

May 20, 1969

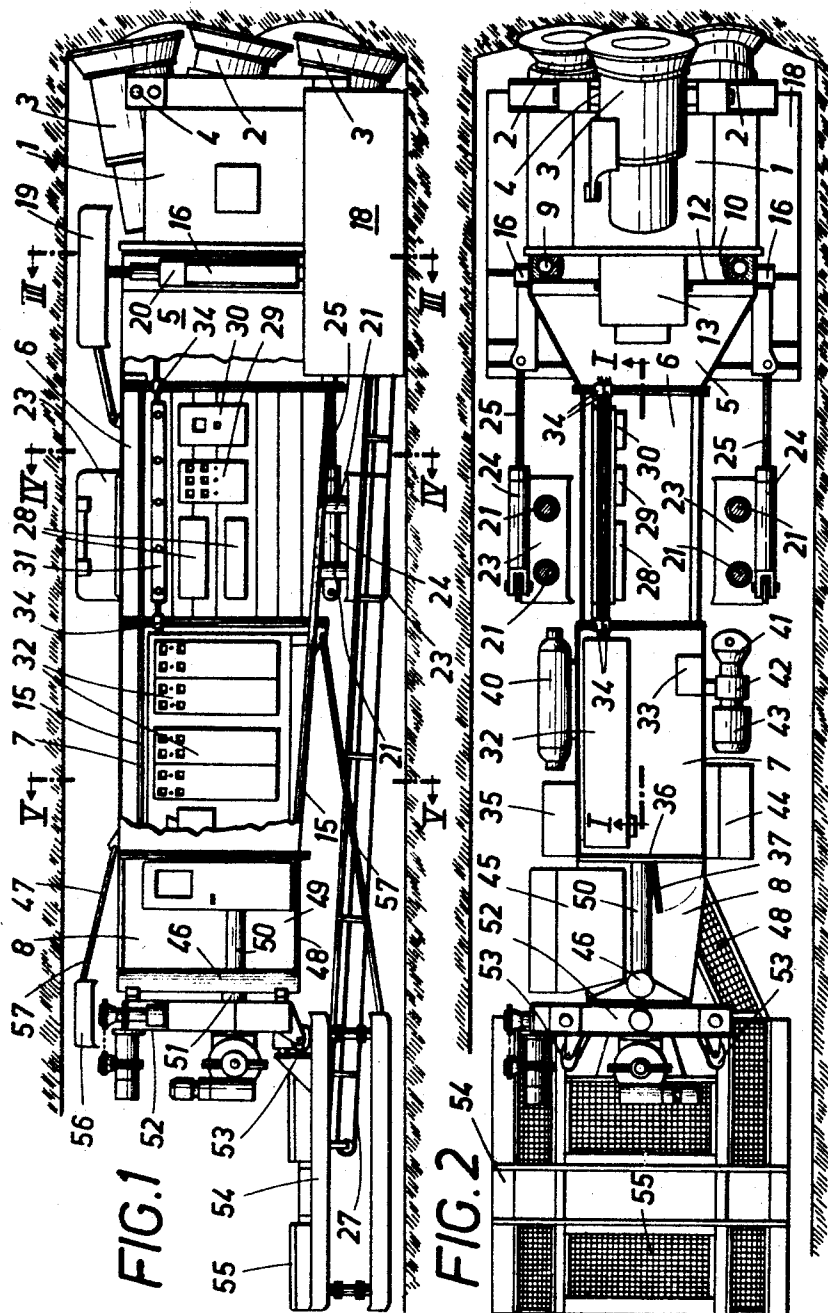
E. LAUBER

3,445,137

SECTIONAL TUNNEL BORING MACHINE

Filed March 10, 1967

Sheet / of 2



INVENTOR.

ERNST LAUBER

BY

Kurt Kelman

AGENT

May 20, 1969

E. LAUBER

3,445,137

SECTIONAL TUNNEL BORING MACHINE

filed March 10, 1967

Sheet 2 of 2

FIG. 3

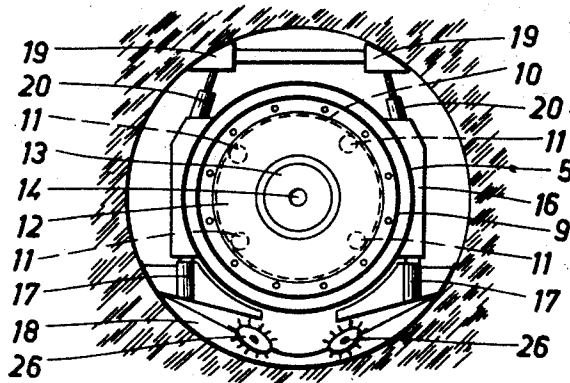


FIG. 4

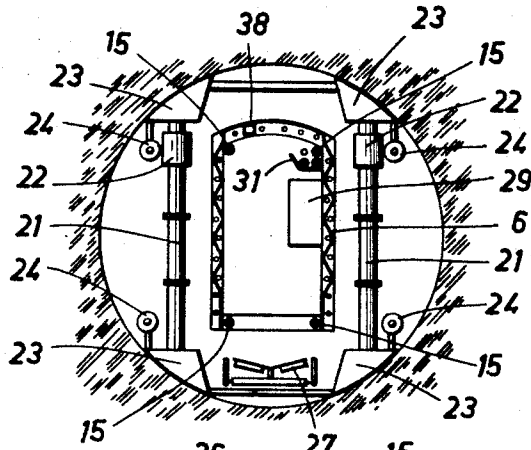
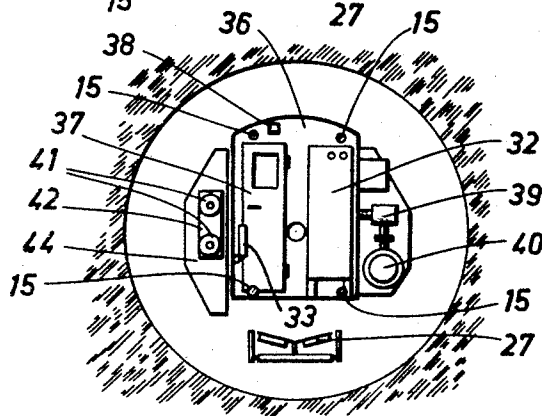


FIG. 5



INVENTOR.
ERNST LAUBER
BY *Kurt Kelman*
AGENT

1

3,445,137

SECTIONAL TUNNEL BORING MACHINE

Ernst Lauber, Thun, Switzerland, assignor to Maschinenfabrik Habegger AG., Thun, Switzerland

Filed Mar. 10, 1967, Ser. No. 622,155

Claims priority, application Germany, Mar. 25, 1966, M 68,904

Int. Cl. E21c 29/00, 27/20; E21d 9/00

U.S. Cl. 299—31

6 Claims

ABSTRACT OF THE DISCLOSURE

The machine body is composed of a plurality of flange-connected tubular sections. The tools are carried by a drum, which is rotatably connected to the axially outer end of the leading tubular section by a thrust and radial anti-friction bearing conforming to the diameter of the drum.

This invention relates to a machine for driving tunnels, which machine comprises a machine body, that is supported in the tunnel, and a drum, which is rotatably mounted at the forward end of the machine body and carries the tools. In a known tunnel driving machine, the body of the machine consists of a strong rectangular frame, which is disposed below the axis of the drum and carries lateral crawlers for feeding the machine. The frame carries the bearing for the drum and the means for driving the drum, as well as the transmission for driving the working tools. The crawlers may be replaced by wheels, which are mounted in the frame and adapted to be driven. In another embodiment, supporting and control skids rather than the running gear are secured to the frame and slide on the floor of the tunnel, and hydraulic jacks bearing on the tunnel effect the feed movement. This design of the machine body as a frame has the important disadvantage that highly unfavorable conditions are obtained as regards the transmission of the considerable axial and cutting forces from the bearing for the drum to the frame, which is disposed on a lower level. These forces must be rearwardly and downwardly transmitted so that the rigidity of the means for mounting and supporting the drum is adversely affected.

It is also known to provide as a machine body a central spine, which has a square or round cross-section, and to connect two sets of four arms, which are telescopically adjustable to the forward and rear ends of the spine, which sets of arms carry crawlers, rollers or skids. This design involves a highly unfavorable deflection of the axial and cutting forces from the large diameter of the drum through the bearing, which is mounted at the forward end of the central spine, to the relatively small cross-section of this spine. The spine is long and heavy and involves difficulties in the assembly and transport of the machine. Nevertheless, the bending strength which is required for a rigid machine is not achieved. Besides, the electrical and hydraulic switching and control equipment, which is required for the operation of the machine, is exposed although said equipment is highly delicate in most cases, and the operator of the machine is not adequately protected from dust, heat and noise. Owing to the restricted space, the assembling of the various units for driving the drum and for feeding the machine, removing the detached material, cooling, etc., on the central spine is difficult and time-consuming. For maintenance and repairs, the units are accessible only with difficulty and it is often necessary to knock down the entire machine when individual important parts are to be removed.

It is an object of the invention to eliminate these disadvantages and to provide a machine which is suitable for driving tunnels and which has a particularly rigid and

2

rugged structure, such as is required for driving a tunnel in rock with the aid of a machine, whereas the machine can easily be knocked down, assembled and transported, and can be adjusted to different tunnel diameters and adapted for use with different excavating and material-removing systems and affords additional advantages.

This invention resides essentially in that the body of the machine is tubular and composed of a plurality of flange-connected, approximately coaxial tubular sections, the leading one of which supports the drum by a thrust and radial anti-friction bearing, which conforms to the diameter of the drum. As a result, the drum, the bearing and at least the forward portion of the leading tubular section have approximately the same diameter. The bearing transmits all axial and cutting forces from the drum to the body of the machine so that the transmission of said forces is effected substantially without change in cross-section. The bending moment is transmitted directly by the shell of the tubular sections, which have a very high section modulus so that the machine has in fact the high rigidity which is required for driving a tunnel in hard rock. The division of the machine body into individual tubular sections simplifies the assembling of the machine in the restricted space and with a few implements as each tubular section can be flange-connected to the next, beginning at the leading end. The tubular sections constitute desirable units for transportation so that the transportation of the machine is much facilitated. The tubular sections can be individually replaced.

The outer race of the bearing is fitted in the cylindrical forward portion of the leading tubular section and the inner race of the bearing is firmly connected to the drum and carries a gear ring, which meshes with drive pinions so that desirable conditions are obtained for driving and supporting of the drum.

Behind the cylindrical forward portion of the first tubular section, the latter tapers to a basically rectangular cross-section in its axially terminal rear portion. The other tubular sections have also a rectangular cross-sectional shape and a cambered top. The fact that the tubular sections of the machine body are smaller in cross-section than the drum affords the advantage that the same tubular sections can be used for different tunnel diameters. The tool units can be adjustably mounted on the drum in a known manner so that the tunnel diameter can be changed to some extent. If this range of adjustment is not sufficient, only the drum and the leading tubular section of the machine body need be replaced whereas the remaining tubular sections are suitable for use in tunnels having diameters within a very wide range. Besides, the rectangular form of the tubular sections ensures that space for the feeding means or the like is provided on the sides of the tubular sections.

For guiding the forward part of the machine, the first tubular section is provided on the outside with a carrying structure, by which said section is supported on upper and lower skids. Hydraulic jacks are interposed between the carrying gear and at least the upper skids so that the latter can be set to the roof of the tunnel and the first tubular section can be restrained in the tunnel.

According to the invention, feeding means are radially offset from both sides of the second tubular section and said feeding means comprise columns, which can be hydraulically expanded to clamp the same against the roof and floor of the tunnel, and feeding cylinders, which are connected to said columns and have piston rods, which engage the carrying structure for the leading tubular section. As the feeding means engage directly the leading tubular section and are not connected to the following tubular section, there are desirable conditions for a transmission of the feeding forces and for the steering of the machine.

The rigidity of the machine is improved by the provision of tie rods which brace the tubular sections together.

It will be particularly desirable if the tubular sections constitute electric, hydraulic and/or pneumatic functional units, which can be exchanged when the material-removing system or the mode of driving the tools or the like is to be changed. In this case the same machine may be used with different material-removing systems, such as bucket wheels succeeded by a belt conveyor, scraper flight conveyor, pneumatic or hydraulic conveyors, which conveyors are selected in view of the properties of the rock which is encountered and require different drive means. It is sufficient to install or replace a suitable tubular section. The tool units may be provided, e.g., with electric or hydraulic drive means so that a tubular section provided with the required electrical switchgear or a tubular section provided with hydraulic pumps and valves may be used. In this case, the machine may be converted under ground, if this is desired.

Owing to the design of the machine in the form of a rectangular tube, the interior of the second and, if desired, of a following tubular section may be used as an operator's station to accommodate the required electrical and/or hydraulic control, switching and measuring equipment whereas the motors, pumps, hydraulic vessels and the like are provided on the outside of the body of the machine. With this arrangement, the delicate equipment is protected and the operator in his station is not exposed to dust, heat and noise. The operator's station may be provided with an air-conditioning system and the walls defining said station may be provided with a sound-insulating layer.

According to the invention, the hydraulic and electrical lines are firmly installed in the tubular sections and plug connections or pipe couplings for the lines are provided at the joints between the tubular sections. This arrangement results in a much simpler knocking-down and assembling of the machine because of the tubular sections constitute pre-assembled units and it is not necessary to remove cables or hydraulic flexible tubes, etc.

The tubular sections or sections forming the operator's station may be provided at the ceiling with a rail for an overhead trolley for use during the installation and removal of units, e.g., during repairs.

It has already been mentioned that the top of the tubular sections is cambered so that any debris, moisture, etc. can be better diverted to the side and favorable strength values are obtained. As the tubular sections serve for the major part as an operator's station, the floor of the tubular sections is flat. The floor may be inclined, e.g., in adaptation to a rearwardly rising conveyor belt or the like. The side walls may be corrugated for higher rigidity.

An illustrative embodiment of the machine shown on the accompanying drawings, in which—

FIG. 1 is a side elevation showing a tunnel driving machine with the central part of the body of the machine cut open on line I—I of FIG. 2.

FIG. 2 is a top plan view showing the machine with the body of the machine shown in horizontal central section, and

FIGS. 3 to 5 are transverse sectional views taken on lines III—III, IV—IV and V—V, respectively, in FIG. 1.

A rotating drum 1 is disposed at the forward end of the body of the machine and carries four tool units 2, 3. Each of said units comprises a motor, a transmission, and an inserted-tooth cutter head. The units 2 serve for machining the inner portion of the tunnel face and the units 3 for machining the portion of the tunnel face near the periphery thereof. To enable a change in the diameter of the tunnel, the outer units 3 are mounted in mutually opposite recesses in the drum 1 on strong bolts 4 and can be pivotally moved about these bolts with the aid of screws. The body of the machine comprises the tubular sections 5, 6, 7 and a trailing tubular section 8. The forward portion of the leading tubular section 5 is cylindrical and

has approximately the same diameter as the drum. The outer race of an anti-friction bearing 9 is fitted or screw-threaded into the forward portion of the tubular section 5. The inner race of this bearing is firmly connected to the drum 1 and carries a gear ring 10, which is in mesh with drive pinions 11. The bearing 9 transmits axial and radial forces from the drum 1 to the body of the machine. The inner race of the bearing serves also for driving the drum. The bearing space is closed toward the rear by a partition 12, which has a manhole that can be closed. A slip ring space 13 is provided for transmitting power to the drive motors of the tool units. The slip rings may be electrical or hydraulic. The heat generated by the transmissions and motors and the major part of the heat generated by the inserted-tooth cutter heads is dissipated by cooling water flowing through additional water slip rings. A central duct 14 for probing operations carried out through the body of the machine and the drum is left free at the center of the space 13 and of the drum 1.

Behind its cylindrical forward portion, the first tubular section 5 tapers to form a basically rectangular cross-section and a cambered top. Adjacent ends of tubular sections 5 to 8 are provided with flanges, which are bolted together. The tubular sections are also braced together by tie rods 15.

The cylindrical forward portion of the first tubular section 5 is provided with a carrying structure 16, which comprises four ball sockets. Two of the ball sockets face upwardly and two sockets face downwardly. Supports 17 of a lower skid 18 engage the lower ball sockets. Two upper skids 19 are interconnected and are supported by the carrying structure 16 with the aid of hydraulic jacks 20. In this way, the forward part of the machine can be guided and restrained in the tunnel. On both sides of the tubular section 6, feeding means are provided, which comprise on each side two carrying columns 21, provided with hydraulic jacks 22, and top and bottom friction shoes 23. In this way, the feeding means are restrained with a large force at the roof and floor of the tunnel. Four feeding cylinders 24 are provided and have piston rods 25, which engage the carrying structure 16 for the leading tubular section 5. These cylinders serve for pushing the entire machine forwardly or rearwardly.

The lower skid 18 carries two bucket wheels 26, which serve for a removal of material and are provided with a suitable drive. A belt conveyor 27 receives the excavated material and carries it to the rear end of the machine. Owing to the rise of the belt conveyor 27, the tubular sections 5, 6, 7, have an inclined bottom. Depending on geological conditions, different conveyors may be used for removing the excavated material and the drum 1 may be provided with different tools, such as roller bits. As is shown in FIG. 4, the tubular sections can have corrugated side walls to increase their stiffness. Sound-insulating layers may be provided on the side walls.

The tubular sections 5, 6 and 7, more particularly the interior thereof, constitute an operator's station. The tubular section 6 accommodates the hydraulic control system, which comprises the blocks of valves 28, a control box 29 and an automatic control device 30. Above these means, there is a cable duct 31 provided with hydraulic pressure gauges. An electrical switchgear cabinet 32 with the required contactors, switches and measuring instruments as well as a tip-up seat 33 are accommodated in the tubular section 7. The electrical cables extend from the switchgear cabinet 32 to the several drive motors. Plug connections 34 for the cables are provided at the joints between the tubular sections so that the body of the machine can be knocked down without need for removing the cables. The side wall of the tubular section 7 is apertured behind the switchgear cabinet 32, and an air conditioning device 35 is attached on the outside at this point and supplies the operator's station with air which has been freed from dust, cooled and dehumidified so that pleasant working conditions are provided. To

5

prevent an ingress of dust or the like from the outside, the tubular section 7 is closed by a rear end wall 36, which is provided with a door 37. A continuous rail 38 for an overhead trolley for use in assembling operations is secured at the ceiling of the operator's station.

The hydraulic drive and the device for supplying cooling water to the machine are attached to the outside of tubular section 7. A cooling water pump 39 is disposed on the side of the switchgear cabinet 32 and provided with a heat exchanger 40, in which the heat generated in the various units is transferred to cold water supplied from the outside. The opposite side wall of the tubular section carries the hydraulic drive, which comprises the pumps 41, the power-distributing transmission 42 and the electric motor 43. There is an oil supply tank 44. Another supply tank 45 is provided on the rear tubular section 8, but is required only if the conveyor is hydraulically driven. The pump unit which is needed in this case is mounted in the tubular section 6 below the blocks of valves 28 and the control box 29. All attachments to the tubular section 7 conform to the circular cross-section of the tunnel. The outside dimensions are as small as possible so that tunnels can be driven which are smaller in diameter than is shown in the drawings and a tunnel can be driven along a curve.

The trailing tubular section 8 is connected to a steering device and comprises a flange for connection to the tubular section 7, a rear tubular column 46, top and bottom plates 47, 48, and a central longitudinal wall 49, in which a horizontal longitudinal tube 50 is inserted. A hollow trunnion 51 is secured to the column 46 and longitudinally alined with the tube 50. A drill pipe for probing operations can be extended through the hollow trunnion 51 and the tube 50.

The trunnion is held by a steering device 52 so as to be adjustable laterally and in height. The steering device 52 has flanged wheels 53 resting on a sliding carriage 54, which carries a platform 55 for mounting a probing machine or for use during steps taken to consolidate the rock. The steering device 52 is provided at the top with skids 56, which can be hydraulically set against the roof of the tunnel. The carriage 54 and the skids 56 are connected to the body of the machine by towing rods 57 and are pulled along with the machine during the feeding thereof.

What I claim is:

1. In a tunneling machine, in combination:

- (a) a machine body composed of a plurality of substantially coaxial tubular sections flangedly connected to each other in axial sequence, one of said sections being the leading section of said body;
- (b) a drum coaxial with said leading section;
- (c) an anti-friction bearing centered on the axis of said leading section and having outer and inner race

6

members respectively attached to the axially terminal front portion of said leading section and to said drum respectively,

- (1) the diameters of said portion, of said bearing, and of said drum being substantially equal;
 - (d) an excavating tool on said drum;
 - (e) a carrying structure on said leading section outside said body;
 - (f) top and bottom skid means radially projecting from said carrying structure for engagement with the walls of a tunnel formed by said machine;
 - (g) two power transmitting lines on two of said sections respectively; and
 - (h) coupling means for coupling said power transmitting lines when said two sections are connected.
2. In a machine as set forth in claim 1, an operator's station in one of said two sections, and control means at said station for controlling the operation of said machine.
3. In a machine as set forth in claim 1, said portion of said leading section being cylindrical, a gear ring fixedly fastened to said inner race member, and a drive pinion meshingly engaging said gear ring.
4. In a machine as set forth in claim 3, said leading section tapering from said axially terminal portion toward the other sections of said body and having an axially terminal rear portion of substantially rectangular cross section, said other sections being of substantially rectangular cross section.
5. In a machine as set forth in claim 3, a hydraulic jack interposed between said carrying structure and at least one of said skid means.

6. In a machine as set forth in claim 5, feeding means for moving said leading section in a forward direction, said feeding means including two columns, means for expanding said columns so as to clamp the same to the walls of said tunnel, and jack means axially interposed between said columns and said carrying structure, said columns being offset radially in opposite directions from the section of said body contiguously adjacent said leading section.

References Cited

UNITED STATES PATENTS

- | | | | | |
|----|-----------|---------|-----------------|----------|
| 45 | 1,473,498 | 11/1923 | Morgan | 299—31 |
| | 3,266,257 | 8/1966 | Larrouze et al. | 299—31 X |

FOREIGN PATENTS

- | | | | |
|----|---------|--------|----------------|
| 50 | 934,996 | 8/1963 | Great Britain. |
|----|---------|--------|----------------|

ERNEST R. PURSER, *Primary Examiner*.

U.S. Cl. X.R.

299—33, 56