



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 314 852 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.05.2003 Bulletin 2003/22

(51) Int Cl.7: **E21D 9/08**

(21) Application number: **02025625.1**

(22) Date of filing: **19.11.2002**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
IE IT LI LU MC NL PT SE SK TR**
Designated Extension States:
AL LT LV MK RO SI

(72) Inventor: **Kumao, Yoshimitsu**
Mitsubishi Heavy Ind. Ltd.
Hyogo-ku, Kobe-shi, Hyogo (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(30) Priority: **21.11.2001 JP 2001355520**

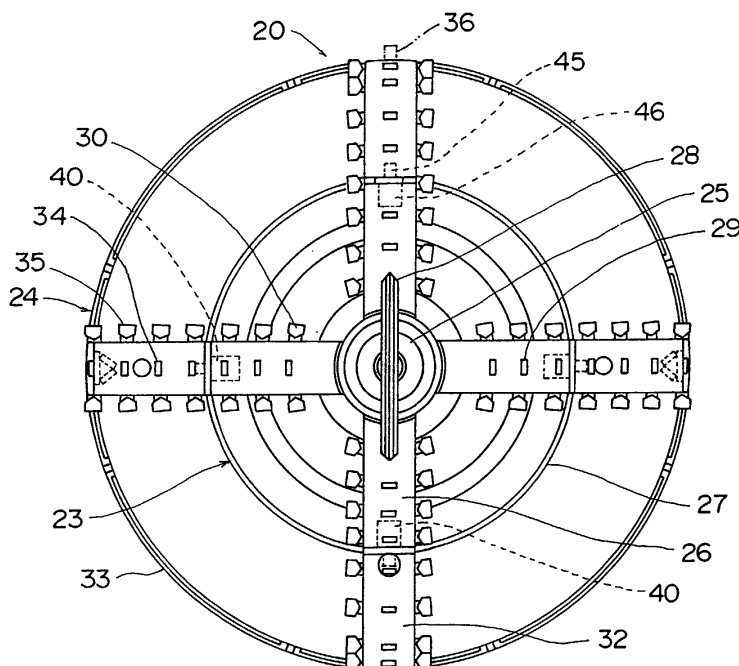
(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo (JP)

(54) Tunnel excavating machine and method for its recovery

(57) In a tunnel excavating machine, a cutter head (20) is composed of a cutter head central portion (23) and a cutter head outer peripheral portion (24). A drive component body (14) mounted with a rotating ring (17),

a ring gear (18), and drive motors (21) is detachable from an excavating machine body (11). The cutter head central portion (23) is detachable from the rotating ring (17), and the cutter head outer peripheral portion (24) is detachable from the cutter head central portion (23).

FIG. 1



EP 1 314 852 A1

Description

[0001] The entire disclosure of Japanese Patent Application No. 2001-355520 filed on November 21, 2001 including specification, claims, drawings and summary is incorporated herein by reference in its entirety.

Technical Field

[0002] This invention relates to a tunnel excavating machine, which is advanced to excavate a tunnel of a predetermined length, and in which its constituent members such as a cutter head can then be separated and recovered, and a method for recovering the tunnel excavating machine. The tunnel excavating machine and the method for its recovery are preferred when used for a pressurized slurry shield excavator, a muddy water shield excavator, and a tunnel boring machine.

Background Art

[0003] Generally, a shield excavator is constituted in the following manner: A disk-shaped cutter head is rotatably mounted in a front portion of a cylindrical excavating machine body, and the cutter head is supported rotationally drivably by a drive device. Many shield jacks for advancing the excavating machine body are mounted in a rear portion of the excavating machine body. An erector device for assembling segments onto an inner wall surface of an existing tunnel is also mounted in the rear portion of the excavating machine body. Thus, when the shield jacks are stretched, with the cutter head being rotated by the drive device, the excavating machine body receives a reaction force from the established segments and moves forward. Many cutter bits attached to the cutter head excavate strata lying ahead, and can form a tunnel thereby.

[0004] In constructing a tunnel in a predetermined construction zone with the use of such a shield excavator, a departure pit and an arrival pit are dug beforehand in this construction zone. Then, the shield excavator is carried into the departure pit. With a reaction force for excavation being secured within the departure pit, the shield excavator penetrates the strata lying ahead through a departure port, performing excavation along a predetermined route. When the shield excavator advances up to the arrival pit, a shield body is pulled out into the arrival pit through an arrival port formed beforehand. In this manner, a tunnel is constructed at a predetermined location.

[0005] The shield excavator, which has arrived at the arrival pit, is disassembled, and a part of it is recovered above ground. The remainder is buried in the ground as a structure for the tunnel. That is, the shield excavator is treated in the following manner: First, the cutter head is divided into small pieces by a gas cutter, and lifted above ground by a crane through the arrival pit. Then, the drive device for the cutter head is similarly divided

into small pieces by a gas cutter, and lifted above ground by the crane through the arrival pit. The shield jacks, the erector device, and a soil discharge device (a slurry feed pipe, a slurry discharge pipe, an agitator, a screw conveyor, etc.) are detached from the excavator body, and lifted above ground by the crane. The remaining excavator body is connected to the existing segments and buried as a part of the tunnel structure. In this case, the cutter head and the drive device therefor, which have been divided and lifted above ground, are handled as scrap.

[0006] From the aspect of the global environment, increases in industrial wastes due to scrapping of tunnel excavating machines are not desirable. From the aspect of the manufacturing cost of tunnel excavating machines, too, scrapping only from excavation work in a single construction zone is inefficient, and the materials for scrap should be reused.

Summary of the Invention

[0007] The present invention has been accomplished in an attempt to solve the above-mentioned problems. Its object is to provide a tunnel excavating machine which has made it possible to recover a structure constituting the excavating machine and reuse it, and a method for recovering the tunnel excavating machine.

[0008] As described in detail in the embodiment, according to a first aspect of the invention, there is provided a tunnel excavating machine having a rotationally drivable cutter head mounted in a front portion of a cylindrical excavating machine body, wherein the cutter head is composed of a divisible central portion, and an outer peripheral portion located on an outer peripheral side of the central portion, and is provided with a connecting pin which moves from one of to the other of the central portion and the outer peripheral portion to connect the central portion and the outer peripheral portion.

[0009] Therefore, after tunnel excavation work is completed, the outer peripheral portion of the cutter head is separated from the excavating machine body, and is easily recovered above ground, so that it can be reused. Since the recovered member is reused in the excavating machine, the manufacturing cost of the excavating machine can be decreased, and increases in industrial wastes due to scrapping can be curtailed. Moreover, simply by moving the connecting pin, engagement between the central portion and the outer peripheral portion can be released, and the outer peripheral portion can be easily detached. Furthermore, the operator does not need to enter a working place during this disassembly operation, so that the operability and the safety of the operation can be improved.

[0010] In the tunnel excavating machine, the central portion of the cutter head may be connected to an output transmission portion of a cutter drive device loaded in the excavating machine body, and the outer peripheral portion may be detachably connected to the central por-

tion. Thus, the central portion and the outer peripheral portion can be easily attached and detached, so that the operability of the cutter head recovery operation can be improved.

[0011] In the tunnel excavating machine, the cutter drive device may have rotors rotatably supported in the front portion of the excavating machine body, and a drive motor for driving the rotors, and the central portion may be connected to the rotors via an intermediate beam extending forward from the rotors. Thus, the removal operations for the central portion and the outer peripheral portion are performed in the chamber, so that the operability of the cutter head recovery operation can be improved.

[0012] In the tunnel excavating machine, a connecting jack having the connecting pin may be provided in one of the central portion and the outer peripheral portion of the cutter head, and a connecting block having a connecting hole, which the connecting pin can be engaged with and disengaged from, may be provided in the other of the central portion and the outer peripheral portion. Thus, the operability of the operations for attaching and detaching the central portion and the outer peripheral portion of the cutter head can be improved using a simple construction.

[0013] In the tunnel excavating machine, driving force transmission paths may be provided in an interior of the connecting pin. Thus, the operations for removing the hydraulic pipings, electric power cables, etc. can be performed simultaneously and easily during the operation for detaching the outer peripheral portion from the central portion of the cutter head. Hence, the operability can be improved.

[0014] In the tunnel excavating machine, the driving force transmission paths may be hydraulic pipings for driving a copy cutter mounted on the outer peripheral portion of the cutter head. Thus, simplification of the structure and improvement of the operability can be achieved.

[0015] In the tunnel excavating machine, the central portion of the cutter head may be constituted by having front end portions of a plurality of radial spokes connected by a connecting ring, and the outer peripheral portion of the cutter head may be constituted by having front end portions of a plurality of radial spokes connected by a connecting ring. Thus, the central portion and the outer peripheral portion of the cutter head can each be constituted of a simple construction with the use of the spokes and connecting ring, and can be rendered lightweight thereby. The cutter head central portion and the cutter head outer peripheral portion can be connected easily by a connecting pin, and the operation for detaching the cutter head outer peripheral portion from the cutter head central portion can be performed easily.

[0016] In the tunnel excavating machine, the outer peripheral portion of the cutter head may be in the shape of a ring, and may be separable into a plurality of parts in a circumferential direction. Thus, the member to be

recovered is rendered lightweight, so that the recovery operation can be facilitated, and the departure pit and the arrival pit can be formed with small diameters.

[0017] According to a second aspect of the invention, there is provided a method for recovering a tunnel excavating machine, comprising:

advancing the tunnel excavating machine to excavate a tunnel;
stopping rotation of a cutter head when the cutter head penetrates into an arrival pit;
then extracting a connecting pin connecting a cutter head central portion and a cutter head outer peripheral portion;
separating the cutter head outer peripheral portion from the cutter head central portion;
recovering the cutter head outer peripheral portion above ground through the arrival pit;
then separating the cutter head central portion from an excavating machine body; and
recovering the cutter head central portion above ground through the arrival pit.

[0018] Thus, the cutter head can be easily disassembled and recovered, so that it can be reused. Since the recovered cutter head is reused in an excavating machine, the manufacturing cost of the excavating machine can be decreased, and increases in industrial wastes due to scrapping can be curtailed.

[0019] According to a third aspect of the invention, there is provided a method for recovering a tunnel excavating machine, comprising:

advancing the tunnel excavating machine to excavate a tunnel for a predetermined distance by a cutter head rotated;
then stopping rotation of the cutter head;
then extracting a connecting pin connecting a cutter head central portion and a cutter head outer peripheral portion;
separating the cutter head outer peripheral portion from the cutter head central portion;
then separating the cutter head central portion and a cutter drive device from an excavating machine body;
recovering the cutter head central portion and the cutter drive device above ground through the existing tunnel lying behind; and
then recovering the cutter head outer peripheral portion above ground through the existing tunnel lying behind.

[0020] Thus, the cutter head can be easily disassembled and recovered, so that it can be reused. Since the recovered cutter head is reused in an excavating machine, the manufacturing cost of the excavating machine can be decreased, and increases in industrial wastes due to scrapping can be curtailed.

Brief Description of the Drawings

[0021] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. 1 is a front view of a tunnel excavating machine according to an embodiment of the present invention; FIG. 2 is a schematic sectional view of the tunnel excavating machine according to the present embodiment; FIG. 3 is a front view of a cutter head central portion; FIG. 4 is a front view of a cutter head outer peripheral portion; FIG. 5 is a sectional view showing a junction between the cutter head central portion and the cutter head outer peripheral portion; FIG. 6 is a sectional view of a connecting jack; and FIG. 7 is a schematic sectional view of the tunnel excavating machine from which the cutter head outer peripheral portion has been detached.

Detailed Description

[0022] An embodiment of the present invention will now be described in detail with reference to the accompanying drawings, which in no way limit the invention.

[0023] FIG. 1 shows a front of a tunnel excavating machine according to the embodiment of the present invention. FIG. 2 schematically shows a section of the tunnel excavating machine according to the present embodiment. FIG. 3 shows a front of a cutter head central portion. FIG. 4 shows a front of a cutter head outer peripheral portion. FIG. 5 shows a section of a junction between the cutter head central portion and the cutter head outer peripheral portion. FIG. 6 shows a section of a connecting jack. FIG. 7 schematically shows a section of the tunnel excavating machine from which the cutter head outer peripheral portion has been detached.

[0024] In the tunnel excavating machine of the present embodiment, as shown in FIGS. 1 and 2, an excavating machine body 11 is cylindrical in shape, and has a pair of bulkheads 12 and 13 formed in a fore-and-aft direction in a front end portion thereof. A drive component body 14 is fixed to flanges of the bulkheads 12, 13 by a plurality of bolts 15. A rotating ring 17, as an output transmission portion, is rotatably supported by the drive component body 14 via a bearing 16. A ring gear 18 is joined to a rear part of the rotating ring 17, while a cutter head 20 is mounted on a front part of the rotating ring 17 via a plurality of intermediate beams 19. A plurality of drive motors 21 are mounted on the drive component body 14, and drive gears 22 of the respective drive motors 21 are in mesh with the ring gear 18, so that a cutter drive device is constituted by the drive component body 14, rotating ring 17, ring gear 18, and drive motors 21. Hence, when the drive motor 21 is driven to drive the drive gear 22 rotationally, the cutter head

20 can be rotated via the ring gear 18 and the rotating ring 17.

[0025] The cutter head 20 is composed of a cutter head central portion 23, and a cutter head outer peripheral portion 24 located on an outer peripheral side of the cutter head central portion 23. The cutter head central portion 23 is detachable from the rotating ring 17, while the cutter head outer peripheral portion 24 is detachable from the cutter head central portion 23. That is, as shown in FIGS. 2 and 3, the cutter head central portion 23 comprises a plurality of spokes 26 connected radially to a central portion 25, and a plurality of connecting rings 27 connected to front end portions of the respective spokes 26. A fishtail bit 28 is fixed to the central portion 25, many forward bits 29 are fixed to the front surfaces of the spokes 26, and cutter bits 30 are fixed to both sides of the spokes 26. A rotary joint 31 is mounted on a central portion of the drive component body 14 to accommodate electrical wiring, hydraulic hoses, etc. in its interior.

[0026] As shown in FIGS. 2 and 4, on the other hand, the cutter head outer peripheral portion 24 is constituted in the following manner: A plurality of spokes 32, corresponding to the respective spokes 26 of the cutter head central portion 23, are connected to a connecting ring 33. Many forward bits 34 are fixed to the front surfaces of the spokes 32, and cutter bits 35 are fixed to both sides of the spokes 32. A copy cutter 36 can appear at or disappear from the front end of one or two of the spokes 32 by the action of a hydraulic jack 37. The cutter head outer peripheral portion 24 takes a ring shape, but may be separable into a plurality of parts in the circumferential direction in consideration of ease of recovery.

[0027] In the cutter head central portion 23, the intermediate beams 19 can be attached to and detached from the rotating ring 17 using a plurality of bolts 38. The cutter head outer peripheral portion 24 can be attached to and detached from the cutter head central portion 23 using connecting pins 45 to be described later.

[0028] That is, in the cutter head central portion 23, a hydraulic connecting jack 40 is fixed to an end plate 39 at the front end of each spoke 26 by fixing bolts 41. The connecting jack 40 comprises a hollow casing 42 in which a drive rod 43 and a piston 44 integral therewith are movably fitted, and the connecting pin 45 is formed integrally at the front end of the drive rod 43, as shown in FIGS. 2, 5 and 6. An oil pressure is fed to and discharged from oil compartments 42a, 42b within the casing 42 which are defined by the piston 44, whereby the connecting pin 45 can be caused to appear and disappear. In the cutter head outer peripheral portion 24, a connecting block 47 is fixed to an end plate 46 at the base end of each spoke 32 by fixing bolts (not shown). The connecting block 47 has a connecting hole 48 formed therein which the connecting pin 45 of the connecting jack 40 can be engaged with and disengaged from.

[0029] A plurality of through-holes 49, 50, as driving

force transmission paths, are provided within the drive rod 43 and the connecting pin 45. These through-holes 49, 50 are hydraulic pipings for driving the hydraulic jack 37 for the copy cutter 36, and have piping ports 49a, 49b, 50a, 50b provided at the ends thereof. Connecting hoses 51a, 51b, 52a, 52b for feeding and discharging an oil pressure can be connected to the piping ports 49a, 49b, 50a, 50b. In the present embodiment, the plurality of through-holes 49, 50 formed within the drive rod 43 and the connecting pin 45 serve as the hydraulic pipings for the copy cutter 36, but may be used as disposition holes for electric power cables of various sensors, or as feed holes for slurry fluidifying additives.

[0030] As shown in FIGS. 1 and 2, moreover, a plurality of shield jacks 53 are arranged parallel along the circumferential direction in a rear portion of the excavating machine body 11. The shield jacks 53 are stretched rearward in an excavating direction and pressed against existing segments S which have been constructed on the inner peripheral surface of an excavated tunnel. As a result, the excavating machine body 11 can be moved forward by a reaction force generated thereby. Furthermore, a swivel ring 55 is supported, in a pivotally drivable manner, at a rear end portion of the excavating machine body 11 via a support bracket 54, and an erector device 56 for assembling segments S is mounted on the swivel ring 55.

[0031] A plurality of tail packings 57, which intimately contact the outer peripheral surfaces of the existing segments S, are attached to the rear end portion of the excavating machine body 11 to prevent muck and muddy water from invading the interior of the excavating machine body 11. A screw conveyor 58 is disposed in a forwardly inclined manner within the excavating machine body 11, and is held in this inclined state by a support rod 59. A front end portion of the screw conveyor 58 communicates with a chamber 60 via openings of the bulkheads 12, 13 so that earth and sand excavated by the cutter head 20 can be discharged to the outside.

[0032] Tunnel excavation work by the tunnel excavating machine of the above-described embodiment, and recovery work for the tunnel excavating machine after excavation will be described below.

[0033] To form a tunnel by excavation, as shown in FIGS. 1 and 2, a departure pit of a predetermined depth is dug at the position where excavation is to be started, and the tunnel excavating machine is carried into the departure pit. With the cutter head 20 being rotated by the drive motors 21, the shield jacks 53 are stretched to move the excavating machine body 11 from within the departure pit while obtaining a reaction force for excavation. During this movement, the upright wall of the departure pit is dug to start tunnel excavation work. Earth and sand produced in accordance with excavation of the strata by the cutter head 20 are discharged from the chamber 60 to the outside by the screw conveyor 58. At the same time, segments S are assembled in a ringlike shape by the erector device 56 to proceed with the con-

struction of a tunnel.

[0034] An arrival pit of a predetermined depth is dug at the position in a construction zone where excavation is to be completed. The tunnel constructed by the tunnel excavating machine, starting at the departure pit, is extended to this arrival pit. In this case, the arrival pit needs to be dug to suit the size of the cutter head 20, etc. which are to be separated and recovered. After tunneling work in the predetermined construction zone is completed and the cutter head 20 of the tunnel excavating machine penetrates into the arrival pit, the rotation of the cutter head 20 by the drive motors 21 is stopped. Then, this tunnel excavating machine is disassembled, and its constituent members are recovered from the arrival pit.

[0035] That is, when the front end portion of the excavating machine body 11 penetrates into the arrival pit, the rotation of the cutter head 20 is stopped. In this state, the respective connecting jacks 40 of the cutter head central portion 23 are driven to contract the drive rods 43, thereby pulling the connecting pins 45 out of the connecting holes 48 of the connecting blocks 47 fixed to the cutter head outer peripheral portion 24. By so doing, the connection between the cutter head central portion 23 and the cutter head outer peripheral portion 24 is released. Thus, as shown in FIG. 7, the cutter head outer peripheral portion 24 is detached from the cutter head central portion 23, and the cutter head outer peripheral portion 24 is moved forward by dedicated jacks along rails (not shown) laid in the arrival pit. Then, a suspending jig (not shown) is attached to the cutter head outer peripheral portion 24, and a rope lowered into the arrival pit from a crane installed above ground is connected to the suspending jig. The cutter head outer peripheral portion 24 is lifted above ground by this crane for the purpose of recovery. In this case, if the cutter head outer peripheral portion 24 is separable into a plurality of parts in the circumferential direction, the separate parts are lifted above ground by the crane for recovery.

[0036] Then, the bolts 38 are loosened to detach the cutter head central portion 23 from the rotating ring 17, and the cutter head central portion 23 is moved forward along the rails. Then, a suspending jig (not shown) is attached to the cutter head central portion 23, and a rope lowered into the arrival pit from the crane installed above ground is connected to the suspending jig. The cutter head central portion 23 is lifted above ground by this crane for the purpose of recovery.

[0037] Then, the bolts 15 are loosened to detach the drive component body 14 (cutter drive device) from the excavating machine body 11, and the drive component body 14 is moved forward along the rails. Then, a suspending jig is attached to the drive component body 14, and a rope lowered into the arrival pit from the crane is connected to the suspending jig. The drive component body 14 is lifted above ground by this crane for the purpose of recovery. In this case, if the diameter of the arrival pit is sufficient, the cutter head central portion 23 and the drive component body 14 may be integrally lifted

above ground and recovered.

[0038] In the above-described manner, the cutter head 20 and the cutter drive device are detached from the excavating machine body 11 and recovered. Then, the shield jacks 53, erector device 56, screw conveyor 58, and various sensors are detached and recovered. The excavating machine body 11 left underground is bonded to the existing segments S by welding or concreting for use as a tunnel structure.

[0039] In the tunnel excavating machine of the present embodiment, the cutter head 20 is composed of the cutter head central portion 23 and the cutter head outer peripheral portion 24. The drive component body 14 mounted with the rotating ring 17, ring gear 18, and drive motors 21 is detachable from the excavating machine body 11. The cutter head central portion 23 is detachable from the rotating ring 17, and the cutter head outer peripheral portion 24 is detachable from the cutter head central portion 23.

[0040] After tunnel excavation work is completed, therefore, the cutter head outer peripheral portion 24, cutter head central portion 23 and drive component body 14 can be separated in this sequence from the excavating machine body 11. These members can be recovered above ground from within the arrival pit, and can be reused. Since the cutter head 20 and drive motors 21 are reused, the manufacturing cost of the excavating machine can be decreased, and increases in industrial wastes due to scrapping can be curtailed. Where necessary, moreover, the excavating machine body can be separated into constituent parts, recovered from within the arrival pit, and reused.

[0041] If the cutter head 20 is recovered, the fishtail bit 28, forward bits 29, 34, cutter bits 30, 35 and copy cutter 36, which have been worn, may be replaced. The drive component body 14 including the drive motors 21 may be given some maintenance. In reusing the drive component body 14, the number of the drive motors 21 to be mounted may be changed in response to a required output different according to the diameter of the tunnel to be excavated or the type of the strata to be dug.

[0042] In the present embodiment, moreover, the connecting jack 40, which enables the connecting pin 45 to appear and disappear, is mounted in the spoke 26 of the cutter head central portion 23, while the connecting block 47 having the connecting hole 48, which the connecting pin 45 can be engaged with and disengaged from, is mounted in the spoke 32 of the cutter head outer peripheral portion 24. Simply by driving the connecting jack 40 to pull out the connecting pin 45 engaged with the connecting hole 48, therefore, the engagement between the cutter head central portion 23 and the cutter head outer peripheral portion 24 can be released, and the cutter head outer peripheral portion 24 can be easily detached from the cutter head central portion 23. This disassembly operation may be performed by remote control of the connecting jack 40. The operator does not need to enter a working place or the chamber 60, but

the safety of the operation can be ensured sufficiently.

[0043] Besides, the plurality of through-holes 49, 50 are provided in the drive rod 43 and the connecting pin 45, and these through-holes 49, 50 can be used as the driving hydraulic pipings for the copy cutter 36, as disposition holes for electric power cables of various sensors, and as feed holes for slurry fluidifying additives. Thus, operations for separating the hydraulic pipings, electric power cables, and slurry fluidifying additive feed pipes become easy during the operation for disassembly of the cutter head outer peripheral portion 24 from the cutter head central portion 23.

[0044] In the above-described embodiment, the arrival pit is dug beforehand together with the departure pit, and after completion of tunneling work, the cutter head 20, etc. are disassembled and recovered above ground from within the arrival pit. However, they can be returned to the departure pit, and recovered. That is, when the tunnel has been excavated over a predetermined distance, the rotation of the cutter head 20 is stopped. Then, the connecting pin 45 is pulled out of the connecting hole 48 by the connecting jack 40 to release the engagement between the cutter head central portion 23 and the cutter head outer peripheral portion 24, and the cutter head outer peripheral portion 24 is detached from the cutter head central portion 23. Then, the cutter head central portion 23 and the drive component body 14 are detached in this sequence from the excavating machine body 11. On this occasion, the shield jacks 53, erector device 56, screw conveyor 58, and various sensors are detached from the excavating machine body 11. These members are transported by a transport bogie movably supported within the existing tunnel, and recovered from the departure pit. Furthermore, the cutter head outer peripheral portion 24 and the cutter head central portion 23 are similarly transported by the transport bogie and recovered from the departure pit.

[0045] In the above-described embodiment, the cutter head outer peripheral portion 24 is in the shape of a ring, but may be constituted as two divided parts or three or more divided parts. In this case, each of the members, which is single, is lightweight, so that the recovery operation can be facilitated, and the departure pit and the arrival pit can be formed with small diameters. Besides, the excavating machine body 11 is buried underground to serve as a tunnel structure. However, if the segments are assembled and bonded to the inner wall surface of the tunnel by the erector device 56 as far as they reach the arrival pit, the excavating machine body 11 may be recovered above ground from the arrival pit.

[0046] In the present embodiment, moreover, the connecting jack 40 is mounted in the cutter head central portion 23, and the connecting jack 40 is expanded and contracted, whereby the connecting pin 45 is engaged with and disengaged from the connecting hole 48 of the cutter head outer peripheral portion 24, so that the cutter head central portion 23 and the cutter head outer peripheral portion 24 are connected to and separated from

each other. However, the connecting jack 40 and the connecting pin 45 may be provided in the cutter head outer peripheral portion 24, and the connecting hole 48 may be provided in the cutter head central portion 23. Furthermore, the connecting jack 40 may use an air cylinder or electric motor as well as a hydraulic cylinder which can be remote controlled. The connecting pin 45 may be a fixing bolt.

[0047] While the present invention has been described by the aforementioned embodiment, it is to be understood that the invention is not limited thereby, but may be varied in many other ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the appended claims.

Claims

1. A tunnel excavating machine having a rotationally drivable cutter head (20) mounted in a front portion of a cylindrical excavating machine body (11), **characterized in that**

said cutter head (20) is composed of a divisible central portion (23), and an outer peripheral portion (24) located on an outer peripheral side of said central portion (23), and is provided with a connecting pin (45) which moves from one of to other of said central portion (23) and said outer peripheral portion (24) to connect said central portion (23) and said outer peripheral portion (24).

2. A tunnel excavating machine according to claim 1, **characterized in that** said central portion (23) of said cutter head (20) is connected to an output transmission portion (17) of a cutter drive device (14, 21) loaded in said excavating machine body (11), and said outer peripheral portion (24) is detachably connected to said central portion (23).

3. A tunnel excavating machine according to claim 2, **characterized in that** said cutter drive device (14, 21) has rotors (17, 18) rotatably supported in the front portion of said excavating machine body (11), and a drive motor (21) for driving said rotors (17, 18), and said central portion (23) is connected to said rotors (17, 18) via an intermediate beam (19) extending forward from said rotors (17, 18).

4. A tunnel excavating machine according to claim 1, **characterized in that** a connecting jack (40) having said connecting pin (45) is provided in one of said central portion (23) and said outer peripheral portion (24) of said cutter head (20), and a connecting block (47) having a connecting hole (48), which said connecting pin (45) can be engaged with and disengaged from, is provided in said other of said cen-

tral portion (23) and said outer peripheral portion (24).

5. A tunnel excavating machine according to claim 1, **characterized in that** driving force transmission paths (49, 50) are provided in an interior of said connecting pin (45).

6. A tunnel excavating machine according to claim 5, **characterized in that** said driving force transmission paths (49, 50) are hydraulic pipings (51a, 51b, 52a, 52b) for driving a copy cutter (36) mounted on said outer peripheral portion (24) of said cutter head (20).

7. A tunnel excavating machine according to claim 1, **characterized in that** said central portion (23) of said cutter head (20) is constituted by having front end portions of a plurality of radial spokes (26) connected by a connecting ring (27), and said outer peripheral portion (24) of said cutter head (20) is constituted by having front end portions of a plurality of radial spokes (32) connected by a connecting ring (33).

8. A tunnel excavating machine according to claim 1, **characterized in that** said outer peripheral portion (24) of said cutter head (20) is in a shape of a ring, and is separable into a plurality of parts in a circumferential direction.

9. A method for recovering a tunnel excavating machine, **characterized by:**

advancing said tunnel excavating machine to excavate a tunnel;
stopping rotation of a cutter head (20) when said cutter head (20) penetrates into an arrival pit;
then extracting a connecting pin (45) connecting a cutter head central portion (23) and a cutter head outer peripheral portion (24);
separating said cutter head outer peripheral portion (24) from said cutter head central portion (23);
recovering said cutter head outer peripheral portion (24) above ground through said arrival pit;
then separating said cutter head central portion (23) from an excavating machine body (11);
and
recovering said cutter head central portion (23) above ground through said arrival pit.

10. A method for recovering a tunnel excavating machine, **characterized by:**

advancing said tunnel excavating machine to

excavate a tunnel for a predetermined distance
by a cutter head (20) rotated;
then stopping rotation of said cutter head (20);
then extracting a connecting pin (45) connect- 5
ing a cutter head central portion (23) and a cut-
ter head outer peripheral portion (24);
separating said cutter head outer peripheral
portion (24) from said cutter head central por-
tion (23);
then separating said cutter head central portion 10
(23) and a cutter drive device (17, 21) from an
excavating machine body (11);
recovering said cutter head central portion (23)
and said cutter drive device (17, 21) above 15
ground through the existing tunnel lying behind;
and
then recovering said cutter head outer periph-
eral portion (24) above ground through the ex-
isting tunnel lying behind.

20

25

30

35

40

45

50

55

FIG. 1

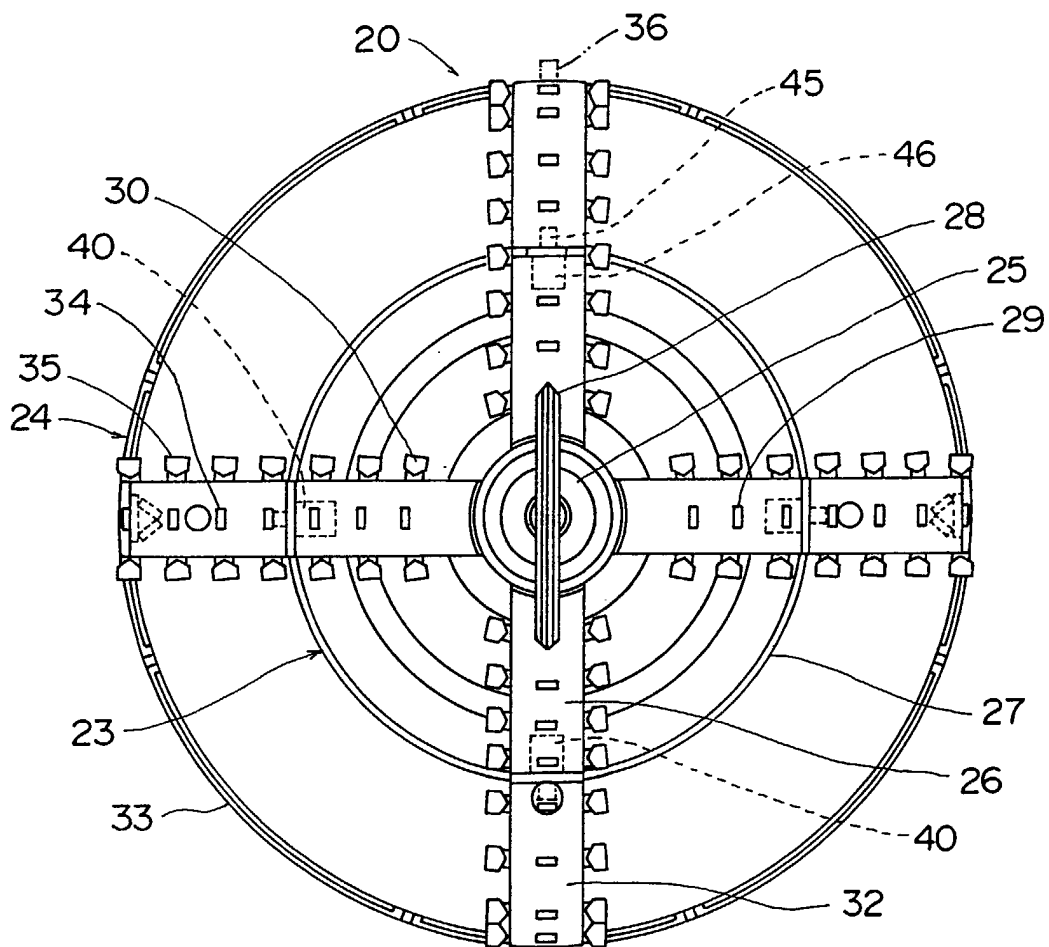


FIG. 2

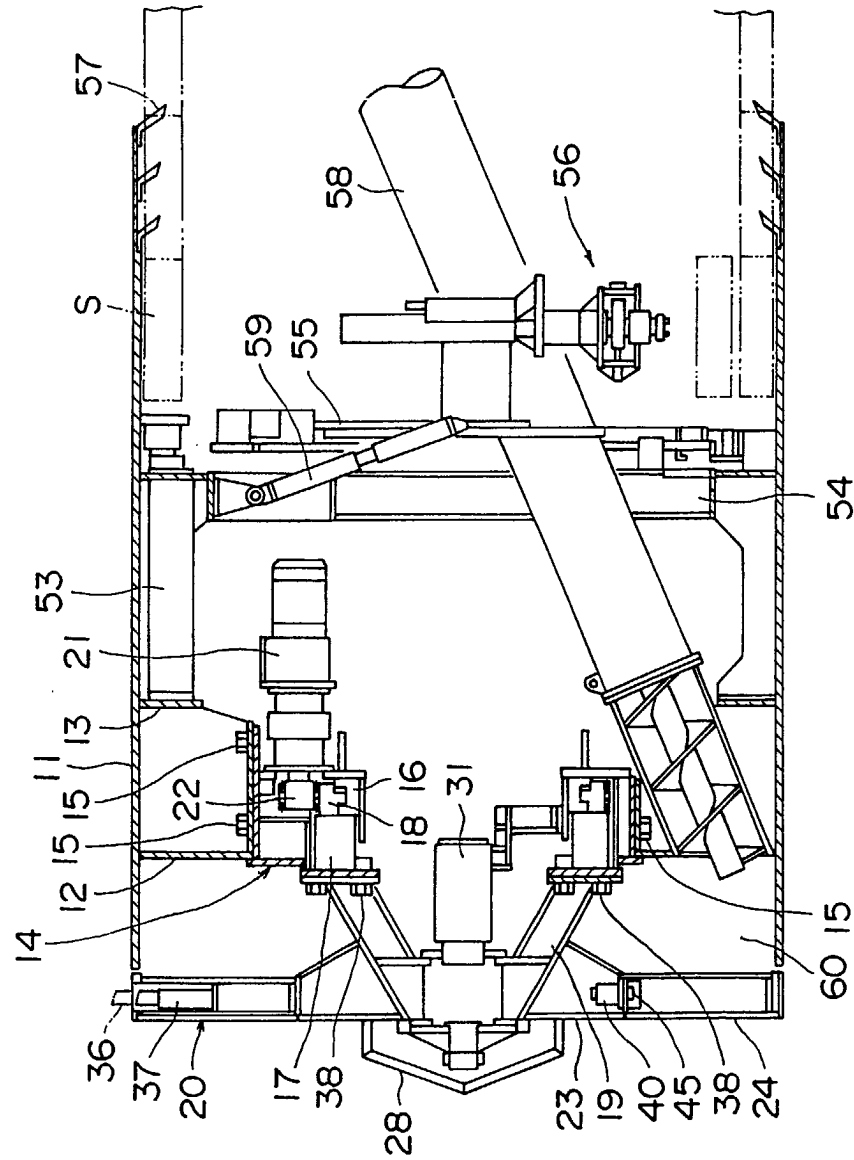


FIG. 3

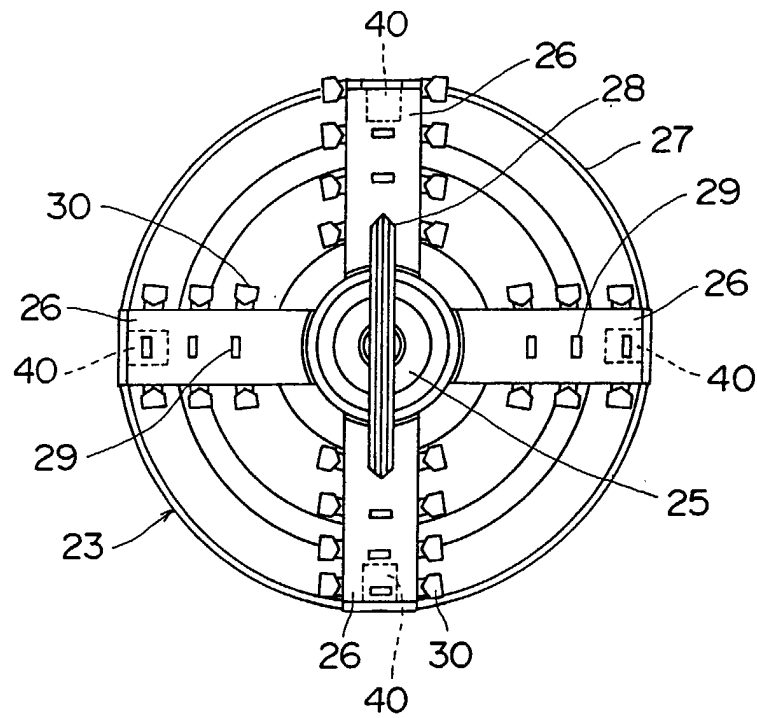


FIG. 4

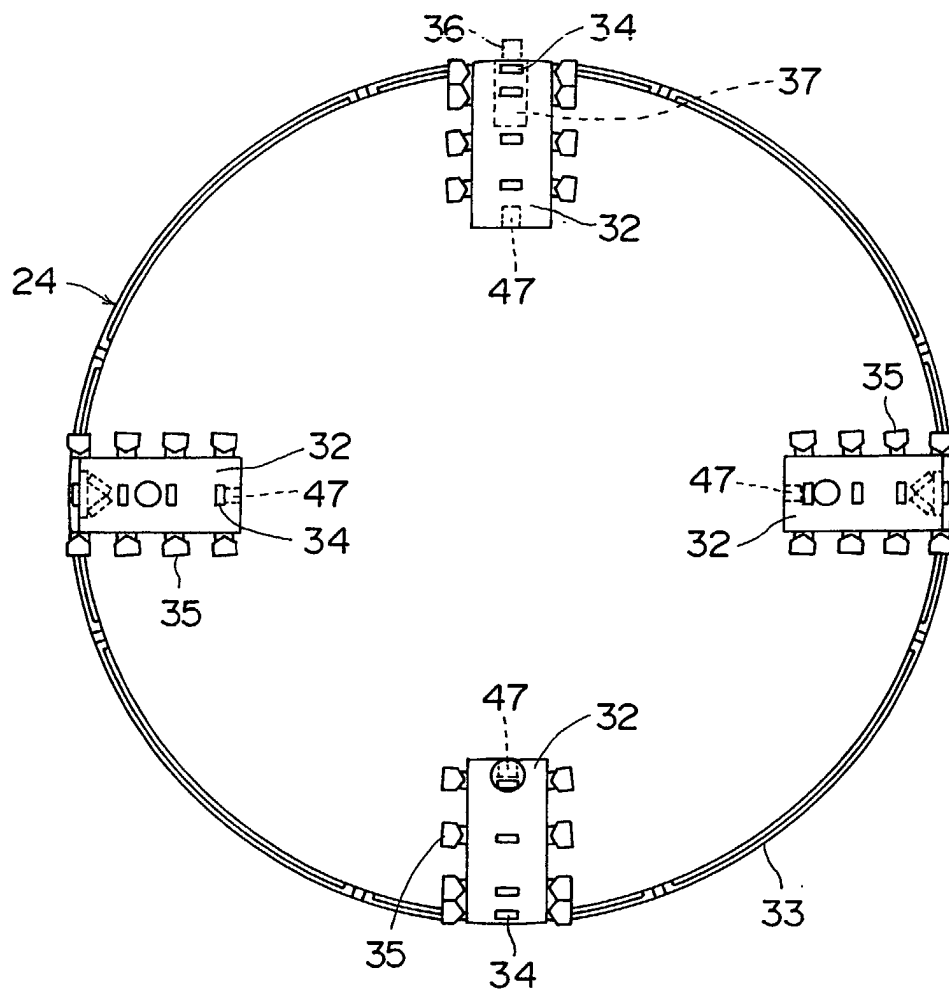


FIG. 5

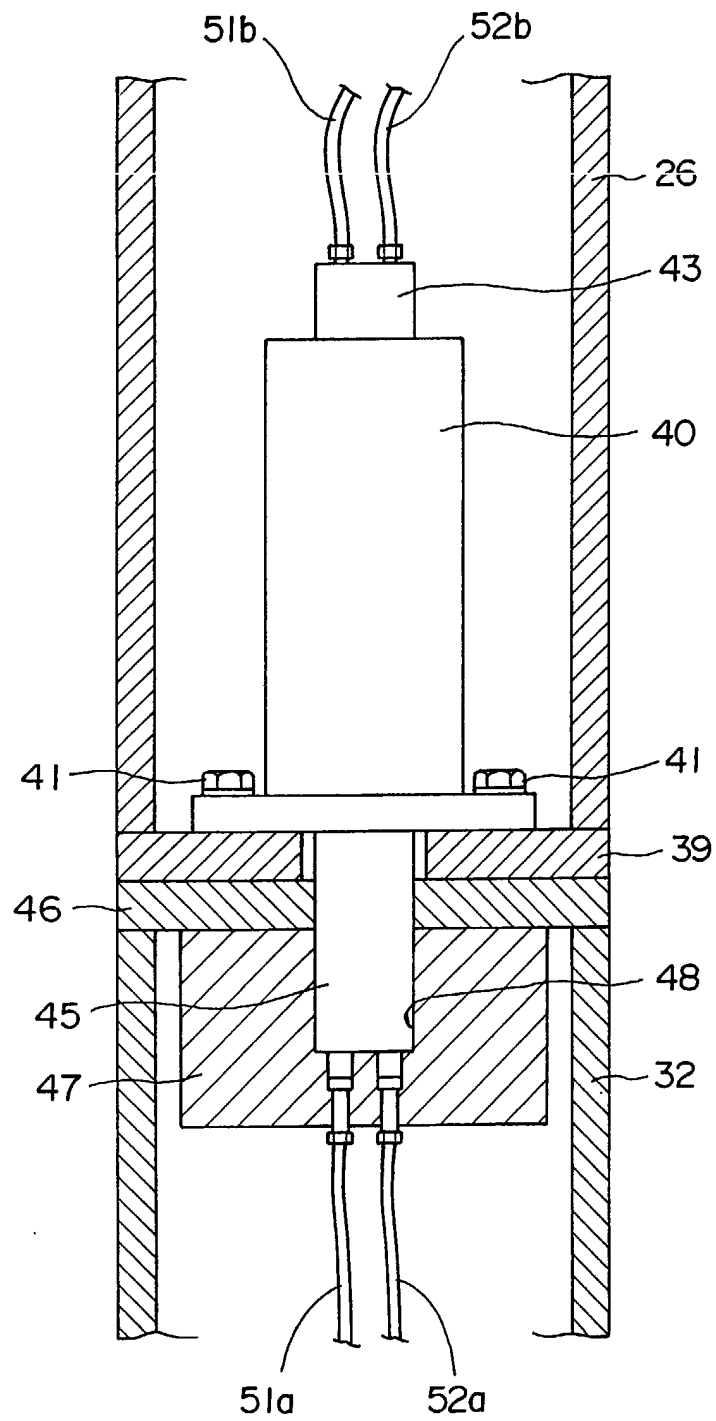


FIG. 6

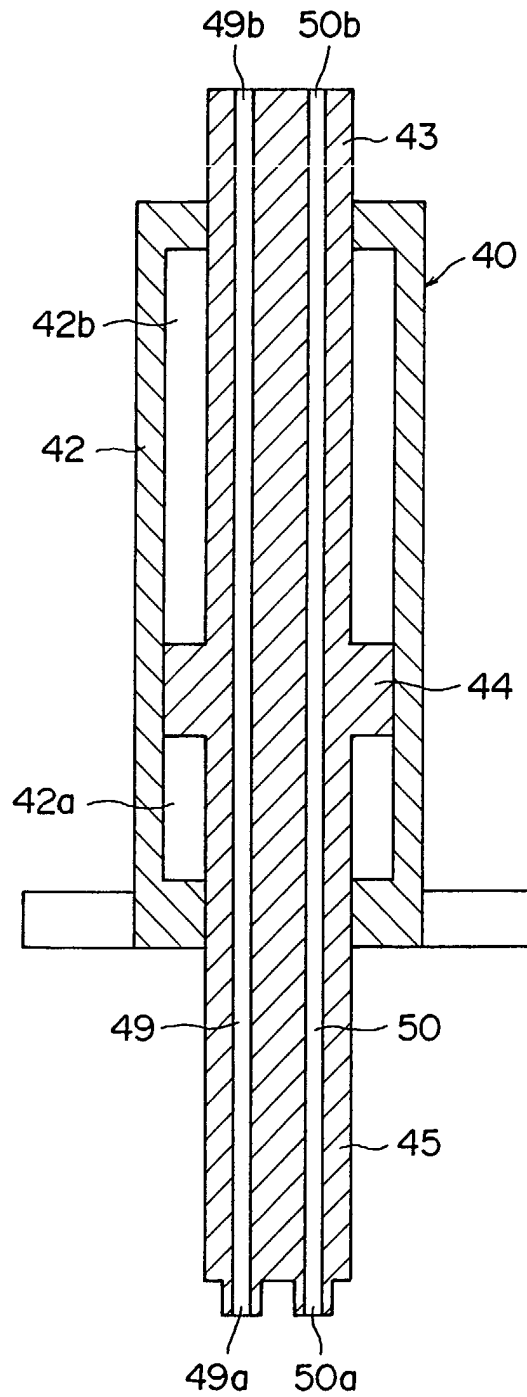
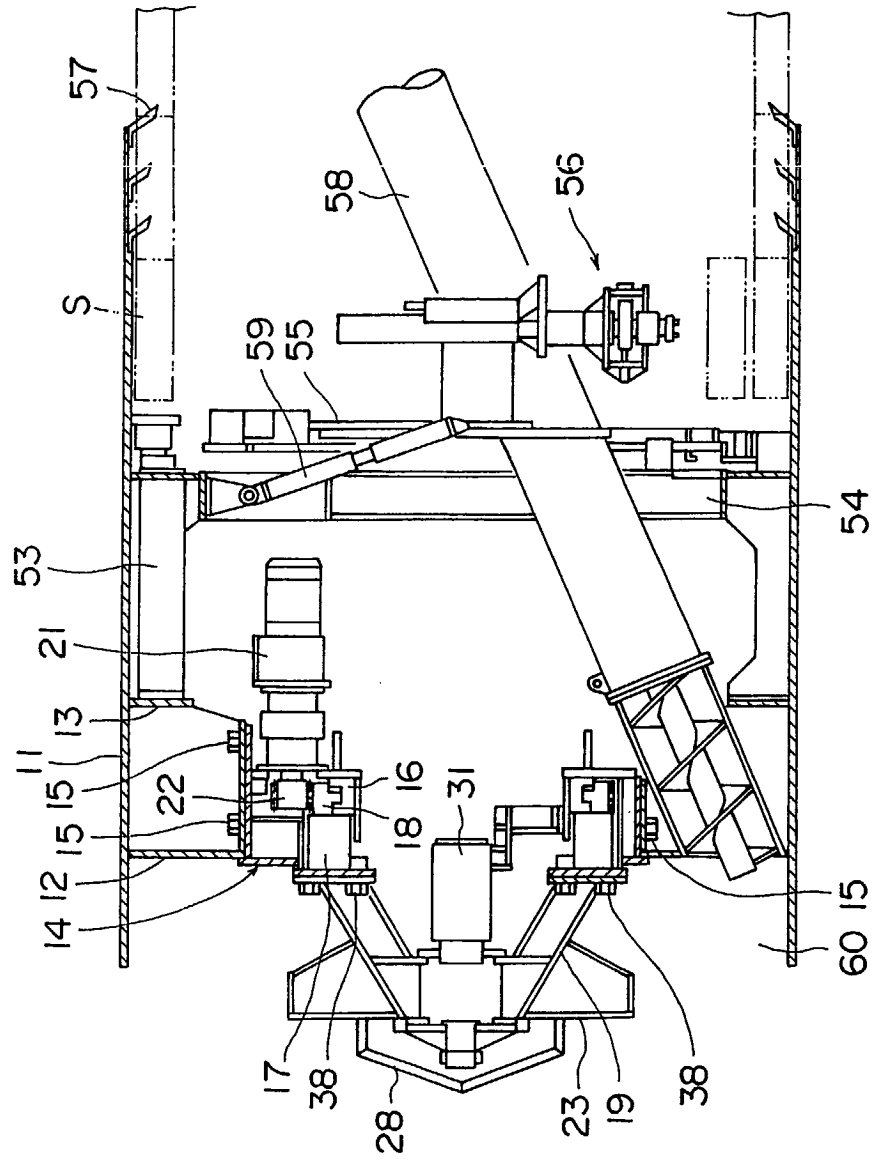


FIG. 7





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 02 5625

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	JP 11 006387 A (KAWASAKI HEAVY IND LTD) 12 January 1999 (1999-01-12)	1-5	E21D9/08
Y	* paragraph '0033! - paragraph '0035! *	6,7,9,10	
Y	--- PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) & JP 11 200764 A (MITSUBISHI HEAVY IND LTD), 27 July 1999 (1999-07-27) * abstract *	6	
Y	--- US 3 382 002 A (TABOR JOHN R) 7 May 1968 (1968-05-07) * column 5, line 45 - line 75 *	7	
Y	--- PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) & JP 11 210375 A (SHINWA GIJUTSU KAIHATSU KK), 3 August 1999 (1999-08-03) * abstract *	9,10	
X	--- EP 0 432 901 A (TAISEI CORP ; ISHIKAWAJIMA HARIMA HEAVY IND (JP)) 19 June 1991 (1991-06-19) * column 3, line 49 - line 57; figure 4 *	1-3	E21D
A	--- PATENT ABSTRACTS OF JAPAN vol. 1996, no. 04, 30 April 1996 (1996-04-30) & JP 07 324591 A (FUJITA CORP), 12 December 1995 (1995-12-12) * abstract *	9,10	
		-/--	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 30 January 2003	Examiner Garrido Garcia, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03 82 (P04C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 02 5625

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 11, 6 November 2002 (2002-11-06) & JP 2002 188391 A (MITSUBISHI HEAVY IND LTD;KOMATSU LTD), 5 July 2002 (2002-07-05) * abstract *	1-10	
A	EP 0 781 895 A (TAISEI CORP) 2 July 1997 (1997-07-02) * column 3, line 49 - line 54 * * column 4, line 39 - column 5, line 1 * -----	1-10	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
Place of search THE HAGUE		Date of completion of the search 30 January 2003	Examiner Garrido Garcia, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 02 02 5625

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-01-2003

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
JP 11006387	A	12-01-1999	JP	3073463 B2	07-08-2000
JP 11200764	A	27-07-1999	NONE		
US 3382002	A	07-05-1968	JP	48025778 B	31-07-1973
JP 11210375	A	03-08-1999	NONE		
EP 0432901	A	19-06-1991	JP	2852948 B2	03-02-1999
			JP	3183895 A	09-08-1991
			JP	2036970 C	28-03-1996
			JP	3191196 A	21-08-1991
			JP	7065457 B	19-07-1995
			DE	69010862 D1	25-08-1994
			DE	69010862 T2	10-11-1994
			EP	0432901 A1	19-06-1991
			US	5051032 A	24-09-1991
JP 07324591	A	12-12-1995	NONE		
JP 2002188391	A	05-07-2002	NONE		
EP 0781895	A	02-07-1997	JP	9184393 A	15-07-1997
			DE	69616001 D1	22-11-2001
			DE	69616001 T2	04-07-2002
			EP	0781895 A1	02-07-1997

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82