



(51) International Patent Classification:

E21D 11/18 (2006.01) E21D 9/00 (2006.01)  
E21D 11/40 (2006.01) E21D 11/24 (2006.01)

(21) International Application Number:

PCT/IB2019/056096

(22) International Filing Date:

17 July 2019 (17.07.2019)

(25) Filing Language:

Italian

(26) Publication Language:

English

(30) Priority Data:

102018000007585 27 July 2018 (27.07.2018) IT

(71) Applicant: **VEXA S.R.L.** [IT/IT]; Via A. Caggioli, snc,  
25055 Pisogne, Brescia (IT).

(72) Inventor: **GUERINI, Elio**; c/o VEXA S.R.L., Via A. Caggioli, snc, 25055 Pisogne, Brescia (IT).

(74) Agent: **GAMBA, Alessandro** et al.; c/o Jacobacci & Partners S.P.A., Piazza della Vittoria, 11, 25122 Brescia (IT).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: EQUIPMENT ASSEMBLY

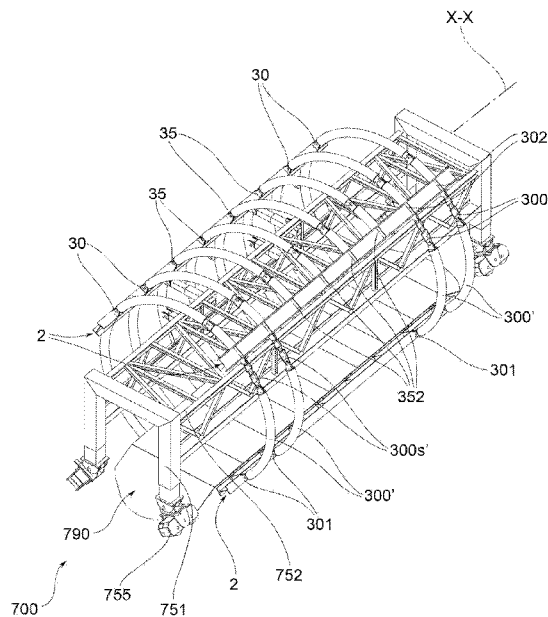


FIG. 2b

(57) Abstract: An equipment assembly (1) suitable to engage a vault (950) of a tunnel (900). The equipment assembly (1) extends along a main axis (X-X) comprising a plurality of longitudinal members (2) and a plurality of centerings (3) positionable in an open configuration wherein they extend circumferentially by connecting the longitudinal members (2) and engaging the vault (950). The centerings 3 comprise main centerings (30) positioned at the axial ends of the equipment assembly (1), wherein each comprises main girder elements (300), hinged together in such a way as to be positionable in the shape of a circular segment on a base, and an auxiliary girder element (300'), in such a way that the positioning of main girder elements (300) and the engagement with the auxiliary girder element (300') compose the circular-shaped main centering (30). The centerings 3 comprise intermediate centerings (35) positioned axially between the main centerings (30), wherein each intermediate centering (35) comprises intermediate girder elements (350) mu-



**(84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

**Published:**

- *with international search report (Art. 21(3))*

---

tually hinged together in such a way that they are positionable in the shape of a circular segment on a base to engage circularly a section of the side wall (955), defining a work opening (9) wherein the side wall (955) is accessible for the execution of the operations for the construction of a by-pass tunnel (990).

**DESCRIPTION****"EQUIPMENT ASSEMBLY"**

[0001] The present invention concerns an equipment assembly, a trailer for the transport and positioning of said equipment assembly, an operating system comprising said equipment assembly and said trailer, and a method for the construction of a by-pass tunnel.

[0002] In particular, the field of application wherein the present invention is placed is the construction of a "major civil work", such as the construction of a tunnel for connecting a section of a road or railway. Specifically, the present invention is part of a specific phase in the construction of a civil work that provides for the construction of "twin tunnels", which extend in length parallel to each other, wherein in each respective tunnel there will be a respective direction of travel by road or rail.

[0003] Going into still more detail, the present invention is part of the construction phase of a by-pass tunnel necessary to connect the two twin tunnels. In fact, it is known to put the two tunnels in communication approximately every five hundred meters by means of said by-pass tunnels. Intuitively, the longer the tunnels, the greater the number of by-pass tunnels.

[0004] In the state of the art, it is known to construct a

by-pass tunnel only once the construction operations of an entire tunnel along the entire tunnel axis has been completed. In other words, it is known to perform the operations of building a by-pass tunnel once the moles  
5 (also known as mechanical tunneling machines or tunnel boring machines) have completed the excavation operations and once the masonry operations of the respective vaults of the tunnels have been completed for the construction of the concrete segmental liner. In other words, in the  
10 state of the art, the operations for the construction of by-pass tunnels are only begun once the construction operations of the entire main tunnels have been completed.

[0005] In light of the above, the time of construction of  
15 twin tunnels includes the time of construction of the main tunnels to which is added the time of construction of the by-pass tunnels.

[0006] In particular, the construction of the by-pass tunnels provides for a first moment wherein a special  
20 support structure is mounted on the side walls of the tunnel, and a second moment wherein the excavation operations of the by-pass tunnel are carried out through a special opening delimited by said support structure.

[0007] In light of the above, the time needed to complete  
25 these civil works is by no means negligible, and does not

go hand in hand with the need to execute civil works as quickly as possible.

[0008] The object of the present invention is to provide an equipment assembly, a trailer for the transport and the positioning of said equipment assembly and an operating system comprising said equipment assembly and said trailer by which the aforesaid requirement is fully resolved.

[0009] In particular, this object is achieved by the equipment assembly claimed in claim 1, by the trailer claimed in claim 9 and by the operating system in accordance with claim 14. In addition, this object is also achieved by a method for constructing a by-pass tunnel in accordance with claim 15. The claims dependent thereon show preferred variant embodiments involving further advantageous aspects.

[0010] Further features and advantages of the invention will become apparent from the following description of the preferred examples of embodiment thereof, given by way of non-limiting example, with reference to the accompanying figures wherein:

- Figures 1 and 1a illustrate two schematic views of two twin tunnels and their related by-pass tunnels along a longitudinal cross-sectional plane and a transverse cross-sectional plane;

- Figures 2a and 2b represent an operating system comprising an equipment assembly and a trailer, respectively, wherein the equipment assembly is in a closed configuration and in an open configuration;
- 5 - Figures 3a, 3b, 3c and 3d show cross-sectional views in a closed configuration, a first intermediate configuration, a second intermediate configuration and an open configuration of the operating system along a cross-sectional plane at a main centering;
- 10 - Figures 4a, 4b, 4c and 4d illustrate cross-sectional views in a closed configuration, a first intermediate configuration, a second intermediate configuration and an open configuration of the operating system along a cross-sectional plane at an intermediate centering.
- 15 [0011] In the accompanying figures, an equipment assembly in accordance with the present invention is indicated at reference number 1. A trailer for transporting and positioning the equipment assembly 1 is indicated at reference number 700.
- 20 [0012] A tunnel wherein the equipment assembly 1 is intended to be positioned and is intended to operate is further indicated at number 900. In particular, the tunnel 900 extends along a tunnel axis Z-Z, which is the axis along which the mole excavates. In addition, the
- 25 reference number 950 indicates the vault of the tunnel

950 defined by side walls 955 having a circumferential extension with respect to said tunnel axis Z-Z. Specifically, the vault 950 corresponds to the segmental liner of the tunnel 900.

5 [0013] In the accompanying figures, the by-pass tunnel is indicated at the reference number 990. Said by-pass tunnel extends along the transverse axis Y-Y connecting two twin tunnels 900.

[0014] The equipment assembly 1 of the present invention  
10 extends along a main axis X-X. Said main axis X-X corresponds to the tunnel axis Z-Z when the equipment assembly 1 is inside the tunnel 900.

[0015] The equipment assembly 1 comprises a plurality of longitudinal members 2 that extend parallel to the main  
15 axis X-X and are suitable to engage the side walls 955 of the tunnel 900 parallel to said main axis X-X. In other words, the longitudinal members 2 are suitable to extend along the tunnel 900.

[0016] In accordance with a preferred embodiment, the  
20 longitudinal members 2 have an open section, preferably the longitudinal members have an I-profile.

[0017] In accordance with a preferred embodiment, the equipment assembly 1 comprises a plurality of longitudinal members 2, spaced angularly from each other.

25 [0018] Preferably, the equipment assembly 1 comprises four

longitudinal members 2. In other embodiments, the equipment assembly 1 comprises a greater number of longitudinal members.

[0019] In accordance with the present invention, moreover, the equipment assembly 1 also comprises a plurality of centerings 3 that is positionable in an open configuration wherein they extend circumferentially with respect to the main axis X-X, connecting the longitudinal members 2 to each other.

[0020] In other words, the centerings 3 extend in a circumferential direction, along the entire circumference or along a single circumferential arc, to execute an action of engagement of the side wall 955 in a radial direction. Preferably, the centerings 3 engage the plurality of longitudinal members 2 in the circumferential direction, connecting them to each other.

[0021] In accordance with the present invention, the number of centerings 3 is variable. In particular, embodiments are provided comprising a plurality of centerings 3, axially spaced from each other with respect to the main axis X-X.

[0022] The equipment assembly 1 comprises at least two main centerings 30 respectively at the two axial ends.

[0023] Preferably, the equipment assembly 1 comprises at least two main centerings 30 for each axial end.



[0024] In accordance with the present invention, the main centerings 30, in an open configuration of the equipment assembly 1, extend entirely around the main axis X-X to engage the side wall 955 at 360°. In other words, the  
5 main centerings 30, in the open configuration, are annular, or O-shaped.

[0025] According to the present invention, the equipment assembly 1 comprises at least one intermediate centering 35 positioned axially between the main centerings 30.

10 [0026] Preferably, the equipment assembly 1 comprises at least two intermediate centerings 35.

[0027] In accordance with the present invention, the intermediate centerings 35, in an open configuration of the equipment assembly 1, extend around the main axis X-X  
15 for a circumferential arc. Specifically, the intermediate centerings 35 in open configuration have the shape of a circular segment with a base defining on said base a work opening 9 wherein the side wall 955 is accessible for the execution of the construction operations of a by-pass  
20 tunnel 990. In other words, the intermediate centerings 35 extend along a circumferential arc of approximately 270°. Preferably, an intermediate centering 35, in the open configuration, has an open, or C-shaped.

[0028] Specifically, in accordance with the present  
25 invention, each centering is made up of a plurality of

arch-shaped girder elements, respectively hinged to each other so as to be movable in rotation to be positionable along the circumferential direction.

[0029] Each girder element has, between one end and the other, a box-shaped cross section, preferably a square-shaped cross section. Preferably, hinge portions which allow the mutual engagement are obtained on the ends. Preferably, therefore, the girder elements are characterized by uniform inertia. Preferably, therefore, the girder elements have high inertia, for example compared to the inertia of open section girder elements.

[0030] In particular, each main centering 30 comprises main girder elements 300 having an arched shape, mutually hinged to each other in such a way that they are positionable in mutual rotation in the shape of a circular segment on a base comprising a main tail end 301 and a main head end 302. In other words, said main girder elements 300 are positionable, guiding their respective relative rotation, in the C-shaped tunnel 900.

[0031] In accordance with the present invention, moreover, each main centering 30 comprises an auxiliary girder element 300' engageable on the main tail end 301 and the main head end 302, so that the positioning of the main girder elements 300 and the engagement with the auxiliary girder element 300' make up the main circular-shaped

centering 30 suitable to engage circularly the entire side wall 955. In other words, the auxiliary girder element 300' is suitable to close the "base" of the circular segment at a base along which the main girder elements 300 extend in an open configuration.

[0032] In particular, in accordance with a preferred embodiment, the main girder elements 300 of each main centering 30 comprise a first main girder element 300a connecting two longitudinal members 2 and second main girder elements 300b positioned hinged at the ends of the first main girder element 300a and movable in rotation with respect thereto.

[0033] In other words, said first main girder element 300a is suitable to be positionable on the side wall 955 while the second main girder elements 300b are movable in rotation therefrom.

[0034] In accordance with some preferred embodiments, on the same side there is also a plurality of second main girder elements 300b hinged together consecutively and suitable to be moved in mutual rotation.

[0035] According to a preferred embodiment, each main centering 30 comprises handling members 30m suitable to carry out an action of opening/closing in rotation between some main girder elements 300.

[0036] In accordance with a preferred embodiment, the

handling members 30m comprise a hydraulic piston handling device having the ends connected to two consecutive main girder elements 300.

[0037] In other words, two consecutive main girder elements  
5 300 are moved in rotation on hydraulic control by means of the handling devices 30m.

[0038] In accordance with a preferred embodiment, each auxiliary girder element 300' comprises a thrust member 300s' suitable to carry out a thrust action in a  
10 circumferential direction between the main tail end 301 and the main head end 302 to adjust and ensure the action of circumferential engagement of the respective main centering 30 with the side wall.

[0039] In other words, the thrust member 300s' carries out  
15 an action by which the correct (i.e. perfectly circumferential) engagement of the main centering 30 is achieved with the side wall portion 955. Due to the thrust member 300s', any dimensional discrepancies between the side wall 955 and the main centering 30 are  
20 recovered.

[0040] Preferably, each thrust member 300s' is suitable to carry out a different thrust action depending on the needs of the respective main centering 30 and depending on the shape of the corresponding side wall portion 955.

25 [0041] In accordance with a preferred embodiment, each

thrust member 300s' comprises a thrust piston device preferably having one end that engages the tail end 301 or head end 302 while the other end engages the auxiliary girder element 300'.

5 [0042] According to a preferred embodiment, the thrust member 300s' comprises a mechanical stop suitable to lock the position reached, keeping it fixed and constant over time. In this way, the circumferential thrust action of the main centering 30 is maintained over time, avoiding  
10 the need to keep the hydraulic thrust action of the thrust member 300s' constant.

[0043] In accordance with a preferred embodiment, said mechanical stop is a threaded ring operating on the rod of the piston thrust device, wherein the positioning of  
15 the threaded ring prevents further displacement of the rod.

[0044] Preferably, the piston thrust device is sized so as to be suitable to withstand the action of the tunnel walls in the same way in which the girders are suitable  
20 for doing so. In other words, the rod and liner of the piston thrust device are suitable to support the same effort as the other components.

[0045] As described in reference to the main centerings 30, also each intermediate centering 35 comprises arch-shaped  
25 intermediate girder elements 350. The intermediate girder

elements 350 are mutually hinged together in such a way that they is positionable in mutual rotation in the shape of a circular segment on a base comprising an intermediate tail end 351 and an intermediate head end 352. In other words, the intermediate girder elements 350 are positionable, guiding their respective relative rotation, in the C-shaped tunnel 900.

[0046] The intermediate girder elements 350 thus circularly engage a section of the side wall 955. Between the intermediate tail end 351 and the intermediate head end 352 is defined the work opening 9 wherein the side wall 955 is accessible for the execution of the operations for constructing a by-pass tunnel 990.

[0047] Preferably, respective longitudinal members 2 are found at the intermediate tail end 351 and the intermediate head end 352.

[0048] Again, as described with reference to the main centerings 330, the intermediate girder elements 350 of each intermediate centering 35 comprise a first intermediate girder element 350a connecting in turn said two longitudinal members 2 and second intermediate girder elements 350b positioned hinged to the ends of the first intermediate girder element 350a, movable in rotation with respect thereto.

[0049] In other words, said first intermediate girder

element 350a is suitable to be positioned on the side wall 955, while the second intermediate elements 350b are movable in rotation starting therefrom.

[0050] In accordance with some preferred embodiments, on the same side there is also a plurality of second intermediate girder elements 350b hinged together consecutively and suitable to be moved in mutual rotation.

[0051] According to a preferred embodiment, each intermediate centering 35 comprises handling members 35m suitable to execute an action of opening/closing in rotation between some intermediate girder elements 350.

[0052] In accordance with a preferred embodiment, the handling members 35m comprise a hydraulic piston handling device with the ends connected to two consecutive intermediate girder elements 350.

[0053] In other words, by means of the handling devices 35m, two consecutive intermediate girder elements 350 are moved in rotation on hydraulic control.

[0054] In accordance with the present invention, each movement of the respective axially aligned components is carried out at the same time. In other words, the rotary movements of the main girder elements of the main centerings and the intermediate girder elements of the intermediate centerings described above are carried out

simultaneously in such a way as to induce a planar translation movement in the respective longitudinal members 2 connected axially by said centerings.

[0055] In accordance with the above, according to a preferred embodiment, the aforesaid movements are all hydraulically controlled.

[0056] The subject of the present invention is also a trailer 700 suitable to transport and position the equipment assembly 1 described above.

[0057] In particular, the trailer 700 comprises a support structure 750 whereon the equipment assembly 1 is houseable in a closed configuration.

[0058] In addition, the trailer 700 comprises handling groups 755 housed on the support structure and suitable to allow the handling thereof in the tunnel 900.

[0059] Preferably, said handling groups 755 comprise multidirectional wheel groups.

[0060] Preferably, said handling groups 755 are drive groups. Preferably, said handling groups 755 are electrically driven, each controlled by a respective electric motor comprised in the respective handling group 755.

[0061] According to a preferred embodiment, the drive groups are controllable remotely, for example they are telecontrolled.



[0062] In accordance with a preferred embodiment, the support structure 750 comprises two axially spaced portal elements 751, preferably in the shape of an inverted U. The handling groups 755 are located at the feet of said  
5 portal elements 751. Preferably, therefore, said portal elements 751 define a region of passage at the center, wherein, for example, vehicles and people may pass.

[0063] In accordance with a preferred embodiment, the support structure 750 comprises a lattice girder frame  
10 752 suitable to join the two portal elements. Preferably, the support structure is positioned in a high position, not occupying or occupying as little as possible the region of passage.

[0064] In particular, on the trailer 700 (in particular by  
15 means of the trailer 700) the first positioning operations of the equipment assembly 1 are also carried out.

[0065] The trailer 700 comprises, in effect, positioning means 780, preferably comprising a plurality of hydraulic  
20 piston positioning devices, is houseable on the support structure 750 and engaging the equipment system 1 to move the main centerings 30 and the intermediate centerings 35 between a closed configuration and an open configuration (or at least an intermediate open configuration),  
25 engaging the side walls 955 of the tunnel 900. In

particular, the positioning means 780 are suitable to move the main girder elements 300 and the intermediate girder elements 350.

[0066] For example, in accordance with a preferred  
5 embodiment, the positioning means 780 comprise axial handling members 780a suitable to guide axially, in a radial direction with respect to the main axis X-X, the first main girder elements 300a and the first intermediate girder elements 350a.

10 [0067] In addition, the positioning means 780 comprise rotary handling members 780b suitable to guide the second main girder elements 300b and the second intermediate girder elements 350b in rotation.

[0068] In other words, in accordance with a preferred  
15 embodiment, in the passage between the closed configuration and the open configuration of the equipment assembly 1, the positioning means 780 are suitable to execute a first action in a radial direction wherein the main centerings 30 and the intermediate centerings 35 are  
20 brought to engage the side walls 955 of the tunnel 900, and a second action wherein some main girder elements 300 and some intermediate girder elements 350 are moved in mutual rotation in such a way as to obtain the engagement of the main centerings 30 and the intermediate centerings  
25 35 with the side wall 955 along a circular segment on a

base. Subsequently, the auxiliary girder elements 300' may be assembled to complete the main centerings 30.

[0069] In accordance with a preferred embodiment, said positioning means 780 comprise specific hydraulic  
5 positioning devices, for example comprising telescopic arms or piston elements specifically engaging their respective components.

[0070] According to a preferred embodiment, the trailer 700 also comprises a vehicle-accessible element 790 for the  
10 passage of work vehicles.

[0071] In particular, the trailer 700 is suitable to transport and position also said vehicle-accessible element 790 in the tunnel 900; said vehicle-accessible element comprises, at its axial ends, two ramp elements,  
15 and a walkway joining them. On the vehicle-accessible element the work vehicles may pass, for example in a situation wherein the assembly equipment 1 is in an open configuration avoiding contact with the components of the assembly equipment 1 engaging the side walls 955.

[0072] The subject of the present invention is an operating  
20 system comprising a trailer 700 as described above and an equipment assembly 1 as described above. Through the operating system by means of the trailer 700, the assembly equipment 1 is transported, moved and positioned  
25 within the tunnel 900. In accordance with the above, the

equipment assembly 1 is easily moved and configured in its open configuration wherein the construction operations of the by-pass tunnel 900 may be carried out through the work opening 9.

5 [0073] In addition, the present invention also concerns a method for the construction of a by-pass tunnel 990 for connecting two twin tunnels 900 comprising the step of excavating a by-pass tunnel 990 at the same time as the operations, along the tunnel axis Z-Z, for the execution  
10 of the tunnel 900.

[0074] In accordance with a preferred embodiment the method comprises the steps of inserting in a tunnel 900 an equipment assembly 1, in accordance with that which is described above, configuring it in an open configuration  
15 engaging the side walls 955 of said tunnel 900 and carrying out the excavation operations through the work opening 9 defined by the equipment assembly 1 in its engagement of the side wall 955.

[0075] Innovatively, the equipment assembly, trailer, operating system and method of implementation described  
20 above largely fulfill the object of the present invention by overcoming the typical problems of the prior art.

[0076] Advantageously, in effect, it is possible to optimize the construction time of a large work that  
25 provides for the construction of twin tunnels and related

by-pass tunnels, it being possible to construct said by-pass tunnels during the execution of the main tunnels.

[0077] Advantageously, the equipment assembly is insertable into the tunnel and positionable in an open configuration  
5 of engagement of the tunnel vault with simple and intuitive operations.

[0078] Advantageously, the equipment assembly in the closed configuration is housed on the trailer and is easily transportable.

10 [0079] Advantageously, the equipment assembly may be sized according to the size of the tunnel, however, advantageously, the operating principles described above are valid regardless of the size and measurements of the various components.

15 [0080] Advantageously, the equipment assembly remedies the need to mount special scaffolding or framing to be positioned in the tunnel.

[0081] Advantageously, due to the equipment of the present invention, the vault of the tunnel remains substantially  
20 intact and is not damaged: unlike what happens with the equipment of the state of the art that is in effect flanged and fixed to the wall of the tunnel by means of special pins inserted in the liner.

[0082] Advantageously, the equipment assembly is removable  
25 from the tunnel walls (i.e. it may be configured in a

closed position) for reuse. Advantageously, the equipment assembly may be used along the same tunnel for the construction of subsequent by-pass tunnels.

[0083] Advantageously, the equipment assembly has a  
5 positioning time (assembly) that is much shorter than the positioning time (assembly) of the equipment in the state of the art.

[0084] Advantageously, the box-shaped girder elements ensure a high inertia of said components combined with  
10 great lightness relative to girder elements of equal inertia.

[0085] Advantageously, the thrust member is suitable to carry out a thrust action suitable to ensure over time the burden of the action of the weight force supported by  
15 the tunnel walls (even during drilling operations of the by-pass tunnel).

[0086] Advantageously, the open configuration of the equipment assembly is maintained mechanically; in other words, the open configuration of the equipment assembly  
20 is maintained safely over time.

[0087] Advantageously, the trailer comprises all the components and related systems that guide the handling of the equipment.

[0088] It is clear that a person skilled in the art, in  
25 order to meet contingent needs, could make changes to the

equipment assembly, the trailer, the operating system and implementation method all contained within the scope of protection defined by the following claims.

**CLAIMS**

1. An equipment assembly (1) suitable to engage a vault (950) of a tunnel (900) engaging the side walls (955) defining the vault (950), wherein the tunnel (900) extends in length along a tunnel axis (Z-Z) and the side walls (955) extend circumferentially with respect to said tunnel axis (Z-Z), wherein the equipment assembly (1) extends along a main axis (X-X) suitable to correspond with the tunnel axis (Z-Z), comprising:
- 10       - a plurality of longitudinal members (2) extending parallel to the main axis (X-X);
- a plurality of centerings (3) positionable in an open configuration wherein they extend circumferentially with respect to the main axis (X-X), connecting the
- 15 longitudinal members (2) to each other, comprising:
- i) main centerings (30) positioned at the axial ends of the equipment assembly (1), wherein each main centering (30) comprises:
- main girder elements (300) with an arched shape,
- 20 reciprocally hinged to each other in such a way as to be positionable in mutual rotation in the shape of a circular segment on a base comprising a main tail end (301) and a main head end (302);
- an auxiliary girder element (300') engageable at
- 25 the main tail end (301) and at the main head end (302),



in such a way that the positioning of the main girder elements (300) and their engagement with the auxiliary girder element (300') compose the circular main centering (30) which circumferentially engages the entire side wall (955);

5 ii) at least one intermediate centering (35) positioned axially between the main centerings (30) comprising:

- intermediate girder elements (350) with an arched shape, wherein the intermediate girder elements (350) are mutually hinged to each other in such a way as to be positionable in mutual rotation in the shape of a circular segment on a base comprising an intermediate tail end (351) and an intermediate head end (352) composing the intermediate centering (35) engaging a section of the side wall (955), defining a work opening (9) wherein the side wall (955) is accessible for carrying out the operations of constructing a by-pass tunnel (990).

2. Equipment assembly (1) in accordance with claim 1, comprising at least two intermediate centerings (35).

3. Equipment assembly (1) in accordance with any one of the preceding claims, comprising at least two main centerings (30) for each axial end.

4. Equipment assembly (1) in accordance with any one of the preceding claims, wherein:

- the main girder elements (300) of each main centering (30) comprise a first main girder element (300a) connecting two longitudinal members (2) and second main girder elements (300b) positioned hinged at the ends of the first main girder element (300a) movable in rotation with respect thereto;

- wherein the intermediate girder elements (350) of each intermediate centering (35) comprise a first intermediate girder element (350a) connecting in turn said two longitudinal members (2) and second intermediate girder elements (350b) positioned hinged to the ends of the first intermediate girder element (350a) movable in rotation with respect thereto.

5. Equipment assembly (1) in accordance with any one of the preceding claims, wherein each auxiliary girder element (300') comprises a thrust member (300s'), preferably comprising a hydraulic piston thrust device, suitable to perform a thrust action in a circumferential direction between the main tail end (301) and the main head end (302) to adjust and ensure the action of circumferential engagement of the respective main centering (30) with the side wall (955).

6. Equipment assembly (1) in accordance with claim 5, wherein the thrust member (300s') comprises a mechanical stop suitable to lock and maintain fixed and constant the

circumferential thrust action of the respective main centering (30) holding the position reached over time.

7. Equipment assembly (1) in accordance with any one of the preceding claims, wherein each main centering (30) and each intermediate centering (35) comprises handling members (30m, 35m), preferably comprising a hydraulic piston handling device, operating respectively between two consecutive main girder elements (300) or between two consecutive intermediate girder elements (350), to perform a rotary opening/closing action.

8. Equipment assembly (1) in accordance with any one of the preceding claims, wherein each main girder element (300), each intermediate girder element (300'), and each intermediate girder element (350), between one end and the other, have a box-shaped cross-section.

9. Trailer (700) for the transport and positioning of an equipment assembly (1) in accordance with any one of the preceding claims, being suitable to transport and handle said equipment assembly inside a tunnel (900) and being suitable to perform at least part of the operations of positioning the equipment assembly (1) in the tunnel (900), wherein the trailer (700) comprises:

- a support structure (750) whereon the equipment assembly (1) is houseable in a closed configuration;
- handling groups (755) housed on the support

structure and suitable to permit the handling thereof in the tunnel (900), for example comprising multidirectional and drive wheel groups.

10. Trailer (700) in accordance with claim 9, comprising:

5       - positioning means (780), preferably comprising a plurality of hydraulic piston positioning devices, housed on the support structure (750) and engaging the equipment assembly (1) to move the main centerings (30) and the intermediate centerings (35), in particular the main  
10 girder elements (300) and intermediate girder elements (350), between a closed configuration and an open configuration engaging the side walls (955) of the tunnel.

11. Trailer (700) in accordance with claim 10, wherein,  
15 in the positioning between the closed configuration and the open configuration of the equipment assembly (1), the positioning means (780) perform a first action in a radial direction wherein the main centerings (30) and the intermediate centerings (35) are brought to engage the  
20 side walls (955) of the tunnel (900), and a second action wherein respective main girder elements (300) and respective intermediate girder elements (350) are moved in reciprocal rotation in such a way as to obtain the engagement of the main centerings (30) and the  
25 intermediate centerings (35) with the side wall (955)

along a circular segment on a base.

12. Trailer (700) in accordance with any one of claims 9 to 11, wherein the support structure (750) comprises:

- two portal elements (751), preferably in the shape  
5 of an inverted U, axially spaced in such a way as to support the handling groups (755);

- a lattice girder frame (752) suitable to join the two portal elements (751).

13. Trailer (700) in accordance with any one of claims 9  
10 to 12, comprising:

- a vehicle-accessible element (790) whereon the work vehicles pass, being positionable at the bottom of the tunnel (900).

14. Operating system comprising:

15 - a trailer (700) in accordance with any one of claims 9 to 13;

- an equipment assembly (1) in accordance with any one of claims 1 to 8.

15. Method of construction of a by-pass tunnel (990) for  
20 the connection of two twin tunnels (900) comprising the steps of:

- inserting into a tunnel (900) an equipment assembly in accordance with any one of claims 1 to 8 by configuring it in an open configuration engaging the side  
25 walls (955) of said tunnel (900);

- carrying out excavation operations through the work opening (9);

wherein the preceding steps are executable simultaneously with the excavation operations along the tunnel axis (Z-

5 Z).

16. Method of construction of a by-pass tunnel (990) in accordance with claim 12, wherein the steps of insertion and relative positioning of an equipment assembly (1) are performed by means of a trailer (700) in accordance with

10 any one of claims 9 to 13.

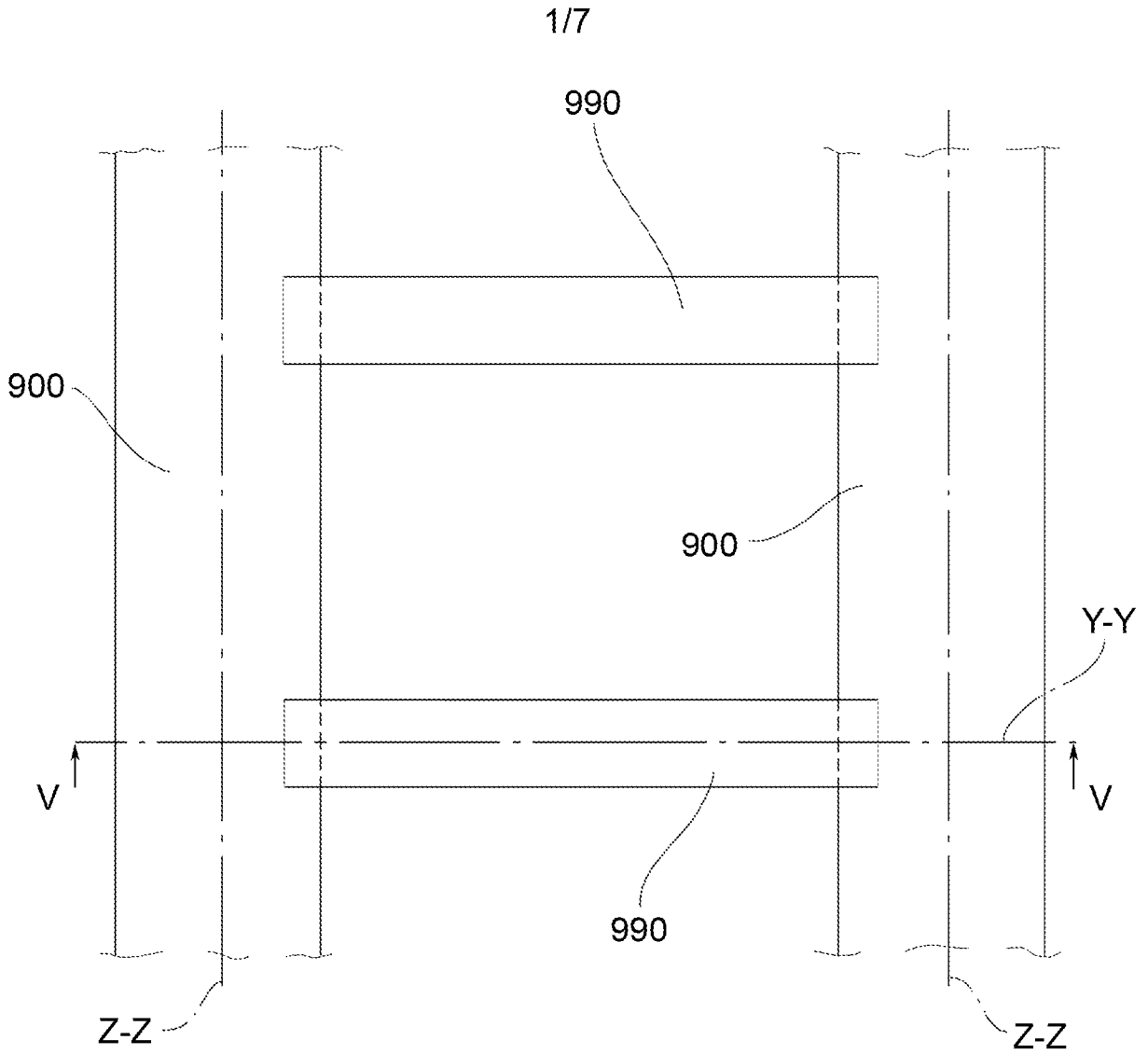


FIG. 1

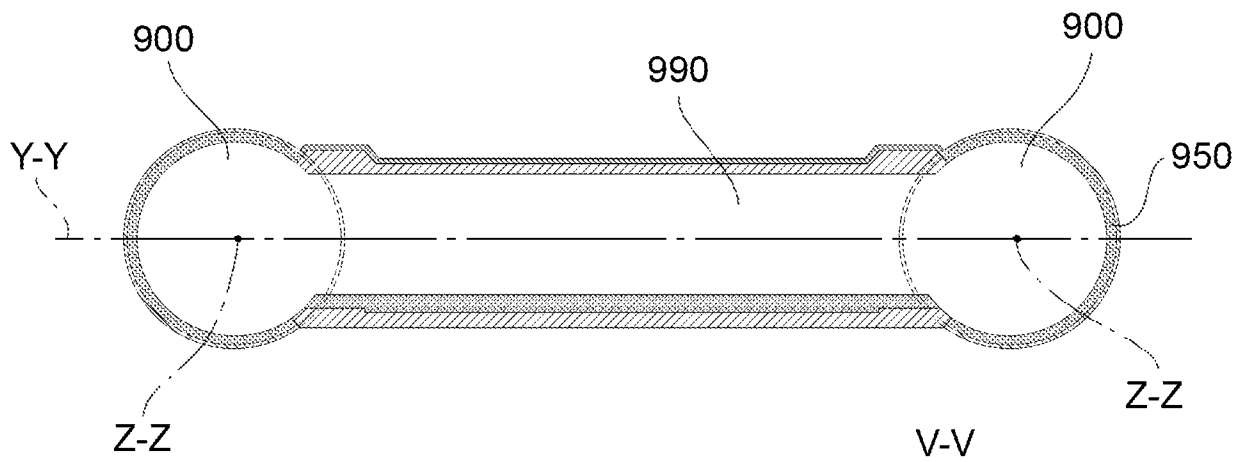


FIG. 1a

2/7

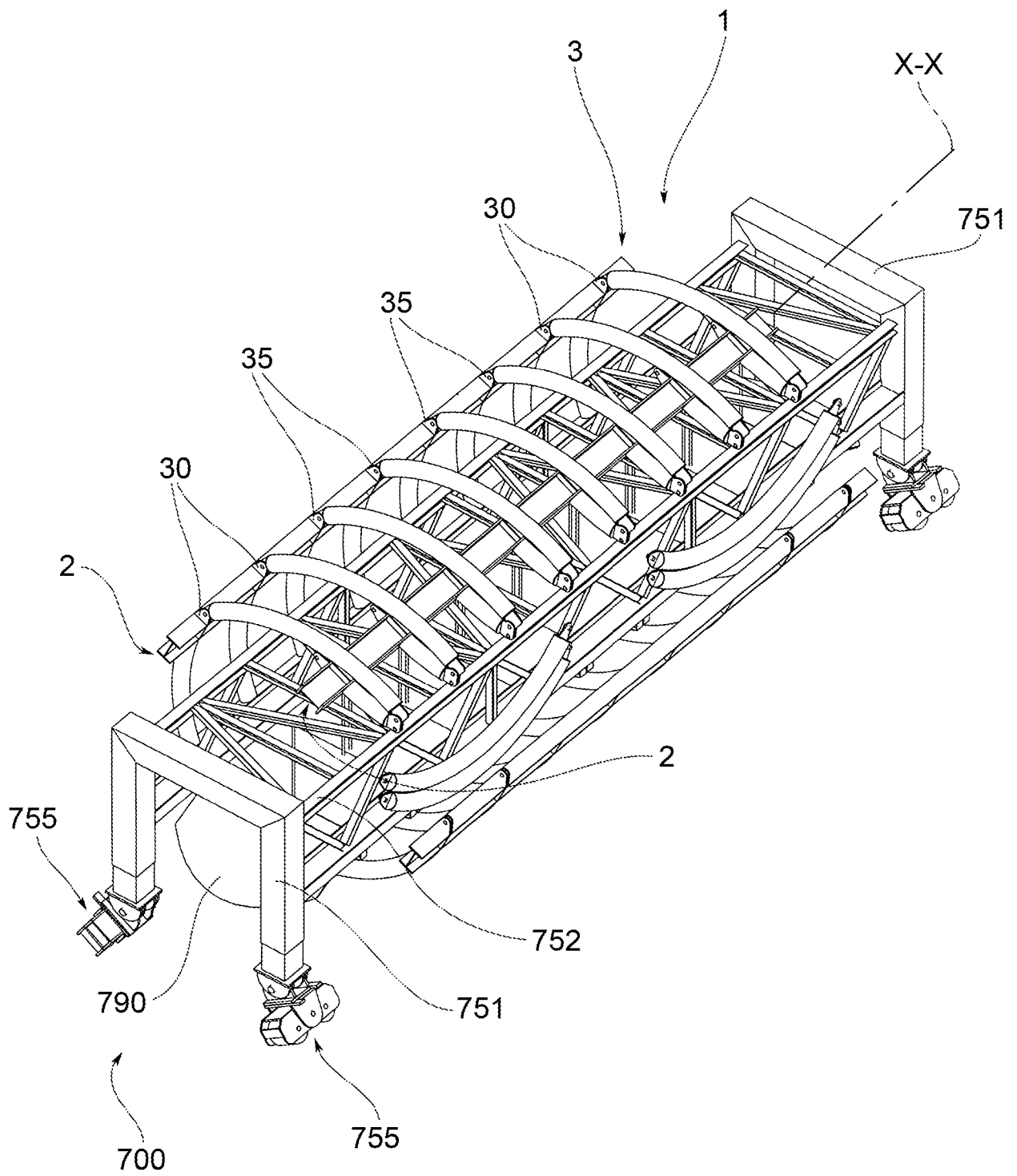


FIG.2a



3/7

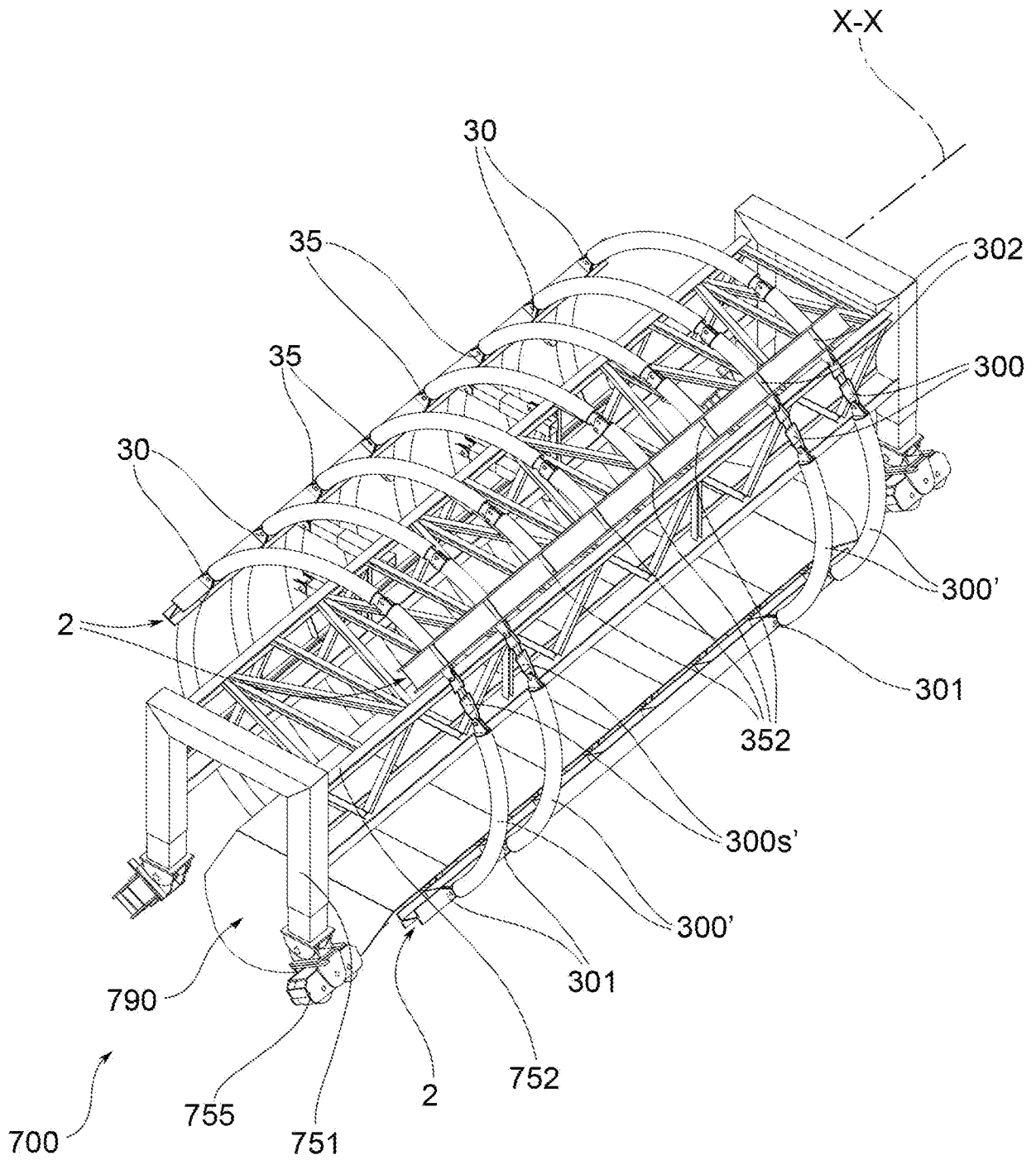


FIG.2b

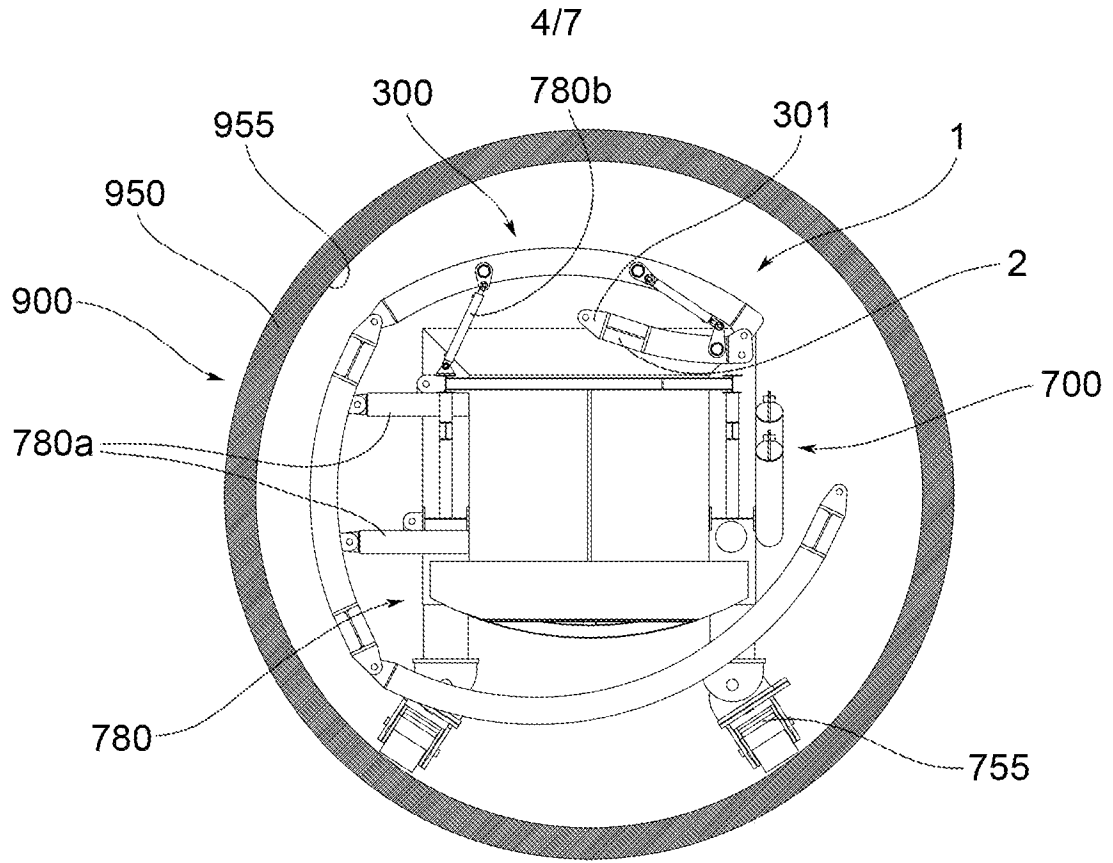


FIG. 3a

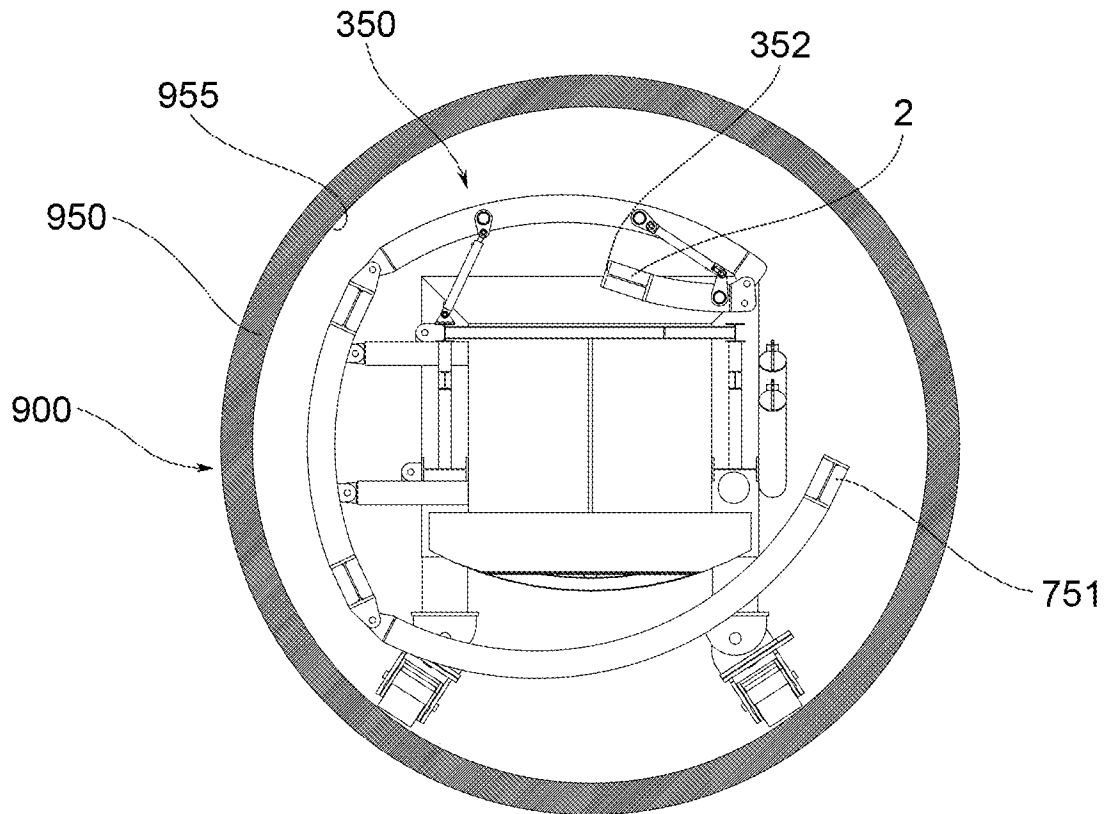


FIG. 4a

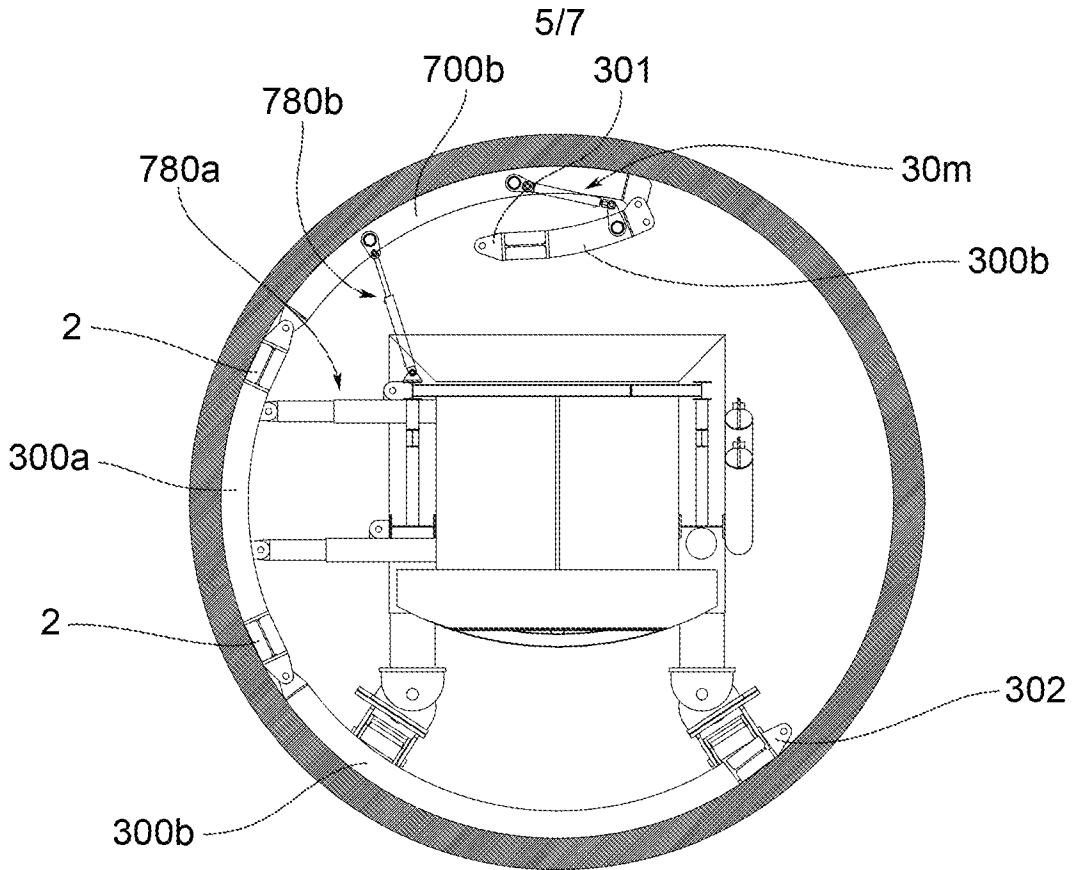


FIG. 3b

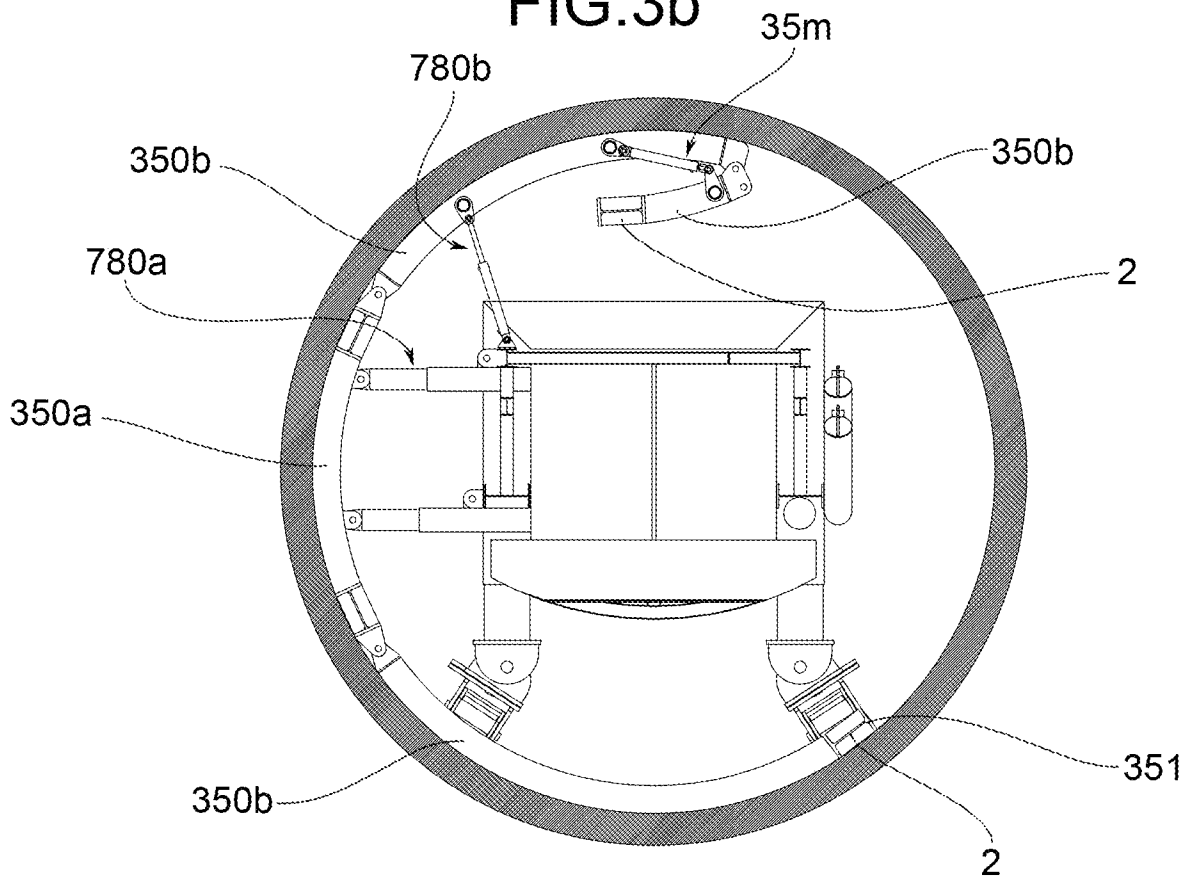


FIG. 4b

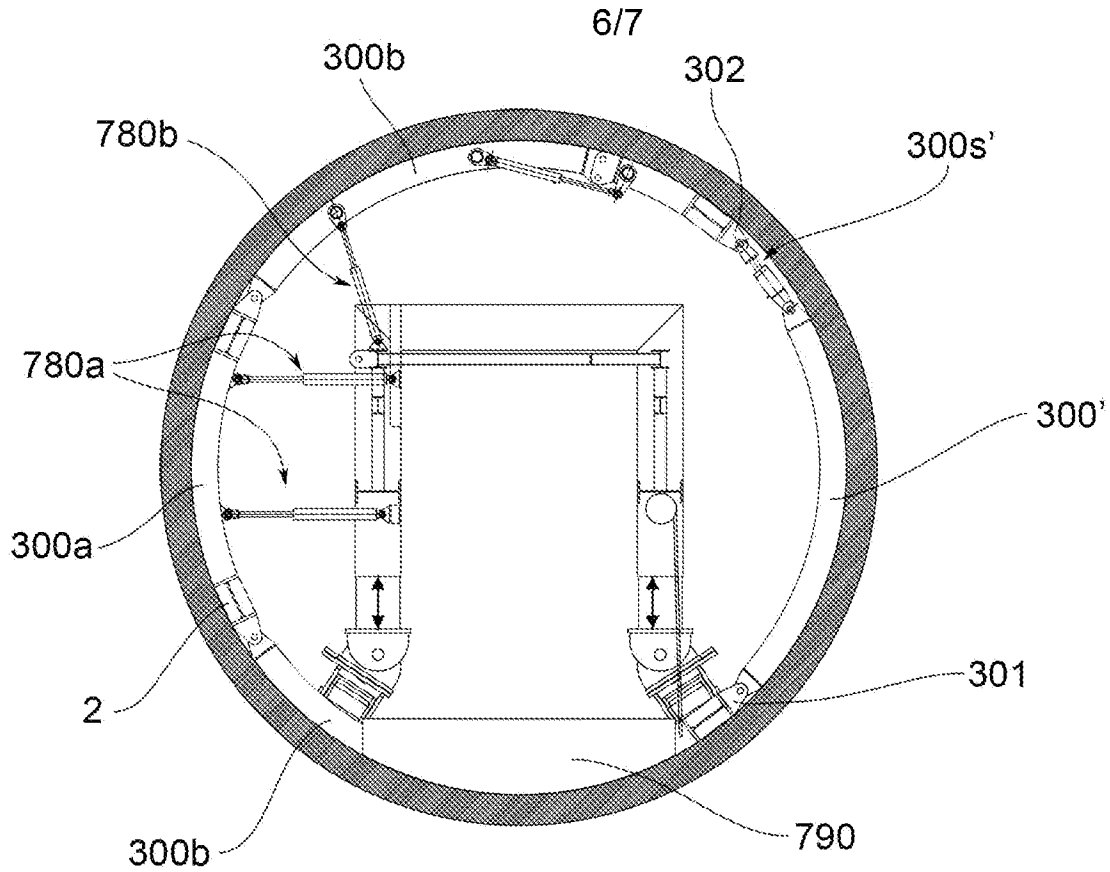


FIG. 3c

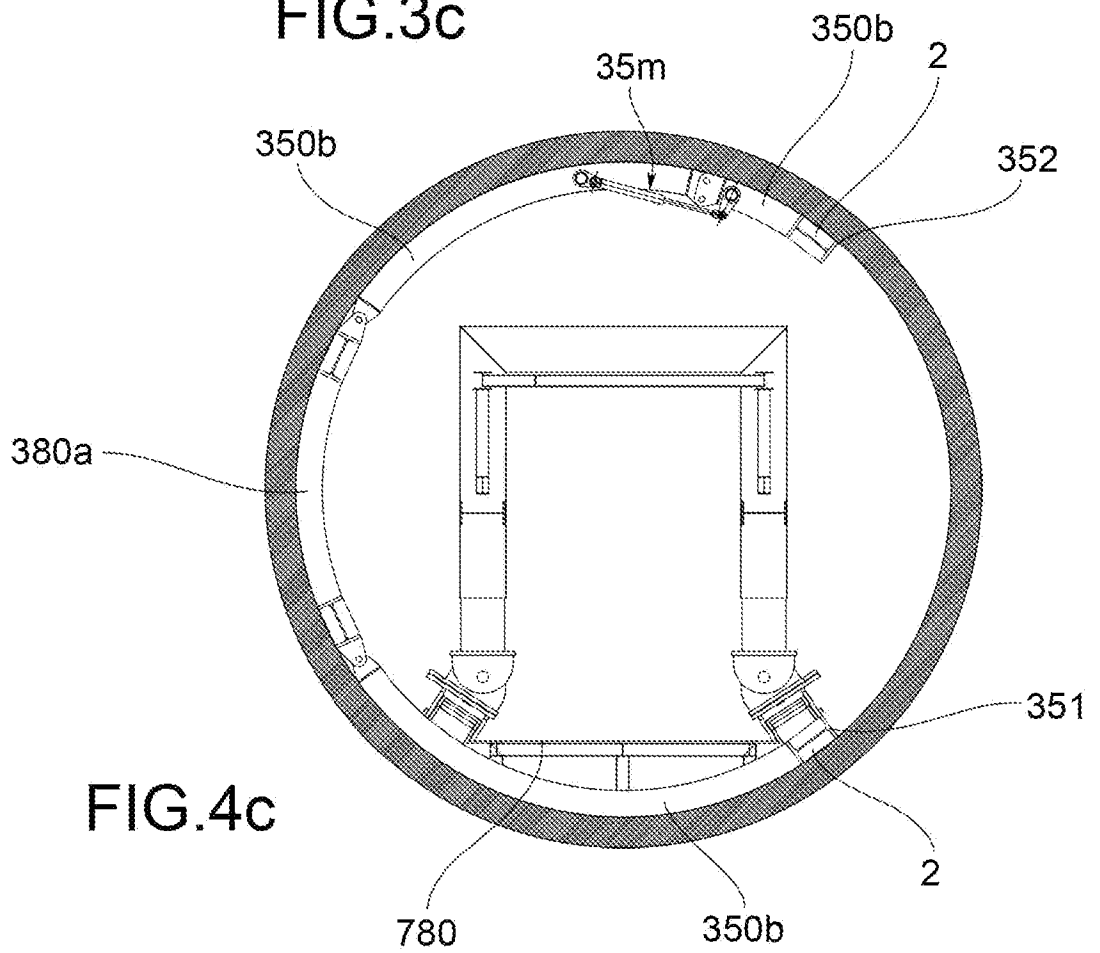


FIG. 4c

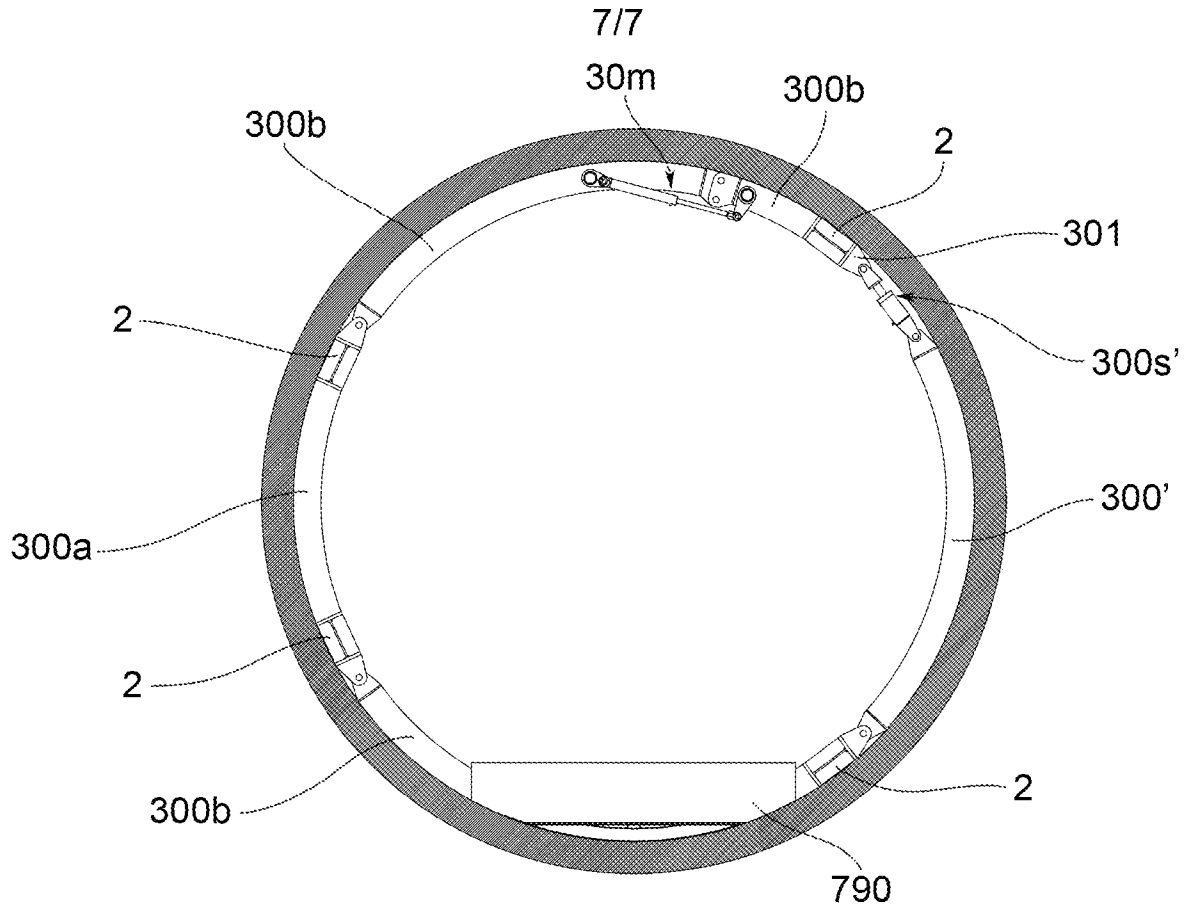


FIG. 3d

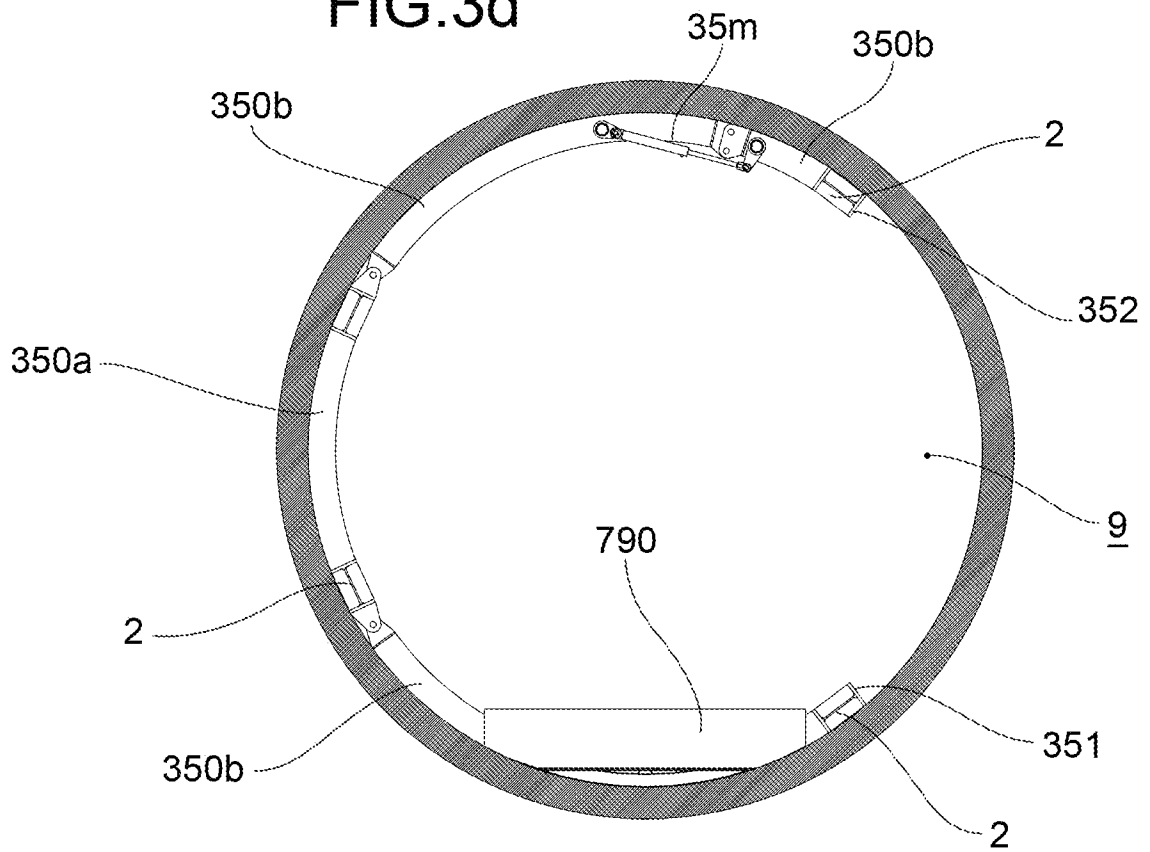


FIG. 4d

INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2019/056096

A. CLASSIFICATION OF SUBJECT MATTER  
INV. E21D11/18 E21D11/40 E21D9/00 E21D11/24  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
E21D  
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/186029 A2 (ELAS GEOTECNICA SRL [IT]) 10 December 2015 (2015-12-10) figures 19-23 -----	1-14
X	EP 3 225 778 A1 (CP TECH S R L [IT]) 4 October 2017 (2017-10-04) figures 4-10 -----	1-14
X	EP 1 136 650 A1 (MECSIDER S P A [IT]) 26 September 2001 (2001-09-26) figures -----	9-13
A	JP 2009 121158 A (SHIMIZU CONSTRUCTION CO LTD; HITACHI SHIPBUILDING ENG CO) 4 June 2009 (2009-06-04) figures 2,8-10 ----- -/--	1,15

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search  9 October 2019	Date of mailing of the international search report  18/10/2019
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Maukonen, Kalle

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/IB2019/056096

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/087311 A2 (SWS ENGINEERING S P A [IT]; PALMIERI S P A [IT]) 18 June 2015 (2015-06-18) figures	1,15
A	----- WO 2018/082714 A1 (CHINA RAILWAY ENGINEERING EQUIPMENT GROUP CO LTD [CN]) 11 May 2018 (2018-05-11) figures 1,6,7,11 -----	1,15

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2019/056096
---

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015186029	A2	10-12-2015	AU 2015270177 A1 12-01-2017 BR 112016028327 A2 22-08-2017 CA 2949446 A1 10-12-2015 CL 2016003125 A1 20-10-2017 CN 106795766 A 31-05-2017 EP 3152399 A2 12-04-2017 PE 05962017 A1 28-05-2017 SG 11201609645Y A 29-12-2016 US 2017096895 A1 06-04-2017 WO 2015186029 A2 10-12-2015
EP 3225778	A1	04-10-2017	NONE
EP 1136650	A1	26-09-2001	EP 1136650 A1 26-09-2001 IT T020000282 A1 24-09-2001
JP 2009121158	A	04-06-2009	JP 4986819 B2 25-07-2012 JP 2009121158 A 04-06-2009
WO 2015087311	A2	18-06-2015	CA 2933655 A1 18-06-2015 DK 3080395 T3 26-08-2019 EP 3080395 A2 19-10-2016 US 2016319664 A1 03-11-2016 WO 2015087311 A2 18-06-2015
WO 2018082714	A1	11-05-2018	AU 2017353067 A1 20-06-2019 CN 106437735 A 22-02-2017 WO 2018082714 A1 11-05-2018