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Patented Dec. 9, 1902.

T. COOPER.
PNEUMATIC TUNNELING SHIELD.

(Application filed May 31, 1902.)

(No Model.)

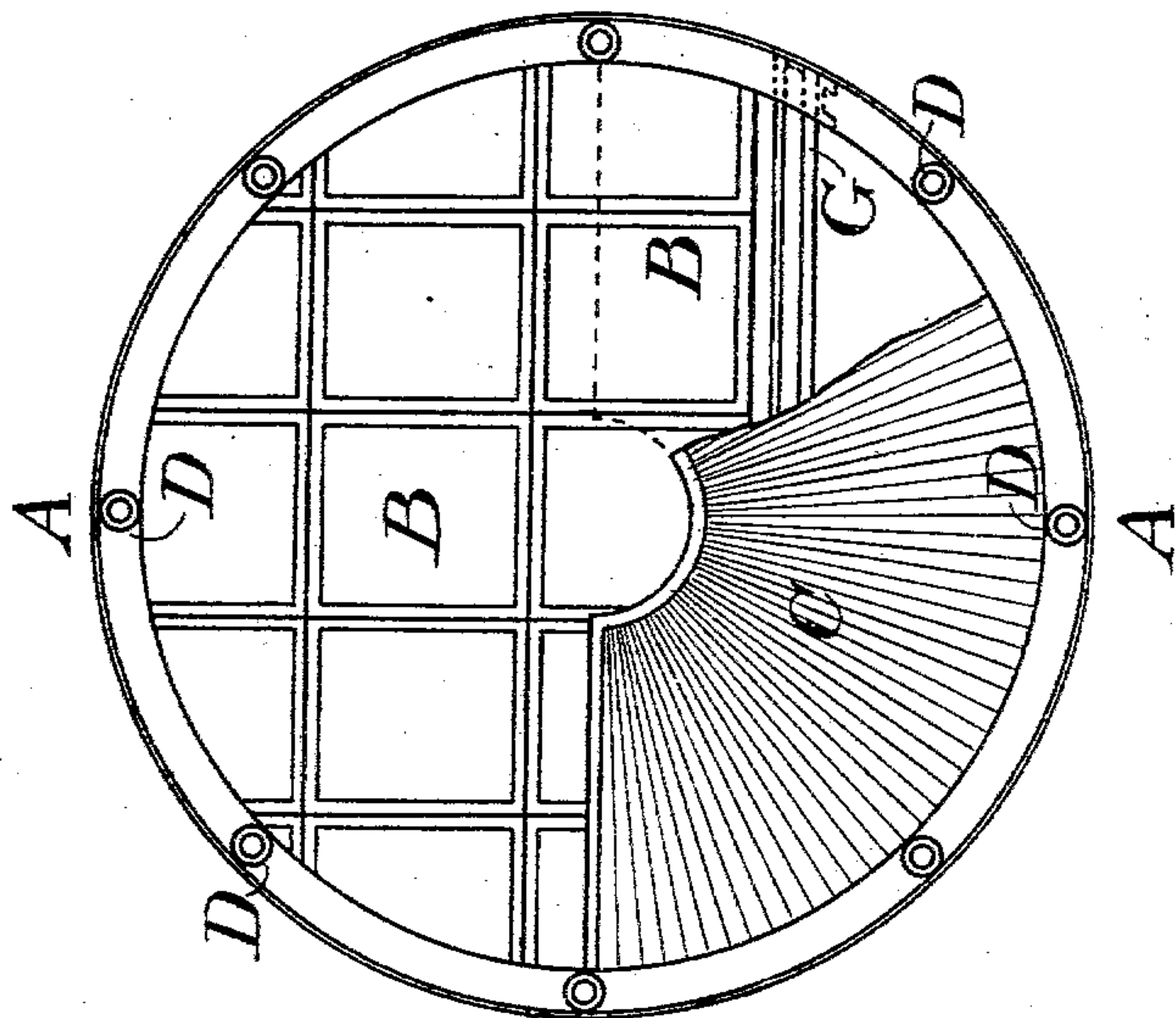


Fig. 2.

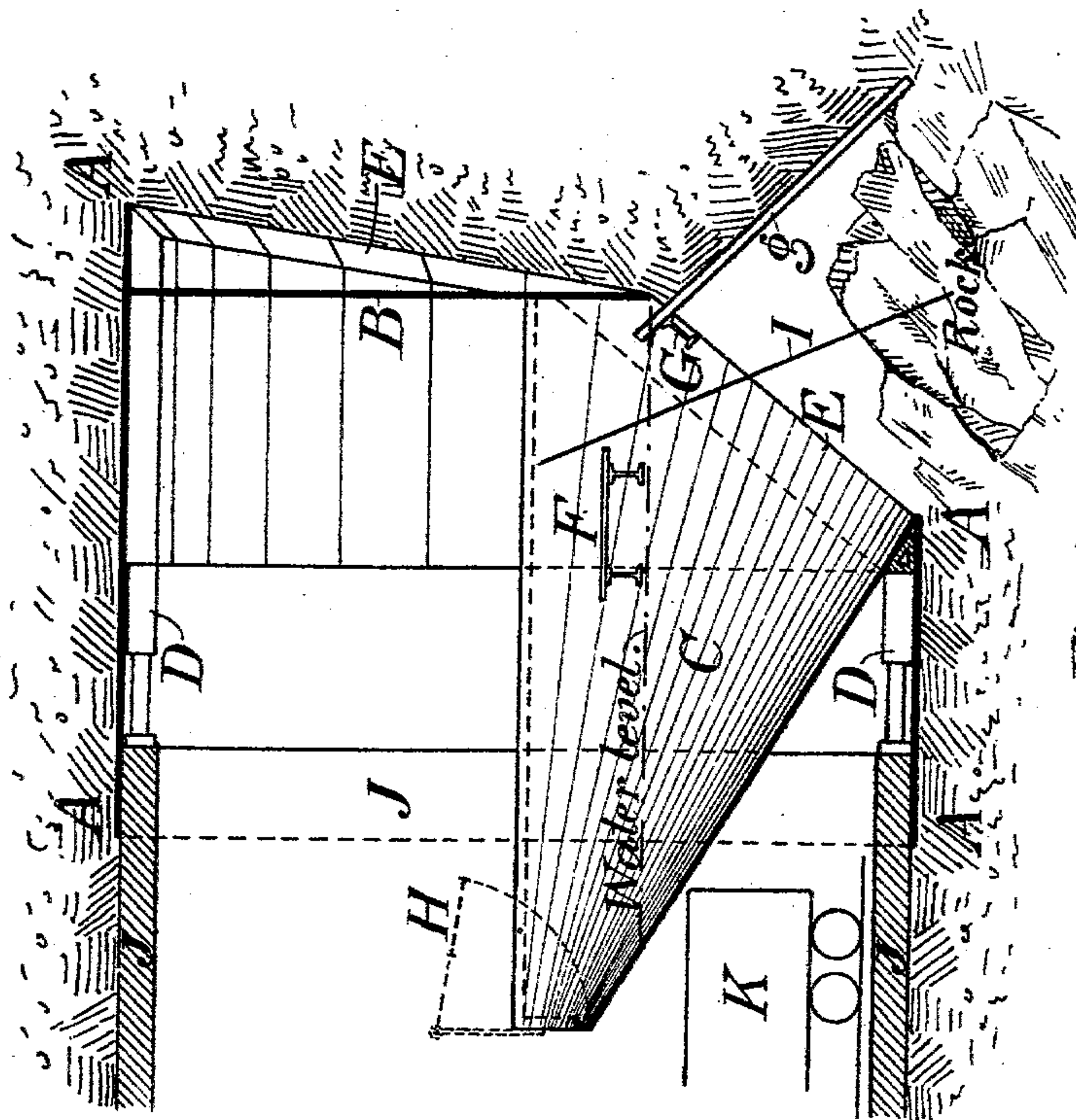


Fig. 1.

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PNEUMATIC TUNNELING-SHIELD.

SPECIFICATION forming part of Letters Patent No. 715,244, dated December 9, 1902.

Application filed May 31, 1902. Serial No. 109,648. (No model.)

To all whom it may concern:

Be it known that I, THEODORE COOPER, a citizen of the United States, and a resident of the city, county, and State of New York, have
5 invented certain new and useful improvements in pneumatic tunneling-shields for tunneling through water-bearing ground—such as marsh or river silt, clay, sand, or gravel, or any combination of the same—and
10 also where such materials may be in combination with boulders or rock ledges, of which the following is a specification.

The object of this invention is to reduce the risks involved in tunneling through such
15 materials and to increase the efficiency of the shield method of tunneling by reducing the cost and time needed for building such tunnels.

More particularly I purpose to have the
20 work of excavation carried on from within the forward bulkhead of the shield by an arrangement which gives access to the material in front of the bulkhead and at the same time protects the workmen and the structure of
25 the shield under all conditions. Heretofore it has been the practice in many cases for the men to work outside of and ahead of the forward bulkhead, excavating the material in advance of the shield preparatory to its
30 being pushed forward by the rams. This method of tunneling is practically impossible in water-bearing material for any considerable distance. When such material is encountered incidentally and for a short distance,
35 it has been necessary to build up what is practically a water-tight wall ahead of the shield by poling-bars, grouting, and similar means, by which the excavation can be carried on inch by inch until the watery stratum
40 has been passed. Such work is, however, slow and dangerous. In brief, I aim to avoid this difficulty by providing just back of the forward bulkhead an after bulkhead of a somewhat trough-like form, having its
45 forward open end presented to the material in front of the shield below the forward bulkhead, which is cut away for this purpose. The rear end of this after bulkhead rises upward to a point above the water-level maintained by the internal air-pressure counterbalancing the external hydrostatic pressure.
50 The forward end of this after bulkhead is at-

tached to the shield at or near to the cutting edge of the shield, and preferably the lower portion of such edge is cut away to a point
55 back of the front bulkhead to bring the forward end of the trough still closer to the external material. The water can then enter freely into the trough up to the level aforesaid, while from a platform within the trough
60 and back of the forward bulkhead, and, if desired, above the water-level, the workmen can reach through the water to the material in front of and below the shield. The excavated material can then be brought back-
65 ward and upward (by conveyer mechanism, if desired) through the trough to a point where it can be conveniently removed—preferably a point back in the completed tunnel, to which the trough is extended. If the
70 material is sufficiently soft, little or no excavation will be required, since it can by forcing the shield forward be squeezed back into the trough and up its inclined bottom wall to a point directly over a car, into which it will
75 fall without handling, such an after bulkhead forming an interior trough-like compartment presented directly to the outside material through the front end of the shield, so that such material can be worked through
80 it by men stationed back of the forward bulkhead and protected not only by the forward bulkhead, but by the internal air-pressure acting on the limited water-surface in the after bulkhead to counterbalance the hydro-
85 static pressure, and so keep out the water. Such a feature constitutes the leading characteristic of my invention.

The invention consists of the parts and combination of parts, as hereinafter particularly described, and specially set forth in the
90 claims.

Figure 1 shows a vertical cross-section of a partially-completed tunnel and typical form of shield as proposed. Fig. 2 is an end elevation
95 of the same looking forward in line of advancement, with portions broken to show parts otherwise hidden.

Similar parts have identical letters in each figure.

The principal parts of this form of shield are: A A, circular shell of shield with its stiffening-ribs; B B, forward bulkhead, closing
100 the end of the shield for a certain depth, but

not fully, against inflow of materials at the front; C C, the sloping and tapering after bulkhead; D D, the rams for moving and adjusting the shield, and E E the cutting edge of the shield.

The accessory parts and tools shown are: F, working platform; G, removable beam for supporting poling-bars when they may be needed; H, an emergency-door for closing mouth of after bulkhead; I, a drill or other tool; J, completed part of tunnel, and K material-car.

The forward bulkhead B may be placed vertically or at any angle, and the cutting edge E above the lower edge of the forward bulkhead B may be vertical or inclined at any angle considered most suitable for each case; but that portion of the cutting edge E below the lower edge of the bulkhead B should preferably be inclined into the curved rear back of the bulkhead B sufficient to give more ready access of the forward end of the bulkhead C C to the materials in front of the lower portion of the shield. This will allow the free use of excavating apparatus or tools to enable boulders or rock to be drilled, blasted, and prepared for removal, and, if desired, permit the forcing or screwing of piles into the ground from the working platform inside of the tunnel-chamber. The forward bulkhead and cutting edge may be braced and stiffened in any desired manner against the pressure of the external water and materials. The bulkhead may also be fitted with traps, manholes, or exploration-openings.

The after bulkhead C is permanently attached to the shield at or in the neighborhood of its cutting edge and moves therewith. It takes the form of an inclined trough extending rearwardly from the cutting edge of the shield, to which its forward edge is attached, while its walls are separated from and contained within the walls of the shield proper. It slopes and tapers with a reducing section to the rear (being preferably of a semiconical or approximately semiconical form) and has its inner end preferably within the completed tunnel. It should be so placed that the lowest point of the inner end should be high enough to prevent the inflow of water when the hydrostatic head of the external water is balanced by the internal air-pressure in the tunnel-chamber. Preferably the lowest point of the inner end of bulkhead C should be a moderate height above the lowest point of bulkhead B to allow for slight variations in the air-pressure. The top area of this bulkhead C is open, but may be fitted, if desired, with removable covers and have a door to close the end. In most cases, if not in all, it would be preferable to carry up the sides of this bulkhead several feet, as shown, or higher, if desired, and fit the end with an emergency-door only.

The operating-rams, or at least a portion of

them, should be pivoted, so as to restrain or counteract any tendency of the shield to rotate in moving forward.

The use of an after bulkhead of the form and character herein shown and described and for the purposes herein claimed is new and useful. It answers all the purposes for which previous forms of after bulkheads have been intended and has additional advantages—viz., it allows of the use of mechanical excavators and carriers to take up and deliver loose materials to the material-cars at the rear beyond the operations of lining the tunnel and forcing the rams. In soft ground it allows and constrains the external material forced inward by the pressure of the rams to flow directly into these material-cars with but little or no manual or mechanical assistance. It allows the placing of the stiffening-arch rings without being obstructed or delayed by removal of the material or process of excavation. Whether operating in dry ground subject to sudden influx of water and material or in water-bearing ground, where the hydrostatic head must be always maintained, it gives greater security against injury to the workmen or delay to the operations. It also strengthens and stiffens the lower edge of the shield, where the greatest resistance is. In connection with the cutting back of the lower part of the shield to the rear of the forward bulkhead it gives, while acting either as a safeguard in dry ground or as an after bulkhead to maintain the hydrostatic balance in wet ground, abundant and ready access to the bottom in front of the shield for loosening and excavating the materials, blasting and removing boulders or rock, or for sinking piles in soft ground for giving additional support to the finished tunnel, if needed.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination with a tunneling-shield of an after bulkhead therein comprising a conically-shaped trough having its axis parallel with the axis of the shield and extending rearwardly from the cutting edge of the shield at or near which its forward edges attach.

2. The combination with a tunneling-shield of an after bulkhead therein comprising a trough having its axis parallel with the axis of the shield and extending rearwardly and with reducing section from the cutting edge of the shield at or near which its forward edges attach.

3. The combination with a tunneling-shield of a forward bulkhead having an excavating-aperture in its lower part an after bulkhead consisting of a trough extending rearwardly from the front of the shield and having its axis substantially horizontal and its walls tapering or reduced in section from the periphery toward the axis of the shield.

4. The combination with a tunneling-shield having its lower front edge cut back to ex-

pose the horizontal surface of the external materials, of an after bulkhead secured to the shield at or near the cutting edge and consisting of a conically-shaped trough projecting rearwardly and having its walls at a height above the water-level maintained by the internal air-pressure counterbalancing the external hydrostatic pressure.

5. The combination with a tunneling-shield having its lower front edge cut back to expose the horizontal surface of the external materials, of an after bulkhead consisting of a trough extending rearwardly from the cut-away portion of the front edge of the shield and its walls inclined or reduced in section from the periphery toward the axis of the shield.

6. The combination with a tunneling-shield of an after bulkhead secured thereto comprising a trough parallel to the axis of the shield having its forward edge attached at or near the cutting edge of the shield and its walls extending rearwardly therefrom to a point within the completed tunnel and of a height reaching above the water-level maintained by the internal air-pressure counterbalancing the external hydrostatic pressure.

7. The combination with a tunneling-shield of an after bulkhead consisting of a conically-shaped trough extending rearwardly from the front of the shield and having its axis substantially horizontal and its walls reduced in section from the periphery toward the axis of the shield and having its inner end within the completed tunnel and at a height to maintain the water-level due to the

internal air-pressure counterbalancing the external hydrostatic pressure.

8. The combination with a tunneling-shield having its lower front edge cut back to expose the horizontal surface of the external materials, of an after bulkhead consisting of a trough extending rearwardly from the cut-away portion of the front edge of the shield into the completed tunnel and having its walls inclined from the periphery toward the axis of the shield and at a height above the water-level maintained by the internal air-pressure counterbalancing the external hydrostatic pressure.

9. The combination with a tunneling-shield of an after bulkhead therein secured to and moving with the shield and of a conical trough-shaped form having its walls reaching above the water-level and extending rearwardly to a point above the railway-track in the tunnel.

10. The combination with a tunneling-shield having its lower front edge cut back to expose the horizontal earth surface, of an inclined bulkhead secured to the cut-away portion of the shield and projecting rearwardly within the shield, transverse bar *G* within the shield and poling-bars *g*.

In witness whereof I have hereunto set my hand, before two subscribing witnesses, this 29th day of May, 1902.

THEODORE COOPER.

Witnesses:

L. T. SHAW,

A. M. DEWHURST.