C. G. HASTINGS.

TUNNELING SHIELD.

APPLICATION FILED NOV. 19, 1914.

1,256,313.

Patented Feb. 12, 1918.

6 SHEETS—SHEET 1.

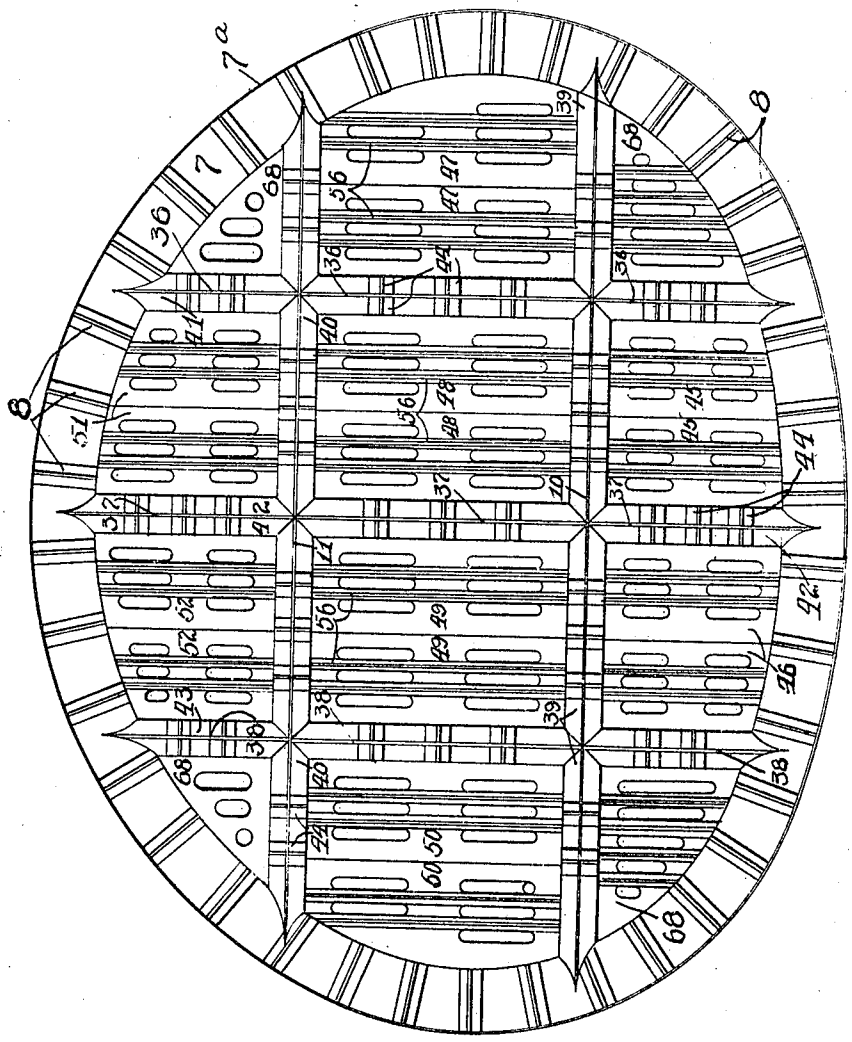


Fig. 1.

Witnesses

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6 SHEETS—SHEET 2.

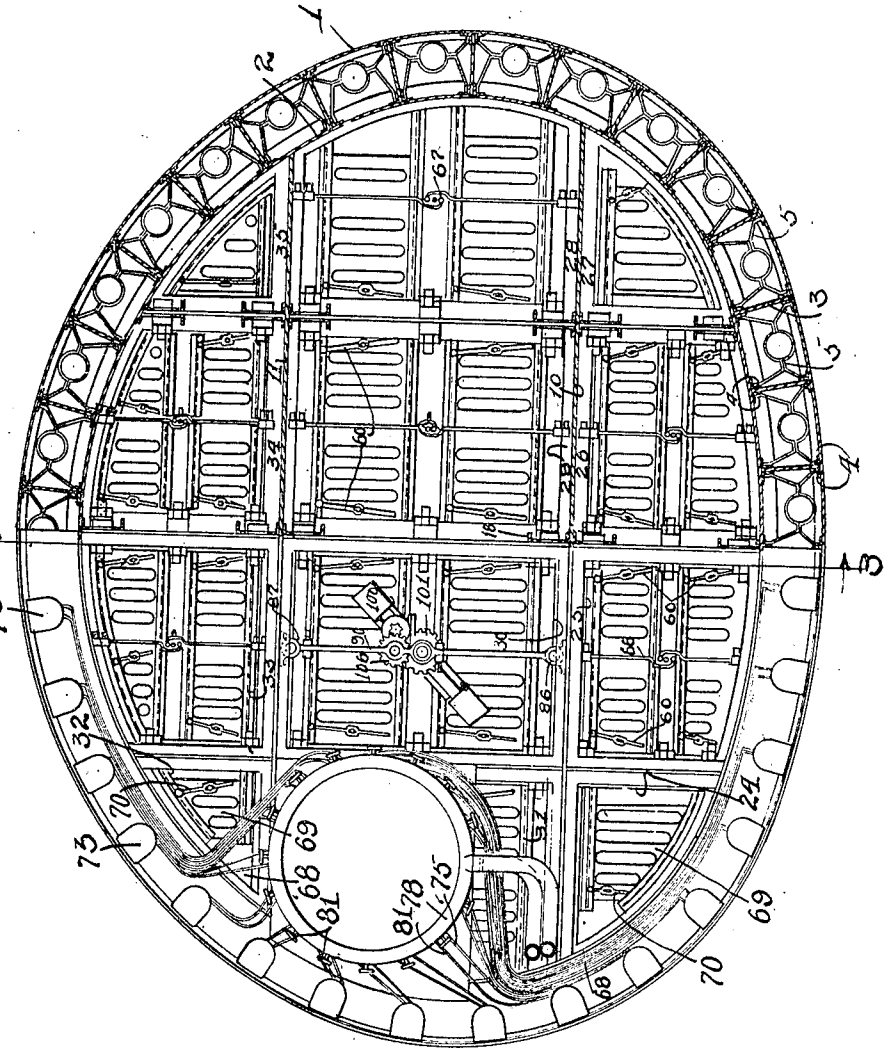


Fig. 2.

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TUNNELING SHIELD.

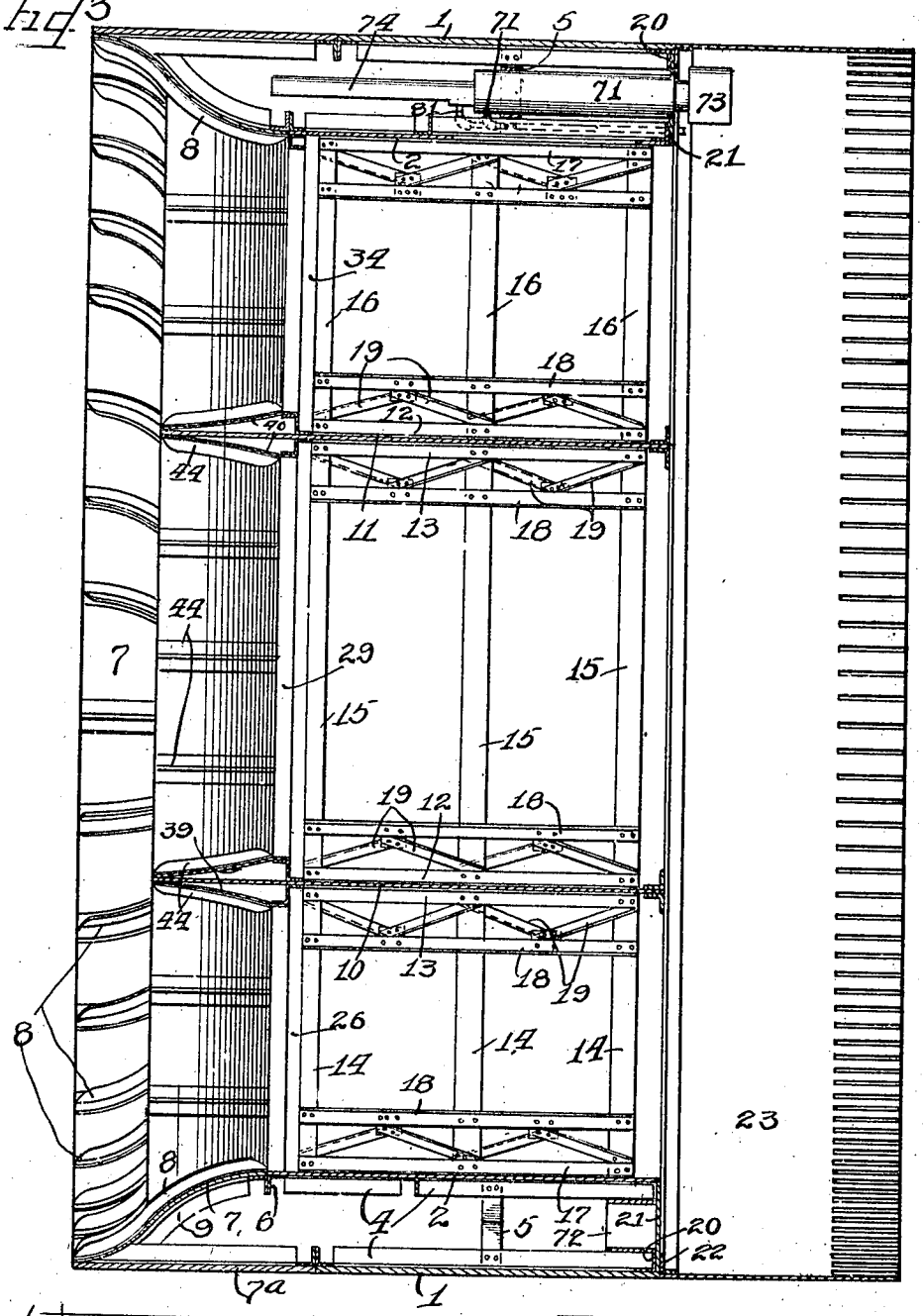
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Patented Feb. 12, 1918.

6 SHEETS—SHEET 3.

Fig. 3




Witnesses

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6 SHEETS—SHEET 4.

Fig. 5

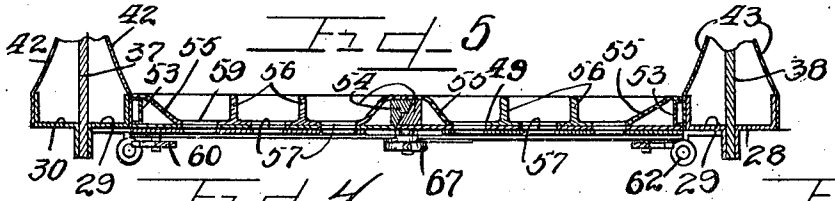


Fig. 4

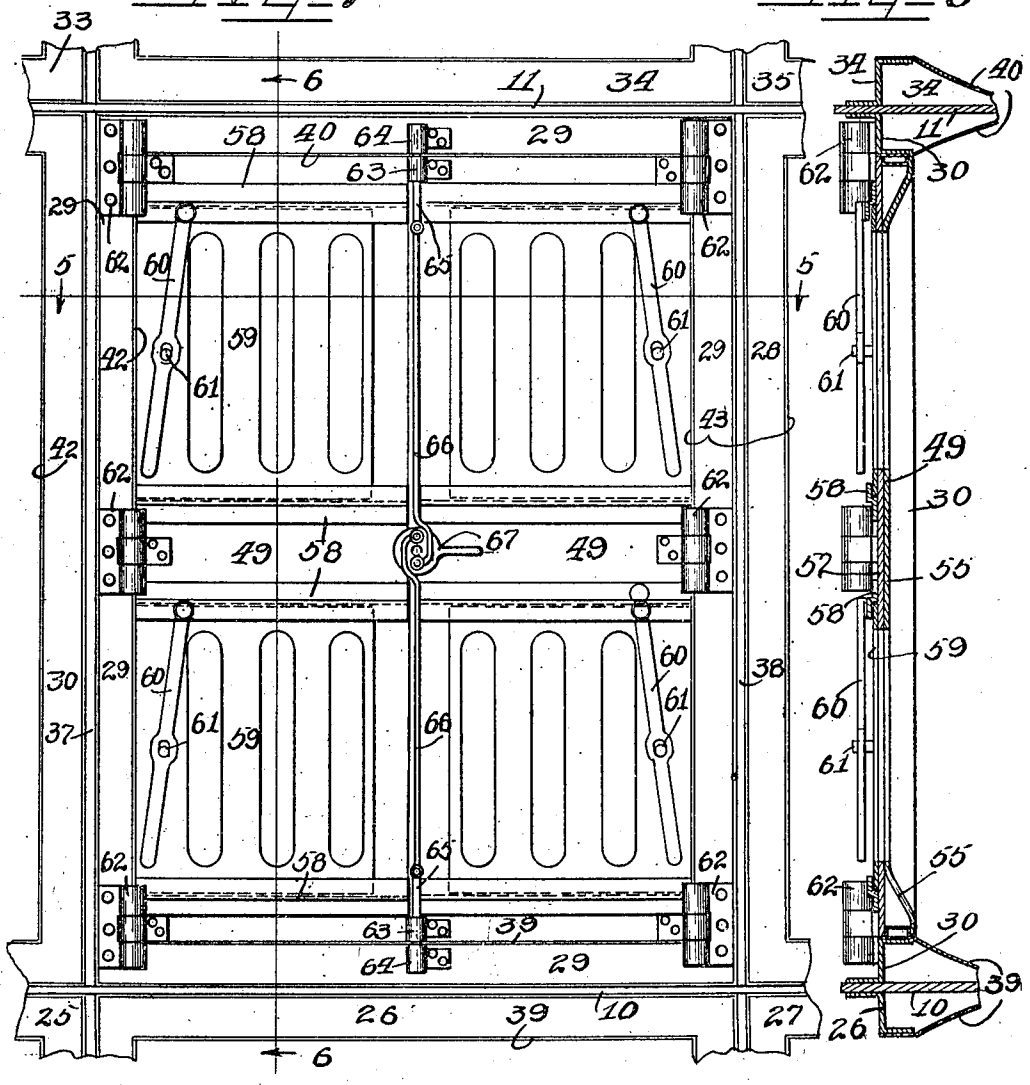


Fig. 6



Witnesses

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6 SHEETS—SHEET 5.

Fig. 7

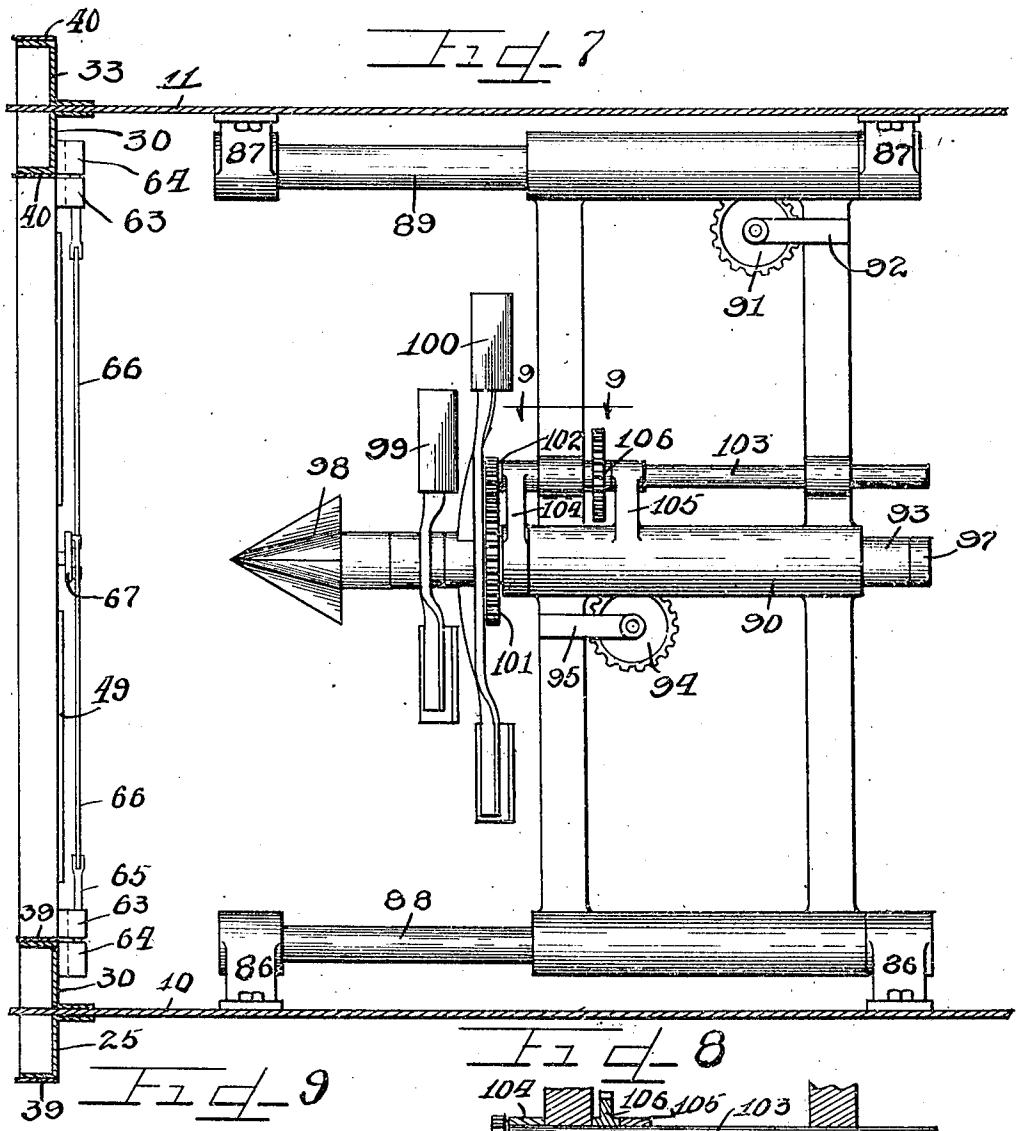



Fig. 9

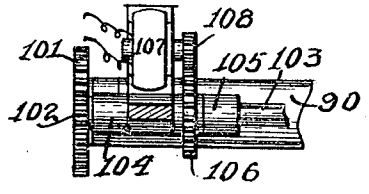
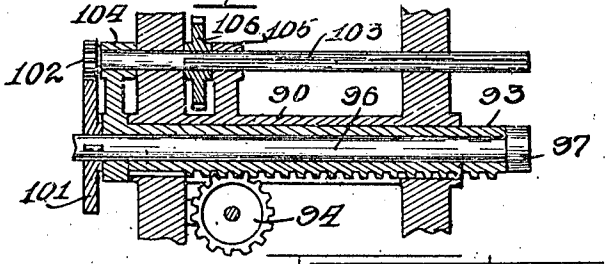



Fig. 8




Witnesses

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TUNNELING SHIELD.

APPLICATION FILED NOV. 19, 1914.

1,256,313.

Patented Feb. 12, 1918.

6 SHEETS—SHEET 6.

Fig. 10

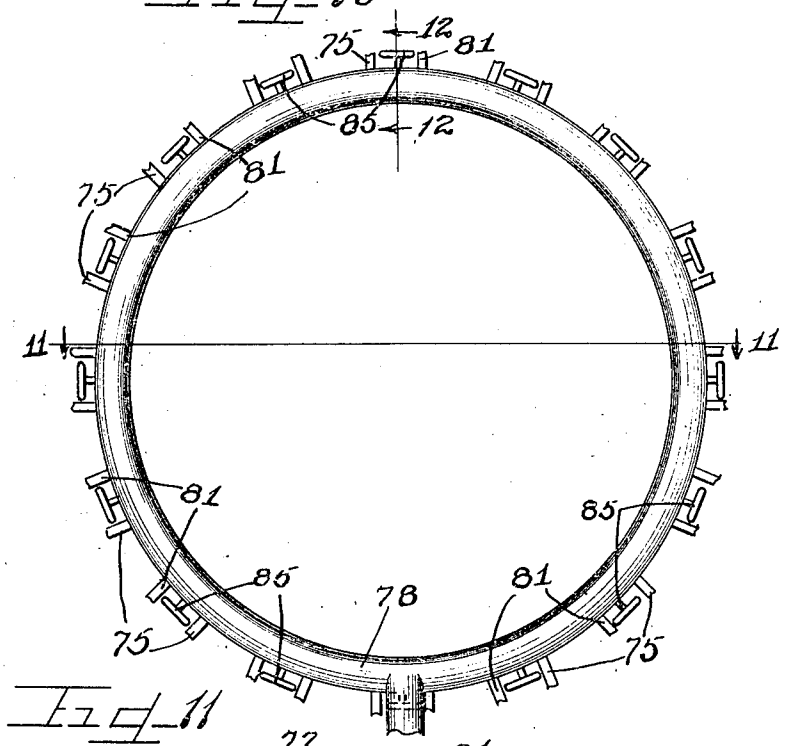



Fig. 11

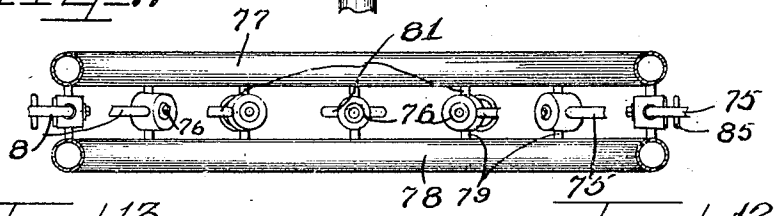



Fig. 13

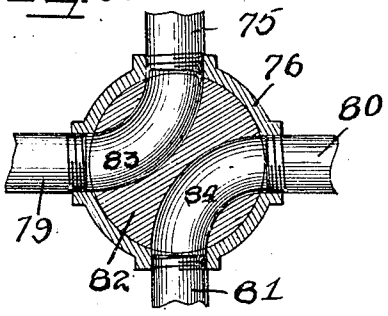
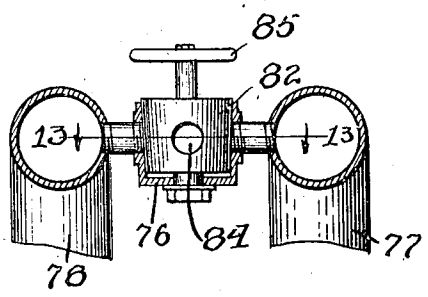



Fig. 12




Witnesses

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# UNITED STATES PATENT OFFICE.

CORNELIUS G. HASTINGS, OF WEST HOBOKEN, NEW JERSEY.

## TUNNELING-SHIELD.

1,256,313. Specification of Letters Patent. Patented Feb. 12, 1918.

Application filed November 19, 1914. Serial No. 872,921.

*To all whom it may concern:*

Be it known that I, CORNELIUS G. HASTINGS, a citizen of the United States, and a resident of the city of West Hoboken, in the county of Hudson and State of New Jersey, have invented certain new and useful Improvements in Tunneling-Shields; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, and to the numerals of reference marked thereon, which form a part of this specification.

This invention relates to an improved method or system for projecting a tunnel bore, and involves the use of a shield which is of the shape of the cross section of the tunnel to be built. The use of the shield permits the lining of masonry or concrete, as the case may be, to be built up with perfect safety to the workmen, the respective layers of masonry being laid up within the rear end of the shield, and with motive mechanisms mounted within said shield and bearing upon the masonry as an abutment to project said shield forwardly.

It is an object of this invention to construct a device for use in an improved method of boring a tunnel which acts to shelter and protect the workmen from caveins, and permits rapid building up of the walls of the tunnel, the device being provided with power means for projecting the same forwardly, at the same time correcting any deviation from the true line of the bore.

It is also an object of this invention to construct a circular or elliptical shield consisting of a shell of metal conforming to the cross section of the tunnel to be built, and provided around its periphery with hydraulic mechanisms for driving the same through the soil under ground, means being provided for the transfer of the material excavated in front of said shell through the same to a point of deposit.

It is also an important object of this invention to construct a tunneling shield or shell adapted to be projected through the ground at any angle and in straight or curved lines as necessary, permitting the earth in front of the shield to be excavated and transferred therethrough and rearwardly to a point of deposit and also permitting the walls of the bore or tunnel to be immediately built up behind the shield after each projecting movement of the shield.

It is furthermore an important object of this invention to construct a tunneling shield strongly reinforced both vertically and horizontally, and provided with doors at the front end thereof which may be opened or which may be locked closed, with apertures therein then opened to permit a flow of the material excavated therethrough and into the shell for transfer to a point of deposit as said shield is projected through the ground.

It is finally an object of this invention to construct a device which, by its use, admits of the rapid projection of a tunnel bore under ground in any direction and at the same time permitting the walls of said bore to be built up affording an abutment for mechanisms which act to project said device further into and through the ground.

The invention (in a preferred form) is illustrated in the drawings and hereinafter more fully described.

In the drawings:

Figure 1 is a front elevation of a shield embodying the principles of my invention.

Fig. 2 is a rear elevation thereof with parts omitted and parts broken away to illustrate the construction.

Fig. 3 is a section taken on line 3—3 of Fig. 2.

Fig. 4 is a fragmentary rear detail view of one of the pairs of adjustable grid doors in the shield.

Fig. 5 is a detail section taken on line 5—5 of Fig. 4.

Fig. 6 is a detail section taken on line 6—6 of Fig. 4.

Fig. 7 is a side view of a boring tool which may be connected within the shield behind certain of the doors therein.

Fig. 8 is a sectional detail showing the adjusting and driving means for the boring tool illustrated in Fig. 7.

Fig. 9 is a fragmentary section taken on line 9—9 of Fig. 7.

Fig. 10 is an elevation of one of the sets of the circular air supply and exhaust lines from which the hydraulic mechanism for projecting the shield head are operated.

Fig. 11 is a section taken on line 11—11 of Fig. 10.

Fig. 12 is an enlarged section taken on line 12—12 of Fig. 10.

Fig. 13 is a detail section taken on line 13—13 of Fig. 12.

As shown in the drawings:

The tunneling shield consists of two cylindrical shells concentric with one another, the outer one of which is denoted by the reference numeral 1, and the inner one, by the reference numeral 2, and said shells are, as clearly shown in Figs. 1 and 2, of an oval cross section. As clearly shown in Fig. 2, said respective inner and outer shells are rigidly connected and spaced one from another by radial plates 3, riveted to angles 4, which are in turn riveted to the walls of said respective shells, and intermediate bracing members 5, are riveted between said radial plates 3, reinforcing and spacing the same circumferentially around the shield. Connected to the forward edge of the inner shell 2, by means of angle irons 6, riveted to one another and to said shell 2, is a smoothly curved outwardly flaring ring of metal 7, which at its outer flared margin is riveted or otherwise positively secured to the forward edge of a section or ring of metal $7^a$, which is joined to said outer shell 1. Relatively heavy T-bars 8, are riveted upon the outwardly flaring surface of said ring member 7, tapered down at their forward ends near the leading edge of the shield, and being riveted to and through said ring 7, and connected to reinforcing T-bars 9, on the opposite surface thereof.

A framework is built within said inner shell 2, comprising horizontal plates 10 and 11, respectively, joined thereto and at their forward edges extended beyond the shell 2, as clearly shown in Fig. 3. Riveted upon the upper and lower surface of each of said respective plates 10 and 11, are the angle irons 12 and 13, respectively, which afford a means of attachment thereto of a series of vertical or rigid upright frame bars 14, 15, and 16, the lower bars 14 and upper bars 15, being connected to angle irons 17, secured upon the inner surface of the shell 2, as well as to the aforesaid angle irons on said horizontal plates 10 and 11. Riveted to said respective upright bars 14, 15, and 16, are horizontal longitudinally extending angle irons 18, each of which is connected to one of the respective horizontal angle irons 12 or 13, as the case may be, by diagonal bracing angle irons 19.

A continuous peripheral angle iron 20, extends around and is secured within the outer shell 1, and attached thereto by rivets or in any other suitable manner, are end plates 21, closing the end of the compartments between the respective shells 1 and 2, and radial plates 3. Riveted to the plates 21, is a continuous peripheral angle iron 22, extending around the shield affording a means of attachment thereto of a spring steel tempered apron 23, the outer surface of which is flush with the outer surface of the shell 1. The trailing or rear margin of said apron is provided with a plurality of slots to further increase the flexibility thereof at that portion.

A plurality of frames which are of Z-bar section and which may be built up of standard Z-bars or cast as a single integral unit, are shown mounted in vertical position between the respective horizontal plates 10 and 11, and the inner walls of the shell 2, and are denoted respectively by the reference numerals 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, and 35, of which the frames 29 and 30, are rectangular in shape and disposed centrally within the shield between the plates 10 and 11. The other frames, one side of which abuts against and is secured to the inner wall of the shield, are curved on the abutting portion in a manner conforming to the curvature of said shell.

The horizontal portions of certain said Z-bar frames bear against the surfaces of said horizontal plates 10 or 11, and the different frames, which are on opposite sides of said plates, are riveted to one another through said plates, as, for instance, the lower horizontal portion of the Z-frame 29, is riveted to the upper horizontal portion of the Z-frame 26, through the horizontal plate 10. The vertical or upright portions of adjacent Z-bar frames, have interposed therebetween vertical forwardly projecting plates 36, 37 and 38, respectively, with the flanges of said Z-bar frames riveted therethrough and to one another. As clearly shown in Fig. 1, each of the vertical plates 36, are alined with one another, at one side of the shield, and similarly the plates 38, are disposed in vertical alinement one above the other on the other side of the shield, while the plates 37, are disposed centrally of the shield and also alined vertically one above the other.

Riveted, brazed or otherwise secured to the horizontal forwardly projecting flanges of the Z-bar frames to afford a breaker edge are plates 39 and 40, which, as clearly shown in Figs. 3 to 6 inclusive, are outwardly concave and extend forwardly of the shield and are attached to the outer end of the horizontal plate 10 and 11, respectively. Similarly associated with the vertical plates 36, 37, and 38, are outwardly concave plates 41, 42, and 43, respectively, and at the junction of said vertically and horizontally disposed plates, the same are joined to one another in any suitable manner, affording a breaker point, the shield being provided with six of such points, as clearly shown in Fig. 1. Secured both upon said outwardly concave vertical and horizontal breaker plates, are a plurality of T-bars 44, conforming to the

curvature of said plates, and tapered off at their forward ends as clearly shown in Fig. 3, acting to reinforce said breaker plates and also serving as cutting or breaking elements as the shield is driven through the earth. A number of pairs of rearwardly swinging doors are mounted vertically within the shield between the respective horizontal and vertical breaker members described, denoted respectively by the reference numerals 45, 46, 47, 48, 49, 50, 51, and 52. However, the construction of the pair of doors 49, is typical of the others, and hence a description thereof will suffice for all.

Each of said doors comprises an outwardly directed small channel member 53, which extends around the top, bottom and hinge side thereof, and with a filler member 54, extending along the other side or opposite the hinge side of the door. A heavy plate 55, is bent outwardly along its margins and riveted or brazed to said respective channel frame member 53, at the top, bottom and side of the door, and to the filler member 54.

Integral vertical ribs 56, are formed on said door plate 55, and intermediate said ribs slots are cut through said plate. Bolted or riveted on the rear surface of said door plate is another slotted plate 57, and disposed thereon both above and below the double row of slots therein, are Z-bar guides 58, in which slotted grid plates 59, are mounted to slide, acting, when the slots in said latter plates are in register with the openings to permit passage of material through the closed doors, and when moved out of register therewith, entirely closing the apertures in said doors. For the purpose of moving said slidable grid plates 59, levers 60, are pivoted at their upper ends on the guide members 58, and each receives a pin 61, which is secured on a slidable grid plate, through a slot in the middle portion of said lever, so that by swinging said levers the grid plates may be easily adjusted.

Said doors are hingedly mounted upon the side members of the respective Z-bar frames, hinges 62, being connected to each of said doors at the ends and middle thereof, and to the web of the Z-bar frame 29. For the purpose of locking said doors in closed position one of the doors is adapted to close over the other, as clearly shown in Fig. 5, and said latter door at its top and bottom ends is provided with guide members 63. Similarly constructed members 64, are mounted in alinement therewith upon the web portion at the top and bottom of the Z-frame 29, and slidable bolts 65, are mounted in said guide members 63, and act when thrust downwardly to engage in guide members 64, to maintain the doors locked in closed position. For the purpose of actuating said slidable bolts 65, long levers 66, are pivotally connected thereto and to a rotatable handle 67, at the middle of the door, which when swung upwardly from the position shown in Fig. 4, and through an angle of one hundred eighty degrees, serves to thrust said bolts 65, into a locked position. The Z-bar frames 24, 27, 32, and 35, are not provided with doors, but merely have a fixed slotted plate 68, secured therein, each with a slidable grid plate 69, on the rear surface thereof, actuated by a lever 70, similar to the levers 60, already described.

Mounted within the compartments formed between the inner and outer shell and between the radial plates 3, are hydraulic or pneumatic jacks, as clearly shown in Fig. 3, consisting of a cylinder 71, suitably supported in a circular yoke, one band of which is removable, afforded by said cross brace members 5, and in a curved or cylindrical support 72, at the rear end of the compartment. A piston connected to a piston rod (not shown) is movable within each of said hydraulic cylinders 71, and on the outer end of the piston rod is secured a head 73, adapted to abut against the masonry built up within the resilient apron 23, in order to thrust the shield forwardly when compressed air or other fluid is admitted into the cylinder 71. For the purpose of retracting said head 73, another small cylinder 74, is connected on the end of said large cylinder 71, and contains a piston and piston rod (not shown) connected to the piston and piston rod of the large cylinder 71, so that air admitted to the small cylinder causes retraction of the head 73.

For the purpose of actuating the pistons in said respective hydraulic cylinders 71 and 74, an inlet pipe 75, leads into the large cylinder 71, and is then led to one of a number of valves 76, each of which is connected between two circular manifold pipes 77 and 78, respectively, the former an exhaust line and the latter a pressure supply line. The short pipe leading from the valve 76, into the pressure ring or manifold 78, is indicated by the reference numeral 79, and another short pipe 80, is also connected to said valve 76, and to the exhaust ring or manifold 77. Leading from each of the small cylinders 74, is a pipe 81, which is connected to the same valve 76, as the particular pipe 75, for that pair of hydraulic cylinders, and within each of said valves 76, is a rotatable member 82, provided with passages 83 and 84, therein. A hand wheel 85, is provided on the end of a stem secured on said valve member 82, for the purpose of rotating the same into its various positions of adjustment. A set of said pressure and exhaust ring manifolds 78 and 77, are mounted one on each side of the shield, one of which is shown properly connected to half of the total number of hydraulic jack members in Fig. 2, while

the other (not shown) is of course similarly mounted and connected upon the other side of the shield.

In Figs. 7, 8, and 9 I have illustrated a boring or cutting tool which may be mounted behind certain of the doors of the shield, and when the doors are opened brought into operation to break through the soil ahead of the shield. However, I have only shown such a mechanism positioned behind one of the doors of the shield, but it is obvious that any number thereof may be utilized.

For this purpose brackets 86, are attached upon the upper surface of the horizontal floor plate 10, and similar brackets 87, are connected directly thereabove on the under surface of the plate 11. Secured in the lower brackets 86, is a rod 88, and similarly in the upper brackets 87, a rod 89, is mounted. Slidably engaged upon said respective rods is a vertically disposed carriage 90. For the purpose of adjusting said carriage 90, upon the rods 88 and 89, a pinion 91, is journaled in a bracket 92, formed on said carriage, and is actuatable by a crank (not shown), said pinion engaging a rack formed by teeth cut in the under side of the rod 89. A sleeve 93, is slidably mounted within a tubular portion of said carriage 90, at the middle thereof, and as clearly shown in detail in Fig. 8, is provided on its under surface with a series of teeth affording a rack, which is engaged by a pinion 94, journaled in a bracket 95, formed on said carriage 90. A crank (not shown) is suitably connected to said pinion 94, for the purpose of rotating the same, and advancing said sleeve 93, forwardly through the carriage. Journaled within said sleeve 93, is a shaft 96, having a collar 97, on its rear end to maintain the same in position in the sleeve and at its forward end having keyed thereon in successive order a relatively large sharp cutting point 98, a small pair of cutting blades 99, and a pair of large cutting blades 100. A driving gear 101, is also keyed upon the forward end of said shaft 96, directly behind the large pair of cutting blades 100, and receives its drive from a small pinion 102, keyed upon a shaft 103, which is journaled in the arms of the carriage 90, and also in brackets 104 and 105, respectively, the bracket 104, being integral with the traveling sleeve 93, and the bracket 105, being integral with the main carriage 90. Said shaft 103, is grooved, as clearly shown in Fig. 8, and feathered upon said shaft by means of a key slidably engaging in said groove is a gear 106. An electric motor 107, is mounted upon an extension bracket formed on one side of the carriage 90, and secured upon the armature thereof is a driving pinion 108, which meshes with said gear 106, to drive the same and said shaft 103, the drive being transmitted therefrom to the pinion 102, to the gear 101, and thence to the shaft 96, whereby the excavating mechanisms 98, 99, and 100, are rotated.

The operation is as follows:

The shield is set up in an excavation made for the purpose beneath the ground, or if more convenient the shield may be assembled above the ground and lowered through a proper shaft to the line of bore of the tunnel to be built. For certain kinds of soil the doors may be left entirely open, and as fast as the soil in front of the shield is excavated it is passed through the shield and then transferred to a point of deposit. The masonry forming the walls of the tunnel or bore is built up in successive layers withing the resilient steel apron 23, and the jacks are adjusted by means of the respective valves 76, so that the heads 73 bear upon the last layer of masonry which, forming an abutment therefor, permits the shield to be advanced when the compressed air is admitted into said jack cylinders.

The sharp leading cutting edge of the shield facilitates the movement thereof through the ground and the pointed horizontal and vertical breaker members formed by the concavely curved plates 39, 40, 41, 42 and 43, respectively, serve to break their way through the soil, permitting easy digging thereinto if the same is necessary, from wthin the shield, the workmen standing on the lower portion of the inner shell 2, and also upon the respective floor plates 10 and 11. In certain kinds of soil, such as dry clay, the shield may be rapidly advanced by the jacks at successive intervals, the material which is compressed and forced into the shield being admitted through certain of the doors and transferred away. However, for use in shifting soil such as quicksand or the like, the doors are closed and the apertures therein regulated to the desired amount by the levers 60 and 70, which operate the grid plates, so that the soil is first compressed into the bell shaped mouth of the shield, and then admitted in the quantities and at the rate desired through the openings in the doors. When encountering a rock or very hard strata where blasting is necessary certain of the doors are opened, the charge set, and the doors are then closed, the workmen retiring to a safe distance back in the bore. After the charge has been fired the doors are opened and the material excavated by hand or in some instances, opening of the doors will permit the material to flow into the shield, where it may be loaded into the tunnel cars and transferred away. In any event, the shield which is of the shape of the bore being projected, prevents a cave-in taking place, and serves to accurately break its way through the ground. Any deviation of the shield from the line of

bore may be instantly corrected by manipulating the proper valves 76, controlling certain of the jacks, so that the shield may be advanced upwardly or downwardly, or at any necessary lateral angle. The framing of the entire shield is exceedingly strong and of course due to its arched shape it is capable of withstanding enormous exterior loads.

The valves for operating the hydraulic jacks which thrust the shield forwardly as clearly shown in Figs. 12 and 13, consist of a rotatable element 82, provided with two curved passages 83 and 84. The pipe 75, from the valve leads to the large cylinder 71, of the hydraulic jack, whereas the pipe 81, on the opposite side of said valve, leads to the small cylinder 74. With the valve in the position shown in Fig. 13, air under pressure is admitted from the ring manifold pipe 78, through the pipe 79, and thence through the valve into the pipe 75, and thence into the large cylinder 71, thus causing the head 73, to be thrust outwardly. At the same time of course it is necessary to release the air trapped within the small cylinder 74, and this is effected by the passage 84, in said valve, which leads to the pipe 81, communicating with said small cylinder, and to the pipe 80, which is connected to the exhaust ring manifold 77.

When it is desired to retract the rams after the shield has been thrust forwardly the desired amount, the valve elements 82, are rotated by means of the hand wheels 85, through an angle of ninety degrees, thereby establishing connection between the pipes 79, and pipes 81, through the passages 83, in said valve elements, so that the pressure from the ring manifold 78, is transmitted behind the pistons in the small cylinders 74, thus forcing the same rearwardly. Communication having been established by means of the passages 84, in said valve element between the pipes 75, and the pipes 80, the air trapped within the large cylinders 71, is exhausted therefrom into the ring manifold pipe 77.

As shown in Figs. 2 and 7, I have illustrated a cutting or boring tool which may be mounted behind certain of the doors in the shield, the tool being adjustably mounted upon a traveling carriage 90, which is secured between the respective floor plates 10 and 11, of the shield. The tool, when retracted into the position shown in Fig. 7, which is a side elevation, is in such a position that the doors can easily be swung rearwardly into an open position, sufficient clearance being provided for the purpose. The carriage 90, may then be advanced by rotating the small pinion 91, and after the same has been advanced the proper amount, the tool, which is driven from the electric motor 107, is caused to rotate and at the same time is gradually advanced by rotation of the pinion 94, by means of a suitable crank provided for the purpose but not shown. The cutting point 98, serves to break the material and clear a way for the cutting blades 99 and 100, which act efficiently to excavate the material and enlarge the cut. After a certain amount has been cut away the tool may be stopped and withdrawn and the material raked or shoveled back through the shield, any of the doors being opened for the purpose to permit most convenient transfer thereof.

The shield is readily adapted to sinking shafts as well as projecting tunnel bores, and acts efficiently in any instance to cut through the soil in a most efficient manner properly shaping the cut to receive the masonry in the desired outline of the tunnel or shaft being built.

I am aware that the device is susceptible of numerous modifications without departing from the principles of this invention, and I therefore do not purpose limiting the patent granted otherwise than necessitated by the prior art.

I claim as my invention:

1. In a tunneling shield of the class described, a cylindrical shell, means advancing the same through the ground, and mechanism controlling the quantity of soil admitted through the shield as the same is advanced, said mechanism comprising a frame-work, door frames hingedly mounted thereon, a slotted door plate rigidly secured on each of said door frames, reinforcing ribs integrally formed on one side of said door plate between said slots, a second slotted door plate rigidly secured to the other side of said first mentioned door plate, upper and lower guide bars secured on said second door plate, slotted grid plates slidably mounted in said guide bars, and a lever pivotally mounted on each of said grid plates and to one of said upper guide bars adapted to actuate said grid plates to register the slots therein with the slots in said door plates to control the passage of material through said doors when said doors are closed.

2. In a tunnel shield of the class described, a cylindrical shell, means mounted therein for advancing the same through the ground, a frame-work secured across the interior of said shell, slotted doors hingedly mounted thereon, guide bars on said doors, slotted grid plates slidably mounted therein, and levers pivoted to said guide bars and to said grid plates adapted when actuated to slide said grid plates laterally to control the slots in said doors to admit material through the doors when the same are closed and said shield is advanced through the ground.

3. In a tunneling shield of the class described concentrically arranged cylindrical shells, a flaring mouthpiece connecting the

forward edges thereof one to another, horizontal and vertical partition walls within said shield, the forward ends thereof extended, breaker members formed on the extended ends of said partition walls and extending across said device within said mouthpiece, a plurality of doors each comprising slotted double door plates connected in said shield between said partition walls adapted to be swung rearwardly into an open position, upper and lower guides on one of said door plates, slotted adjustable grid plates mounted in said guides, levers pivoted on said grid plates and on said upper guides adapted to slidably move said grid plates for controlling openings in said doors to admit material through the doors when said doors are closed, and means advancing said shield through the ground.

4. In a tunneling shield of the class described concentrically arranged elliptically shaped shells, a flaring mouth-piece connecting the forward edges thereof one to another, breaker members extending across said device within said mouth-piece, a plurality of doors connected in said shield adapted to be swung rearwardly into an open position, adjustable grid plates slidably mounted thereon controlling openings in said doors, and means pivoted on said doors and grid plates adapted to laterally actuate said grid plates to admit material through the doors when said doors are closed.

5. In a tunneling shield of the class described concentrically arranged elliptical shells, a flaring mouthpiece connecting the forward edges thereof one to another, breaker members extending across said device within said mouthpiece, a plurality of doors connected in said shield adapted to be swung rearwardly into an open position, laterally adjustable grid plates controlling openings in said doors, levers connected to said doors and grid plates adapted to actuate said grid plates to admit material through the doors when said doors are closed, means advancing said device through the ground, and means independently operatable for advancing said shield forwardly through the ground different amounts at different points therearound.

In testimony whereof I have hereunto subscribed my name in the presence of two subscribing witnesses.

CORNELIUS G. HASTINGS.

Witnesses:
LLOYD P. LOTT,
PAUL J. OTTO.

**Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."**