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(54) SCAFFOLDING BRIDGE POSITIONABLE IN A TUNNEL TO ALLOW TO BE PROCESSED AS WELL AS A METHOD OF PROCESSING A TUNNEL

(57) Scaffolding bridge which can be positioned in a tunnel (**G**) with an inverted arch (**R**) so as to allow its construction having a rear access portion (**11**), and a front access portion (**12**) and at least one operative area (**13**) interposed between the latter which includes support means (**20**) adapted to interact with the inverted arch (**R**) of the tunnel (**G**) to support the scaffolding bridge (**1**). The scaffolding bridge further comprises a walkway (**130**) configured and or dimensioned to support heavy-duty vehicles and to allow the passage thereof even during the construction operations carried out on the inverted arch (**R**).

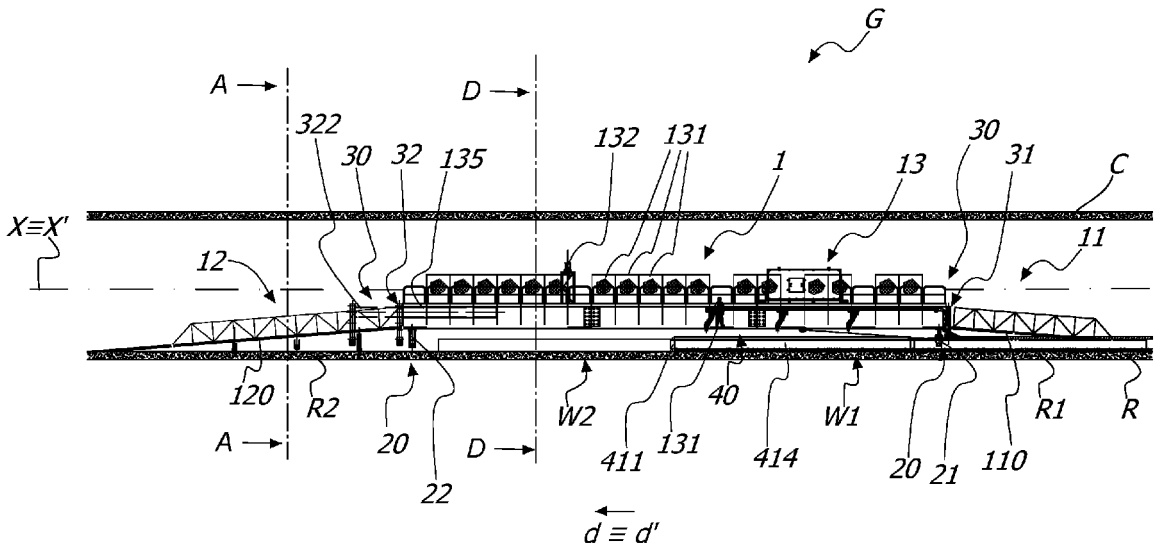

FIG. 1

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Description

Field of the invention

[0001] The present invention generally relates to the field of large infrastructures and it particularly relates to a scaffolding bridge which can be positioned in a tunnel to allow its construction, as well as a method for constructing a tunnel.

Definitions

[0002] In the present document, with the expression "inverted arch" and derivatives reference will be made to the overturned arch arranged at the base of a tunnel which has the function of closing the arch already made in the roof, distributing the mechanical stresses thereof.

[0003] In the present document, with the expression *"invert"* and derivatives reference will be made to a portion made of concrete, cement or the like which is obtained at the inverted arch in a tunnel and which acts as a base for the road or railway.

State of the Art

[0004] Generally, parallel to tunnel excavation works, therefore there arises the need to carry out operations for reinforcing the internal structure of the latter for example by means of the per se known lining, the dome with prefabricated ashlars or the like. Subsequently, whether the tunnel is a road or railway tunnel, service pipes or iron rods are laid on the inverted arch for reinforcement.

[0005] During such construction, the passage of the vehicles required for excavation and for carrying out the inner lining of the tunnel and possibly also of the emergency vehicles normally occurs through the inverted arch portion, which, as a result, is occupied throughout the time required to complete the operations mentioned above and therefore which cannot be constructed.

[0006] Therefore, the construction of the invert by casting cement or concrete along the entire inverted arch portion of the tunnel is carried out only once through with the excavation works, the dome reinforcement operations and the operations for laying the pipes and iron rods on the inverted arch.

[0007] Therefore, this results in a dilatation of the tunnel construction times, therefore resulting in a significant waste of time and financial resources.

[0008] Furthermore, during the construction of the invert, the construction vehicles and emergency vehicles must necessarily access from one or the other end, therefore resulting - on the one hand - in an increase in the times and costs and - on the other - in an increase of the rescue times in case of need.

Summary of the invention

[0009] An object of the present invention to provide a scaffolding bridge which can be positioned in a tunnel so as to allow its construction that is highly efficient and cost-effective.

[0010] Another object of the present invention is to provide a scaffolding bridge which can be positioned in a tunnel capable of quickening the construction thereof.

[0011] Another object of the present invention is to provide a scaffolding bridge which can be positioned in a tunnel which allows the passage of heavy-duty or emergency vehicles even during the construction of the inverted arch.

[0012] A further object of the present invention is to provide a method for constructing a tunnel that is particularly easy.

[0013] A further object of the present invention is to provide a method for constructing a tunnel that is easy to implement.

[0014] A further object of the present invention is to provide a method for constructing a tunnel that is markedly beneficial from a financial and construction point of view.

[0015] These and other objects that will be more apparent hereinafter, are attained by an scaffolding bridge and/or method for constructing a tunnel as described, illustrated and/or claimed herein.

[0016] The dependent claims describe advantageous embodiments of the invention.

Brief description of the drawings

[0017] Further characteristics and advantages of the invention will be more apparent in the light of the detailed description of the main embodiments, shown by way of non-limiting example with reference to the attached drawings, wherein:

FIG. 1 is a lateral view of a scaffolding bridge **1** positioned in a tunnel, while **FIGS. 1A** and **1B** show enlarged views of some details of the scaffolding bridge **1** in which there is respectively shown a front access portion **12** and a rear access portion **11** of the scaffolding bridge **1;**

FIGS. 2A and **2B** show two top views of the scaffolding bridge **1:** in the first, the decks **131** are in closed position to provide the walkway **130,** while in the second only some decks **131** are in closed position;

FIG.3 is a cross-sectional view along plane A-A of **FIG. 1;**

FIG.4 is a cross-sectional view along plane B-B of **FIG. 1A;**

FIG.5 is a cross-sectional view along plane C-C of **FIG. 1A;**

FIG.6 is a cross-sectional view along plane D-D of **FIG. 1;**

FIGS.7A and **7B** are cross-sectional views along plane E-E of **FIG. 1B,** with respectively the containment frame **41** in distal position and in proximal position.

Detailed description of some preferred embodiments

[0018] With reference to the aforementioned figures, herein described is a scaffolding bridge **1** which can be positioned in a tunnel **G,** for example a road or railway tunnel, and which can be moved in the latter to allow its construction.

[0019] As known, the tunnel **G** may have an inner section that is substantially circular and therefore a cylindrical development which extends from the entrance of the tunnel up to the excavation area, if any, so as to identify an extension axis **X.**

[0020] Although in the present description reference will be made to a tunnel **G** generally having a longitudinal extension, the tunnel **G** may possibly have curves or different heights: in this case, the reasoning below may be applied in these areas in an entirely equivalent manner.

[0021] As known, the tunnel **G** may have an upper roof portion **C** and a lower inverted arch portion **R.**

[0022] The same roof **C** and inverted arch **R** portions may be continuous along the entire length of the tunnel **G** and arranged facing each other.

[0023] During the construction of the *invert,* the inverted arch **R** may therefore have ab constructed area **R1,** and therefore provided with the *invert,* and an area to be constructed **R2,** and therefore without the *invert,* subsequent to the former, so as to identify a works advancement direction **d'** oriented from **R1** to **R2.** Generally, such works direction **d'** may coincide with the extension axis **X** of the tunnel.

[0024] The areas **R1** and **R2** may have two different heights, given that the area **R1,** provided with *invert,* will have a thickness greater than the area **R2,** without *invert* instead.

[0025] Although in the present description particular reference will be made to an area **R1** and an area **R2** subsequent to the latter, it is clear that the tunnel **G** may also have multiple areas **R1** and multiple areas **R2,** without departing from the scope of protection of the attached claims.

[0026] Generally, the scaffolding bridge **1** may have a longitudinal extension along the axis **X',** as shown in **FIGS. 1, 2A** and **2B.**

[0027] During use, the scaffolding bridge **1** may be positioned in the tunnel so that its axis **X'** is substantially coincident with the extension axis **X** of the tunnel **G.**

[0028] The scaffolding bridge **1** may include a rear access portion **11** and a front access portion **12** arranged along the axis **X'** and designed to rest, during use, respectively on the area **R1** and on the area **R2.**

[0029] The latter may actually guarantee a safe and stable support to the scaffolding bridge **1** during use.

[0030] In order to guarantee the support and anchoring of the scaffolding bridge **1** during the construction operations, it may include support means **20** connected to the rear and front access portions **11, 12** to support the scaffolding bridge **1** respectively at the area **R1** and at the area **R2.**

[0031] In a preferred but non-exclusive embodiment, the support means **20** may be in the form of one or more rear support legs **21** connected with the rear portion **11** and resting, during use, on the area **R1** and one or more front support legs **22** integrally connected with the front portion **12** and resting, during use, on the area **R2.**

[0032] Each rear and front support leg **21, 22** may therefore comprise an upper portion **21', 22'** integrally coupled with the respective rear **11** or front **12** portion and a lower portion **21", 22"** designed instead to rest, during use, on the respective area **R1, R2.**

[0033] In order to guarantee a stable support even at the area **R2,** which is curvilinear, each lower portion **22",** and possibly also each lower portion **21"** if need be, may comprise - at the end thereof - appropriate support elements **220",** made of plastic material, such as for example neoprene rubber or the like, so as to adapt to the angular change and the curvilinear configuration of the inverted arch **R** at the area **R2** and possibly at the area **R1.**

[0034] The scaffolding bridge **1** may move step by step along a direction **d.** Such direction may be defined by the sum of the individual advancement pitches.

[0035] Suitably, such direction **d** may substantially coincide with the works direction **d'** so that the scaffolding bridge **1** advancing step by step along **d** allows to construct subsequent sections along **d'.**

[0036] Suitably, there may be provided for appropriate guide means for guiding the movement of the scaffolding bridge **1** so that it advances along the works direction **d'.** In other words, thanks to the guide means, the direction **d** defined by the step-by-step advancement may coincide with the direction **d'.**

[0037] Advantageously, the guide means may be configured to guide the scaffolding bridge **1** even should the tunnel reveal discontinuity and/or have slight bends and/or should it not be symmetrical with respect to the central axis **X.**

[0038] For example, there may be provided for a front crosspiece element **23** which extends transversely to the axis **X'** so as to interact with two lateral sections opposite to the axis **X** of the base surface of the planimetric curve of the inverted arch **R,** for example as shown in FIG. 5.

[0039] In other words, the crosspiece **23** may comprise two curved opposite operative areas each designed to interact with the curved surface of the inverted arch **R** so that the crosspiece **23** is centred with respect to the inverted arch **R.** This may allow to prevent the displacement perpendicular to the axis **X** of the crosspiece **23.**

[0040] In this manner, the crosspiece **23** may guide the advancement pitch **d** of the scaffolding bridge so that the latter is along the works direction **d'.**

[0041] Possibly, the walkway **130** and/or the portion

13 may be operatively connected with the crosspiece **23** so as to allow the transversal displacement of the axis **X'** with respect to the crosspiece **23.**

[0042] To this end, there may be provided for appropriate adjustment means **24,for** example in the form of one or more oil-hydraulic cylinders.

[0043] This characteristic may allow to operate precisely, for example precisely follow the desired works direction **d',** even should the tunnel not be perfectly symmetrical and/or should the inverted arch be slightly uneven.

[0044] Furthermore, the guide means may comprise an element **414** which may interact with the central channel of the area **R2.** Such channel may have an extension defining the axis **X.**

[0045] In this manner, the scaffolding bridge **1** may be guided frontally by means of the crosspiece **23** which prevents the lateral movement, and possibly using means **24** which allow the centring of the scaffolding bridge 1, and at the rear part using the element **414.**

[0046] The element **414** may actually act as a rotary pin. This aspect is particularly clear upon the movement of the means **24.**

[0047] In any case, upon the advancement of the scaffolding bridge 1 it may be guided along the direction d' thanks to the guide means **30.**

[0048] The scaffolding bridge **1** may further include a central operative area **13** interposed between the rear access portion **11** and the front access portion **12.**

[0049] The operative area **13** may further have an extension that is substantially planar along an extension plane π parallel to the median extension plane of the tunnel **G.** Preferably, the axis **X** may be coplanar or parallel to the plane π**.**

[0050] Suitably, the operative area **13** may define a walkway **130.** The operative area **13** may therefore be arranged - in use - facing the inverted arch **R.** The area **13** may have a main extension along the axis **X'.**

[0051] Although in the present description particular reference will be made to the particular case in which the scaffolding bridge has a single central walkway **130,** there may also be present multiple central walkways **130** possibly operatively connected to each other, without departing from the scope of protection of the attached claims.

[0052] In this case, the reasoning below may be applied in an entirely equivalent manner.

[0053] In any case, the walkway **130** may therefore lie on the extension plane π and be suitably configured and/or dimensioned to allow the passage of heavy-duty vehicles, such as for example trucks, multi-service vehicles, concrete mixers or the like, as well as emergency vehicles, such as ambulances or the like.

[0054] In this sense, the walkway **130** will be advantageously walkable.

[0055] To this end, the walkway **130** may comprise one or more decks **131.** For example, should there be multiple decks **131,** the latter may be arranged sequentially to form the walkway **130.**

[0056] It is clear that the decks **131** may be configured so as to have a high resistance and allow the passage of heavy-duty vehicles over them.

[0057] According to a preferred but non-exclusive embodiment, one or more of the decks **131** may be movable between a closed position in which they allow the passage of people, heavy-duty vehicle, emergency vehicles and the like, and an open position in which they allow, for example, one or more operators to access the inverted arch **R,** as schematically shown in **FIGS. 2A, 2B, 5** and **6.**

[0058] Such aspect may be particularly advantageous should there arise the need for emergency rescue operations or other operations such as the manual laying of pipes, cables, reinforcement iron rods or the like at the inverted arch **R** underlying the walkway **130.**

[0059] Possibly, the scaffolding bridge **1** may also include a jib crane **132** which can be controlled by an operator so as to allow an easier laying of pipes, iron rods, armours or anything else.

[0060] Possibly, the pipes may be stored in a special rack **133** arranged on the operative area **13.**

[0061] The operative area **13** may comprise a central walkway so as to allow the passage of heavy-duty vehicles. In addition, it may include one or more lateral walkways so as to allow operators to cross the scaffolding bridge **1** by foot.

[0062] Advantageously, the operators may therefore cross the scaffolding bridge **1** entirely safely and both during the construction steps and during the passage of the heavy-duty vehicles.

[0063] Suitably, the scaffolding bridge **1** may include one or more access ramps **110, 120** operatively connected with the central portion **13.** In greater detail, one or more access ramps **110, 120** may be at the access areas **11** and/or at the access area **12.**

[0064] There may preferably be provided for a ramp **110** arranged at the rear area **11** so as to allow the passage of the vehicles between the section **R1** and the portion **13,** that is the central walkway **130,** and a ramp **120** arranged at the front area **12** so as to allow the passage of the vehicles between the section **R2** and the portion **13,** that is the central walkway **130.**

[0065] In other words, the scaffolding bridge **1** may allow to place the sections **R1** and **R2** in communication. Such configuration may therefore allow the passage of emergency vehicles or heavy-duty vehicles, such as for example concrete casting means, trucks, multi-service vehicles or the like, between the area **R1** and the area **R2.**

[0066] Advantageously, as will also be detailed hereinafter, the aforementioned vehicles may also be allowed passage even during the operations for constructing the inverted arch **R,** without the passage thereof jeopardising the operations.

[0067] Suitably, the access ramps **110, 120** may have a slope such to facilitate the passage of heavy-duty vehicles.

[0068] In particular, an advantageous slope may be

comprised between 6 % and 10 %. A particularly excellent slope of the ramp may be comprised between 7 % and 9 %, for example approximately 8 %.

[0069] According to an advantageous aspect of the invention, the scaffolding bridge 1 may identify - at the lower part during use - a section **W1** interposed between the area **R1** and the area **R2** and designed to be constructed.

[0070] According to a preferred but non-exclusive embodiment, the section **W1** to be constructed may be constructed by casting one or more construction materials, for example concrete, cement or the like, therefore allowing to obtain the invert along the works advancement direction **d'** mentioned above.

[0071] It is clear that the section **W1** to be constructed may be subject to other operations, as will also be detailed hereinafter, without departing from the scope of protection of the attached claims.

[0072] Irrespective of the type of operation, the section **W1** may be constructed even during the passage of heavy-duty vehicles on the scaffolding bridge **1,** without the construction of the latter being jeopardised in any manner whatsoever.

[0073] The section **W1** may generally have a predetermined length defined with respect to the extension axis **X.**

[0074] In particular, the length of the section **W1** may be preferably comprised between 10 m and 20 m. Preferably, the length of the section **W1** may be of 15 m.

[0075] Once the section **W1** has been constructed, the scaffolding bridge **1** may be moved along an advancement direction **d** from the operative position in which the operative area **13** is at the latter **W1** to a new operative position in which the operative area **13** is at a new section **W2** to be constructed of the inverted arch **R** subsequent to the first **W1** so as to allow its construction.

[0076] Furthermore, once the scaffolding bridge has been moved, the constructed section **W1** may remain at the rear part with respect to the operative area **13** along the direction **d.**

[0077] In other words, the constructed section **W1** may be external to the scaffolding bridge **1.** Suitably, the constructed section **W1** may be stable and therefore it may define an area for supporting the scaffolding bridge **1.** In other words, the constructed section **W1** may define the area **R1.**

[0078] According to a further particular aspect of the invention, the movement of the scaffolding bridge **1** , may be carried out by a predetermined advancement pitch **p.** As explained above, the sum of the pitches **p** may define the direction **d.**

[0079] The pitch **p** may preferably be equal to the length **L1** of the area **W1** to be constructed.

[0080] As described above, the predetermined advancement pitch **p** may preferably measure 10-20 m, preferably measuring about 15 m.

[0081] However, it is clear that even different advancement pitch **p** values may be taken into account, without departing from the scope of protection of the attached claims.

[0082] In greater detail, the length of the operative area **13** may coincide or, preferably, may be significantly greater than the pitch **p.** The length of the operative area **13** may be substantially equal to the gap of the scaffolding bridge **1,** that is the distance between the supports.

[0083] The length of the operative area **13** may measure about 20-40 m. Such length may be advantageous to avoid a high number of movements like in the case of smaller lengths and simultaneously avoid the need for particularly resistant structures like in the case of greater lengths.

[0084] Preferably, the length may measure about 30 m. Such length is excellent with respect to the described above.

[0085] Suitably, the operative area **13** may have a length that is substantially double with respect to the pitch **p.** In this manner, advantageously, beneath the operative area **13** there may be defined the section **W1** and the section **W2** which may have substantially the same length.

[0086] Advantageously, as better explained hereinafter, operations on the section **W1** (for example casting) may therefore be carried out and other preparation operations (for example laying pipes and/or iron rods) may be carried out on the section **W2.**

[0087] Suitably, the operations on the section **W1** and on the section **W2** may be carried out before moving the scaffolding bridge. Possibly, the operations on the section **W1** and the preparation operations on the section **W2** may be carried out simultaneously.

[0088] The subsequent movement of the pitch **p** may allow to construct a section **W1** which has already been subjected to preparation operations and carry out preparation operations on a new section **W2.**

[0089] Suitably, the scaffolding bridge **1** may comprise movement means **30** to selectively promote the movement of the scaffolding bridge **1** along the advancement direction **d,** preferably by the predetermined pitch **p.**

[0090] Specifically, the movement means **30** may be selectively activated to allow the movement of the scaffolding bridge **1** upon completing the construction of the section **W1.**

[0091] In this manner, the portion **13** may be at a new section **W2** subsequent to the first. Such new section **W2** may therefore be a section of the inverted arch **R** portion **R2** still to be constructed.

[0092] Upon identifying the new section **W2** to be constructed, the means **30** may be selectively disabled so as to allow the anchoring **1** of the scaffolding bridge and the operations on the section **W1** and possibly on the new section **W2.**

[0093] According to a preferred but non-exclusive embodiment, the movement means **30** may be in the form of at least one first and at least one second telescopic elements **31, 32** respectively positioned at the rear access portion **11** and at the front access portion **12** of the scaffolding bridge **1.**

[0094] Preferably, the scaffolding bridge **1** may include a pair of telescopic elements **31** and a pair of telescopic elements **32** in the form of telescopic legs.

[0095] In any case, each telescopic element **31, 32** may include an upper portion **31', 32'** which is fixed and integrally coupled to the respective front and rear access portion **11, 12** and a lower portion **31", 32"** instead designed to interact with the inverted arch **R** to support the scaffolding bridge **1.**

[0096] As a matter of fact, the respective lower portions **31", 32"** may be movable - with respect to the respective upper portion **31', 32'** - between a proximal position (defined hereinafter as "retracted "position) and a distal position (instead defined as "extended" position).

[0097] Preferably, the movement of each of the telescopic elements **31, 32** may be carried out along a transversal axis **Z** with respect to the axis **X',** preferably perpendicular to the latter.

[0098] Therefore, it is therefore clear that the telescopic elements **31, 32,** when in the retracted and extended position may respectively have a minimum length and a maximum length, defined along the axis **Z.**

[0099] Specifically, the aforementioned minimum and maximum lengths may advantageously be such to allow the scaffolding bridge **1** to rest on the support means **20** when the telescopic elements **31, 32** are in the retracted position and exclusively rest on the latter when they are in the extended position.

[0100] In order to guarantee the movement of the scaffolding bridge **1,** at least one of the lower portions **31", 32"** may include respective rotatable elements, wheels in the preferred but non-limiting embodiment.

[0101] The latter may for example be made of steel and neoprene. However, it is clear that different embodiments may also be provided for without departing from the scope of protection of the attached claims.

[0102] According to a preferred but non-exclusive embodiment, only the rear telescopic elements **31** may comprise respective wheels **311** designed to interact with the area **R1** when in extended position.

[0103] The front telescopic elements **32** may instead include one or more support feet **321**susceptible - during use - to come into contact with the inverted arch **R,** and in particular with the area **R2,** when the telescopic elements **32** are in the extended position.

[0104] Although in the present description reference will be made to this particular embodiment, it is however clear that the front telescopic elements **32** may include wheels at the respective ends, additionally or alternatively to the support feet **321,** so as to allow the movement of the scaffolding bridge **1,** without departing from the scope of protection of the attached claims.

[0105] According to a further embodiment, the telescopic elements **32** may further be suitable to be moved between a position proximal to the operative area **13** and a distal position with respect to the latter.

[0106] Preferably, such movement may be carried out along respective axes **X"** parallel to the extension axis **X'** of the scaffolding bridge **1.**

[0107] To this end, according to a preferred but non-exclusive embodiment, each telescopic element **32** may be connected - at the respective upper portion **32'** - to a support arm **322** movable along a respective sliding track **135** extending longitudinally along an operative area **13.**

[0108] In this manner, each telescopic element **32** may therefore be moved between the proximal position, in which respective support arms **322** are inserted into the respective sliding track **135** and the telescopic elements **32** are in an inserted position, and the distal position, in which the respective support arms **322** are instead partially inserted into the respective sliding track **135** and the telescopic elements **32** are in the removed position.

[0109] In this specific case, such movement may be carried out when the telescopic elements **32** will be in the retracted position, that is when the scaffolding bridge **1** is anchored to the inverted arch **R.**

[0110] In particular, the support arms **322** may have a length such to allow the telescopic elements **32** a stroke along respective sliding tracks **132** with length equal to the predetermined advancement pitch **p** of the scaffolding bridge **1.**

[0111] As a result, in order to enable the movement of the scaffolding bridge **1,** it will be sufficient to move - first and foremost - the telescopic elements **32** from the proximal position to the distal position and subsequently move both telescopic elements **31, 32** from the retracted position to the extended position, so as to allow the latter to interact with the inverted arch **R.**

[0112] In this specific case, the feet **321** of the telescopic elements **32** and the wheels **311** of the telescopic elements **31** may respectively rest at the area **R2** and at the area **R1.**

[0113] At this point, the presence of the wheels **311,** will allow to return the scaffolding bridge **1** to the initial position, translating the support structure towards the advancement direction **d** and allowing the support arms **322** to fully return into the respective sliding tracks **132.**

[0114] At this point, the scaffolding bridge **1** will have moved along the advancement direction **d** by a distance equal to the predetermined pitch **p.**

[0115] Possibly, the movement may be carried out semi-automatically or automatically, through suitable drive means that can be selectively activated by the operator, for example upon completing the construction of the section **W1.**

[0116] Advantageously, the scaffolding bridge **1** may move by a predetermined velocity, for example comprised between 0.5 m/min and 1.5 m/min, preferably about 1 m/min.

[0117] According to a further advantageous aspect of the invention, the scaffolding bridge **1** may further include means **40** for casting a construction material, such as for example concrete, cement or the like.

[0118] In the description hereinafter, particular reference will be made to concrete. However, it is clear that even other construction materials, and their potential

combinations, may be taken into account without departing from the scope of protection of the attached claims.

[0119] The means **40** may be configured to allow the construction of the section **W1,** for example the casting of construction material at the section **W1.** Preferably, the means **40** may be operatively connected with the central portion **13.** More preferably, the means **40** may be positioned beneath the central portion **13.**

[0120] According to a particular aspect of the invention, the means **40** may be at half of the portion **13** close to the rear area **11** so as to allow to construct the section **W1** and not construct the section **W2.**

[0121] Preferably, the concrete casting may be carried out by pouring through the walkway **130.** Suitably, the walkway **130** may have a plurality of holes suitably arranged thereon. In other words, at least one part of the portion **13** may comprise such holes.

[0122] Suitably, the means **40** may comprise such holes which may be configured to convey the concrete towards the underlying area, that is the section **W1.**

[0123] In particular, the holes may receive the concrete coming, for example, from the concrete mixer trucks positioned on the walkway **130** or positioned externally to the scaffolding bridge **1** to convey and spread it evenly on the section **W1** under construction, as shown in **FIG.** 1.

[0124] There may possibly be present suitable conveyance funnels arranged in proximity of the holes to facilitate the pouring of the concrete into the holes and/or the spreading of the concrete in the area underlying the walkway **130.**

[0125] Upon completing the casting, it will therefore be possible to obtain a constructed section **W1.**

[0126] More specifically, the means **40** for the casting, particularly shown in **FIGS. 2, 7A** and **7B,** may further include a containment frame **41** of the concrete positioned beneath the central portion **13.**

[0127] In other words, the containment frame **41** may be - in use - interposed between the central portion **13** and the inverted arch **R.**

[0128] The containment frame **41** may further be suitable to be moved selectively between a position proximal to the central portion **13,** shown in **FIG. 7B,** and a distal position with respect to the latter, shown instead in **FIG. 7A.**

[0129] The movement of the containment frame **41** may preferably be carried out along a direction substantially perpendicular to the axis **X'** of the scaffolding bridge **1.**

[0130] In particular, the containment frame **41** in proximal position may be spaced with respect to the inverted arch **R** and, specifically, to the section **W1** to be constructed. Suitably, the frame **41** may be configured so that the proximal position can allow the movement of the scaffolding bridge **1** without intercepting the constructed section **W1,** which has a greater height with respect to the section **W1** to be constructed, due to the casting.

[0131] On the other hand, the containment frame **41** in distal position may instead be in proximity of or in contact with the inverted arch **R.** In particular, the frame **41** may delimit the section **W1** to be constructed, to contain the concrete during the casting.

[0132] According to a preferred but non-exclusive embodiment, the containment frame **41** may include a support structure **410** operatively connected with the central portion **13** through suitable connection means **42,** preferably of the telescopic type such as for example one or more telescopic cylinders **420,** for example oil hydraulic actuation hydraulic telescopic cylinders.

[0133] The connection means **42** may therefore allow to move the containment frame **41** from the proximal to the distal position and vice versa.

[0134] The support structure **410** may further include support feet **413** designed to come into contact with inverted arch **R** at the section **W1,** when in distal position, to support the containment frame **41** and hold it in position.

[0135] The support structure **410** may further include - frontally - a front closing element for the casting **411.**

[0136] The latter may allow to prevent the outflow of the concrete during the construction step, allowing to precisely delimit and define the section **W1** to be constructed.

[0137] To this end, the support structure **410** may have a lower portion **411'** suitably dimensioned to adapt to the planimetric curve of the inverted arch **R** and to come into contact with the latter when the containment frame **41** is in distal position.

[0138] In this manner, the concrete cast at the section **W1** will be frontally limited by the front closing element **410,** at the rear part by the front of the area **R1** constructed previously and laterally by the profile of the tunnel **G.**

[0139] When it is in proximal position, the front closing element **410** may instead remain suspended above the inverted arch **R,** therefore preventing any interference with the movement of the scaffolding bridge **1.**

[0140] Preferably, the containment frame **41** may further include means **43** for levelling the concrete.

[0141] According to a preferred but non-exclusive embodiment, the levelling means **43** may for example be one or more vibrating straight edges **430,** per se known, integrally coupled with the support structure **410** so as to allow to level the concrete when the containment frame **41** is in distal position.

[0142] According to a further advantageous aspect of the invention, the scaffolding bridge **1** may further include anti-vibrating means **50** for selectively preventing the vibration of the frame **41.** In particular, the means **50** may be configured to prevent the vibrations from passing through (for example cause the passage of heavy-duty vehicles) from the portion **13** to the frame **41.**

[0143] For example, the means **50** may be de-coupling means **50** acting on the containment frame **41** and possibly also on the operative area **13** so as to allow the functional de-coupling between the containment frame **41** and the operative area **13,** and therefore the scaffolding bridge **1.**

[0144] The expression functional de-coupling is used to indicate that when the de-coupling means **50** are activated, the vibrations and stresses induced on the operative area **13** will not be transmitted to the containment frame **41** and vice versa.

[0145] Such aspect may therefore allow to carry out an excellent construction at the section **W1,** therefore without the passage of heavy-duty vehicles simultaneously with the construction affecting the latter.

[0146] When the de-coupling means **50** are disabled, the vibrations and the stresses induced on the operative area **13** may therefore also be transmitted to the al containment frame **41.**

[0147] In particular, the de-coupling means **50** may be activated when the containment frame **41** will be in the distal position, so as to allow the construction of the section **W1,** and they may instead be disabled when the containment frame **41** will be in the proximal position, so as to allow the movement of the scaffolding bridge **1.**

[0148] Possibly, the means **50** may comprise or consist of damping elements of the per se known type.

[0149] According to a preferred but non-exclusive embodiment, the de-coupling means **50** may comprise the one or more telescopic hydraulic cylinders **420.**

[0150] Actually, the latter may allow to functionally decouple the containment frame **41** of the operative area **13** during the construction of the section **W1,** damping any vibrations and stresses induced, for example, by the passage of heavy-duty vehicles on the operative area **13.**

[0151] Upon completing the casting, the telescopic hydraulic cylinders may further allow to return the frame **41** in proximal position.

[0152] At this point, the containment frame **41** will be functionally coupled to the portion **13** and therefore it may be integrally joined with the latter.

[0153] In this manner, upon completing the casting, the scaffolding bridge **1** may be moved as described above along the advancement direction **d** so as to carry out the casting on a section **W2** subsequent to the section **W1** just constructed.

[0154] Possibly, the containment frame **41** may further include a raceway formwork **44** extending longitudinally along an axis parallel to the axis **X'.**

[0155] The raceway formwork **44** may be suitably sized to allow to obtain of a channel at the casting in the section **W1** when the containment frame **41** is in distal position.

[0156] The channel thus made using the raceway formwork at the surface of the constructed section **W1** may, if need be, house suitable water draining systems.

[0157] According to a particular inventive aspect of the invention, there may be provided a method for constructing a tunnel **G.**

[0158] Preferably, but not exclusively, such method may be implemented using the scaffolding bridge **1** described above.

[0159] First and foremost, the method may provide for a step for preparing a scaffolding bridge, preferably the scaffolding bridge **1** described above.

[0160] Subsequently to the preparation step, the scaffolding bridge **1** may be positioned in the tunnel **G.**

[0161] The scaffolding bridge **1** may therefore be positioned in the latter so that the rear access portion **11** and the front access portion **12** can respectively rest on a constructed area **R1** and on an area **R2** to be constructed of the inverted arch **R.**

[0162] Upon positioning the scaffolding bridge **1,** there may be defined - beneath it, for example beneath the operative area **13** - at least one section **W1** to be constructed interposed between the areas **R1** and **R2.**

[0163] Subsequently, there may be carried out a step for constructing the section **W1** so as to obtain a constructed section **W1.**

[0164] Upon completing the construction of the section **W1,** the scaffolding bridge **1** may be moved along the advancement direction **d** to allow the construction of a section **W2** subsequent to the constructed section **W1.**

[0165] Possibly, upon the advancement, the constructed section **W1** may remain outside the scaffolding bridge **1** and it may subsequently become part of the support area **R1.**

[0166] In particular, the steps for constructing the section **W1** and advancement step may be carried out iteratively until the completion of the inverted arch **R.**

[0167] In this case, the reasoning and expressions used for the sections **W1** and **W2** may therefore be repeated in an entirely equivalent manner at each construction cycle.

[0168] According to a preferred but non-exclusive embodiment, the construction step may comprise or consist of a step for casting a construction material, preferably concrete or the like.

[0169] In greater detail, the construction of the section **W1** may comprise the steps of:

- moving the containment frame **41** from the proximal to the distal position;
- casting the selected construction material, for example concrete, preferably such casting step may be carried out through the operative area **13,** for example by means of through holes present thereon;
- waiting for a period of time sufficient for the hardening of the casting;
- moving the frame **41** from the distal position to the proximal position.

[0170] Possibly, before the casting step there may be provided for a functional de-coupling step between the operative area **13** and the containment frame **41** and before the step for moving the frame **41** there may be provided for the functional de-coupling step between the operative area **13** and the containment frame **41.**

[0171] Subsequently to the construction of the section **W1,** the scaffolding bridge **1** may be moved towards the section to be constructed subsequent to the section **W1** just constructed.

[0172] According to a particular aspect of the invention,

before moving the scaffolding bridge **1** there may be carried out a preparatory construction step on the section **W2,** that is the section prior to the section **W1** at the scaffolding bridge **1.** Such preparatory construction may possibly be carried out simultaneously with the construction on the section **W1.** This may allow to significantly save time.

[0173] Possibly, the preparatory construction on the section **W2** may be carried out during the step of waiting for the casting hardening time.

[0174] The preparatory construction step may comprise the laying of the reinforcement, iron rods and/or pipes at the section **W2.**

[0175] According to a particular aspect of the invention, the advancement pitch **p** may be equal to the length **W1** which may be substantially equal to the length **W2.** In this manner, in each advancement pitch there may be carried out the step for constructing the section **W1** and the preparatory construction of the section **W2.**

[0176] Although a method for carrying out a construction one the section **W1,** in particular a casting operation, as well as other operations on the section prior to **W2,** in particular preparation operations, has been described, it is clear that the scaffolding bridge **1** may be particularly adapted to carry out only some of such construction steps.

[0177] As a matter of fact, the method according to the present invention allows to obtain any construction along the extension of the tunnel simultaneously always allowing the passage of the vehicles through the tunnel.

[0178] For example, the method may provide for construction step for providing pipes and/or wiring only.

[0179] The step for moving the scaffolding bridge 1 may preferably be carried out as described above using telescopic means. In any case, the scaffolding bridge may be placed frontally on a stable area **R2** still to be constructed, while - at the rear part it may be placed on a stable area **R1** which may be the section just constructed **W1.**

[0180] It is clear that the areas **R1** and **R2** may be any areas having structural strength and not necessarily an area without the invert and an area in which the invert has already been constructed.

[0181] As a matter of fact, the method and the scaffolding bridge **1** described above may be equally used for any maintenance operation, for example renovating a part of the invert of a tunnel, in which both areas **R1** and **R2** provide for the invert.

[0182] In the light of the above, it is clear that the scaffolding bridge **1** attains the preestablished objectives.

[0183] Furthermore, it is clear that the present invention may include various parts and/or similar or identical elements. Unless otherwise specified, similar or identical parts and/or elements will be indicated using a single reference number, it being clear that the described technical characteristics are common to all similar or identical parts and/or elements.

[0184] The invention is susceptible to modifications and variants, all falling within the scope of protection of the attached claims. All details can be replaced by other technically equivalent elements, and the materials can be different depending on the needs, without departing from the scope of protection of the invention defined by the attached claims.

Claims

1. A scaffolding bridge which can be positioned in a tunnel **(G)** which includes an inverted arch **(R)** to allow its construction at at least one section **(W1)** to be constructed of the inverted arch **(R)** interposed between a first constructed area **(R1)** and a second area **(R2)** to be constructed subsequent to the section **(W1)** also to be constructed, the scaffolding bridge extending along a main axis **(X')** and comprising:

   - a first and a second access portion **(11, 12)** which can be positioned - in use - at said first and second area **(R1, R2);**
   - an operative area **(13)** interposed between said first and second access portion **(11, 12)** which can be positioned - in use - at the section **(W1)** to be constructed;
   - means **(20)** for supporting said scaffolding bridge respectively arranged at least at said first and second access portion **(11, 12);**

   wherein said operative area **(13)** comprises at least one runway **(130)** configured and or dimensioned to support heavy-duty vehicles, said at least one walkway **(130)** being operatively connected with said first and second access portion **(11, 12)** to allow - during use - the passage of the heavy-duty vehicles between said first and second area **(R1, R2).**

2. Scaffolding bridge according to claim 1, further comprising movement means **(30)** configured to move the scaffolding bridge along an advancement direction **(d).**

3. Scaffolding bridge according to claim 2 wherein said movement means **(30)** are configured to move the scaffolding bridge step by step with a predetermined pitch **(p)** along said advancement direction **(d).**

4. Scaffolding bridge according to claim 3 wherein said operative area **(13)** has a first length, said predetermined pitch **(p)** having a second length substantially equal to half of said first length of said operative area **(13).**

5. Scaffolding bridge according to claim 2 or 3 or 4, wherein said movement means **(30)** are configured to selectively promote the movement of the scaffold-

ing bridge from a first operative position in which said operative area **(13)** is at the section **(W1)** at at least one second operative position in which said operative area **(13)** is at a section **(W2)** to be constructed of the inverted arch **(R)** subsequent to the constructed section **(W1).**

6. Scaffolding bridge according to the preceding claim, wherein said first and second access portion **(11, 12)** respectively include at least one first and at least one second telescopic element **(31, 32)** movable along a direction substantially perpendicular to said axis **(X')** between a retracted position and an extended position, said at least one first and at least one second telescopic element **(31, 32)** and said support means **(20)** being mutually configured so that, when said at least one first and at least one second telescopic element **(31, 32)** are in said retracted position, the latter are spaced from the inverted arch **(R)** and said support means **(20)** respectively interact with said first and second area **(R1, R2)** to support the scaffolding bridge; vice versa when said at least one first and at least one second telescopic element **(31, 32)** are in said extended position, the latter interacting with the inverted arch **(R)** to support the scaffolding bridge and said support means **(20)** being spaced from the latter **(R).**

7. Scaffolding bridge according to the preceding claim, wherein one of said at least one first and at least one second telescopic element **(31, 32)** includes at least one wheel **(311, 321)** designed - in use - to come into contact with the inverted arch **(R)** when said one of said at least one first and at least one second telescopic element **(31, 32)** is in said extended position so as to allow the advancement of the scaffolding bridge, and wherein the other of said at least one first and at least one second telescopic element **(31, 32)** includes at least one foot **(321)** designed - in use - to come into contact with the inverted arch **(R)** when said other of said at least one first and at least one second telescopic element **(31, 32)** is in said extended position, said other of said at least one first and at least one second telescopic element **(31, 32)** being further selectively movable along a direction substantially parallel to said axis **(X')** between a proximal position and a distal position with respect to said operative area **(13)** to define an advancement pitch **(p).**

8. Scaffolding bridge according to any one of claims 2 to the preceding, further comprising guide means configured to guide the scaffolding bridge so that said advancement direction **(d)** coincides with a predetermined works advancement direction **(d').**

9. Scaffolding bridge according to any one of the preceding claims, further comprising means **(40)** for casting a construction material operatively connected with said operative area **(13)** so as to cast the construction material at least on the section **(W1)** to be constructed to obtain a constructed section **(W1).**

10. Scaffolding bridge according to the preceding claim, wherein said casting means **(40)** comprise a containment frame **(41)** which can be selectively moved between a position proximal to said operative area **(13)** in which it is spaced from the section **(W1)** to be constructed so as to allow the movement of the scaffolding bridge and a position distal from said operative area **(13)** in which said containment frame **(41)** is designed to interact - in use - with the section **(W1)** to be constructed to contain the construction material cast on the latter **(W1).**

11. Scaffolding bridge according to the preceding claim, further comprising de-coupling means **(50)** acting on said containment frame **(41)** so as to allow the functional de-coupling of the latter and at least said operative area **(13)** at least when said containment frame **(41)** is in said distal position.

12. A method for constructing a tunnel **(G)** which includes an inverted arch **(R)** with a first constructed area **(R1)** and a second area **(R2)** to be constructed, the method sequentially comprising the steps of:

- providing a scaffolding bridge **(1)** comprising a walkway;
- positioning said scaffolding bridge **(1)** in the tunnel **(G)** so that it is supported - at the front part - by the second area **(R2)** and - at the rear part - by the first area **(R1)** so as to identify - at the inverted arch **(R)** - at least one first section **(W1)** to be constructed interposed between the first constructed area **(R1)** and the second area **(R2)** to be constructed;
- constructing the at least one first section **(W1);**

wherein, once positioned, the walkway allows - during use - the passage of heavy-duty vehicles between the first and second area **(R1, R2).**

13. Method according to the preceding claim, comprising the steps of:

- first construction of the first section **(W1)** to obtain a first constructed section **(W1);**
- advancement of said scaffolding bridge **(1)** by a predetermined pitch **(p)** along a direction **(d)** so that the scaffolding bridge is at a second section **(W2)** to be constructed subsequent to the first section **(W1)** along the direction **(d);**

wherein said steps are repeated iteratively for a predetermined number of times.

14. Method according to the preceding claim, wherein said construction step is a casting operation, the scaffolding bridge comprising a containment frame **(41)** movable between a position proximal to the scaffolding bridge and a position distal from the same, said construction step comprising:

- first movement of said containment frame **(41)** from said proximal position to said distal position in which said containment frame **(41)** interacts with the inverted arch **(R)** to define the first section **(W1)** to be constructed;
- functional de-coupling between said containment frame **(41)** and said operative area **(13)** of the scaffolding bridge;
- casting the construction material at the first section **(W1);**

functional de-coupling between said containment frame **(41)** and said operative area **(13);**

- second movement of said containment frame **(41)** from said distal position to said proximal position.

15. Method according to claim 13 or 14, comprising:

- said first construction of the at least one first section **(W1)** and a second construction of a second section **(W2)** prior to the first section **(W1);** and subsequently
- said step for advancing said scaffolding bridge **(1);**

wherein said predetermined pitch **(p)** has a length substantially equal to the first section **(W1).**

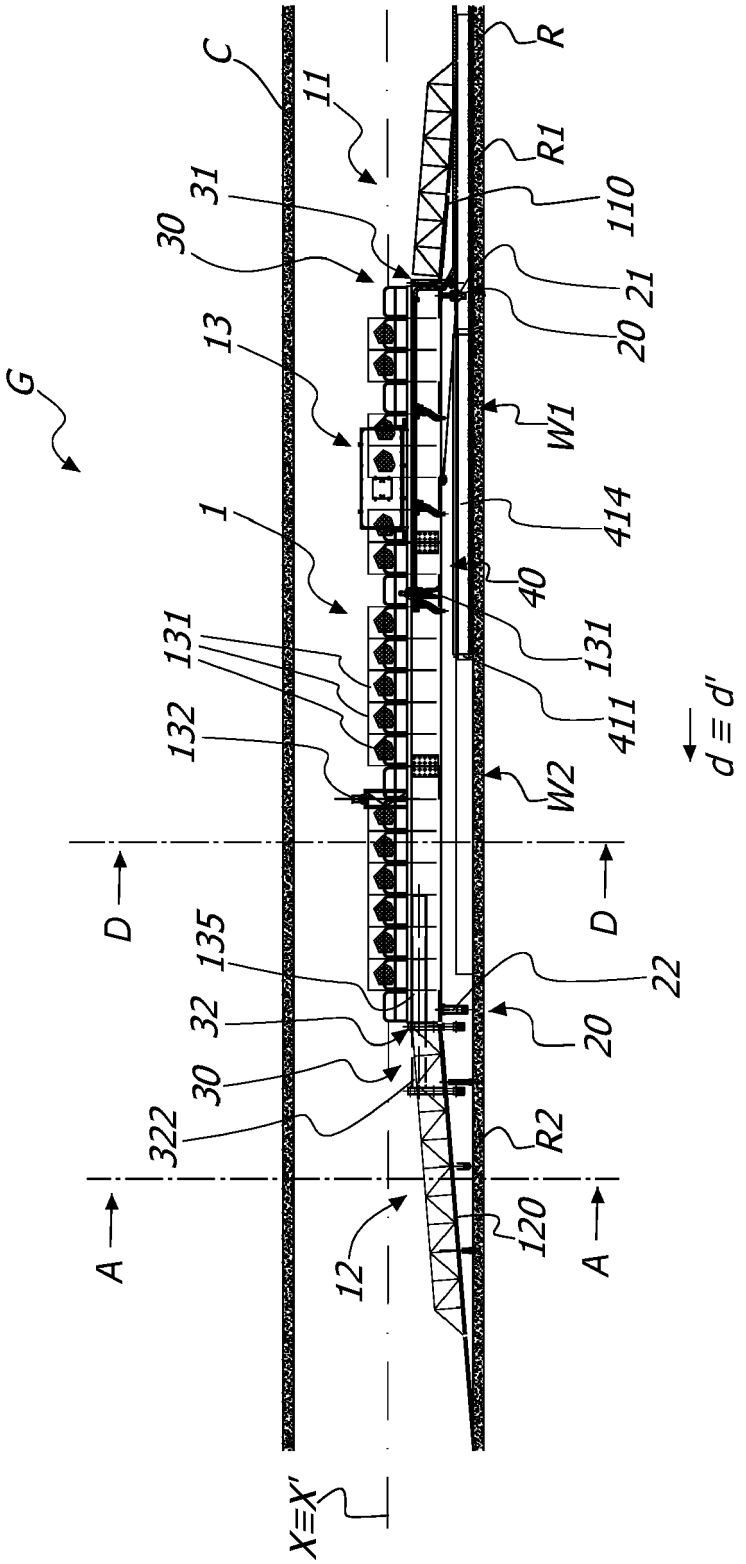
G
C
11
R
R1
110
30
31
21
20
13
W1
414
1
40
131
132
411
W2
d ≡ d''
D
D
135
22
32
20
30
322
R2
A
A
12
120
X≡X'

FIG. 1

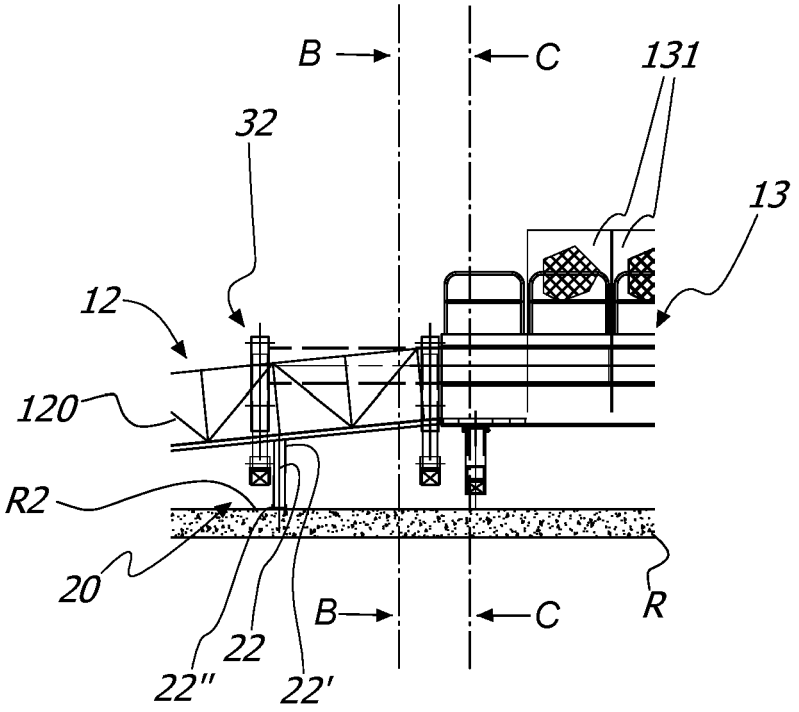
B
C
131
32
13
12
120
R2
20
22''
22
22'
B
C
R

FIG. 1A

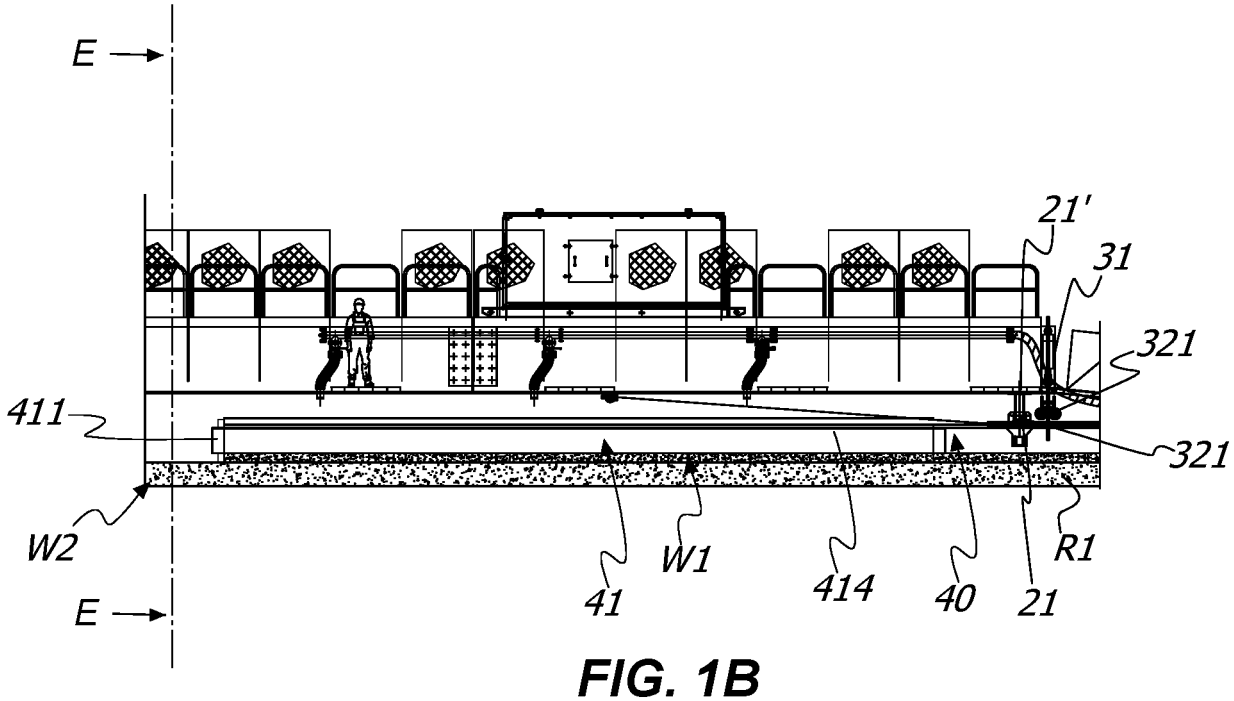
E
21'
31
321
411
321
W2
41
W1
414
40
21
R1
E

FIG. 1B

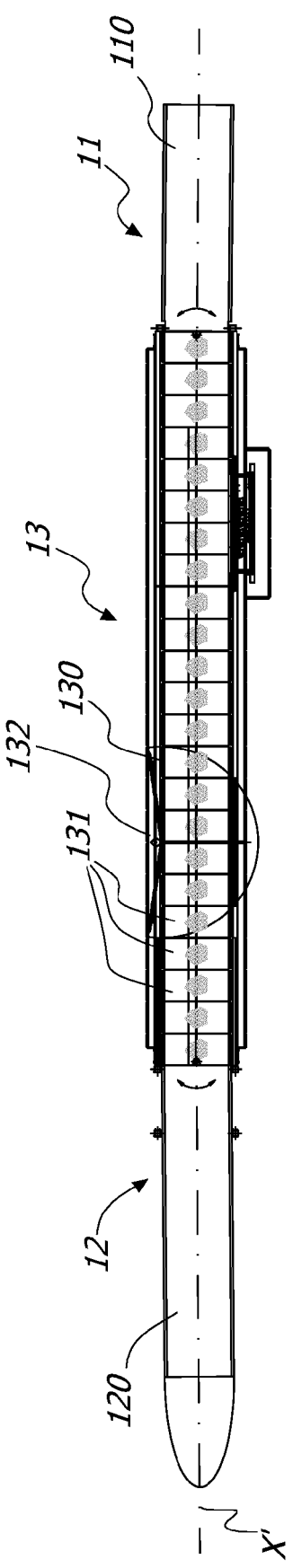

FIG. 2A

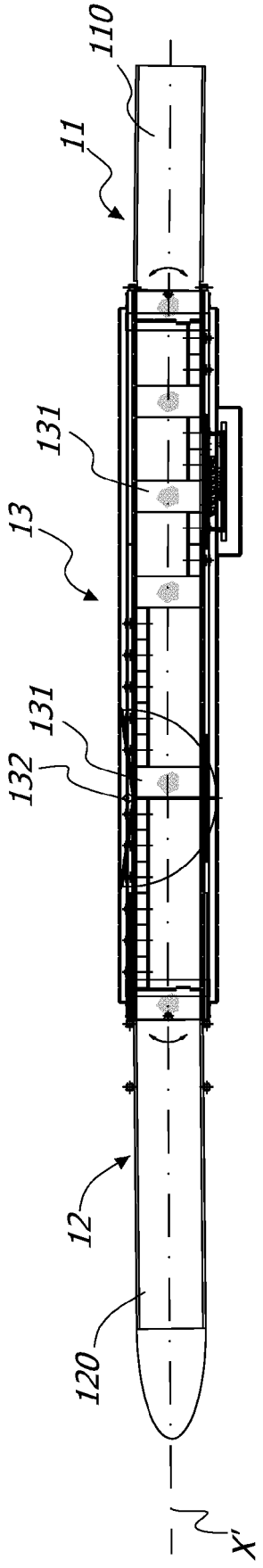

FIG. 2B

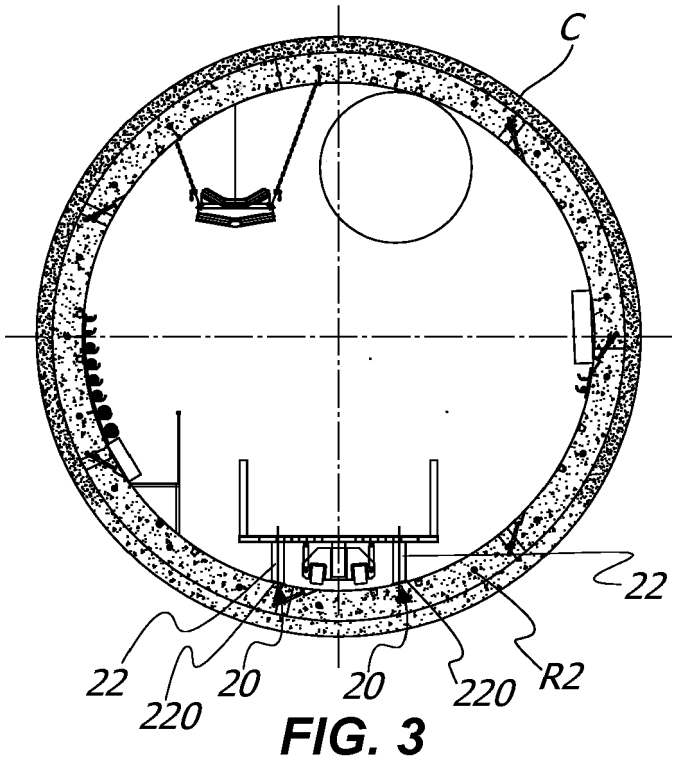

FIG. 3

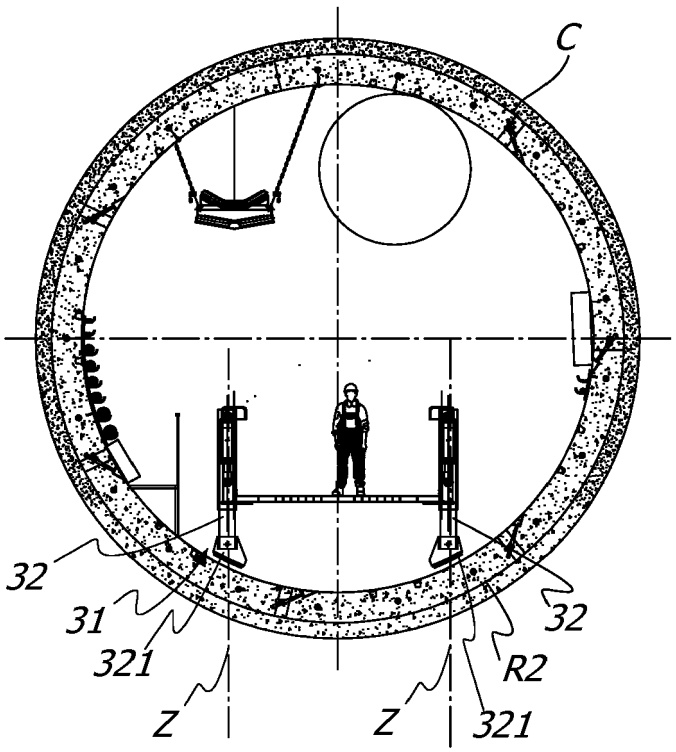

FIG. 4

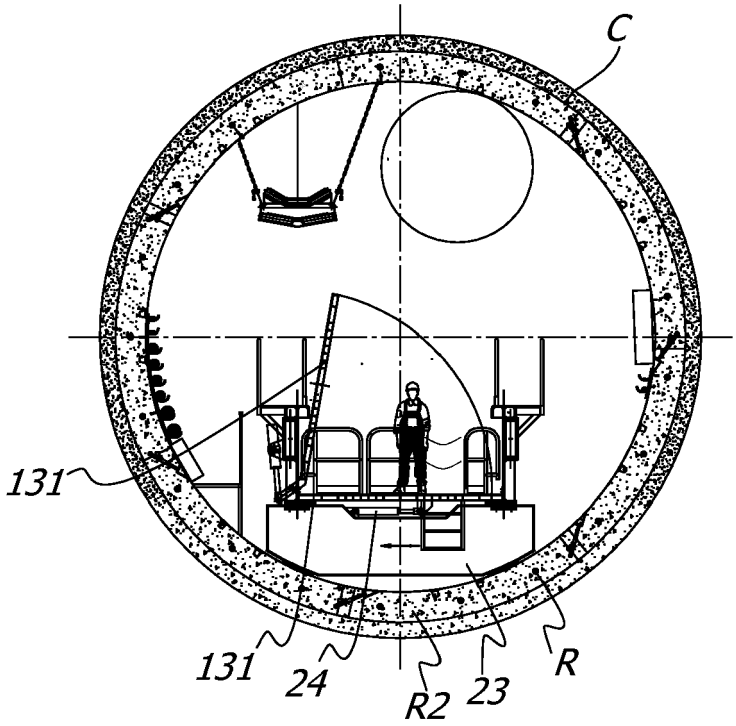

FIG. 5

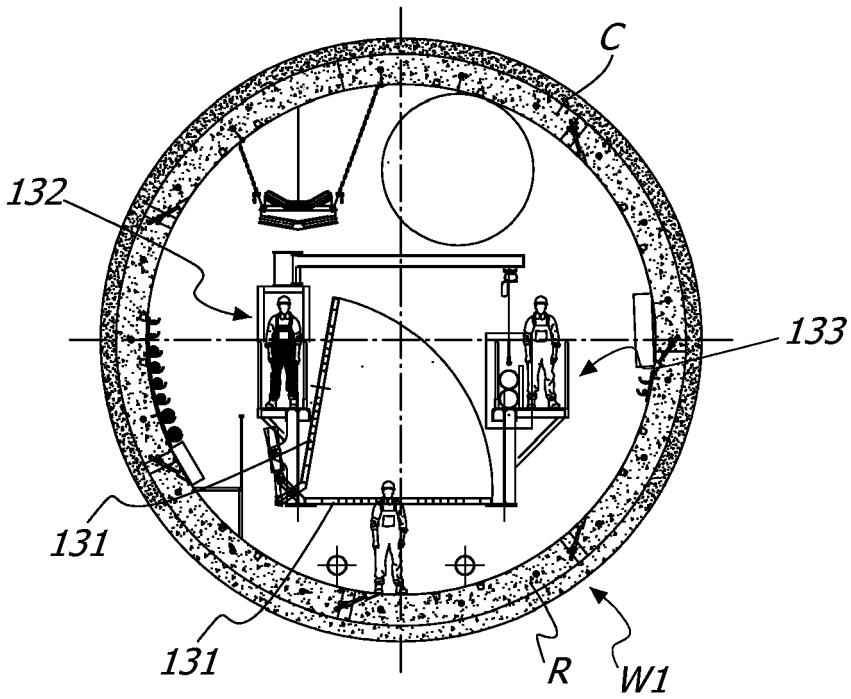

FIG. 6

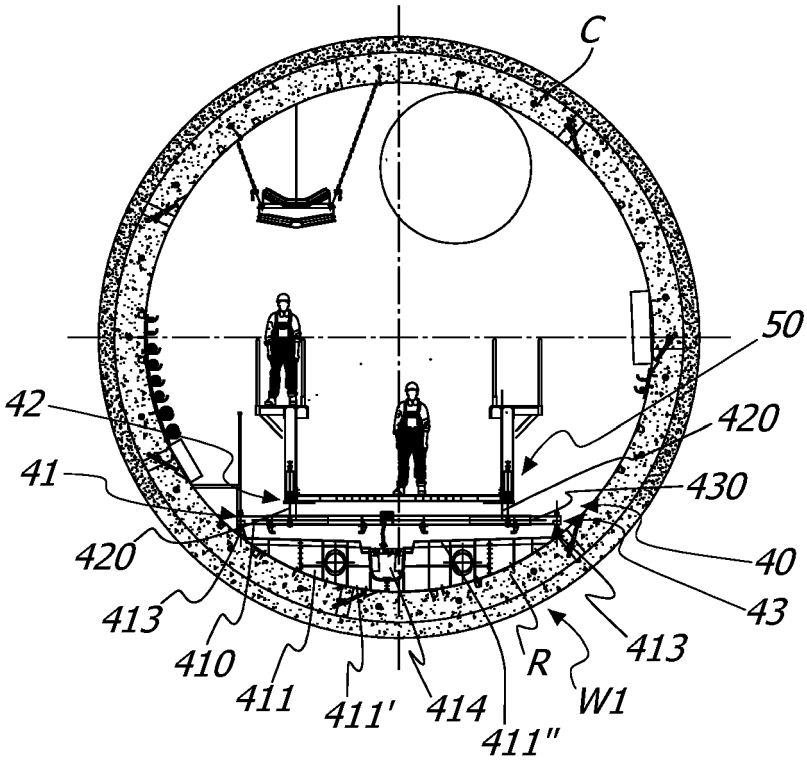
C
50
42
420
41
430
420
40
43
413
410
411
411'
414
R
W1
413
411"

FIG. 7A

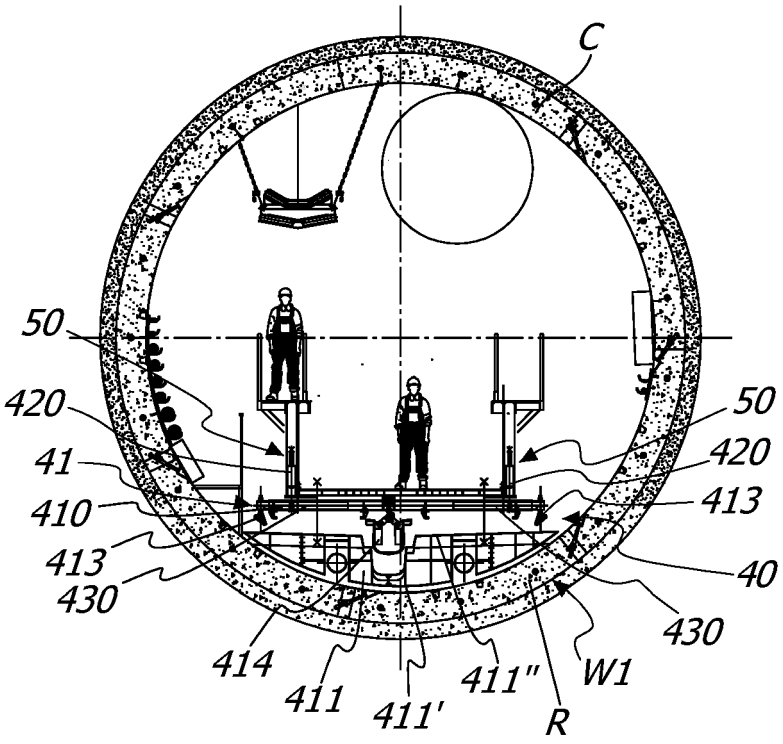
C
50
420
41
410
413
430
50
420
413
40
430
414
411
411'
411"
W1
R

FIG. 7B

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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 1131

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	WO 02/31316 A2 (PLANINC ROBERT [HR]; PLANINC MARKO [HR] ET AL.) 18 April 2002 (2002-04-18)	12	INV. E21D11/40
A	* abstract * * figure 1 * * page 3, line 5 - line 13 * * page 6, line 10 - line 15 *	1-11, 13-15	
A	WO 2006/134408 A2 (PLANINC ROBERT [HR]; PLANINC MARKO [HR]) 21 December 2006 (2006-12-21) * abstract * * figures 5-17 * * page 3, line 20 - page 4, line 9 * * page 6, line 7 - line 19 *	1-15	
A	CN 106 437 741 B (CHINA RAILWAY ENGINEERING EQUIPMENT GROUP CO LTD) 5 April 2019 (2019-04-05) * abstract * * figures 1-3 * * paragraph [0026] *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC) E21D E01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 August 2024	Hustedt, Bernhard

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 17 1131

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12-08-2024

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