Oct. 8, 1968 J. R. TABOR 3,404,920

TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

Filed July 13, 1966 6 Sheets-Sheet 1

Fig. 1

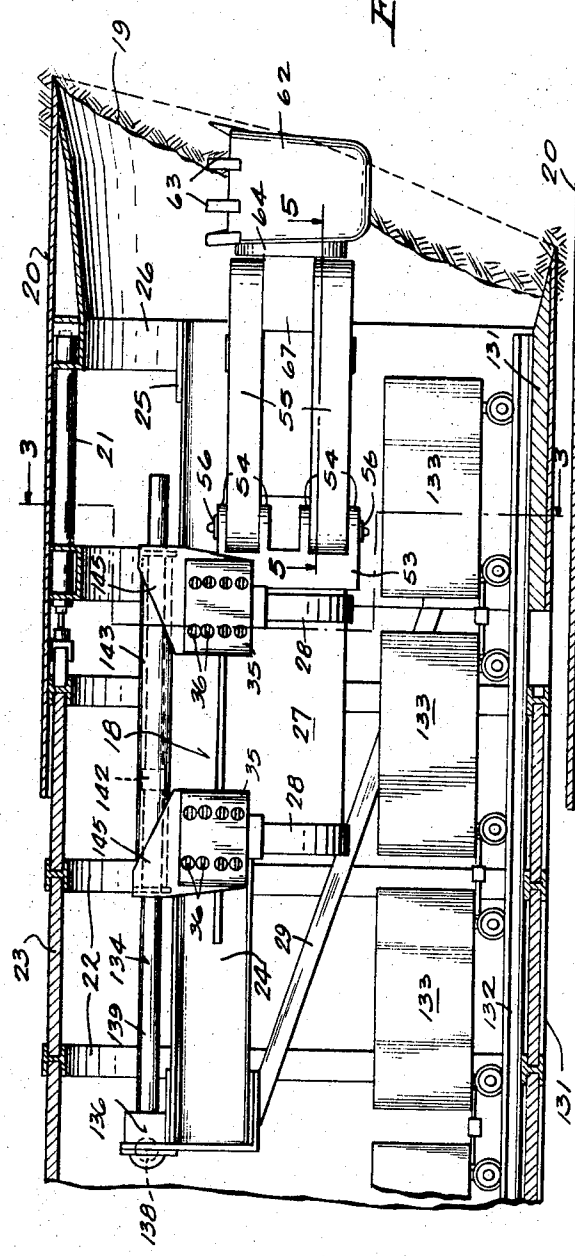
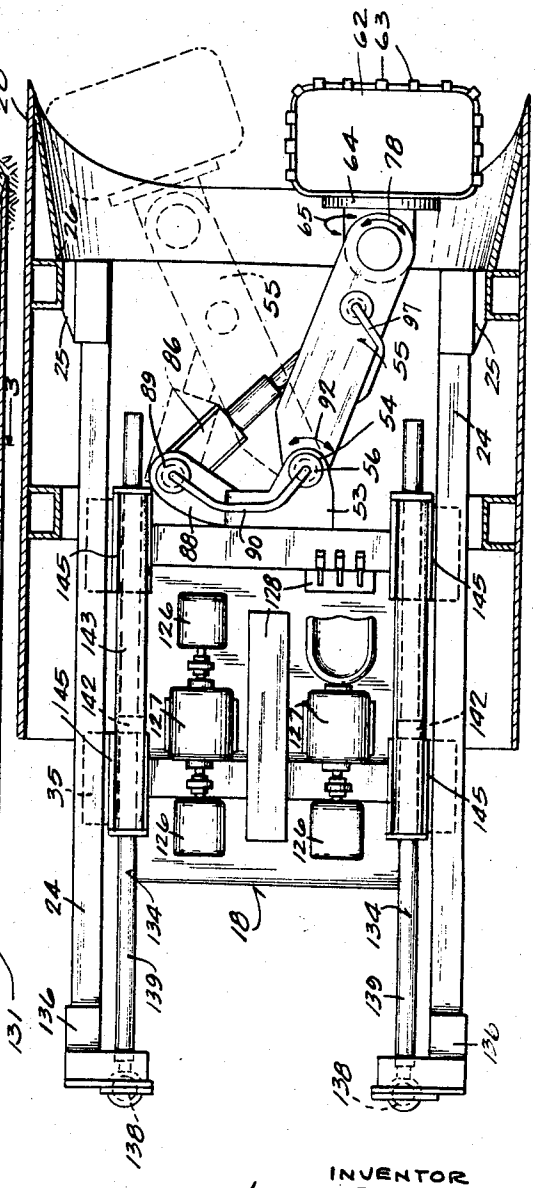


Fig. 2



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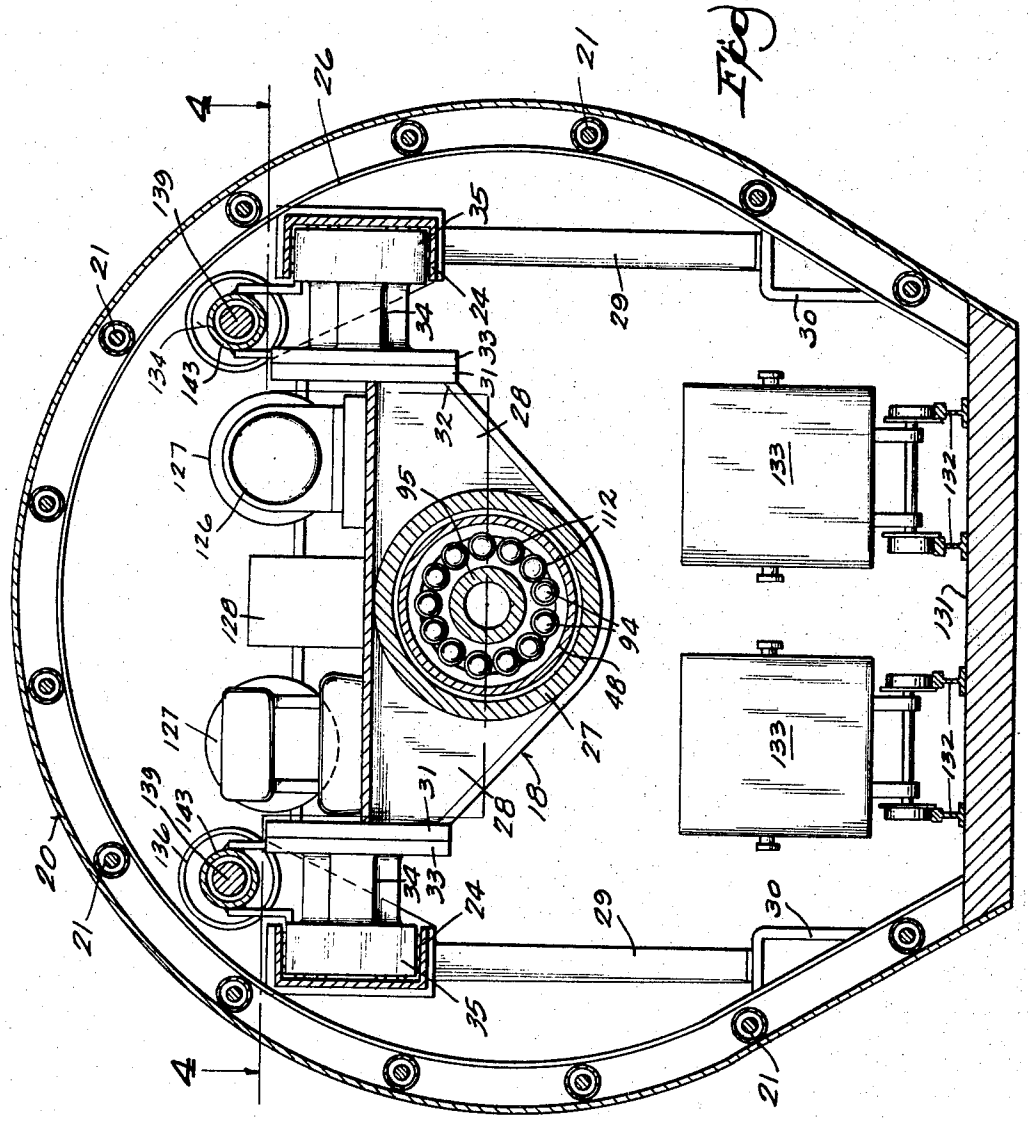
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ATTORNEYS

Oct. 8, 1968 J. R. TABOR 3,404,920

TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

Filed July 13, 1966 6 Sheets-Sheet 2

Fig. 3



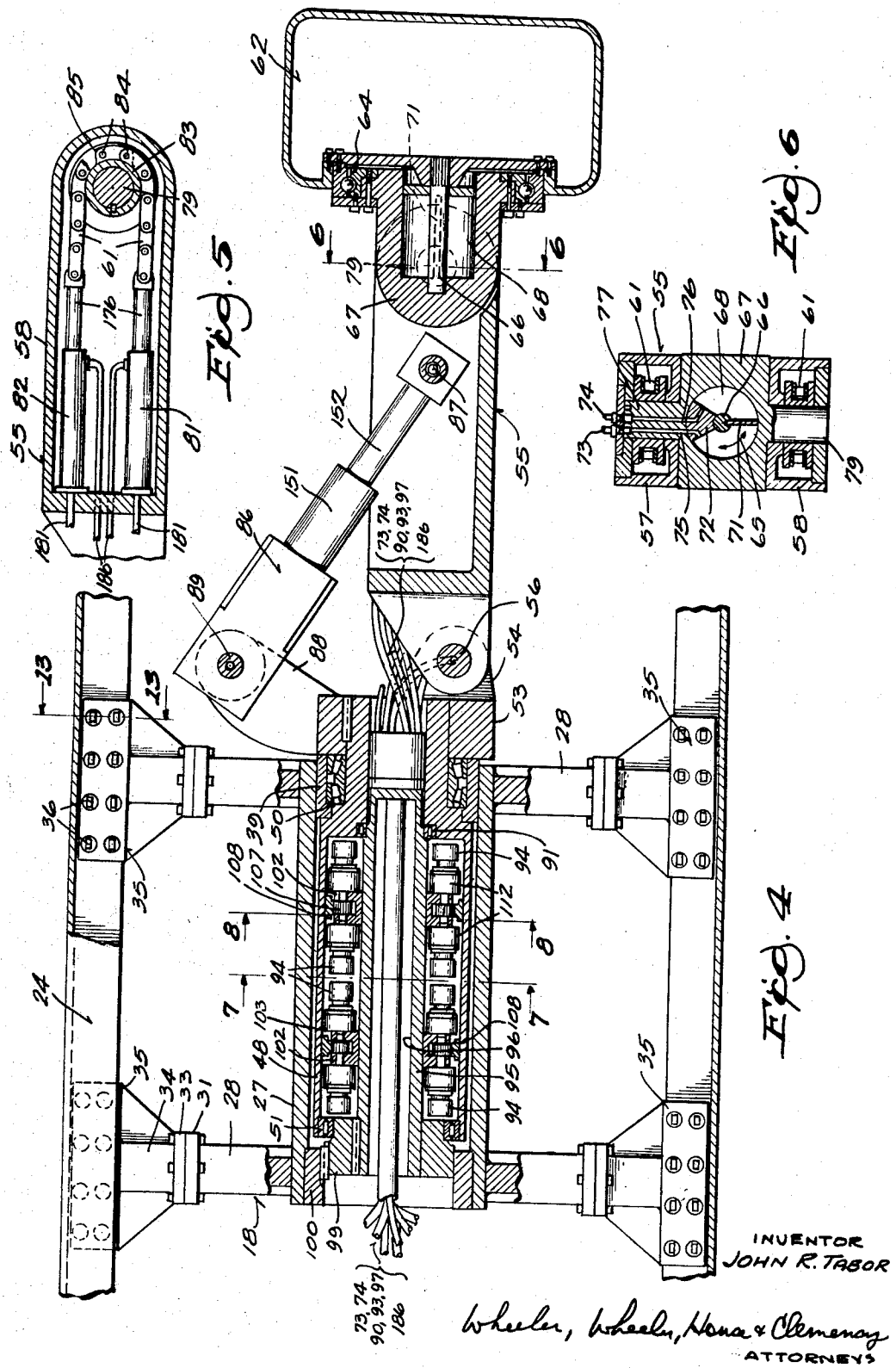
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TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

Filed July 13, 1966 6 Sheets-Sheet 3



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Oct. 8, 1968 J. R. TABOR 3,404,920

TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

Filed July 13, 1966 6 Sheets-Sheet 4

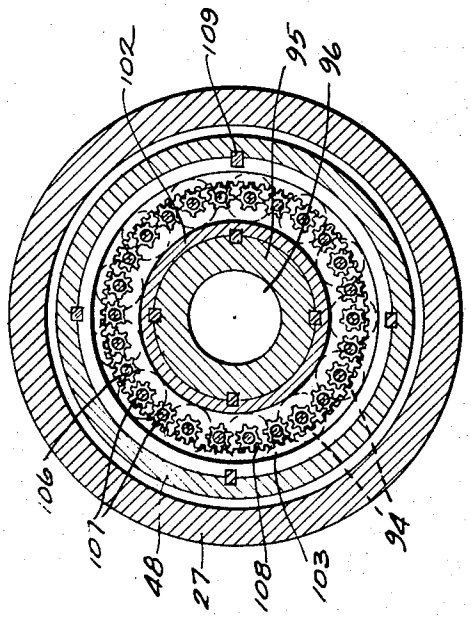


Fig. 8

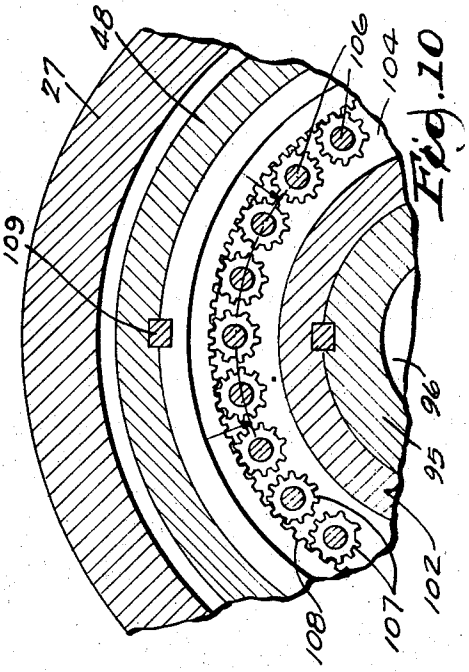


Fig. 10

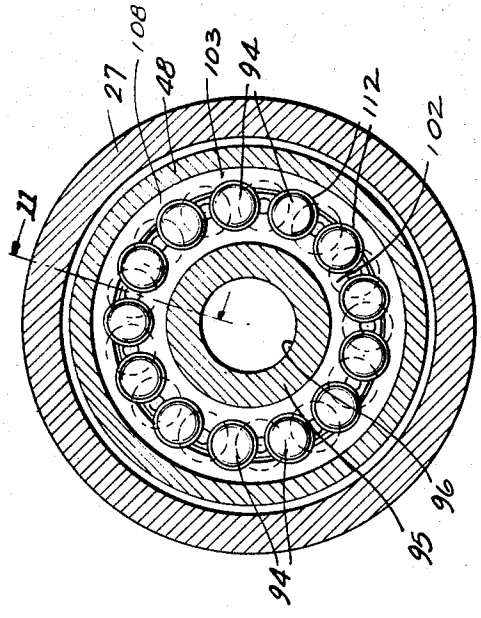


Fig. 7

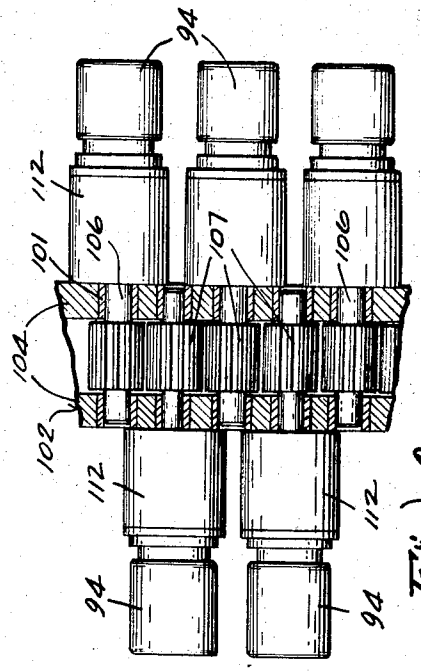


Fig. 9

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Oct. 8, 1968 J. R. TABOR 3,404,920

TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

Filed July 13, 1966 6 Sheets-Sheet 5

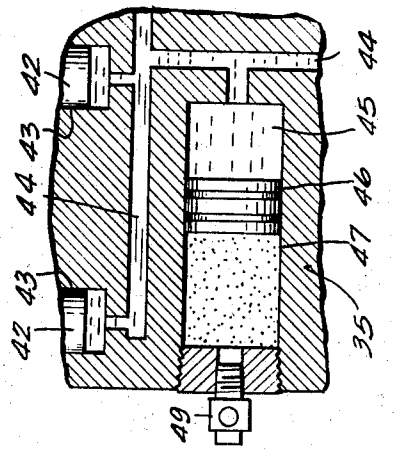


Fig. 15

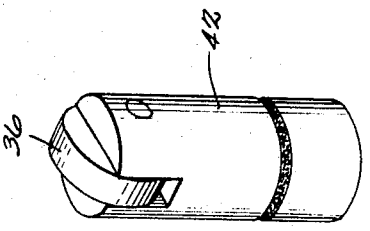


Fig. 14

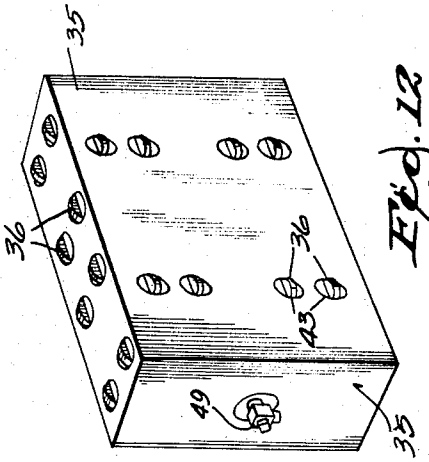


Fig. 12

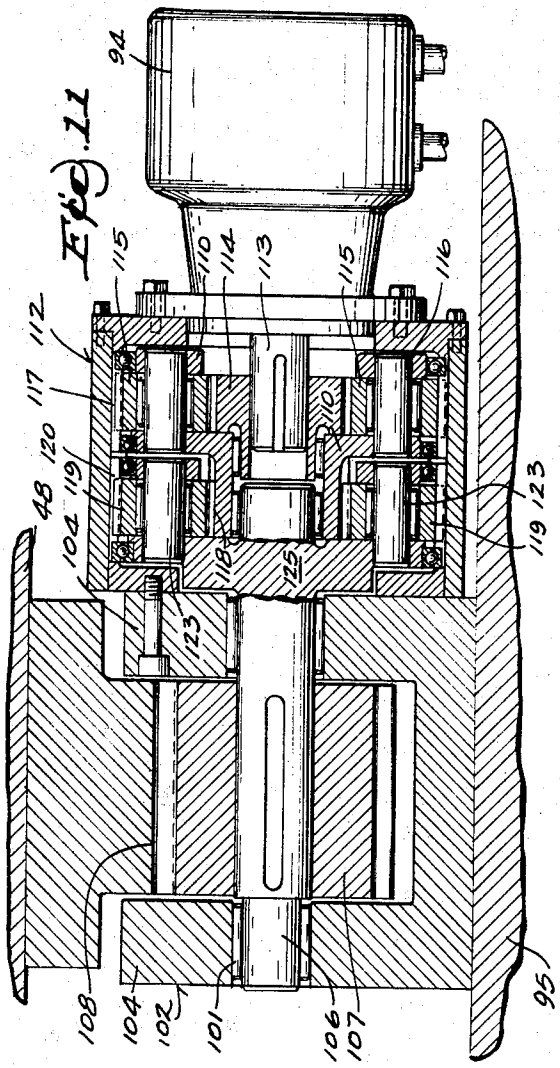


Fig. 11

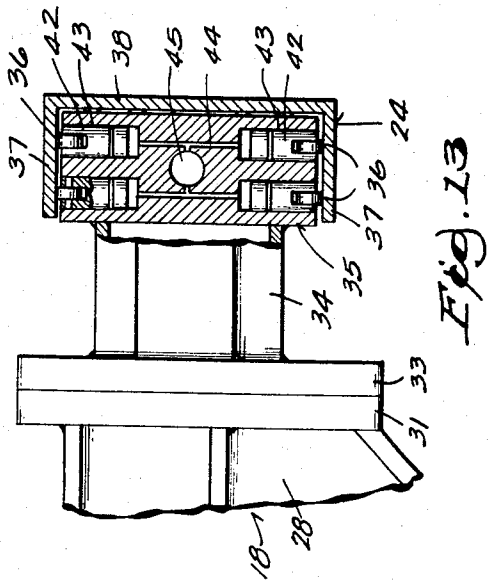


Fig. 13

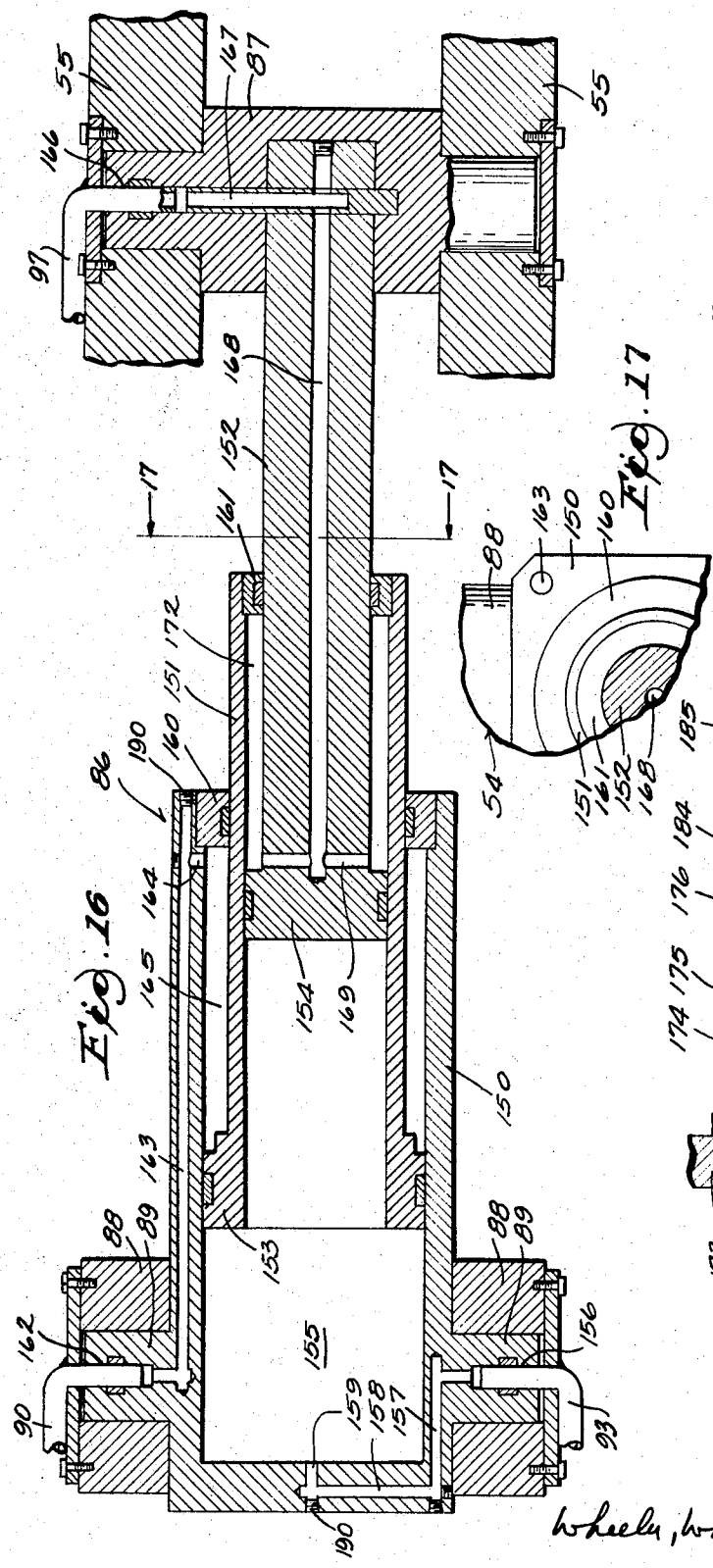
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Oct. 8, 1968 J. R. TABOR 3,404,920

TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

Filed July 13, 1966 6 Sheets-Sheet 6



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3,404,920

TUNNELING MACHINE WITH SHIELD SUPPORTED TRAVELING EXCAVATOR

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Filed July 13, 1966, Ser. No. 564,844
18 Claims. (Cl. 299—31)

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a tunneling machine comprising a tunneling shield, an excavator support mechanism on the shield and conveyed by the shield as it moves forwardly in the tunnel, a power operated excavator mounted on the support mechanism to be carried within the shield and conveyed by the shield, said excavator having a boom, a cutting tool and means for moving the cutting tool in all directions across the tunnel face.

This invention relates to a tunneling machine.

The tunneling machine of the present invention consists of a power operated excavator supported in elevated relation to the tunnel floor on the sides of a tunneling shield modified to bear tracks on its sides to support the excavator for movement with respect to the tunnel face. The machine of the present invention is particularly designed to tunnel through hard ground and fissured or broken rock.

An important feature of the tunneling machine of the present invention is the articulate mounting of the cutting tool by which it may be swung universally in all directions to cut the spoil from the face of the tunnel. Desirably, the cutting tool incorporates a bucket by which the spoil may be transported between the tunnel face and take out apparatus, such as mine boxes, carts, a belt conveyor or other conveyance apparatus.

By mounting the excavator on the shield, it will be conveyed forwardly in the tunnel automatically when the shield is moved forwardly and by the same apparatus which is used to periodically advance the shield. Moreover, the shield furnishes elevated support for the excavator. In this manner the utility of the shield is greatly enhanced. The shield becomes an integral part of the tunneling machine, while continuing to perform its conventional functions.

In the disclosed embodiment of the invention, the shield is provided with longitudinal tracks along its sides and about midway between its roof and floor. The excavator consists of a central rigid tubular frame or backbone having outrigger arms or beams with end carriages which ride on the shield tracks. Mechanism is provided to advance and retract the excavator on said tracks to and from the face of the tunnel, whereby to facilitate transfer of cut debris from the face to the take out apparatus.

The excavator of the present invention is power operated. It is adapted to be made in different sizes to operate in tunnels of various sizes. The excavator must cut and remove large amounts of heavy material. For this service, the machine has a heavy demand for power. The motors for tunneling machines embodying the invention, and adapted to work in tunnels from 12 to 24 feet in diameter, typically have an aggregate power requirement in the range of 350 H.P. Accordingly, all of the mechanism must be strong enough to transmit this much power. In a practical embodiment of the invention, the excavator weighs about 50 tons. Notwithstanding the high weight, strength and capacity of this device, its power transmission mechanism is concentrated into a relatively compact assembly within the tubular frame aforesaid. This frame is desirably disposed substantially at the central axis of the tunnel. Accordingly, there is ample clearance beneath the excavator for the take out apparatus and ample space about the central tubular frame for workmen. This structure also advantageously locates the boom and the cutting tool for easily reaching all areas of the tunnel face.

In preferred embodiments of the invention, the various working motors, such as rams, jacks and rotary motors, are hydraulically operated. Pressurized hydraulic fluid for these motors is provided by one or more hydraulic pumps actuated by one or more electric motors. This provides a convenient, simple and easily controlled power transmission for energizing the various parts of the mechanism. The electric motors are energized by a power cable extending to an energy source remote from the tunnel.

An advantageous feature of the hydraulically operated embodiments resides in the ducting of the hydraulic lines within the wall or body parts of the pistons, cylinders, etc., thus to eliminate as much as possible exposed hydraulic hoses and protect the lines from breakage hazards.

Other objects, features and advantages of the invention will appear from the following disclosure in which:

FIG. 1 is a view partially in vertical axial section and partially in side elevation of a tunnel showing a tunneling machine embodying the present invention in position for use.

FIG. 2 is another view of the apparatus of FIG. 1, partially in horizontal axial section and partially in plan. Various positions of the cutting tool, its support boom and its rotatable head are illustrated in this figure.

FIG. 3 is a lateral cross section taken along the line **3—3** of FIG. 1.

FIG. 4 is an enlarged fragmentary horizontal cross section, as along the line **4—4** of FIG. 3.

FIG. 5 is a cross section taken through one of the chain housings of the boom, substantially along the line **5—5** of FIG. 1.

FIG. 6 is a cross section taken along the line **6—6** of FIG. 4.

FIG. 7 is a cross section taken along the line **7—7** of FIG. 4.

FIG. 8 is a cross section taken along the line **8—8** of FIG. 4.

FIG. 9 is a detailed view, partly in cross section and partly in elevation, showing the power transmission arrangement of hydraulic motors, gear reducers and feed pinions by which the head sleeve or neck within the frame tube is rotated.

FIG. 10 is a fragmentary, greatly enlarged view similar to FIG. 8.

FIG. 11 is an enlarged cross section taken along the line **11—11** of FIG. 7, showing details of the gear reduction mechanism between the hydraulic motors for the rotating head sleeve and the drive pinions therefor.

FIG. 12 is a perspective view of one of the end carriages on which the excavator is supported from a track on the tunneling shield.

FIG. 13 is a fragmentary vertical cross section taken along the line **13—13** of FIG. 4.

FIG. 14 is an enlarged perspective view of one of the wheels in the carriage and the fluid actuated piston on which it is mounted.

FIG. 15 is an enlarged cross section taken through the carriage and showing the pressure system for maintaining pressure on the carriage wheels.

FIG. 16 is an enlarged cross section taken through the hydraulic motor or ram which swings the boom.

FIG. 17 is a fragmentary cross section taken along the line **17—17** of FIG. 16.

FIG. 18 is an enlarged cross section taken through one of the hydraulic motors in the chain case of FIG. 5.

Although the disclosure hereof is detailed and exact to

enable those skilled in the art to practice the invention, the physical embodiments herein disclosed merely exemplify the invention which may be embodied in other specific structure. The scope of the invention is defined in the claims hereto.

As shown in FIG. 1, excavation of the tunnel is facilitated by a conventional shield **20** which is periodically shoved forwardly toward the tunnel face **19** by hydraulic motor rams **21**. As the shield **20** is moved forwardly through the tunnel, the excavated part of the tunnel behind the shield is supported by curved ribs or beams **22** and wooden or steel lagging or plates **23**. This is conventional in the tunneling art. The rams **21** react against the most recently emplaced rib **22** in thrusting the shield **20** forwardly. The excavated spoil or earth debris is moved rearwardly through the shield on mine cars or other means of conveyance.

The tunneling machine of the present invention comprises an excavator **18** mounted on channel-shaped tracks **24** which face inwardly toward the center axis of the shield and which are mounted on brackets **25** to ribs **26** within the shield **20**. The excavator **18** is novel in construction and comprises a tubular frame **27** which functions as a rigid backbone or body for the excavator.

Tracks **24** are desirably further supported near their rear ends by struts **29** which are disposed obliquely as shown in FIG. 1. The ends of struts **29** remote from tracks **24** are supported on brackets **30** attached to the ribs **26** near their foot ends. Tracks **24** are desirably disposed somewhat above the center axis of the tunnel shield, to clear as much working space therebelow as possible.

Tubular frame **27** is elevated above the shield floor by outrigger beams or arms **28** which extend laterally toward the tracks **24**. Arms **28** have coupling plates **31** removably attached by bolts **32** or the like to complementary plates **33** on stub beams or arms **34** which carry at their ends carriages **35** from which project a plurality of wheels **36** in pressure contact with the side flanges **37** and connecting web **38** of the track **24**. See FIG. 13.

Each wheel **36** is mounted for rotation on its motor piston **42**. The respective motor pistons **42** are movable in respective cylinders **43** within the carriage **35**. The several cylinders **43** are connected by ducts **44** with a hydraulic fluid chamber **45** having a free piston **46** subject to the pressure of nitrogen gas or the like in piston cylinder chamber **47**. The nitrogen gas is under pressure of about 2000 p.s.i. The gas is furnished under pressure through valve **49**. Accordingly, the respective wheels **36** are biased under considerable pressure against the channel track **24** to take up any slack between the track walls and the carriage.

Within its tubular backbone **27**, the excavator **18** is provided with a rotatable sleeve **48** journaled for rotation on the anti-friction bearings **50**, **51**. Front end bearing **50** is supported on annular ring **39** which aligns laterally with the forward set of outrigger beams **28**, to receive direct bracing support therefrom. Rear end bearing **51** receives support from tail block **99** mounted within the tube **27** on support ring **100** which aligns with the rearward set of outrigger beams **28** to receive direct support therefrom.

The end of sleeve **48** projecting frontally beyond front bearing **50** is provided with a rotary head **53**. Two sets of paired ears **54** project forwardly from the head **53** and at one side of the axis of head rotation. An excavator boom **55** is pivotally connected on the ears **54** by pins **56**. The boom has two housing portions **57**, **58** which respectively contain bucket drive chains **61**, as shown in FIG. 5. At the end of the boom **55** is mounted a bucket **62** which has earth cutting teeth **63**. The bucket and teeth are typical of a cutting tool with which the boom can be provided. The toothed bucket will not only cut into the tunnel face **19** to remove earth and debris therefrom, but will convey rearwardly the cut material in the bucket as will hereinafter be described.

Bucket **62** is rotatable on bearing **64**, as shown in FIGS. 2 and 4, in the direction of arrows **65**, through about 340°. The bucket **62** has a shaft **66** which extends rearwardly from the bucket into bracket **67** by which the bucket is mounted on the boom **55**, and which also provides an internal cylindrical chamber **68** for a hydraulic motor. See FIG. 6. The bucket shaft **66** has a vane **71** projecting across the chamber **68**. The chamber has a fixed vane or partition **72** to either side of which hydraulic fluid may be admitted through the hydraulic lines **73**, **74** through the ducts **75**, **76**.

Body bracket **67** is mounted to the boom **55** on transverse stub pintles **77**, **79** which project into the boom chain housings **57**, **58**, and which turn in the direction of arrows **78** in FIG. 2, through about 180°. The pintles **77**, **79** are rotated by respective sets of hydraulic motors **81**, **82** in the chain cases **57**, **58**, as shown in FIG. 5. The pistons of the motors **81**, **82** are connected to the chains **61** which respectively are connected to the coupling rings **83** respectively fastened to the pintles **77**, **79**. The chain links are fastened to end pins **84** in ears **85** projecting laterally from the rings **83**.

There is chain **61** in each housing **57**, **58** with corresponding hydraulic cylinders **81**, **82**. Hydraulic fluid under pressure is communicated to the cylinders **81**, **82** through piping **97**.

The boom **55** may be swung about the axis of its support pintles **56** by the hydraulic motor ram **86** which is connected to the boom **55** on pin **87**, and by pin **89** to ears **88** which extend laterally from head **53**. Jack **86** is provided with hydraulic fluid through piping **90**, **93**, **97**. Accordingly, the boom **55** may be rotated about the pins **56** as indicated by the arrows **92** in FIG. 2, through about 120°.

The rotatable sleeve **48** in the fixed tube **27** is rotated by a plurality of hydraulic rotary motors **94**, shown in FIGS. 7 through 11. In a practical embodiment of the invention, there are some fifty-two of these motors **94** clustered about a central tube **95** which is fast to the stationary tail block **99**, and thence to tube **27** through ring **100**, and is shouldered at **91** to bear on rotary sleeve **48**. Stationary tube **95** has a hollow interior **96** which provides a conduit for the hydraulic lines **97**, **98**, etc.

The central, fixed tube **95** is coaxial with and is radially spaced from rotatable sleeve **48** so that there is an annular space or chamber **103** therebetween. The motors **94** and the associated transmission mechanism are mounted in said annular space **103**.

In the disclosed embodiment, fixed central tube **95** is provided with two axially spaced annular channels **102** respectively having axially spaced flanges **104** which have sleeve bearings **101** (FIG. 9) for the respective shafts **106** of an annular series of toothed pinions **107**. Each annular series of pinions **107** mesh as with a ring gear **108** which is fast by locking keys **109** to inside of sleeve **48**.

There are speed reducing gear transmission sets **112** between each motor **94** and its driven pinion **107**, as best shown in FIGS. 9 and 11. The details of each transmission gear set **112** is broadly immaterial, the structure herein shown being for exemplification only. Each hydraulic motor **94** has a shaft **113** and pinion **114** fixed thereon. Pinion **114** meshes with a series of arcuately disposed pinions **115**, each having a shaft **116** mounted on a cage **110** having an axially extending gear **118**. Each pinion **115** also meshes with the teeth on a ring gear **117** on the inside of housing **112**. Pinions **115** walk around the ring gear **117** and rotate the cage **110**, thus to turn its gear **118**.

There is a second cage **125** with a set of pinions **119** which walk around the inside of another ring gear **120** on the inside of housing **112**, as pinions **119** are turned on their shafts **123** by gear **118**. Cage **125** has an output shaft **106** keyed to a drive pinion **107**. Accordingly, the

hydraulic motors **94** can be driven at relatively high speed, the speed being greatly reduced at the output pinions **107**. As is shown in FIG. 4, there may be several circular rows of motors **94** clustered about the central, fixed tube **95**, four rows being shown in FIG. 4. The motors **94** and transmission **112** are staggered at opposite sides of the channels **102**. Accordingly, power is transmitted from the hydraulic motors **94** smoothly to many points of power transmitting thrust contact with the sleeve **48**.

Hydraulic fluid for pressurizing the various hydraulic motors derives from one or more pumps **126** driven by one or more electric motors **127**. Pump output goes through a control valve console **128** by which the fluid is directed and controlled for each of the hydraulic motors above referred to, as through lines **97**, **98**, etc.

As shown in FIGS. 1 and 3, the excavator is elevated from floor **131** of the tunnel. This places it substantially on the center axis of the tunnel so that the toothed bucket **62** can most conveniently reach all parts of the tunnel face **19**. Tunnel floor **131** may be provided with tracks **132** for mine cars **133** by which earth and other debris removed from the tunnel face **19** can be taken out of the tunnel and disposed of. Alternatively, a conveyor belt or the like may function as take out apparatus as a substitute for the tracks **132** and mine cars **133**. In any event, the tubular frame **27** of the machine is desirably elevated clear of the floor and is disposed in compact array near the axis of the tunnel so as to leave room therebeneath for the mine cars or the belt conveyor, and to provide ample room about the machine for movement of operation personnel.

The excavator **18** may be advanced and retracted longitudinally of the tunnel on the channel tracks **24**. This movement is also desirably powered hydraulically. For this purpose, hydraulic rams **134** are provided at each side of the machine. For each ram **134** there is a bracket **136** attached to the tail end of corresponding track **24**. Bracket **136** has a coupling **138**, such as a ball joint, to the end of piston rod **139** of the jack **134**. Each jack **134** desirably has a piston **142** movable in jack cylinder **143**. Cylinder **143** has hydraulic fluid at both sides of piston **142**, under control of the valve console **128**. Cylinders **143** are attached to the excavator arms **34** by brackets **145**.

Accordingly, the excavator **18** may be moved longitudinally of the shield. In a practical embodiment, the range of movement is twelve feet and six inches.

In operation, the excavator bucket **36** is manipulated by an operator at console **128** to excavate the tunnel face. The boom **55** can swing laterally about pivot pins **54**. The boom may also rotate about the axis of rotation of the sleeve **48**. The bucket **62** is not only rotatable on its ring bearing **64**, but can be swung about the axis of pintles **77**. Accordingly, the cutting tool is subject to universal movement for good control of excavating motions thereof. A full bucket can be retracted by the hydraulic motors **134** to deposit the bucket load in a mine car **133** or on a conveyor belt or the like. Advance of the shield under pressure of hydraulic jacks **21** concurrently advances the excavator **18**.

The excavator **18** could be supported on mechanism other than the tracks **24**, for example, on a conventional jumbo or on tracks laid on the tunnel floor. However, the disclosed embodiment in which the excavator is mounted from tracks on the side of the shield **20** has the advantages aforestated which make the disclosed embodiment greatly preferred.

FIG. 16 shows details of the double-acting multi-stage hydraulic motor or ram **86** for actuating the excavator boom **55**. This figure illustrates an important feature of the invention in which the hydraulic lines from the pump **126** are protected from injury by ducting the lines within the walls of the hydraulic motor parts, such as the cylinder, piston, etc.

Motor **86** comprises a base cylinder **150** which is pivotally mounted on the support ears **88** on pintles **89**. Within cylinder **150** is an annular piston **153** which supports one end of a sleeve cylinder **151** which is slidable in ring bearing **160** at the end of cylinder **150**. Within the sleeve **151** there is another piston **154** which supports one end of piston rod **152** which is slidable in ring bearing **161** at the end of sleeve cylinder **151**. The end of rod **152** carries the pintle **87** which is connected to suitable bearings on the boom **55**.

Hydraulic fluid is supplied from pumps **126** to the chamber **155** within cylinder **150** through the fluid line **93** through a rotary bearing **156** in pintle **89**, and through ducts **157**, **158**, **159** formed in the wall of the cylinder **150**. Pressure within chamber **155** is exerted on both the annular piston **153** for sleeve cylinder **151** and on the piston **154** for the rod **152**, whereby to extend the ram **86** and swing boom **55**.

Means are provided for retraction of the motor **86** in two stages and at selected different speeds. For one stage hydraulic fluid is furnished from pipe **90** through the rotary bearing **162** in the other pintle **89** and through the ducts **163** and **164** to an annular space or chamber **165** between cylinders **150** and **151**. Pressure in chamber **165** will move the sleeve cylinder **151** to the left in FIG. 16. Fluid trapped in chamber **155** will be exhausted through line **93**.

For another stage of motor retraction fluid pressure is derived through line **97** which is coupled to the pintle **87** on the rotatable coupling **166** and through the internal ducts **167**, **168**, **169** into a chamber **172** formed between the piston rod **152** and the sleeve cylinder **151**. Pressure in chamber **172** will be exerted on piston **154** to move the rod **152** to the left in FIG. 16 for additional retractive movement of the motor **86**. If the pipes **90**, **97** are pressurized independently, the motor **86** will retract slowly. If pipes **90**, **97** are pressurized concurrently, motor **86** will retract rapidly.

An important feature of the invention resides in the internal ducting, as above described, within the walls or bodies of the various cylinders and pistons, thus to protect these ducts from injury or damage. Accordingly, hydraulic hoses which might otherwise be exposed to breakage and injury are eliminated.

FIG. 18 illustrates one of the two hydraulic motors **81**, **82** incorporated in the respective chain cases **57**, **58**, as shown in FIG. 5. Motor **81** is illustrated. It is connected at one end to a link of the chain **61**, and at its other end to an end wall **173** of the chain case.

Means are provided producing selected multiple force motor action. For this purpose, motor **81** comprises a base cylinder **174** having therewithin a piston **175** which carries one end of a sleeve **176** which functions as a piston rod, which slides in bearing **170** at the other end of cylinder **174**. The exposed end of rod **176** carries an end head **177** which is coupled to the chain **61** on pin **178**. Fixed within the motor **81** is a hydraulic fluid tube **181** which carries at its end a fixed position piston **182** which is within the chamber **183** of sleeve **176**. One stage of hydraulic fluid is admitted to the motor through the tube **181** and is ported into a chamber **184** at one side of the fixed piston **182** through end ducts **185**, thus to exert pressure on movable piston **175** and pull the chain to the left, as shown in FIG. 18.

Additional pressure can be supplied through pipe **186** to chamber **187** between cylinders **174**, **176**, thus to exert further pressure on the piston **175** to move it to the left. Controls are provided to pressurize chambers **187** and **184** independently or concurrently to vary the total force exerted by the motor **81** on the chain **61**.

The respective motors **81**, **82** are single acting and have a working stroke in one direction only to pull on the chain **61**. When one motor pulls the other is de-actuated, and it is pulled along with the chain. Accordingly, the chain will travel in the direction in which it is pulled by

one or the other of the motors **81**, **82**, thus to turn post **79** and swing the bucket **62**.

The ends of the several internal ducts **157**, **158**, **159**, **163**, **164** in FIG. 16 are closed by threaded plugs **190**, the ends of which are desirably flush with the outer wall of the part to which they are attached.

What is claimed is:

1. A tunneling machine comprising:

a tunneling shield disposed on a substantially horizontal axis and having a roof for supporting earth over an excavated part of the tunnel,

excavator support mechanism on said shield and conveyed by said shield as the shield moves forward in the tunnel,

a power operated excavator mounted on said support mechanism to be carried within the shield and conveyed by the shield,

said excavator comprising a frame, a bottom extending forwardly of the frame, a cutting tool on the boom to remove spoil from the tunnel face, and

means for moving the cutting tool in all directions across the tunnel face.

2. The tunneling machine of claim **1** in which the tool comprises a bucket, said support mechanism comprising a track longitudinal of the shield and on which the excavator is retractable from the tunnel face to deposit a bucket load on take out apparatus spaced rearwardly from the tunnel face.

3. The tunneling machine of claim **1** in which the excavator frame comprises a central rotor on which the boom is mounted and a bearing on which the rotor turns on an axis longitudinal of the tunnel.

4. The machine of claim **1** in which the excavator frame comprises a rigid tube, outrigger arms supporting said tube from said support mechanism substantially at the center of the shield, a rotor journaled on said tube, a motor to turn the rotor, and a coupling between the rotor and the boom.

5. The machine of claim **1** in which said support mechanism comprises a track longitudinal of the shield, said frame having wheeled support means movable along said track, and a motor reacting between the shield and frame for advancing and retracting said frame on said track with respect to the tunnel face.

6. The tunneling machine of claim **1** in combination with a hydraulically powered motor to swing the boom, a pump for hydraulic fluid and a hydraulic line from the pump to the motor, said motor comprising a cylinder having a wall, said line comprising a duct within said wall whereby the wall shields the line duct from injury.

7. The machine of claim **1** in which the said support mechanism comprises tracks mounted on the sides of the shield, the excavator being disposed substantially at the center of the shield in the space between said tracks and having laterally projecting outrigger arms with wheeled carriages movable along said tracks.

8. The machine of claim **7** in which said wheels are provided with means for pressing them against their respective tracks.

9. A tunneling machine excavator comprising:

a tube,

a support to hold the tube on a substantially horizontal axis,

a rotor journaled in the tube for rotation on said substantially horizontal axis,

motor means to turn the rotor,

a boom pivotally connected to the rotor,

a cutting tool pivotally connected to the end of the boom,

a motor for pivotally moving the boom about its connection to the rotor,

and a motor for pivotally moving the tool about its connection to the boom.

10. The excavator of claim **9** in which the support for the tube comprises laterally extending outrigger arms, carriages at the ends of said arms, wheels on the carriages and motors to project the wheels from the carriages for pressure contact with a track.

11. The excavator of claim **9** in which the support for the tube comprises front and rear sets of paired, laterally extending outrigger arms, and front and rear journals for said rotor respectively proximate said sets of arms to receive loading support therefrom.

12. The excavator of claim **8** in combination with a tunneling shield, tracks spaced at the sides of the shield, the support for the tube comprising laterally projecting outrigger arms to support the tube in the space between said tracks, said arms having end carriages carried on said tracks and a motor for moving said excavator along said tracks.

13. The combination of claim **12** in which the tracks comprise inwardly facing channels in which the carriages fit.

14. The combination of claim **12** in which said motor comprises a jack between said track and said excavator.

15. A tunneling machine excavator comprising a tube, a support for the tube, a rotor journaled in the tube, motor means to turn the rotor, a boom pivotally connected to the rotor, a cutting tool pivotally connected to the end of the boom, a motor for pivotally moving the boom about its connection to the rotor, and a motor for pivotally moving the tool about its connection to the boom, a sleeve coaxially within the tube, another tube coaxial with said tube and sleeve and spaced radially inwardly with respect to said sleeve to leave an annular space therebetween, said motor means comprising a plurality of motors distributed annularly in said space about said other tube.

16. A tunneling machine comprising a shield, an excavator in the shield, said excavator having a boom and a cutting tool at the end of the boom, a hydraulically powered motor to swing the boom, said motor comprising a ram having multiple telescopically retractable sections and a multiple of fluid chambers corresponding to the number of telescopically retractable sections and means for independently or concurrently pressurizing said chambers for selected multiple speed ram action.

17. A tunneling machine comprising a shield, an excavator in the shield, said excavator having a boom, a cutting tool at the end of the boom, and hydraulically powered motor means to swing the cutting tool at the end of the boom, said motor means having multiple telescopically related sections and a multiple of fluid chambers corresponding to the number of telescopically related sections and means for independently or concurrently pressurizing said chambers for selected multiple force motor action.

18. The tunneling machine of claim **17** in which the cutting tool is mounted on the boom on a pintle, a chain about said pintle, said motor means comprising two hydraulic motors, one at each end of the chain, each said motor having multiple telescopically related sections and multiple fluid chambers.

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U.S. DEPARTMENT OF COMMERCE

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,404,920 October 8, 1968

John R. Tabor

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 18, "bottom" should read -- boom --.

Signed and sealed this 3rd day of March 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents