

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number:

0 334 262
A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 89104960.3

(51) Int. Cl. 4: E21D 9/00

(22) Date of filing: 20.03.89

(30) Priority: 24.03.88 IT 1992188

(43) Date of publication of application:
27.09.89 Bulletin 89/39

(84) Designated Contracting States:
AT CH DE ES FR GB IT LI

(71) Applicant: ING. GIOVANNI RODIO & C.
IMPRESA COSTRUZIONI SPECIALI S.P.A.
5, Via Pandina
I-20070 Casalmaiocco (Milan)(IT)

(72) Inventor: Volpe, Antonio
8, Via Europa
S. Donato Milanese Milan(IT)
Inventor: Casagrande, Bruno
3, via Molignani
Fontanafredda Pordenone(IT)

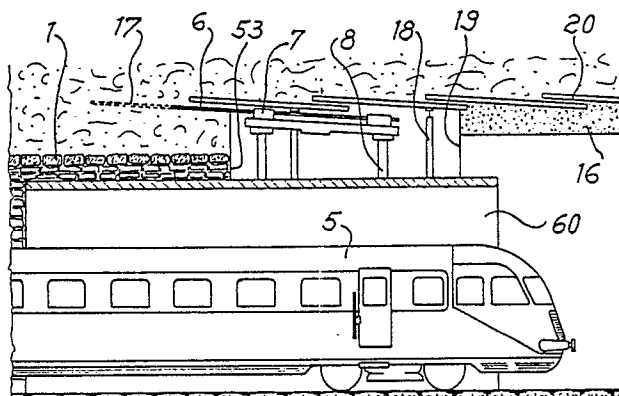
(74) Representative: Marietti, Giuseppe
CENTRO DI CONSULENZA IN PROPRIETA'
INDUSTRIALE Viale Caldara, 38
I-20122 Milano(IT)

(54) Method and apparatus for enlarging tunnels.

(57) Method and apparatus for enlarging tunnels in service, characterised by installing a protection shield (60) within the original tunnel to protect through traffic (5) in the section of the tunnel involved in the enlarging operations, consolidating the section to be enlarged on a profile corresponding substantially to the extrados of the enlarged tunnel, demolishing the old lining down to the level of the direct bearings, demolishing the direct bearings and lining the enlarged tunnel.

EP 0 334 262 A1

Fig. 3



Xerox Copy Centre

METHOD AND APPARATUS FOR ENLARGING TUNNELS

The present invention relates to a method for enlarging existing tunnels while maintaining services; it refers in particular, but not exclusively, to railway tunnels.

Tunnels are particularly critical points in the expansion of road and rail networks. Tunnels are obligatory sections in which the work is of necessity carried out in confined spaces, without the possibility of acceptable traffic diversions, and with technical problems associated with the nature of the soil in which the expansion excavation is being carried out.

While on a motorway it is usually possible to divert the traffic onto a contra-flow system using the opposite carriageway at the cost of increased rush-hour congestion, the same is not normally possible with the ordinary road network, and is never a practical possibility with rail traffic.

Therefore upgrading of ordinary road tunnels are railway tunnels - usually for electrification, widening the permanent way, or doubling the tracks - almost always involves suspension of the service with consequent substitution by road services for passengers, and re-routing of freight trains.

It is a fact that tunnels are built in general through soil whose structure and geology varies, so excavation techniques may vary over the entire section to be enlarged. This involves the use of different equipment, to be used according to the nature of the soil, with high costs for waiting-time and/or transport of the equipment.

It is, therefore, the aim of the present invention to present a method and apparatus for enlarging tunnels, which are without the inconveniences and drawbacks outlined above, and in particular, permit the continuation of services during enlarging operations.

A further aim of the present invention is to present a method of the kind indicated above in which it is possible to use various kinds of consolidation and excavation, so that the basic equipment can be better used for the variety of soil encountered in the different tunnels. These are other advantages of the present invention can be conferred by a method for enlarging existing in-service tunnels, characterized by the following phases:

a) installing a protecting shield within the original tunnel to protect through traffic at least in the section of the tunnel involved in the enlarging operations;

b) consolidating the section to be enlarged on a profile corresponding substantially to the extrados of the eventually enlarged tunnel;

c) demolishing the old lining and the overlying cover down to the level of the direct bearings;

d) demolishing the direct bearings; and
e) lining the enlarged tunnel.

The present invention also concerns the apparatus for the implementation of the above-cited method, characterized by consisting of at least one portal structure and a guide or rack for at least one tool carriage, and at least one protective shield set up as a fixed or mobile structure within the original tunnel lining at least in the area involved in the enlarging operation; the said structure having a configuration corresponding to the final enlarged tunnel, and the said shield being of such size as to leave part of the cross-section of the original tunnel substantially free, to allow the unhindered passage of traffic with the apparatus in place.

The present invention will now be described with reference to some preferred, though not limiting, embodiments and the attached drawings in which:

Fig 1 shows a cross section of the old and new profiles of the tunnel to be enlarged;

Fig 2 shows a back view of the apparatus during enlarging operations;

Fig 3 is a longitudinal section showing a train passing through the tunnel while the latter is being enlarged;

Fig 4 and 5 show the enlarged tunnel consolidated by the infiltration or injection method, respectively during consolidation and after the addition of the final lining;

Fig 6 shows the demolition of the old lining and a spoil wagon, used when traffic allows;

Fig 7 shows the demolition of the direct bearings, in the previous case;

Fig 8 shows a longitudinal section of the tunnel in which the enlarging operation is being carried out using a plurality of portal structures;

Figs 9 - 11 show a cross-section of the tunnel before, during and after the enlarging operation;

Figs 12, 13, 15 and 16 show schematic views of the tunnel during construction of the inverted arch; and

Fig 14 shows a top view of a detail of the section involved in the construction of the inverted arch.

Fig 1 shows a typical case for enlargement, in which an existing railway tunnel, shown by the reference number 1 and with a vault 2, is to be enlarged upwards (e.g. to allow the line to be electrified) to the dimensions of the tunnel 3, with a higher vault 4.

Other cases are the enlarging of a double line

tunnel, or the enlarging of the tunnel to increase the number of lines; these cases, although not illustrated in detail are substantially the same as the previous example, except that the greater expansion will be in the horizontal direction and the tracks will have to be repositioned.

Figs 2 and 3 show partial cross and side sections of the tunnel being enlarged by a mechanical pre-cut excavation method known as the Premill (registered trade mark) method which is particularly useful in many, clay or soft-cohesive grounds. According to this technique, before excavating the part to be enlarged, an advance cut 17 is made along the extrados 3 of the section of the final enlarged tunnel, with a mechanical cutter driven by the mechanical head mounted on the self-propelled portal 8. The shape and length of the cut is determined in advance.

More precisely, the cutter 7 with its blade 6 is moved along a rack 9 (Fig 2) supported by the structure 8 and following the final profile of the enlarged tunnel section.

The portal structure 8, which is also of similar dimensions of the final tunnel profile, permits the passage of trains 5 underneath; to ensure greater protection for trains and other vehicles in transit under the portal or portals while carrying out the aforementioned operations, the present invention provides for the presence of a protective vault or shield 60 either fixed or mobile inside the original tunnel 1, i.e. under the portal structure 8. As shown in fig. 3, the shield 60 is installed at least in that section of the tunnel involved in the enlarging operation, i.e. the section between the old lining 1 in advance of the pre-cut 17 and the newly lined enlarged section 19. Obviously, the shield cross-section is high and wide enough to allow the unhindered passage of through traffic.

The present invention thus allows the consolidation and lining operation to be carried out without interruption of the services through the tunnel.

The portal structure 8 rests on the tunnel floor on two series of supports which can be raised in turn and moved longitudinally, so as to advance self-propelled inside the tunnel, keeping up with the consolidation and/or pre-lining operations.

The cutter 7 can move on longerons (not shown) to allow the insertion of the blade 6 into the excavation face, after which the cutter is moved along the rack 9 to make the cut 17 along the entire extrados 3.

When the pre-cut 17 has been made, it is filled by injecting concrete (sprit-beton) to form a protective lining 20 shown in Figs 2 and 3. In this way a stabilized shell is obtained which is external to the final lining 16 and which has the purpose of withstanding the pressure of the soil and providing better operating conditions for the excavation of the

soil underneath, until the definitive lining 16 is cased. Preferably the shell is reinforced with ribs 18, shown in Fig 3, installed corresponding to the individual lengths of pre-lining 20.

Depending on the nature of the ground, the consolidation and pre-lining can be carried out by other means, e.g. by the method known as infiltration, or the injection of concrete mixture (jet-grouting).

In any case, whether the Premill (Registered trade mark), infiltration or jet-grouting technique is used, the operation is carried out by a unit with interchangeable heads (e.g. for cutting, boring, injection, or jet-grouting) which is mounted on a mobile fitting on the portal structure in a way similar to that described for Figs 2 and 3. Preferably the cutter 7 and the aforementioned replaceable heads are interchangeable on the same portal 8.

Fig 4 shows schematically the application of the aforementioned consolidation methods, where a tool 51, moving along a portal can create a series of cylindrical consolidation elements 50. The consolidation elements thus obtained are also shown in the following Fig 5, which shows a train 5 passing through the enlarged tunnel, with the final lining 16 in place, together with any pre-lining 20A applied by methods already known, similar or different to those used in applying the pre-lining 20 of Figs 2 and 3.

Referring now to Figs 6 - 11, once the consolidation has been carried out, either by infiltration or jet-grouting, and/or after any pre-lining has been completed, the excavation and final lining phases are proceeded with.

The excavation and demolition of the old lining and the excavation of the surrounding ground can be accomplished in various ways.

If the traffic is sufficiently light and no vehicles will pass through the tunnel for a time long enough, the system shown in Figs 6 and 7 can be used.

According to this system the shield must be mobile to allow access from underneath to the old lining for its excavation and removal; in fact one spoil wagon 22 runs on the train rails 21, carrying a hopper or upper spoil collector 23 which extends across the full width of the original tunnel between the direct bearings 30 and 31. The hopper is so shaped that, as can be seen in Fig 5, as it advances, it leaves behind it the direct bearings which can be excavated later. In this way debris 24 resulting from the demolition of the old vault lining 1 is prevented from falling on the floor of the tunnel, which remains clean, so that the rails remain perfectly serviceable.

The excavation and demolition in this phase can be by any method which is consistent with the type of soil and the safety regulations; the excava-

tion equipment has not been shown.

In Fig 7 is shown the demolition of the direct bearings 30, 31, carried out by the use of at least one wagon 26 which moves on the wheels 29 and is fitted with a container 25 for the loading and transport of the spoil to the outside of the tunnel. The wagon 26 is equipped with one or, where necessary, two articulated digging arms 27, 28 fitted with buckets for digging and removing the spoil to the container 25.

The shield is then returned to its protecting position, and the wagons 22 and 26 are shunted to a siding outside the tunnel mouth; thus the tunnel remains in service for trains and other vehicles.

It should be noted that, according to the method of the invention, the operations of consolidation, any pre-lining, excavation and application of the final lining proceed together in such a way as to leave an unfinished section between the end 53 of the old tunnel and the beginning of the new finished tunnel 19 (Fig 3).

The embodiments shown in Figs 8 to 11 show the operating method in practice when the protective shield is continuously in place while the tunnel is being enlarged. In this case, after all the service equipments (including the signals and the power line for the train) have been located under the shield, the shield itself is installed, preferably on service rails 62 laid at the side of the rails 21, and is made steadfast e.g. by means jacks 66 against the inside of the lining 68 of the old tunnel (Fig 9). As previously said, the length of the shield may vary, but will be such to ensure the completion of work on any section of the tunnel without exposing the train or the zone of passage of the same.

With the shield in place, the aforementioned phases of the operation can proceed.

In particular and with reference to the foregoing and to Figs. N. 8 and 10, the apparatus in this case consists of a vault or portal structure 8 fitted with bracing to strengthen it. To this structure is fitted an external rack on which moves a tool-carrying carriage 54 which can be moved by a system of geared motors/pinions from one end of the rack to the other, faithfully following the profile of the enlarged tunnel.

This movement is facilitated by the tool-carrying carriage being mounted on a sliding base which allows it to follow the profile of the vault, thus compensating for any deviations in the radius of curvature of the rack.

On the tool-carrying carriage 54 is provided a sled 72 mounted on rails that can be inclined from the horizontal, thus allowing the cutter blade to make inclined cuts 17 along the extrados 3 of the tunnel or, replacing the cutter head with the appropriate tool, allowing consolidation by either the infiltration, innjection or jet-grouting method. The sled

can be moved horizontally to allow the tool head to be inserted in the withdrawn from the excavation face.

The entire apparatus is preferably located close to a standard service portal 88 for either normal maintenance operations or simply for the exchange of the machine head with one of those housed inside the portal 88 itself.

In front and on the sides of the portal structure 8 (Fig 8) there are one or more mechanical arms 55 fitted with interchangeable tools for the excavation and demolition along the entire arc of the tunnel underneath the consolidation elements.

Besides the aforementioned function of housing equipment not being used at the excavation face, the service portal is used for the transport and storage of the vault reinforcing ribs 18, thus facilitating the installation of the same.

In a preferred embodiment, more than one service portal is provided, each of said service portals being used for such operations as the installation of a temporary lining, of a waterproof lining or of the final lining.

Both the face portal and the service portals are preferably self moving by means of motorized walking beams fitted with anchors and stabilizers activated during the operational phase.

Advantageously, as shown in Fig 10, service ducts and passageways can be provided above the protective shield for the electrical supply 78, removal of expired air 80 and for pumping concrete, compressed air and water 82. Spoil dug by the mechanical arms 55 can be removed by conveyor belts 100. Following the excavation and dismantling of the old tunnel, work proceeds to the installation of the temporary lining, waterproof lining, and casting of the final lining. These phases are not shown in detail in Figs 8 to 11, in as much as the equipment used is substantially known, but must be operated in the space remaining between the consolidation 76 and the outside of the protective shield 60.

At the end of the operations, the tunnel takes the shape shown in Fig 11, in which is shown the final lining 16, spaced from the protective barriers 96 which separates the railway for the train 5 from the passageways for the excavated material being removed by the conveyor belt 100, the dumpers 98 or decauville wagons (not shown).

The remaining figures 12 - 16 show three possible solutions for stabilizing a tunnel without any existing inverted arch, or when the existing inverted arch cannot be used or has to be improved.

Figs 12 - 14 show schematically three phases of construction of an inverted arch, working under the railway.

The excavation is carried out using a pair of cutters 56 similar to those used in the aforemen-

tioned Premill (Registered trade mark) method, mounted laterally on the portal 8. After the excavation has been completed, the final lining is put in place (fig. 13).

In the section involved in the operation, the train rail 21 are provided with adequate support such as the beams 57 (Fig 14). In Fig 13 the final appearance of the tunnel is shown. Alternatively, recourse may be made to the installation of struts 35 (Fig 15), either casted, or consisted of prefabricated concrete beams or metal girders. Again, in certain conditions, a direct bearing subfoundation 49 may be laid and/or the ground may be consolidated by pile-driving or jet-grouting, to perform the function of the inverted arch (fig 19).

While the present invention has been described with reference to the enlargement of railway tunnels, it is obvious that the method may also be applied, making the necessary modifications, to road and motorway tunnels.

Claims

1. Method for enlarging existing tunnels in service, characterized in consisting of the following phases, applied successively to sections of predetermined length:

a) installing a protection shield within the original tunnel to protect through traffic at least in the section of the tunnel involved in the enlarging operations;

b) consolidating the section to be enlarged on a profile corresponding substantially to the extrados of the eventually enlarged tunnel;

c) demolishing the old lining and the overlying cover down to the level of the direct bearings;

d) demolishing the direct bearings; and

e) lining the enlarged tunnel.

2. Method according to Claim 1, characterized by the said consolidation being effected on a section of the tunnel immediately preceding that already subject to demolition and by the final lining being applied to a section following that subject to demolition.

3. Method according to Claim 1 or 2, characterized by the said consolidation operation also consisting of the construction by sample or section of an inverted arch and/or by operations of subfoundation and consolidation of the direct bearings of the said tunnel.

4. Method according to one of the preceding Claims, characterized by the consolidation and any final lining being effected by tools moving along one or more guides or racks supported by a portal structure, said racks and said portal being configured to conform to the final enlarged tunnel profile.

5. Method according to Claim 4, characterized by the portal structure and guide being made to advance step by step between the excavation face and the final lining face.

6. Method according to one of the preceding Claims, characterized by phase b) being carried out by making an advancing cut, starting from the excavation face of the tunnel, along the extrados of the final section of the enlarged tunnel, the said cut being subsequently filled with concrete to form a protective and stabilizing shell for the vault.

7. Method according to one of the Claim 1 to 5, characterized by the consolidation being effected by one of the techniques known as infiltration, injection or jet-grouting.

8. Method according to Claim 6 or 7, characterized by each series of consolidation elements overlapping the following series for an adequate distance.

9. Method according to any of the preceding Claims, characterized by phase (c) and (d) being carried out respectively by means of at least a first wagon moving along the tunnel and having a material collector hopper as wide as the original tunnel above the height of the direct bearings and at least a similar second wagon provided with at least one digging arm and a spoil container.

10. Method according to any of Claims 1 to 8, characterized by carrying out the enlarging of the tunnel outside the extrados of the said shield.

11. Method according to Claim 10, characterized by carrying out the demolition or the excavation of phases (c) and (d) by means of mechanically articulated arms and tools supported and actuated by at least one portal structure operating between the extrados of the protective shield and the intrados of the consolidated zone.

12. Method according to Claim 10, characterized by the removal of the spoil of phases (c) and (d) being by dumpers and/or decauville wagons and/or conveyor belts, operating outside the protective shield.

13. Method according to any of the preceding Claims, characterized by carrying out the said lining phase by a plurality of portal structures mounting equipment for the waterproofing and final lining of the tunnel.

14. Apparatus for implementing the method according to any of the preceding Claims, characterized by consisting of at least one portal structure and a guide or rack for at least one tool carriage, and at least on protective shield set up as a fixed or mobile structure within the original tunnel lining at least in the area involved in the enlarging operation; the said structure having a configuration corresponding to the final enlarged tunnel, and the said shield being of such size as to leave part of

the cross-section of the original tunnel substantially free , to allow the unhindered passage of traffic with the apparatus in place.

15. Apparatus according to Claim 14, characterized by the said portal structures consisting of a vault structure fitted with reinforcing cross-members resting on motorized support beams, and by the said guides for the tool carriage being on the external surface of the structure. 5

16. Apparatus according to Claim 15, characterized by the tool carriage being fitted with rack and pinion means to effect its translation along the said guide, hydraulic cylinder means to regulate its inclination, and rack and pinion means to effect a longitudinal translation of the tool fitted on the said carriage, for the replacement of the tool itself. 10 15

17. Apparatus according to Claims from 14 to 16, characterized by consisting of a first portal structure carrying means for carrying out said consolidation of the vault the direct bearings and/or the inverted arch of the said tunnel and for carrying out said excavation operations, and a plurality of additional portal structures, downstream of the said first portal structure, said additional portal structures being provided with means to carry out the successive operations related to the waterproofing and lining of the said tunnel. 20 25

18. Apparatus according to Claim 17, characterized by the means for carrying out the said consolidation of the vault and direct bearings being supported on a portal structure separate to that carrying the means for consolidating the inverted arch of the said tunnel. 30

19. Apparatus according to Claim 17 or Claim 18, characterized by all means for the consolidating, excavating and lining operations being located outside said protecting shield. 35

20. Apparatus according to any one of Claims 14 to 18, characterized by having means for spoil removal consisting of at least a first wagon moving along the tunnel and having a material hopper substantially as wide as the original tunnel above the height of the direct bearings; and means for demolishing direct bearings consisting of at least a second wagon provided with at least one digging arm and a spoil container. 40 45

50

55

Fig. 1

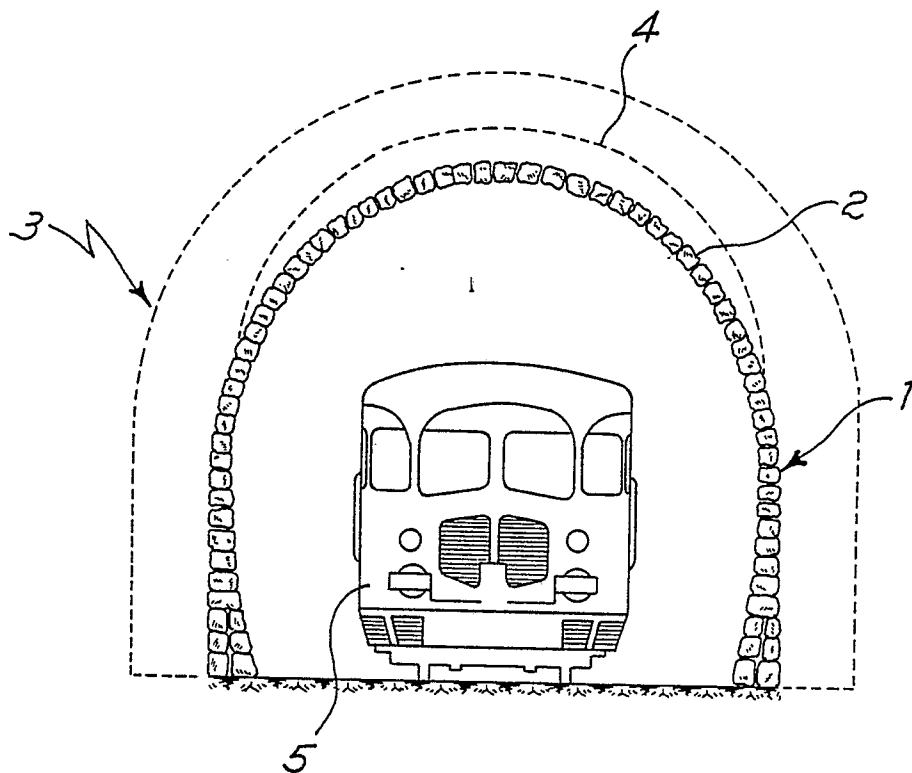


Fig. 2

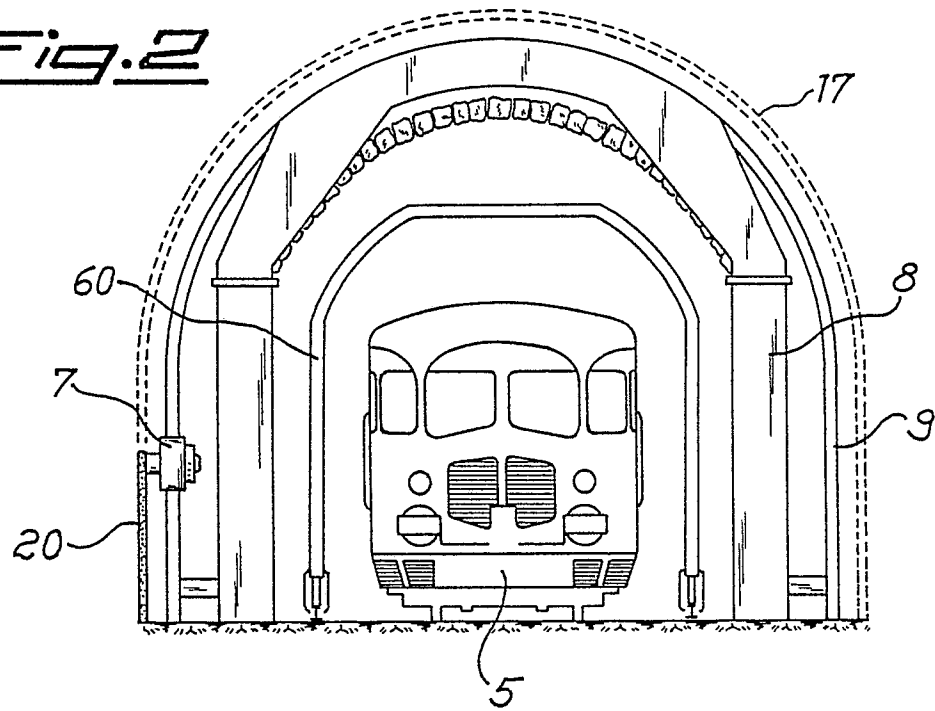
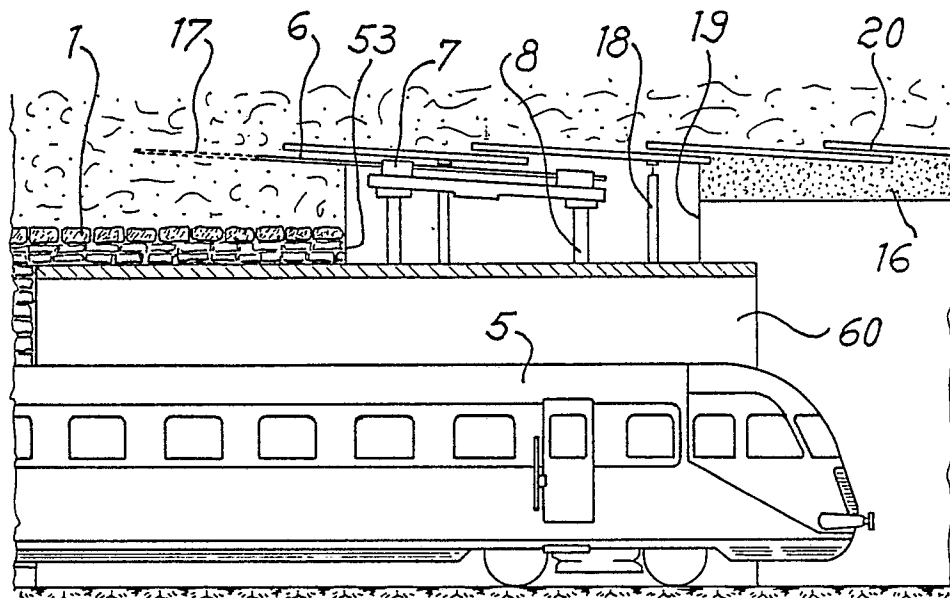


Fig. 3



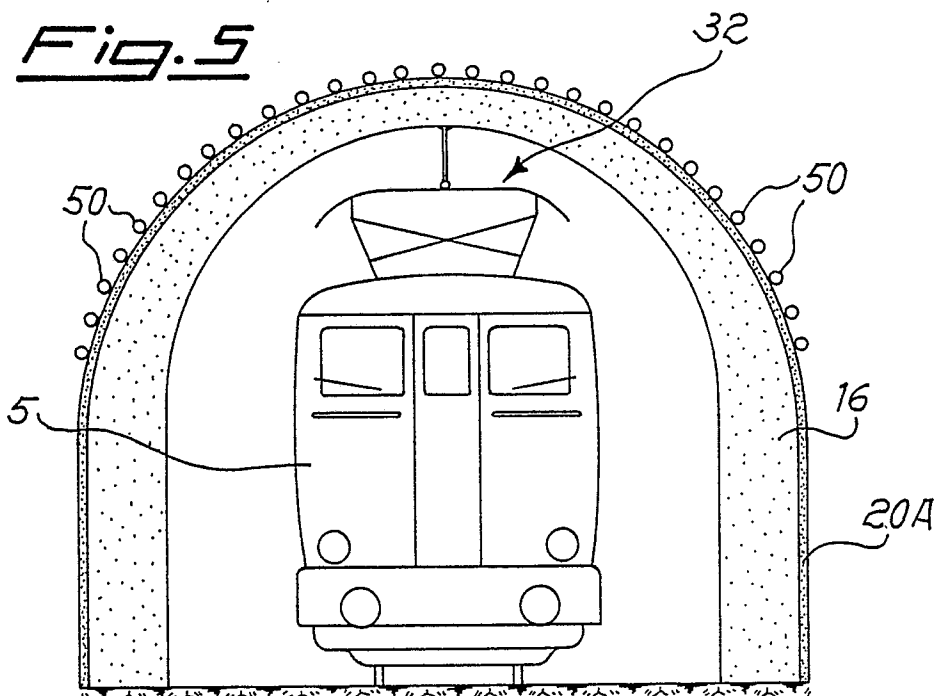
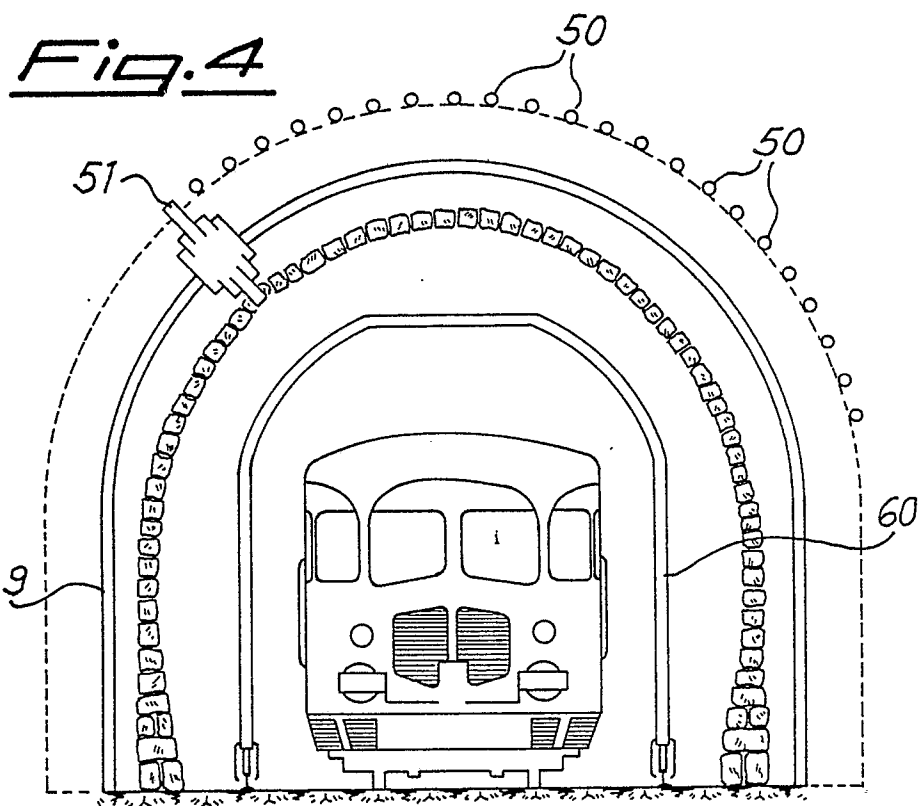


Fig. 6

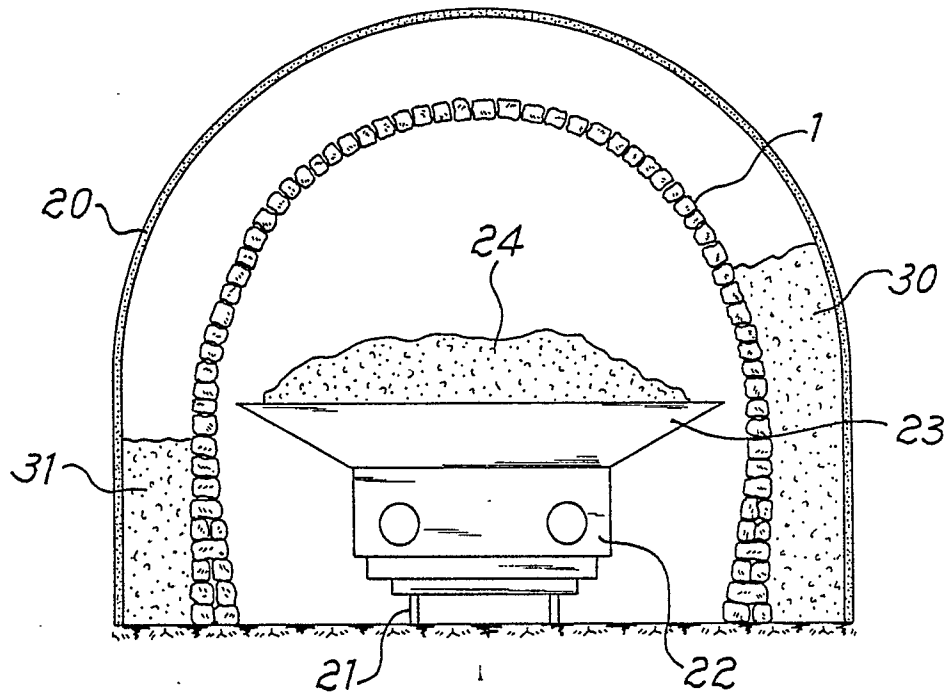


Fig. 7

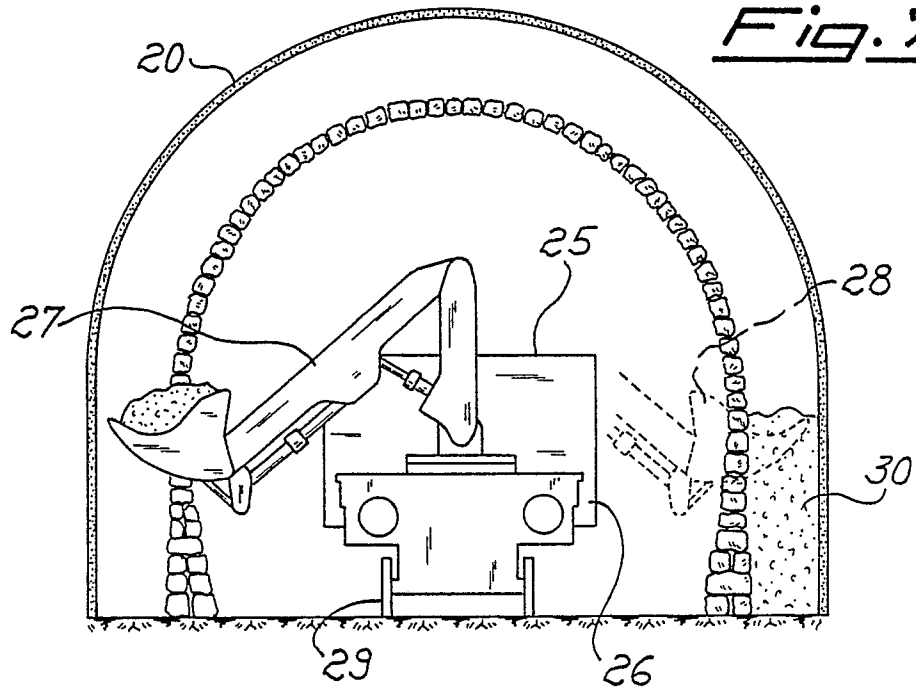


Fig. 8

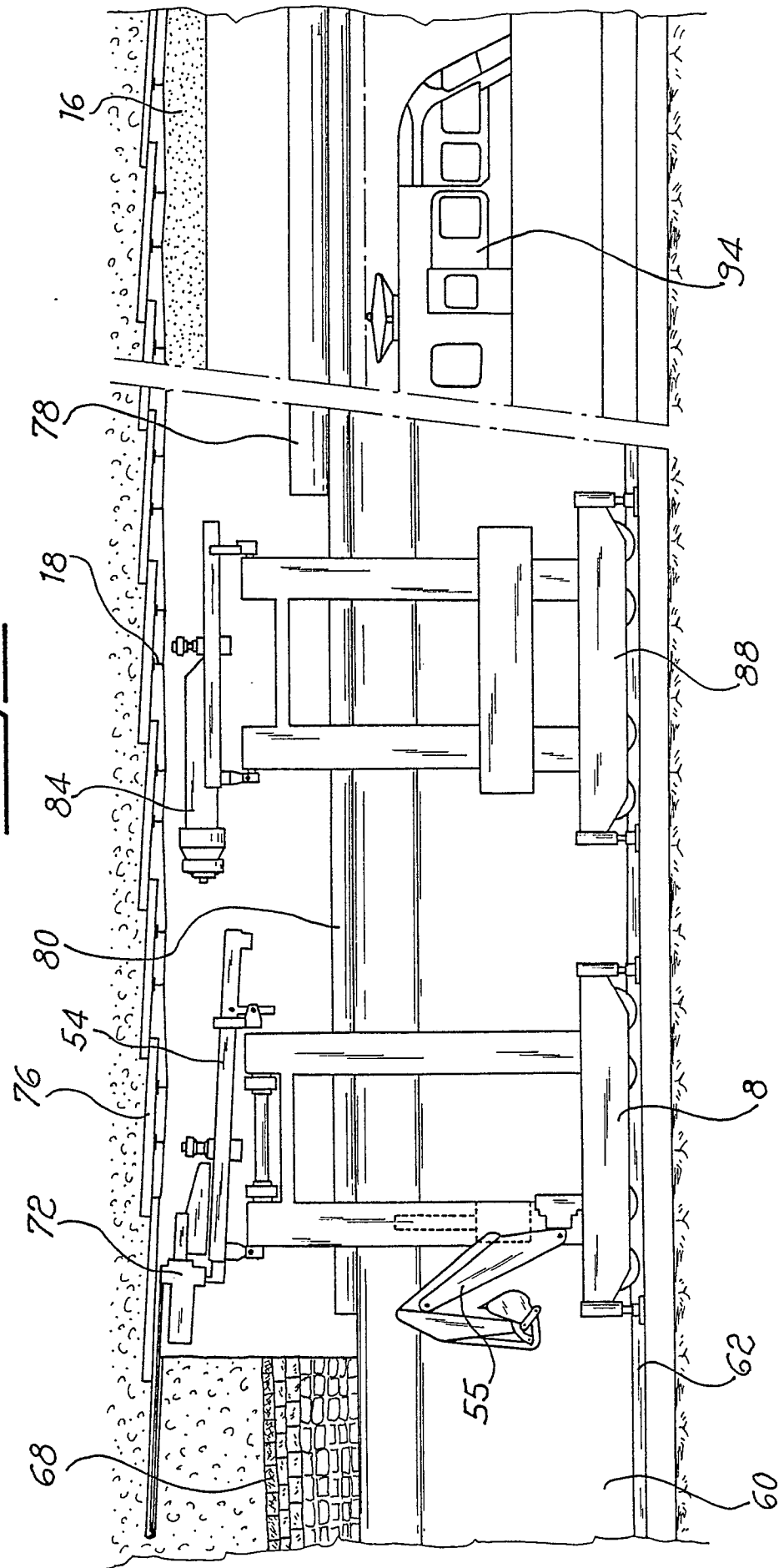


Fig. 10

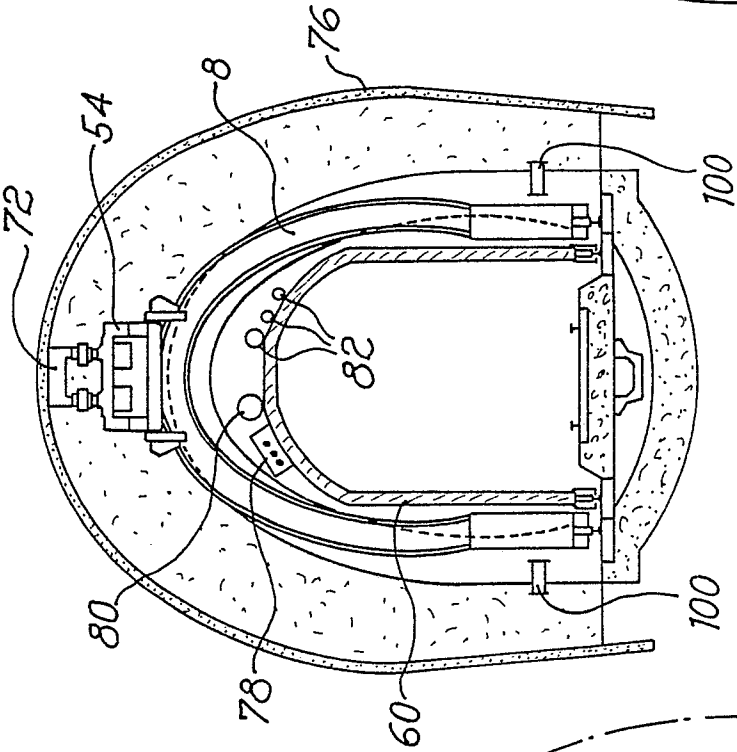


Fig. 9

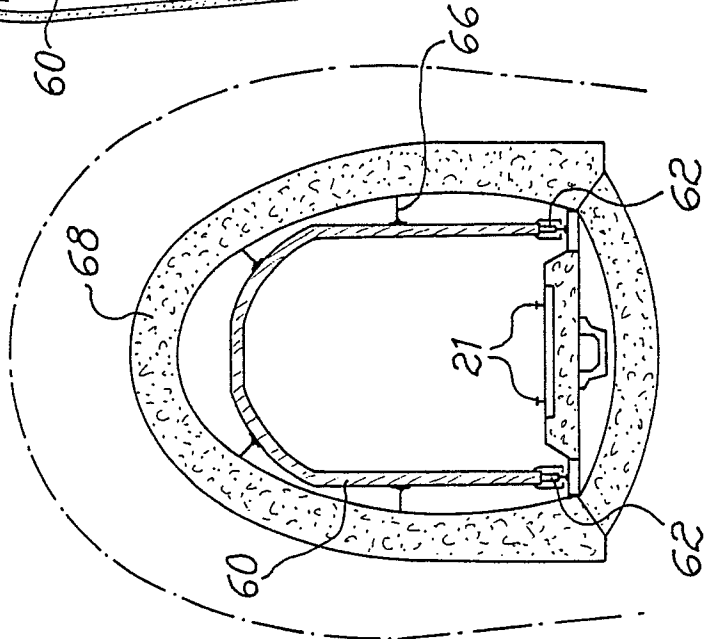
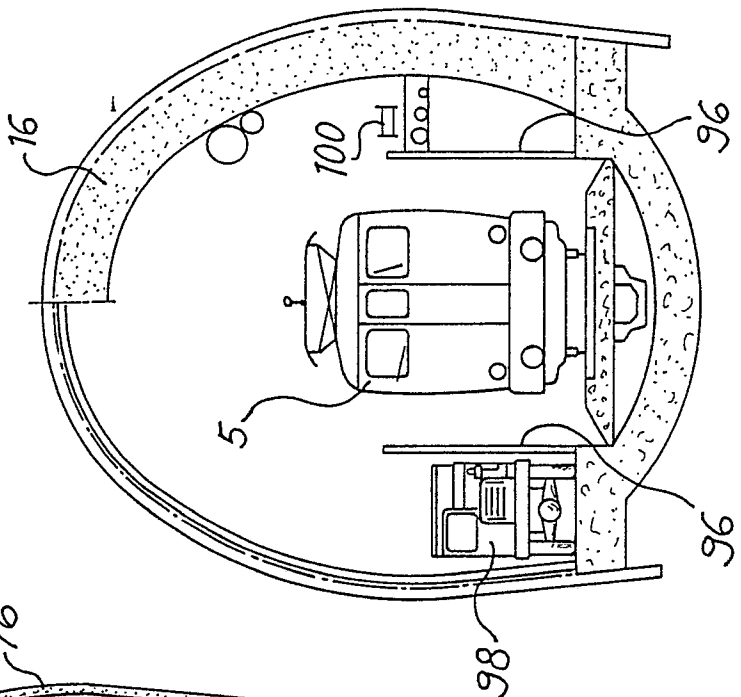


Fig. 11



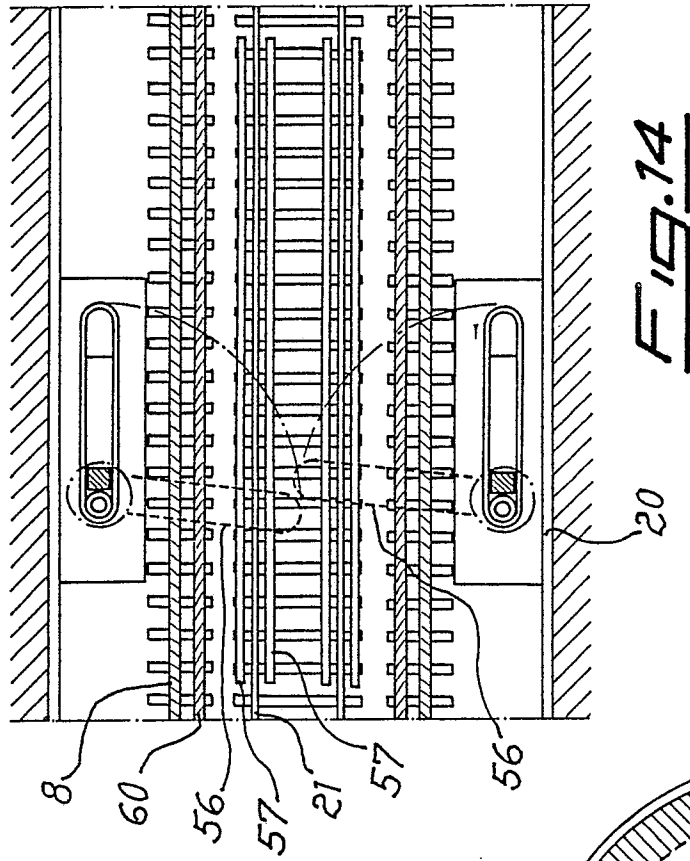
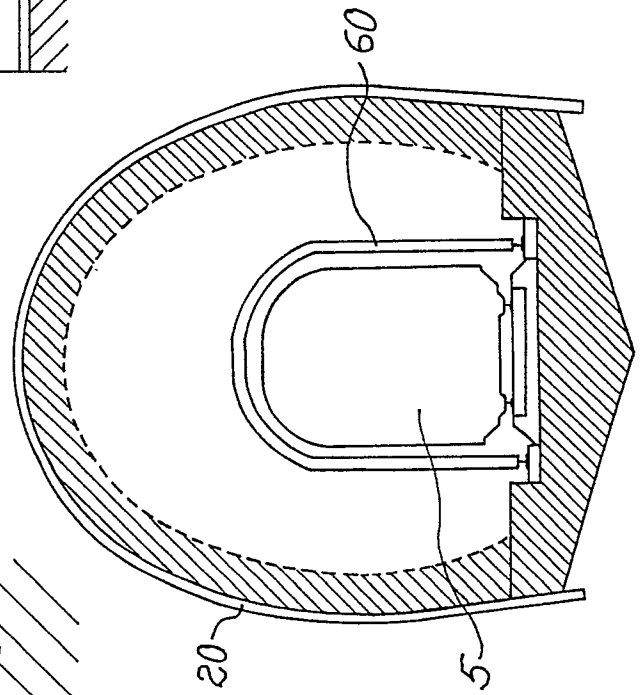
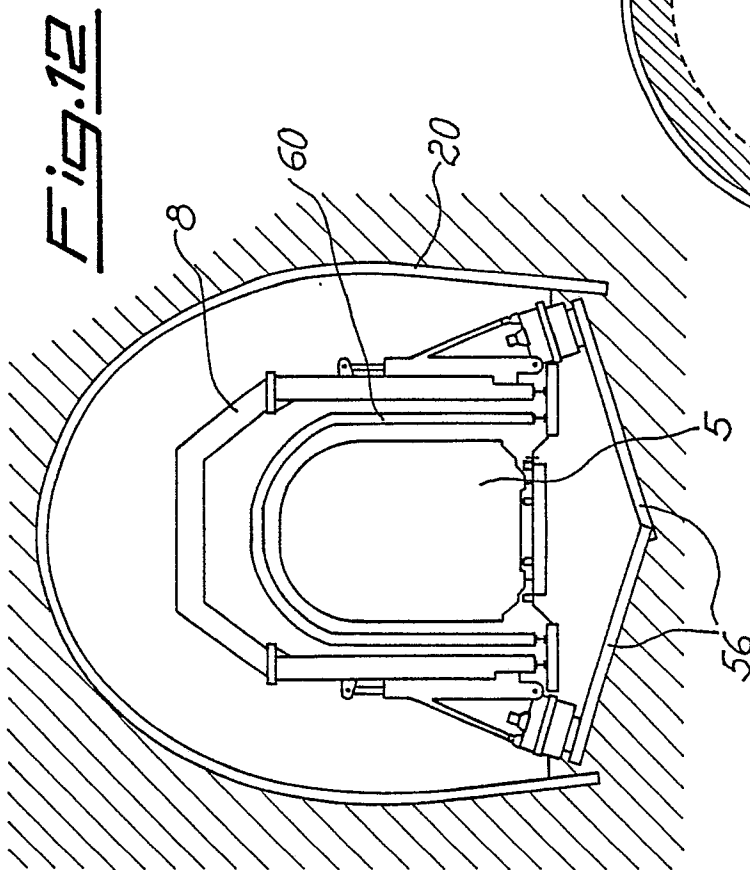


Fig. 15

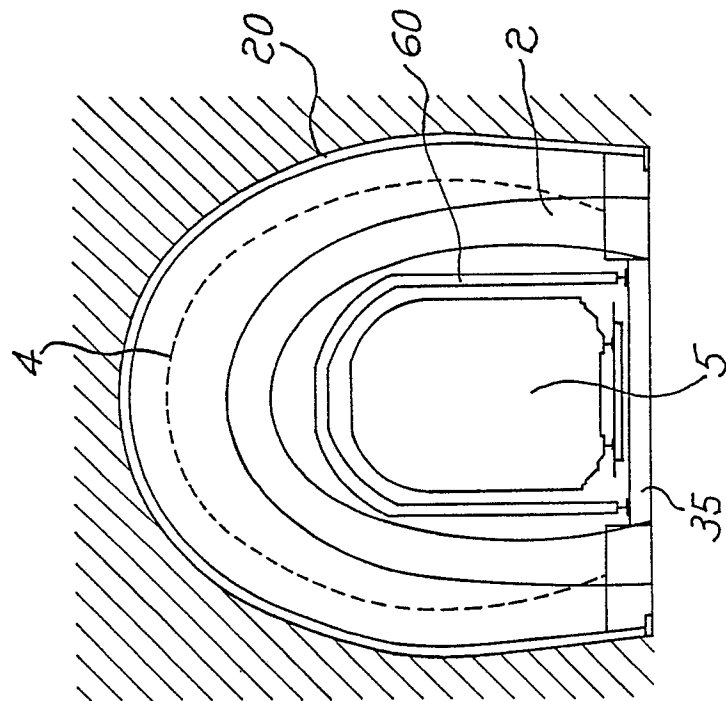
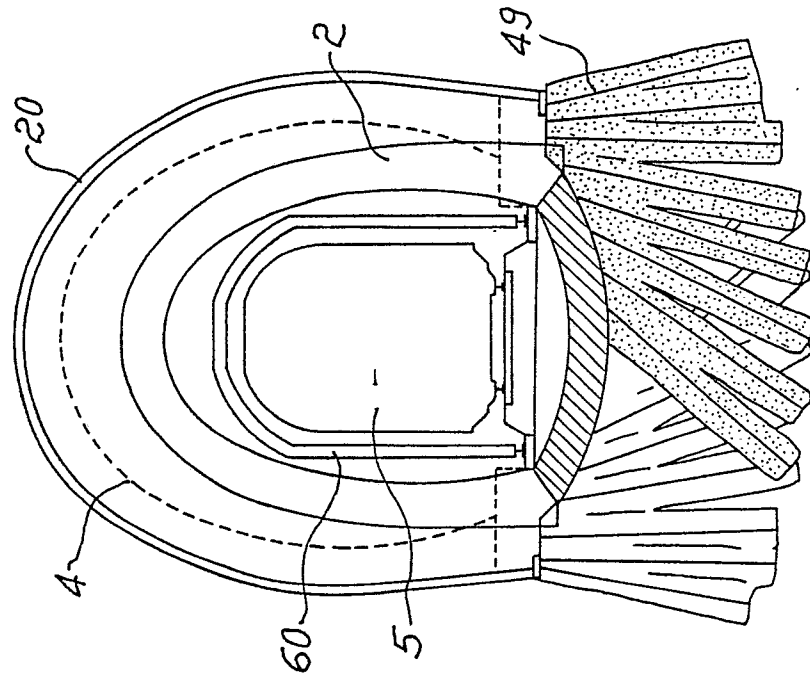


Fig. 16





DOCUMENTS CONSIDERED TO BE RELEVANT																			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)																
A	DE-A-2 747 975 (RUHRKOHLE) * Page 3, line 19 - page 4, line 3; figures * ----	1,14	E 21 D 9/00																
A	FR-A-2 230 806 (BUFFET) * Figures * ----	1,14																	
A	FR-A-2 305 583 (PERFOREX) -----																		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)																
			E 21 D																
The present search report has been drawn up for all claims																			
Place of search THE HAGUE		Date of completion of the search 16-06-1989	Examiner RAMPELMANN J.																
<table border="0"><tr><td>CATEGORY OF CITED DOCUMENTS</td><td>T : theory or principle underlying the invention</td></tr><tr><td>X : particularly relevant if taken alone</td><td>E : earlier patent document, but published on, or</td></tr><tr><td>Y : particularly relevant if combined with another</td><td>after the filing date</td></tr><tr><td>document of the same category</td><td>D : document cited in the application</td></tr><tr><td>A : technological background</td><td>L : document cited for other reasons</td></tr><tr><td>O : non-written disclosure</td><td>.....</td></tr><tr><td>P : intermediate document</td><td>& : member of the same patent family, corresponding</td></tr><tr><td></td><td>document</td></tr></table>				CATEGORY OF CITED DOCUMENTS	T : theory or principle underlying the invention	X : particularly relevant if taken alone	E : earlier patent document, but published on, or	Y : particularly relevant if combined with another	after the filing date	document of the same category	D : document cited in the application	A : technological background	L : document cited for other reasons	O : non-written disclosure		P : intermediate document	& : member of the same patent family, corresponding		document
CATEGORY OF CITED DOCUMENTS	T : theory or principle underlying the invention																		
X : particularly relevant if taken alone	E : earlier patent document, but published on, or																		
Y : particularly relevant if combined with another	after the filing date																		
document of the same category	D : document cited in the application																		
A : technological background	L : document cited for other reasons																		
O : non-written disclosure																			
P : intermediate document	& : member of the same patent family, corresponding																		
	document																		