Jan. 26, 1932. C. B. CUSHWA 1,843,102

TUNNEL LINER

Filed Aug. 13, 1928 4 Sheets-Sheet 1

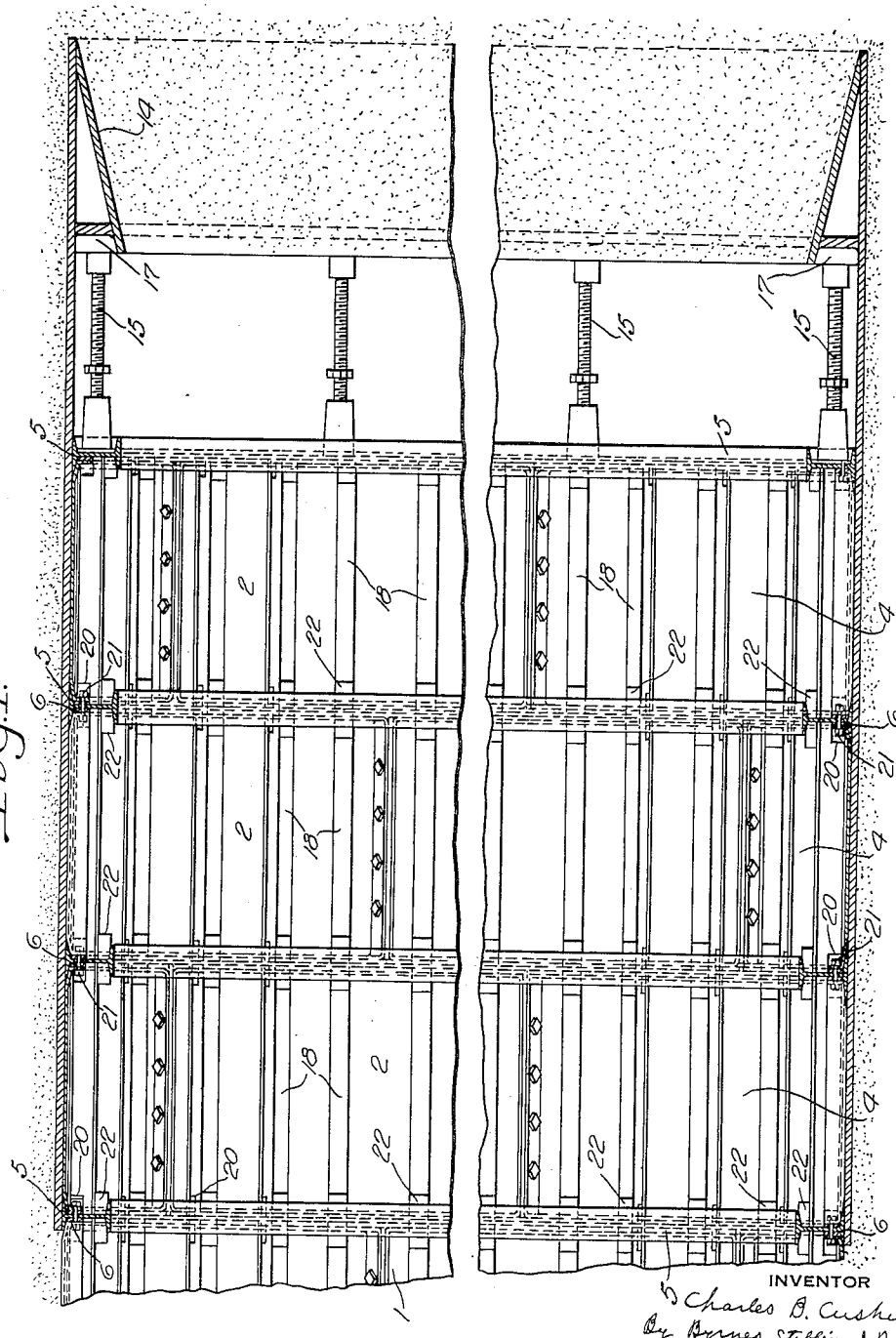


Fig. 1.

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Fig. 6.

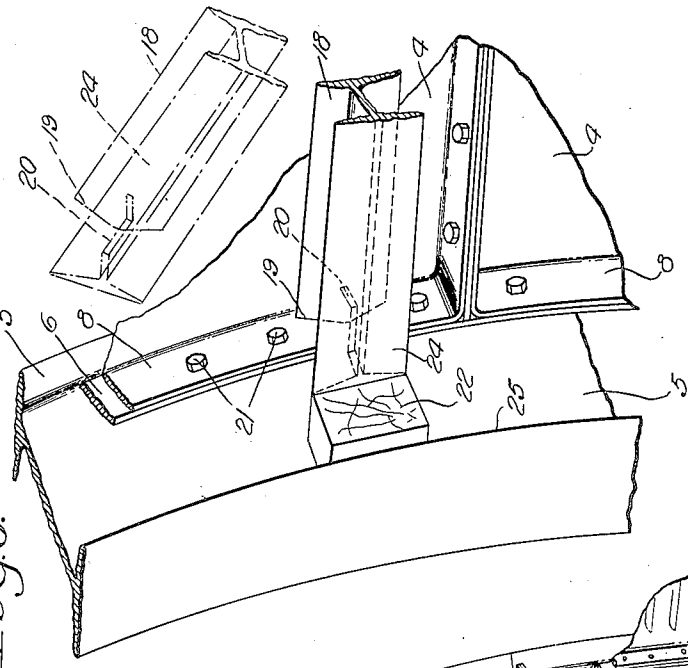
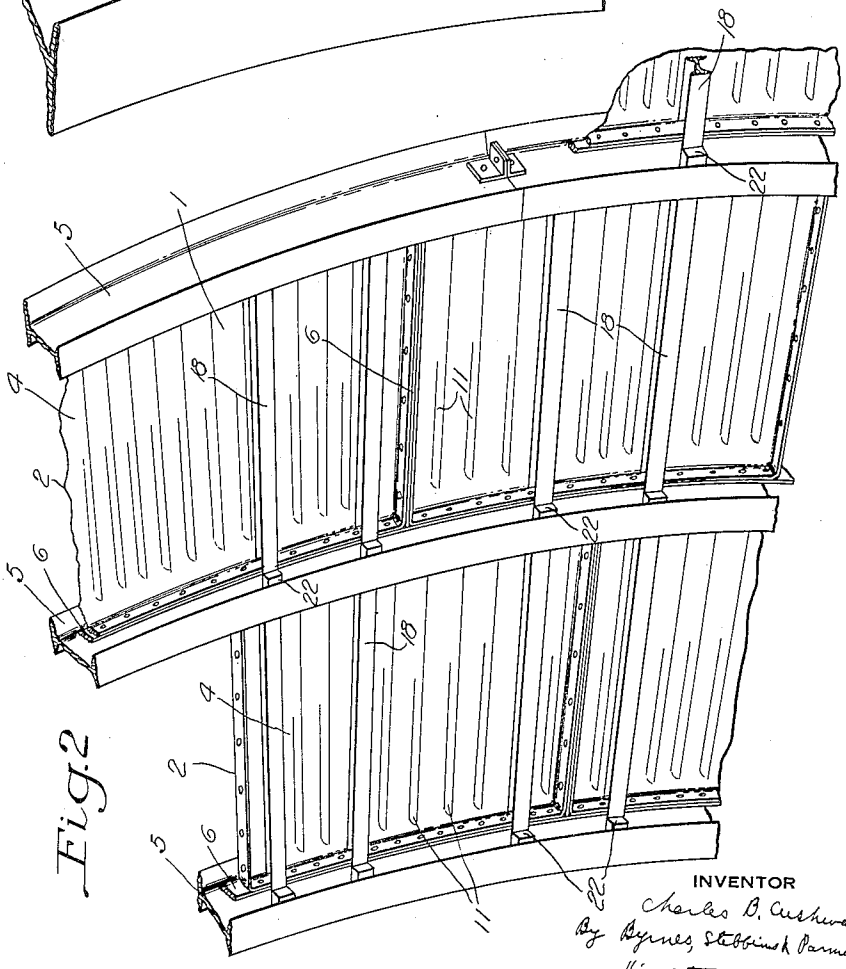


Fig. 2



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TUNNEL LINER

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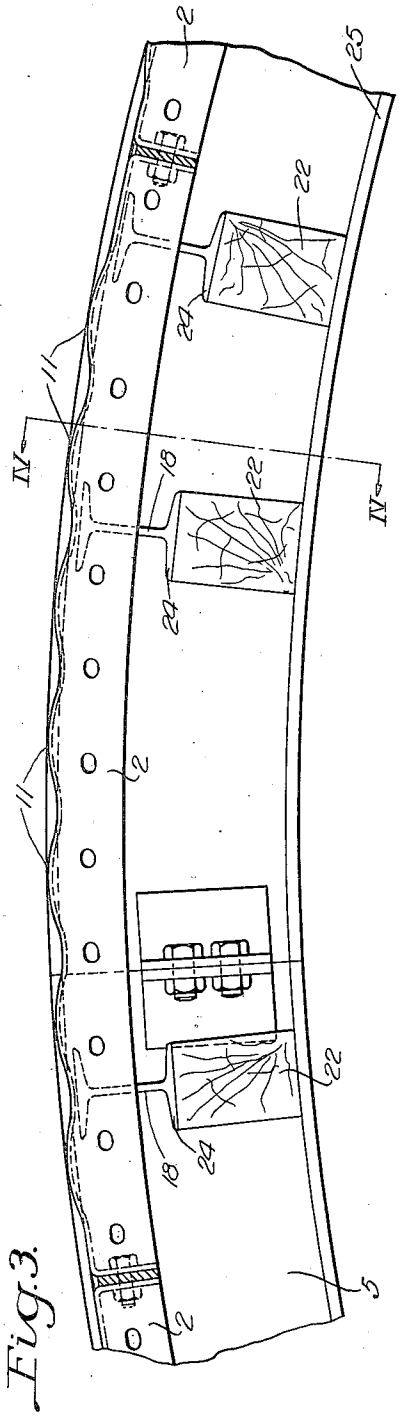


Fig. 3.

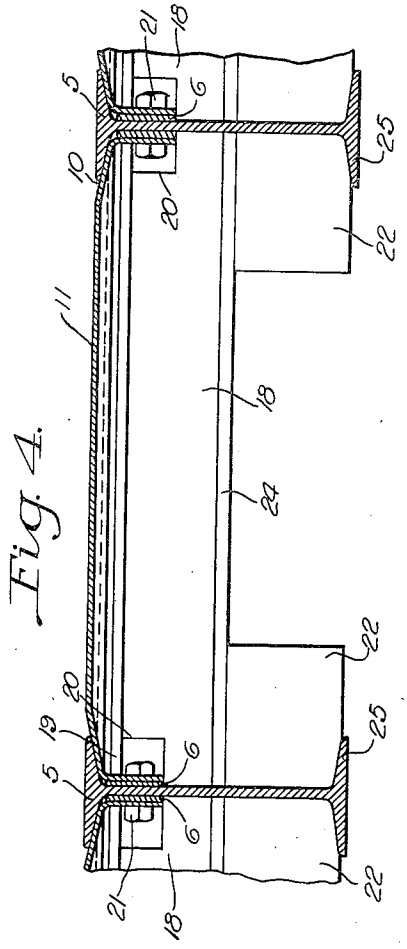


Fig. 4.

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TUNNEL LINER

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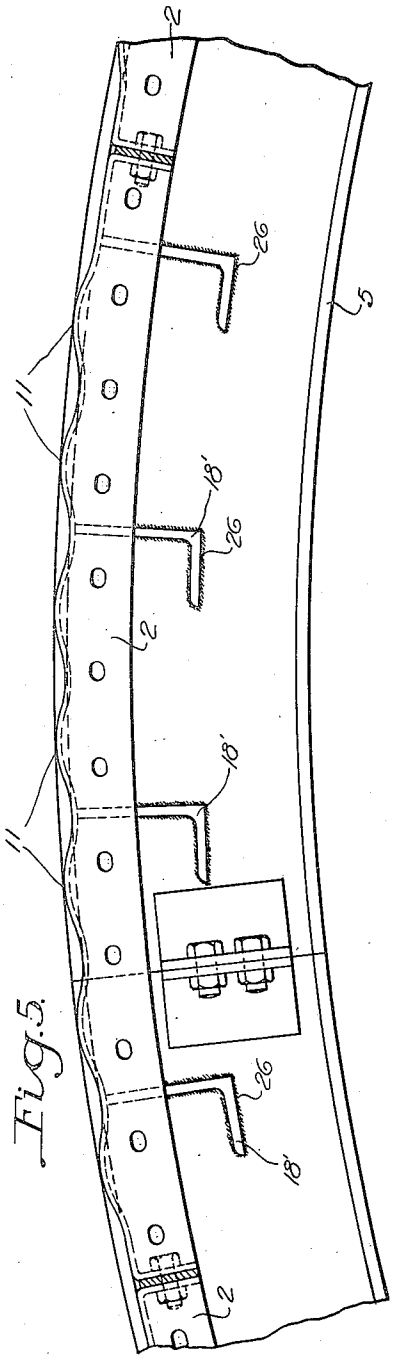


Fig. 5.

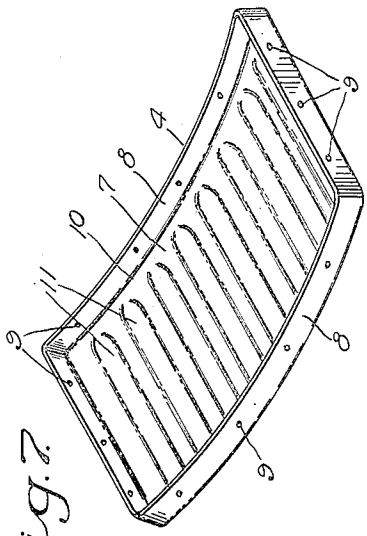


Fig. 7.

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Patented Jan. 26, 1932 1,843,102

UNITED STATES PATENT OFFICE

CHARLES B. CUSHWA, OF YOUNGSTOWN, OHIO, ASSIGNOR TO THE COMMERCIAL SHEARING AND STAMPING COMPANY, OF YOUNGSTOWN, OHIO, A CORPORATION OF OHIO

TUNNEL LINER

Application filed August 13, 1928. Serial No. 299,139.

My invention relates to tunnel liners and more particularly to tunnel liners adapted to receive longitudinal thrusts during the forward movement of a shield for advancing a tunnel.

When driving a tunnel through soft earth, shields of various types are driven forward into the earth. The earth in the opening defined by the shield is removed and a course or section of a tunnel liner is added to the portion of the tunnel liner previously completed. The gauge of the metal used in the tunnel liner and reinforcing means associated therewith are sufficient to withstand the pressure put upon the tunnel by the earth after the tunnel is complete.

During the forward movement of the shield, jacks or other forms of driving mechanisms are interposed between the end of the completed tunnel liner and the shield. The jacks or other driving mechanism exert concentrated forces of considerable magnitude upon the forward end of the liner in a longitudinal direction. These forces are of sufficient magnitude to require a relatively thick metal in the tunnel liner if the liner alone resists them.

These forces tend to produce a buckling effect in the plates of the courses of the sections. The application of forces of such a magnitude to the forward edges of the courses also tends to move the plates of the courses out of alinement sufficiently to cause the formation of open spaces between the cooperating edges of the plates and supports.

I provide a sectional tunnel liner in which the individual plates are curved circumferentially of the tunnel and are corrugated longitudinally of the tunnel for resisting longitudinal forces in the tunnel lining. Circumferential reinforcing bands are disposed between adjacent courses and reinforcing members are disposed longitudinally of the liner between the reinforcing bands for relieving the pressure upon the individual plates. The reinforcing members may be permanently attached to the reinforcing bands or they may be detachably secured thereto. When detachable reinforcing members are employed, they are removed from a rear course and carried forward to the forward course of the liner.

The number of courses in which the removable reinforcing members are disposed is sufficient to permit the concentrated longitudinal thrusts on the liner to be uniformly distributed throughout the liner. By relieving the plates of the liner, it is possible to utilize metal of a smaller gauge, thereby effecting a considerable economy in the cost of the liner. A further saving is effected by the use of removable reinforcing members.

As the amount of longitudinal thrust imposed upon the different courses of the liner after the shield has been removed from its neighborhood is not very great, the reinforcing members may frequently be omitted from the finished tunnel liner.

The accompanying drawings illustrate certain preferred embodiments of the invention in which

Figure 1 is a broken longitudinal sectional view of a portion of a tunnel liner and a shield;

Figure 2 is an inner perspective view of a portion of the tunnel liner;

Figure 3 is an end view of a portion of a course of the tunnel liner with the forward reinforcing band removed;

Figure 4 is a sectional view of a tunnel liner course taken along a section corresponding to the section line IV—IV of Figure 3;

Figure 5 is a similar view to Fig. 3 of a modified form of the invention;

Figure 6 is a perspective view illustrating the manner of securing removable reinforcing members in place; and

Figure 7 is a perspective view of one of the plates used in the tunnel liner.

Referring to Figures 1, 2 and 3, a tunnel liner 1 is made up of a plurality of circumferential courses 2 each of which is constituted by a plurality of plates 4 secured together circumferentially and secured to reinforcing bands 5 along their ends.

The joints between the plates 4 and between the reinforcing bands 5 are closed by gaskets 6. The joints may also be closed by welding or calking if desired. Certain of the features of the tunnel lining are shown

and described in my co-pending application Serial No. 303,185, filed August 31, 1928.

Referring to Figure 7 each plate 4 comprises a body portion 7 having a continuous inwardly directed flange 8 formed around its perimeter. The flange 8 is provided with openings 9 for receiving bolts or rivets. The edges of the bodies 7 are flattened slightly as at 10 to cause the plates to snugly fit the flanges of the angle irons constituting the reinforcing bands 5. By having the edges of the plates engage the reinforcing bands over considerable areas the pressures are uniformly distributed over the engaging surfaces. Each plate 4 is curved along its longitudinal axis to conform to the curvature of the tunnel. Ribs or corrugations 11 are disposed transversely of each plate or longitudinally of the tunnel for better transmitting compressive thrusts between adjacent reinforcing bands 5.

Referring to Figure 1 the tunnel is advanced by driving a cylindrical shield 14 disposed externally of the forward courses 2 into the earth ahead of the tunnel. The shield 14 is advanced by a driving mechanism in the form of jacks 15. The jacks 15 are interposed between the forward reinforcing band 5 and a shoulder 17 on the shield.

Forward movement of the shield 14 meets with considerable resistance and accordingly the thrust exerted on the forward reinforcing band 5 is considerable. If the gauge of the metal in the plate 4 constituting the forward course is made sufficient to withstand such compressive forces without buckling the cost of the liner is excessive.

For distributing such compressive forces over a number of courses 2 until the concentrated thrusts are uniformly distributed throughout the plates constituting the liner, I provide removable reinforcing members 18 in addition to the longitudinal ribs 11 of the plates 4. As the shield 14 advances the space between the shoulder 17 and the last reinforcing band 5 is filled with another course 2 of plates and another reinforcing band 5. The removable reinforcing members 18 are taken from a course considerably to the rear of the forward end of the liner and placed in the foremost course. In some tunnels the temporary reinforcing members are utilized in as many as ten of the forward courses. The presence of the temporary reinforcing members, by preventing the bending of the plates, insures a tighter fit along the flanges 8 of the different plates.

To permit the reinforcing members 18 to be readily placed in position or removed from the rear courses they are preferably made of I-beams disposed with the web extending axially of the liner. One of the flanges of the beam is provided with sloping surfaces 19 extending backwardly from the center thereof at each end.

The presence of the sloping surfaces 19 permits a turning movement of the beam as a whole about each end. The web of the beam is cut away forming a re-entrant portion 20 beneath the surface 19. The depth of the cut away portion is sufficient to span the flanges 8 and it is long enough to clear the heads 21 of the rivets or bolts extending through the flanges and adjacent supporting structure.

The remainder of the web and the other flange of the I-beam extend outwardly to engage the surfaces of the adjacent bands 5. Wooden blocks 22 are driven into place between the inner flange 24 of the reinforcing member and a flange 25 formed on the reinforcing band 5. When it is desired to remove a reinforcing member 18 the blocks 22 at the ends are removed and the reinforcing member is turned from the full line position shown in Figure 6 to the dotted line position for causing the corners of the flanges 24 to clear the edge of the flanges 25. The reinforcing member is then removed. The reinforcing members 18 are seated between the reinforcing bands 5 by placing one end in position and turning the other end until it engages the adjacent reinforcing band after which the block 22 is driven in position. As the inner ends of the web and the inner flange of the I-beam engage the reinforcing bands at each end thereof the beams are put under compression during the forward movement of the shield 14. The presence of the beams transmits the thrust between the reinforcing bands that would otherwise have to be carried by the plates constituting the liner.

The plates to withstand such thrusts would have to be of metal of thicker gauge than is used where the reinforcing members are employed. The corrugations 11 of the plates cooperate with the reinforcing members 18 in transmitting the longitudinal thrusts.

The number of courses in which the reinforcing members 18 are present varies with the size of the tunnel and the magnitude of the thrust composed on the tunnel liner in advancing the shield. The reinforcing members are always maintained in a sufficient number of the forward courses of the tunnel liner to provide for the transfer of the concentrated thrust upon the forward course to a uniform distribution of them throughout the entire tunnel liner.

Referring to Figure 5 the reinforcing members 18′ may be permanently secured to the bands 5 by welded joints 26 where desired to retain the reinforcing members as part of the permanent tunnel lining.

While I have illustrated and described certain preferred forms of my invention, it will be understood it may be otherwise embodied or practiced within the scope of the appended claims.

I claim:

1. A plate for a tunnel liner comprising a

longitudinally curved body having corrugations extending transversely thereof, the length of the corrugations being less than the width of the plate.

2. A plate for a tunnel liner comprising a circumferentially bent body portion, flanges formed along the edges thereof and corrugations extending transversely of the body for resisting compressive forces between the flanges at the sides of the body portion, the length of the corrugations being less than the width of the plate.

3. A plate for a tunnel liner, comprising a longitudinally curved body having corrugations extending transversely thereof, the length of the corrugations being less than the width of the plate, the portions of the plate between the ends of the corrugations and the side edges thereof being flattened to fit the flanges of angle irons used as reinforcing bands between circumferential courses of plates forming the tunnel liner.

In testimony whereof I have hrereunto set my hand.

CHARLES B. CUSHWA.