Nov. 20, 1923. 1,474,808

P. ZUCCO

METHOD OF TUNNEL CONSTRUCTION

Filed Feb. 24, 1920 2 Sheets-Sheet 1

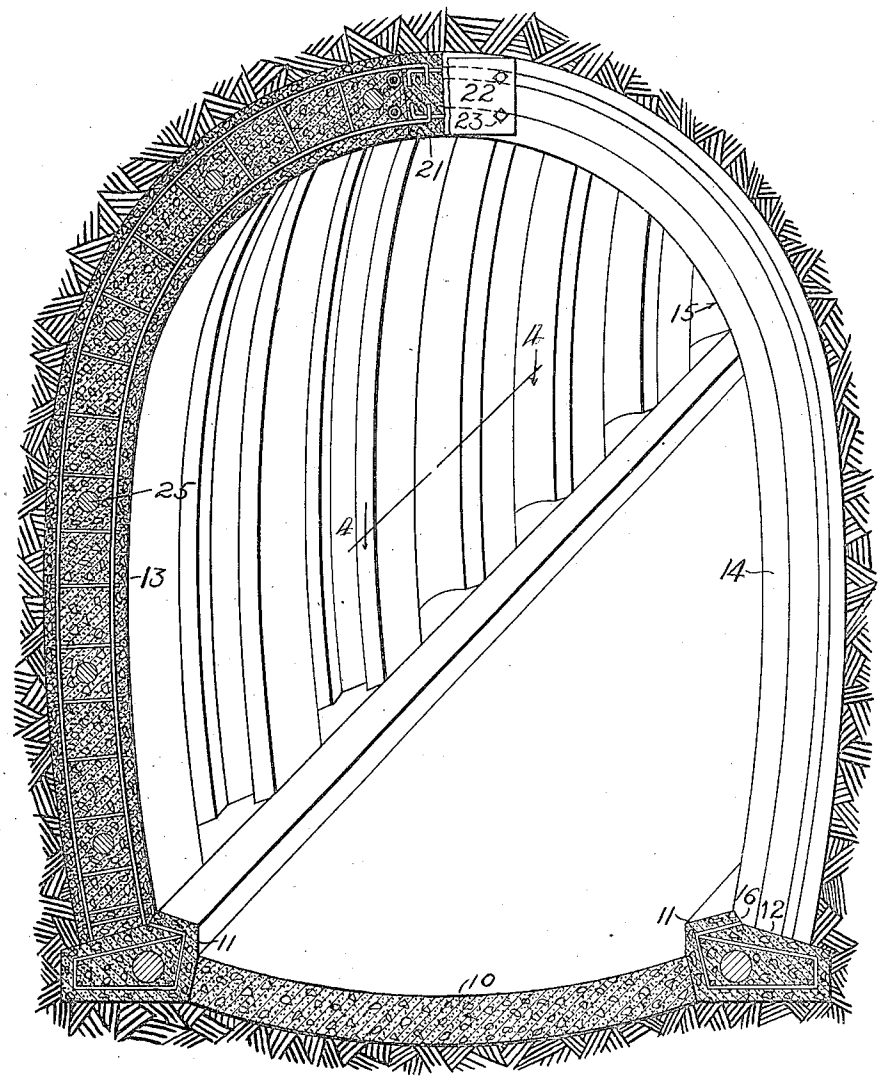


Fig. 1

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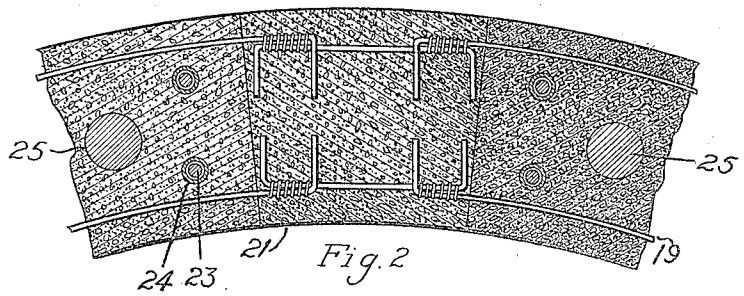
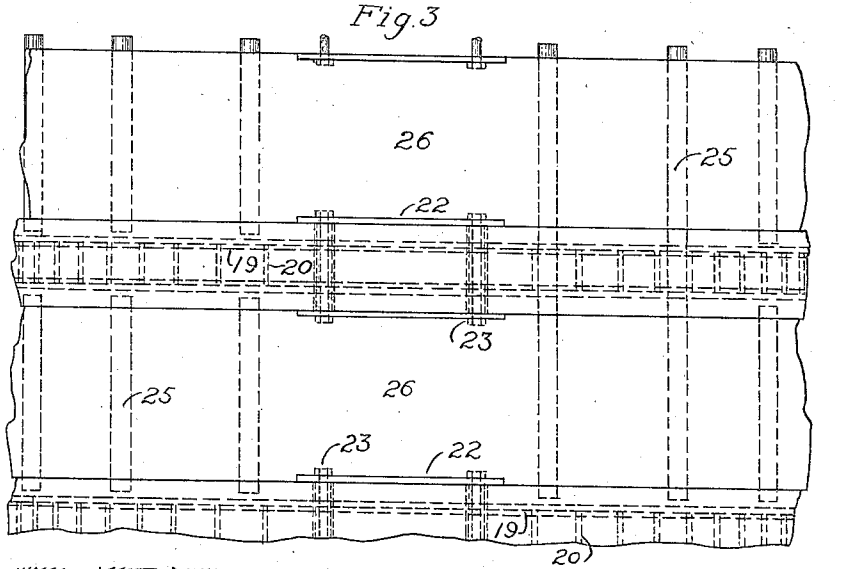


Fig. 2

Fig. 3



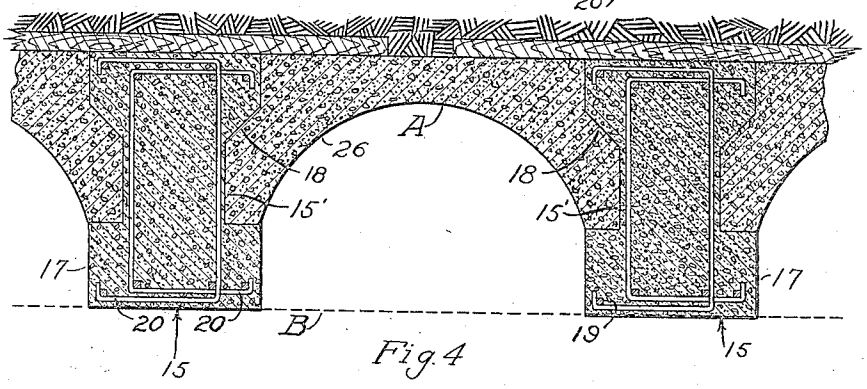


Fig. 4

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UNITED STATES PATENT OFFICE.

PIERRE ZUCCO, OF SAN FRANCISCO, CALIFORNIA.

METHOD OF TUNNEL CONSTRUCTION.

Application filed February 24, 1920. Serial No. 360,592.

To all whom it may concern:

Be it known that I, PIERRE ZUCCO, a citizen of the United States, residing at city and county of San Francisco and State of California, have invented new and useful Improvements in Methods of Tunnel Construction, of which the following is a specification.

This invention relates to a tunnel construction.

It is the principal object of the present invention to provide a system of tunnel construction which embodies the use of reinforced concrete and contemplates using pre-cast reinforced concrete elements adapted to be bonded together by intervening sections of reinforced concrete to form the wall of a tunnel, said pre-cast elements acting as supporting structures so that the staging within the tunnel may be removed as the elements are set up and the walls are cast, or said elements might be used first hand in the process of driving a tunnel.

In the present invention a plurality of segmental pre-cast concrete elements preferably arched are used, and when assembled combine to form a rigid arch member extending from the floor of a tunnel upon one side to the floor of the tunnel on the other side and resting upon suitable concrete footing blocks, the sides of said elements being recessed to insure that intervening concrete cast in place will be keyed between the arches and will combine therewith to form an integral concrete structure.

The invention is illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a view in transverse section through a tunnel showing the floor footing blocks and the segmental pre-cast supporting element resting thereupon with interior perspective of the same.

Fig. 2 is an enlarged fragmentary view showing the joint formed by the sections of the supporting element at their upper ends.

Fig. 3 is an enlarged fragmentary view in plan showing a section of the tunnel as viewed from above and particularly disclosing the manner in which the pre-cast ribs are fastened.

Fig. 4 is an enlarged view in transverse horizontal section on the line 4—4 of Figure 1 showing two of the pre-cast ribs and the intervening cast tunnel wall.

In the drawings, 10 indicates the floor of the tunnel. This floor is shown as formed of concrete and as being spaced between footing blocks 11. This floor may be poured in place or pre-cast. The blocks 11 have outwardly and downwardly inclined upper faces 12 upon which pre-cast sections 13 and 14 of load supporting elements 15 are positioned. These sections 13 and 14 stand substantially perpendicular to the supporting faces 12 of the blocks and their inward movement is prevented by shoulders 16 of the blocks. The sections 13 and 14 may be of any desired formation to construct a tunnel of a given dimension and with a predetermined sectional area and are here shown as forming an arch.

The pre-cast ribs 13 and 14 are substantially T-shaped in cross section. Thus they form square shoulders 17 in their opposite sides and which shoulders face the walls of the tunnel. A narrowed neck 15′ emanates from these shoulders and terminates in an enlarged outer portion having a beveled face 18. The ribs are suitably reinforced by longitudinally extending rods 19 and binding wires 20. The reinforcing rods 19 extend outwardly from the upper and adjacent ends of the pre-cast sections 13 and 14 and form a bond with cementitious material poured in between and indicated at 21.

The sections 13 and 14 are rigidly secured in fixed relation to each other by means of bolting plates 22 or other suitable fastening means. These bolting plates receive bolts 23 extending horizontally through pipes 24 in the pre-cast ribs. The pre-cast sections are maintained in spaced relation to each other along the tunnel by spacing bars 25 which project into seats in the adjacent side faces of the sections and are embedded within a body of cementitious material 26 which fills the space between the pre-cast ribs and completes the tunnel wall structure.

In carrying out the present invention the tunnel may be first formed with the footing levels previously prepared for receiving the pre-cast footing blocks 11. These blocks may be maintained in spaced relation to each other by thereafter pouring the floor 10 or assembling pre-cast floor slabs. The complementary pre-cast sections 13 and 14 are then mounted upon their respective footing blocks. A jack or other expansion tool may be interposed between the upper and adjacent ends of the sections 13 and 14 to hold the sections in proper position to

permit the bolting plates 22 to be fastened. When this has been done, concrete as indicated at 21 may be poured into the space defined by the two ends of the adjacent pre-cast sections and the bolting flanges. The intervening concrete 26 may then be poured and forms may be used to shape its inner surface to describe the concave surface as indicated at A in Fig. 4, or the dotted line B in the same figure. In any event it will be seen that this material will fill in to the recesses in the sides of the pre-cast elements and between the square shoulders 17 and the tapered shoulders 18. This will insure that concrete sections 26 will be securely keyed to the pre-cast ribs and will therefore form a continuous tunnel wall having alternate sections of pre-cast reinforced concrete and "cast in place" concrete. The pre-cast sections are sufficiently strong to uphold any load which might be imposed upon it while the intervening concrete is being poured.

It will thus be seen by means of the present method of tunnel formation that it is possible to progressively build a tunnel of strong reinforcing ribs and successively fill the intervening spaces between said ribs with concrete as the boring of the tunnel progresses, thereby eliminating staging and large and cumbersome forms, and avoid uncertainty as well as preventing accidents by collapse of the structure.

While I have shown the preferred form of my invention as now known to me, it will be understood that various changes in the combination, construction and arrangement of parts may be made by those skilled in the art without departing from the spirit of the invention as claimed.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is:—

1. A method of tunnel construction in which footing blocks are positioned upon the floor of a tunnel upon each side thereof and in spaced relation to each other, after which pre-cast ferro-concrete rib sections are erected between each pair of oppositely disposed blocks to form a supporting element from one of said blocks to the other, a plurality of said elements being spaced along the length of the tunnel, then concrete is molded into the spaces between said elements to form a continuous wall therewith.

2. A method of tunnel construction which consists in forming pre-cast ferro-concrete footing blocks and disposing them in spaced relation to each other upon each side of the floor of a tunnel, thereafter forming a tunnel floor between said blocks, then erecting pre-cast ferro-concrete elements from the complementary footing blocks between each pair of oppositely disposed blocks, after which the upper ends of the elements are rigidly secured to each other and concrete poured in the space therebetween, then forms are erected and concrete poured between the pre-cast elements to become keyed thereto and form a continuous wall therewith.

3. A tunnel construction formed with a floor, a plurality of spaced footing blocks formed of ferro-concrete material and arranged in spaced relation the length of the floor upon each side of the tunnel, outwardly and downwardly inclined faces upon the tops of said blocks, pre-cast ferro-concrete elements resting upon said faces between each pair of oppositely disposed blocks, bolting plates securing the upper ends of adjacent elements in rigid relation to each other, said pre-cast members being substantially T-shaped in transverse section and intervening cementitious material filling the spaces between the pre-cast elements and interlocking therewith by virtue of their T sections.

4. A tunnel construction comprising a plurality of precast arched and interspaced ribs, each composed of two sections connected together at the top at the center of the arch, and continuous plastic monolithic members extending entirely across the tunnel in arch formation and formed to interconnect the ribs and thereby form a continuous wall.

5. A tunnel construction comprising a plurality of pre-formed arch-like ribs, the same being interspaced, and continuous plastic monolithic members extending entirely across the tunnel in arch formation and formed to occupy the space intermediate the ribs for interconnecting the latter and thereby form a continuous wall.

6. A tunnel like structure comprising a plurality of pre-formed arch-like concrete ribs, the same being interspaced, and continuous plastic monolithic members extending entirely across the tunnel in arch formation and formed to occupy the space intermediate the ribs for interconnecting the latter and thereby form a continuous wall, said members being also arched transversely of the said space between the ribs.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

PIERRE ZUCCO.

Witnesses:
JOHN H. HERRING,
W. W. HEALEY.