United States Patent

Hänig et al.

[15] **3,673,806**

[45] **July 4, 1972**

[54] LINER FOR TUNNEL WALL

[72] Inventors: **Siegfried Hänig; Alfred Langer,** both of Peine, Germany

[73] Assignee: **Firma Ilseder Hutte,** Peine, Germany

[22] Filed: **June 23, 1970**

[21] Appl. No.: **48,997**

[30] **Foreign Application Priority Data**

June 25, 1969 Germany ..... P 19 32 107.4

[52] **U.S. Cl.** ..... **61/45 R,** 61/42

[51] **Int. Cl.** **E21d 5/08**

[58] **Field of Search** ..... 61/45 R, 42, 43, 84, 85

[56] **References Cited**

UNITED STATES PATENTS

1,837,134	12/1931	Porter et al.	61/45 R
349,301	9/1886	Buckelew	61/45 R
1,923,006	8/1933	Proctor	61/45 R
1,923,008	8/1933	Proctor	61/45 R
2,098,915	11/1937	Foukal	61/45 R
2,114,834	4/1938	Foukal	61/45 R
2,188,448	1/1940	Smith	61/45 R
2,366,961	1/1945	Fine et al.	61/45 R

FOREIGN PATENTS OR APPLICATIONS

1,020,570	2/1966	Great Britain	61/45 R
506,453	5/1939	Great Britain	61/45 R
560,849	4/1944	Great Britain	61/45 R

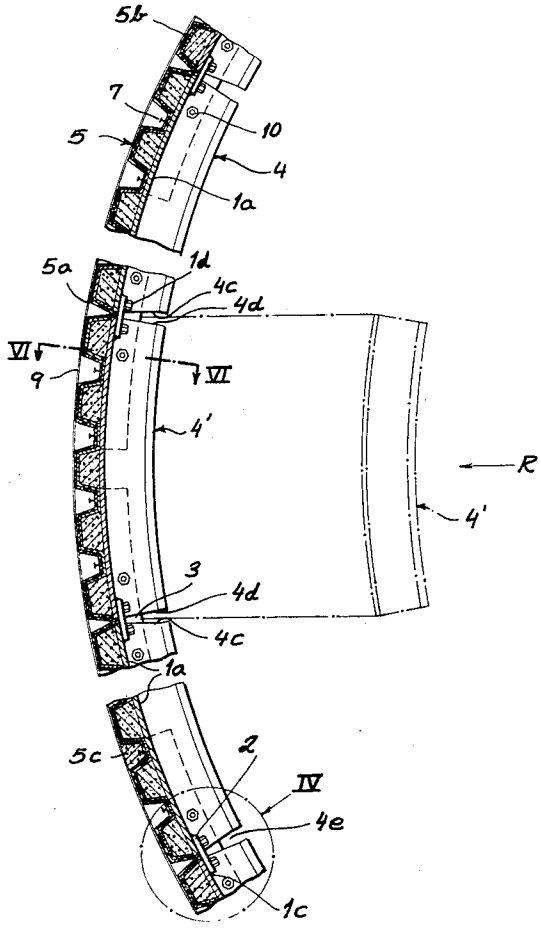
Primary Examiner—Dennis L. Taylor

Attorney—Karl F. Ross

[57] **ABSTRACT**

Cylinder segments of plate steel, their junctions bridged by relatively narrow axially extending steel strips welded and bolted thereto, are juxtaposed to form several axially adjoining tubes with interposition of annular reinforcements projecting radially outwardly beyond the tubes to support a protective outer jacket composed of complementary part-cylindrical shell segments. The annular reinforcements consist of complementary arcuate T-profiles with inwardly directed flange portions and complementary flat ring segments overlappingly adjoining the web portions of the T-profiles. The webs of the T-profiles, which are peripherally coextensive with respective cylinder and shell segments, can be cut off along generally radial edges except at two neighboring locations where the edges diverge from the radial direction and are substantially parallel to facilitate radial insertion, in the manner of a keystone, of an intervening shorter segment.

14 Claims, 7 Drawing Figures



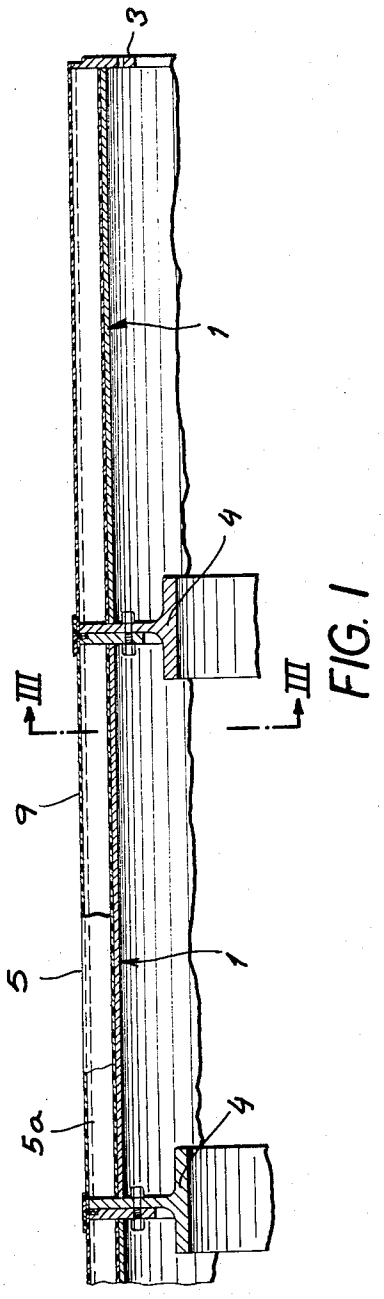


FIG. 1

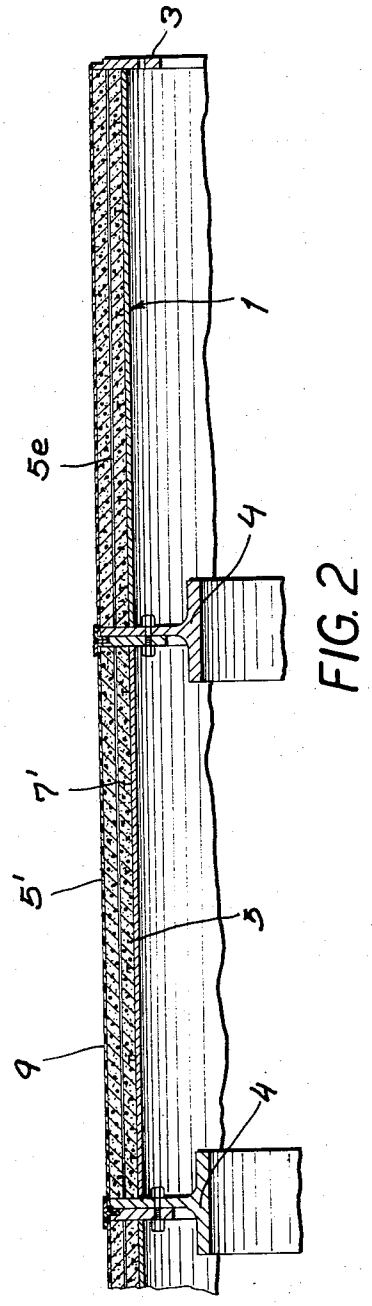


FIG. 2

Siegfried Hänig
Alfred Langer
INVENTORS.

BY

Karl F. Ross
Attorney

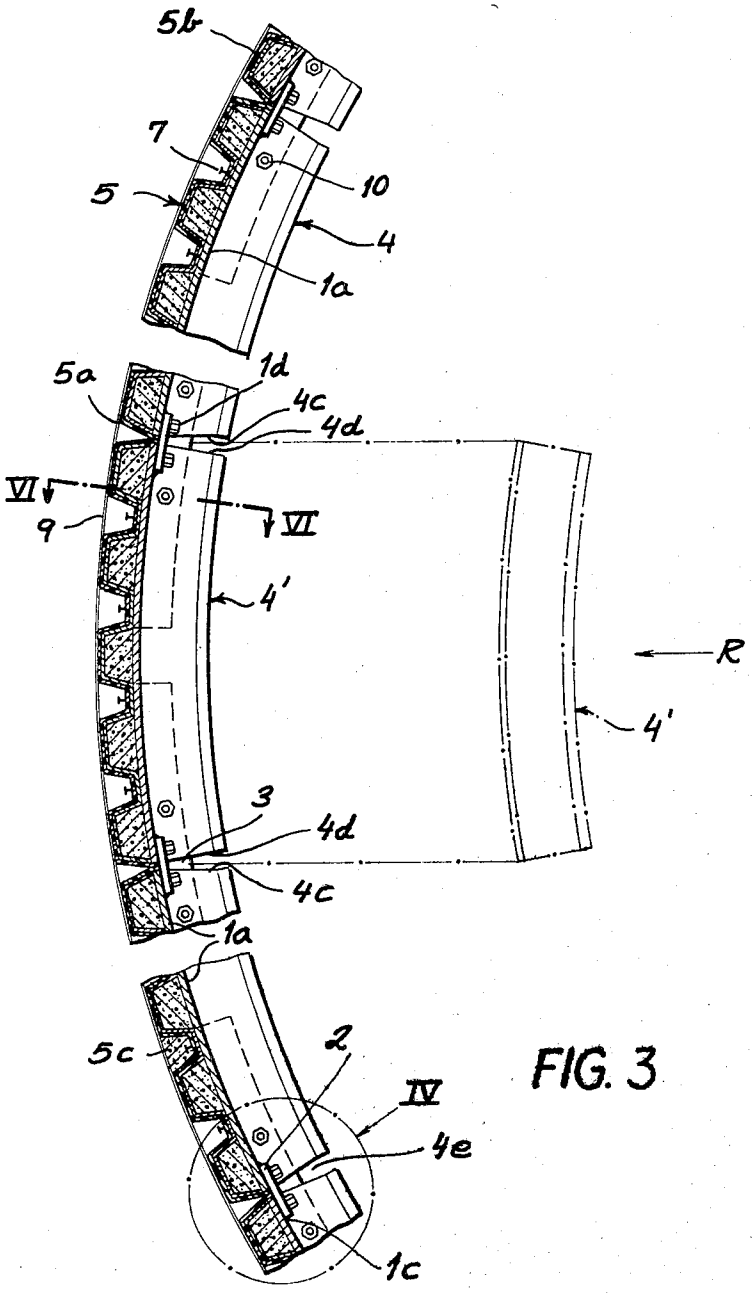


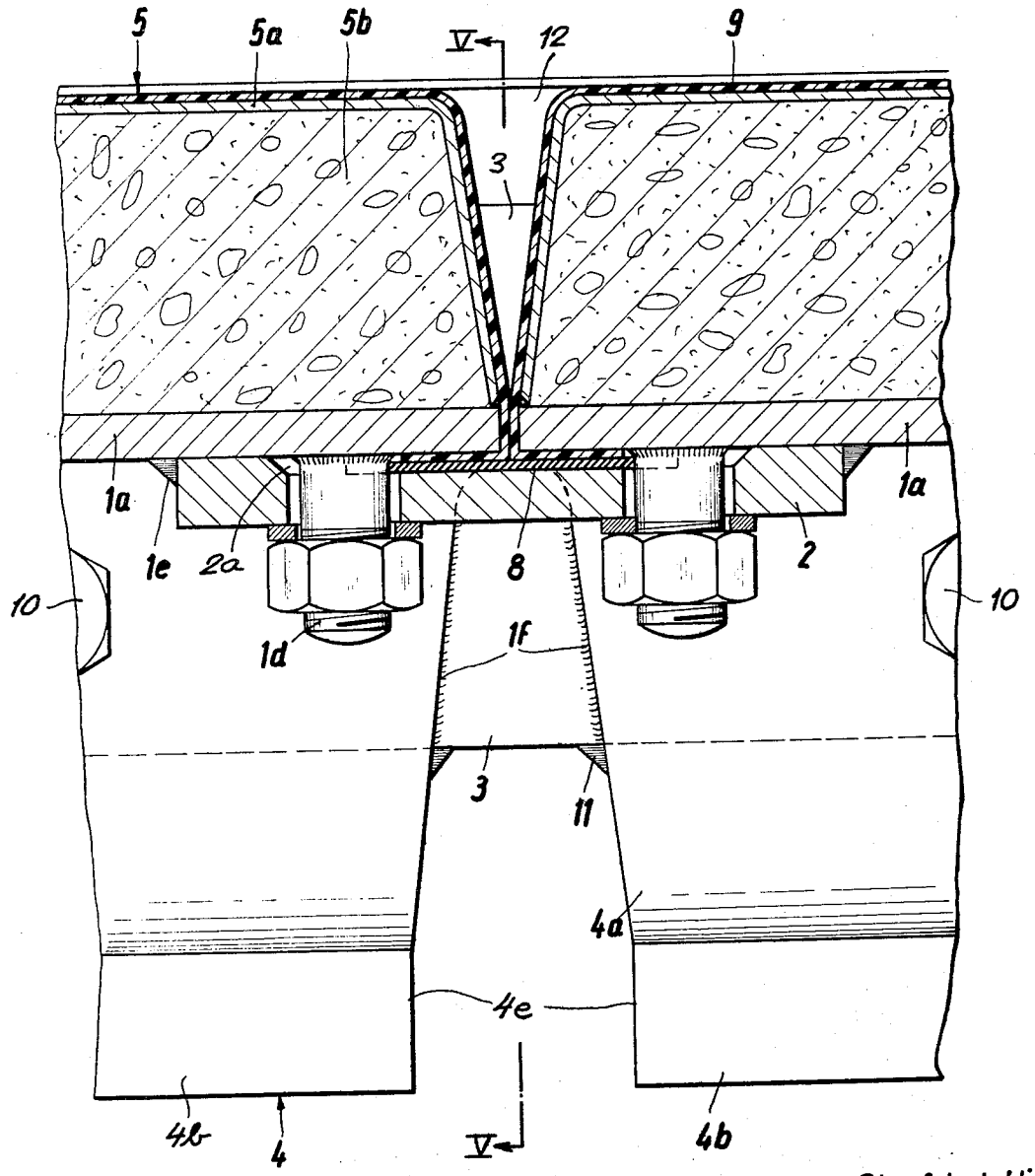
FIG. 3

Siegfried Hänig
Alfred Langer
INVENTORS.

BY

Karl F. Ross
Attorney

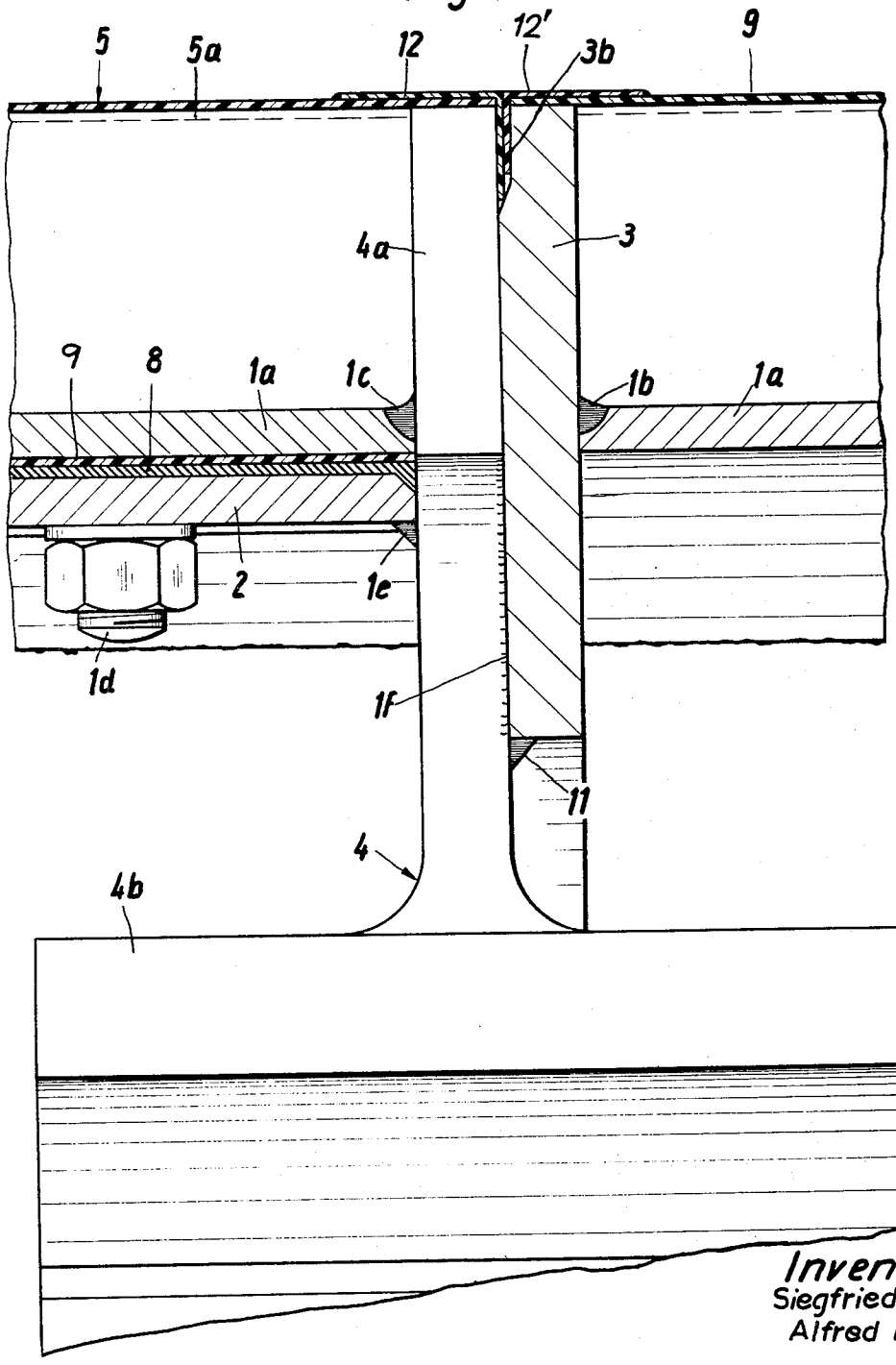
Fig. 4



Siegfried Hänig
Alfred Langer
Inventors.

By
Karl F. Ross
Attorney

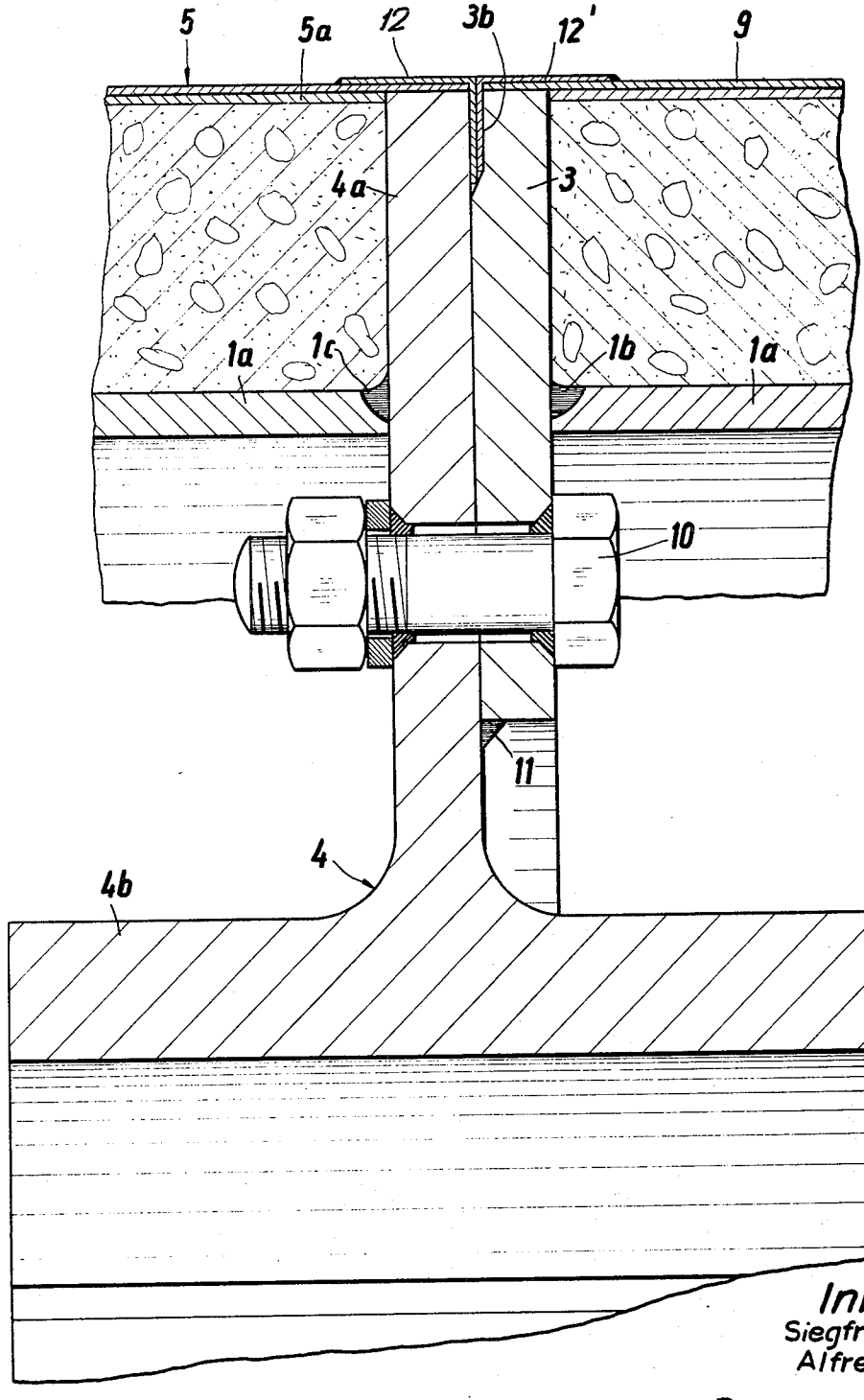
Fig. 5



Inventors:
Siegfried Hänig
Alfred Langer

By Karl F. Ross
Attorney

Fig. 6



Inventors:
Siegfried Hänig
Alfred Langer

By Karl G. Ross
Attorney

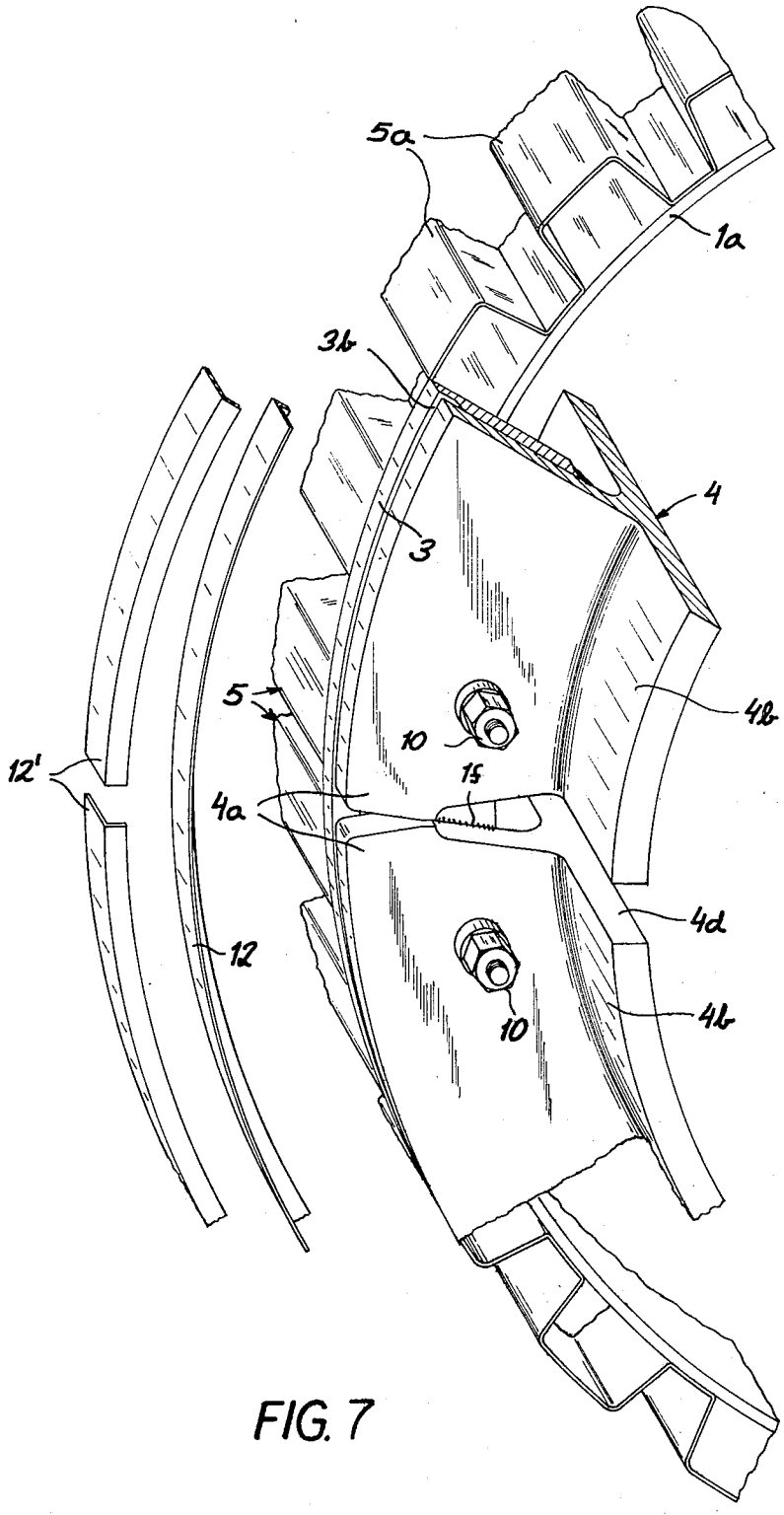


FIG. 7

Siegfried Hänig
Alfred Langer
INVENTORS.

BY

Karl F. Ross
Attorney

LINER FOR TUNNEL WALL

Our present invention relates to sheathings, known as tubbings, used in tunnel construction to line the tunnel walls.

Conventional tubbings are frequently made of cast iron or reinforced concrete. Cast-iron tubbings are of relatively low tensile strength and must therefore be made relatively heavy to resist the developing stresses. Reinforced-concrete tubbings, cast between coaxial metal shells, are also bulky and unwieldy besides making adjacent tubbing sections difficult to interconnect. The comparative thickness of these tubbings requires additional excavation work for a tunnel of given diameter.

Tubbings of rolled metal, particularly steel plate, are lower in cost and easier to install but, despite their high compressive and tensile strength, have hitherto found little acceptance because of their susceptibility to corrosion. The usual anticorrosive layers do not afford sufficient protection since they are easily scratched during the emplacement of the tubbings, thereby exposing the metal to oxidation by its contact with the surrounding soil.

Attempts have been made to solve this problem by leaving an annular clearance between the tubbings and the soil to accommodate a layer of concrete forced into that clearance. Owing to the inaccessibility of the space behind the tubbings, however, it is impossible to ascertain whether the concrete has completely penetrated that space or whether some parts of the metallic cylinder are in corrosive contact with the soil.

It is, therefore, an object of our present invention to provide an improved tubbing structure, consisting essentially of metal plate, which avoids the above-described drawbacks and can be easily installed in a tunnel.

More specifically, our invention aims at providing means for positively spacing a metallic cylinder from the tunnel wall while at the same time conferring upon that cylinder the necessary structural rigidity.

In accordance with this invention we provide a plurality of axially adjoining cylindrical tubbing sections consisting essentially of metal, preferably steel; each tubbing section includes a tube preferably subdivided into cylinder segments which are held together by relatively narrow strips extending axially along their junctions, any two adjoining tubbing sections being separated by an interposed annular reinforcement also divided into ring segments which are disposed in a radial plane and project both inwardly and outwardly beyond the cylinder segments.

Such an annular reinforcement, in addition to forming a link between two adjoining tubbing sections, acts as a spacer by bearing outwardly upon the tunnel wall. Advantageously, pursuant to another feature of our invention, a more complete separation between the tubbing cylinders and the tunnel wall is achieved by means of a cylindrical outer jacket surrounding the metal tube over the full length of a tubbing section and bearing upon the aforementioned reinforcement, or preferably on two such reinforcements supporting the jacket at opposite ends. This jacket need not itself be corrosion-resistant since its primary purpose is to protect the steel tube during and immediately after installation; nevertheless, the jacket may be provided with protective coatings which also extend over the outer edges of the supporting ring segments as well as around confronting edges of adjacent cylinder segments and over part of the inner surfaces of the latter segments to seal the intervening gaps.

To facilitate its installation, the jacket should also be peripherally subdivided into complementary shell segments which are substantially coextensive with respective cylinder segments of the associated metal tube and which preferably consists at least partly of metal to simplify their mechanical connection (e.g. by welding) with the supporting ring segments or segment pairs.

According to a further feature of our invention, the ring segments constituting the annular reinforcement or support form two mutually overlapping sets, the ring segments of one set being substantially coextensive in peripheral direction with the associated cylinder segments. One of these sets of segments, advantageously the last-mentioned one, preferably from a T-profile with flat web portions in the radial support plane and arcuate flange portions spaced inwardly from the confronting cylinder segments to stiffen the latter. One of these profiled ring segments, in particular, may be relatively short to fit as a keystone between two neighboring ring segments in order to be slidable into position from within the tunnel during completion of the assembly.

The above and other features of our invention will be described hereinafter in greater detail with reference to the accompanying drawing in which:

FIG. 1 is a fragmentary axial sectional view of a tunnel lining formed from tubbing sections embodying our invention;

FIG. 2 is a view similar to FIG. 1, showing a modification;

FIG. 3 is a partial cross-sectional view of a tubbing section taken on the line III—III of FIG. 1;

FIG. 4 is an enlarged cross-sectional detail view of the area IV of FIG. 3;

FIG. 5 is a cross-sectional view taken on the line V—V of FIG. 4;

FIG. 6 is a view similar to FIG. 5 but taken on the line VI—VI of FIG. 3; and

FIG. 7 is a perspective view of the assembly shown in FIGS. 4–6.

The tunnel liner shown in the drawing comprises a plurality of coaxial cylindrical tubbing sections 1 each including a steel tube composed of cylinder segments 1*a*, a like number of steel strips 2 covering the junctions of segments 1*a* onto which they are fastened by bolts 1*d* and welding seams 1*e*, and an outer jacket subdivided into shell segments 5 (FIGS. 1, 3–7) or 5′ (FIG. 2) which are coextensive with the adjoining cylinder segments 1*a*. Shell segments 5 are shown to include corrugated steel plates 5*a* defining with cylinder segments 1*a* a multiplicity of longitudinal channels of generally trapezoidal cross section into which, as shown in FIG. 4, a filler 5*b* of concrete may be introduced to strengthen the jacket. Other suitable filler materials include expanded clay, glass or furnace slag as well as open-celled hard foam plastic. A similar filler, e.g. of grout, could be additionally or alternatively introduced into the outer channels of the jacket as shown at 5*c* in FIG. 3. To help retain these fillers, stirrups 7 may project into the voids as likewise illustrated in FIG. 3.

The jacket 5′ shown in FIG. 2 comprises simply an array of shell segments 5*d* of reinforced concrete held in position by stirrups 7′, the reinforcing armatures being partly in the form of axially extending rods 5*e*.

Axially adjoining tubbing sections are separated by annular reinforcements each consisting of two sets of mutually overlapping ring segments 3, 4 lying flat against one another in a radial plane. Ring segments 4 are curved T-profiles with webs 4*a* and flanges 4*b*, the latter being coaxial with the cylinder segments 1*a* and inwardly spaced therefrom. It will be noted that the profiled ring segments 4 are separated by gaps registering with the junctions of adjacent cylinder segments 1*a* and shell segments 5*a* (or 5*b*), these gaps being bridged by ring segments 3. Ring segments 3 and 4 are welded to cylinder segments 1*a* at 1*b* and 1*c*, respectively, and to each other at 1*f*. Seams 1*b* and 1*c* can also be used to hold the corrugated steel plates 5*a* in position as shown in FIG. 4; with the modified jacket 5′ of FIG. 2 the concrete segments 5*d* may be secured to adjoining reinforcing rings by a welding of the ends of armatures 5*e* to their segments 3 and 4, respectively. Thus, the radially outwardly projecting parts of ring segments 3 and web portions 4*a* form ribs bearing endwise upon the jackets 5 or 5′.

Since especially the ring segments 4 are of substantial radial depth, their interfitting to a substantially continuous annular profile would be difficult if the webs of all these segments were cut off along approximately radial edges as illustrated at 4*e* in FIGS. 3 and 4, at least if each of these segments extended over a large arc of a circle (e.g. of 60° or 90°). We therefore prefer to provide at least one ring segment 4′ (FIG. 3) whose length is only a minor fraction of a quadrant, e.g. not more than

about 30°, and which terminates in a pair of substantially radial edges 4*d* confronting a pair of parallel edges 4*c* on adjoining ring segments 4. Segments 4' can thus be radially slid, in the manner of a keystone, into the space formed between the parallel edges 4*c* as indicated by an arrow R in FIG. 3.

The structure so far described may be installed one tubbing section at a time, with each cylinder segment 1*a* initially welded to the associated shell segment 5*a* (or 5*d*) and the web portion 4*a* of the corresponding ring segment 4 in the manner indicated above, as by means of a weld seam 1*e*. The other end of the segmental unit 1*a*, 5*a* (or 5*d*) may be joined to a ring segment 3 which, however, is peripherally staggered with reference to that unit and to segment 4. After the wider segmental units have been positioned side by side against the tunnel wall, the narrower unit rigid with keystone 4' is slid into place whereupon the several webs 4*a* are bolted at 10 to the adjoining ring segments 3 of the previously formed tubbing section. The joint between these tubbing sections is then completed by a welded connection 11 between elements 3 and 4*a*. Furthermore, the junctions between segments 1*a* are covered by the strips 2 which are bolted down at 1*d* and welded in position at 1*e*.

As seen in FIGS. 6 and 7, elements 3 and 4*a* are separated near their outer peripheries by an annular recess 3*b* adapted to receive angularly profiled inserts 12 and 12' of corrosion-resistant plastic or possibly metallic material. These inserts have flanges which overlie the outer edges of elements 3 and 4*a* and are in contact with the ends of protective coatings 9 of similar material adhering to the external surface of jacket 5. These coatings, which may completely cover the outer trapezoidal channels of the corrugated plates 5*a* in the embodiment shown in FIGS. 1–7, abut the webs of inserts 12 and 12' which are wedged into the clearance 3*b*; these inserts are also subdivided into segments, preferably in overlapping relationship as seen in FIG. 7, and are emplaced together with the shell segments of a new tubbing section on the exposed faces of ring segments 3 secured to a previously installed section.

As best seen in FIG. 4, the coatings 9 (omitted for clarity in FIG. 7) of juxtaposed jackets 5 may also extend through the narrow gap between the segments 1*a* of two adjacent steel tubes 1*a* and over part of the inner surfaces of these tubes into a recess 2*a* of a strip 2 overlying this gap, the strip 2 thus bearing upon the segments 1*a* only by its longitudinal edges while also exerting clamping pressure upon the terminal zones of the coatings, received in recess 2*a*, through a resilient pad 8 of rubber or other elastomeric material. Weld seam 1*e* advantageously extends completely around the strip 2 to join the ends of the strip to segments 3 and 4 while forming a bead which spans the narrow gap between webs 4*a* sealed by the coatings 9.

It will thus be seen that we have provided a tubbing structure which is easily sealed against penetration by groundwater with the aid of continuous weld seams along the edges of their overlappingly adjoining metal elements and which, prior to such sealing, can be readily assembled from a combination of more or less complementary cylindrical segments. Conventional automatic equipment is available for such welding along an inner tube surface. Upon installation, the steel plates 5*a* forming part of jacket 5 may rust away without thereby weakening the structure or facilitating corrosion of the inner tube 1.

We claim:

1. A liner for a tunnel wall, comprising:

a plurality of axially adjoining cylindrical tubbing sections each including a metallic tube peripherally subdivided into cylinder segments;

a cylindrical outer jacket surrounding said tube over the full length of a tubbing section thereof, said jacket being peripherally subdivided into a plurality of corrugated metallic shell segments substantially coextensive with respective cylinder segments, said shell segments forming axially extending channels along the outer periphery of said tube; and

fastening means interconnecting said cylinder segments and said shell segments

2. A liner as defined in claim 1 wherein said jacket includes a nonmetallic filler occupying at least some of said channels.

3. A liner as defined in claim 1 wherein said fastening means comprises a plurality of relatively narrow metallic strips extending axially along the junctions of said cylinder segments in overlapping relationship therewith for unifying same, and an annular reinforcement interposed between any two adjoining tubbing sections.

4. A liner as defined in claim 3 wherein said reinforcement includes at least one set of substantially complementary ring segments disposed in a radial plane and projecting both inwardly and outwardly beyond said segments.

5. A liner as defined in claim 4 wherein said reinforcement includes a second set of substantially complementary metallic ring segments, the two sets overlappingly overlying one another said radial plane and extending radially outwardly beyond said tube to the outer periphery of said jacket.

6. A liner as defined in claim 5 wherein one of said sets forms a T-profile with web portions in said radial plane and arcuate flange portions spaced inwardly from said cylinder segments.

7. A liner as defined in claim 1 wherein said flange portions are substantially peripherally coextensive with confronting cylinder segments.

8. A liner as defined in claim 7 wherein said web portions are cut off along substantially radial edges except at two locations spaced apart a fraction of a quadrant in alignment with a pair of successive junctions of said cylinder segments, said locations forming the boundaries of two spaced-apart web portions and one intervening web portion, said spaced-apart web portions being cut off along substantially parallel confronting edges facilitating insertion of said intervening web portion therebetween.

9. A liner as defined in claim 7 wherein said cylinder segments, strips and ring segments are interconnected by bolting and welding.

10. A liner as defined in claim 4 wherein said shell segments are provided with protective coatings extending around confronting edges of adjacent cylinder segments and over part of the inner surfaces thereof to seal an intervening gap, said coatings having terminal zones along said inner surfaces clamped between said cylinder segments and said strips.

11. A liner as defined in claim 9 wherein said reinforcement includes a second set of substantially complementary metallic ring segments, the two sets overlappingly overlying one another along said radial plane, the coatings of adjoining tubbing sections extending over the outer peripheries of respective sets of ring segments of an interposed reinforcement.

12. A liner as defined in claim 9 wherein said outer peripheries are separated by a narrow peripheral clearance, further comprising an insert received in said clearance and partly overlying said coatings over the full thickness of said sets of ring segments.

13. A liner as defined in claim 12 wherein said strips are provided with longitudinal central recesses confronting said cylinder segments and receiving said terminal zones.

14. A liner as defined in claim 7, further comprising resilient pad means in said recesses bearing upon said terminal zones.

* * * * *