Nov. 29, 1932. J. F. O'ROURKE 1,889,563

TUNNEL OR CONDUIT LINING

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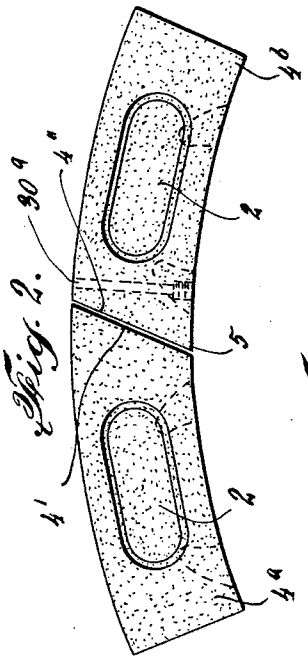

Fig. 2.

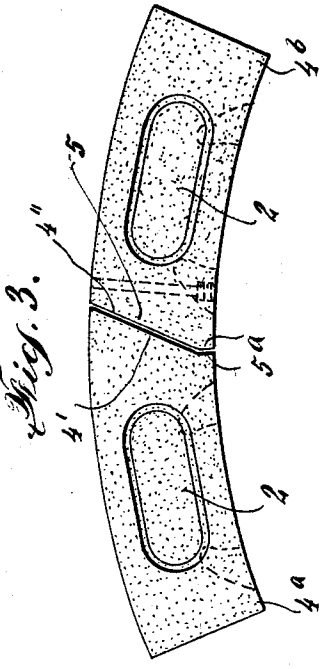

Fig. 3.

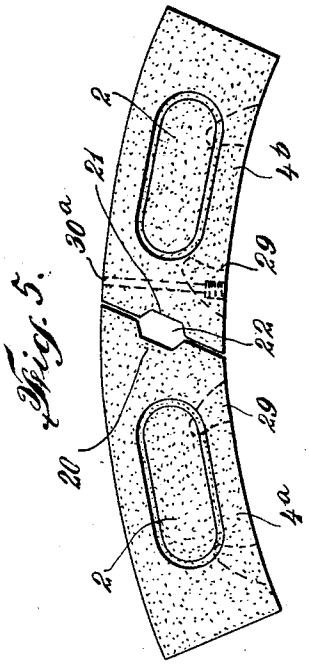

Fig. 5.

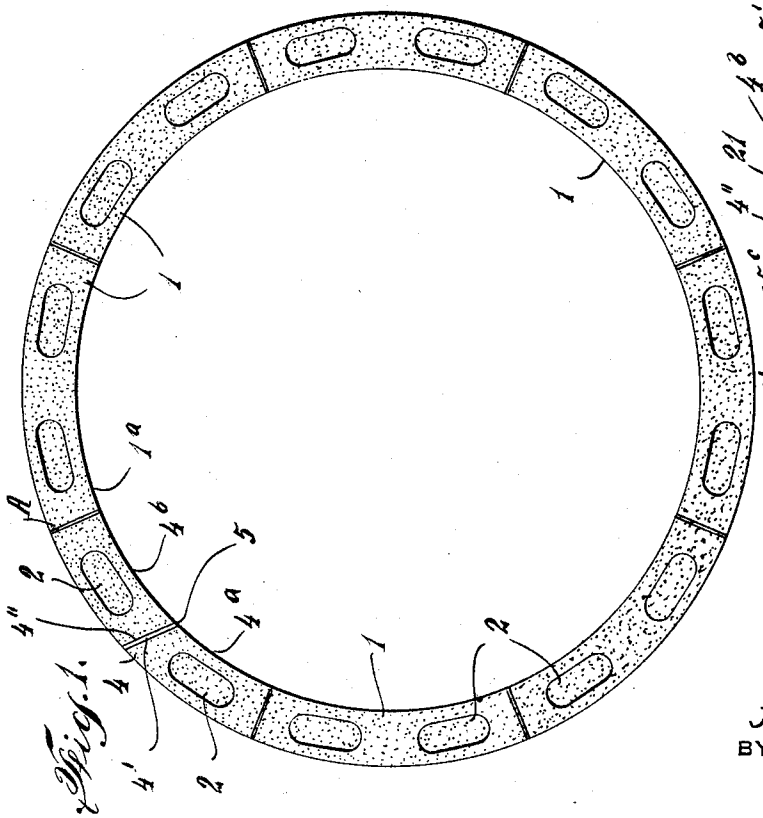

Fig. 1.

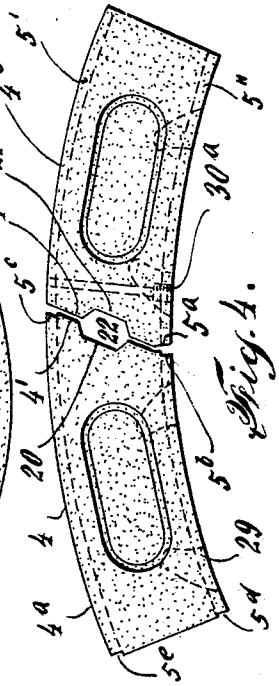

Fig. 4.

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Fig. 7.

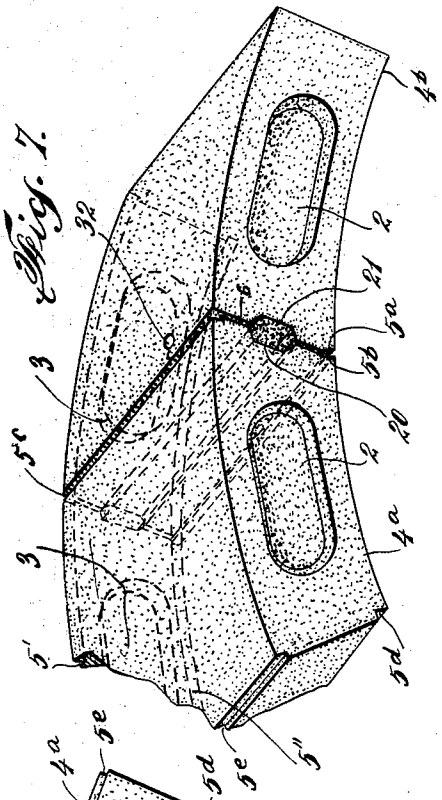


Fig. 8.

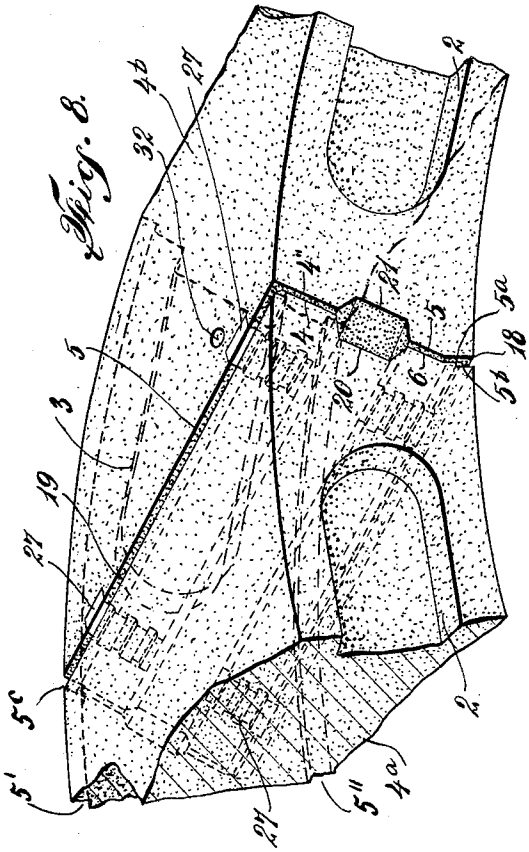


Fig. 6.

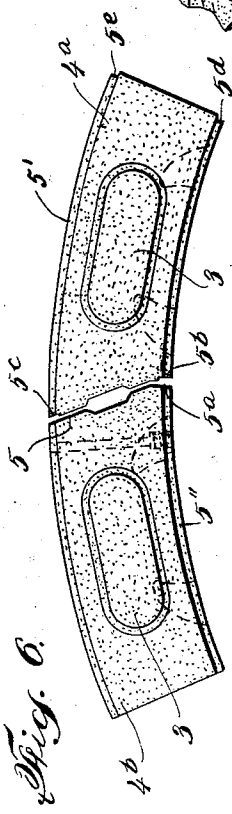
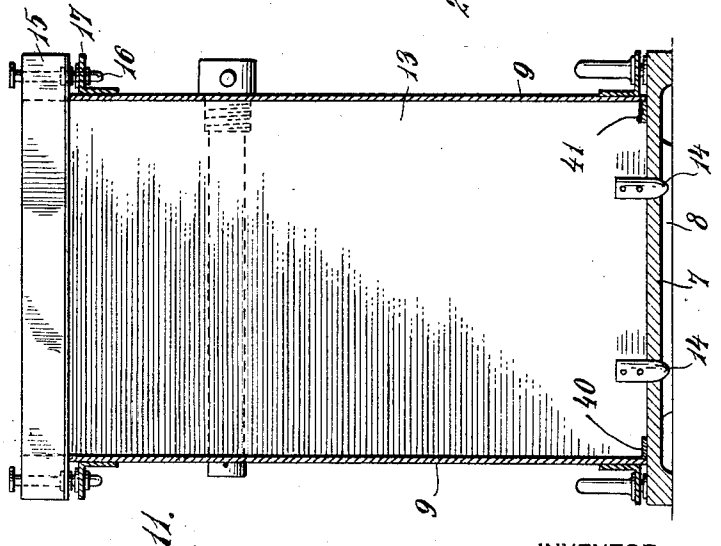


Fig. 11.



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TUNNEL OR CONDUIT LINING

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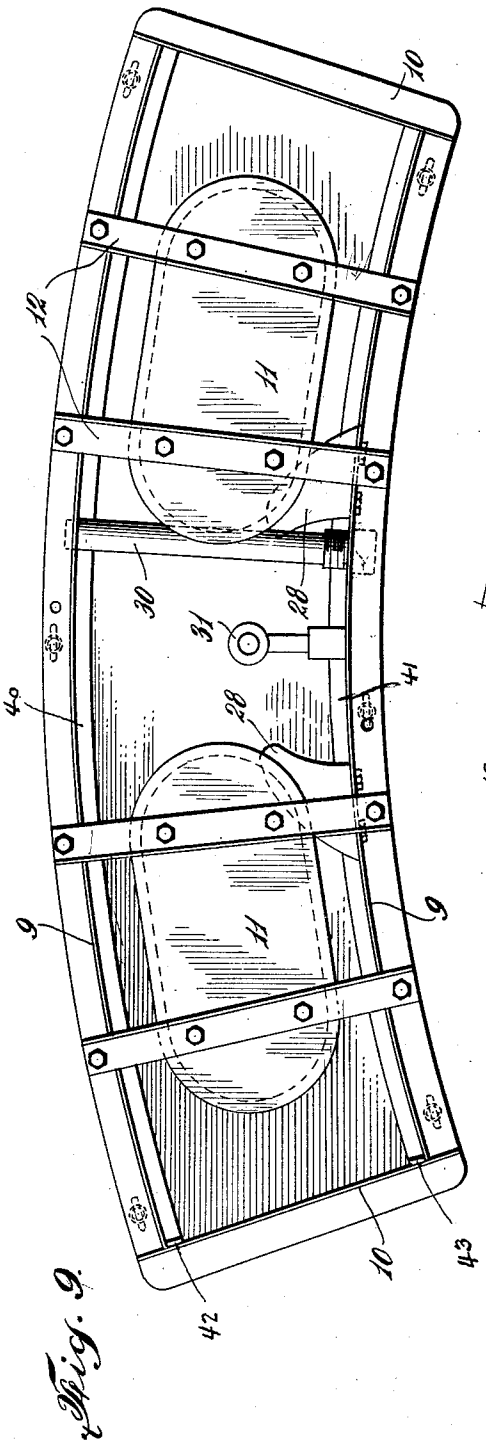

Fig. 9.

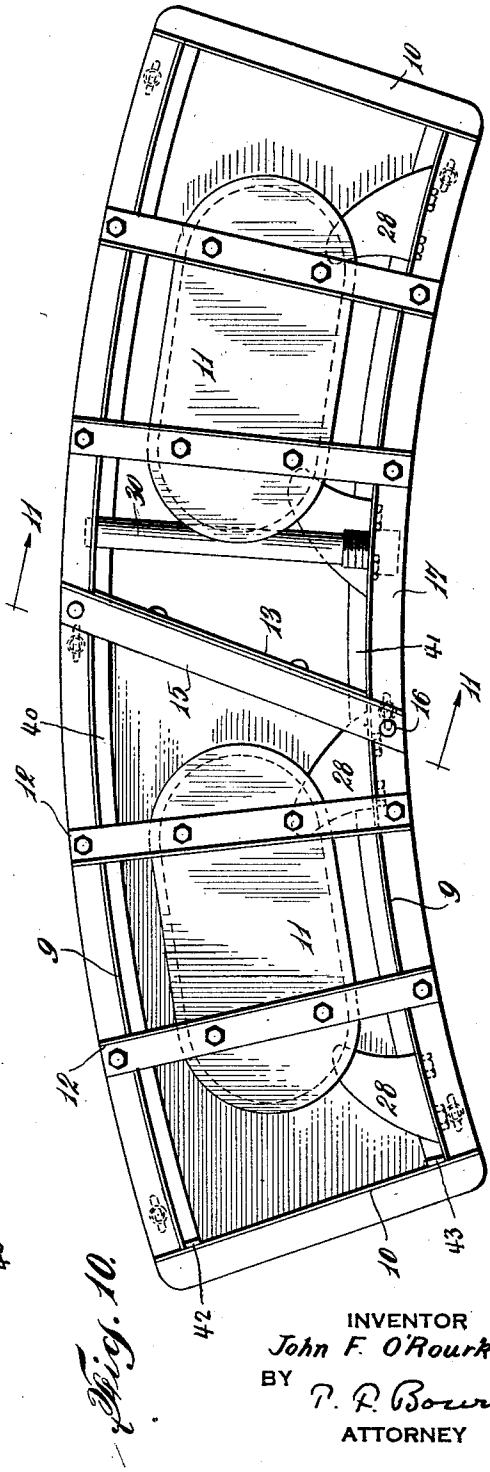

Fig. 10.

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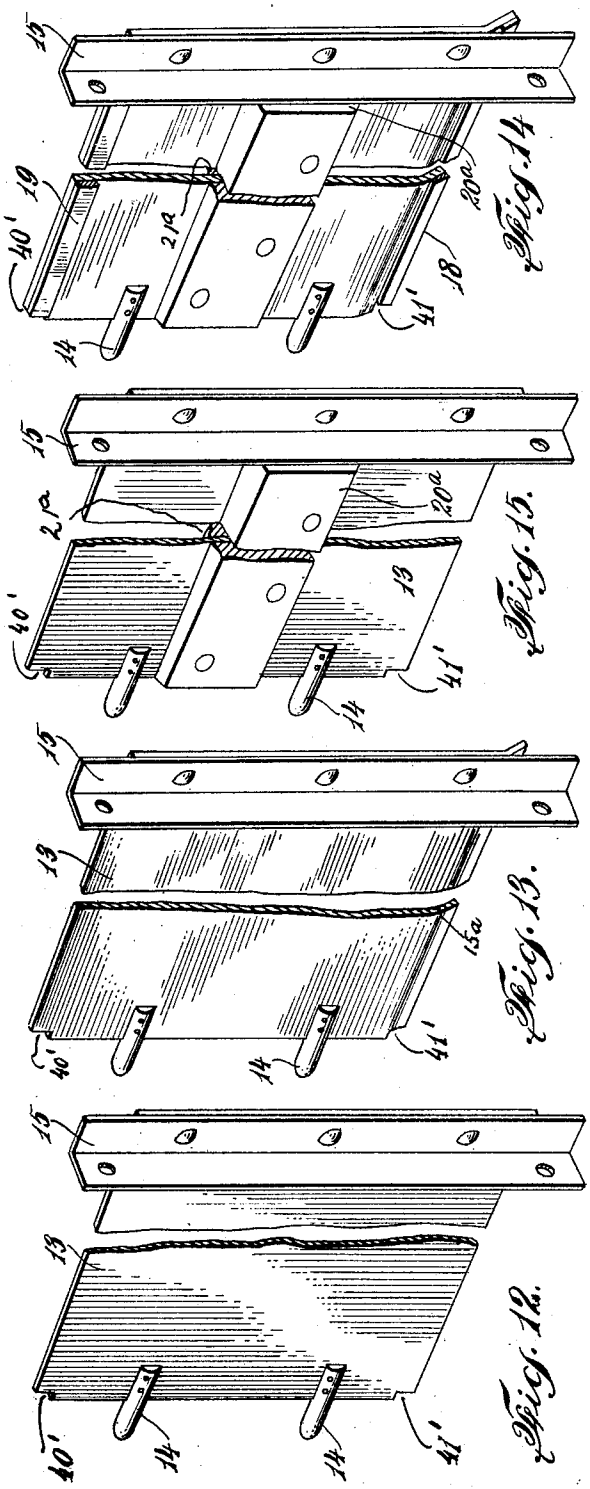

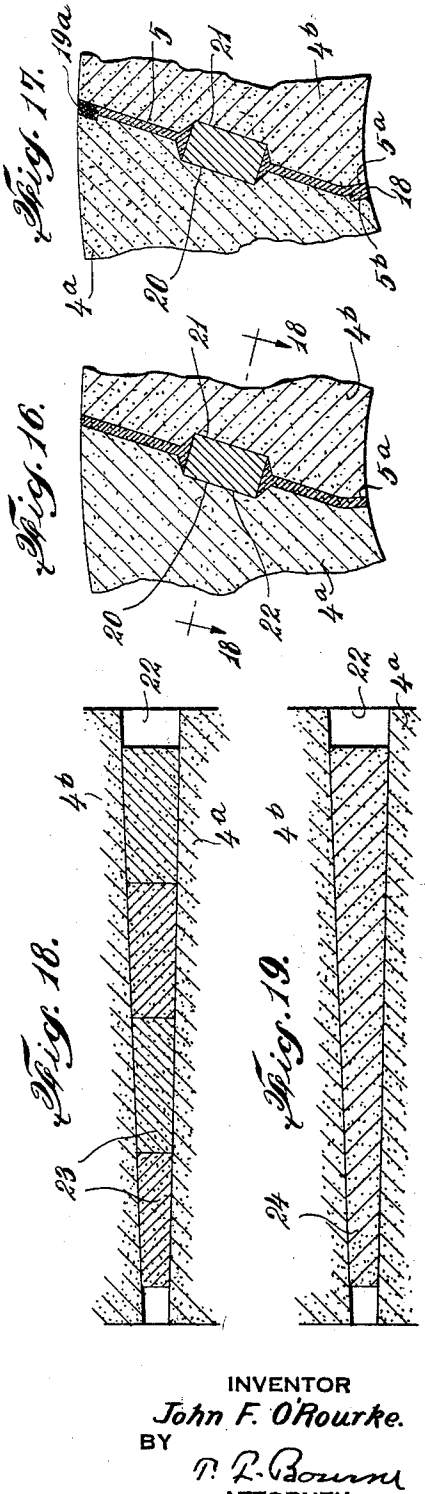

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Fig. 24.

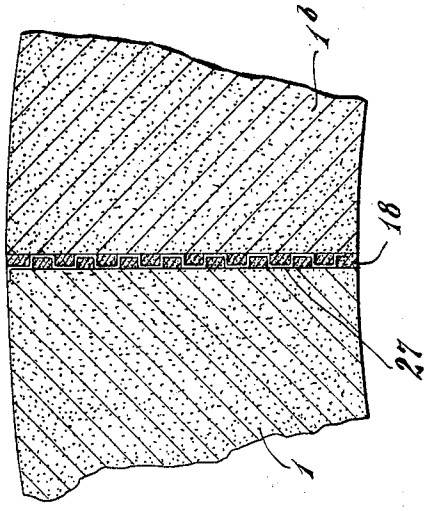


Fig. 23.

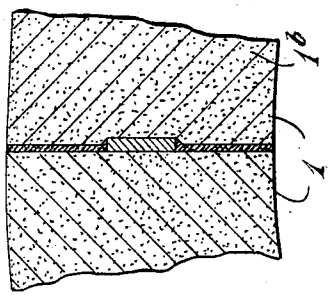


Fig. 22.

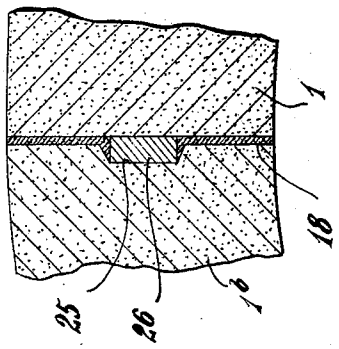


Fig. 20.

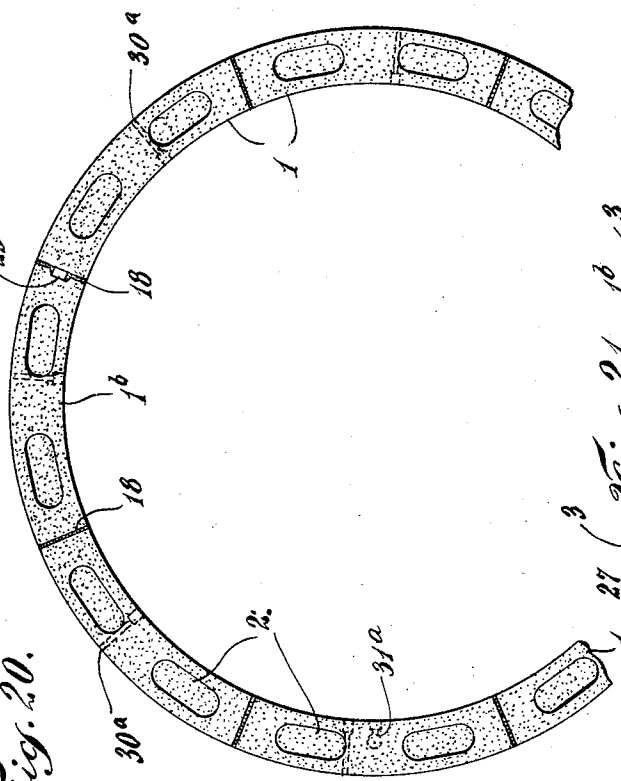
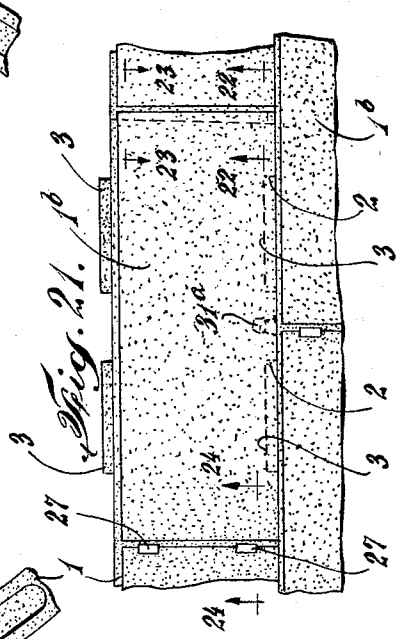


Fig. 21.



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UNITED STATES PATENT OFFICE

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TUNNEL OR CONDUIT LINING

Application filed December 16, 1930. Serial No. 502,659.

In the construction of interlocking concrete-block tunnels it is of practical importance that the lines of projections and recesses of the blocks be spaced equally apart so that each ring, as erected, may break joints with the previous ring and that the projections shall fit into the corresponding recesses of the joints between the rings. This has been done by spacing the projections and recesses on each block the theoretical equal distance each way from the middle of the block, and by having the blocks of such equal lengths that the distance from the projections and recesses of adjoining blocks to the centre line of the joint between them shall equal the space between the projections and recesses on the blocks. This necessitates blocks of uniform dimensions when the longitudinal joints are radial and are called "standard" blocks. Where longitudinal joints are not radial, as hereinafter described, the length along a middle arc is approximately the same as that of a standard block along the same arc. The rings are erected so that the projections are on the barkward side of the rings and fit into the recesses on the forward side of each adjoining previous ring.

In the erection of concrete block tunnel rings two methods have been used for closing the rings. By one method a key block is pushed radially outward into a space between two set blocks, the planes of whose end joints are at such at angle to one another that a wedge shaped opening is formed between them which is wider on the inside of the ring than on the outside. The concrete key block end joints are at a similar angle with each other so that when the key block is set in place it leaves an open joint between itself and each adjoining block which closes the ring when these are shimmed. This has been done with corrugated steel plates, as shown in the drawings. These corrugated shims are further shown and explained in my patent application, Serial #400,108. The advantages of these shims are that they take up the arch stresses and at the same time permit a free flow of grout until all the joints are filled with mortar from the grout. The angles of these joints of the concrete key blocks as heretofore used in the manner described are symmetrical with the middle axis of the key block, the same as the angles of longitudinal joints of symmetrical keystones of stone arches. Concrete block rings closed in this way require three different special blocks in addition to the uniform or standard blocks composing the remainder of the ring, so that four different kinds of block moulds are required, varying in size and form, which, with the difficulties of separate moulding, separating the blocks in different piles for storage, and selecting the proper blocks for each ring as they are taken into the tunnel for erection, adds to the complexity and cost of the work. Moreover, no concrete block tunnels built in this way, so far as I am aware, have ever had efficient independent means within the key block to hold it from falling out of the ring, without outside support, prior to its being held in place by compressive arch stresses after the ring takes the weight of the overlying ground.

The other method of closing concrete block rings consists in having the rings composed entirely of standard blocks, including the closing block, which latter is taken forward by the erector into the space for the next ring, swung up opposite its intended position in the ring, and then backed into its position in the ring where it is supported and shimmed. In this case, also, no efficient means has been provided within the closing block to hold it rigidly in place and to positively close up the blocks of the ring against the shims in the joints prior to the ring taking up the arch stresses after being loaded with the weight of the surrounding ground. This method of closing the ring requires the use of an erector having independent longitudinal motion. In the case of shield driven tunnels a dummy block is set and wedged in the space left for the key block, to close the ring before the shield is shoved, from which dummy block the shield jacks are shoved, the same as from other blocks of the ring, in moving the shield forward to make room in its tail for the next ring. After the shield is shoved and space is thus provided for the next ring the dummy block is removed and the erector

carries forward a standard concrete block into the space for the next ring and places it in position to complete a ring as described. The objections to this method of closing a ring in shield driven tunnels are the increased cost and complexity of the erector platform and of the erector, and the additional time required to erect and remove a dummy block and then to set the key block in place. In cases where the tunneling is done without a shield and each ring as erected supports the ground, the removal of the dummy block and substitution of a standard block after excavation for the next ring is completed presents a serious problem of holding the overlying ground where it tends to fall when unsupported during the substitution in the ring of a standard block for the dummy block as a key block.

In accordance with my invention one of the standard blocks of a ring is omitted, leaving a space which a standard block would fill. The closing of the ring is completed by inserting in said space what is in effect a standard block, which may be moulded in two parts in a standard block mould, said parts being successively inserted radially. The two parts have an oblique angle joint between them. The part in which the outside length is greater than that of the inside is first erected and held in place in the usual manner. The key block part with its outer side slightly shorter than the inner side is next pushed into place by the erector to close the ring, where it may be supported and shimmed in much the same manner as is done when full length special blocks are used to close the ring, as in the first method described.

When it is desired to have uniformity of appearance in the pointing of joints inside of a tunnel, which could not be done with the oblique joints described, the joint is made radial for a short distance in from the inside surface of the tunnel. These joints would be uniform in appearance with the other joints of the ring both before and after the pointing.

In carrying out one of the modifications of my invention I provide the inner end of the joint between the key-block parts with a tapered recess along the edge of the joint, which adds to the width of opening through which the key block is shoved into position by the erector. This recess performs two functions: the reduction of the obliquity of the joint and the enlargement of the joint between the blocks for the necessary distance inward to facilitate entering the pointing mortar in the joint and also the locking of it into the joint by the inward taper. I may also provide a recess in the joints at the outer side of the tunnel to contain means for excluding gravel packing or ground from entering the joint before said joint has been grouted or otherwise filled up. It is obvious that similar recesses can be used to advantage in all the other joints of the rings.

Means for locking the key-block parts together whenever desired is shown. It is accomplished by moulding opposing wedge shaped recesses in the sides of the blocks which form the joint between them. When the key-block is set in place in the ring the opposing wedge shaped recesses form a wedge-shaped keyway or channel between the blocks into which wedges of any desired length may be forced, so as to bring the blocks into close relation with the blocks on each side of them, at the same time firmly clamping them together.

This means of wedging the closure through a suitable wedge keyway can be done to great advantage when the key block, like all the other blocks in the ring, is a "standard" block. In the erection of rings composed entirely of standard blocks, as shown in Fig. 20, a wedge keyway is moulded at one end of the key block of each ring by means of which they are wedged tightly in place against the radial joints of the adjoining blocks. This pressure in turn is communicated to all the other blocks of the rings adding to the effect of their weight in bringing them into close relation to their respective shims. It is obvious that two or more wedge keyways can be provided at one end of the key blocks and that one or more wedge keyways can be provided at each end of the key blocks and that one or more wedge keyways can be provided in the ends of other blocks of the rings and that wedge keyways in the ends of adjoining blocks may be made to register with one another, in carrying out my invention.

Reference is to be had to the accompanying drawings, wherein

Fig. 1 is a face view of a tunnel ring embodying my invention; Fig. 2 is an enlarged face view of the two part key-block of Fig. 1; Fig. 3 is a similar view showing the joint between the block parts as radial for a short distance from the inner surface of the block parts; Fig. 4 is a face view of a modified form of the key-block parts; Fig. 5 is a face view of the key-block of Fig. 2 showing a modification; Fig. 6 is the opposite side of block parts shown in Fig. 4; Fig. 7 is an enlarged perspective view of the key block parts of Fig. 4; Fig. 8 is a view substantially similar to Fig. 7, illustrating corrugated shims in the joint between the block parts; Fig. 9 is a plan view of a mold for the standard blocks; Fig. 10 is a similar view, showing the mold provided with a dividing plate to form the oblique joint between the key-block parts; Fig. 11 is a section on line 11, 11 in Fig. 10; Fig. 12 is a perspective view illustrating the division plate for the mold for forming the oblique joint between the key-block parts of Figs. 1 and 2; Fig. 13 illustrates the mold division plate for the

joint between the key-block parts in Fig. 3; Fig. 14 illustrates the mould division plate for the joint between the key-block parts in Fig. 4; Fig. 15 illustrates the mould plate for blocks as in Fig. 5; Fig. 16 is a detail sectional view through a key-block joint, illustrating recesses containing a wedge; Fig. 17 is a similar view, illustrating a modification; Fig. 18 is a section on line 18, 18 in Fig. 16 illustrating wedges between the key-block parts; Fig. 19 is a similar view illustrating a single wedge; Fig. 20 is a face view of a portion of a concrete block tunnel ring comprising uniform-length standard blocks, the standard block for closing the ring having a wedge keyway and wedge at one end of the block and corrugated steel shims in the joint at the other end of the block; Fig. 21 is an enlarged plan view of part of Fig. 20 and adjoining ring, and Figs. 22, 23 and 24 are enlarged sections on lines 22, 22, 23, 23, and 24, 24 respectively, in Fig. 21.

Similar numerals of reference indicate corresponding parts in the several views.

The numeral 1 indicates standard blocks for the rings of a tunnel, subway or conduit lining. The blocks 1 illustrated are of well known form and comprise moulded concrete. Said blocks have spaced recesses 2 in one face and correspondingly spaced projections 3 on the reverse face. The rings are usually erected with the recesses 2 facing forwardly to receive the projections 3 extending rearwardly from the next ring erected, in a well known way. The rings are usually set so that the blocks of one ring will break joints with the blocks of the rings on opposite sides thereof. In the example illustrated in Fig. 1 a tunnel ring includes a sufficient number of standard blocks 1 to nearly complete the ring, one of such blocks being omitted providing a space A between certain blocks 1 to receive one of my improved key-blocks 4, which comprises block parts 4*a* and 4*b*, to complete the ring. The outer ends of all the blocks are shown radial and the inner or meeting ends 4′, 4″, of the key block parts 4*a* and 4*b* are at angle oblique to the radial ends thereof, as indicated at the joint, 5, that is oblique to a plane lying in the longitudinal axis of the ring and intersecting said joint. The overall length of the key-block parts is substantially the same as a standard block, whereby when a required number of standard blocks have been erected, with a space A between the end blocks of the series, the key-block parts will properly fit in said space. The outside length of the key-block part 4*a* is greater than the length of its inside, and the outside length of the key-block part 4*b* is less than the length of its inside part.

After the series of standard blocks, for a ring, have been erected, with a space between the end blocks, the key-block part 4*a* is erected in said space, with its radial end adjacent to a standard block, and said block part is held in place in any usual manner. The key-block part 4*b* is next inserted in said space, and by reason of the adjacent obliquely inclined ends of the block parts 4*a* and 4*b* the part 4*b* may be placed in position by moving it in an outward radial direction, where it may be supported and shimmed in any well known way. The construction described is advantageous in that it overcomes the previous requirements of an erector for the key-blocks having an independent longitudinal movement to insert backwardly the last block of a ring into the space provided for it after having swung such block outwardly within the space to be occupied by the next ring to be erected in front of where it is to be set, since merely the vertical movement of the erector is required with my improved key-block 4*b* to place it in the space between the block part 4*a* and the adjacent standard block without delay and before a space in which to erect the next ring is provided, (Fig. 1). The dimensions of the two block parts 4*a* and 4*b* are such that the recesses 2 in one face and the projections 3 on the reverse face are spaced apart, when the key-block is in the ring, substantially the same distance as the recesses 2 and the projections 3 on the standard blocks 1, whereby as each ring is erected the projections 3 will enter the recesses 2 of the ring previously erected. By preference the blocks are so placed in a ring being erected as to break joints with the blocks in the previously erected ring. The oblique joint between the block parts 4*a* and 4*b* may be filled with mortar or grout in a usual way, as indicated at 6 in Figs. 7 and 8. Shims 27 are shown in the joint 5 between the block parts 4*a*, 4*b*, in Fig. 8.

A mould suitable for making the standard blocks 1 and the block parts 4*a* and 4*b*, of the same general dimensions for a given ring, is illustrated in Figs. 9, 10 and 11. The mould shown comprises a bottom 7 having spaced recesses at 8 for the production of the projections 3 of the blocks, spaced side walls 9, and end walls 10, with an open top. Cores 11, to produce the recesses 2 of the blocks, are suspended over the mould by cross bars 12, secured to the cores and to the mould. The mould, as shown in Fig. 9, will produce the standard blocks 1 by pouring concrete into the mould in a well known way. The same mould may be used to produce the key-block parts 4*a* and 4*b* by placing a division plate 13, in the mould, set at an oblique angle to the length of the mould, to divide the mould into two spaced portions, as indicated in Figs. 10 and 11. The bottom of the division plate 13 is shown provided with projections 14 to enter holes in the mold bottom 8, and recesses 40′, 41′, on each side to fit over bars 40 and 41 in the mold which produce recesses 5′ and 5″ in the concrete

blocks. The plate 13 has a top cross bar 15 to be secured to the mould, as by taper plugs or pins 16 entering flanges 17 on the mold sides, as indicated in Fig. 11. When the division plate 13 is in the mould each end portion of the mould may be charged with concrete to produce the key-block parts 4*a* and 4*b* having meeting ends corresponding to the angle of the division plate 13 in the mould.

To produce uniformity of appearance in the pointing joints inside of a tunnel, which could be done only with the oblique joints 5 between the block parts 4*a* and 4*b*, the adjacent ends of said parts are made radial for a short distance from their inner surfaces, as indicated at 5*a* in Fig. 3. This may be done by bending the division plate 13 of the mould to a radial direction at 15*a* at a desired distance from where it abuts against the inside of a side wall of the mould, as indicated in Fig. 13. When the concrete is poured into the mould the oblique angular edges 4′, 4″, and the radial edge portions 5*a*, will be produced at the adjacent ends of the block parts 4*a* and 4*b*.

As illustrated in Figs. 4, 6, 7, 8 and 17 a tapered recess 5*b* is provided along the inner edge of the joint 5 away from the key-block part 4*b*, which adds to the width of the opening or space into which the part 4*b* is shoved into position by the erector. Said recess provides for the reduction of the obliquity of the joint 5 and the enlargement of the joint between the block parts 4*a* and 4*b* for the necessary distance inwardly to facilitate entering or filling pointing mortar in the joint and locking the mortar in the joint by the inward taper. Said recesses may be formed in the end of the block part 4*a* by attaching a bar 18 to the appropriate side edge of the dividing plate 13, as in Fig. 14. A recess 5*c* may be provided on the outer part of one of the key-blocks, such as the part 4*a*, to contain means such as a gasket 19*a*, Fig. 17, for excluding gravel packing or ground from entering the joint before the joint has been grouted or filled up, Figs. 7, 8 and 17. The recess 5*c* may be formed by attaching a bar 19 to the division plate 13 along the side edge opposite the bar 18, Fig. 14. Recesses similar to 5*a* and 5*c* may be formed in all the other joints of a ring for similar purposes. To provide for packing the circumferential joints between rings of the tunnel lining the blocks may have recesses 5′ along their outer or upper circumferential corners, and recess 5″ along their inner or lower corners, providing open joints, to be filled with pointing or caulking material, such as mortar. Also, at the appropriate ends of the blocks recesses may be provided at 5*d* (Fig. 7), to be filled with pointing or caulking material, such as mortar. Bars 40, 41, 42 and 43, Figs. 9 and 10 produce recesses 5′, 5″, 5*d* and 5*c*, Figs. 6 and 7.

I provide means for locking the key-block parts 4*a* and 4*b* together, when such is desired. For such purpose the adjacent oblique edges of said block parts are provided with recesses 20 and 21, which oppose, forming a channel or recess 22 extending across the joint 5, Figs. 4, 5, 7, 8, and 16 to 19. The recesses may be formed by attaching wedge shaped cores 20*a* and 21*a*, back to back along opposite faces of the dividing plate 13, as shown in Figs. 14 and 15. When such plate 13 is in the mould and the concrete is poured therein the wedge shaped recesses 20 and 21 will be produced in the respective ends of the block parts 4*a* and 4*b*. When the key-block parts are in place in a ring the wedge shaped channel or recess 22 will be provided, as a keyway, into which wedges of any desired length may be forced, and driven with a follower, if desired, to bring the block parts 4*a* and 4*b* into close relation with the blocks 1 on either side thereof, at the same time firmly clamping them together. Several relatively short wedge keys 23 may be driven into the channel 22, (Fig. 18), or a wedge key 24 of single length may be driven into the channel 22, (Fig. 19). Recesses 20 and 21 may be moulded so that the opposite sides of recess 22 would be parallel. Two opposed wedges could be used in this keyway to carry out my invention.

The advantage of a wedge key or keys between a standard block 1 and a standard key-block 1*b* may be obtained, as illustrated in Figs. 20 to 23. At one end of the standard key-block 1*b* a transverse channel or keyway 25 is moulded, into which channel a wedge key or keys 26 may be driven, by which means the standard key block 1*b* is wedged tightly in place against the radial joints of the adjacent blocks. The pressure thus obtained by the wedge or wedges may be communicated to some or all of the blocks of the ring, adding to the effect of their weight in bringing them into close relation, and especially with respect to the interposed shims 27 when same are used, which is also true of any other kind of shims that might be employed for this purpose.

Projections 28, suitably placed in the mould, produce recesses 29 in the moulded blocks to receive erector grippers, in a well known way. Cores 30 and 31 in the mould are provided to make gravel holes 30*a* and grout holes 31*a* in the moulded blocks.

Having now described my invention what I claim is:

1. A tunnel ring comprising a plurality of substantially similar blocks, and a two-part key-block, each of said key-block parts having radial outer ends and inclined inner ends.

2. A tunnel ring as set forth in claim 1 having a joint between the two parts of the

key-block at their inner ends at an angle oblique to a radius of the ring.

3. A tunnel ring as set forth in claim 1 having a joint between the two parts of the key-block at their inner ends which is radial for a part of its length and is oblique to said radial part for the remainder of the joint.

4. A tunnel ring having a two-part key-block provided with a joint between said parts at their inner ends that extends at an angle oblique to a plane lying in the longitudinal axis of said ring and intersecting said joint the outer ends of the key-block parts being radially disposed.

5. A tunnel ring as set forth in claim 4 in which the blocks are provided with recesses at the inside of joints for filling at the inside of the ring.

6. A tunnel ring as set forth in claim 4 in which the blocks are provided with angularly shaped recesses at the inside of joints for filling at the inside of the ring.

7. A tunnel ring comprising blocks having radially disposed outer ends and having joints between adjacent ends of the blocks, said blocks having recesses for filling at the inner portions of said joints.

8. A tunnel ring comprising blocks having radially disposed outer ends and having joints between adjacent ends of the blocks, said blocks having recesses for filling at the outer portions of said joints.

9. A tunnel ring comprising a plurality of substantially similar blocks, and a two-part key-block, one of said key-block parts having a recess in one end, and a key in said recess to force said key-block parts respectively against adjacent blocks of the ring, the outer ends of the key-block parts being radially disposed.

10. A tunnel ring as set forth in claim 9 in which the recess is tapering and the key is wedge shaped.

11. A key-block for a tunnel ring having two parts and a joint between adjacent ends thereof, said parts having opposing recesses in the adjacent ends providing a channel, and a key in said channel to force said key-block parts respectively against adjacent blocks in a ring, the outer ends of the key-block parts being radially disposed.

12. A tunnel ring comprising a series of substantially similar blocks and a key-block, said key-block having a recess at one end, and a key in said recess to drive the blocks of the ring into close relation, the outer ends of the key-block parts being radially disposed.

13. A tunnel ring as set forth in claim 12 provided with shims between one of the parts of the key-block and one of the first named blocks.

14. A key-block for a tunnel ring comprising two parts having adjacent ends providing a joint between them the outer ends of the key-block part being radially disposed, the outer surface of one key-block part being longer than the outer surface of the other key-block part.

15. A key-block as set forth in claim 14 in which the inner surface of one key-block part is longer than the inner surface of the other key-block part providing adjacent ends between said parts said ends being oblique to a radius of one of said blocks.

16. A concrete-block tunnel lining comprising a plurality of adjacent rings having circumferential joints therebetween, the rings including a plurality of concrete blocks having radially disposed outer ends, some of the joints of said blocks having recesses at the inside portions of the joints to receive filling material.

17. A concrete block tunnel lining comprising a plurality of adjacent rings having circumferential joints therebetween, the rings including a plurality of concrete blocks having radially disposed outer ends, some of the joints of said blocks having recesses at the outside portions of the joints to receive filling material.

18. A concrete block tunnel lining comprising a plurality of adjacent rings having circumferential joints therebetween, the rings including a plurality of concrete blocks having radially disposed outer ends, some of the joints of said blocks having recesses at the inside and the outside portions of said joints to receive filling material.

19. An interlocking concrete block tunnel or conduit lining having rings comprising a plurality of blocks having substantially similar lengths and a key-block, the first named blocks having projections on one side and recesses in the other side in equally spaced relation to permit the projections of one ring to enter recesses in the blocks on an adjoining ring, the key-block of each ring comprising two parts, the combined length of said two parts being substantially the same as the length of the other blocks of said ring, said key-block parts having radial outer ends and having inclined inner opposing ends, whereby the key-block parts may be moved outward successively in a radial direction between other blocks of the ring to close the ring.

20. An interlocking concrete block tunnel or conduit lining as set forth in claim 19 in which each key-block part has a projection on one side and a recess on the opposite side, said projections and recesses being located in position to cooperate with recesses and projections, respectively, of other blocks of adjacent rings.

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