United States Patent [19]

Patin

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[45] **Jan. 29, 1974**

[54] **METHOD AND APPARATUS FOR USE IN TUNNELLING**

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[21] Appl. No.: **247,363**

[52] **U.S. Cl.** **61/84,** 61/42, 61/85

[51] **Int. Cl.** **E21d 19/04**

[58] **Field of Search** ..... 61/85, 84, 45 R, 42, 63

[56] **References Cited**

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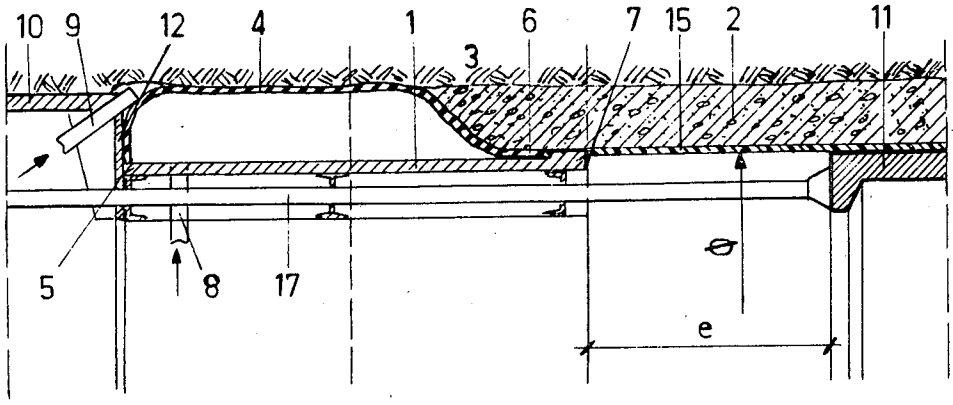
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Primary Examiner—Dennis L. Taylor

[57] **ABSTRACT**

During tunnelling the terrain is supported by an annular fluid mass under pressure moved either continuously or stepwise. A lining compound is introduced outside the fluid mass and sets to form a tube. The tube may then be internally coated.

15 Claims, 6 Drawing Figures



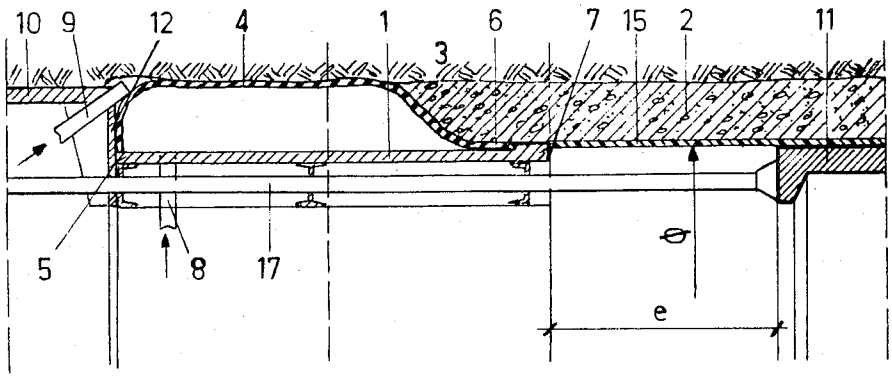


Fig.1

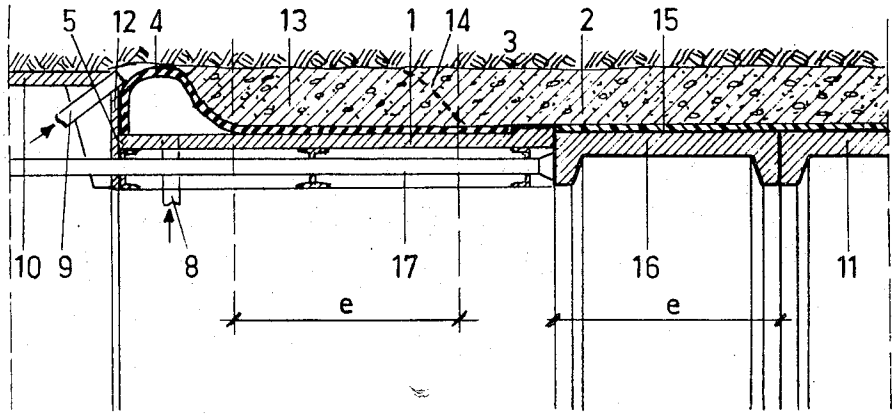


Fig.2

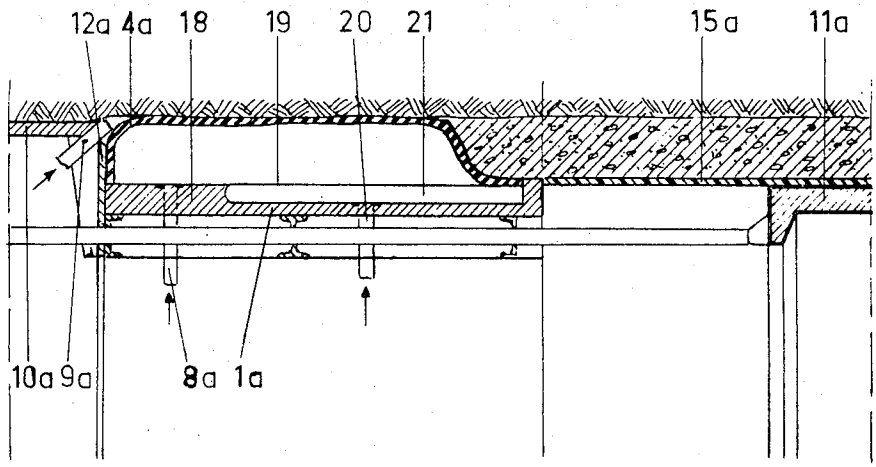

12a
4a
18
19
20
21
15a
11a
10a
9a
8a
1a

Fig.3

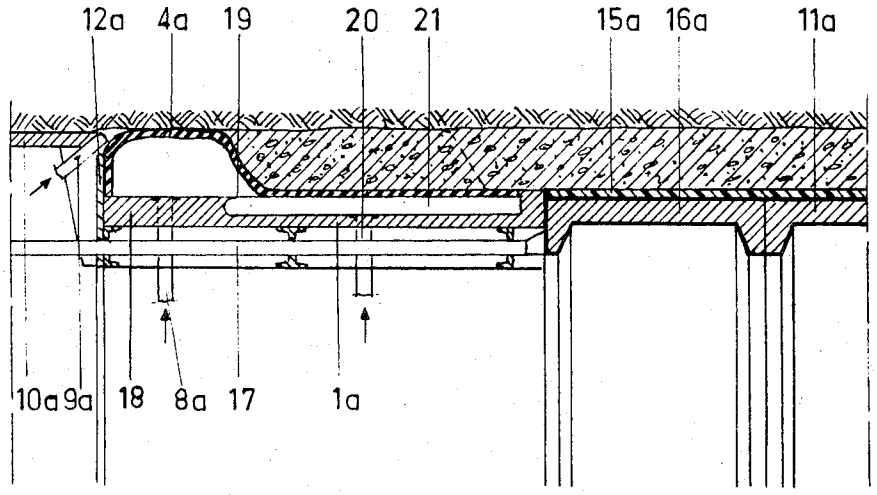

12a
4a
19
20
21
15a
16a
11a
10a
9a
18
8a
17
1a

Fig.4

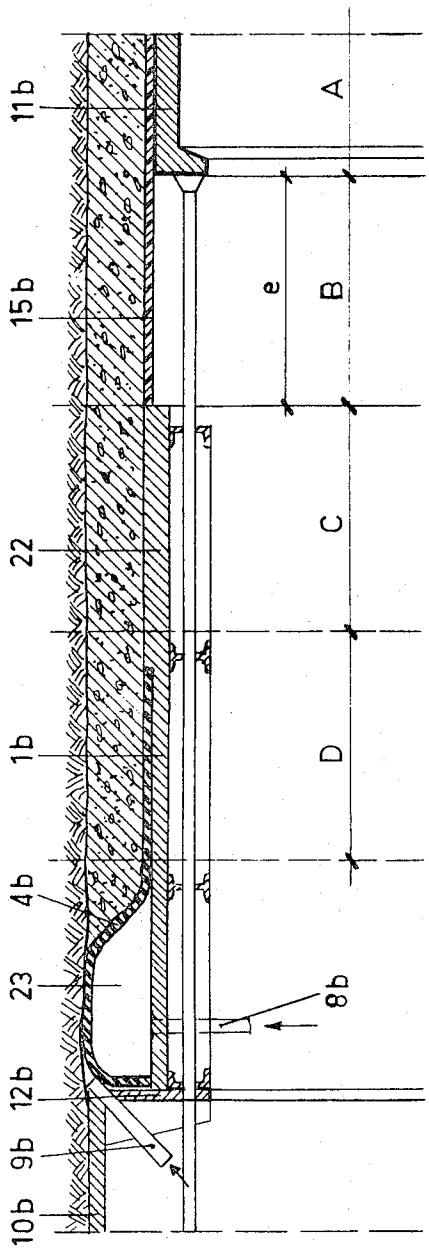

11b
15b
22
1b
4b
23
12b
9b
10b
8b
A
B
e
C
D

Fig.5

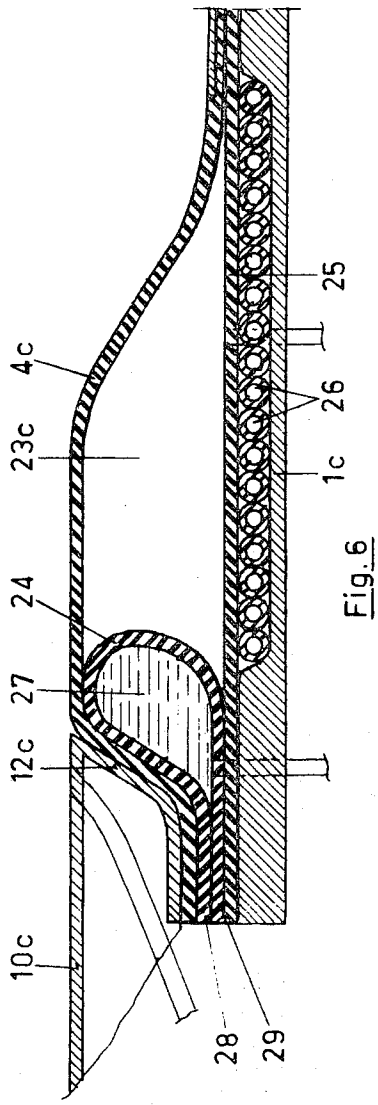

4c
23c
24
27
12c
10c
25
26
1c
28
29

Fig.6

METHOD AND APPARATUS FOR USE IN TUNNELLING

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for use in tunnelling.

Ever since the creation of large-section underground tunnels and galleries in non-rocky terrain, the drilling of the terrain has taken place generally over relatively short lengths and has been immediately followed by the installation of supporting means to prevent falls of earth. In the case of sufficiently compact terrain support can be achieved by timbering or by placing buttresses and arches or metal props, as is generally the case in mining galleries. On the other hand, if the terrain is liable to crumble, alluvial terrain for example, it is provided before drilling with the desired compactness by injecting chemical filling, most often on a silica gel base or made of synthetic resin. Apart from the ever present possibility of the danger of falls of earth during the course of the injection procedure or before the filling substances sets, the cost of excavation is very considerably increased.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method of tunnelling comprising supporting the terrain with an annular fluid mass under pressure, advancing the fluid mass, and introducing lining compound, allowing the lining compound to set in the form of a tube, and internally coating the tube over a length substantially equal to that of the lining compound which has been introduced.

According to a further aspect of the present invention there is provided apparatus for use in tunnelling comprising a tube whose external diameter is substantially equal to the internal diameter of a lining compound support and connected to a shield of the apparatus, a flexible wall joined to the external wall of the tube in the neighborhood of its leading edge and a portion of the tube intermediate its ends to define a pocket between the tube and the flexible wall at least one conduit for injecting lining compound on the outer side of the flexible wall of the pocket and a pipe for introducing fluid under pressure into the inside of the pocket.

The tube can be of a uniform thickness or can have at the front a short shoulder, an inflatable wall integral with this shoulder and with the trailing edge of this tube and a means for introducing fluid under pressure into this inflatable wall.

REFERENCE TO THE DRAWINGS

The invention will now be described in more detail, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

FIG. 1 is a partial vertical section of apparatus for supporting a tunnel under construction before the injection of a lining compound;

FIG. 2 shows the apparatus of FIG. 1 after injection of the lining compound;

FIG. 3 is a partiial vertical section of a second form of apparatus for supporting a tunnel under construction before the injection of a lining compound;

FIG. 4 shows the device in FIG. 3 after the injection of the lining compound;

FIG. 5 is a partial vertical section of a third form of apparatus for supporting a tunnel under construction after the injection of a lining compound; and

FIG. 6 is a partial vertical section of a fourth form of apparatus for supporting a tunnel under construction.

In the drawings like parts are designated similar reference numerals, letter subscripts being employed to distinguish between the various embodiments.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The apparatuses shown in FIGS. 1 to 4 which deal with non-continuous advance, are shown in the positions they occupy at the end of the advance of a shield **10.**

The apparatus for supporting a tunnel under construction shown in FIGS. 1 and 2 comprises a tube **1** of substantially constant thickness, whose external diameter is substantially equal to the internal diameter ϕ of a dry lining compound **2,** which may be mortar or grout, for supporting the terrain **3.** An inflatable pocket **4** is mounted over the greater part of the tube **1,** and is integral with the leading edge **5** of the tube **1** and with a zone **6** disposed at a short distance from its trailing edge **7.** A pipe **8** opening through tube **1** makes it possible to connect the internal volume of the pocket **4** with a source of compressed air. A conduit **9** opening above the external wall of the pocket **4** is used for the injection of fresh lining compound. The tube **1,** pocket **4** and conduit **9** are integral with the shield **10.**

The apparatus operates as follows:

The shield **10** is advanced to leave a space *e* between the rear end **7** of the tube **1** and a lining ring **11** previously put in place, space *e* having a length equal to that of the ring **11.** During the advance of the shield **10,** the pocket **4** is kept under pressure to follow both the shape of the terrain **3** and that of the dry lining compound **2.** Fresh lining compound is then injected via the conduit **9** which flows between the terrain **3** and the pocket **4** to reach the point **13** as it cannot flow in front of the pocket **4** which is integral with a rigid ring **12.** The injection ceases when the length of the fresh lining compound which has been injected in to point **13** is practically equal to the distance *e.* While drying the fresh lining compound sets on the face **14** of the dry lining compound **2.** While the lining compound is being injected and is setting, a sealing layer **15,** for example epoxy resin and tar, is applied on the internal surface of the dry lining compound **2.** A new ring **16** (FIG. 2) is then put in place using jacks **17** to support the arch stones of ring **16** on ring **11,** in the normal way, the arch stones being keyed on the jacks.

The method of providing support as described above ensures a continuous means of supporting the terrain without the risk of earth falls and without necessitating, in the case of alluvial terrain, any prior expensive injection into the mass in order to ensure that the terrain is compact. Injections over a very limited thickness around the cutting elements of the shield can however be useful in facilitating the insertion of the annular lining compound without causing the terrain to break up.

The apparatus in FIGS. 3 and 4 differs from that in FIGS. 1 and 2 only by internal tube **1***a*. Tube **1***a* has a short external shoulder **18** at the front and over the remainder of tube **1***a* is fixed a second inflatable wall **19.**

A pipe **20** provides a connection of chamber **21** to a source of compressed air. This apparatus can be used for minimizing the risks of the tube and the inflatable wall **4***a* adhering to the newly injected filling of grout or mortar when the shield advances.

The apparatus shown in FIG. **5** can be used in the case of continuous advance for drilling. The apparatus differs from that in FIGS. **1** and **2** only by internal tube **1***b*. The tube **1***b* has a rear portion **22** the length of which is greater than the length *e* of the lining rings and is shaped as an external shoulder in order to take up the thickness of the inflatable wall **4***b*.

With this apparatus, the advance of boring is fixed at the length *e* for the duration of setting of a length *e* of injected lining compound. In the position shown in this figure the zone A corresponds to the n^{th} ring which has been assembled, the zone B to the start of the mounting of the $(n + 1)^{th}$ ring. In the dry lining compound the zone C corresponds to the lining compound which is in the process of setting and the zone D to fresh lining compound, all these zones having a length *e*. In this case too, as in the case of FIGS. **1** to **4**, the support of the terrain is continuous because of the action of the compound which is supported when fresh and during setting by skirt **22** and by annular chamber **23** filled with compressed air.

In order to facilitate the mounting, dismounting and exchange of flexible walls, the inflatable wall is made preferably as shown in FIG. **6**. The compression chamber **23***c* for the terrain is defined externally by the inflatable wall **4***c* and on the inside by a sheet of rubber **25** resting on internal tube **1***c* and on inflatable tubes **26**. Tubes **26** and sheet **25** replace the second inflatable sheet **19** of FIGS. **3** and **4** and in addition the sheet **25** guarantees the internal tightness of the compression chamber **23***c*. Between the inflatable wall **4***c* and the sheet **25** there is interposed on the side of the ring **12***c* a chamber **27** defined by a flexible wall **24**. The two edges **28** and **29** of the wall **24**, the inflatable wall **4***c* and the sheet **25** are fixed on the ring **12***c* by means of the steel arch members constituting the tube **1***c*.

During assembly, the chamber **27** is flattened which facilitates the insertion of the inflatable wall **4***c*. Chamber **27** is then filled with non-compressible fluid, generally water, so as to force the inflatable wall against the ring **12***c* which to this end has a frusto-conical shape widening towards the rear as shown in the figure. The inflatable tubes **26** are filled with either compressed air or advantageously water.

The method and apparatus for providing support as described can be used when working galleries, tunnels, pits and the like.

What I claim is:

1. A method of tunnelling comprising the steps of supporting the terrain with an annular fluid mass under pressure, introducing a lining compound between the fluid mass and the terrain, progressively displacing the fluid mass by the lining compound, progressively shifting the support of the terrain from the fluid mass to the lining compound, allowing the lining compound to set in the form of a tube, advancing the fluid mass and internally coating the tube over a length substantially equal to that of the lining compound which has been introduced.

2. A method as claimed in claim **1** wherein the fluid mass is advanced continuously.

3. A method as claimed in claim **1** wherein the fluid mass is advanced in a stepwise manner.

4. A method as claimed in claim **3** wherein the length of the lining compound which is introduced during one operation is equal to the length of a lining ring.

5. A method as claimed in claim **2** wherein the advance rate of tunnelling is such that a length of one lining ring is travelled in the time it takes for an equivalent length of lining material to set.

6. Apparatus for use in tunnelling comprising a shield, a tube having an external diameter substantially equal to the internal diameter of a lining compound support and connected to said shield, a flexible wall connected to the external surface of said tube adjacent its leading edge and connected to said tube intermediate its ends, a pocket between said tube and said flexible wall, at least one conduit for injecting lining compound on the outer side of said flexible wall outside said pocket and a pipe for introducing fluid under pressure into said pocket.

7. Apparatus as described in claim **6**, said flexible wall being connected to an external shoulder on the leading edge of said tube.

8. Apparatus as described in claim **6**, said pocket having an inner sheet of rubber resting on tubular inflatable rings disposed around said tube.

9. Apparatus as described in claim **8** including a chamber defined by a second flexible wall interposed between said first mentioned flexible wall and said sheet, the front edges of said first mentioned flexible wall of said chamber and of said sheet being secured to a connecting ring of said shield by arch members of said tube.

10. Apparatus as described in claim **9**, said chamber being filled with a non-compressible fluid.

11. Apparatus as described in claim **9**, said connecting ring having a frusto-conical shape widening towards the rear.

12. Apparatus as described in claim **6**, the length of said tube being substantially equal to double the length of a lining ring of the tunnel.

13. Apparatus as described in claim **6**, said tube having at the rear of said pocket a skirt of slightly greater length than that of a lining ring of the tunnel.

14. Apparatus as described in claim **6**, the fluid under pressure being selected from the group consisting of compressed air and water.

15. Apparatus for terrain support during tunnelling comprising a drilling shield, means associated with said drilling shield for supporting a lining compound during setting of the lining compound, means associated with said drilling shield utilizing a mass of fluid under pressure to sustain the terrain before injection of the lining compound, means associated with said drilling shield for injecting the lining compound between the terrain and said means utilizing the mass of fluid under pressure, whereby the lining compound progressively displaces the mass of fluid and progressively supports the terrain.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,788,087 Dated January 29, 1974

Inventor(s) Pierre Patin

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The claim of priority was omitted. It should read

-- French Application 71 16398, May 6, 1971 --.

Signed and sealed this 1st day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334