United States Patent

Chlumecky

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[45] **July 18, 1972**

[54] TUNNEL LINING

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[73] Assignee: **Commercial Shearing & Stamping Company**

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[21] Appl. No.: **127,553**

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

[51] **Int. Cl.**.....**E21d 11/14**

[58] **Field of Search**.....61/45 R, 42, 84, 63; 49/475, 49/479, 483

[56] **References Cited**

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[57] **ABSTRACT**

A tunnel liner is provided in the form of a plurality of rectilinear arcuate side by side members forming a cylinder, each member having inturned flange on all edges, a triangular low compressibility elastomer member on each corner of each arcuate member, a layer of elastomer foam on each flange surface and triangular member, and means acting on adjacent flanges to draw them together and place the foam under compression.

4 Claims, 6 Drawing Figures

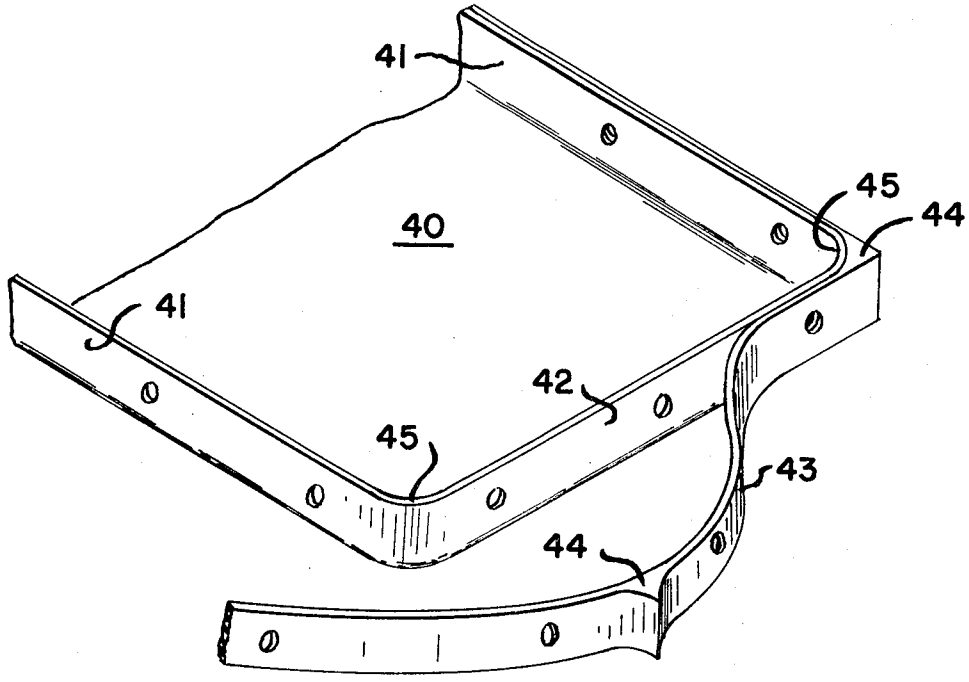


Fig. 1.

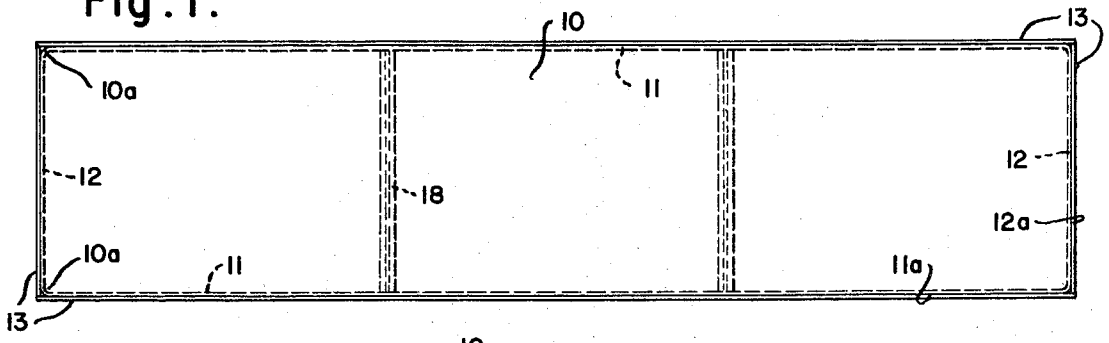


Fig. 2.

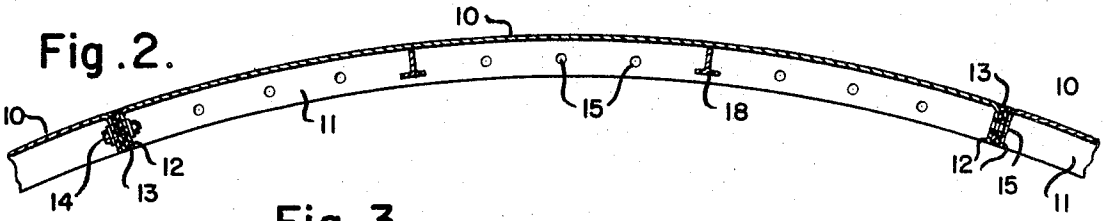


Fig. 3.

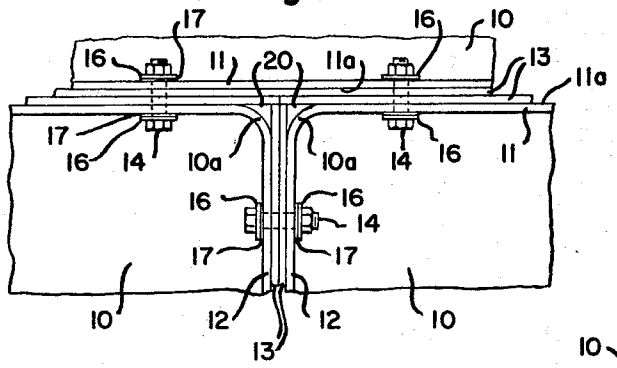
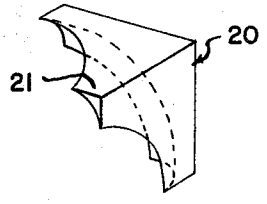


Fig. 4.



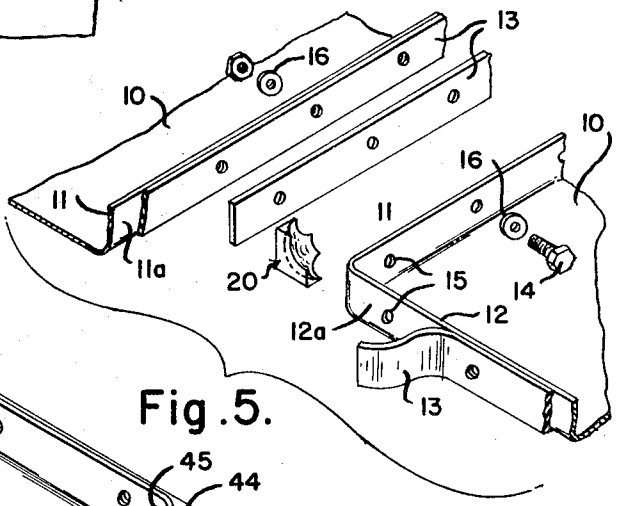
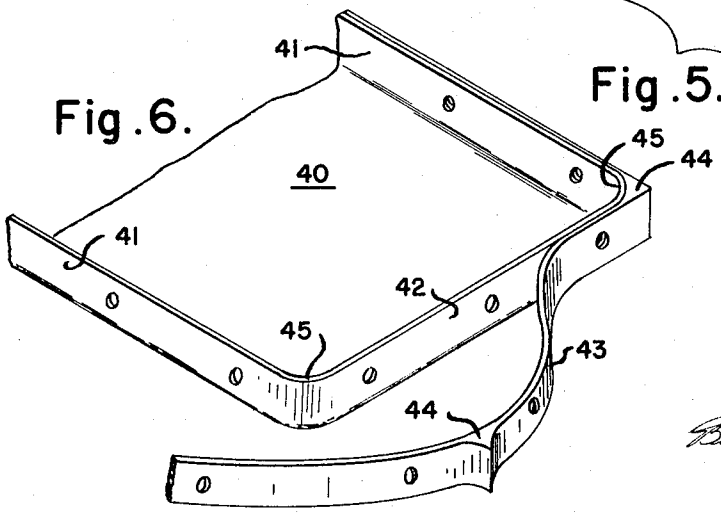


Fig. 5.

Fig. 6.



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TUNNEL LINING

The invention relates to tunnel lining and particularly to watertight steel tunnel lining. The problems of providing a watertight tunnel lining having been recognized for many years by engineers and builders of tunnels. For years people have been experimenting with various methods and materials to make a tunnel lining watertight. Throughout this period the only satisfactory and successful method of driving a tunnel through water-bearing ground has been to complete all tunnel operations using compressed air to keep the water from entering the tunnel and caulking and/or filling the area surrounding the tunnel with grout.

The time honored practice of driving a tunnel under compressed air involves very substantial costs in addition to the mere cost of excavating and lining. For example, such a practice involves in addition (1) a plant with electrical substations to supply large quantities of compressed air pressure to the tunnel, (2) standby diesel power units for the air supply, (3) a source of additional volume of air as the tunnel lengthens, (4) extra labor costs resulting from shorter shifter because of health hazards from the high air pressure and higher wage rates commanded by labor for the extra hazards involved, and (5) extra labor costs resulting from the longer time needed to erect reinforcing and pour permanent concrete linings at short intervals as is required when working under high air pressure as well as the disruption of normal mining and mucking cycles by these frequent concreting intervals, all of which labor rates are higher because of the health hazard under high pressure.

In the past attempts have been made to caulk a tunnel lining with lead caulking, asbestos rope or tar. These materials have been applied while the tunnel was being erected or were driven or injected into place after the lining was erected. Uniformly these caulkings have met with little or no success and were abandoned. Mining has continued to be practiced under high air pressure with pouring of concrete linings at short intervals because of the lack of a satisfactory means of sealing the joints and particularly the corners of liner plates.

I have solved these problems of prior art tunnel lining by very simple expedients and have made it possible to mine tunnels using much smaller air volumes and to completely eliminate intermediate concreting so that the entire concrete operation and clean up is done in free air.

Preferably I provide a tunnel liner made up of a plurality of rectilinear arcuate members having inturned flanges on all edges adapted to be bolted together at said flanges and a foamed resilient material fixed to each flange surface, said plurality of members being drawn together under pressure to cause deformation of said resilient foam, thereby sealing the adjacent edges together. Preferably the resilient material is a neoprene or silicone type foam or some similar long life acid resisting elastomer. A generally triangular member of rigid low compressibility elastomer. A generally triangular member of a rigid low compressibility elastomer, preferably having enlarged pyramidal end, is fixed to each corner of each liner plate within or beneath the foamed elastomer. Spaced reinforcing members are preferably formed in the members to take edge to edge thrust.

In the foregoing general description I have set out certain objects, purposes and advantages of my invention. Other objects, purposes and advantages will be apparent from a consideration of the following specification and the accompanying drawings in which:

FIG. 1 is a top plan view of a single liner plate according to my invention;

FIG. 2 is a section through a tunnel segment showing adjacent liner plates connected;

FIG. 3 is a fragmentary bottom view of a segment of tunnel liner;

FIG. 4 is an isometric view of a corner piece according to this invention;

FIG. 5 is an exploded isometric view of the joint of FIG. 3; and

FIG. 6 shows a second embodiment of liner plate according to my invention.

Referring to the drawings I have illustrated an elongated rectilinear plate **10** bent to arcuate pan form and provided with arcuate side flanges **11** and end flanges **12** which form depending flanges on the plates **10**. Each of the outer flange surfaces **11***a* and **12***a* on the side flanges **11** and end flanges **12** are provided with a layer of foamed elastomer **13** preferably neoprene. The flanges of adjacent plates are bolted together by bolts **14** passing through openings **15** and provided with washers **16** carrying an elastomer sealing surface **17** which bears against the interior of the flanges. When bolts **14** are tightened the elastomer foam **13** is compressed and creates a tight water proof seal between the adjacent flanges of the rectilinear plates making up a tunnel lining. Each corner **10***a* of each liner plate is provided with a generally triangular member **20** of solid neoprene having at one end an enlarged pyramidal portion **21** which bears on the compound curve formed by bending the corner **10***a* in the forming operation. This member **20** is covered with the elastomer foam layer **13**.

Strengthening members **18** may be welded at spaced intervals between side flanges **11** to take the thrust of the jacks used in moving the tunnel excavating head.

A typical segmental steel lining according to the invention consists in ¼ in. gauge × 24 in. wide × 37-11/16 in. long four flanged liner plates as illustrated in FIG. **1**. The plates according to my invention are provided with neoprene foam strips ¼ in. × 2½ in. cemented to the four flanges. All bolt holes are sealed using **12** gauge dished galvanized washers with a bonded neoprene seal under the washer. The neoprene foam on the liner flange preferably complies with Specification ASTM-D 1056-62 T, grade SCE-42 and on the washers with ASTM-D 735 grade SC-715. Steel for the liner plates conformed to Specification ASTM-A 283-Grade C.

Referring to FIG. **6** I have illustrated a liner plate **40** having side flanges **41** and end flanges **42**. A strip of neoprene or the like sponge **43** having spaced triangular projections **44** is applied to the flanges **41** and **42** with the triangular projections **44** spaced to fall at the corners **45** to form a rectangular peripheral outline. When two liner plates **40** are bolted together the triangular projections **44** seal the otherwise open pocket at the corners.

The lining of this invention will tend to rise whereas conventional linings tend to dive below grade. This is significant because adjustments to maintain tunnel grade when linings tend to rise are far less difficult to manage than in cases where they tend to dive.

Tests showed that two portions of liner one with and one without foamed elastomer had essentially the same crown deflection, hoop compressive stresses and bending stress. It can therefore be stated that the elastomer foam gasket cemented to the liner plate flanges in accordance with this invention does not deleteriously affect the load carrying capacity of the liner.

While I have illustrated and described certain preferred practices and embodiments of my invention, it will be understood that this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. A tunnel liner comprising a plurality of rectilinear arcuate side by side rigid members forming a cylinder, said arcuate members having inturned flanges on all edges, a triangular low compressibility substantially rigid elastomer member on each corner of said arcuate member forming with adjacent flanges a right angle, a layer of foamed elastomer on each flange surface and triangular member, said arcuate members being drawn together at the flanges to place the facing elastomer layers under compression and means acting on said flanges to draw them together.

2. A tunnel liner as claimed in claim **1** wherein the foamed elastomer is foamed neoprene and the triangular member is solid neoprene.

3. A tunnel liner as claimed in claim **1** wherein said arcuate members are drawn together at the flanges by bolts passing through holes in said flanges to place the elastomer layers under compression and elastomer sealing means is provided

on said bolts between said bolts and sealing said bolts to said flanges.

4. A tunnel liner as claimed in claim 3 wherein the sealing means are metal washers having a foam neoprene layer thereon.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,677,015 Dated July 18, 1972

Inventor(s) Nicholas Chlumecky

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

Column 1, line 53, after "elastomer." delete --A generally triangular member of a rigid low compressibility elastomer--.

Signed and sealed this 24th day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents