W. M. McDOWELL.

SHIELD FOR EXCAVATING TUNNELS AND SHAFTS.

APPLICATION FILED APR. 11, 1913.

1,100,142.

Patented June 16, 1914.

5 SHEETS—SHEET 1.

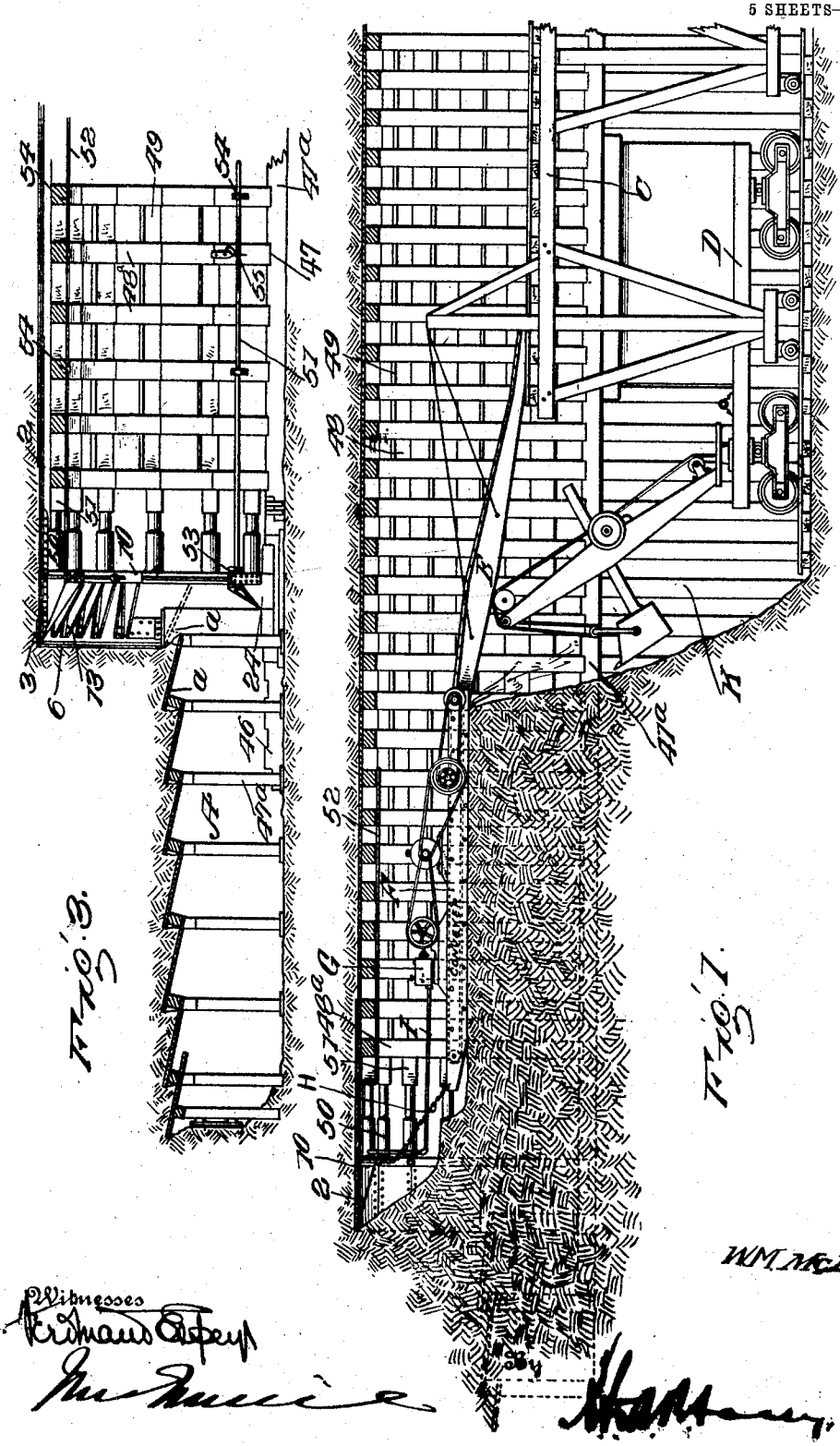


FIG. 1.

FIG. 2.

Witnesses

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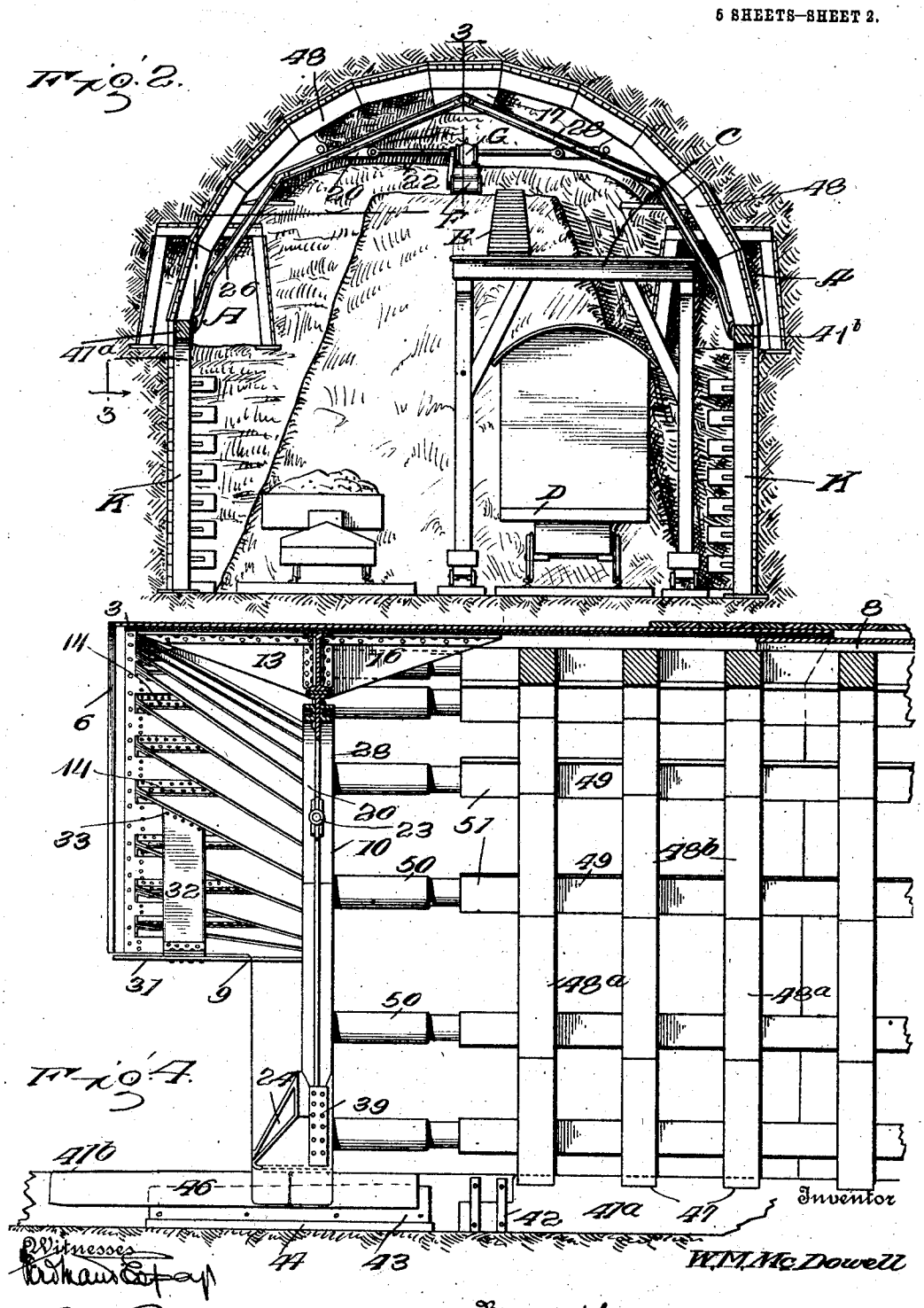
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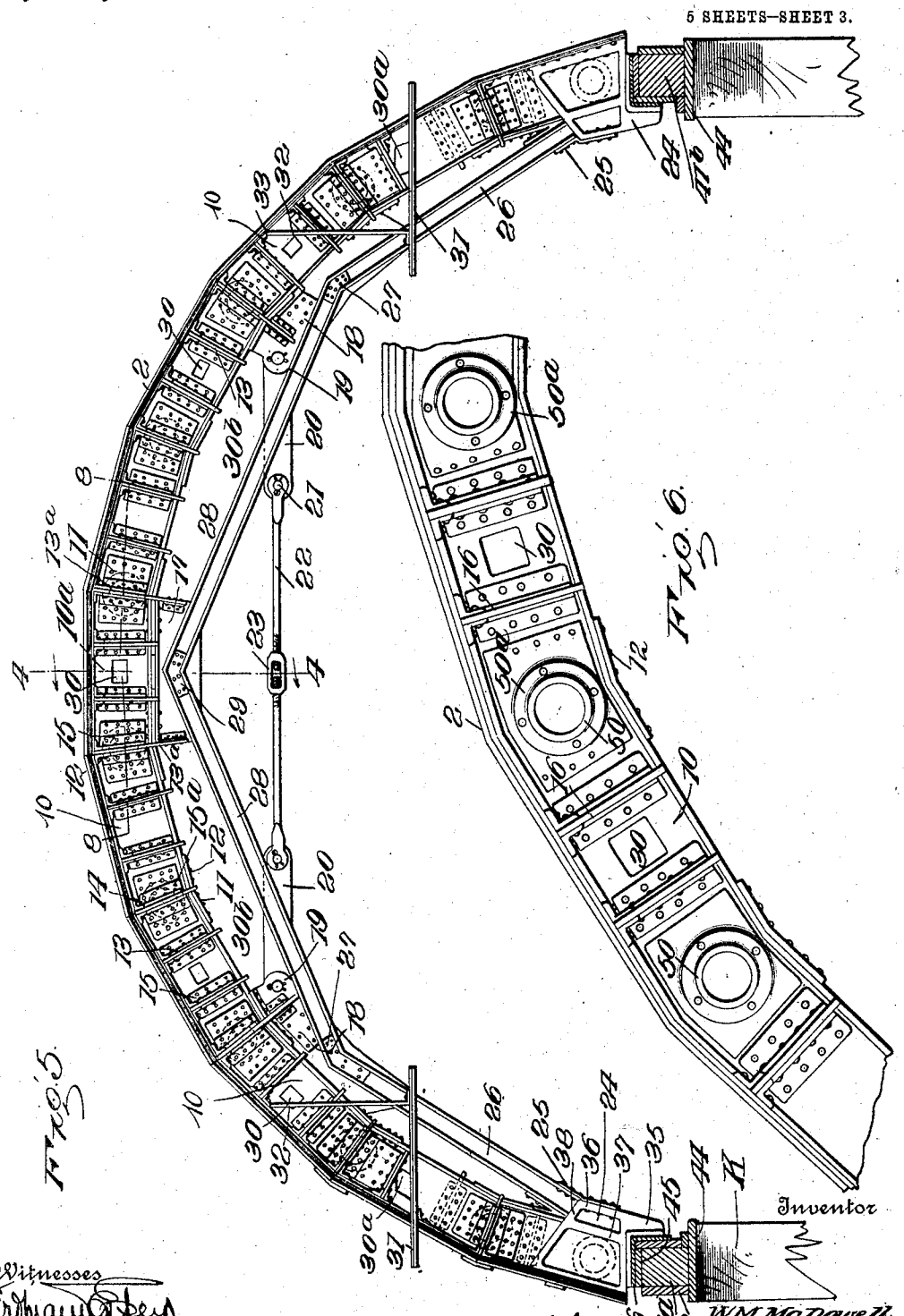


Fig. 5.

Fig. 6.

Witnesses

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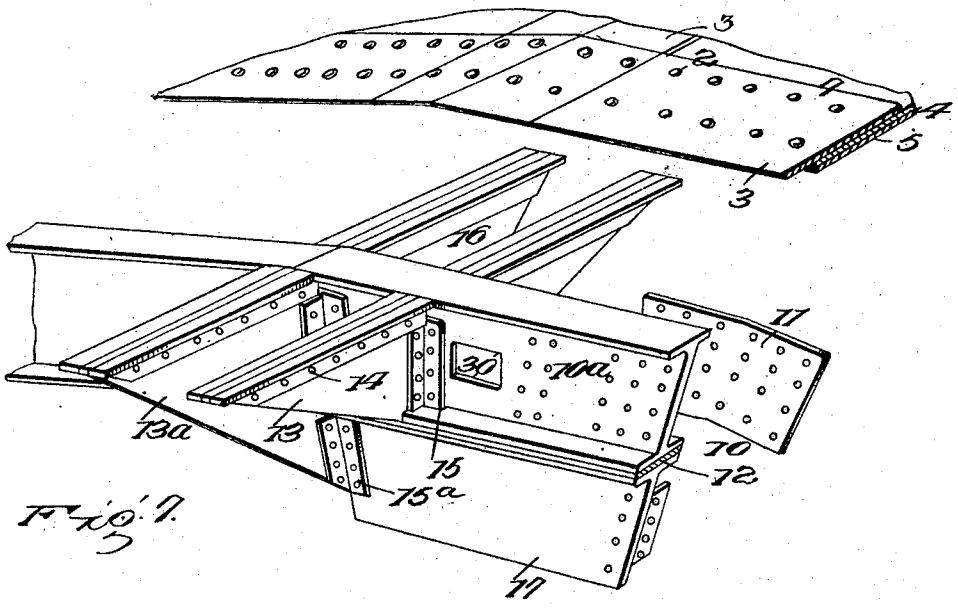


Fig. 7.

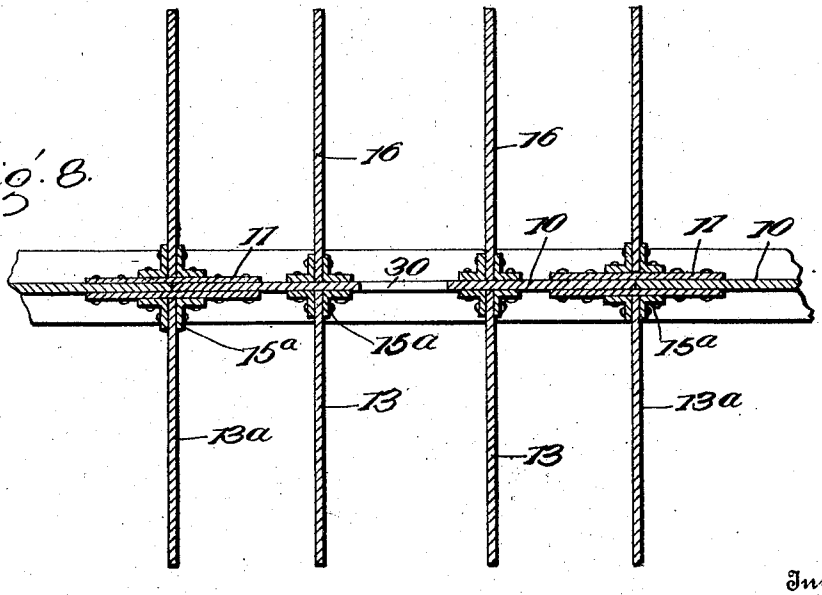


Fig. 8.

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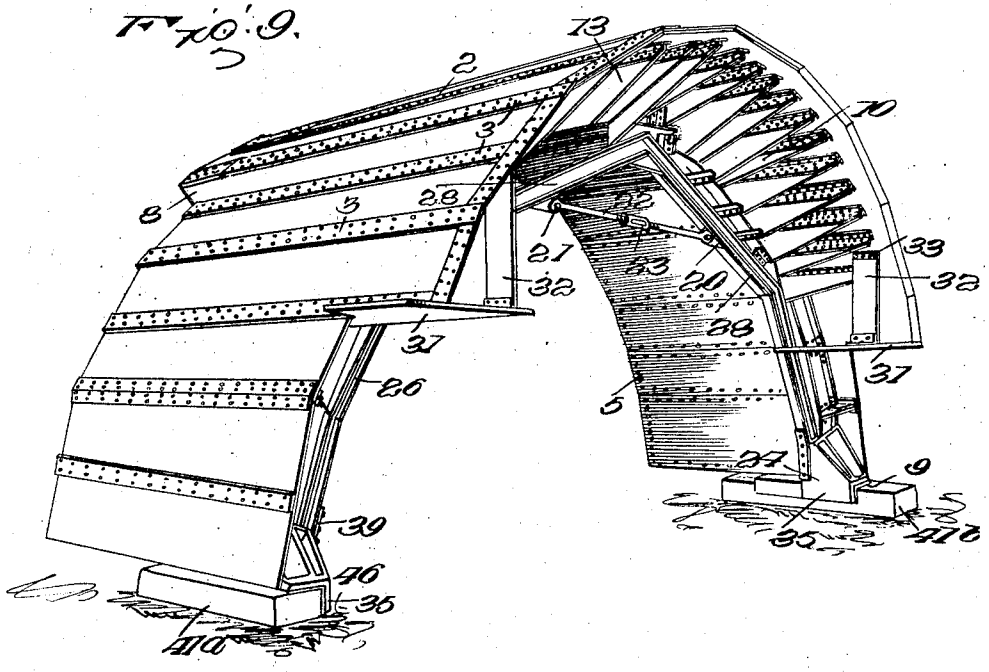
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FIG. 9.



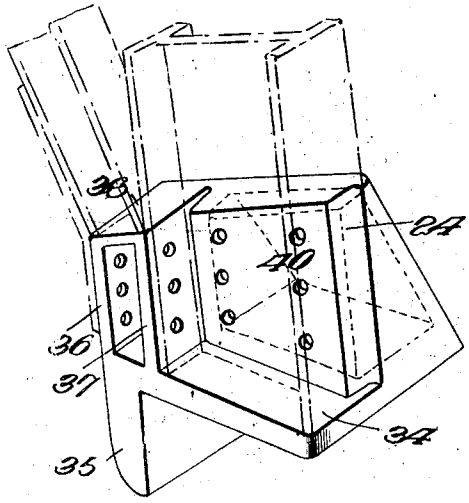
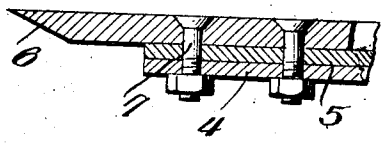


FIG. 11.

FIG. 10.



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UNITED STATES PATENT OFFICE.

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SHIELD FOR EXCAVATING TUNNELS AND SHAFTS.

1,100,142. Specification of Letters Patent. Patented June 16, 1914.

Application filed April 11, 1913. Serial No. 760,528.

To all whom it may concern:

Be it known that I, WILLIE M. McDOWELL, citizen of the United States, residing at Tacoma, in the county of Pierce and State of Washington, have invented certain new and useful Improvements in Shields for Excavating Tunnels and Shafts, of which the following is a specification.

My invention relates to the art of tunneling, and particularly to a tunnel shield designed to be disposed at the breast of the tunnel under construction and forced forward as the breast is cut away.

The primary object of my invention is the provision of a tunnel shield so formed that it may be disposed between the false work that supports the tunnel roof and the breast of the tunnel and forced forward as this breast is cut away.

A further object is to provide a tunnel shield which will protect the workmen cutting away the breast from any over-break or caving in of the earth or other material from above.

A further object is to so construct the shield that it will support the great weight of the superincumbent material between the temporary false work and the breast so as not to allow any settling of the earth.

A further object is to so construct and mount the shield that it may be readily shifted forward from time to time as the work progresses, and in this connection to provide controllable means for uniformly moving the shield forward.

A still further object is to provide in connection with the shield a plurality of hydraulic jacks so mounted as to contact with separated portions of the shield and so controlled as to subject the shield only to a uniform strain while it is moving forward.

A further object is to so construct the shield that it shall afford protection to the workmen engaged in removing the sections of the "skid irons" and the roof of the wall plate drift.

Another object is to so construct the shield that it shall be supported at its forward end upon the wall plates and at its rear end upon segments.

Other objects will appear in the course of the following description.

My invention is illustrated in the accompanying drawings wherein:

Figure 1 is a longitudinal vertical section of a tunnel under construction taken on a central vertical plane; Fig. 2 is a transverse vertical section looking from the rear of the tunnel toward the breast thereof and into the wall plate drifts. Fig. 3 is a vertical section upon the line 3—3 of Fig. 2 and cutting through the crown of the middle of the tunnel and through one of the wall plate drifts. Fig. 4 is an enlarged vertical section of the tunnel shield and the segments supporting the rear of the tunnel shield. Fig. 5 is a face elevation of the tunnel shield looking from the front edge thereof. Fig. 6 is an enlarged fragmentary rear face view of the tunnel shield. Fig. 7 is a perspective view of the elements composing the tunnel shield, the parts being separated. Fig. 8 is a fragmentary cross section on the line 8—8 of Fig. 5. Fig. 9 is a perspective view of the shield. Fig. 10 is an enlarged detail section of the cutting edge of the shield. Fig. 11 is a perspective view of one of the shoes supporting the shield.

Corresponding and like parts are referred to in the following description and indicated in all the views of the accompanying drawings by the same reference characters.

I will first describe the construction of the shield itself and then describe its method of use. The construction of the shield is best shown in Figs. 4, 5, 6, 7, 8 and 9. The shield itself or skin which forms the roof supporting the crown of the tunnel is designated generally 2 and is composed preferably of sections of sheet metal overlapped and riveted together.

Preferably the shield consists of two sheets of metal as illustrated in Figs. 7 and 10. These plates are designated respectively 4 and 5. The longitudinal edges of these plates are abutted against each other and riveted to longitudinal strips 3. The inner plates 4 and 5 are respectively $\frac{5}{8}$ and $\frac{1}{4}$ of an inch in thickness and the outer shoe which projects beyond the inner plates to form a cutting edge 6 is one inch in thickness. These plates are held together by bolts or rivets 7, the heads of the bolts being countersunk within the plate 6. As illustrated, the cutting edge projects about four inches in advance of the plates 4 and 5. The shell formed by the plates 4 and 5 is about 15 feet, 6 inches in length.

As illustrated in Fig. 4, the side walls of the rear end of the shell do not extend as far back as the crown of the shell but are cut away as at 8 for a purpose to be later stated.

It will also be seen from Fig. 4 that the forward or cutting edge of the shell is cut away on each side of the lower portion of the arch as at 9 for a purpose which will appear more specifically when the operation of the shell is described. Supporting the forward portion of the shell of the shield is an arch designated generally 10 and composed of segments of I-beam 10ª more fully illustrated in Figs. 5 and 7. These sections or I-beam segments are beveled or inclined at their ends so that when placed together the sections or segments of I-beam will form an approximate arch-shaped member fitting the inside face of the shell as illustrated clearly in Figs. 7 and 5. These segments are held in engagement with each other by butt-straps 11 which are riveted to the segments of the I-beam, there being butt-straps on each side of the I-beam segments or sections, and they are also held together by butt-straps 12 disposed below the junction of each pair of segments. The upper flanges of the I-beam segments may also be riveted to butt-straps and riveted through the shell, the outer ends of the rivets or bolt holes being countersunk flush with the exterior face of the shell for a purpose heretofore stated. Disposed at the joints between all of those I-beam segments 10 which are located above the cutaway portion 9 of the shield are a plurality of outwardly projecting triangular braces designated 13ª, these braces being held to the inner sheet of the shell by means of angle irons 14 riveted to the braces and to the shell. While I do not wish to limit myself to the number of these braces, I preferably provide these triangular braces at the junction between each two of the sections or segments of I-beam 10 and two more of these braces 13 set equidistantly between the outer braces, all of the braces however being of practically the same construction. The braces are held to the faces of the I-beam segments by means of angle irons 15. The intermediate braces project below the segments and are held to the flanges thereof by angle irons 15ª. Projecting rearward from the arch formed by the I-beam sections are a plurality of back braces 16 corresponding in construction to the braces 13 but only located between the joints of the I-beam sections. These triangular braces 16 are also held to the rear faces of the I-beam sections by means of angle irons riveted to the braces and to the faces of the I-beam sections and are held to the shell by means of angle irons as described for the braces 13 as shown clearly in Fig. 8.

Attached to the central segment 10ª of the segments 10, as illustrated in Figs. 5 and 7, is a short section of T-beam or plate flanged at its upper edge and designated 17 which is riveted to the I-beam section 10ª and the two braces 13ª which are disposed at the ends of the I-beam section 10ª are extended downward so as to engage with this beam 17. These two braces are designated 13ª but they have the same construction as the braces 13 and are attached to the beams 17 by means of angle irons 15ª. Attached to opposite points of the arch formed by the I-beam segments are plates $\frac{5}{8}$ of an inch in thickness and designated 18. These plates are flanged at their upper edges for attachment to the lower flanges of the I-beam segments and at their upper ends are provided with ears 19 for the attachment of tension bars 20 which at their outer ends are pivotally connected by pins 21 to a tension rod 22 provided with a turn buckle 23. At the lower ends of the arch formed by the segments and supporting said arch, is a shoe which will be hereafter described in detail and which is designated 24. Extending upward from each shoe and attached thereto by butt-straps 25 are pairs of brace rods 26 of channel iron which are riveted at their upper ends to the plate 18 and at their upper ends are also riveted by a butt-strap 27 to a pair of upwardly and centrally inclined braces 28 also formed of channel iron, the upper ends of both pairs of these braces 28 being held together by a butt-strap 29 and riveted or otherwise attached to the plate 17, as illustrated, in Fig. 5. Each of the I-beam segments is formed with an opening 30 or "muck-hole" whereby earth or other material collecting in front of the supporting arch may be shoveled through to the rear thereof. Projecting inward at the top of the cutaway portion 9 and riveted to the forwardly projecting portions of the crown sheets 2 on each side of the shield are the shelves 31. These as shown in Figs. 4, 5 and 9 project outward laterally beyond the shell and the inner ends of these shelves are supported by means of downwardly extending hangers 32 riveted to the inner face of the shell as at 33. These shelves or platforms 31 extend forward as far as the cutting edge of the shield and rearward to the rear wall of each cutaway portion 9.

As before stated, the lower ends of the arch formed by the segments is supported by means of shoes, these shoes being designated 24. A detail view of one of the shoes is illustrated in Fig. 11. The shoes are angular in form, that is, formed with a base portion 34 adapted to rest upon the upper face of a wall plate, and with an inwardly disposed, downwardly extending flange 35 adapted to be disposed parallel to the inner face of the wall plate. The inner end of the shoe is formed with upwardly extending spaced flanges 36 and 37 connected at their upper ends by an inclined web 38 and formed integral with the shoe. The flange 36 is adapted to be attached to a butt-strap 25 which connects the shoe to the braces 26 and

the inner flange 37 is adapted to be riveted to the inner flange of the lowest adjacent I-beam segment 10, as shown in dotted lines in Fig. 11, and to form a firm support and bed for the same, the shoe being riveted or otherwise rigidly attached to this I-beam segment. The shoe is formed with an upwardly extending transverse web 40 which bears against the inner face of the segment 10 and is riveted thereto. The shoes rest upon "wall plates" designated 41ª and 41ᵇ. These wall plates are formed of beams notched at their ends for interengagement and connected by straps 42 or in any other suitable manner. The wall plates are 12 inch by 12 inch timbers about 16 feet long, and to these timbers is spiked a 4 inch by 12 inch plank designated 43, also 16 feet long. This plank is spiked longitudinally along the outside edge of the wall plate for the purpose of adding to its strength and at the same time afford a footing for lagging as will be later described. The wall plate is laid upon a plank foundation designated 44. Planks 45 are placed upon the top of the wall plate to afford a smooth surface upon which skid irons 46 are disposed, these skid irons being angular in cross section and resting immediately upon the planks 45. The shoes 24 rest immediately upon these skid irons. These skid irons prevent the crushing of the wall plate and the planks 45 and permit the shoes to be moved along smoothly in the course of construction. The wall plates are notched on their upper faces as at 47 for the reception of segment blocks 48ª or 48ᵇ which are built up in the form of a series of arches spaced from each other and so disposed as to support that portion of the shield which extends rearward from the arch formed by the segments 10. These segment blocks 48 rest one upon the other as illustrated in Fig. 2 and are braced apart from each other by spreaders 49. There are two sets of these segment blocks, one set being distinguished from the other set by the exponents *a*, the other set being designated 48ᵇ. The segment blocks 48ª are spaced from each other a distance about 4 feet between centers. The other set 48ᵇ while used at the beginning of the forward movement of the shield, are afterward removed to make more space for concrete lining. When the spreaders are set 4 feet between centers, the length of the tail sheets or skin plates of the shield is 11 feet from the center of the I-beam segments to the ends of the plates. The shield is moved forward by means of a plurality of hydraulic jacks designated 50, these jacks having their forward ends or bases 50ª bolted or otherwise attached to the I-beam segments 10 at the junction of each two segments. The pistons of the jacks bear against 10 inch by 10 inch blocking 51 which are disposed against the segment blocks 48ª. Thus the jacks take their thrust from the timbered section of the completed tunnel. Each of the jacks is equipped with a valve. The bases of the jacks take their thrust at the joints of the I-beam segment where the heavy butt-straps are and it will be noted that there are braces extending forward from these points and attached to the shell so that the arch is fully braced to stand the pressure of these jacks and so that the pressure of the jacks shall be distributed over the whole extent of the shield. It may be noted at this point that in the practical operation of this shield, 50 tons' pressure have been applied upon the jacks making a total of 600 tons on the shield, this pressure being resisted successfully by the particular construction described.

It will be seen from the description that has gone before that the forward end of the shield is slidably supported upon the wall plates while the rear or tail end of the shield, that is to say, the shell, is simply dragged over a portion of the timbered section of the tunnel.

Inasmuch as the jacks are independently operable, it is necessary to provide means for measuring the forward movement of the shield so that all portions of the shield may move together properly. To this end I provide measuring rods 52 graduated in inches, one end of each measuring rod being attached to the shield and there being three measuring rods disposed at different locations, one at each of the steel shoes and one at the top of the shield. Each measuring rod has notched graduations marked upon it and each measuring rod is attached at its forward end to any suitable point of the shield by means of a cotter pin 53 and an eye. The rods are supported in guides 54 attached to the inner faces of the segment blocks 48 so that the rods may slide through these eyes. A pointer 55 is fastened on the segment blocks so as to coact with the markings on the rods. There is an operator or director of the movement of the shield with two assistants. These assistants are stationed at each of the lateral measuring rods which are attached to the shoes of the shield and it is their duty to call off the figures to the chief operator as the shield advances. These assistants also under the direction of the chief operator close off one or more jacks as the shield advances. The chief operator of the shield is stationed in convenient location to the upper jacks and notes the position of the top measuring pole. It is by means of closing or opening one or more of the jacks that the shield is kept under constant control and headed in proper direction with relation to the wall plates.

While the shield as before described may be used for tunneling where a straight course

is at all times maintained, it is possible also to use this shield on a curve by a proper regulation of the jacks. The shield as illustrated for instance, is capable of being used on a curve.

While I have shown an 11 segment arch, such for instance as would be used in building a very large tunnel, it will be obvious that the number of segments to the arch and the diameter of the arch, its height, etc., will depend upon the size of the tunnel. In single track tunnels, either 5 or 7 segments are used to form the arch. Of course, the shield would have the same curvature as the completed arch. Thus the shield can be built to conform to any sized or any shaped tunnel.

While I have described what I believe to be the best and most practical form of my improved shield, and a form which has been thoroughly tested by actual work, I do not wish to be limited to the details of the construction as set forth as it is obvious that these details may be varied in many cases to conform to the special conditions of any particular piece of work without departing from the spirit of the invention. The operation of my invention is as follows:

While my improved shield is adapted to be used for any kind of tunneling, I will consider its operation with particular reference to soft ground tunneling. The method generally practised in soft ground tunneling is that known as the "poling board" method. In this well known method there is a great liability of the strutting giving away by breaking or crushing from the tremendous weight which it has to support, and in the event of the strutting giving away an over-break is sure to follow which delays the progress of the tunnel construction by necessitating the substitution of whole timbers for the broken timbers, and the necessity of excavating the earth fallen from above.

It will be noted from Figs. 1, 2 and 3 that the whole area of the tunneled section is not excavated at one time but that it is removed in sections and as each section is excavated the walls thereof are timbered. The first section to be excavated are the wall plate drifts shown in section in Fig. 3 and in elevation in Fig. 2, these drifts being lettered A. These wall plate drifts which are two in number and are designed to excavate a place for the wall plates 41^a or 41^b are driven with a poling board method in advance of the general excavation, one on each side of the tunnel, with the floor line about 12 inches below the spring of the roof arch. These wall plate drifts are about 6 feet high and 6 feet wide, affording space for two workmen in each drift. The wall plate drifts are so worked that the breast of the drift is always about 18 to 20 feet in advance of the cutting edge of the shield.

The wall plates are placed by the engineers in charge of the work and securely blocked. The planks 45 are placed on the top and side of the wall plates to afford a smooth surface upon which the skid irons may be placed. This work is done by miners who take care of the roof of the wall plate drift and also move the skid irons ahead to afford a track for the shoe to run on. Each of these men is protected by the shelf 31 which extends over the rear end of the wall plate drift. This shelf thus answers two purposes, the other purpose being to keep the dirt from running from the roof arch down into the drift and thus making a very heavy over-break which has to be guarded from at all times. This shelf absolutely prevents this form of over-break. As the shield is advanced, the 2 by 6 lagging which forms the roof of each wall plate drift is chopped away as at the point *a* in Fig. 3 and removed. This is the duty of the man who places the skid irons upon the wall plate. The skid irons are in three sections of 2 feet each and as one is released from under the shoe it is again placed upon the wall plate in advance of the shoe. The heading is that portion of the excavation for which the shield is primarily intended. The cutting edge of the shield is forced into this heading or breast.

It will be noted that the front end of the shield or shell extends a distance 4 feet 6 inches forward of the I-beam segments and that thus a large sized working space is afforded for the workmen and the entire face of the breast may be attacked. The roof of the heading section is supported by the front end roof plates of the shields and affords protection to the workmen from loose material falling from above.

In stable material like rock which would ordinarily not crumble down but would have a vertical face, the distance between the forward end of the shield and the turn buckle truss rod 22 is nearly 6 feet, and as the excavation progresses the shield could be advanced without trouble. In soft ground tunneling, however, the workmen excavating the face of the heading stand upon the turn buckle truss rod 22 which affords them a good footing and lean against the excavation which has a slope of about 1 to 1. With shovels the workmen cut away the earth from 1 to 2 inches in advance of the cutting edge. There are four men engaged in this work of keeping the excavation a little in advance of the cutting edge, and a gradual slope of the earth from the cutting edge from a point of 3 inches to 6 inches below the turn buckle truss rod 22 is at all times maintained. The muck holes 30^a which are located in those I-beam sections on a level

with the shelves 31, provide means for removing the earth that would otherwise pack in front of the 18 inch I-beam, this earth preventing the forward progress of the shield. There is a workman stationed at this point to shovel the earth away from in front of the I-beam as well as from in front of the space between the inner edge of the I-beam and the outer edge of the channel iron braces, this space also forming a muck hole designated 30ᵇ. There are four men who take care of dirt in front of the I-beam segments and under the cutting edge of the roof arch while the shield is advancing and about eight "muckers" shovel into the conveyer.

In the completed portion of the tunnel, that is, that portion which is temporarily supported by false work, tracks are laid and I have shown in Fig. 1 a "jumbo" truck and a steam shovel or excavator as operating upon these tracks. The jumbo truck as illustrated in Fig. 2 comprises a platform C having depending standards engaging with trucks, these standards being spaced sufficiently apart to permit the platform of the excavator to pass beneath the jumbo truck, the excavator being designated D. The excavator D may be of any suitable character but I have illustrated it as a steam shovel of an ordinary type. This steam shovel discharges into a "muck car" which moves upon tracks at the side of the first named tracks.

Extending from the forward end of the jumbo truck is a stage plank designated E and which rests upon the rear end of the breast of the excavation. From the forward end of the stage plank extends a conveyer F of any suitable type and operated by any suitable means as by the engine G. The forward end of the conveyer is connected to the shield by means of a chain or other connection H and as the shield moves forward, the conveyer will follow. The engine G is also used as a means of forcing motive fluid into the jacks and is connected by means of a pipe line I to the several jacks. Men are stationed in front of this conveyer to shovel the earth into it, this earth being in turn shoveled downward by the men keeping the heading excavation in trim. Water may be delivered to the pump driven by the engine G, a pipe line being laid and keeping pace with the progress of the shield. A hose or other flexible connection connects the delivery end of the pipe line and the suction inlet of the pump. The discharge pipe of the pump is connected to a main header and from this main header connections are made to each of the twelve jacks. Inasmuch as the connection of the pump and jacks is an obvious one and is no part of my invention, I have not described it in detail.

As previously stated, the shield is jacked forward in stages according to the length of the pistons of the jacks. As soon as the shield has advanced a stage which we will consider to be 4 feet, the jack blocks 51 are taken down and two sets of segment blocks are assembled and put in place. They are then lagged and packed between the top of the arches formed by the segment blocks and beneath the skin plates. There is over 4 feet, in the construction described, between the I-beam segments of the shield and the foremost set of timber segment blocks and this permits the 4 foot lagging and packing to be readily put in place. As the shield advances and the earth is cut away beneath this shield, the earth is also cut away at the sides of the excavation and below the wall plates and plumb posts K are put in position as in ordinary tunneling. This completes the tunneling as far as the false work is concerned. Temporary tunnel lining is put in place as the tunnel is extended forward and the tunnel is eventually finished in any desired manner.

With my improved shield it is possible when working rapidly to cause the shield to travel forward at a rate of one inch a minute including blocking and jacking. In other words, it takes about one hour and forty minutes to two and one-half hours to move the shield forward 4 feet. Where the crown bar system is employed, it would take ten pieces of timber 12 inches by 12 inches and 32 feet long; 640 pieces of timber 4 inches by 6 inches each 5 feet long, and 88 posts 5 feet long to make 32 feet of tunnel. With the poling board system it takes the same amount of timber only smaller in size. In the crown bar system from 85 to 120 men are usually employed on a shift for excavating 4 to 6 feet a day. With the poling board system there are thirty men employed on a shift for excavating 4 to 6 feet a day and with my improved shield system thirty men are employed to excavate from 10 to 12 feet and no false timbers have to be used. In other words, the segment blocks once put in place, act to support the tunnel until the permanent work is finished.

It will, of course, be obvious that the dimensions and character of the shield will to a large extent depend upon the character of the work to be done and will depend upon the nature of the soil to be penetrated, the size of the tunnel to be excavated, and the dimensions of the temporary timber lining. In some instances temporary timber lining is not employed, as for instance in the use of cast iron lining for tunnels but instead cast iron segments are made, bolted together and assembled in the same manner that the timbered segments are assembled. Masonry lining may also be used but with my construction in

any case the tail end of the shoe is carried and sustained by the lining, whether this lining be masonry, metal or timber, and the jacks which act to shove the shield forward take their thrust from this lining. The use of this shield is, of course, not confined to soft ground tunneling as it is possible to use it for tunneling under any circumstances and to use it for sinking shafts or like purposes.

What I claim is:

1. In a tunnel shield, a supporting arch mounted on shoes for forward movement, and a shell supported on and movable with the arch, said shell having a cutting edge.

2. In a tunnel shield, a supporting arch, shoes forming the bases for the arch, wall plates on which the shoes are adapted to slide, a shell having its forward end supported on and attached to the arch and being movable therewith, said shell having a cutting edge, and braces extending from the face of the arch upward to the forward end of the shell.

3. A tunnel shield including a supporting arch formed of beam segments connected together, a shell supported on and attached to the arch and having a forward cutting edge, and forwardly and rearwardly projecting braces attached to the beam sections and to the shell.

4. A tunnel shield including a supporting arch formed of beam segments connected to each other, shoes forming the bases of the arch and supporting the same for sliding movement, wall plates on which the shoes slide, an outer shell supported on and attached to the arch, triangular braces attached to the beam segments at the joints thereof and extending forwardly and rearwardly and attached to the shell, the forward end of the shell being formed with a cutting edge.

5. A tunnel shield comprising an arch formed of beam segments and butt-straps, forwardly and rearwardly projecting triangular braces attached to and projecting from the faces of the beam segments, an outer shell consisting of a plurality of thicknesses of material riveted to the beam segments, and angle irons riveted to the braces and to the outer shell.

6. A tunnel shield including an arch formed of beam segments I-shaped in cross section and connected to each other, chordal braces rigidly attached to the arch, a tension rod connected to opposite portions of the arch, and a shell extending over and supported upon the arch and having a forward cutting edge.

7. A tunnel shield comprising an arch formed of beam segments, butt-straps connecting the beam segments, an outer shell supported upon the beam segments and attached thereto, shoes forming the bases of the arch, braces extending from the shoe and attached to the arch between the apex thereof and each base, braces extending from said last named braces to the middle of the arch, a tensioning rod attached to the arch at opposite points thereon, and means on the tensioning rod for applying tension thereto.

8. A tunnel shield including an arch-shaped roof supporting shell, the forward end of the shell being cut away on each side from the base of the arch upward, and horizontally disposed shelves mounted upon the shell at the upper end of the cutaway portion and projecting on either side of the shell.

9. A tunnel shield including a supporting arch, a shell mounted upon the arch, the forward end of the shell being cut away from the spring of the arch upward, and shelves supported upon the arch at the upper end of the cutaway portion on each side of the shell and projecting on either side of the shell.

10. A tunnel shield including a supporting arch, an arch-shaped shell mounted thereon, the forward end of the shell on each side thereof being cut away from the spring of the arch upward to a height approximately equal to that of a wall plate drift, and horizontal shelves, one on each side of the arch supported at the upper end of the cutaway portions at a height approximately equal to the height of said wall plate drift.

11. In tunneling apparatus, a supporting arch, a shield mounted on the arch and extending forward and rearward of the same, a plurality of segment blocks forming arches and slidably supporting the rear end of the shield, spacing members disposed between the series of segment blocks, and means abutting against said arch and thrusting against said series of segment blocks and spacing members for forcing the arch and the shield carried thereby forward.

12. In tunneling mechanism, wall plates, a supporting arch including shoes having sliding engagement upon the wall plates, a shield attached at its forward portion to the arch but projecting forwardly beyond the same, removable supports for the rear end of the shield over which the shield slides, and jacks engaging the arch to force the shield forward.

13. In tunneling mechanism, a supporting arch including shoes for slidingly supporting the arch upon wall plates, a shell supported at its forward end upon the arch projecting forwardly beyond the same, means for supporting the rear end of the shell and permitting it to move forward, and jacks having their bases attached to said arch.

14. In tunneling mechanism, oppositely

disposed, parallel wall plates, shoes mounted upon the wall plates for sliding movement therealong, a supporting arch having its ends attached to said shoes, a shell mounted upon the arch near its forward end and projecting forwardly beyond the same, removable segments supporting the rear end of the shield and over which the shield slides, jacks having their bases attached to said arch and projecting rearward therefrom, said jacks taking their thrust against the said segments and acting to move the shield forward.

15. In tunneling mechanism, parallel wall plates, shoes mounted upon the wall plates, each shoe having a horizontal flange and a vertical flange, a supporting arch made up of segments attached to each other, braces for the arch, a shell attached to the arch near its forward end but projecting forwardly beyond the arch, a plurality of removable segments slidingly supporting the rear end of the shield, spreaders disposed between the supporting segments, and jacks attached at their bases equidistantly around the arch and taking their thrust against said segments.

16. In tunneling mechanism, oppositely disposed, parallel wall plates, shoes mounted upon the wall plates for movement therealong, an arch made up of beam segments and butt-straps joining the segments, hydraulic jacks having their bases attached to the arch at the joints between the segments, a shell mounted upon the arch and projecting forward and rearward of the same, braces attached to the arch and to the forward portion of the shell, and means for slidably supporting the rear portion of the shell, said means also affording abutments for the pistons of said hydraulic jacks.

17. A tunneling mechanism including an arch made up of beam segments rigidly connected to each other and oppositely disposed shoes attached to the ends of the arch, wall plates upon which said shoes rest and have sliding engagement, a shell mounted upon the arch near its forward end, said shell projecting forward beyond the arch and formed with a cutting edge, the forward end of the shell from a height equal approximately to the height of a wall plate drift being cut inward toward the arch, horizontally disposed shelves forming platforms disposed at the upper end of the cutaway portion, said shelves extending inward of the shell and outward thereof, braces extending from the arch and attached to the shell, bracing means for the arch, a battery of jacks having their bases attached to the inner face of the arch, and removable means for slidingly supporting the rear portion of the shell, said means affording abutments for the jacks.

18. The combination with a tunneling shield slidably mounted for forward movement, and means for forcing said tunneling shield forward, of graduated guide rods attached to spaced portions of the shield and movable therewith, and relatively fixed pointers co-acting with the guide rods.

19. A tunnel shield including a shell, a supporting arch therefor attached to the shell, said arch having muck holes formed in its web, and shoes forming the lower ends of the arch and slidingly supporting the same.

20. A tunnel shield including an arched shell having a forward cutting edge, an arched support made up of beam segments attached to each other and to the shell, shoes upon which the lower ends of the arch are mounted, and by which the arch is slidingly supported, and horizontally disposed, transversely extending shelves supported from the shield and forward of the arch, the arch being provided with a muck hole behind each shelf.

21. The combination with a tunneling shield and means for forcing the shield forward, of graduated guide rods attached at separated points to the shield, and fixed pointers coacting with the guide rods.

22. The combination with a tunnel shield including a supporting arch, slidably mounted for forward movement, a shell supported upon the arch, and jacks disposed at separated portions of the arch and adapted to move the shield forward, of fixed removable supports slidably supporting the rear end of the shield, graduated guide rods attached to separated portions of the shield and movable therewith, and pointers attached to the supports for the rear end of the shield and coacting with the guide rods.

In testimony whereof I affix my signature in presence of two witnesses.

WILLIE M. McDOWELL. [L. S.]

Witnesses:
J. B. MITCHELL,
THADDEUS HILL.

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