

Aug. 15, 1933.

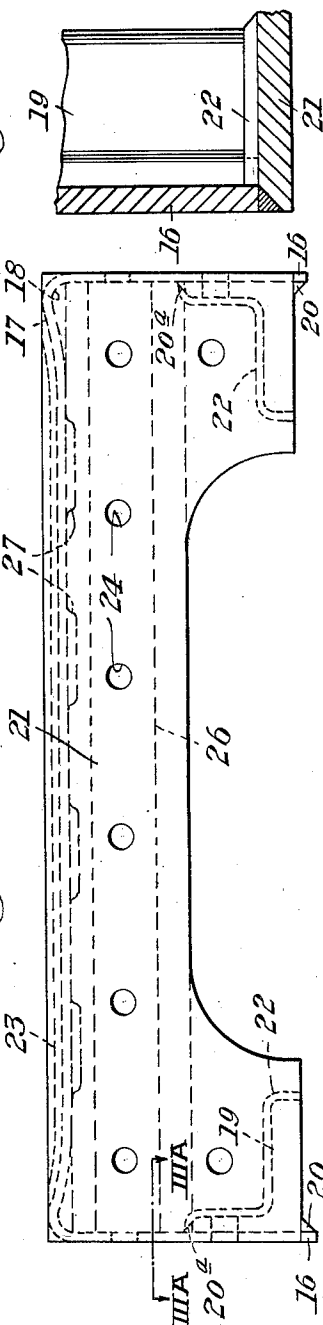
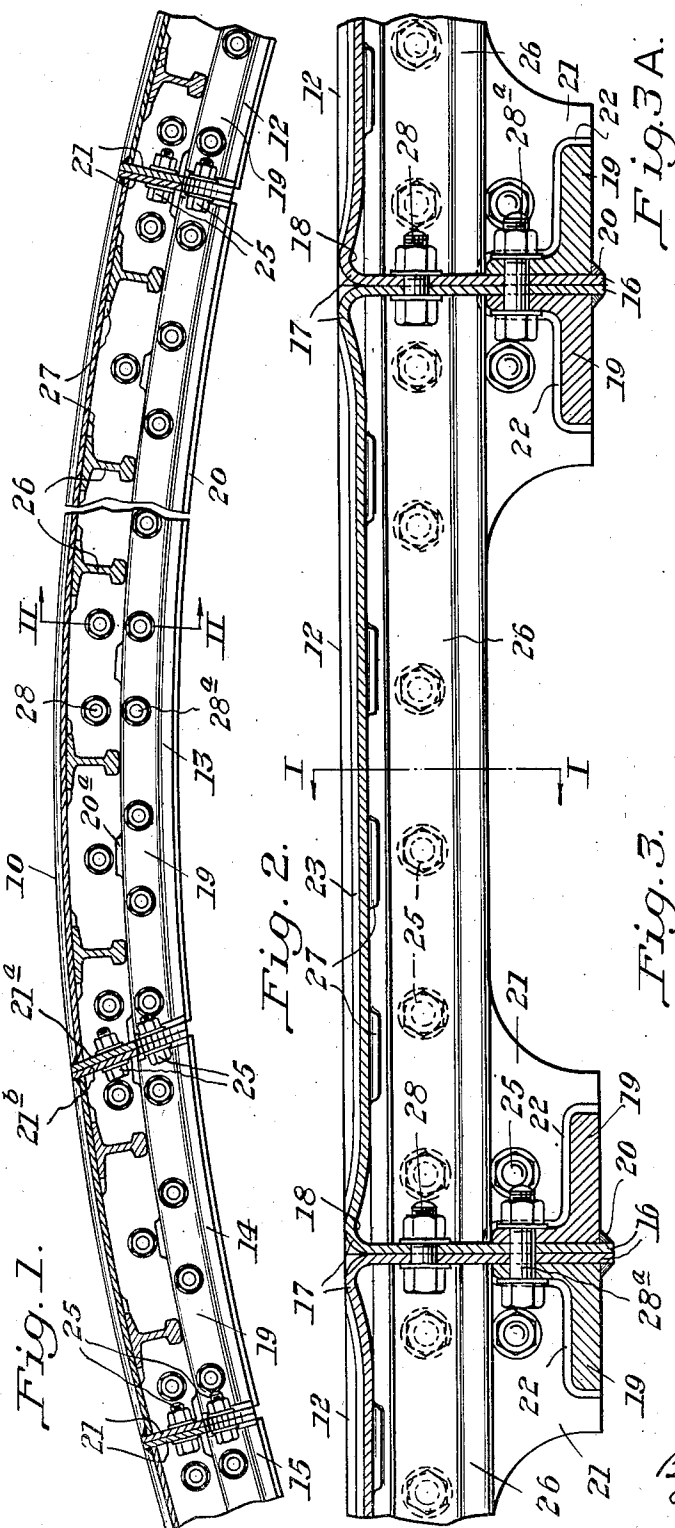
R. V. PROCTOR

1,923,007

TUNNEL LINER

Filed May 28, 1931

2 Sheets-Sheet 1



INVENTOR
Robert V. Proctor
by his attorneys
Byrnes, Stebbins,
Purmes & Blenko

Aug. 15, 1933.

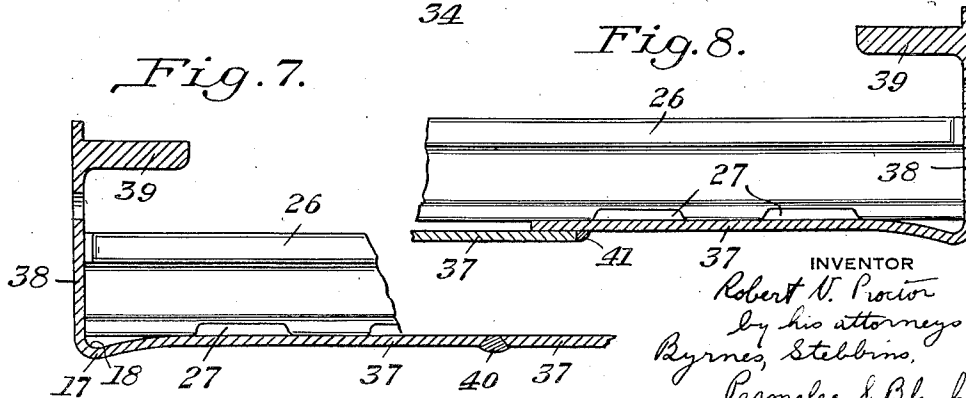
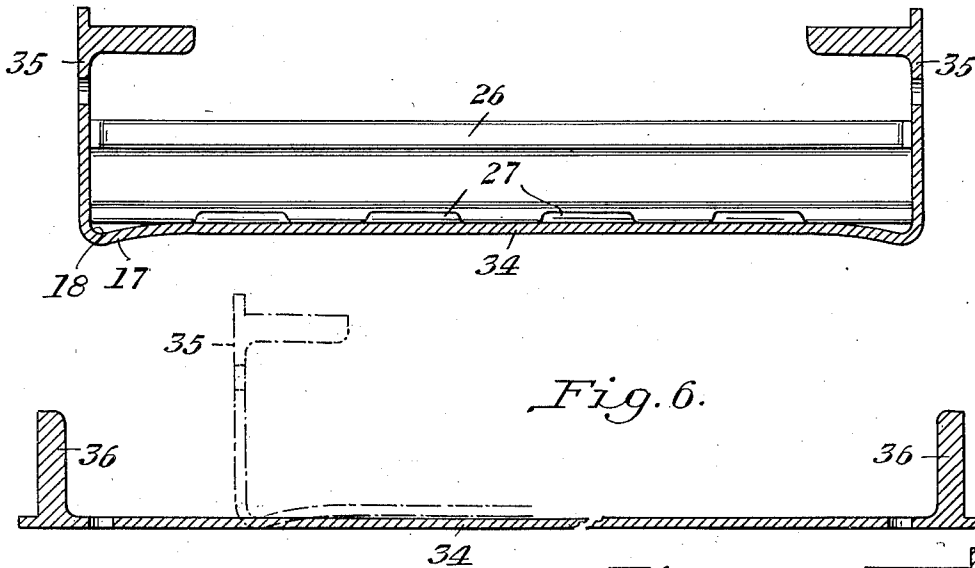
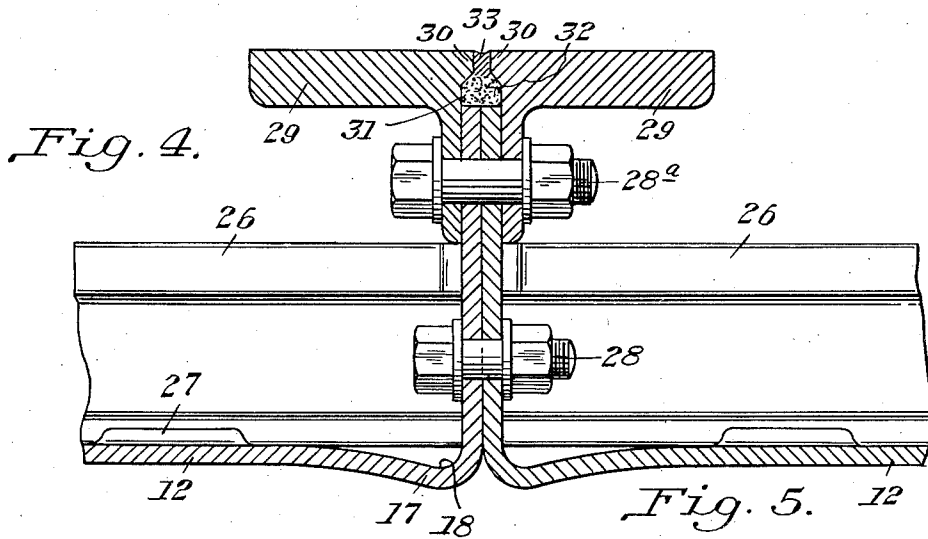
R. V. PROCTOR

1,923,007

TUNNEL LINER

Filed May 28, 1931

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

1,923,007

TUNNEL LINER

Robert V. Proctor, Youngstown, Ohio, assignor
to The Commercial Shearing & Stamping
Company, Youngstown, Ohio, a Corporation of
Ohio

Application May 28, 1931. Serial No. 540,640

12 Claims. (Cl. 61—45)

My invention relates to liner segments for subterranean tunnels or other similar structures.

According to present practices, subterranean tunnels are generally provided with a lining made up of steel segments assembled in courses or rings circumferentially of the tunnel, said rings being secured together side by side. A tunnel liner segment is formed of a steel plate having its edges bent up substantially at right angles to form side walls. The edges of the side walls are reinforced by angle irons welded thereto. End walls for the liner segment in the shape of separate plates are welded to the ends of the bent plate forming the body of the liner.

It is desirable to secure adjacent courses in a tunnel lining together by means of bolts fastened through the bent up side wall of the segment, as well as through one of the legs of the reinforcing angle irons welded thereto. The holes for the bolts are preferably punched through the side wall of the liner segment and the leg of the reinforcing angle adjacent thereto in one operation.

It is well known that, in punching operations, if the thickness of the material to be perforated exceeds the diameter of the hole to be punched, considerable trouble with the punching dies will be experienced. The thickness of the side wall of liner segments, according to the present construction, together with the thickness of the leg of the angle iron secured thereto, is such as to exceed the diameter of the bolt hole to be punched. As a result, considerable difficulty with the punching dies is experienced.

In addition to the difficulty with the dies, the angle irons previously used, having equal legs, did not dispose of the available section of metal to the best advantage or with the maximum efficiency.

In order to improve upon the liner segments known heretofore in the above respects, I have invented a liner segment consisting of a steel sheet having its edges bent up to form side walls. Reinforcing angles having unequal legs are welded to the bent up side walls with the thinner legs of the angle iron in contact with the side walls. This arrangement of the reinforcing angle iron has a two-fold purpose. In the first place, it reduces the depth of the hole which must be punched through the side walls and reinforcing angle iron for admitting the bolts for securing adjacent plates together. In the second place, it disposes the metal section of the angle iron most efficiently, in that the greater area of section is disposed at a maximum distance from the body of the plate, whereby the moment of inertia of the

section is increased so as to give the plate greater resistance to bending stress.

For a complete understanding of the invention, reference is made to the accompanying drawings, in which—

Figure 1 is a partial sectional view taken circumferentially of a course in a tunnel liner; Figure 1 may also be described as a partial transverse sectional view of the tunnel liner, or as a longitudinal sectional view of several plates connected together to form part of a liner course;

Figure 2 is a sectional view taken along the plane indicated by the line II—II in Figure 1; the line I—I of Figure 2 indicates the plane of the section shown in Figure 1.

Figure 3 is an end view of a complete liner plate;

Figure 3A is a partial sectional view along the line III—A—III—A of Figure 3, showing a detail;

Figure 4 is a partial sectional view similar to Figure 2, to enlarged scale, showing a modified form of liner plate;

Figure 5 is a view similar to Figure 2, showing a still further modified form of plate;

Figure 6 is a transverse sectional view showing the rolled shape from which segments of the character shown in Figure 5 may be produced;

Figure 7 illustrates a further modified form of the invention; and

Figure 8 shows a similar modification which differs in a slight detail from that of Figure 7.

Referring now in detail to the drawings, and in particular to Figures 1 through 3, a tunnel liner 10 comprises a plurality of courses. Each course extends circumferentially of the tunnel and consists of an assembly of liner segments 12, 13, 14 and 15. As shown in Figure 2, each segment 12 is made up of a steel plate, the body portion of which forms the outside wall or "skin" of the liner. The lateral edges 16 of the sheet are bent up substantially at right angles to form side walls for the segment 12. Instead of bending the side walls 16 up from the plane of the body of the sheet 12, I prefer to introduce a reverse bend 17 in the plate so that the fillet 18, which is inevitably formed between the angularly extending portions of the segment, is offset from the plane of the body portion thereof. The reason for this reverse bend will appear later.

Reinforcing angle irons 19, having legs of unequal thickness, are welded to the side walls 16 adjacent their edges by welds 20 and 20a with the thinner leg of the angle in contact with the side wall 16. The thicker leg of the angle iron thus

projects inwardly of the segment substantially parallel with the body portion thereof.

The ends of the segments 12 are closed by end plates 21, the shape of which may perhaps be best observed in Figure 3. These plates are welded to the side walls 16 of the plate 12, as well as the body portion thereof, and to the ends of the reinforcing angle irons 19. The welds joining the end plates to the reinforcing angle irons and the body portion of the plate are shown at 22 and 23. Bolt holes 24 are formed in the end walls 21 to facilitate end-to-end connection of adjacent segments in the liner course by means of bolts 25.

As shown in Figure 3A, the ends of the end plates 21 are beveled toward their inner surfaces, to facilitate welding to the ends of the side walls 16. The weld is ground smooth to permit a close fit between laterally adjacent liner plates.

The construction just described provides a water tight seal for the joint between the side walls and the end plates. By the method of fabrication used previously the side walls were attached to the end plates by an internal welded fillet. This left open the space between the edge of the side wall and the inner face of the end plate. And however tight this joint was made, it was not waterproof. The novel construction just described avoids the leaky joints characterizing the earlier types of liner segments.

In order to enable the tunnel lining to withstand axial strains, especially those resulting from the application of pressure on the forward end of the liner during the advancing of the shield by which the tunnel is bored, I provide reinforcing elements 26 extending transversely of the segments 12. In the plate illustrated in Figures 1 through 3, these reinforcing elements take the form of suitable lengths of ordinary T-rails. Other rolled shapes, such as I-beams, may be employed for the same purpose. The members 26 are welded to the body portion of the plate 12 by welds 27, and to the side walls thereof. The offsetting of the fillet 18 at the edge of the body portion of the plate makes it possible for the reinforcing elements 26, having their ends cut square, to abut the body portion and side walls of the liner segment firmly so as to provide the desired reinforcement therefor. Without the offsetting of the fillets, it would be necessary to clip the corners of the reinforcing members or else to leave a space between the latter and the body portion of the liner segment.

The plates 12 are curved longitudinally, as shown in Figure 1 and, when assembled end to end by means of the bolts 25, they constitute a ring-shaped course for a tunnel lining. For completing the arc formed by a series of segments 12 into a complete circle, I provide special sections 13 and 14, which are similar to the other sections except that they have one end wall disposed at an oblique angle to the body portion of the segment. The segment 13, for example, has its end wall 21a at an acute angle to the body portion of the segment. Similarly, the segment 14 has its end wall 21b at an obtuse angle to the body portion thereof. The other end walls of the segments 13 and 14 are similar to those of the segments 12. Thus, when a liner course has been completely built up of segments 12, except for the space occupied by the segments 13 and 14, the course may be completed by inserting the segment 13 in position and bolting it to the adjacent segment 12. The segment 14, being slightly wedge-shaped, is well adapted to being forced between the ends of the segments 13 and 15 to bring the liner course to its proper final dimensions. When the segment 14 has been

bolted in position, the course is complete and the next succeeding course may be constructed.

Adjacent courses in the liner are connected by bolts 28 and 28a. Segments in adjacent courses may be connected by such bolts as the courses are successively built up. The bolts 28 pass through the side walls 16 only of adjacent segments 12. The bolts 28a, however, traverse the thinner leg of the reinforcing angle iron 19 as well and, therefore, are somewhat longer than the bolts 28.

It will be apparent from the foregoing description that I have provided a liner segment which is characterized by numerous advantages. The segment is simple and inexpensive to manufacture and is characterized by great strength and rigidity. By welding the reinforcing angle irons to the edges of the side walls of the segments with their thinner legs abutting the side walls, I reduce the depth of the hole which has to be punched for the bolts connecting plates in adjacent courses. This arrangement of the angle irons, with the thicker legs projecting outwardly from the side walls in the form of a flange, contributes to the increased strength and rigidity of the segment, because a greater portion of the metal section is thereby disposed at a distance from the neutral axis of the transverse section of segment.

In a modified form of the invention illustrated in Figure 4, the angle irons 19 are replaced by similar reinforcing members 29. The angle irons 29, however, are provided with a heel 30. The angle irons are welded to the side walls 16 of the plates 12 so that the adjacent heels 30 define a narrow mouthed recess 33 for the reception of caulking material 32. In addition to the caulking material 32, a weld 33 may be employed to make the joints between adjacent segments waterproof.

In the modification of the invention shown in Figures 1 through 3, similar objects can be accomplished by welding or caulking the joints in any convenient manner.

Figure 5 illustrates a further modified form of the invention, in which a liner segment 34 has an integral body portion and side walls 35. As shown in Figure 6, the segment 34 is rolled flat with reinforcing flanges 36 thereon. After rolling, the edges of the segment are bent up in the manner indicated in chain lines in Figure 6 to form the finished plate, as shown in Figure 5. End walls 21 may be welded thereto in the manner described, and reinforcing members 26 inserted therein.

Figure 7 shows a further form of the invention in which, instead of rolling the complete segment as a unit, as in Figures 5 and 6, I form the segment in two halves 37, each forming a portion of the body of the segment and having side walls 38 and reinforcing flanges 39 integral therewith. The two halves 37 of the plate are butt welded at 40.

Figure 8 illustrates a form of liner segment similar to that shown in Figure 7, except that the joint between the sections 37 is effected by means of a lap weld 41.

Although I have illustrated and described herein but a few of the preferred forms of the invention, it will be apparent that many changes in the embodiments described can readily be made. Such changes, of course, can be made without departing from the spirit of the invention, as set forth in the appended claims, or sacrificing the advantages of the invention as above enumerated.

I claim:

1. A tunnel liner segment comprising a plate curved longitudinally, side walls extending per-

- pendicularly to the plate, flanges on said walls parallel to said plate and thicker than a portion, at least, of said side walls, and reinforcing members extending transversely of the plate, abutting
- 5 said side walls, the portions of the plate adjacent said side walls being offset permitting a close fit between said members, the plate and side walls.
2. In a tunnel liner segment, a plate, side walls therefor, and end walls welded to the edges of
- 10 the plate and side walls, the edges of the end wall abutting the edges of the side walls being chamfered.
3. In a tunnel liner segment, a metal sheet having a body portion, side wall portions bent up
- 15 therefrom, the edges of the body portion being offset from the general plane thereof, angle irons having legs of unequal thickness welded to said side walls with the thinner legs in engagement therewith, and walls welded to said body portion,
- 20 and reinforcing members positioned transversely of the liner and secured to the body portion thereof.
4. In a tunnel liner segment, a metal sheet having a body portion, side wall portions bent up
- 25 therefrom, angle irons having legs of unequal thickness welded to said side walls with the thicker leg projecting perpendicularly therefrom, end walls welded to said body portion and side walls, and transverse thrust members engaging said side
- 30 walls.
5. In a tunnel liner segment, the combination with a plate having side walls bent up therefrom, of angle irons having legs of unequal thickness secured to the edges of the side walls with the
- 35 thinner leg in engagement therewith.
6. In a tunnel liner segment, an outer wall and side walls integral therewith, end plates secured to the outer wall and side walls, and reinforcing angle bars secured to said side walls, said bar
- 40 having legs of unequal thickness.
7. A tunnel liner segment comprising a plate, side walls therefor, flanges projecting from the side walls, said flanges being thicker than at least a portion of the side walls, and reinforcing members extending across the segment engaging said
- 80 plate and side walls, and secured at least to the plate.
8. A tunnel liner segment comprising a plate curved longitudinally, side walls extending perpendicularly to the plate, flanges on said walls
- 85 parallel to said plate and thicker than a portion, at least, of said side walls, and reinforcing members extending transversely of the segment, abutting said side walls.
9. A tunnel liner segment comprising a plate,
- 90 side walls therefor, formed, at least in part, of a rolled member, flanges projecting at right angles to said walls and being thicker than a portion, at least of said walls, and reinforcing members extending across the plate in engagement there-
- 95 with.
10. In a tunnel liner segment, a plate having side walls perpendicular thereto, flanges at right angles to said walls substantially thicker than portions of said walls, said walls and flanges being
- 100 formed, at least in part, of rolled structural shapes.
11. A tunnel liner segment comprising a plate, side walls extending substantially at right angles to the plate, and reinforcing members extending
- 105 the length of the walls and at right angles thereto, said members being substantially thicker than the walls and composed of a rolled structural shape.
12. A tunnel liner segment comprising a skin
- 110 plate, a side wall integral therewith and bent relative thereto, and a flange on said side wall substantially parallel to said plate and thicker than a portion, at least, of said side wall.
- ROBERT V. PROCTOR.
- 115

45

120

50

125

55

130

60

135

65

140

70

145

75

150