H. W. SCHLUETER.

TUNNEL CONSTRUCTION.

APPLICATION FILED MAY 12, 1917.

1,353,274. **Patented Sept. 21, 1920.**

2 SHEETS—SHEET 1.

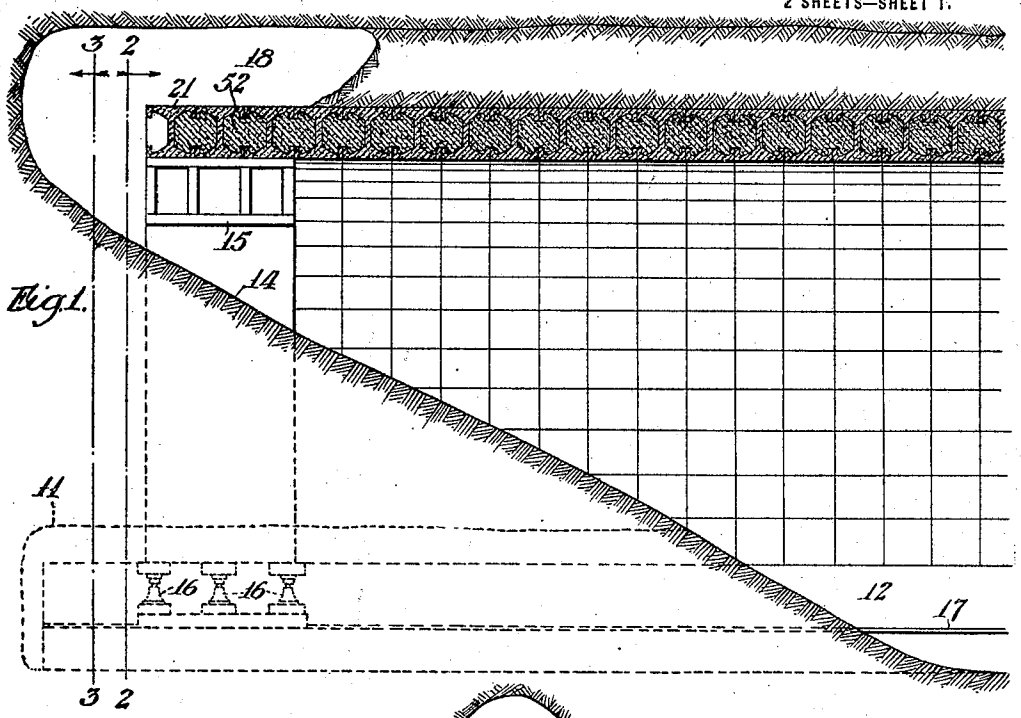


Fig. 1.

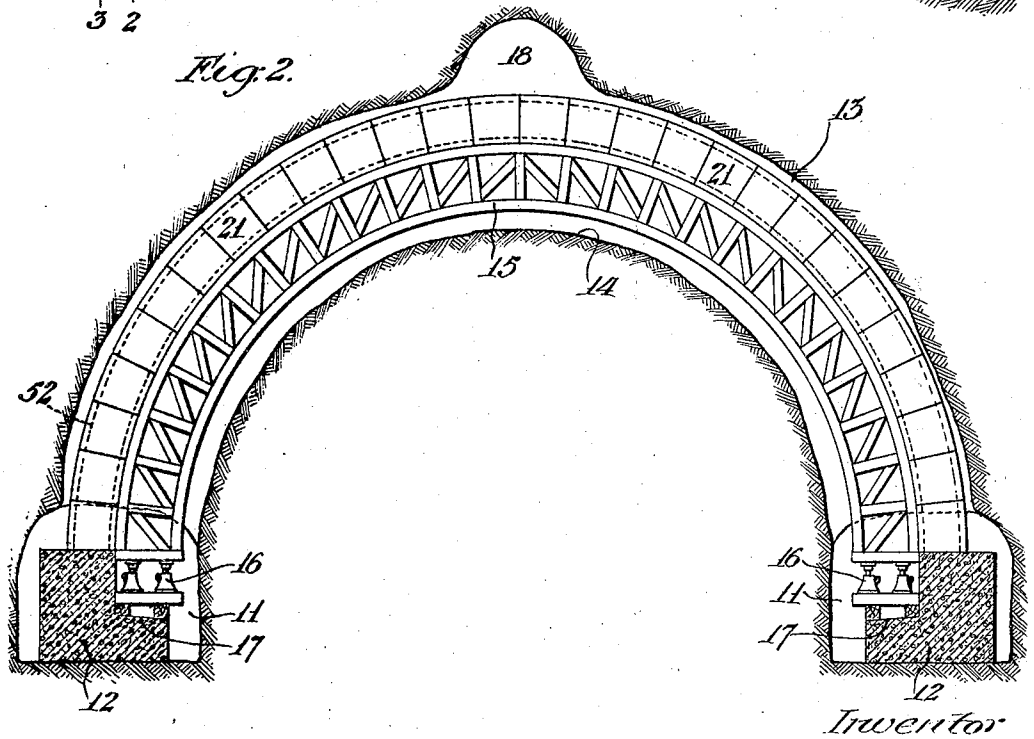


Fig. 2.

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2 SHEETS—SHEET 2.

Fig. 3.

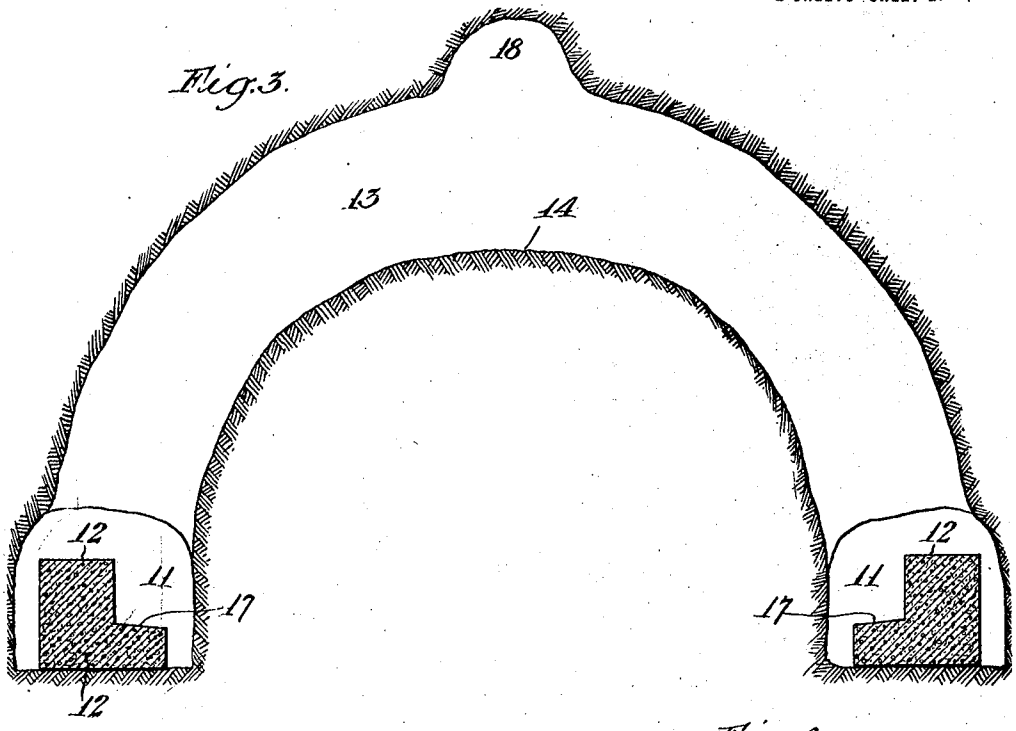


Fig. 4.

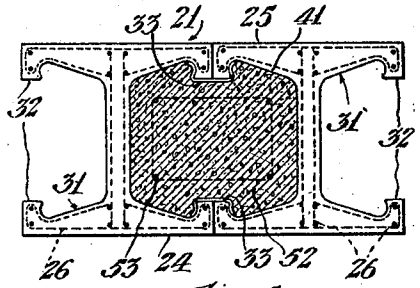


Fig. 5.

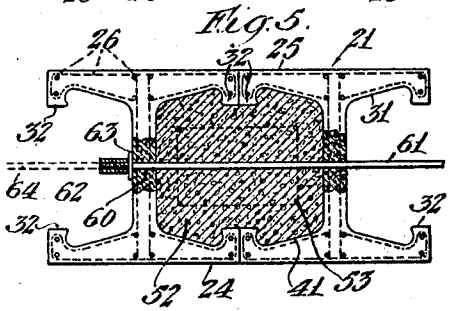
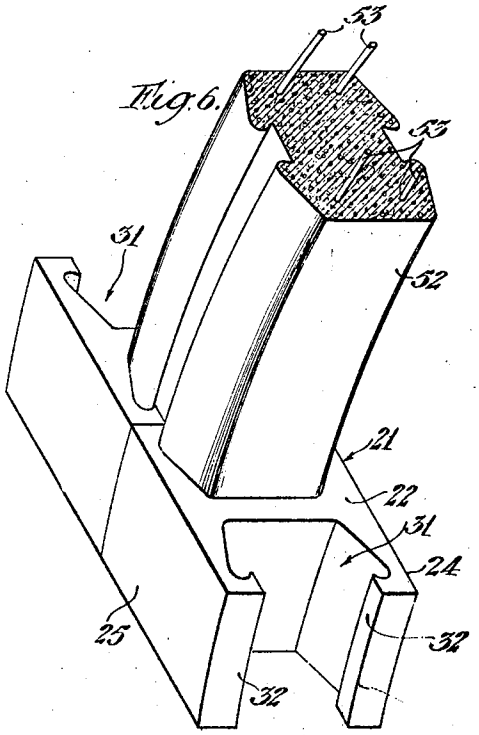


Fig. 6.



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UNITED STATES PATENT OFFICE.

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TUNNEL CONSTRUCTION.

1,353,274. Specification of Letters Patent. Patented Sept. 21, 1920.

Application filed May 12, 1917. Serial No. 168,231.

To all whom it may concern:

Be it known that I, HENRY W. SCHLUETER, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented a new and useful Tunnel Construction, of which the following is a specification.

My invention relates to the art of tunnel, subway or other sub-terrestrial construction, and the principal object of my invention is to provide a novel and useful method and means for building a lining for such construction.

In such construction it is common practice to drive a bore through the earth and to line the roof of this bore with a metal, stone, brick, or concrete lining. This lining must in many cases have great mechanical strength, and at the same time it must be cheap to construct. In the art of tunnel building, concrete linings are common, but the construction of such linings is often a difficult matter, as elaborate forms must be erected and there is considerable difficulty in handling large masses of wet concrete in the small space available in such construction.

The method employed by me, and the advantages thereof, will be set forth in the following specification.

In the drawings, which are for illustrative purposes only:

Figure 1 is a longitudinal section through a tunnel in which my invention is used.

Fig. 2 is a section on a plane represented by the line 2—2 of Fig. 1.

Fig. 3 is a section on a plane represented by the line 3—3 of Fig. 1.

Fig. 4 is a view, on an enlarged scale, of a pair of precast members used in my invention, with a single rib cast therebetween, the rib being shown in section.

Fig. 5 is a similar view showing a preferred form of retaining means.

Fig. 6 is a perspective view of a portion of the tunnel lining, a number of the precast members being broken away to better illustrate the form and location of the ribs.

My invention can best be described by describing the method of driving a tunnel and lining it by my method. One very convenient method is illustrated in the drawings, but it is evident that other methods may be used without departing from the spirit of my invention, as set forth in the claims. In the method illustrated, a pair of footing tunnels 11 are first driven at either side of the tunnel and at the base thereof. Footings 12 are constructed in these footing tunnels preferably of concrete which may be reinforced. A main bore 13 of more or less annular shape is then driven, leaving a central core 14. A false ring 15 of wood or metal is then supported on suitable jacks 16 on projecting ledges 17 of the footings 12, this ring having the same general shape as the desired inside wall of the tunnel.

A built-up lining is then formed on the ring 15, this lining being constructed of precast reinforced concrete members 21. These members when laid up, as shown in the drawing, form an annular ring having the same inside shape and size as the inner wall of the desired tunnel as defined by the false ring 15. Each of the members 21 is formed of flat sides 22 which projected form a dihedral angle having its apex at the center of the tunnel and having edges 23 which are parallel planes. The inner surfaces 24, and the outer surfaces 25 are preferably portions of cylinders having their center at the axis of the tunnel. These members 21 are laid one upon the other on the sides 22 with the edges 23 of adjacent rings or courses abutting. The outer surfaces 25 then form the outer surface of the lining, and the inner surfaces 24 form the inner surface of the lining resting on the false ring 15. The members 21 are preferably laid up in mortar or neat cement, and when assembled form a continuous lining for the main bore 13. If desired, the members 21 may be reinforced in any suitable manner as by rods 26.

Formed in each of the members 21 at either edge thereof are recesses 31. The members 21 are extended to form lips 32 at either side of the recesses 31, as shown in Fig. 4. For the purpose of tying the different courses of members 21 together during construction, I provide metal clenching bars 33 which are hooked over the lips 32 as the courses are laid.

At the same time, or before the main bore

13 is driven, a filling tunnel 18 is driven at the extreme top of and outside the main bore 13. As the courses of members 21 are laid up they form arches temporarily supported by the false ring 15. The spaces 31 in adjacent members 21 form continuous channels 41 which extend completely around the walls of the tunnel from one footing to the other. As soon as a course or member 21 is laid, and before the last or keystone member 21 is inserted in the arch, the space 41 is filled with concrete forming a continuous rib 52. If desired, an opening may be left in the outer surface 25 of the keystone member 21 through which the cement may be inserted in the channels 41. Reinforcement 53 may be placed in the channels 41, as they are produced, so that the ribs 52 are reinforced. The channels 41 are most conveniently filled through the use of the filling tunnel 18, concrete being carried by any convenient means up the inclined face of the core 14 and into the forward end of the filling tunnel 18. A number of courses of members 21 are preferably laid at one time on the false ring 15. As soon as these courses are completed and the ribs 52 are poured, the false ring 15 is lowered by means of the jacks 16, and the ring 15 is moved forward and jacked up into its new position where new courses may be built on it. The core 14 is excavated at the convenience of the workers as the lining progresses.

In the place of using the retaining members 33, shown in Fig. 4, I find in many forms of construction that longitudinal reinforcements, as shown in Fig. 5, are preferable. In this form, openings 60 are formed through the centers of the members 21, and rods 61 are used to tie the members 21 together longitudinally. As the members 21 are put in place, several courses at a time, it is convenient to use rods 61 which pass through several members 21, these rods being threaded at either end into couplings 62 which are made of some length and which abut on washers 63. As new courses are added, new rods 64 are screwed into the couplings 62, so that the rods 61 and 64 and the couplings 62 form a continuous longitudinal metal reinforcement which passes through all the members 21 on either side of the tunnel at any level and which is locked solid in place by the ribs 52.

Where it is desired to line old tunnels, no preliminary boring is necessary, the false ring 15 being erected inside the tunnel and the work progressing thereon as has just been explained. It is to be noted that this work can be done without blocking the tunnel, so that it can, with proper precautions, be used for traffic during the construction period.

It will be noted that by using my method of construction that the cost of construction is very low. The members 21 are made of such a size that they can be conveniently handled manually by one or at most two men. The building of the rings or courses is therefore a matter of ordinary masonry construction. When the courses are completed it is an easy matter to fill the channels 41. This may be done by pumps in some cases. The construction of the tunnel lining therefore progresses rapidly.

While this low cost is an important factor in the success of my method, it is not as important as the very uniform character, and, therefore, great reliability of the finished construction. The members 21 are precast outside the tunnel under absolutely controlled conditions. They are of the proper mixture and they are cast and set under ideal conditions. The result is that the members 21 are all alike and of the most reliable character. The lining formed of such members is therefore much superior to any masonry lining, and this lining alone is of great strength and rigidity. After the lining formed of the members 21 is completed, the ribs 52 are cast therein. It will be noted that the members 21 taken together make a perfect form for the ribs 52. The channels 41 are entirely closed except at the top where the channel 41 is filled, and all stone, earth, etc., is therefore excluded therefrom. As a result, the ribs 52 are of clean and uniform concrete. This concrete is inside an impervious wall of precast concrete formed by the members 21 and it sets under ideal conditions.

The completed construction comprises a built-up precast lining in which the cast ribs 52 are embedded. The ribs 52 serve not only to support the roof of the tunnel resting on the footings 12, but they also tie together the adjacent courses of members 21. As the members 21 may be readily tested and inspected outside the tunnel, the character of the completed work is assured, as the pouring or casting of the ribs 52 is a matter on which even unskilled labor cannot go wrong.

I believe that I am the first to employ ribs 52 which are cast in place in a built-up lining formed of precast slabs or members 21.

I claim as my invention:—

1. A tunnel lining comprising alternate courses of preformed members and cast monolithic ribs, each of said courses being continuous and self supporting throughout the arch; said cast monolithic ribs being interlocked with the adjacent courses in such a manner as to tie said courses together; a series of rods placed parallel with the axis of the tunnel and passing through said preformed and cast members; and fastening

means on each rod for securing either end of said rod to one of said preformed members.

2. A tunnel lining as in claim 1 in which said fastening means comprises a nut threaded on said rod.

3. A tunnel lining as in claim 2 in which said nuts are each sufficiently long to receive the ends of two adjacent rods, thus connecting a line of said rods to form a continuous tie member.

In testimony whereof I have hereunto set my hand at Los Angeles, California, this 3rd day of May, 1917.

HENRY W. SCHLUETER.