United States Patent [19]

Lauber et al.

[11] **3,784,257**

[45] **Jan. 8, 1974**

[54] **STEERING SYSTEM FOR A TUNNEL BORING MACHINE**

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[73] Assignee: **Atlas Copco Aktiebolag,** Nacka, Sweden

[22] Filed: **Feb. 16, 1972**

[21] Appl. No.: **226,814**

[52] **U.S. Cl.** **299/31,** 175/76

[51] **Int. Cl.** **E01g 3/04**

[58] **Field of Search** 299/31

[56] **References Cited**

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3,598,445	8/1971	Winberg	299/31
3,295,892	1/1967	Winberg et al.	299/31

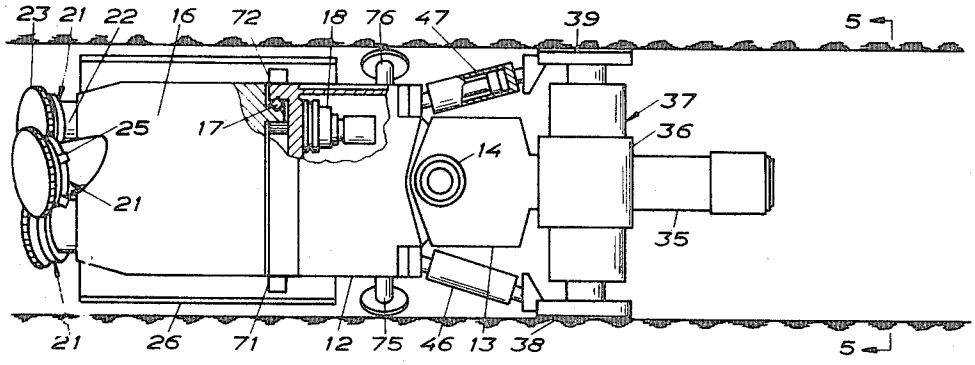
Primary Examiner—Ernest R. Purser

Attorney—Eric Y. Munson et al.

[57] **ABSTRACT**

A tunnel boring machine having a large rotary boring head carried by a main frame which consists of a forward portion and a rear portion, the two portions being hinged together so as to provide for the lateral steering. Power actuated clutches are provided for locking the hinge connection. A bar of the rear frame portion extends rearwards and it is slidably guided in an anchoring device so that the vertical steering can be effected by raising and lowering the slide in the anchoring device. The machine is advanced, and steered laterally as well, by means of two hydraulic jacks connected between the anchoring device and the forward frame portion.

8 Claims, 5 Drawing Figures



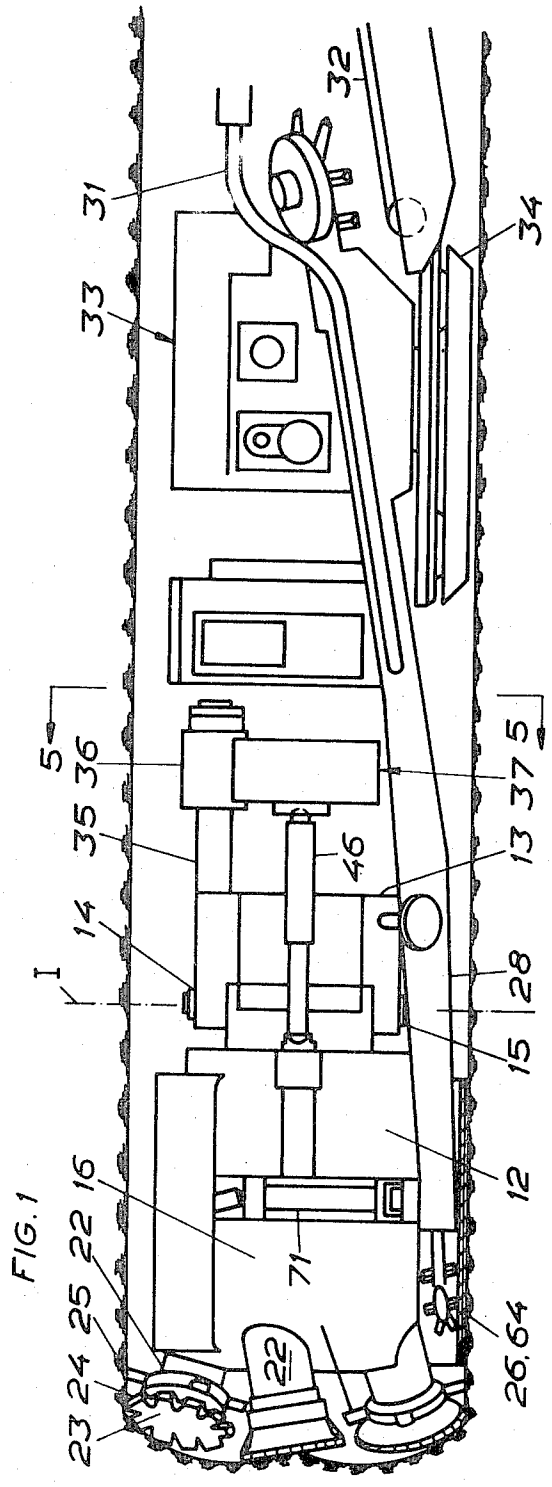

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FIG. 1

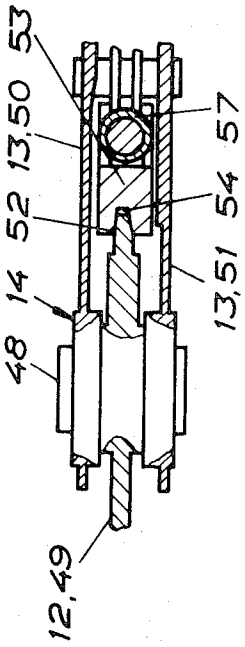

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FIG. 4

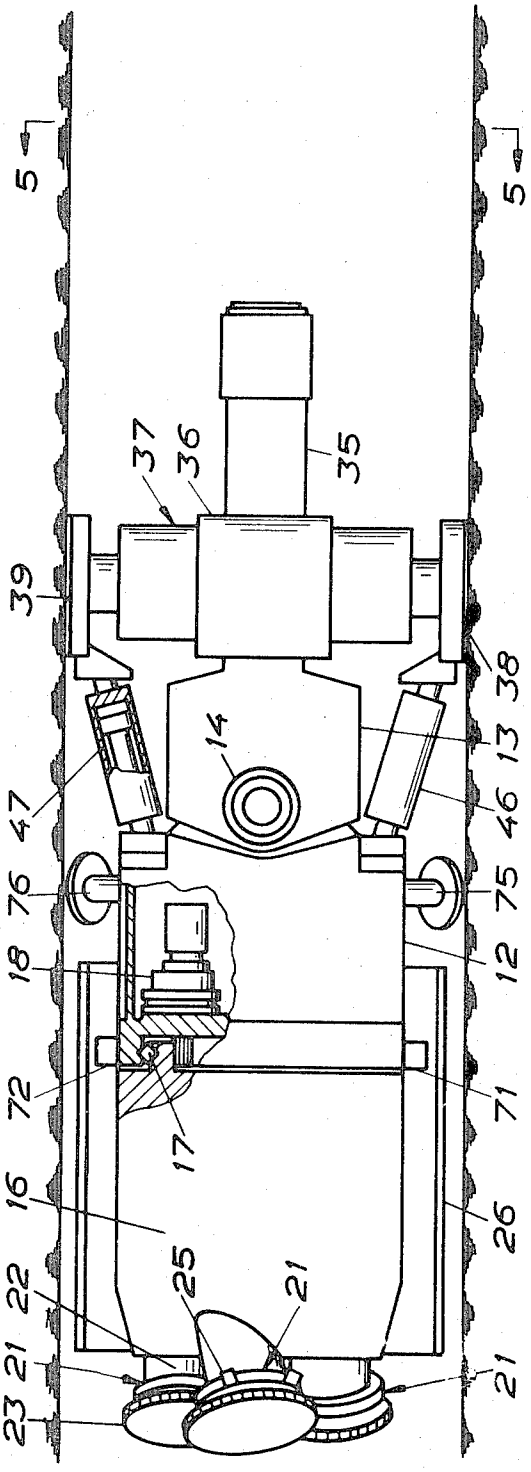
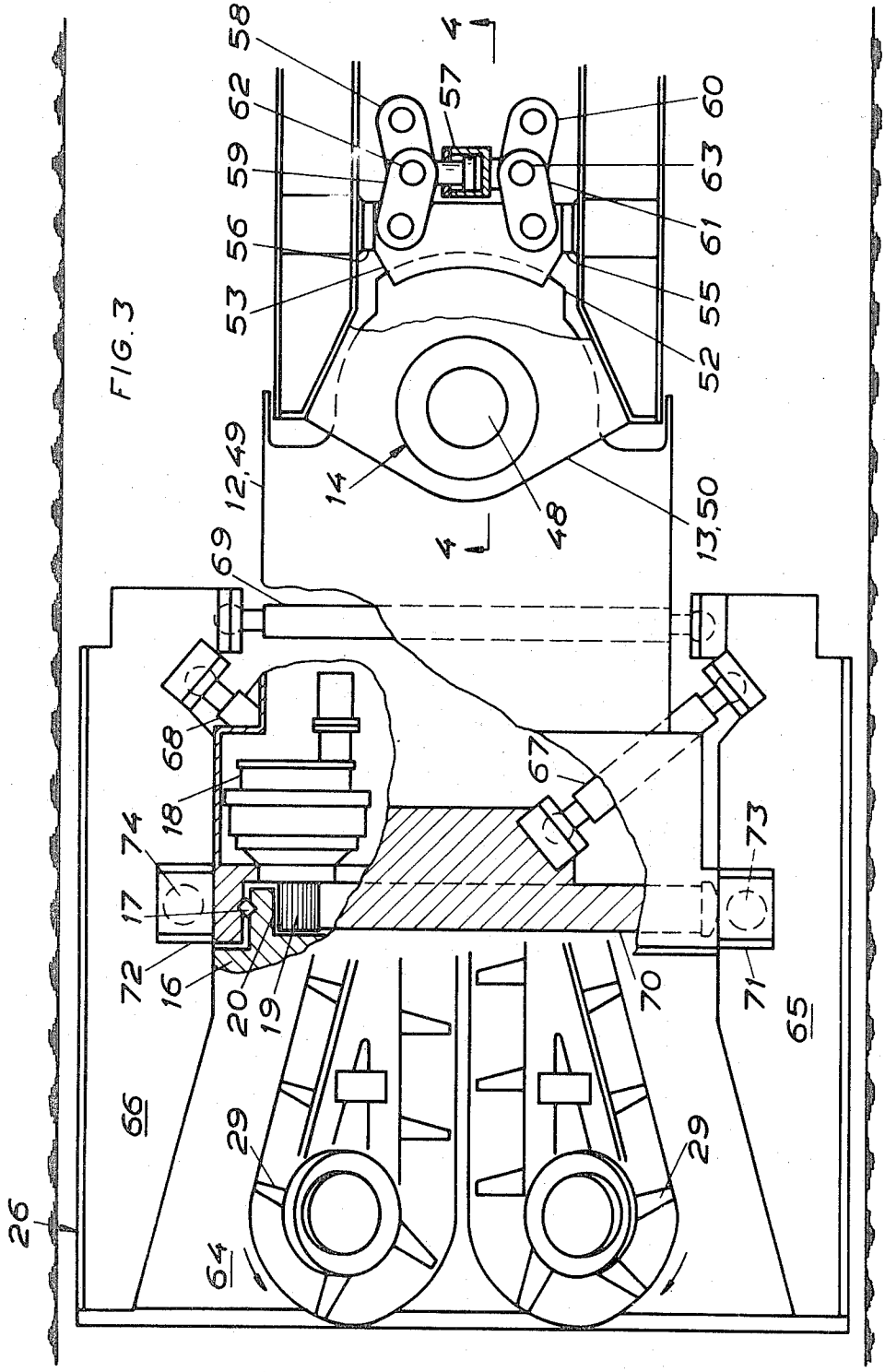

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FIG. 2

FIG. 3


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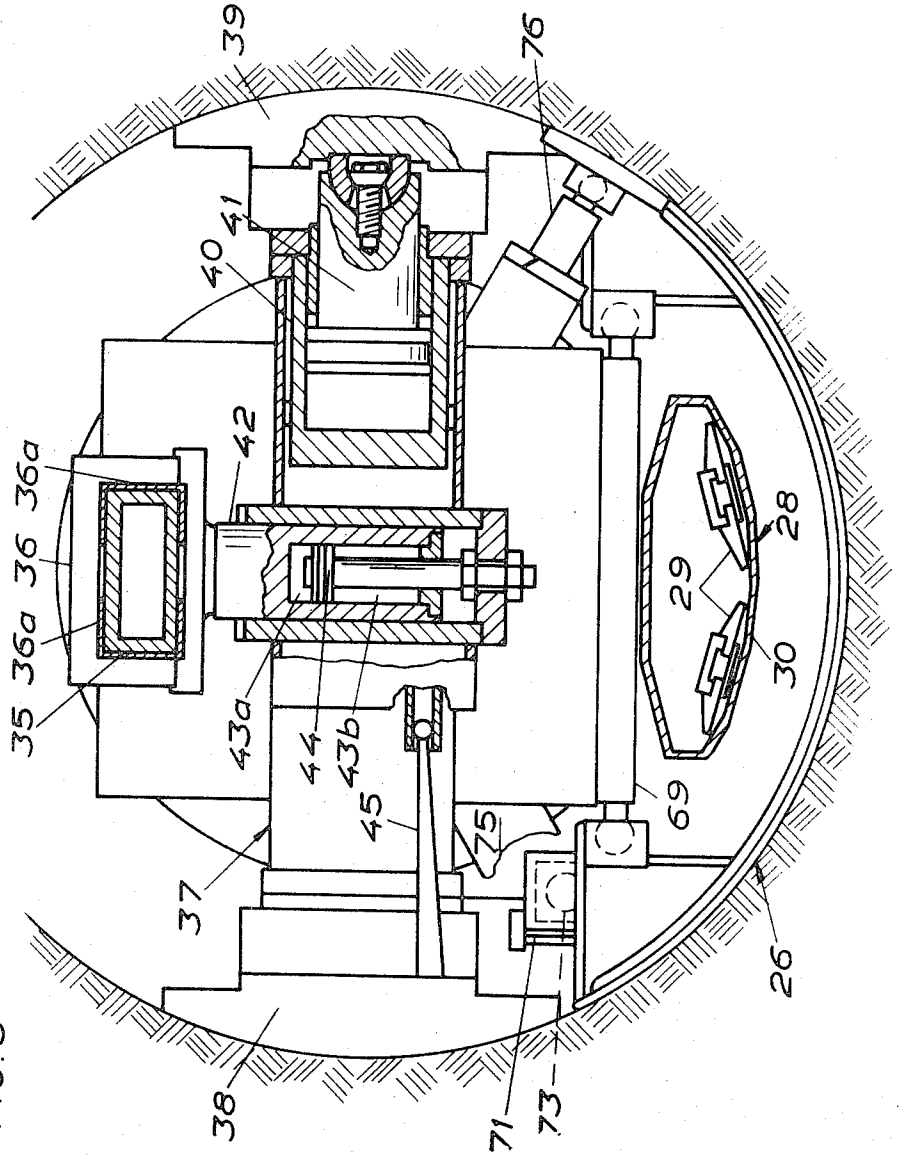

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FIG. 5

STEERING SYSTEM FOR A TUNNEL BORING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to a tunneling machine which travels progressively into the tunnel being bored by its large rotary head. In particular, the invention relates to a machine which has an anchoring device that is arranged to be braced firmly in the tunnel. The main frame carries the rotary head and has a rearwardly extending portion with slideways which slide longitudinally in a guiding member of the anchoring device. Advancing of the machine is effected by moving the main frame with respect to the anchoring device, the latter being immobilized in the tunnel.

In a prior art machine, steering is effected by moving the guiding member laterally and vertically in the anchoring device. Such a prior art steering arrangement does not permit steering laterally in curves of small radius, and it is an object of the invention to provide a tunneling machine which has an improved and rigid steering arrangement that permits the machine to travel along lateral curves of relatively small radius.

The invention will now be described with reference to the accompanying drawings in which a preferred embodiment of the invention is shown by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a tunneling machine,

FIG. 2 is a plan view of the machine;

FIG. 3 is a fragmentary plan section on a larger scale than FIG. 2,

FIG. 4 is a fragmentary section on line 4—4 in FIG. 3, and

FIG. 5 is an enlarged transverse vertical section on line 5—5 in FIGS. 1 and 2.

SUMMARY OF THE INVENTION

The tunneling machine has a main frame which consists of a front portion 12 and a rear portion 13. The two frame portions 12, 13 are hingedly connected by an upper hinge 14 and a lower hinge 15 for pivoting about an axis I which is the common axis of the hinges. A drum-like head 16 is journalled by means of a roller bearing 17 of the crossed roller type in the front frame portion 12 and a motor and gearing unit 18 is mounted so as to rotate the drum 16 by means of a spur gear 19 meshing with an internally toothed ring gear 20 on the drum 16. The ring gear 20 consists of the inner race of the roller bearing 17. The drum 16 is provided with four identical cutting devices 21 each having a motor and gearing portion 22 for rotating a cutter disk 23. The cutter disks have a number of main cutters 24 with sintered carbide hard metal inserts and the outer two disks have four finishing cutters 25 as well. The main frame slides with an arcuate shoe 26 in the tunnel and when the drum 16 is advanced together with the main frame 12, 13 and at the same time rotated, the cutter disks 23 also being rotated, the cutter disks will undercut tangentially the rock along helical paths as described in Wohlmeyer U.S. Pat. No. 2,758,825. However, the inclinations of the cutting devices 21 with respect to the axis of rotation of the drum 16 are exaggerated in the drawings. A conveyor device — shown in FIGS. 1 and 5 only and generally denoted by 28 — comprises two endless scraper bands 29 partly surrounded by a drum 30 from which dusty air is sucked through a suction pipe 31. The conveyor 28 discharges onto a band conveyor 32 on a trailer 33. The drum 30 of the conveyor 28 is pivotably fastened to the front frame portion 12 and its rear end is supported by means of a slide 34 of the trailer. Thus, the drum 30 serves as a bar for pulling the trailer 33. The conveyor 28 and the trailer 33 are not shown in FIG. 2.

The rear frame portion 13 includes a box girder 35 which extends to the rear. The box girder 35 is slidably guided by means of a guide member 36, with replaceable inserts 36*a*, of an anchoring device 37. The anchoring device 37 has two anchoring shoes 38, 39 which grip the tunnel wall at diametrically opposite sides when forced outwardly by means of individually controllable hydraulic jacks 40. The anchoring shoes are mounted on the pistons 41 of the jacks 40 by means of ball-joint connections. The one of the jacks 40 which actuates the anchoring shoe 39 is shown in FIG. 4 but the jack which actuates the shoe 38 is not illustrated since the two jacks are identical. When released, the shoes 38, 39 are held in upright position by spring rods 45 which are firmly attached to the respective shoe by one end and slidably connected to the housing of the anchoring device by the other end. The guide member 36 is mounted on a piston 42 which has two interior pressure chambers 43a, 43b separated by a stationary piston-like element 44. The piston 42 is free to turn about its axis. The sliding connection between the box-girder 35 and the guide member 36 transmits to the anchoring device reaction torque loads created by the rotary motion of the head 16. It is therefore important that the play in the sliding connection is at a minimum and that the box-girder 35 is stiff and torque resistant.

Two double-acting hydraulic advance jacks 46, 47 are connected between the front frame 12 and the anchoring shoes 38, 39 respectively by means of ball-joints. The upper hinge 14, shown in details in FIGS. 3 and 4, comprises a pivot 48 on which a plate 49 of the front frame portion 12 and two plates 50, 51 of the rear frame portion 13 are pivotably mounted. The plate 49 ends in an arcuate wedge 52. A clutch shoe 53 with an arcuate notch 54 is guided against lateral movement by two supports 55, 56 on the rear frame portion 13, and it can be actuated into firm engagement with the wedge 52 by means of a double-acting hydraulic jack 57 over a force amplifying link system with links 58–61. The links 58, 60 are pivotably mounted on the rear frame portion 13, the links 59, 61 are pivotably mounted to the clutch shoe 53, and the jack 57 is pivotably connected to pivots 62, 63 which connect the links 58, 60 with the links 59, 61 respectively. A power actuated clutch, identical with the one described, is connected to the lower hinge 15.

The shoe 26 consists of an arcuate slide plate 64 with two upper side frames 65, 66. The side frames 65, 66 are connected to the front frame portion 12 by means of two rods 67, 68 having ball-joint end connections (FIG. 3). The rear ends of the side frames 65, 66 of the shoe 26 are connected by means of a distance rod 69 which also has ball-joint end connections. The front frame portion 12 has a horizontal distance bar 70 which is slidably guided between the side frames 65, 66 of the shoe 26. The weight of the forward part of the machine is transmitted to the side frames 65, 66 by means of two support brackets 71, 72 which are affixed on the frame portion and rest on the spherical surfaces

of two semispherical slide blocks **73, 74** which are slidable with their flat surfaces on the flat horizontal surfaces of the side frames **65, 66** of the shoe **26.**

As previously described, the rear end of the main frame **12, 13** is supported by the anchoring device **37.** When the shoes **38, 39** of the anchor-ing device are released, a pair of hydraulic jacks **75, 76** are used for supporting the frame **12, 13.**

The operation of the machine will now be described:

With the head **16** and the cutter disks **23** rotating and with the anchoring device **37** immobilized in the tunnel, the frame **12, 13** is advanced by means of the advance jacks **46, 47** so that the machine cuts its way forwards. When the advance jacks **46, 47** have been extended a full stroke, the support jacks **75, 76** are actuated to support the machine, and the anchoring device **37** is released, pulled forwards by the advance jacks **46, 47** and again firmly braced against the tunnel walls. Finally, the support jacks **75, 76** are retracted. The machine is now ready for a new advance by cutting.

Normally, the advance jacks **46, 47** are connected in parallel in the same flow circuit, and the clutches **52, 53** are engaged to lock the hinges **14, 15** so that the machine will cut in a straight path or in a curved path with constant radius.

When it is desired to alter the path laterally, the clutches are released and one of the advance jacks **46, 47** extended, the other being free to retract or being positively retracted. When the desired angle between the front frame portion **12** and the rear frame portion **13** is reached, the clutches are again engaged to lock the hinge **14, 15.** The machine should be cutting during this steering operation as well as during the vertical steering operation which is effected by means of the piston **42.**

The arrangement for connecting the frame portion **12** to the shoe **26** permits vertical steering because of the sliding connection between the distance bar **70** and the side frames **65, 66** of the shoe **26.** Because of the elasticity in this arrangement, especially the elasticity of the shoe and the play in the ball-joint connections, the frame portion **12** can deviate laterally in the shoe. However, the restoring forces on the frame portion **12** will be strong which is desirable. Heavy Belleville-springs can be used instead of this built-in elasticity.

The invention can be varied in many other ways within the scope of the claims. The heat **16,** for instance, can be provided with a large number of conventional free-rotating roller bits or disk-cutters instead of the cutting device **21.**

What we claim is:

1. In a tunnel boring maching: a main frame having a front portion and a rear portion, a head rotatably mounted in said front frame portion adapted to rotate about a central longitudinal axis of said front frame portion, cutting devices mounted on said head for cutting into the face of the tunnel, means for supporting the front frame portion in the tunnel, a vertical joint located rearwardly of the said supporting means and interconnecting the rear end of the front frame portion and the front end of the rear frame portion so as to permit a swinging movement between the two portions only about a vertical axis, a longitudinal slideway on said rear frame portion located rearwardly of said vertical joint, a power actuated anchoring device arranged to be immobilized in the tunnel and provided with pivotably mounted guide means for guiding said slideway, said guide means permitting longitudinal movement of the slideway but restraining the slideway vertically, laterally and torquewise, motor means for displacing said guide means vertically with respect to the anchoring device to provide for the vertical steering of the machine, double acting power jack means connected between the anchoring device and the rear end of the front frame portion for displacing said vertical joint sidewise in the tunnel to thereby turn said slideway and said guide means in the pivotal mounting of the latter to provide for the lateral steering of the machine, and power actuated locking means for locking said vertical joint to interlock said front and rear frame portions in various relative angular positions to thereby permit said double acting jack means to advance the main frame with respect to said anchoring device.

2. A tunnel boring machine as claimed in claim **1,** in which the locking means comprises at least one power actuated notch-and-wedge friction clutch.

3. A tunnel boring machine as claimed in claim **2,** in which the friction clutch is actuated by means of a double-acting hydraulic jack over a force amplifying linkage system.

4. A tunnel boring machine as claimed in claim **1,** in which said anchoring device has two diametrically opposite gripper shoes for engagement with the tunnel wall and hydraulic jacks for pressing the shoes against the wall.

5. A tunnel boring machine as claimed in claim **1,** in which means is arranged for supporting the rear frame portion when said anchoring device is released.

6. A tunnel boring machine as claimed in claim **4,** in which a pair of hydraulic jacks are arranged for supporting the rear frame portion when said gripper shoes of the anchoring device are released.

7. A tunnel boring machine as claimed in claim **1,** in which said means for supporting the front frame portion is an arc-formed shoe sliding on the tunnel bottom.

8. A tunnel boring machine as claimed in claim **1,** in which a conveyor frame is pivotally connected as a pull bar between the front frame portion and a trailer located behind the rear frame portion, said conveyor frame extending under said anchoring device.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,784,257 Dated January 8, 1974

Inventor(s) Ernst Abraham Lauber et al

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

[30] Foreign Application Priority Data

February 25, 1971 Sweden..... 2426/71

Signed and sealed this 18th day of June 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.