United States Patent

[11] **3,578,809**

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[54] **METHOD AND APPARATUS FOR FORMING SUBTERRANEAN STRUCTURES**
4 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **299/33,** 299/70, 61/85, 61/45
[51] **Int. Cl.** **E21d 23/00**
[50] **Field of Search** 61/85, 45, 42; 299/31, 33, 70

[56] **References Cited**

UNITED STATES PATENTS

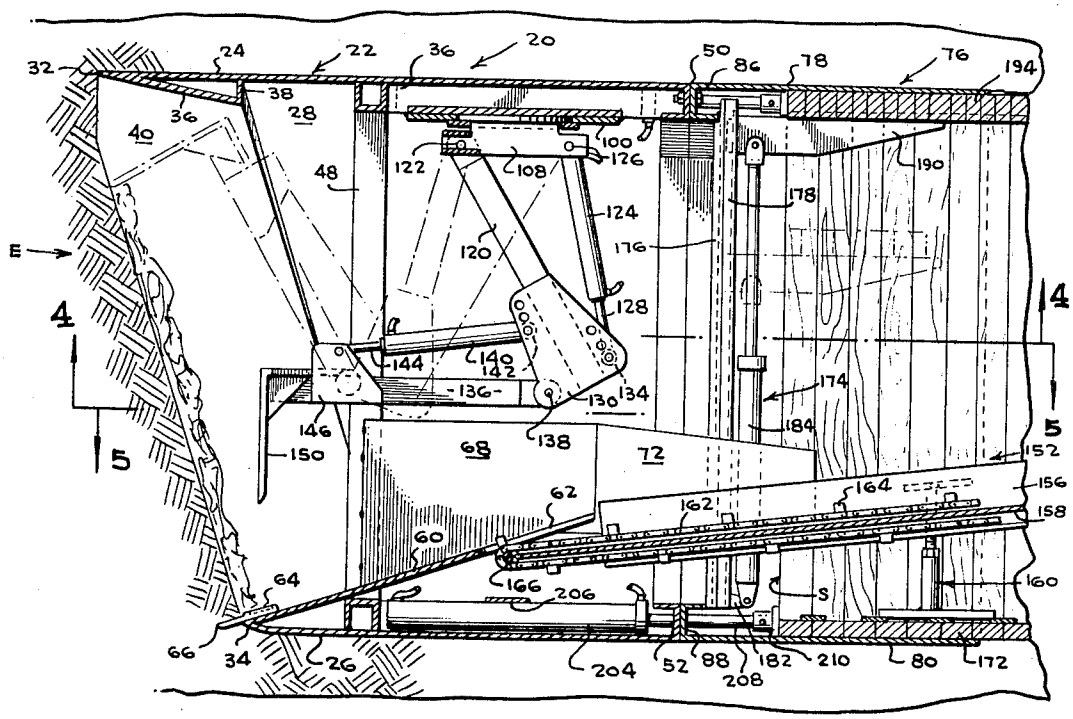
992,813	5/1911	Shepard	61/45
1,098,961	6/1914	Mosher	61/85
1,484,188	2/1924	O'Rourke	61/84
2,149,345	3/1939	Hunsaker	61/84X
2,263,352	11/1941	Dow et al.	61/42
3,314,724	4/1967	Tinlin	299/75X
3,404,535	10/1968	Tabor	61/85
3,404,920	10/1968	Tabor	61/85X
3,427,813	2/1969	Hayes	61/85
3,469,884	9/1969	Kampf-Emden	299/75X

FOREIGN PATENTS

659,229	3/1963	Canada	299/33

Primary Examiner—Dennis L. Taylor
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ABSTRACT: A multisection shield incorporates means for subterranean excavation and for conveyance of excavated materials and provides for the installation of the lining planks within the shield. This apparatus is employed in a system of tunnel or conduit lining wherein floor and roof planks are prepositioned and sidewall planks are wedged in place therebetween.



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SHEET 1 OF 5

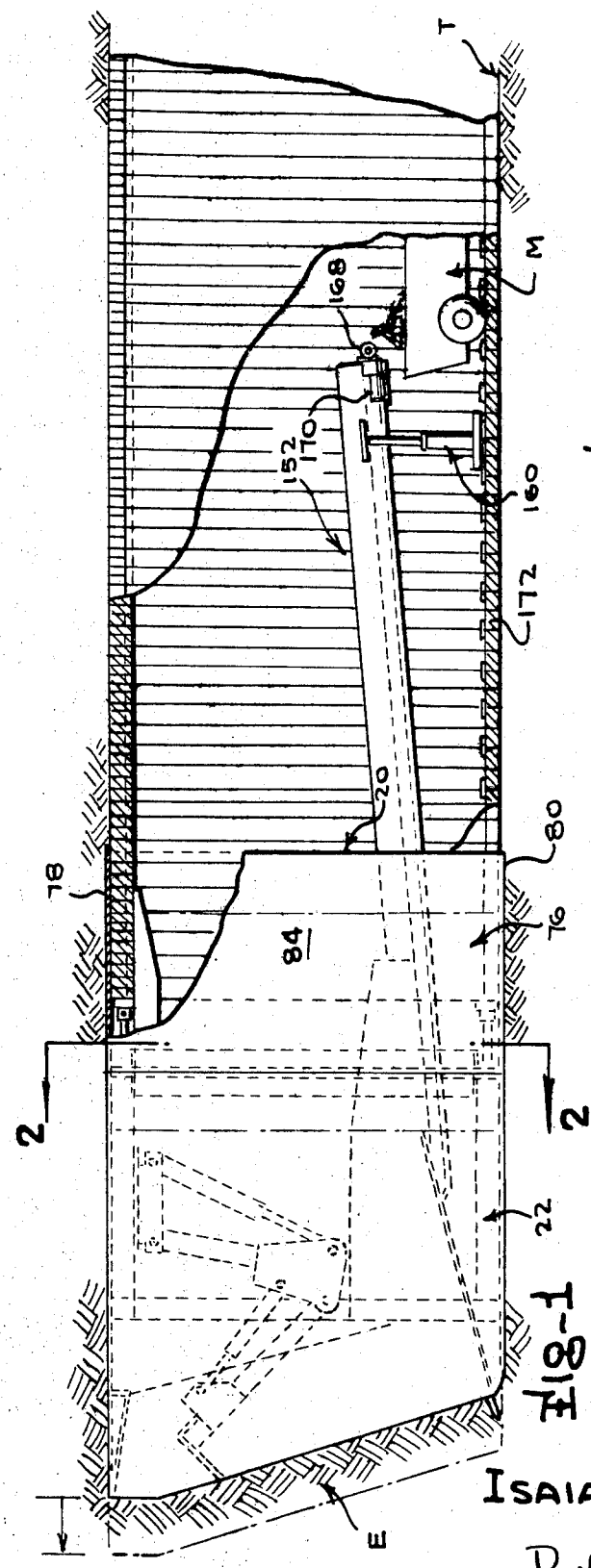


FIG-1

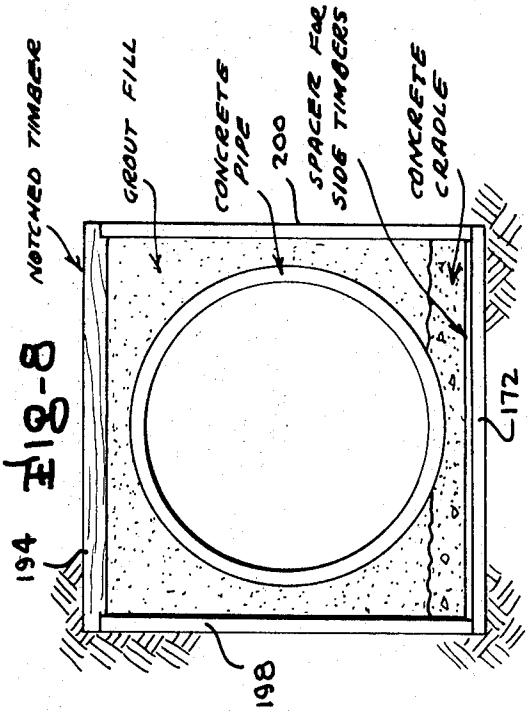


FIG-8

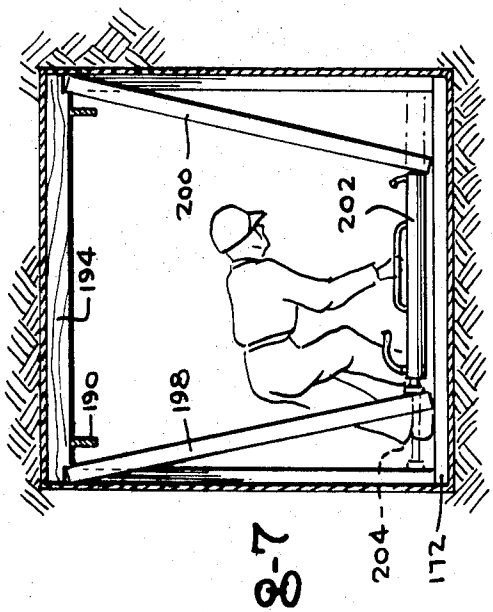


FIG-7

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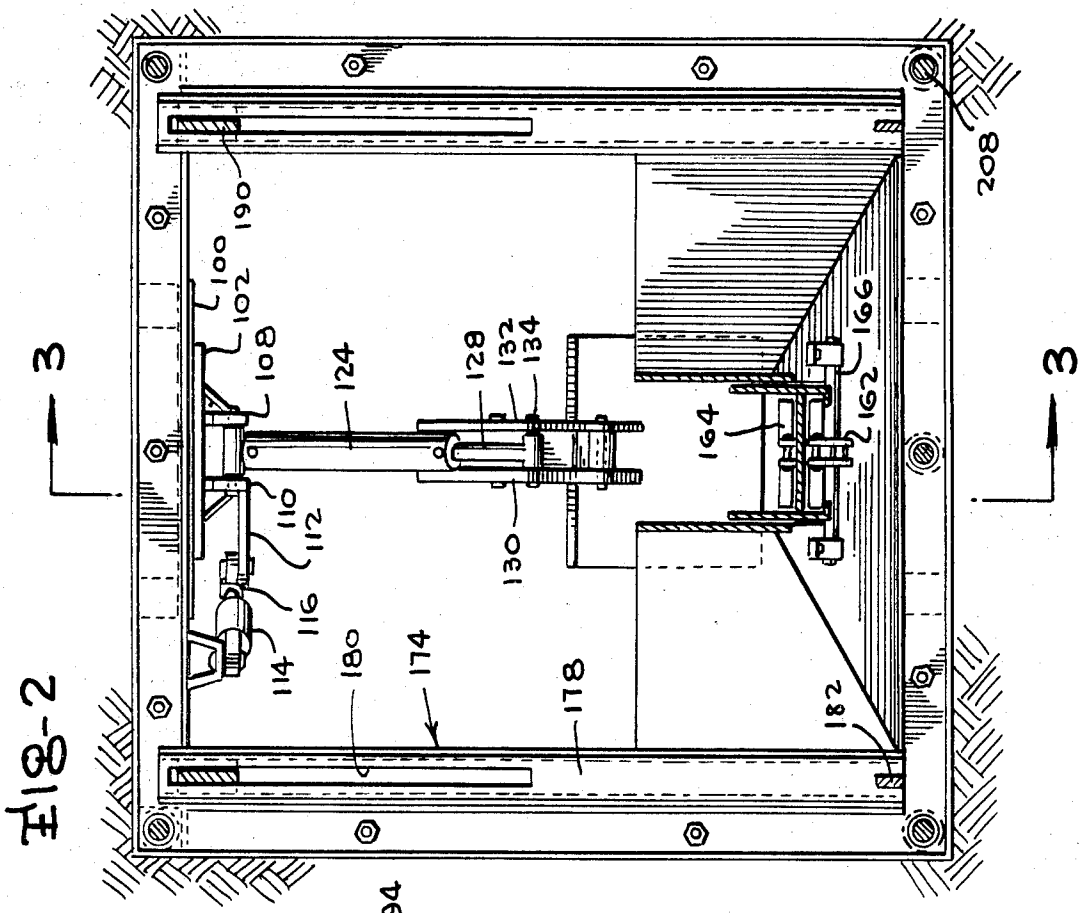


FIG-2

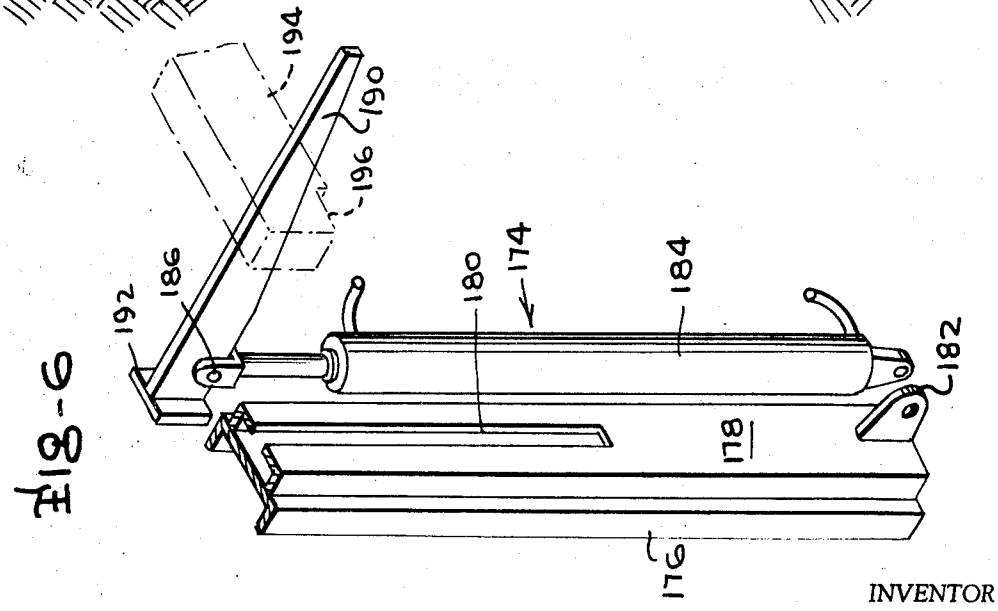


FIG-6

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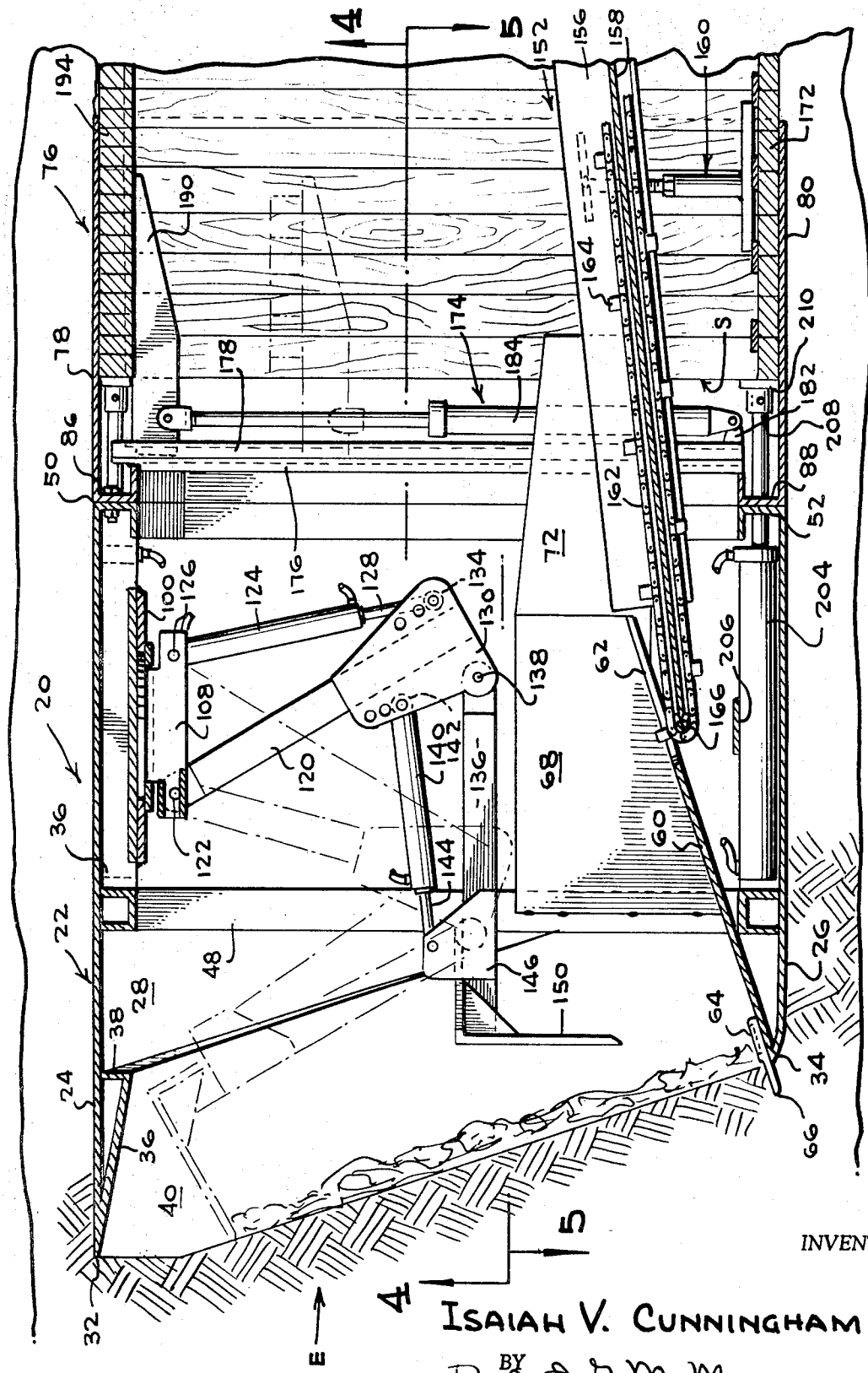


FIG-3

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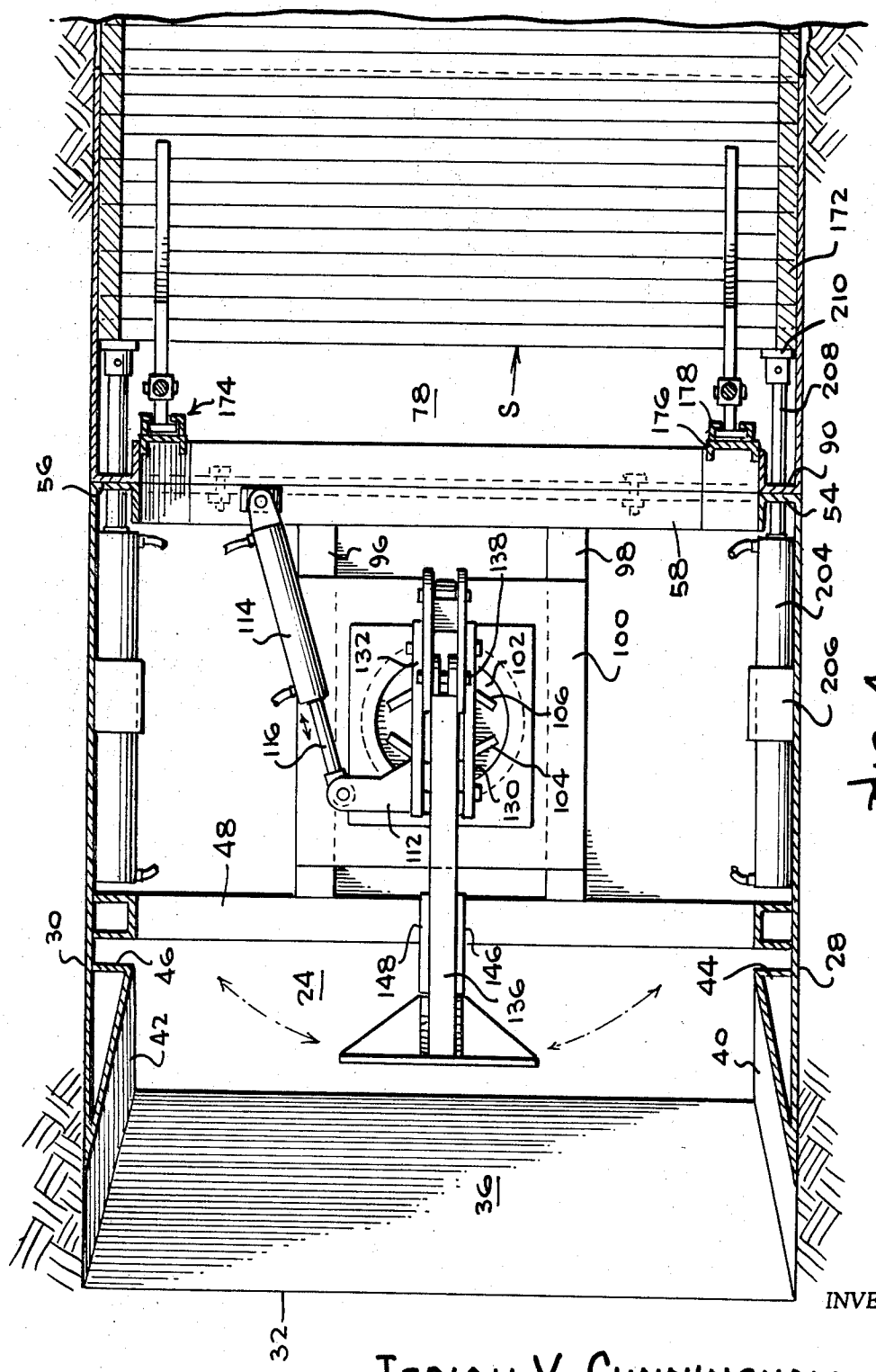


FIG-4

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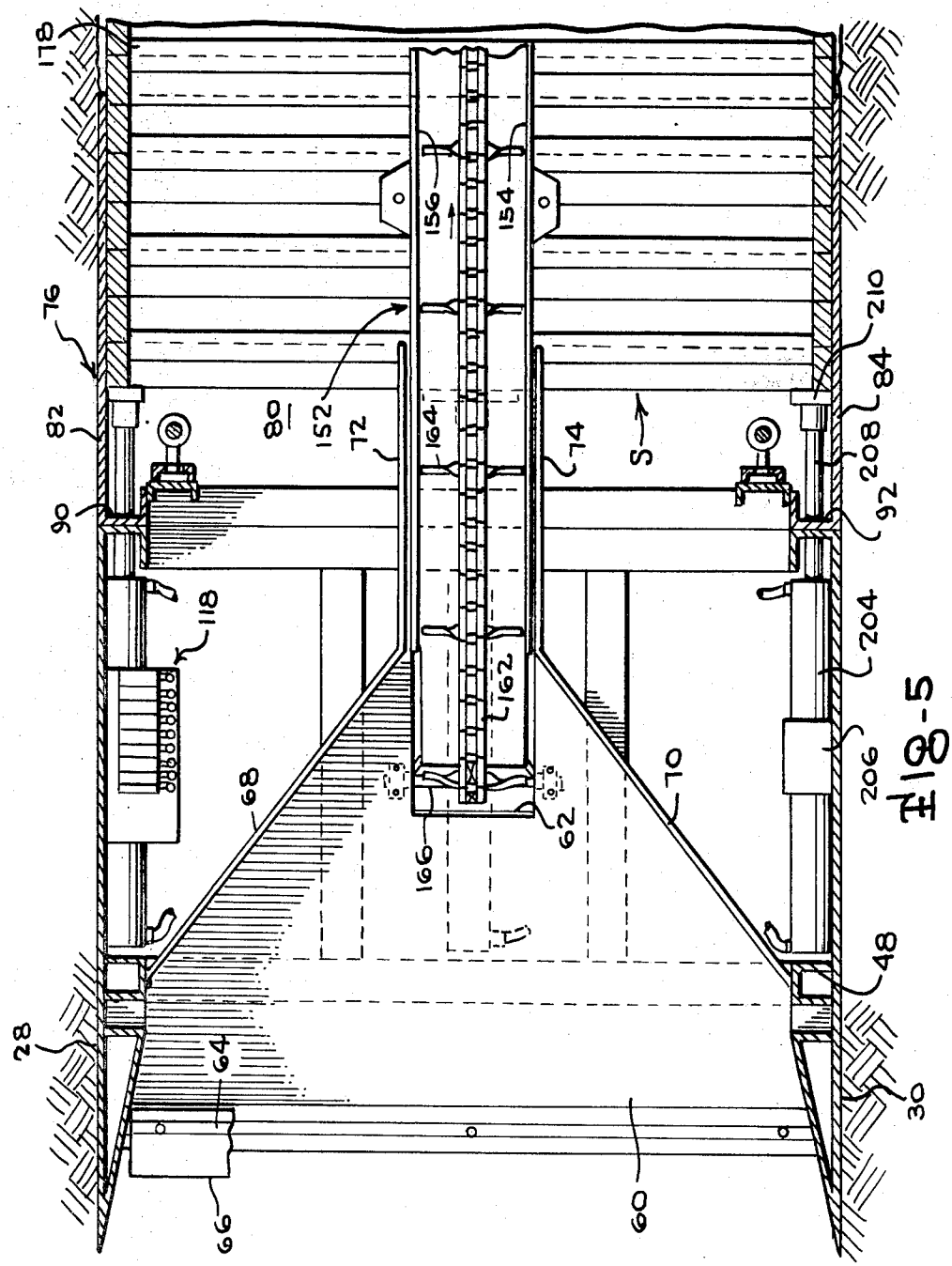


FIG-5

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METHOD AND APPARATUS FOR FORMING SUBTERRANEAN STRUCTURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the formation of subterranean tunnels, conduits and other excavations of the type needed illustratively for sewer lines, in mining, and the like. More specifically, the invention comprehends new and novel equipment for safely and speedily forming subterranean openings.

2. Statement of the Prior Art

It has heretofore been proposed to employ a shield or encasement with an associated conveyor in the formation of subterranean openings. Such prior devices, often including separable conveyors, digging mechanisms and shields, are shown by way of example in the following U.S. Pat. Nos. 2,772,871 to Caine issued Dec. 4, 1956; 3,075,591 to Pirrie et al. issued Jan. 29, 1963; 3,138,933 to Kemper issued June 30, 1964; 3,266,257 to Larrouze et al. issued Aug. 16, 1966; 3,309,142 to Winberg issued Mar. 14, 1967; 3,404,920 to Tabor issued Oct. 8, 1968; 3,410,098 to Winberg issued Nov. 12, 1968.

SUMMARY OF THE INVENTION

This invention relates to that category of tunneling apparatus wherein a shield is forced into the tunneling area, the shield being associated with excavation equipment and conveying means. The present apparatus provides a new and novel means for installation of lining timbers within the shield, and for advance of the shield with respect to the previously installed stand of course thereof, employing said previous stand of course as a base for the advancing mechanism. It is a basic objective of this invention to provide a method and related apparatus for the safe, rapid and economical formation and lining of subterranean tunnels, accomplished through the use of self-contained excavation, conveying and shield means, in which the tunnel lining is prepositioned within the shield. By virtue of the installation of an effective liner within the confines of the shield, there is no section of tunneling exposed to the possibility of cave-ins, dislodgement of large rocks or the like, or other similar mishaps.

A further and related objective of importance accomplished by this invention concerns the provision of a lining system employing planks or timbers which include elongated, substantially rectangular side and base planks, and top planks with slotted corner portions in which the opposite side planks are simultaneously wedged by the application of expansive pressure adjacent the base plank. The apparatus involves elevation means for raising the top planks and for retaining them in elevated location preparatory to installation of the side planks.

This invention comprehends a shield assembly, which, when placed in an initially formed excavation, is thereafter self-advancing as formation of a tunnel progresses. In accomplishing this objective, the shield comprises leading and trailing sections, the leading section having the excavation apparatus, and the trailing section being used as an assembly area for the tunnel lining. Extensible means in the form of a group of spaced apart jacks or the like are positioned medially within the shield and have portions adapted to bear against the lining. Upon extension of these jacks, the shield assembly is advanced with respect thereto, thus providing a space for the positioning of further stands of courses thereof.

By virtue of the employment of spaced apart, individually actuable jack means, the path of movement of the shield is controllable, thereby enabling the operator to maintain a selected course and to readily correct for deviations.

The excavation apparatus hereof, which may take numerous alternative forms and cover various locations, is preferably and ideally located on the roof section of the leading portion of the shield, immediately over a conveyance area. By this means the excavated material is effectively discharged, and the space within the shield is conserved.

The present invention, useful in the formation of any type of underground opening, such as a tunnel, conduit, or the like, is adaptable for use in the formation of an initial opening which is later converted, as by the introduction of pipe and grouting to other forms, or alternatively, the opening, employing suitably creosoted or treated timbers, may form a completed subterranean structure usable as a vehicular tunnel, or to form an opening to an underground seam of material to be mined. The invention, in essence, relates to a unique method and apparatus for the formation of said openings.

The shield is formed of heavy material, and is provided with a forward cutting edge aiding in the advance thereof.

Additional objects and advantages of the invention include the incorporation of a self-contained conveyor means for the removal of excavated material from within the shield during operation, and the provision of an inclined leading end plate which effectively transfers material to the conveyor means.

Other and further objects and advantages of the invention will become apparent to those skilled in the art from a consideration of the following specification when read in conjunction with the annexed drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view, partially broken away for disclosure of details, of apparatus of this invention employed in the interrelated method of forming a subterranean tunnel;

FIG. 2 is an enlarged transverse sectional view taken on the line 2–2 of FIG. 1, looking in the direction of the arrows;

FIG. 3 is a further sectional view taken on line 3–3 of FIG. 2, looking in the direction of the arrows;

FIG. 4 is a sectional view on line 4–4 of FIG. 3, showing the upper inside portion of the assembly as seen from below;

FIG. 5 is a cross-sectional view on line 5–5 of FIG. 3, showing the lower portion of the assembly;

FIG. 6 is a disassembled perspective view of an elevating apparatus subassembly hereof;

FIG. 7 is an illustration of the manner of placement of side timbers in the practice of the method; and

FIG. 8 is a transverse view in section of a completed tunnel.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The environment of employment of the present invention will be understood to be somewhat variable. In some circumstances of use, tunneling excavations are instituted on angular gradients commencing at ground level, while in other circumstances, straight tunneling from a preformed vertical entry bore is desired. In either event, for purposes of description herein, it will be assumed that a section of tunnel has been formed in the ground by whatever means has been dictated by the situation present, and that the apparatus hereof has been assembled and is in place within this preformed tunnel section.

In FIG. 1, the apparatus 20 of this invention is seen in use in the practice of the related method. The apparatus is disposed in the tunnel T in that view, a portion of which has been timbered as will be described below, and a further portion of which is excavated, but not lined. The apparatus is movable forwardly toward the unexcavated area E.

An important and major component of the invention is an enlarged shield 22 formed of heavy metal of the type often employed as armor plating. The shield is here shown in a preferred, rectangular form, but may be polygonal in configuration where tunneling requirements so dictate. As shown in FIGS. 1 and 3, the shield 22 includes a leading section, an intermediate section, and a trailing section. The leading section has a top wall 24, a base wall 26, and sidewalls 28 and 30. The top wall 24 is elongated, and has a leading edge 32 which is extended forwardly of the corresponding front edge 34 of the base wall. An interior reinforcing plate 36 joins the leading edge 32 and declines angularly inward therefrom, having a flange 38 at its connection with the inside of the top wall. In like manner, the sidewalls 28 and 30 have plates 40, 42, respectively, which form sharp leading edges therewith and are inclined from said edges to flanges 44, 46.

At a location spaced inwardly from the leading edges of the walls, a series of channel members collectively identified by reference numeral **48** extend about the inside of the walls and are fixedly secured in place, forming an intermediate brace and support extending about the full interior circumference. The channel members **48** define the interior limits of the leading section of the shield. The top, side and base walls extend over the intermediate section, and terminate at an interior top flange **50**, at a base flange **52**, and at side flanges **54**, **56**, respectively. Each of the flanges has a rebent, retaining and reinforcing member **58** thereon.

In FIGS. **3** and **5** a plate system for directing excavated material to a conveyor hereof is shown. An inclined plate **60** extends from the forward edge **34** of the base wall **26** and has a generally triangular form with a rectangular slot **62** formed at its trailing apex portion within the intermediate section. Secured on the plate **60** over the edge **34** is a reinforcing bar **64** with a leading edge **66** which aids in the movement of the shield through the ground. The plate system further includes vertical guide plates **68** and **70** fixed to the side channel members **48** and to the inner edge of the plate **60**. The vertical plates terminate at the end of the slot **62**, and parallel upstanding plates **72** and **74** extend rearwardly therefrom at that location. Thus, any material which is forced up the plate **60** is discharged through the slot **62** thereof.

The shield assembly **22** further includes a trailing section **72**. Like the previously described sections, the section **76** includes a top wall **78**, base wall **80** and sidewalls **82** and **84**. The walls have flanges **86**, **88**, **90** and **92**, respectively. These flanges also have rebent flange sections **94**, and the flanges **86**, **88**, **90** and **92** are respectively fixedly secured to the flanges **50**, **52**, **54** and **56** of the leading section walls. The respective outer walls are substantially coplanar with one another, and the walls of the trailing section have flat terminal edges uninterrupted by flanges or other protuberances for a purpose made apparent below.

The apparatus hereof includes new and novel self-contained excavation means. In FIG. **4**, it will be noted that the structural members **96** and **98** are extended longitudinally between the flange **50** and the channel member **48** in transversely spaced relation on the top wall **24** in the intermediate section of the shield. A substantially rectangular mounting plate **100** is fixed on the structural members, and has a central swivel plate **102** with curvilinear slots **104**, **106** formed therein. These slots receive upstanding connection portions of side-by-side swivel members **108**, **110**. The members **110** have a fixed extension **112** projecting from one side thereof. A hydraulic cylinder **114** is pivotally connected to the rigidifying member **58** of the top wall, and has an extendable and retractable rod **116** pivotally connected to the extension **112**. Suitable fluid supply lines are provided and extend to a control bank or panel **118** shown in FIG. **5**. These supply lines, and the control connections therefor, are variable and have therefore been omitted from the drawings for clarity of disclosure. As will be apparent, extension and retraction of the member **116** effects a swivel movement of the members **108**, **110** within the limits of the slots **102**, **104**.

A normally substantially vertical boom **120** is pivotally secured between the members **108**, **110** on a pivot pin **122**. A second hydraulic cylinder **124** is pivoted between said members at the opposite ends on a pivot **126**, and the cylinder has an extensible and retractable rod **128**. A pair of enlarged boom plates **130**, **132** are fixedly secured to the distal end of the boom **120** on opposite sides thereof, and the rod **128** is pivotally connected between the plates at **132**. An elongated arm **136** is pivoted between the boom plates at the ends thereof adjacent the leading shield section, at **138**. A third hydraulic cylinder **140** is pivotally mounted between the plates on pivot **142**, and its extensible and retractable member **144** is connected between a pair of arm plates **146**, **148**. A hoe, comprising a flat blade **150** arranged perpendicularly with respect to the longitudinal extent of the arm **136** is fixedly mounted on its outer end, and has rigidifying or reinforcing gussets of appropriate design. As will be understood from the foregoing, the extension and retraction of rod **128** moves the boom and arm forwardly and rearwardly, and the extension and retraction of rod **144** of cylinder **140** results in generally vertical digging strokes of the hoe. In FIG. **3**, it will be noted that downstrokes of the hoe against the material E to be excavated will result in a deposit of loosened material on the inclined plate **60**.

To convey the excavated material for discharge on mine cars M or other removal means, the invention provides a conveyance system generally identified by reference **152**. The conveyor in this form of the invention includes a frame having sides **154**, **156** and a horizontal support plate **158**. A series of jacks **160** are secured to the frame sides at appropriate locations and are adjusted such that the frame is inclined upwardly from front-to-rear. The conveyor further includes an endless chain **162** with a series of spaced crossbars **164** which serve to push material placed on the conveyor to its discharge end. The chain is trained about a sprocket on a cross axle **166**, mounted on the underside of the plate **60** adjacent to the slot **62** at one end, and at the discharge end of the conveyor about a drive sprocket on an axial **168** driven by a motor **170**. The excavated material E is pushed up the plate **60**, through the slot **62**, and from there onto the conveyor. It is pushed up the conveyor by the crosspieces to the discharge end thereof and into the car M.

As stated above, it has been assumed for purposes of description herein that an initial tunnel excavation has been accomplished prior to the institution of use of this apparatus and its method of forming and lining a tunnel. As a shield is placed in use, and advanced a measurable distance, for example, about 6 feet, a lining procedure is instituted. This procedure involves initially the laying in place a group of transverse base timbers **172** which rest on the base wall **80** of the trailing section of the shield.

A pair of elevator assemblies **174**, best shown in FIG. **6**, are employed next in the method. These assemblies **174**, which are identical to one another except as to positioning, are each mounted on a vertical channel member **176**. One such channel member is secured between the rebent portions **94** of the top and base walls **86**, **88** of the trailing section top and base walls, adjacent the opposite sides thereof, whereby an assembly **174** is provided at each side of the shield. Fixed to the channel **176** is an outer channel **178** having a vertical slot **180** extending from substantially its midsection length to its top. A boss **182** is provided at the base end of the outer channel, and a hydraulic cylinder **184** is connected thereto. The cylinder has an extensible and retractable rod **186**, and is of course supplied with suitable supply lines leading to the control bank **118**. The rod **186** has a clevis **188** on its outer end on which an elongated arm **190** is mounted. The arm **190** has a rectangular block **192** at one end thereof which is dimensioned to be slidable within the outer channel **178**, but is too great in size to pass through the slot **180**. The arm **190** extends through the slot, whereby upon extension and retraction of the rod **186**, the arm is raised and lowered. The control means for the elevation assembly is preferably arranged for simultaneous extension and retraction of each assembly. As a second step in the method hereof, a group of roof or rafter timbers **194**, each having slotted lower corners **196** are placed on the arms **190** and elevated into position above the previously placed base timbers **172**, as shown in FIG. **3**.

With the roof timbers **194** elevated to a position in which they bear against the top wall **78** of the trailing shield section, and the base timbers in place therebetween, side timbers **198**, **200** are forced into position. The side timbers are first positioned angularly in opposite pairs, with their upper ends being located in the slotted ends **196** of the roof timbers. A portable hydraulic cylinder **202** with an extensible member **204** is then employed to substantially simultaneously wedge the base ends of the side timbers into place. This frictionally engages the side timbers between the base and roof timbers, and the timbers are, of course, dimensioned for an extremely rigid connection. This procedure is best illustrated in FIG. **7** of the drawing.

The result of completion of the aforesaid process of timber placement results in the formation of tunnel lining or a completed conduit, up to a final course or stand of timbers disposed within the trailing shield section and indicated in the drawing at S. This final course of timbers coacts with the invention apparatus in providing means for advance of the shield. At convenient peripherally spaced positions, a series of push cylinders or jacks **204** are fixed in brackets **206** on the respective walls of the intermediate section of the shield. In FIG. 2, it will be observed that these may be, in the rectangular form of the invention herein shown, at the four corners of the device, with a center thrust cylinder positioned on the base. Each of said cylinders has an extensible and retractable rod **208** associated therewith and extended through suitable openings in the abutting flanges of the intermediate and trailing sections of the shield. Each of said rods has an abutment collar **210** which is engageable against the course S. The lining is, of course, immovable due to its manner of formation and also the fact that it is anchored at its terminal by suitable jack means or otherwise. Joint extension of all of the rods **208** therefore results in straight linear movement of the shield forwardly into the earth E. If one or more of the rods is not actuated with the others, the direction of movement is altered, thereby permitting a steering of course alteration of the manner of movement of the shield.

FIG. **8** of the drawing shows, in a nonlimiting example, one illustrative end use of the system. There, after installation of the timbers according to the invention, a concrete cradle is first poured over the base timbers. A pipe is positioned in the cradle, and a suitable grout fill employed to fill the void space between the pipe and the side and top timbers. Alternatively, if treated timbers are employed, the conduit formed in the practice of the method may be used as is.

I claim:

1. Apparatus in a system for the excavation and lining of subterranean tunnels, comprising:

I. A substantially rectangular shield having:
- a leading section with a base wall, sidewalls and a top wall;
- the top wall having a leading edge projecting forwardly and the base wall having a leading edge;
- the sidewalls having inclined leading edges connecting the leading edges of the top and base walls;
- an inclined plate mounted above the base wall and having a series of cutting teeth projecting forwardly of the leading edge thereof;
- the plate having an elevated discharge end extending inwardly and having side shield members vertically secured thereto;
- an intermediate shield section having base, top, and sidewalls common with the leading section, and having a structural member extending thereabout;
- the plate extending into the intermediate shield section;
- the base, top and sidewalls of the intermediate section terminating at interior, inwardly directed flanges;
- a trailing shield section having top, base and sidewalls coplanar with the respective top, base and sidewalls of the leading and intermediate shield sections;
- the sidewalls of the trailing shield section having flanges thereon which abut and are fixed to the flanges of the intermediate section;

II. Excavation apparatus comprising:
- a mounting plate secured to the top wall of the intermediate section;
- a swivel member connected to the mounting plate for limited rotary movement;
- a generally vertical boom assembly depending from said swivel member and movable therewith;
- first extensible and retractable hydraulic cylinder means connected to the flange of the top wall of the intermediate shield section and to the boom assembly;
- second extensible and retractable hydraulic cylinder means incorporated in the boom assembly for imparting from front to rear tilt in the assembly about its pivot on the swivel plate;
- an arm connected to the boom assembly for vertical pivotal movement, the arm having a cutting blade on its distal end;
- third extensible and retractable hydraulic cylinder means mounted between the arm and the boom assembly, whereby the plate is extendable in a cutting stroke forwardly to at least the leading edge of the top, base and sidewalls of the leading shield sections;

III. A conveyor for excavated material comprising:
- an elongated conveyor frame having a first end located below said elevated discharge end of the inclined plate;
- the frame having a second elevated end trailing the shield;
- support means for the frame; and
- an endless, chain-driven conveyor in the frame to convey material disposed thereon from the plate to a remote discharge location;

IV. A liner plank installation means comprising:
- a pair of brackets secured in vertical position on the flanges of the sidewalls of the trailing shield section, each bracket having an upper end and a lower end;
- each bracket having a vertically extending slot formed in its upper end and having an attachment adjacent its lower end;
- a hydraulic cylinder for each bracket having a stationary portion connected to said attachment and having an extensible rod portion with an exterior clevis thereon;
- an elongated support arm in each of said clevises, the support being perpendicularly related to the slide members on one end and having flattop surfaces;
- the slide members being slidably disposed in the brackets with the support arms extending through said slots whereby a series of roofing planks placed on the top surfaces are elevated to a position adjacent to the top wall of the trailing shield section;
- a lateral hydraulic cylinder portably mounted in the trailing shield section and extensible to a distance such that side planks are forced against the sidewall of the trailing shield section simultaneously; and

V. Shield advance means comprising:
- a series of spaced apart hydraulic cylinder assemblies, each including a fixed housing secured to one of the walls of the intermediate shield section and extensible rod member extended through openings formed in the abutting flanges of the intermediate and trailing shield sections; and
- the rod members having outer end sections engageable against the planks whereby extension of the rod forces the shield forwardly.

2. Apparatus in a system for the excavation and lining of subterranean tunnels, comprising:
- a polygonal shield including a leading section having base, side, and top walls, at least the base and top walls having leading edges;
- an inclined plate mounted above the base and having a remote discharge end;
- an intermediate shield section of polygonal form corresponding to that of the leading section and having corresponding base, top, and sidewalls;
- a trailing shield section having a base, top, and sidewalls corresponding to the respective base, top, and sidewalls of the leading and intermediate sections;
- excavation apparatus operatively disposed within the shield and including a mounting assembly secured to one of the walls of the shield;
- boom means pivotally mounted on the mounting assembly;
- means for swiveling the boom means and for tilting the boom means, the boom means including an arm with a cutting blade thereon;
- means for movement of the arm relative to the boom means;
- a conveyor assembly for excavated material including an elongated conveyor frame having a first end positioned to receive material from the inclined plate and a second discharge end;
- a conveyor in said frame to convey material deposited thereon from the plate;

liner plank installation means comprising plank elevator means, including power-actuated support arms, in the trailing shield section;

support arms having upper surfaces to receive roofing planks whereby upon elevation of the support arms, the roofing planks are elevated; and

means for the installation of side planks.

3. The invention of claim 2 wherein:

said means for installation of the side planks comprises portably mounted expansible cylinder means in the trailing shield section extensible to a distance such that side planks are forced against the sidewalls of the trailing shield section.

4. The invention of claim 3, and:

shield advance means comprising a series of spaced apart hydraulic cylinder assemblies, each including a fixed housing secured to one of the walls of the intermediate shield section and extensible rod members engageable against the planks where extension of the rods forces the shield forwardly.