No. 774,546. PATENTED NOV. 8, 1904.

W. I. AIMS.

SHIELD TUNNEL CONSTRUCTION.

APPLICATION FILED FEB. 29, 1904.

NO MODEL. 5 SHEETS—SHEET 1.

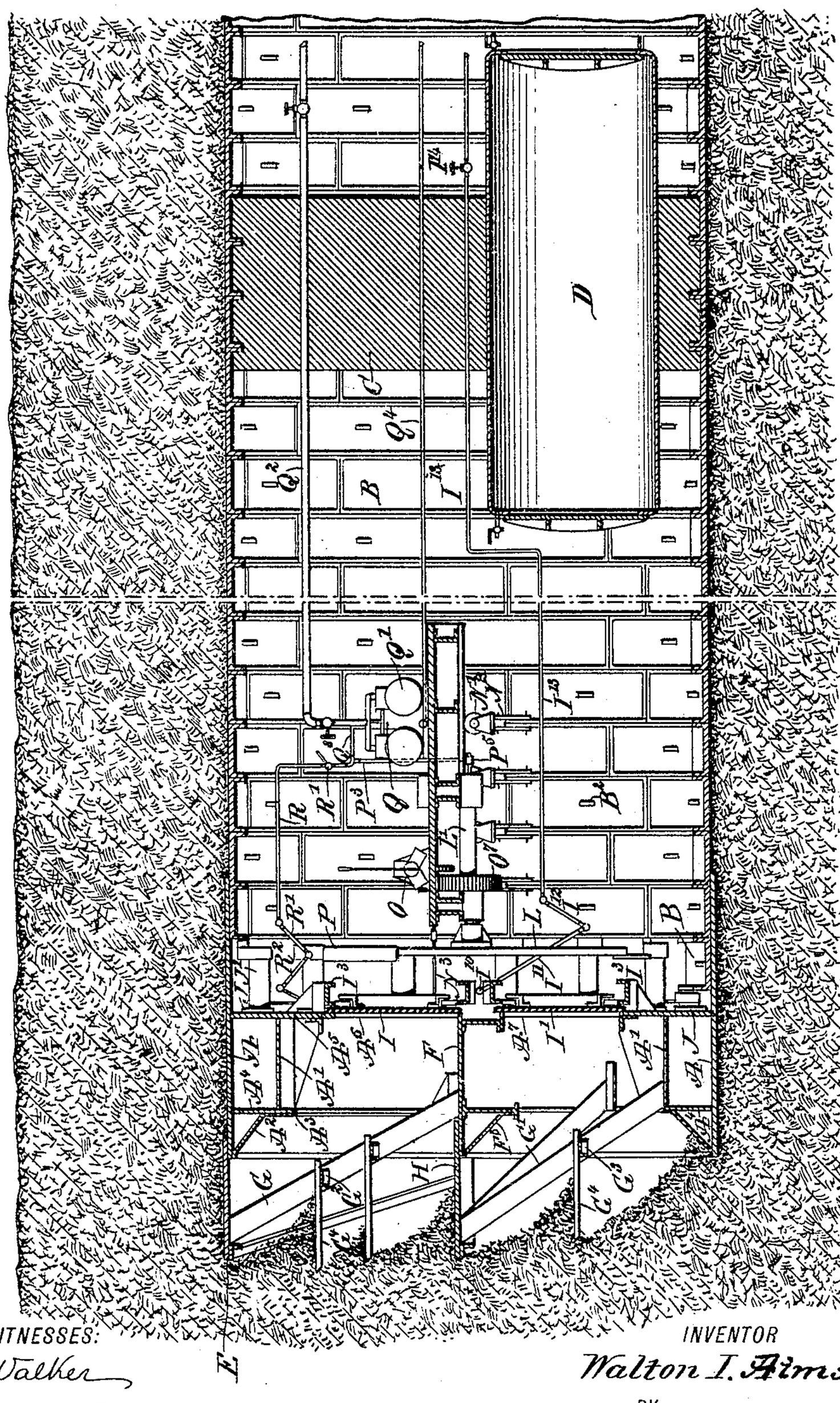

FIG. 1.

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NO MODEL. 5 SHEETS—SHEET 2.

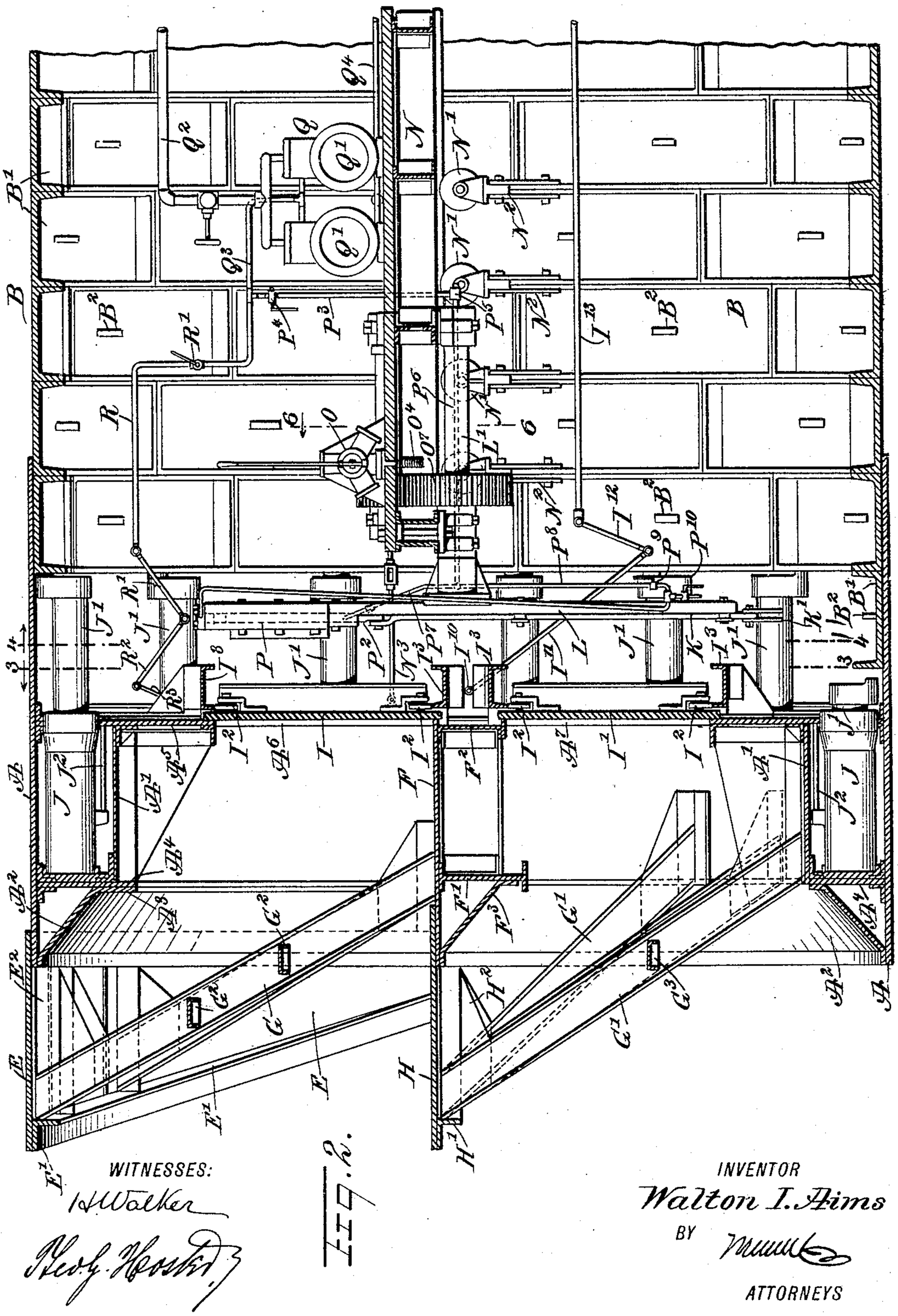

FIG. 2.

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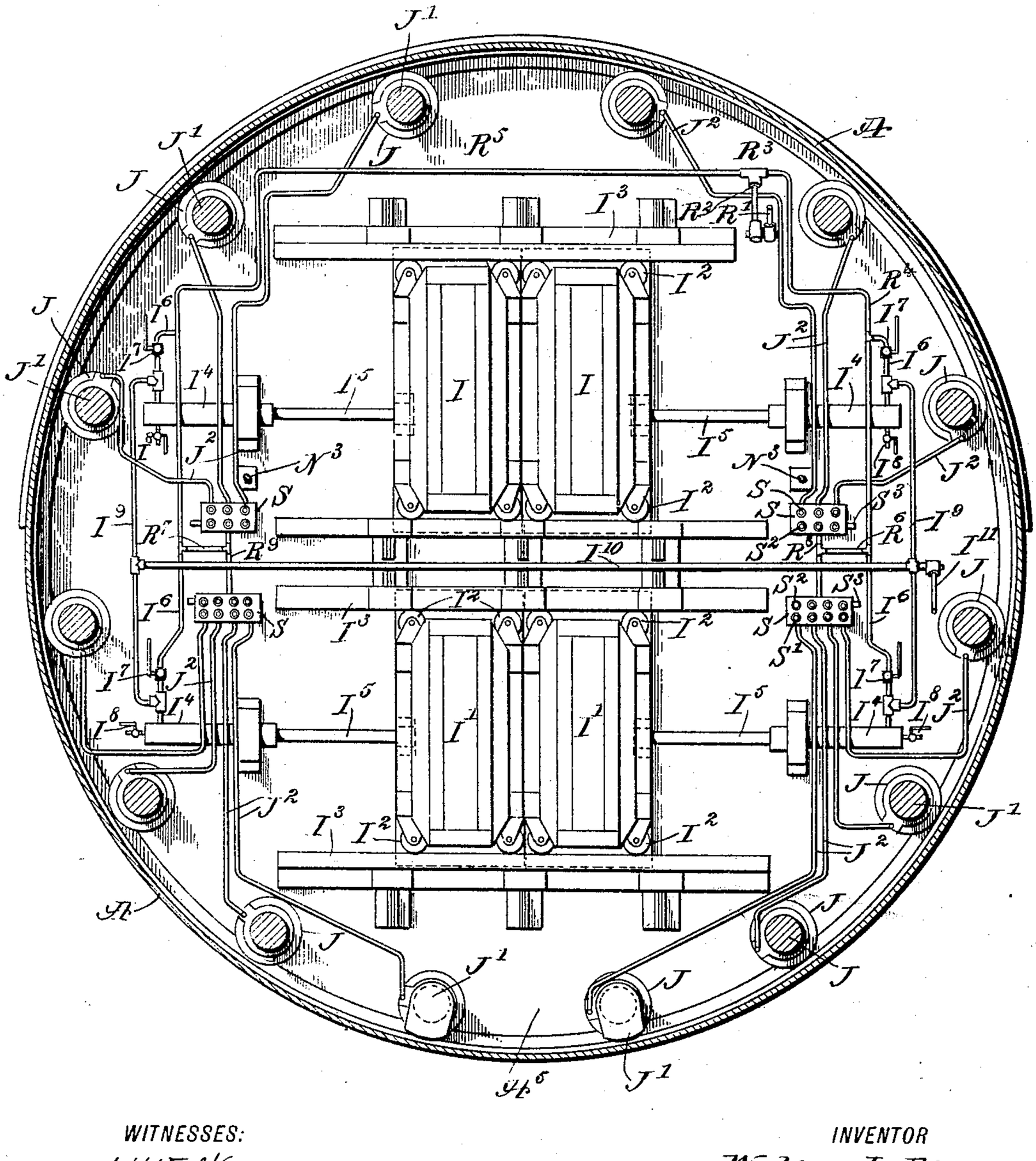
NO MODEL. 5 SHEETS—SHEET 3.

Fig. 3.



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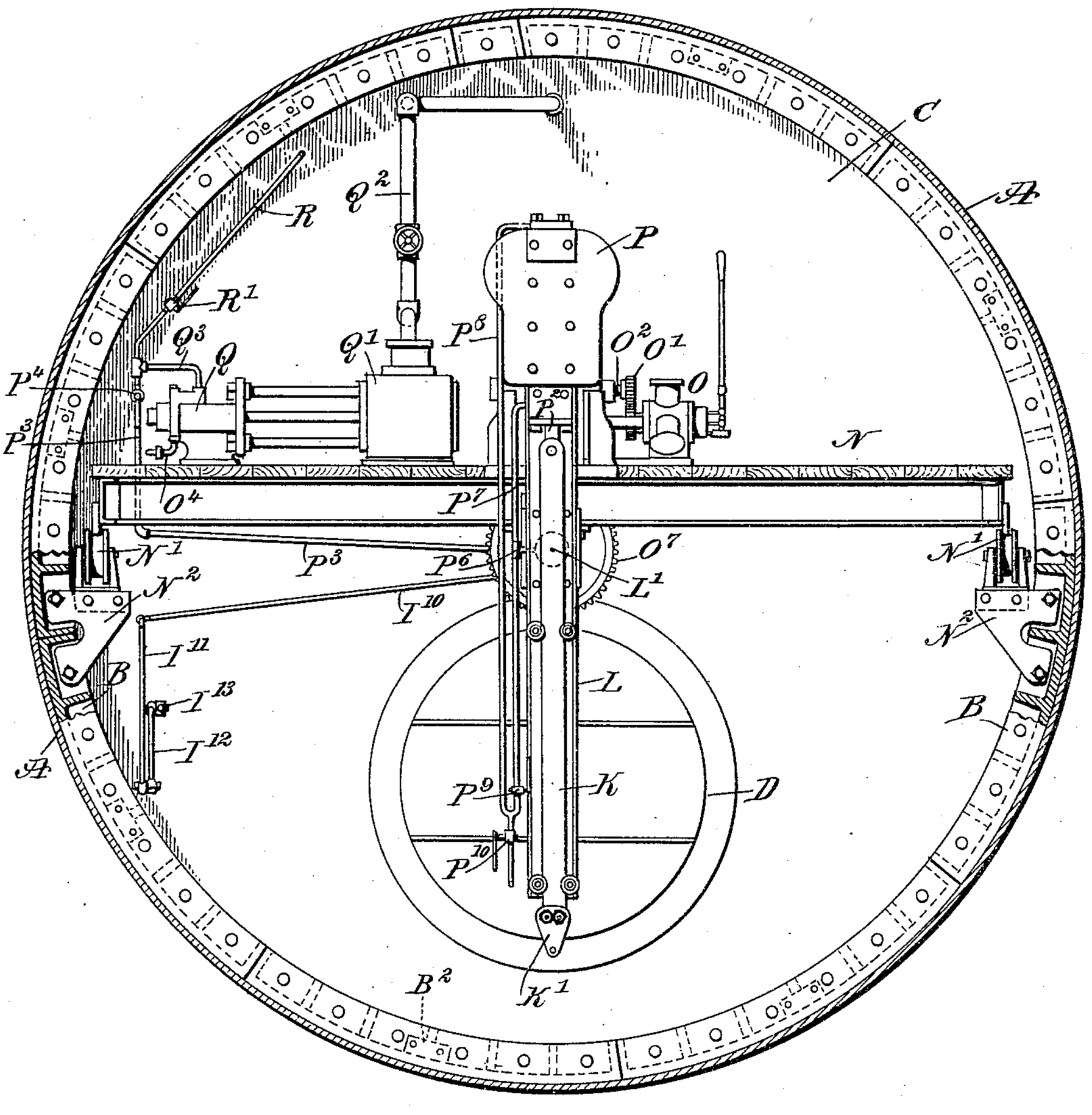
NO MODEL. 5 SHEETS—SHEET 4.

Fig. 4.



WITNESSES:

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APPLICATION FILED FEB. 29, 1904.

NO MODEL. 5 SHEETS—SHEET 5.

Fig. 5.

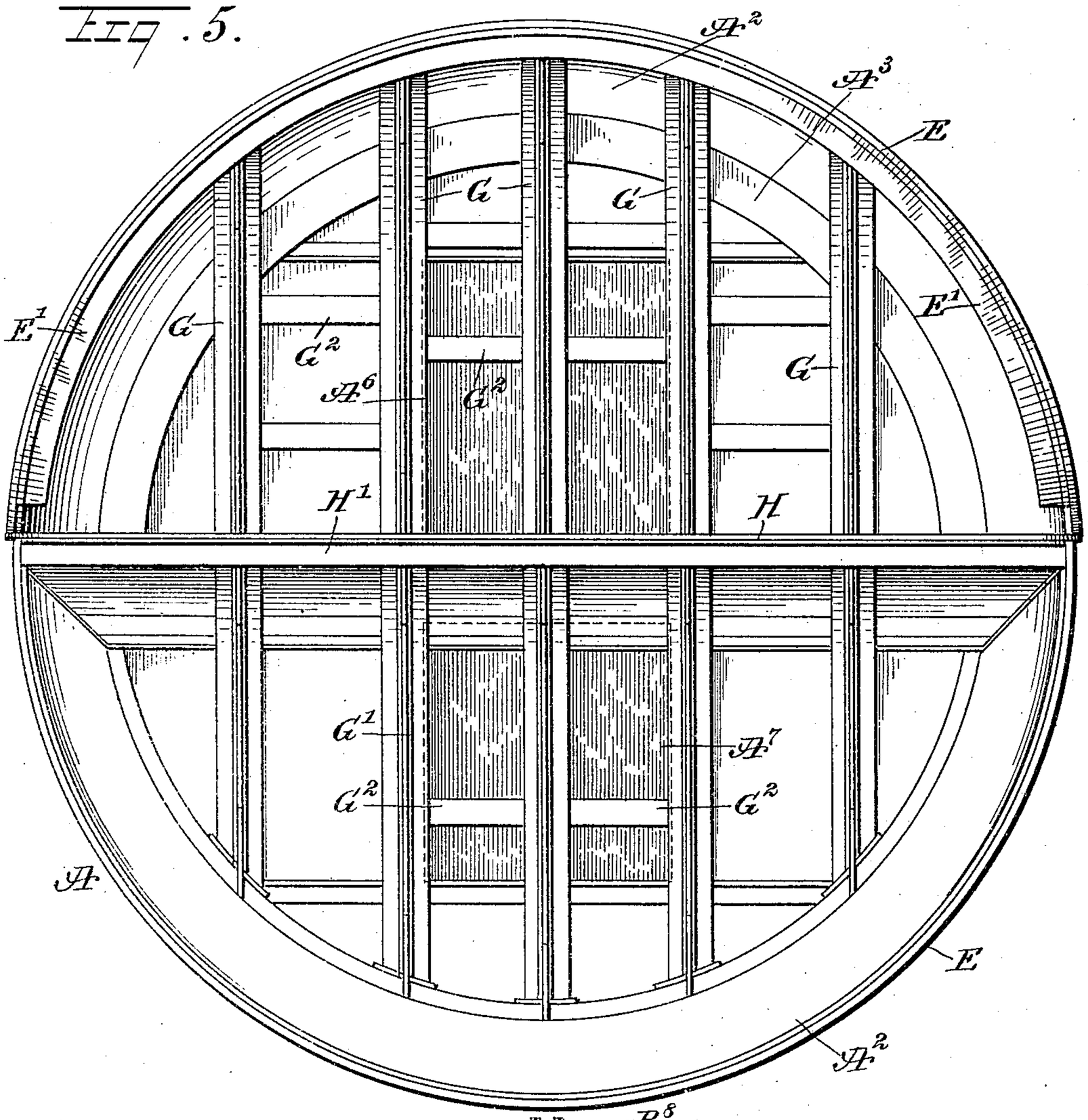
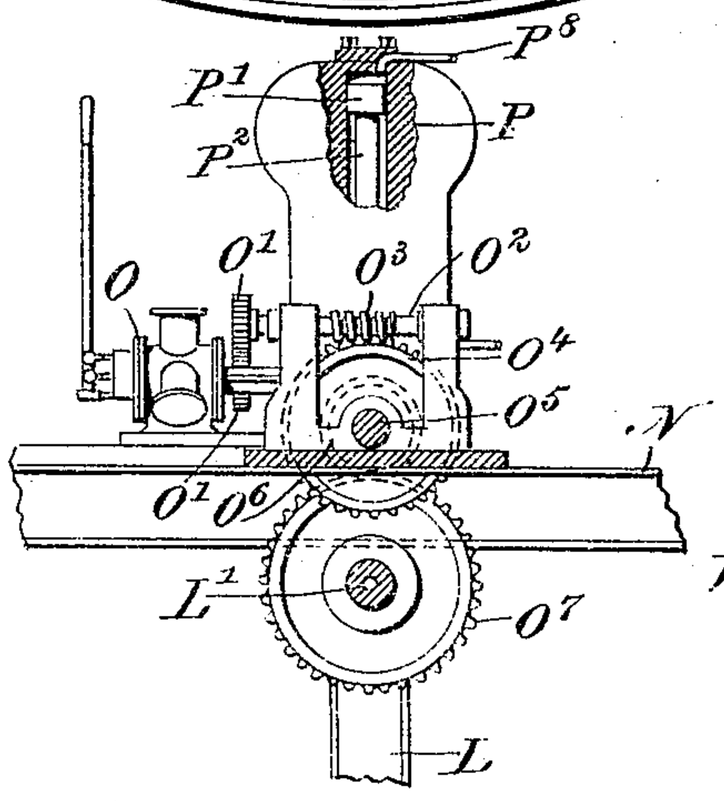


Fig. 6.



WITNESSES:

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No. 774,546. Patented November 8, 1904.

UNITED STATES PATENT OFFICE.

WALTON I. AIMS, OF NEW YORK, N. Y.

SHIELD TUNNEL CONSTRUCTION.

SPECIFICATION forming part of Letters Patent No. 774,546, dated November 8, 1904.

Application filed February 29, 1904. Serial No. 195,821. (No model.)

To all whom it may concern:

Be it known that I, WALTON I. AIMS, a citizen of the United States, and a resident of the city of New York, borough of Manhattan, in the county and State of New York, have invented a new and Improved Shield Tunnel Construction, of which the following is a full, clear, and exact description.

The invention relates to tunnel construction in the bed of waterways and other places; and its object is to provide a new and improved shield tunnel construction arranged to permit of driving the shield readily through sand, gravel, and other loose material, to protect the workmen in the shield in case of a sudden inflow of water or loose material by closing doors in the shield, and to allow of conveniently and quickly placing the sections of the metal lining for the tunnel in position.

The invention consists of novel features and parts and combinations of the same, as will be more fully described hereinafter and then pointed out in the claims.

A practical embodiment of the invention is represented in the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the views.

Figure 1 is a longitudinal sectional elevation of the improvement as applied. Fig. 2 is an enlarged longitudinal sectional elevation of the improvement. Fig. 3 is a cross-section of the same on the line 3 3 of Fig. 2. Fig. 4 is a like view of the same on the line 4 4 of Fig. 2, the hydraulic jacks for pushing the shield forward being omitted. Fig. 5 is a front end elevation of the shield; and Fig. 6 is a cross-section of the mechanism for manipulating the lining-sections, the section being on the line 6 6 of Fig. 2.

In constructing the tunnel use is made of a shield A, made cylindrical in the form of a shell and mounted to slide at its rear or tail end exteriorly on the outermost portion of the tunnel-lining B, formed of rings set in position one in front of the other as the tunneling progresses, each ring being formed of a plurality of segmental metal sections B′, bolted together and bolted to the preceding ring, the sections of successive rings breaking joints, as plainly indicated in the drawings. In the lining B, a distance from the front end thereof, is located a bulkhead C, containing an air-lock D for the workmen to pass through from the rear end of the tunnel to the work-chamber in front of the bulkhead, or vice versa. The air-lock D may be of any approved construction, preferably, however, such as shown and described in the Letters Patent of the United States No. 721,991, granted to me March 3, 1903.

On the front upper half of the circular shield A is secured a segmental hood E, projecting forwardly and having its front edge beveled or tapering downwardly and rearwardly, and within the forward portion of the shield A is arranged a platform F, resting on transverse beams F′ and F², secured to the sides of the shield A, and from the forward end of this platform F extend upwardly and forwardly braces G, reaching to the interior face of the hood E and abutting against a segmental flange E′ in the shape of an angle-iron and riveted or otherwise fastened to the front end of the hood E, as plainly illustrated in the drawings. The hood E is by the braces G greatly strengthened, and longitudinally-strengthening bars E² are secured to the inner face of the hood, as indicated in Fig. 2. From the front end of the platform F, which is located approximately midway between the top and bottom of the shield A, extends forwardly an extension-platform H, the forward end of which is connected by downwardly and rearwardly extending braces G′ with a ring A′, secured concentrically within the shield A. The mouth A² of the shield is made flaring and leads at its inner lower portion to the said ring A′, while the upper half portion of the said mouth is preferably provided with an inwardly-extending flange A³, riveted or otherwise fastened to a transverse strengthening-rib A⁴, forming part of the shield A and to which the forward end of the ring A′ is secured. Between adjacent braces G and G′ are secured transversely-extending rests or beams G² G³, over which poling-boards G⁴ are driven forwardly into the material ahead of the shield and its hood, the angular forward edge maintaining a slope on the face of

the material to be excavated, the material passing partly into the upper portion of the shield to the platforms H and F and partly into the lower portion of the shield onto the lower part of the ring A′.

By the arrangement described the danger of caving in of the material in front of the shield and hood is reduced to a minimum, and at the same time an exceedingly strong shield and hood are obtained. In case the platform H and the hood E become damaged they can be readily removed and replaced by new ones whenever it is deemed necessary.

The forward end of the platform F is preferably strengthened by braces F^3, extending forwardly and upwardly from the transverse beam F′, as plainly shown in Figs. 1 and 2. Approximately at the middle of the shield A is arranged a transverse partition A^5, provided with an opening A^6 above the platform F and with an opening A^7 below the platform, and the said openings A^6 and A^7 are adapted to be closed by sets of doors I and I′, having rollers I^2 mounted to travel on transversely-extending guideways I^3, attached to the rear face of the partition A^5. The material passing onto the platforms H and F and the lower portion of the ring A′ as the shield A is pushed forward is shoveled by the workmen through the open door-openings A^6 and A^7 into the working chamber, from which the material is removed to the surface of the ground in any suitable manner. In case water rushes in the upper or the lower portion, or in both portions, of the shield A then the doors I and I′ are closed, so as to prevent an inrush of water or other material into the working chamber extending between the partition A^5 and the bulkhead C, the said doors being controlled either by a workman in the working chamber or by a workman in the rear of the bulkhead C, as hereinafter more fully described.

The shield A and its hood E are pushed periodically forward the distance of the width of a ring of the lining B, and for this purpose hydraulic jacks J are employed, having their cylinders arranged in the space between the ring A′ and the cylindrical shell forming the shield A, the forward ends of the cylinders abutting against the rib A^4, which thus forms a support for the cylinders of the hydraulic jacks. The pistons J′ of the jacks abut with their rearmost ends against the outer edge or flange of the forward ring-section B′ of the lining B, as plainly indicated in Figs. 1 and 2, so that the lining B forms a resistance to the pistons J′ of the hydraulic jacks, and consequently when the latter are set in motion the shield A is forced forward a sufficient distance to allow of placing the new lining-ring in place between the last lining-ring and the partition A^5. (See lower portion of Fig. 1, which shows a ring-section B′ in position between the last ring and the partition, the corresponding hydraulic jack J being telescoped—that is, its piston J′ being moved forward—to make a space for the lining-ring section B′.) The several hydraulic jacks J are independently one of the other under the control of the operator in charge, as hereinafter more fully described.

In order to place the lining-ring sections B′ in position one after the other to form a ring, an erector is provided, arranged as follows: Each of the lining-ring sections B′ is provided on its inner face, and preferably at the middle thereof, with an apertured lug B^2, adapted to be temporarily fastened by a bolt to the forked head K′ of a slide K, mounted to move lengthwise on an erector-arm L, secured on a shaft L′, extending longitudinally and approximately having its axis coinciding with the axis of the tunnel. The shaft L′ is journaled in suitable bearings attached to the under side of an erector-platform N, mounted to travel longitudinally on rollers N′, journaled in brackets N^2, detachably secured to the lining-rings, at the sides thereof, as plainly illustrated in Figs. 2 and 4, so that the erector-platform N can be moved forward as the work progresses and as hereinafter more fully described, it being understood that by locating the erector-platform about midway between the top and bottom of the tunnel-lining B it is evident that sufficient space is furnished on the top of the platform for supporting the necessary machinery, as hereinafter described, and sufficient space is left below the platform for receiving and disposing of the excavated material placed into this lower portion of the tunnel-lining through the door-openings A^6 and A^7, as before explained. The forward end of the erector-platform N is coupled by links N^3 with the partition A^5 of the shield, so that when the latter is forced outward by the action of the hydraulic jacks J the said erector-platform and the machinery held thereon are moved forward with the shield. As the platform is moved forward the rearmost brackets N^2 and their rollers N′ are removed from the corresponding lining-sections B′ and attached to the proper ring-sections of the foremost ring. When a ring-section B′ is in position on the head K′ of the slide K, a swinging motion is given to the arm L. Then this ring-section is carried to the desired position inward in the circumference of the shield A to be placed in proper position adjacent to the previously-laid ring.

In order to turn the shaft L′, the arm L, slide K, and the ring-section B′, held on the slide-head, a motor O is provided, mounted on the platform N. This motor O may be of any approved construction, and its shaft is connected by gearing O′ with a shaft O^2, journaled in a suitable bracket attached to the platform N, and on this shaft O^2 (see Fig. 6) is secured or formed a worm O^3 in mesh with a worm-wheel O^4, secured on a shaft O^5, ex-

tending longitudinally and likewise journaled in the bracket on the platform N. On the shaft O^5 is secured a pinion O^6 in mesh with a gear-wheel O^7, attached to the shaft L′, so that when the motor O is run either forward or backward a corresponding but slow motion is given to the shaft L′ to swing the arm L around to bring the ring-section B′ to the desired place.

In order to move the ring-section B′ in firm position against the inner face of the shield A, it is necessary to impart a sliding motion to the slide K, and for this purpose a power-cylinder P is provided (see Figs. 2 and 6) containing a piston P′, having its piston-rod P^2 pivotally connected with the end of the slide K. As shown in the drawings, the arm L is extended in both directions on the shaft L′, one end of the arm carrying the power-cylinder P, and adjacent to the other end is the head K′ for supporting the ring-section B′, so as to counterbalance the arm as much as possible. The piston P′ has its outer face of a larger area than the inner face, as plainly indicated in Fig. 6, and in order to actuate the piston P′ within the said cylinder for moving the slide K, its head K′, and the section B′ either inward toward the center of the shaft L′ or outward, as occasion may require, the following device is provided.

A pump Q, preferably driven by an air-motor Q′, is located on the platform N, and the air-motor Q′ has a valved supply-pipe Q^2 extending through the bulkhead C to connect with a compressed-air supply either in the tunnel or above ground, as the case may be. The pump Q is provided with a discharge-pipe Q^3 and with a supply-pipe Q^4, of which the latter extends rearwardly through the bulkhead C to connect with a suitable water-supply. From the discharge-pipe Q^3 of the pump Q leads a branch pipe P^3, containing a valve P^4 under the control of the operator standing on the platform N, and the said branch pipe P^3 is connected by a swivel-joint P^5 (see Fig. 2) with a pipe P^6, extending centrally through a corresponding bore in the shaft L′, and the forward end of this pipe P^6 is connected by a branch pipe P^7 with the inner end of the cylinder P, while a second branch pipe P^8 is connected with the outer end of the said cylinder, as plainly shown in Figs. 2, 4, and 6. The branch pipe P^8 is provided with a valve P^9 for controlling the flow of the water from the pipe P^6 to the outer end of the cylinder P, and the said branch pipe P^8 is provided with an outlet-cock P^{10} for allowing the water from the outer end of the cylinder P to discharge into the tunnel whenever it is desired to drive the piston P′ backward in the said cylinder P by water-pressure passing from the pipe P^6 and branch pipe P^7 into the inner end of the cylinder P. It is understood that when this takes place the valve P^9 is closed while the valve P^{10} is opened, so that the water-pressure passes by way of the pipes P^6 and P^7 into the inner end of the cylinder P. When, however, the valve P^{10} is closed and the valve P^9 is opened and the water-pressure also passes into the outer end of the cylinder and presses against the outer face of the piston P′, then the piston is forced forward in the cylinder, owing to the preponderance of pressure on the face of the piston relative to the pressure on the inner or smaller face of the said piston. Thus by the arrangement described it is only necessary for the operator to manipulate the valve P^9 and the cock P^{10}, which are located close together, to allow of working the piston P′ either inward or outward to properly manipulate the ring-section B′ with a view to placing the same in the desired position. The pump Q also furnishes a supply of water for operating the several hydraulic jacks J, and for this purpose the discharge-pipe Q^3 of the pump Q is connected with a pipe R, having a valve R′ under the control of the operator standing on the platform N. The pipe R is pivotally connected by a link-pipe R′ with a link-pipe R^2, which in turn is connected with a T R^3, (see Fig. 3,) from which extend pipes R^4 and R^5 to opposite sides of the partition A^5, as plainly indicated in the said Fig. 3. The pipes R^4 and R^5 connect by branch pipes R^6 and R^7 with pipes R^8 and R^9, leading to valved boxes S, secured to the rear face of the partition A^5. The valved boxes S are provided with valves S′ and S^2 and a discharge-pipe S^3 for controlling the water-pressure from the pump to the cylinders of the hydraulic jacks J by means of pipes J^2, leading from the said valved boxes S. Now by opening a valve S for a hydraulic jack the water-pressure is passed into the cylinder of the jack to actuate the same for pushing the shield A forward, and when a valve S^2 is opened and the corresponding valve S′ closed then the water in the cylinder of the jack is allowed to return by way of the pipe J^2 and the valve-box S to flow down the same by the discharge-pipe S^3.

In practice the several valves S′ are manipulated simultaneously when it is desired to push the shield outward the desired distance, as previously explained. The valves S^2 are in practice operated singly to allow the piston J′ of hydraulic jack to move back in the cylinder in the usual manner whenever it is desired to place a section B′ in position at the point where the hydraulic jack has been rendered inactive, as above set forth—that is to say, the piston J′ of a hydraulic jack is caused to move into its cylinder immediately previous to placing a ring-section B′ in position, so that the several hydraulic jacks are successively rendered inactive during the time a ring-section B′ is placed in position, and as soon as the section is in place the end of the piston J′ is again free to abut against the forward edge of this section to hold the shield in proper position and against accidental inward

movement. The doors I and I′ are also actuated by the water-pressure passing into the pipes R^4 and R^5 from the pump Q, and for this purpose each door is actuated by a hydraulic jack I^4, having its piston I^5 connected with the corresponding door, the jacks being attached to the rear face of the partition A^5. The cylinder of each hydraulic jack I^4 is connected by a pipe I^6 with the corresponding pipe R^4 or R^5, and each pipe I^6 is provided with a valve I^7 under the control of the operator, so that when a valve I^7 is open water-pressure passes into the jack I^4 to push the piston therein outward and to close the corresponding door I or I′. The cylinder of each hydraulic jack I^4 is also provided with a discharge-pipe I^8, which is opened after the valve I^7 is closed and at the time it is desired to allow the doors I and I′ to open.

The pipes I^6 on each side of the partition are connected with each other by a pipe I^9, and the two pipes I^9 are connected with each other by a pipe I^{10}, having one end pivotally connected by a link-pipe I^{11} with a link-pipe I^{12}, pivotally connected with a pipe I^{13}, extending longitudinally through the bulkhead C to connect with the water-pressure in the rear of the bulkhead, so that in case the workmen are unable to manipulate the valves I^7 for operating the jacks I^4 with a view to closing the doors I and I′ at the time a sudden inrush of water takes place then the said workmen by escaping through the safety-lock D into the rear of the tunnel can either open or cause a valve I^{14} in the pipe I^{13} to be opened, so that water under pressure passes to the several hydraulic jacks I^4 to close the doors I to prevent further inrush of the water or loose material into the working chamber.

It is understood that by having the link-pipes R′ R^2 and I^{11} I^{12} they compensate for the forward movements of the shield A without changing the position of the pipes R and I^{13}.

In the position shown in Figs. 1 and 2 the shield A and with it its hood E have been forced forward into the material to be excavated by the action of the hydraulic jacks J abutting with their pistons on the forward edge of the last-laid ring of the metallic tunnel-lining B, the forward movement of the shield and its hood corresponding to somewhat more than the width of a ring-section B′. The shield in its forward movement has carried along the erector-platform N and the parts supported thereon. The operator in charge now causes the pistons J′ of one or two hydraulic jacks J to return within their cylinders by manipulating the corresponding valves S′ S^2 so that sufficient space is made for placing a ring-section B′ in position against the previous-laid ring of the lining, the section B′ resting on the inner face of the shield. The section B′ after being placed in position is bolted to the last ring of the series. Adjacent hydraulic jacks J are now similarly actuated to allow of laying another ring-section B′ in position adjacent to the first, and the ring-sections are bolted together at the abutting ends, and the last-laid ring-section is bolted to the last ring in the series. This operation is repeated until the ring is completed, it being understood that a return movement of the shield is prevented by allowing the corresponding pistons J′ to abut against the ring-sections B′ as soon as they are placed in position. The ring-sections B′ are one after another attached to the head K′ of the slide K on the arm L while the latter stands in a vertical position, and then the slide K is caused to move upward, so as to lift the ring-section B′ clear of the bottom of the tunnel. The arm L is now caused to swing by the operator starting the motor O in the desired direction until the ring-section B′ is opposite the desired place. The motor O is then stopped. The slide K is now caused to move forward by the operator opening the valve P^9 to force the piston P′ inward, so that the ring-section is pushed into position and held there until bolted to the last ring of the lining B and to the adjacent ring-section for the new ring to be formed. After the ring-section is in position and fastened it is disconnected from the head K′, and then the valve P^9 is closed and the valve P^{10} opened to return the piston P′ and slide K for the head K′ to clear the sections already laid. The valve P^{10} is then closed and the motor O again started to swing the arm L and slide K back to a vertical position. The valve P^9 is now again opened to move the slide K downward to bring the head K′ in engagement with the lug B^2 of another ring-section B′ placed by the workmen in position under the head K′. This ring-section B′ is now fastened to the head K′, and the above-described operation is repeated until all the ring-sections B′ of a ring are in place and fastened together and to the previous ring.

It is understood that as the erector-platform and the parts carried thereby move with the shield the arm L and its slide K are always in proper position relative to the space between the outer edge of the last ring of the lining B and the rear face of the partition, so that the ring-sections can be quickly and conveniently placed in position by the erector, as described. It will also be seen that it requires but little manual labor on the part of the workmen to place the ring-sections B′ in place, and but a few workmen are required to do the work.

The material forced into the shield is shoveled by the workmen through the openings A^6 and A^7 into the working chamber, from which it is removed to the surface by the usual means.

By having the platforms F and H arranged as described two forces of workmen can be employed to quickly remove the material pass-

ing in two distinct layers into the spaces above and below the platforms, thus greatly facilitating the work of excavation. The principal strain is on the upper forward part of the shield A, and by providing the latter with a hood E it is evident that in case the hood becomes damaged it can be replaced without requiring a new shield. Furthermore, by having the front edge of the hood beveled the face of the material is on a slant, and hence the danger of a cave-in is reduced to a minimum, and by providing the poling-boards G^4 the danger of a cave-in is still more reduced.

Should water rush in at the face of the work, the doors I and I′ are closed by the operator in charge manipulating the valves I^7; but should the inrushing water prevent the operator from manipulating the valves I^7 then the workmen after escaping through the air-lock can open the valve I^{14} to cause the doors I and I′ to close, so as to prevent a further inrush of water. The working chamber ahead of the bulkhead C can then be pumped out and operations resumed.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. A shield for tunnel construction, provided with a hood at the forward end of the shield, as set forth.

2. A shield for tunnel construction, provided with a removable hood at the forward end of the shield, as set forth.

3. A shield for tunnel construction, provided with a flaring mouth and a central platform, the forward portion of which extends within the said mouth.

4. A shield for tunnel construction, provided with a hood, a platform in the shield, and an extension-platform in the hood, as set forth.

5. A shield for tunnel construction, provided at its forward end with a hood, and a platform in the shield and rearward of the hood.

6. A shield for tunnel construction, provided with a hood, and braces for the hood, as set forth.

7. A shield for tunnel construction, provided with a hood, a platform, and braces connecting the platform with the hood, as set forth.

8. A shield for tunnel construction, provided with a hood, a platform therein, and braces for the platform, as set forth.

9. A shield for tunnel construction, provided with a hood, a platform in the shield, an extension-platform in the hood, braces connecting the shield-platform with the hood, and braces connecting the shield with the extension-platform, as set forth.

10. A shield for tunnel construction, provided with a hood at its forward upper-half portion, as set forth.

11. A shield for tunnel construction, provided with a hood at its forward upper-half portion, the forward edge of which is tapering rearwardly from the top downward, as set forth.

12. A shield for tunnel construction, provided with a door, and hydraulic means for operating the door, as set forth.

13. A shield for tunnel construction, having a transverse partition, a door thereon, and hydraulic means for operating the door, as set forth.

14. A shield for tunnel construction, having a transverse partition, a door thereon, and hydraulic means for operating the door, arranged at the rear face of the said partition, as set forth.

15. A shield for tunnel construction provided with a transverse partition having a door-opening and door-guideways, doors mounted to slide on the said guideways, to close the said opening, and means arranged on the rear face of the partition and under the control of the operator, for forcibly moving the doors toward each other, to close the opening, as set forth.

16. A shield for tunnel construction, provided with a transverse partition having an upper and a lower door-opening, door-guideways on the partition, adjacent to the door-openings, a set of doors for each opening, mounted to slide on the said guideways, and sets of hydraulic means on the rear face of the partition and under the control of the operator, for closing each set of doors independent of the other, as set forth.

17. A tunnel construction, provided with a shield having means for closing the shield, a bulkhead in the tunnel, in the rear of the shield, and an operating device connected with the said means, for operating the same from the rear of the bulkhead, as set forth.

18. A tunnel construction, provided with a bulkhead in the tunnel, a shield ahead of the bulkhead, provided with doors for closing the shield, jacks for operating the said doors, and a pressure-supply for the said jacks, extending from the same through the bulkhead to the rear thereof, the said supply being under the control of the operator in the rear of the bulkhead, as set forth.

19. A tunnel construction provided with a shield, having doors, means for operating the doors, to close the same, a bulkhead in the tunnel, in the rear of the shield, and means extending through the bulkhead and connected with the said means for operating the doors, as set forth.

20. A tunnel construction provided with a shield, having doors for closing the shield, jacks for operating the doors, a bulkhead in the rear of the shield, a pump connected with the jacks and located between the bulkhead and the shield, and a pressure-supply outside of the bulkhead and connected with the said jacks, for operating the same, as set forth.

21. A shield for tunnel construction, pro-

vided with supports for driving poling-boards, the said supports being located in different horizontal planes.

22. A shield for tunnel construction, provided with a hood, braces for the hood, and supports secured to the said braces, for driving poling-boards into the material ahead, to prevent caving in of the material, as set forth.

23. A shield for tunnel construction, provided with a hood, a platform in the shield, an extension-platform in the hood, braces connecting the shield-platform with the hood, braces connecting the shield with the extension-platform, supports on the braces, and poling-boards resting on the said braces and driven into the material ahead, to prevent caving in of the material, as set forth.

24. A shield for tunnel construction, provided with an inlet for the material, doors for closing the said inlet, mounted to slide transversely, and power-actuated devices for operating the said doors.

25. A shield for tunnel construction, provided with a plurality of inlets for the material and located one above the other, and means for closing the rear end of each inlet, as set forth.

26. A shield for tunnel construction, provided with a plurality of inlets one above the other, doors movable transversely for closing the said inlets, and a power device for actuating the said doors.

27. A shield for tunnel construction, provided with a plurality of inlets one above the other, and means for closing the rear ends of the inlets, independent one of the other, as set forth.

28. In a tunnel construction, the combination of a movable shield, and an erector-platform connected with the shield, to move with the same, as set forth.

29. In a tunnel construction, the combination with a shield, and means for pushing the same ahead, of an erector-platform mounted to travel lengthwise in the tunnel and coupled to the said shield, as set forth.

30. In a tunnel construction, the combination with the tunnel-lining, of a shield having its tail end slidable on the lining, means for moving the shield forward, supports on the sides of the lining, an erector-platform mounted to travel on the said support and leaving unobstructed working spaces above and below the platform, and a coupling for connecting the erector-platform with the said shield, to move the platform with the shield, as set forth.

31. In a tunnel construction, the combination with the tunnel-lining, of a shield having its tail end slidable on the lining, jacks interposed between the lining and the shield, for moving the latter forward, an erector-platform mounted to travel lengthwise in the tunnel, and a connection between the shield and the said erector-platform, to move the latter along on moving the shield, as set forth.

32. A tunnel construction provided with singly-removable bearings secured to the lining at the sides thereof, and an erector-platform mounted on the said bearings, as set forth.

33. A tunnel construction provided with singly-removable bearings secured to the lining at the sides thereof, and an erector-platform mounted on the said bearings and leaving unobstructed working spaces above and below the said erector-platform, as set forth.

34. A tunnel construction provided with brackets for attachment to the inner face of the tunnel-lining, at the sides thereof, rollers journaled on the said brackets, and an erector-platform mounted on the said rollers, as set forth.

35. A tunnel construction provided with singly-removable bearings secured to the lining, an erector-platform mounted on the said bearings, and an arm mounted to swing on the said erector-platform and adapted to support a lining-section for placing the same in position.

36. A tunnel construction provided with singly-removable bearings secured to the lining, an erector-platform mounted on the said bearings, and an arm mounted to swing on the forward end of the said erector-platform and provided with movable means for engaging a lining-section and moving it into position.

37. In a tunnel construction, a device for placing the lining-sections in position, provided with a platform movable lengthwise in the tunnel-lining, an arm mounted to swing on the forward end of the said platform, a cylinder held on the said arm, and a slide on the said arm, connected with the piston-rod of the cylinder, the slide having means for supporting a lining-section.

38. In a tunnel construction, a device for placing the lining-sections in position, provided with an arm mounted to swing, a cylinder held on the said arm, a slide on the said arm, connected with the piston-rod of the cylinder, the slide having means for supporting a lining-section, and a fluid-pressure supply for the said cylinder, to move the piston therein inward, the said supply being under the control of the operator, as set forth.

39. In a tunnel construction, a device for placing the sections of a lining in position, provided with singly-removable bearings secured to the sides of the lining, an erector-platform mounted on the said bearings to travel lengthwise in the tunnel, a shaft mounted to turn and disposed axially on the said platform, and an erector-arm secured on the said shaft and adapted to carry a lining-section to position.

40. In a tunnel construction, a device for placing the sections of a lining in position, provided with singly-removable bearings secured to the sides of the lining, an erector-platform mounted on the said bearings to travel lengthwise in the tunnel, and a swinging arm for sup-

porting a lining-section, journaled on the forward end of the said erector-platform, the axis of rotation of the arm coinciding with the axis of the tunnel.

41. In a tunnel construction, a device for placing the sections of the tunnel-lining in position, consisting of an erector-platform, a shaft journaled thereon and extending centrally in the tunnel, a motor on the platform, connected with the shaft, for driving it, an arm secured on the said shaft, a power-cylinder on the said arm, an erector-slide on the said arm and connected with the piston-rod of the piston in the said power-cylinder, and a motive-agent supply for the said cylinder, extending axially through the said shaft, as set forth.

42. In a tunnel construction, a device for placing the sections of the tunnel-lining in position, consisting of an erector-platform, a shaft journaled thereon and extending centrally in the tunnel, a motor on the platform, connected with the shaft, for driving it, an arm secured on the said shaft, a power-cylinder on the said arm, an erector-slide on the said arm and connected with the piston-rod of the piston in the said power-cylinder, a motive-agent supply for the said cylinder, extending axially through the said shaft, and a pump mounted on the said platform and having its discharge connected with the said motive-agent supply, as set forth.

43. An erector device for tunnel construction, consisting of a power-cylinder, a piston therein, having its faces of different areas, a slide connected with the piston-rod of the said piston, and a pressure-supply pipe connected with a pressure-supply and having branch pipes leading to the ends of the cylinder, one of the branch pipes having two valves, one for the admission and the other for the discharge of the motive agent, as set forth.

44. An erector device for tunnel construction, provided with singly-removable bearings secured to the tunnel-lining, a platform mounted on the said bearings and movable lengthwise in the tunnel, and a support for a section of the tunnel-lining, the said support being mounted on the platform to swing transversely and the support being provided with means adapted to move radially.

45. A shield for tunnel construction, provided with supports for driving poling-boards, the said supports being located in different vertical planes.

46. A shield for tunnel construction, provided with supports for driving poling-boards, the said supports being located in different horizontal planes and in different vertical planes.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WALTON I. AIMS.

Witnesses:

THEO. G. HOSTER,

EVERARD BOLTON MARSHALL.