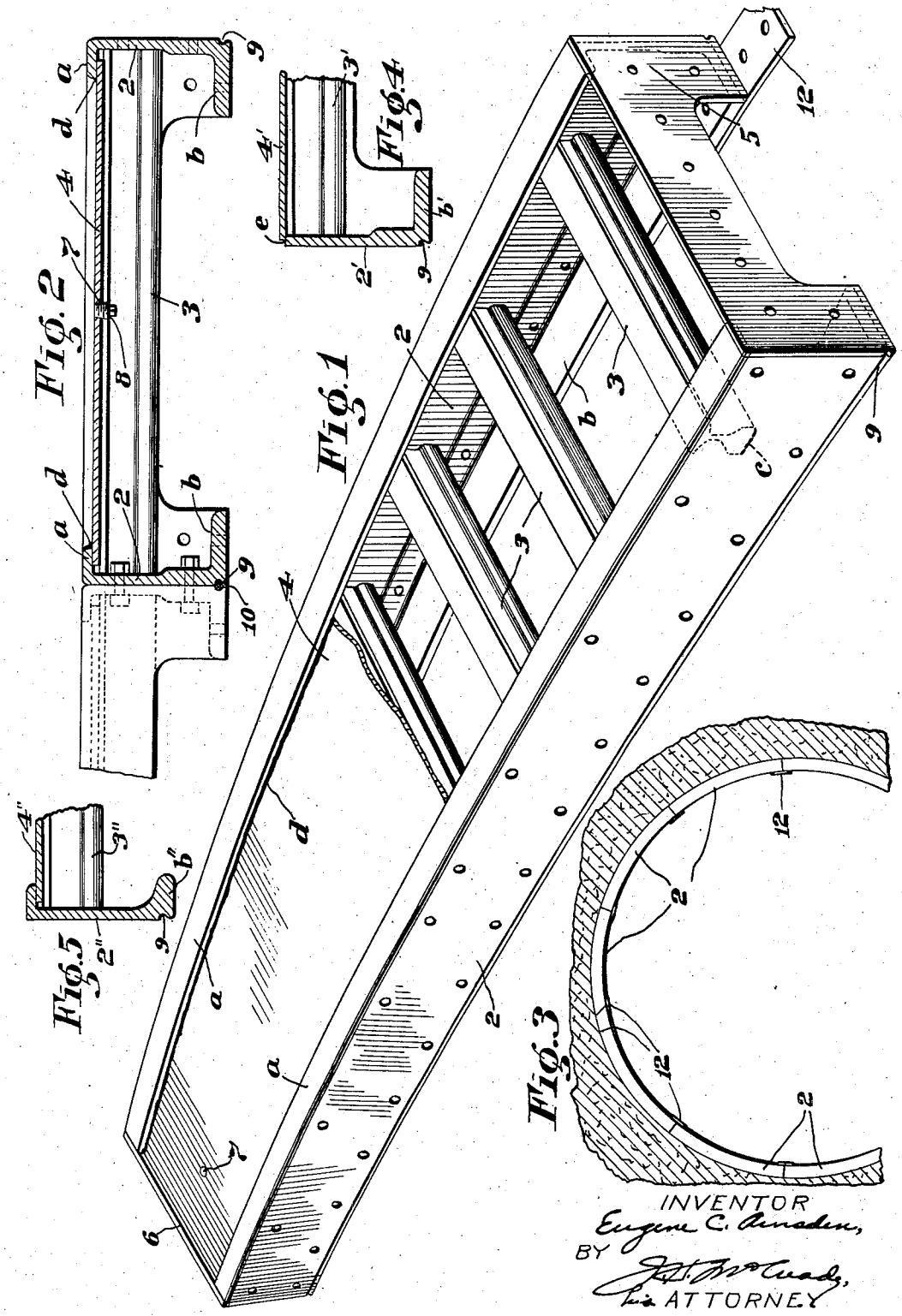
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TUNNEL LINING UNIT

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TUNNEL LINING UNIT

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In building certain kinds of tunnels, especially those bored by the shield method, it is customary to provide the tunnel with a continuous lining usually made of cast iron members rigidly secured together. While such linings usually have been made of cast iron, it has also been proposed to make them of structural steel, but the latter material has been used only to a very limited extent for this purpose. It is necessary to build up these linings from units or elements, and because of the large size of tunnels and the necessity for lining them continuously the expense of the lining represents a very important item in the total cost of the tunnel.

The present invention is especially concerned with these tunnel lining units or elements. It aims to improve the construction of such units with a view to reducing the expense of manufacturing them, making a more economical use of the metal, and devising a construction which will lend itself more readily to modifications necessited by changes in grade, size or direction of the tunnel.

The nature of the invention will be readily understood from the following description when read in connection with the accompanying drawings, and the novel features will be particularly pointed out in the appended claims.

In the drawings,

Figure 1 is a perspective view of a structural steel tunnel lining unit constructed in accordance with this invention, a part of the structure being shown broken away;

Fig. 2 is a transverse sectional view of the unit shown in Fig. 1, and also illustrates this unit placed in cooperative relationship to an abutting unit of similar form;

Fig. 3 is a sectional view of part of a tunnel, at an intermediate stage in the process of erection, lined with units such as those shown in Figs. 1 and 2; and

Figs. 4 and 5 are fragmentary sectional views illustrating modifications.

Referring first to Figs. 1 and 2, the unit there shown comprises two steel side supports 2—2 each of angular cross-sectional form. Since tunnels usually are made of circular section, the side supports 2—2 are curved longitudinally on a radius depending upon the dimensions of the tunnel. In a typical construction the tunnel might be thirty feet in diameter so that the lining units would be curved on a fifteen foot radius. A typical unit might, for example, be nine feet long, thirty inches wide and eight inches thick, the dimensions of the units obviously depending upon the design and dimensions of the individual tunnel in which they are to be used. In the particular unit shown in Figs. 1 and 2 the side supports 2—2 are made of channel form, each support having a web extending radially of the unit and provided with a flange *a* at its outer edge and another flange *b* at its inner edge. It will be seen from an inspection of Fig. 2 that the flange *b* at the inner edge of each support and the portion of the web adjacent to it are made considerably thicker than the parts of the web more remote from the flange.

Connecting the two side supports 2—2 are a series of struts 3 which may conveniently consist of sections of T-rail. A steel back plate 4 rests on these struts 3 and is welded continuously along its opposite edges to the edges of the outer flanges *a*—*a*. End plates 5 and 6 are welded to the opposite ends of the supports 2—2 and back plate 4 and complete the unit.

According to the preferred process of manufacturing this unit the side supports or channels 2—2 are hot rolled to the cross-sectional form shown and later are cut to the proper lengths and bent to the desired curvature. The struts 3—3 are cut accurately to length and the back plate 4 is laid on them and welded to them. These parts next are assembled with the side channels 2—2 and the opposite ends of each strut 3 are welded to the side channels. A relatively small area only at the ends of each strut need be welded to the side members, the welding being confined, for example, to the area indicated by the heavy dotted line *c*, Fig. 1. This operation is facilitated by placing the unit in the reverse position from that in which it is shown, with the back plate 4 resting on the flanges *a*—*a*. At the completion of this welding operation the unit is turned over into the

position shown in Fig. 1 and the edges of the flanges *a*—*a* are welded to the opposite margins of the back plate 4. Preferably this operation is performed by an automatic welding machine which travels along the unit making the continuous welded seams *d*—*d*, Figs. 1 and 2. Finally the plates 5 and 6 are welded continuously to the opposite ends of the back plate and side supports. The bolt or rivet holes in the side channels and end plates may be punched at any convenient point in the process. Usually one or more holes 7 are punched through the back plate and threaded to permit "grout" to be forced through the lining after it is in place, each of these holes subsequently being closed by a plug 8.

When installed in a tunnel these units are bolted together end to end as shown in Fig. 3 and they are also bolted in side by side but staggered relationship to other units. Because of this arrangement and the nature of the stresses to which these units are subjected, the peculiar cross-sectional shape of the side supports 2—2 is of special advantage in making economical use of the metal in these parts. That is, the greater thickness of the flanges *b*—*b* and the parts of the web immediately adjacent to them produces a much stronger construction than could be obtained by the same weight of metal distributed more uniformly. In bolting the units together end to end splice plates, one of which is shown at 12 in Fig. 1, preferably are used, each plate being bolted to the adjacent end portions of the flanges *b* of abutting units.

The method of manufacture above described is economical, it avoids the necessity for highly expensive and unusual equipment, and it can readily be accommodated to the variation in shapes and dimensions of these units required by changes in grade or direction of the tunnel. It will be observed that no great accuracy in the width of the back plate is required. The fact that the manufacture of these units avoids any heavy expense for special tools or equipment other than the rolls required to roll the peculiar cross-sectional form of the side supports is a very important practical advantage. This fact makes it possible to adapt this construction readily to different sizes and shapes of tunnels and to the changes in grades or curvature. One of the chief objections to the use of pressed steel tunnel lining units has been the great expense involved in the manufacture of the necessary shapes or forms. Extremely large presses and very expensive dies have been required for this purpose. A very important advantage of the construction provided by this invention, therefore, is the fact that the expense for special equipment is reduced to a very small item.

While I prefer the construction above described, some of the advantages of this invention can be obtained by using side supports of slightly different form. For example, in Fig. 4 the side support 2′ has the same cross-sectional form as those shown in Figs. 1 and 2 except that the flange *a* has been omitted. The back plate 4′ rests directly on the outer edge of the side support 2′ and is welded to it along the seam *e*. In other respects the two constructions are identical.

A further modification of the invention is illustrated in Fig. 5 in which the side support 2″ is made of channel section including an exceptionally heavy rounded inner flange *b*″, this construction being like that shown in Fig. 2 in other respects.

In each form of side support a groove 9 is rolled in its outer surface adjacent to the inner edge thereof to receive a packing or calking 10, Fig. 2, this calking usually being made of lead. In some constructions this groove is not required.

While I have herein shown and described preferred embodiments of my invention, it will be understood that the invention may be embodied in other forms without departing from the spirit or scope thereof. Steel has been mentioned particularly as the material of which the unit is made, but alloys are available which have the requisite strength and have greater ability to resist corrosion than steel. It is contemplated, therefore, that the unit may be made from such alloys or from any other suitable metal.

Having thus described my invention, what I desire to claim as new is:

1. A tunnel lining unit comprising two side supports each of angular cross-sectional form and each having a web extending from front to back of the unit and a flange bent inwardly from said web at the inner edge thereof, said flange and the part of the web adjacent thereto being thicker than the parts of the web more remote from said flange, and a back plate connecting said supports and welded to them.

2. A tunnel lining unit comprising two side supports each of angular cross-sectional form and curved longitudinally, said supports having webs extending radially of the unit and flanges bent inwardly from said web at the inner edges thereof and extending toward each other, said flanges and the portions of the web adjacent to them being thicker than the parts of the webs more remote from said flanges, and a back plate connecting supports and welded to them.

3. A tunnel lining unit having a side support provided with a web extending from front to back of the unit and with a flange bent inwardly from said web at the inner edge thereof, said flange and the portion of said web adjacent thereto being thicker than portions of said web more remote from said flange.

4. A tunnel lining unit including a side support of channel section curved longitudi-

nally and having a web extending radially of the unit, a flange integral with said web and extending at approximately right angles thereto at the inner edge of the web, said flange and the portion of the web immediately adjacent thereto being substantially thicker than the part of the web more remote from said flange.

5. A tunnel lining unit comprising two side supports each of angular cross-sectional form, a series of struts connecting said supports and rigidly secured to them, and a back plate resting on said struts and having its opposite edges welded to said supports, and end plates welded to said supports and the ends of said back plate at the opposite ends of said unit.

6. A tunnel lining unit comprising two side supports of angular section, said supports being curved longitudinally and each having a web extending radially of the unit, flanges integral with said webs and extending toward each other from the inner edges of said respective webs, said flanges and the portions of their respective webs immediately adjacent to them being thicker than the parts of the webs more remote from said flanges, a series of struts connecting said supports and welded to them, and a back plate secured to said struts and having its opposite margins welded to said supports.

7. A tunnel lining unit comprising two side supports of angular section, said supports being curved longitudinally and each having a web extending radially of the unit, flanges integral with said webs and extending toward each other from the inner edges of said respective webs, said flanges and the portions of their respective webs immediately adjacent to them being thicker than the parts of the webs more remote from said flanges, a series of struts connecting said supports and welded to them, a back plate secured to said struts and having its opposite margins welded to said supports, and end plates welded to said supports and the ends of said back plate at the opposite ends of said unit.

8. A tunnel lining unit including a side support of angular cross-sectional form curved longitudinally and having a web extending radially of the unit, a flange integral with said web and extending from the inner edge thereof, said flange being substantially thicker than the part of said web remote from said flange, and a calking groove in the outer surface of said web and extending along the margin of the web adjacent to the inner edge thereof.

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