. Significant increases in speed can be achieved through improving concrete supply speeds and through altering the mix design.

[0019] Fig. 3 and Fig. 4 show further details of the placement and finishing platform 42. The concrete pipeline 22 extends from a lower position over a pipeline support 46 and connects at an elevated position to a discharge hose 48. The pipeline support 46 can be a gooseneck. The elevated position enables manageable handling of the discharge hose 48 and allows a clear working space for operators to screed and to correctly finish the concrete. The pipeline support 46 can be a frame or similar device arranged on the finishing platform 42A.

[0020] In the embodiment shown in Fig. 3 and Fig. 4 the placement and finishing platform 42 comprises a front or primary screed 50 provided for primary levelling and a secondary rear screed or re-screed 52 provided for precise levelling. Said primary screed 50 and said rear screed 52 comprise height adjusting means for accurate setting of vertical position.In the very front section of placement platform 42B two winches 54 are securely attached. From each winch a winch wire or rope 56 extends into the tunnel where it is attached to the tunnel lining. The winches 54 operate together with the ropes 56 as the propelling means for the train. By driving the winches continuously the train can be moved at constant speed. The winches 54 are connected to the compressor 34 by air pipes extending along the train. In various embodiments the winches are connected to electrical motors. Another embodiment uses driven wheels to control the movement of the train.Hand winches are carried on board in case of breakdowns.

[0021] In operation each screed in a first step is moved to and lowered to a starting position. Then in a second step the screed is moved forward to an end position to complete one pass. The primary screed 50 operates between starting position A and end position B, while rear screed operates between starting position C and end position D. The screeds 50, 52 comprise a blade that acts as a straight edge to cut the fresh concrete to the correct profile, an auger that distributes the concrete evenly along its length and a float that leaves a smooth flat finish. In addition the screed may vibrate to aid in compaction. Each screed is supported by a pair of vertically mounted hydraulic rams 58 which extend and retract to control the screed's vertical position throughout the pass. The extension of each ram and hence vertical position of the screed, is electronically controlled through a receiver 62 which receives a signal from a static Total Station (or similar device) 63, c.f. Fig. 6, providing a constant reference to the required elevation of the concrete at that exact chainage or point in space. The Total Station is typically set up in front of the train and requires the input of existing tunnel survey control points to establish its position. The survey control points can be prism reflectors 65,

[0022] Both hydraulic rams 58 are connected to a headstock that is mounted within a rack or guiding channel 60 which extends between guide channel supports or posts 64. A chain or hydraulic drive acts to move the screed horizontally backwards and forwards. The distance between position A and position B is around 3 meters, such as between 2 and 4 meters. In various embodiments said distance is approximately 2.4 meters.

[0023] The primary screed 50 is then raised off the concrete and moved back to starting position A for repeating the first step. Depending on different conditions such as water content of concrete multiple passes may be required to obtain the correct elevation of the base. The concrete preferably is flowable to facilitate pumping from the pump platform forward to the pouring platform through the concrete pipeline. After first screeding the concrete can slump or shift, especially when there is a significant cross fall or cant on the slab.

[0024] The rear screed 52 is operated in a similar manner to avoid problems of the concrete level and to get a very accurate position of the tunnel base 16. Normally, the concrete will have stiffened up when the rear screed 52 cuts and fills the concrete to the desired level. Also the rear screed 52 may require two or more passes.The rear screed 52 moves in a horizontal direction between position C and position D.

[0025] When the fresh concrete is placed by the operatives, it is left slightly high of the finished elevation so that the primary screed can strike off the excess. This excess will be pushed forward into the invert ahead. Men may be required to rake the concrete to position ahead of this screed. Given that the secondary screed acts only to finely adjust the already screeded concrete should it have shifted, it does not tend to produce an excess but instead, redistributes it to the correct elevation along the screed beam. To this end, the direction of the auger on the screed can be reversed to help bring the concrete back up the slope where steep cants are encountered

[0026] The backwards and forwards motion of primary screed 50 and rear screed or re-screed 52 can be provided by a chain drive, hydraulic ram (not shown) or a similar device. This allows very accurate control of the screeding speed. The screeding speed also will be independent from the speed of the train 10.Using the motion of the train is a little less accurate. In various embodiments the screeds are set to a fixed position on the train 10 and the train movement will provide the screeding operation. At least one of front or primary screed 50 and rear screed or re-screed 52 can be vibrating.

[0027] Fig. 6 illustrates that the Total Station 63 is arranged ahead of the train. A pair of Total Stations can be used when using two screeds. These Total Stations need to be moved and re-set up periodically as the train progresses along the tunnel. Given that the elevation of the concrete may vary throughout the pass, the rams are constantly receiving information to make minor adjustments and allow the screeds to be precisely adjusted to the correct elevation as indicated at arrow V. A manual override is provided as well

[0028] In various embodiments the screed platform comprises manually operated front or primary screed and rear screed or re-screed that move on screed rails previously installed on the tunnel lining to mark the correct concrete level. Two hand winches are welded on posts on both the placement and finishing platform for moving the screeds.

[0029] The above described screeds are used as straightedges that are winched or moved along to accurately strike off the concrete. In alternative embodiments roller strikes or twin beam screeds are used. In various embodiments one screed, preferably the rear screed 52, is maintained at a lowered position when the train is moved for leading the concrete level. The platforms and trailers are provided with access decks 45 along sides for operatives to walk to different sections of the train and to have a safe working place.

[0030] Fig. 4 shows schematically the arrangement with inclined wheels 44 supported by a primary beam 66. The inclination a between the rotation plane of the wheels 44 and a vertical axel is about 52 degrees. However, the inclination is determined by the length of the primary beam 66, the inner diameter of the tunnel lining 14, the expected height of the tunnel base and the desired height of the train above the finished concrete. In various embodiments this angle can be adjusted as can the length of the primary beam to allow the train to operate in various tunnel diameters. In the embodiment shown in Fig. 4 the primary beam 66 has a cut off angled end to provide a support for end plates 68 that will support the wheels 44. In all cases, the wheels run radially.

[0031] In various embodiments the invention comprises a device that contains facilities to enable a variety of concrete finishes to be achieved ranging from steel trowelled and exposed aggregate. The device can also remove all wastewater caused by the greencutting process. A range of toppings and curing compounds can also be stored on the train in order to obtain the desired finish.

[0032] While certain illustrative embodiments of the invention have been described in particularity, it will be understood that various other modifications will be readily apparent to those skilled in the art without departing from the scope and spirit of the invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description set forth herein but rather that the claims be construed as encompassing all equivalents of the present invention which are apparent to those skilled in the art to which the invention pertains.

Claims

1. A device for placing concrete in a bottom section of a tunnel enclosed in a tunnel lining, comprising a placement and finishing platform,
   characterised by
   a concrete receiving and pumping platform,
   a plurality of trailers arranged in a row between said pouring platform and said concrete receiving and pumping platform, each trailer comprising a support for a concrete pipeline extending from the concrete receiving and pumping platform to the pouring platform, wherein said concrete receiving and pumping platform, said trailers and said pouring platform are connected to each other to form a train and are supported by wheels engaging said tunnel lining, and propelling means arranged to propel said train with said pouring platform leading.

2. A device as claimed in claim 1, wherein said pouring platform comprises a primary screed and a rear screed, said primary screed and said rear screed comprising height adjusting means and horizontal guiding means.

3. A device as claimed in claim 1, whereinsaid primary screed and said rear screed are independently movable in a horizontal direction.

4. A device as claimed in claim 3, wherein said primary screed and said rear screed are connected to drives for movement in a horizontal direction.

5. A device as claimed in claim 1, wherein said height adjusting means comprise anelectronic device for sensing a predefined vertical position.

6. A device as claimed in claim 1, wherein said propelling means comprise at least one winch arranged on said pouring platform for pulling said train.

7. A device as claimed in claim 1, wherein the total length of the train is at least 50 meters.

8. A device as claimed in claim 1, wherein said concrete receiving and pumping platform, said trailers and said pouring platform comprise access desks for walking and working along said train.

9. A method for pouring concrete in a bottom section of a tunnel enclosed in a tunnel lining, **characterised by** receiving concrete in a concrete receiving and pumping platform,pumping said concrete from said receiving and pumping platform along a plurality of trailers to a placing platform, wherein said concrete receiving and pumping platform, said trailers and said placing platform are connected to each other to form a train, placing concrete from said placing platform to a tunnel invert of said tunnel, and advancing said train with said placing platform leading.

10. A method as claimed in claim 9, comprising individually operating a height adjustable primary screed and a height adjustable rear screed back and forth along said pouring platform in a horizontal plane, so as to cast the concrete to the correct elevation.

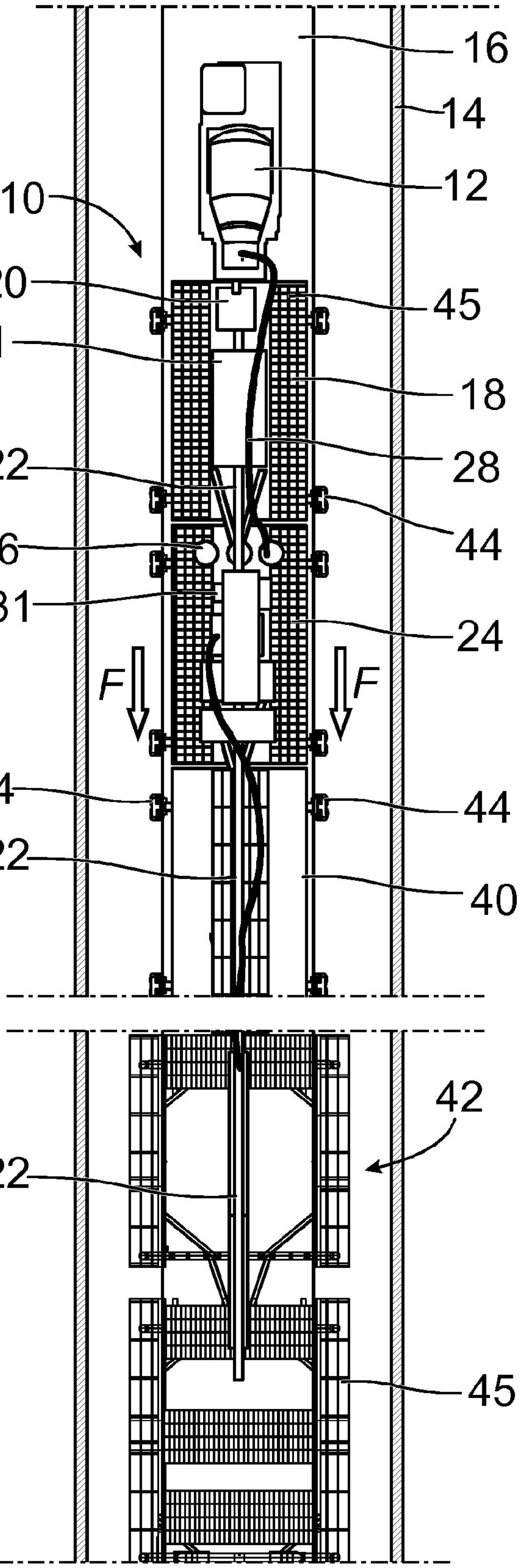
16
14
10
12
20
45
21
18
22
28
44
26
31
24
F
F
44
44
22
40
42
22
45

Fig. 1

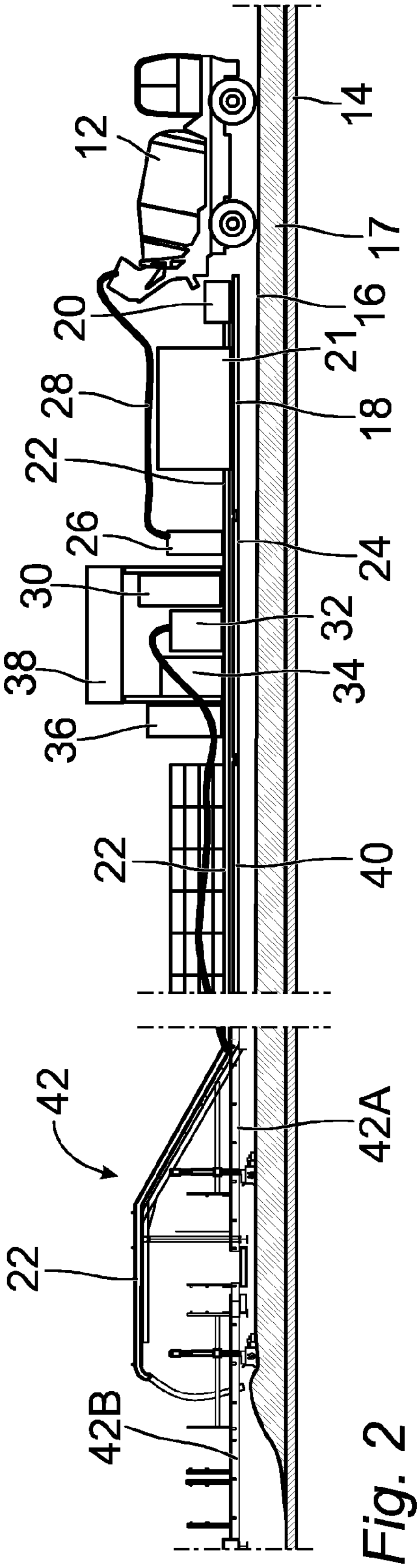
14
12
17
20
16
21
28
18
22
26
24
30
32
38
34
36
22
40
42
42A
22
42B

Fig. 2

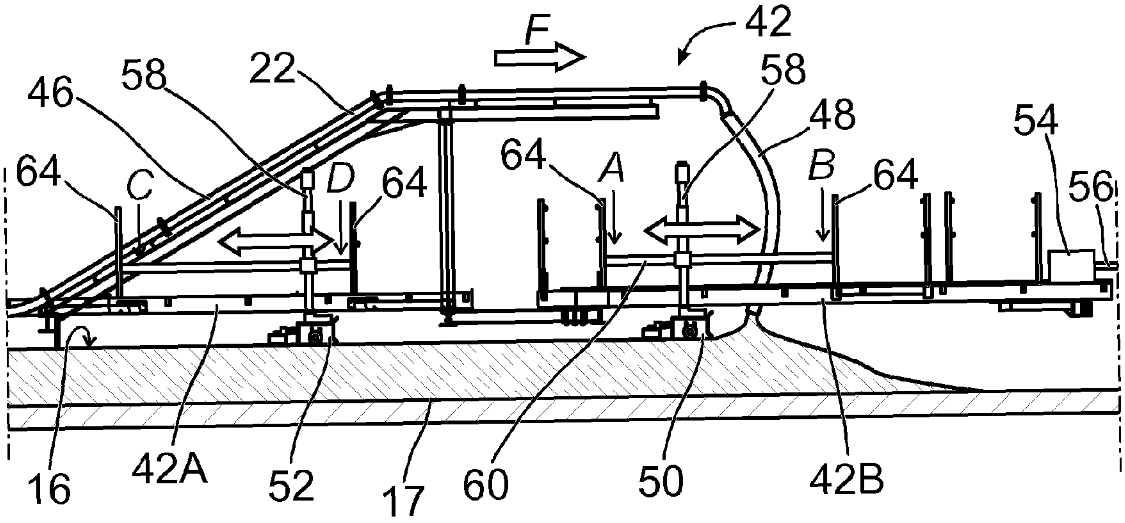
F
42
22
58
46
58
48
54
64
C
D
64
64
A
B
64
56
16
42A
52
17
60
50
42B

Fig. 3

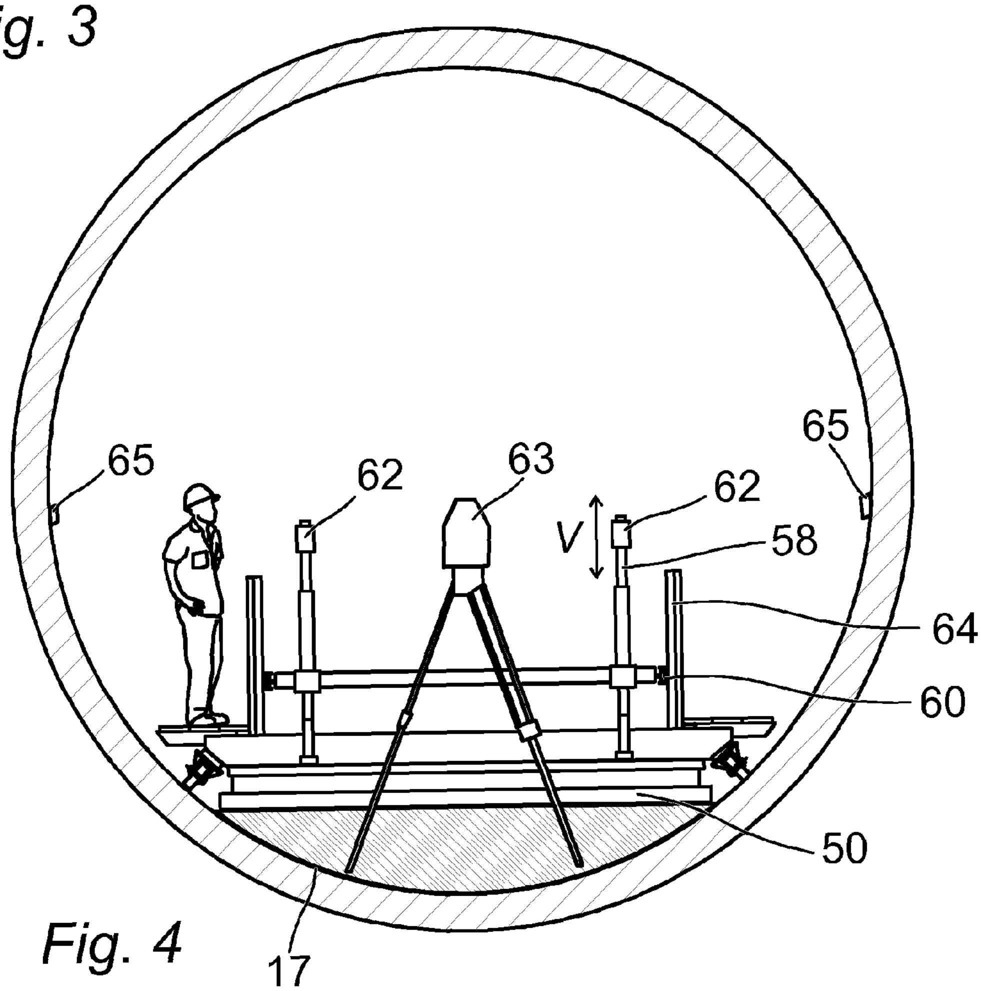
65
63
65
62
62
V
58
64
60
50
17

Fig. 4

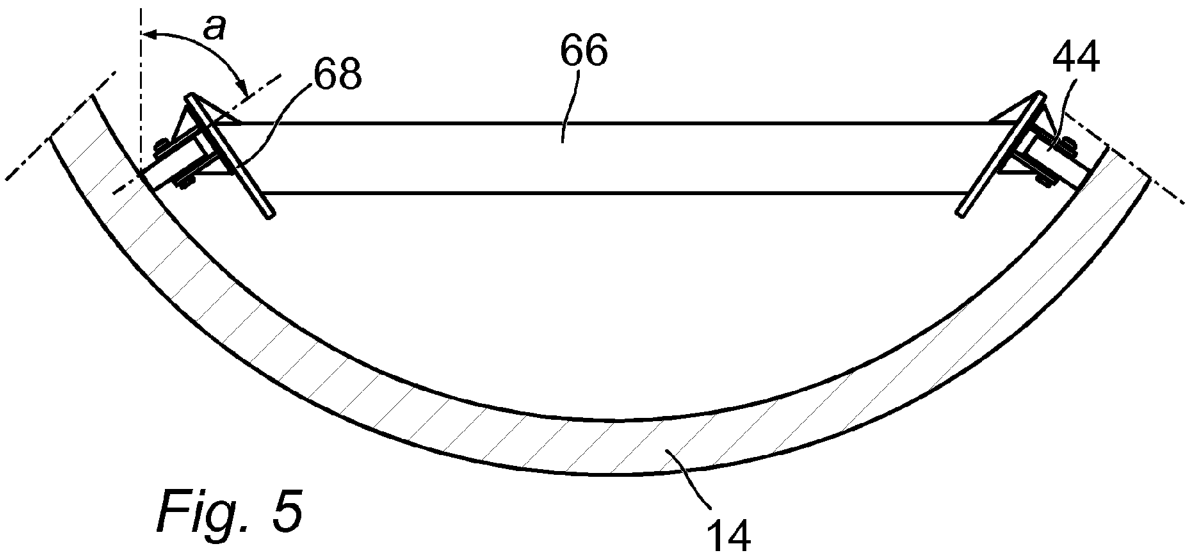

Fig. 5

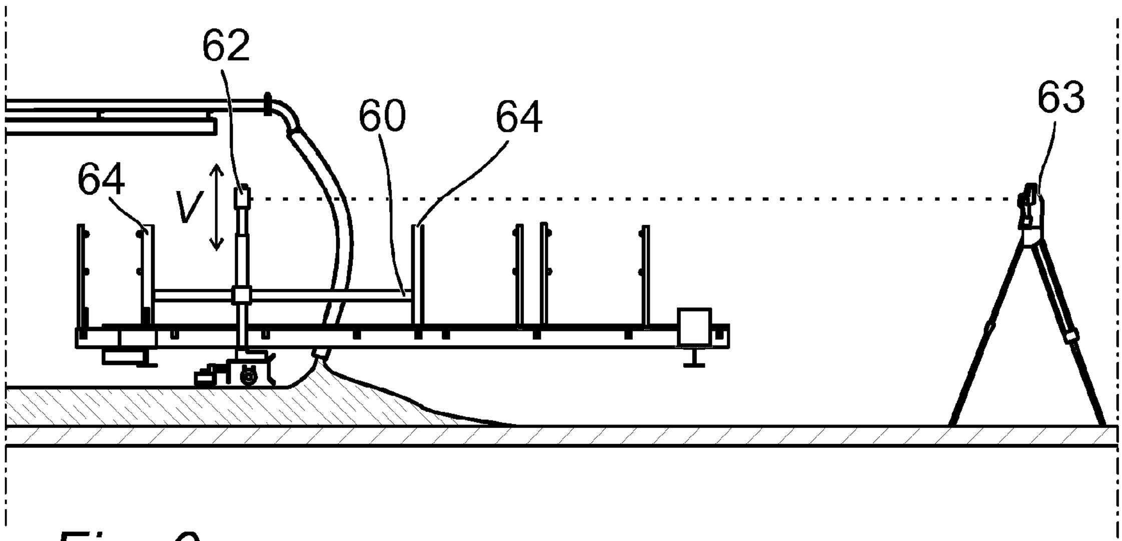

Fig. 6

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 15 17 4809

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2014 080809 A (KAJIMA CORP; GIFU KOGYO CO LTD) 8 May 2014 (2014-05-08) * the whole document * -----	1-10	INV. E21D11/00 E21D11/10
A	JP 2009 127230 A (OKUMURA CORP) 11 June 2009 (2009-06-11) * the whole document * -----	1-10	
A	US 4 706 317 A (HORSTKETTER EUGENE A [US]) 17 November 1987 (1987-11-17) * the whole document * -----	1-10	
A	US 2 429 045 A (BELLOWS KENNETH C) 14 October 1947 (1947-10-14) * the whole document * -----	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

E21D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	3 December 2015	Manolache, Iustin

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 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 17 4809

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-12-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2014080809 A	08-05-2014	NONE	
JP 2009127230 A	11-06-2009	JP 4931777 B2	16-05-2012
		JP 2009127230 A	11-06-2009
US 4706317 A	17-11-1987	NONE	
US 2429045 A	14-10-1947	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82