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(54) Road tunnel and method for building same

(57) The invention relates to a road tunnel (1) with one or more traffic lanes (4), wherein each traffic lane is arranged in a separate tunnel tube (3), which is adapted in cross-sectional form and dimensions to a single vehicle. The tunnel tube (3) can herein have a round cross section and be manufactured from steel. Such a tunnel is structurally simple and can be built at low cost and in a short time.

The invention further relates to a method for build-

ing a road tunnel (1) by forming at a chosen location a number of trenches corresponding with the desired number of traffic lanes (4), manufacturing a number of tunnel tubes (3) corresponding with the desired number of traffic lanes (4) and arranging the corresponding tunnel tubes (3) in the trenches. The tunnel tube (3) can herein be constructed by mutually connecting a plurality of tunnel tube segments (13) which are manufactured at a different location, transported to the trench and there connected to each other.

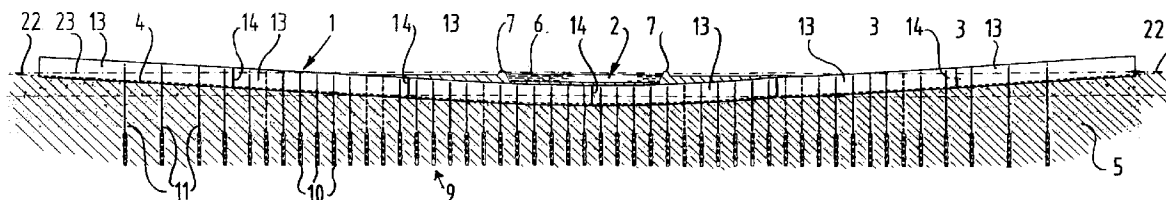


FIG.1

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Description

The invention relates to a road tunnel with one or more traffic lanes. Such road tunnels are generally known.

The known road tunnels generally consist of a tunnel body of for instance concrete, in which a road surface with a number of traffic lanes is arranged. The traffic lanes running in opposite direction are herein generally separated from each other by means of a dividing wall. In countries with a soft ground, such as the Netherlands, such tunnels are generally constructed at a chosen location by forming, damming and draining an excavation, into which the concrete tunnel body with the different traffic lanes therein is then cast. However, the known tunnel and the method for construction thereof have a number of drawbacks. For one thing, the known tunnel is structurally complicated and the building thereof is therefore time-consuming and expensive. Because the building moreover takes place in an excavation closed off by dam walls, the traffic on the route crossed by the tunnel will be subjected to prolonged disruption by the construction operations. Furthermore, as a result of the high building costs of conventional tunnels the financing thereof is difficult for government authorities to realize. While attempts are made to find solutions therefor in the form of joint public and private financing, a problem here is that the interests of the government authority responsible for the general road system and the private partner responsible for the specific tunnel are often in conflict, whereby it is difficult to set up such financial constructions.

There is therefore a need for a road tunnel which is structurally simple and which can be built at low cost and in a relatively short time. According to the invention this is achieved in the case of a road tunnel with one or more traffic lanes in that each traffic lane is arranged in a separate tunnel tube, the form and dimensions of the cross section of which are adapted to those of a single vehicle. By making use of one tunnel tube per traffic lane a relatively light and material-saving construction is obtained, which moreover requires little excavation work for the placing thereof.

Preferred embodiments of the tunnel according to the invention form the subject-matter of the dependent claims 2-8.

The invention also relates to a method for building a road tunnel of the above described type. Such a method is characterized according to the invention by forming at a chosen location a number of trenches corresponding with the desired number of traffic lanes, manufacturing a number of tunnel tubes corresponding with the desired number of traffic lanes and arranging the corresponding tunnel tube in the or each trench. With such a method a road tunnel can be laid rapidly, at low cost and with minimal inconvenience for the traffic on a route intersected by the tunnel.

Preferably applied variants of the method according

to the invention are described in the dependent claims 11 to 13.

The invention will now be elucidated on the basis of a number of embodiments, wherein reference is made to the annexed drawing, in which:

fig. 1 shows a partly cross-sectional side view of a tunnel according to a first embodiment of the invention,

fig. 2 shows a view corresponding with fig. 1 of a tunnel according to a second, shorter embodiment of the invention,

fig. 3 shows a cross section of a tube of the tunnel during building thereof,

fig. 4 is a cross section of a tunnel according to the invention with two tubes, and

fig. 5 is a cross section of one of the tunnel tubes shown in fig. 4 having therein the profile of the free space.

A road tunnel 1 (fig. 1) which is intended to guide the traffic on a road 22 from the one side 7 to the other side of an intersecting traffic route, for instance a waterway 2, is provided with a plurality of traffic lanes 4. Each traffic lane 4 is herein arranged in a separate tunnel tube 3 (fig. 4), which in cross section substantially corresponds in respect of form and dimensions with the form and dimensions of a single vehicle 15. Although the sectional shape of tunnel tube 3 approaches that of a standard vehicle 15, it is preferably as round as possible, since in this manner a strong and rigid construction is obtained with a minimal use of material and therefore minimal weight. Because a separate tube 3 is available for each traffic lane 4, a round cross-sectional shape can in any case be used in efficient manner since the width and height of the largest vehicles making use of the tunnel will be reasonably similar. The wasted space 17 in a tunnel tube 3 is therefore considerably smaller than if such a tube with round cross section would have to be adapted in dimensions to a double traffic lane. Each tunnel tube 3 is constructed from a plurality of segments 13 which are mutually connected by means of flexible couplings 14. Concertina-like folded tube sections can for instance serve as flexible couplings 14. Flexible couplings 14 absorb deformations of tunnel tube 3 resulting from lengthening and shortening of the segments 13 due to temperature influences, loads and the like. Tube segments 13, which can for instance be manufactured from steel or concrete, have a length such that they can be manufactured relatively simply at a different location, for instance in a factory, and can be subsequently transported to the site where tunnel 1 is being built. It is believed that segments 13 with a length of about 40 m will serve the purpose well in practice. Although as stated the segments 13 can be manufactured from any suitable material, it would seem likely that steel is to be recommended in respect of the relatively low own weight of steel segments 13. This has advantages in terms of

transport, while a low weight moreover considerably simplifies working of the ground in the vicinity of the tunnel 1. Because tunnel 1 is in any case constructed from segments 13 with an optimum cross-sectional shape in terms of strength and rigidity, it will be possible to give the tunnel so light a construction that it "floats" in the ground. The earth stresses in the ground will therefore remain relatively low and no complex foundation constructions are necessary. Placing of the tunnel segments can therefore also take place relatively simply, since they do not have to be arranged precisely on a foundation, while sand fill underneath the tunnel will also be unnecessary. It is however necessary to anchor tunnel tube 3 against upward displacement. For this purpose anchoring means 9 are present, in the shown embodiment in the form of tie anchors 10 which are arranged in the ground 5 and connected to tunnel tube 3 by means of traction cables or rods 11. Tunnel tube 3 is provided for this purpose with protrusions 12 (fig. 3) to which the traction cables or rods can be fastened. Due to the substantially round cross-sectional shape of tunnel tube segments 13 the rigidity thereof will be relatively great, whereby loads on the tunnel are spread over a relatively great length. Moreover, because of this shape, the use of transverse or longitudinal reinforcements is not necessary, whereby the construction is further simplified and maintenance can also take place relatively simply as a result of the smooth inner and outer wall of tube segments 13.

At the ends of the tunnel where the own weight of tunnel 1 becomes greater at a determined point than the buoyant effect, it is necessary to provide earth fill under tunnel 1. Because the ground stresses remain low, it will generally not be necessary to compact the earth fill. Where this is necessary however, it can be performed in simple manner, since this occurs close to the tunnel ends, which are of course not located at depth. The tunnel ends will in any case have to continue to above ground level 23, in respect of the watertightness of tunnel 1. The part 23 protruding above ground level 23 herein serves for the stability of the tunnel as a whole and further lends itself to an aesthetically responsible design, whereby tunnel 1 can be absorbed in the landscape in unobtrusive manner.

Arranged on the bottom in tunnel tube 3 is a concrete road surface 20. This road surface 20 contributes a little towards reducing the buoyant effect, whereby lighter tie anchors 10 are possible. The concrete surface 20 is connected with dowels to tunnel wall 19, whereby surface 20 also makes some structural contribution and a good connection between surface 20 and tunnel 3 is ensured. Arranged in the concrete road surface 20 is a pump pit with pipes 21 for draining rainwater which has run in or been driven in.

Tunnel tube 3 can be embodied in light colours on the inside, whereby in combination with a sufficient level of lighting in the tunnel the spatial perception will be increased, which is of importance in respect of the small

inner dimensions of tunnel tube 3. The spaces 17 between tunnel wall 19 and vehicle profile 16 can further be used for arranging the different systems in tunnel tube 3, such as optional ventilation systems and lighting 18.

Because no reinforcements have to be arranged the outside of tunnel tube 3 can be conserved in simple and qualitatively good manner.

Owing to the form of tunnel tubes 3 no traffic guide means are necessary. Tunnel tube 3 acts as the lower plane of a so-called New Jersey profile. The upper plane of the New Jersey profile which is intended to prevent tilting of vehicle 15 is likewise ensured by tunnel wall 19.

Anchoring systems other than the shown tie anchors 10 are likewise possible, optionally in combination with the flexible joints 14. Tunnel tube 3 could thus be weighted with ballast.

In the method for building such a tunnel 1 according to the invention, each tunnel tube 3 is manufactured, assembled and conserved in segments 13 of approximately 40 metres under controlled conditions in factories, thus resulting in an optimal quality. The size of segments 13 is determined by the accessibility of the location (length, depth) and the facilities of the steel construction plants.

Simultaneously with the manufacture of tunnel segments 13 the trench for tunnel 1 can be arranged at the construction site. In the case of tunnel segments 13 with a diameter of 5.50 m the trench will probably be formed between so-called combiwalls 8. These walls can be used inter alia to position the tunnel segments and hold them under control. At the position of the navigation channel the combiwall 8 can be arranged such that it does not protrude above the bottom 5 of the waterway. Shipping will hereby not experience any appreciable hindrance.

Placing of segments 13 takes place underwater. This means that no draining is necessary. The combiwall 8 can hereby be embodied lighter and without struts. The water in the tunnel trench is used to enable transporting in of the tunnel segments.

After the tunnel trench and tunnel segments 13 are completed, a start can be made with building of tunnel 1 at the construction site. The approximately 40 metre-long tunnel segments are shipped from the factory to the construction site. Having arrived on site they are turned transversely in the 40 metre-wide ship channel and transported therefrom to their definitive location. The segments are positioned using combiwalls 8 and optional guide poles and subsequently submerged. The part close to the entrance is transported in first. The second part is then transported in, positioned, coupled and welded to the first part. On the other side of the tunnel trench the same operations are performed with the oppositely located exit. When both exits are ready the 40 metre-long middle part can be placed. It is possible to have this take place before or after immersion.

When tunnel tube 3 is positioned the tie anchors 10

can be arranged and earth fill provided and the ground compacted at the position of the exits.

Once all tie anchors 10 are arranged the tunnel tube can be pumped dry, the trench can be filled in layers and a start can further be made with finishing. Tunnel tube 13 will be covered in the navigation channel with a layer of rockfill or a mat construction.

Although the invention is described above with reference to a tunnel with two traffic lanes 4, this number of traffic lanes can of course be varied as desired. A plurality of tunnel tubes 3 is therefore possible, while in the case of roads with a relatively small volume of traffic, such as for instance local roads in areas rich in water, it is possible to make use of a single tunnel tube 3 for traffic in both directions. A traffic light system must of course then be placed at the entrances. In addition, the tunnel according to the invention can be advantageously applied as for instance cycle or pedestrian tunnel.

Claims

1. Road tunnel with one or more traffic lanes, **characterized in that** each traffic lane is arranged in a separate tunnel tube, the form and dimensions of the cross section of which are adapted to those of a single vehicle.
2. Road tunnel as claimed in claim 1, **characterized in that** the tunnel tube has a substantially round cross section.
3. Road tunnel as claimed in claim 1 or 2, **characterized in that** the tunnel tube is manufactured from steel.
4. Road tunnel as claimed in any of the foregoing claims, **characterized in that** the tunnel tube consists of a plurality of mutually connected segments.
5. Road tunnel as claimed in claim 4, **characterized in that** the segments are prefabricated.
6. Road tunnel as claimed in claim 4 or 5, **characterized in that** the segments are connected with interposing of a flexible coupling.
7. Road tunnel as claimed in any of the foregoing claims, **characterized by** means for anchoring the tunnel tube against upward displacement.
8. Road tunnel as claimed in claim 7, **characterized in that** the anchoring means comprise at least one tie anchor arranged in the ground and connected by a traction cable to the tunnel tube.
9. Method for building a road tunnel, **characterized by** forming at a chosen location a number of trench-

es corresponding with the desired number of traffic lanes, manufacturing a number of tunnel tubes corresponding with the desired number of traffic lanes and arranging the corresponding tunnel tube in the or each trench.

10. Method as claimed in claim 9, **characterized in that** the tunnel tube is constructed by mutually connecting a plurality of tunnel tube segments.
11. Method as claimed in claim 10, **characterized in that** the segments are manufactured at a location remote from the trench, transported to the trench and there connected to each other.
12. Method as claimed in claim 10 or 11, **characterized in that** the segments are submerged in the trench and after mutual connection thereof the tunnel tube is pumped dry.
13. Method as claimed in claim 12, **characterized in that** prior to pumping dry thereof the tunnel tube is anchored against upward displacement.

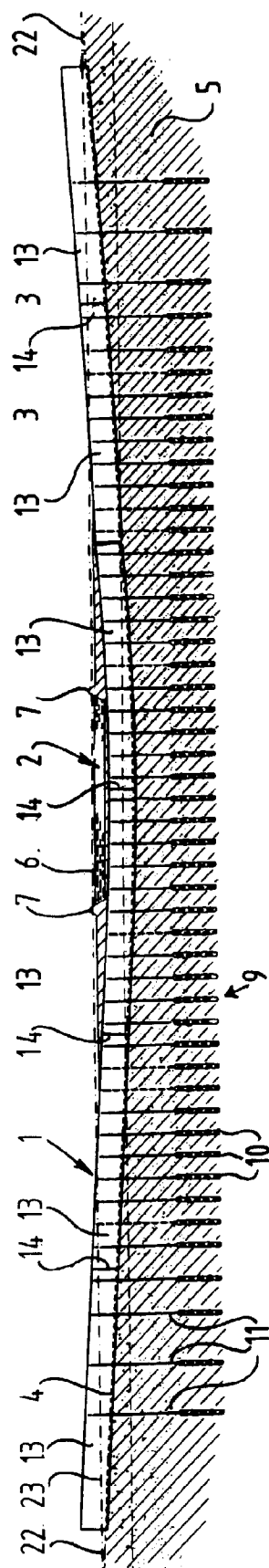


FIG. 1

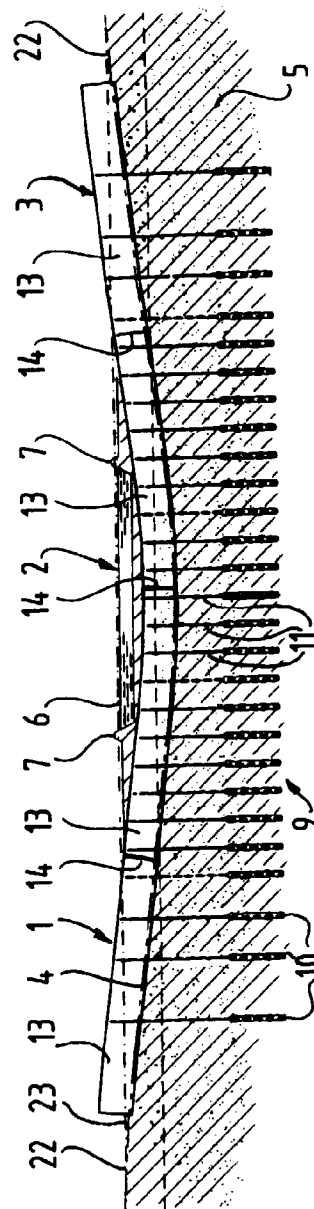
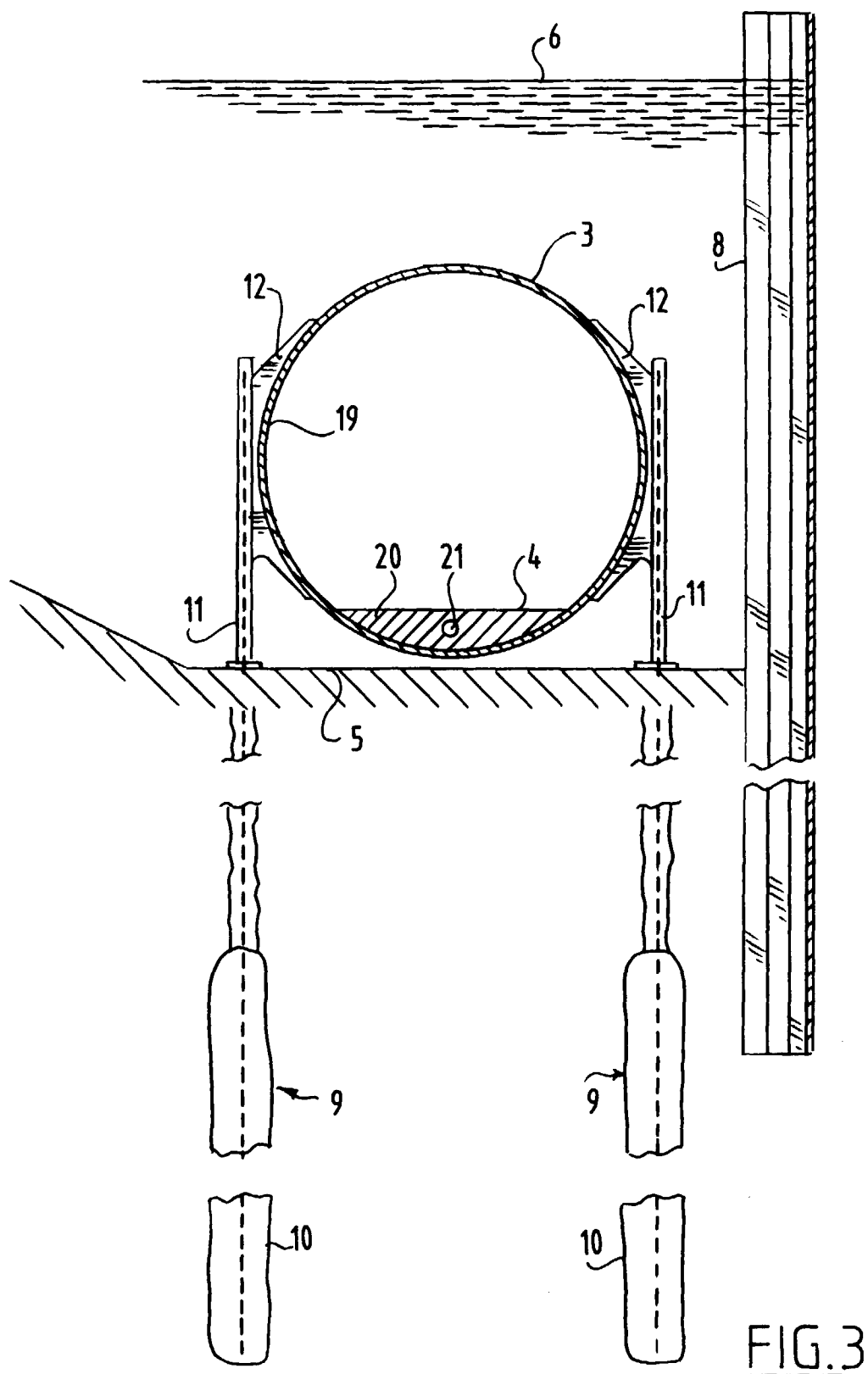
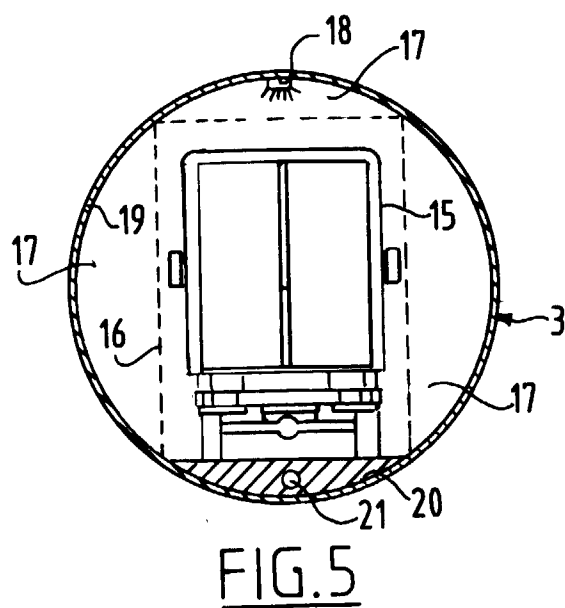
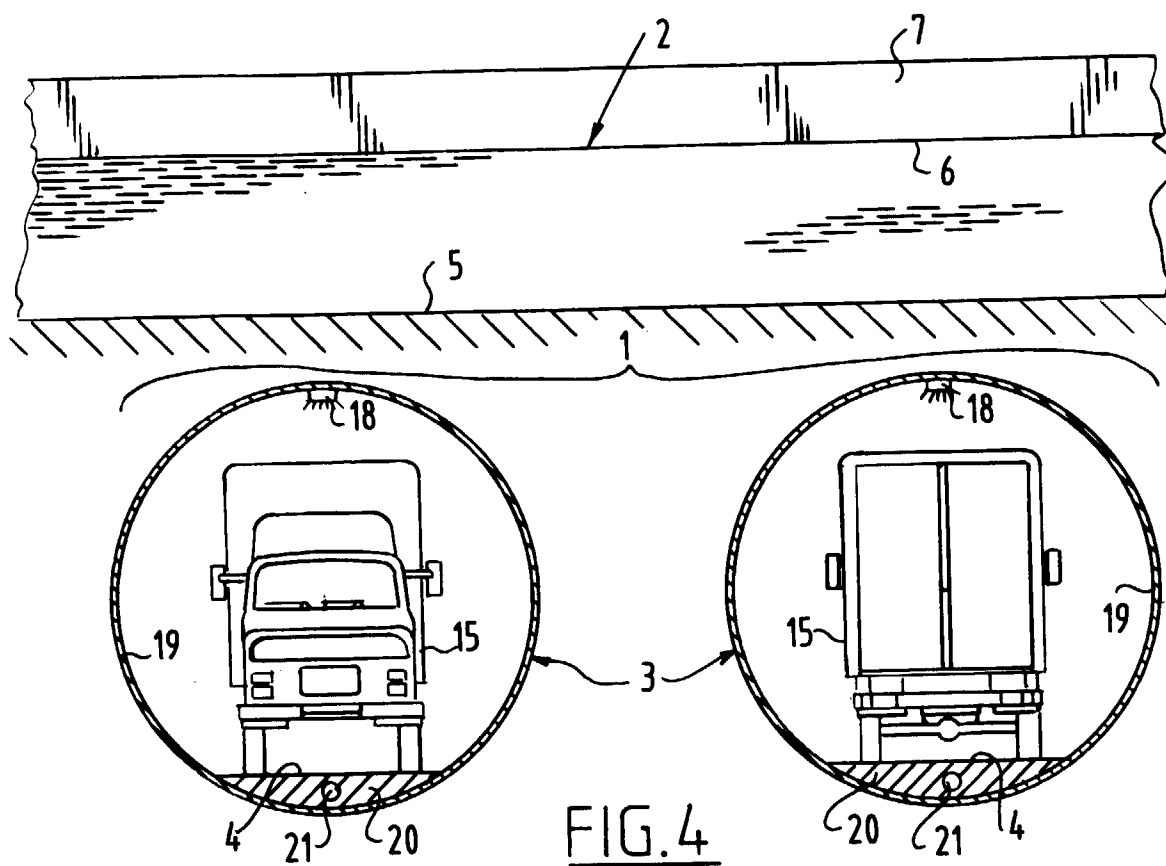


FIG. 2







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EUROPEAN SEARCH REPORT

Application Number
EP 97 20 0531

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	TECHNIQUES ET ARCHITECTURE, vol. 31, no. 5, February 1970, PARIS FR, page 91 XP002024813 LE RICOLAIS: "Trafic sous-marin"	1,2	E02D29/067
Y	* the whole document *	3-8	
Y	US 3 478 521 A (PETRIK DRAGAN RUDOLF) 18 November 1969 * column 3, line 57 - column 4, line 25; figures *	4-8	
Y	WO 89 09870 A (MOSS ROSENBERG VERFT AS) 19 October 1989	3	
A	* claims; figures *	1,2	
A	CEMENT, vol. 24, no. 12, December 1972, AMSTERDAM NL, pages 571-576, XP002024814 NELISSEN: "De zee als bouwterrein voor de naaste toekomst" * page 573, line 13 - line 46; figures *	1,2,4,5, 7,8	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
X	TUNNELLING AND UNDERGROUND SPACE TECHNOLOGY, vol. 3, no. 4, 1988, OXFORD GB, pages 353-361, XP000002613 MOLENAAR: "Applications of immersion technologies in underwater construction"	9-11	E02D E01C
Y	* page 354, left-hand column, line 25 - page 357, left-hand column, line 27; figures 2-4,6,7 *	12,13	
Y	DE 543 871 C (SIEMENS BAUUNION G.M.B.H.) 28 January 1932	12,13	
A	* the whole document *	9-11	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12 May 1997	Examiner Blommaert, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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