

METHOD FOR REPLACING A TUNNEL BORING MACHINE ROLLER
CUTTER, HANDLING DEVICE AND ROLLER CUTTER SUITED TO
SUCH A METHOD

5 FIELD OF THE INVENTION

The present invention relates to a method for replacing a tunnel boring machine roller cutter on the cutting head of a tunnel boring machine, as well as a
10 device for handling the roller cutter and a roller cutter suited to such a method.

BACKGROUND OF THE INVENTION

15 A roller cutter is a cutting tool that revolves freely around a shaft attached to the cutting head of a tunnel boring machine.

During rotation of the head and under the
20 influence of thrust, the roller cutter rolls over the cutting face and chips out the rock in the form of scale-like plates.

Thus the cutting head includes a plurality of
25 roller cutters evenly distributed over its surface.

Conventionally, the roller cutters are mounted within a housing on the cutting head by means of bolts.

5 The problem of changing the roller cutters occurs particularly in the case of a confined face tunnel boring machine, because access to the cutting head and to the roller cutter mounting hardware is difficult and the working environment is under hyperbaric conditions.

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In such tunnel boring machines, the changing of the cutting head is carried out, for safety reasons, from the rear of the cutting head, that is the side of the cutting head opposite the cutting face.

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The procedure for changing a roller cutter often demands the exertion of considerable force (sledgehammer blows for example) for loosening the used roller cutter from its housing, due to jams and the
20 absence of guidance for the roller cutter, which is poorly compatible with work under hyperbaric conditions.

At present, the procedure for changing a roller
25 cutter consists of equipping the roller cutter with lifting eyes, to lift it using a pulley block running along a rail, to load it onto a cart running through the equipment airlock and to bring it back to the rear inside the shield, at atmospheric pressure.

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During dismantling, it is also necessary to progressively collect all the elements (wedges, screws, bolts, etc.) necessary for mounting the roller cutter and which will be re-used for mounting the new roller
35 cutter.

Before inserting the new roller cutter into its housing, it must be properly positioned, which requires a painstaking manual intervention.

5

Once the roller cutter is pushed toward its operating position, several blocking wedges are put in place, which are held by means of bolts.

10 It will be understood that this procedure is long and tedious for the operators.

Embodiments of the present invention seek to to implement a method for replacing a roller cutter which
15 makes it possible to reduce, or even to eliminate, any human intervention during the replacement of a roller cutter.

Embodiments of the invention also seek to provide
20 a roller cutter which lends itself to such a method.

Embodiments of the invention also seek to obtain a roller cutter handling device suited to the implementation of this method, by making it possible in
25 particular to avoid any loss of components.

Likewise, the roller cutter handling device may be easy to clean and not include any areas that retain water or mud.

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Finally, this device may be usable in existing cutting heads without requiring modifications to the same.

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BRIEF DESCRIPTION OF THE INVENTION

According to an aspect of the invention, a method for replacing a roller cutter mounted with preload within a housing built into the cutting head of a tunnel boring machine is provided, the method being implemented with a roller cutter bearing, permanently attached thereto, a member for locking it within the housing and means for applying said preload.

Said method comprises the steps consisting of:

a) removal of a used roller cutter from said housing, comprising the following steps:

- clamping onto the housing of a handling device designed for grasping and guiding the roller cutter,

- grasping of the roller cutter by the handling device,

- release of the preload applied to the roller cutter,

- unlocking the roller cutter from the housing,

- extraction of the roller cutter from the housing,

- unclamping the handling device from the housing,

b) installation in said housing of a replacement roller cutter, comprising the following steps:

- grasping of the roller cutter by the handling device,

- docking, then clamping of the roller cutter handling device on the housing,

- insertion of the roller cutter into the housing,
5 said roller cutter being guided by the handling device,

- locking the roller cutter into the housing,

- applying a preload to the roller cutter.

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With particular advantage, said method may be implemented in an automated fashion using a mechanized system equipping the roller cutter handling device.

15 For implementing this method, the roller cutter permanently bears the elements that allow it to be locked and put under preload in the housing.

This can avoid any loss of components during
20 handling, dismantling and remounting of the roller cutter.

According to a preferred embodiment of the method, the roller cutter is held by the handling device through
25 its locking member.

There is also disclosed a roller cutter designed for implementing said replacement method.

30 The locking member of said roller cutter is designed to be immobilized, so that the roller cutter constitutes a rigid block for the purpose of its handling.

According to a particular embodiment of the invention, the locking member includes a bayonet that is movable in rotation between a position for insertion of the roller cutter into the housing and a position
5 for locking the roller cutter within the housing.

The means for preloading the roller cutter can include screws which are permanently born by the roller cutter.
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Thus, said preloading screws are preferably carried by the bayonet in a way that may preclude loss.

There is also disclosed a device for handling the roller cutter in implementing said method for replacing
15 a roller cutter.

More precisely, this handling device comprises:

- 20
- an element for clamping onto the housing,
 - an element for grasping the roller cutter,
 - means for releasing or applying preload to the
25 roller cutter,
 - an element for extracting the roller cutter,
 - a member for actuating the locking member of the
30 roller cutter.

Advantageously, said device also includes means for cleaning the housing.

Further, said device preferably includes means of transporting, docking and/or clamping onto the housing by means of a robot.

5 There is also disclosed a tunnel boring machine including a cutting head and a plurality of roller cutters such as those described above and housings built into the cutting head, said housings bearing contact surfaces for locking the roller cutters.

10

Said housing advantageously have contact surfaces for docking and guiding a roller cutter handling device such as that described above.

15 Finally, the roller cutters and the housings advantageously have respective complementary supporting contact surfaces for centering and guiding the roller cutter within the housing.

20 BRIEF DESCRIPTION OF DRAWINGS

Other features and advantages of the invention will appear from the detailed description that will follow, with reference to the appended drawings in
25 which:

Figure 1A shows a roller cutter inside a housing and a device for guiding the roller cutter in a roller cutter change situation,

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Figures 1B through 1F illustrate the different steps in the process of mounting a roller cutter conforming to the invention,

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Figure 2 shows the roller cutter in position in its housing according to the invention,

Figure 3 is a top view of a roller cutter in position in its housing,

Figure 4 is a section view along H-H of the roller cutter and of the housing illustrated in Figure 3,

Figure 5 is a section view along G-G of the roller cutter and of the housing illustrated in Figure 3,

Figure 6 is a section view along A-A of the roller cutter and of the housing illustrated in Figure 3,

Figures 7A and 7B show the roller cutter handling device, the housing and the roller cutter in position respectively inserted in and removed from the housing during the replacement cycle,

Figure 8 shows a section view in the longitudinal plane of the objects illustrated in Figure 1 A,

Figure 9 shows a perspective view of the handling device for the roller cutter (which is not shown),

Figures 10A and 10B respectively show an example of a handling device mounted on a semi-automatic positioning means and an example of a handling device mounted on the terminal part of a robotic handling effector.

DETAILED DESCRIPTION OF THE INVENTION

When the tunnel boring machine is put into

service, each roller cutter is installed in its housing while being subjected to a preloading which allows it to resist the forces to which it will be subjected during cutting.

5

Conventionally, the housing for its part is affixed to the cutting head, typically by welding.

As will be seen below, the procedure for
10 installation and extraction of the roller cutter is facilitated by the fact that the locking and preloading elements are permanently born by the roller cutter.

What is meant by "permanently born" is that the
15 different elements allowing locking and preloading of the roller cutter within the housing can have relative motion with respect to one another, but that they remain mechanically connected to one another without the possibility of naturally separating.

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Method for replacing a roller cutter

The extraction of a used roller cutter from its housing is implemented during the following steps.

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Removal of a used roller cutter

First of all, a roller cutter handling device, the structure whereof will be discussed below my means of
30 an example, is brought to the housing via the back face (that is, as stated above, the face opposite the cutting face) of the cutting head.

The delivery of the handling device can be carried
35 out in a semi-automated manner by means of a pulley

block, or in a completely automated manner, through the use of a handling robot.

5 The handling device and the housing have respective contact surfaces which cooperate to allow guidance and docking of the handling device on the housing.

10 Once in position, clamping elements, of the handling device for example, or of the carrying robot, are actuated to provide locking of the device onto the housing.

15 As will be seen below, these elements can consist of retaining pins movable through a quarter-turn arranged on the handling device for holding suitable contact surfaces provided on the housing.

20 The following step consists of grasping of the roller cutter locking member by the handling device.

25 To this end, the handling device advantageously includes a suitable grasping element which allows grasping of the roller cutter by way of the roller cutter's locking member.

30 It also includes an actuating member designed to effect the unlocking of the roller cutter from the housing.

35 For example, in the device example that will be described below, this grasping element includes jaws capable of grasping the roller cutter's locking member and drivable in rotation between a locking position and an unlocking position of the roller cutter.

It will be noted that, while the handling device as described above uses the roller cutter's locking member for grasping the same, it could just as well be contemplated that the roller cutter have distinct means
5 for fulfilling the two functions, to wit a locking member and a grasping interface.

At this stage, the roller cutter is still
10 preloaded in the housing and locked into the same.

The following step of the method consists of the release of said preload.

15 To this end, when this preload is provided by screws, the handling device loosens said screws.

It is then possible to unlock the roller cutter from the housing by actuating the unlocking element of
20 the handling device toward the roller cutter unlocking position.

To make possible the handling of the roller cutter for its extraction, it is necessary that the set of
25 elements permanently born the roller cutter be immobile with respect to one another so as to form a rigid block.

To this end, the locking member of the roller
30 cutter is put back under load so that the elements of the roller cutter become immobile with respect to one another.

In the case illustrated in Figures 1B through 6,
35 where the locking member of the roller cutter 1 is a

bayonet 4 with a pivot connection to a crossmember 6 and where the preloading means of the roller cutter 1 are screws 5 carried by the bayonet, this comes down to tightening the screws 5 to put the bayonet 4 in
5 abutment against the crossmember 6 of the roller cutter.

It is then possible to proceed with the extraction of the roller cutter from its housing, the components
10 of the roller cutter being immobile with respect to one another and constituting a rigid block.

A relatively high force is necessary due to the buttressing resulting mainly from the operating loads
15 which jam the roller cutter into its housing.

The roller cutter handling device therefore includes extraction elements (for example jacks) which make it possible to exert the necessary extraction
20 force.

Once the roller cutter is extracted from the housing, the handling device is unclamped from the housing, then the housing is cleaned, with high-
25 pressure water jets for example, so as to be able to more easily insert the new roller cutter.

Finally, the assembly consisting of the handling device and the roller cutter is conveyed to the
30 workshop where the used roller cutter will be disassembled.

It is possible to proceed with cleaning the handling device before reusing it to install a new
35 roller cutter.

Installation of a replacement roller cutter

5 To install a new roller cutter in the housing,
these steps are followed in reverse order.

 To describe these mounting steps, Figures 1B
through 1F will be relied on as an example, but it is
10 understood that these figures show only one particular
embodiment of the roller cutter and that the method is
not limited to the installation of this particular
roller cutter.

15 First of all, in the workshop, a new roller cutter
(more precisely its locking member in the case
illustrated here, or its grasping interface when the
locking member does not fulfill the function of
grasping the roller cutter) is attached on the handling
20 device by means of the grasping element mentioned
above.

 So that the roller cutter can be handled, it is
arranged that the different components are made
25 immobile with respect to one another so that they
constitute a rigid block.

 With reference to Figure 1B, the roller cutter 1
is held by the handling device by the bayonet 4 (the
30 handling device is not illustrated in Figures 1B
through 1F to allow a better view of the different
components of the roller cutter and of the housing).

 The handling device supporting the roller cutter
35 is brought into position facing the back face of the

housing 2.

It is specified that the front face of the housing is defined as being the face from which the rotating
5 part of the roller cutter extends toward the cutting face; the back face of the housing is the opposite face, through which the roller cutter is inserted.

The housing 2 has contact surfaces (not
10 illustrated here) which allow pre-centering and guidance, then clamping of the handling device.

These contact surfaces are for example male shapes provided on its outer walls, constituting guide rails
15 which cooperate with complementary female shapes provided on the handling device.

Once it is in position centered on the housing, the handling device is clamped to the same by its
20 clamping elements.

With reference to 1C, the grasping element of the handling device is then moved forward to insert the roller cutter 1 into its recess within the housing 2
25 all the way to the stop.

Thanks to the contact areas 20 provided in the inner walls of the housing 2, the roller cutter 1 is automatically centered with respect to the same.

30

Further, the shape of the contact surfaces 20 is designed to provide support surfaces for the ends 10 of the roller cutter shaft in the front part of the housing.

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With reference to Figure 1D, the screws 5 which hold the bayonet 4 under load against the crossmember 6 are then unscrewed, so as to allow rotation of the bayonet.

5

With reference to Figure 1E, the grasping element which holds the bayonet 4 is driven in rotation toward the locking position of the roller cutter 1 in the housing 2.

10

In the case illustrated here, the bayonet 4 is pivoted 90° and lodges behind the contact surfaces 21 (also visible in Figure 6) provided in the housing 2, which has the effect of locking the roller cutter into the housing.

15

It is then a matter of preloading the roller cutter so that it can resist the forces to which it is subjected during cutting.

20

To this end, the actuating member of the handling device actuates the preloading means of the roller cutter to apply a preload through the back of the housing, this force being resisted by the supporting surfaces 20 of the housing 2.

25

The application of the preload can be carried out by simply tightening the screws 5 in the crossmember 6, or preferably by the use of jacks between the crossmember 6 and the bayonet 4 followed by the abutment of the screws 5 in the crossmember 6.

30

This is an "irreversible" preloading in the sense that the means of applying the preload do not allow it to be released in the absence of action by an operator.

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In the case illustrated in Figure 1F, the screwdriver heads of the handling device tighten the screws 5 to the desired torque.

5

The installation of the roller cutter with preloading being completed, the handling device is detached from the roller cutter and it is unclamped from the housing.

10

The implementation of the method which has just been described has therefore been made possible by the design of a new structure for the roller cutter and of a new roller cutter handling device, which will be described consecutively below.

15

Compared to the known method wherein the roller cutter is installed on the cutting head, then attached and preloaded by means of screws and wedges, the method using the roller cutter-handling device assembly has the advantage of being capable of implementation by a mechanized device, which allows a long and tedious human intervention to be reduced or eliminated.

20

Further, centering of the roller cutter in the housing is accomplished automatically by the walls of the housing, which avoids the use of wedges as in existing roller cutters.

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It can also be noted that, the housing being devoid of threads, it poses little risk of damage and requires little repair.

30

Finally, the housing can be installed on an existing cutting head without requiring any special

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adaptation of the same.

It is clearly understood, however, that manual installation of the cutting head as practiced in the prior art is still possible; this installation is even facilitated by the fact that the roller cutter permanently bears all the elements necessary for mounting it, which dispenses the operators from handling the screws and wedges customarily used.

10

Example of a roller cutter suited to the implementation of the method

A roller cutter design suited to the implementation of this method will now be described with reference to Figures 2 through 6.

This is a roller cutter illustrated in Figures 1B through 1F which were commented on above.

20

Figure 2 illustrates the roller cutter 1 inside the housing 2, one of the side walls of the housing not being shown.

In a manner known per se, the roller cutter 1 is freely movable in rotation about a shaft having two ends 10 arranged on either side of the roller cutter.

The ends 10 of the shaft have for example a polygonal shape which allows them to be socketed into two supports 7 having a complementary shape (octagonal in the example of Figure 2), to which they are attached by screws.

Said supports 7 are connected by a crossmember 6

which has a U shape overall.

The supports 7 are attached to the crossmember 6 by screws 70 (also visible in Figures 3 and 5) placed
5 at the four corners of the same.

Further, the roller cutter 1 permanently bears a locking member that can be actuated between a locking position wherein the roller cutter is held inside the
10 housing 2 and an unlocking position allowing the extraction of the roller cutter from the housing.

Here, this locking member includes a bayonet 4 which is mounted on the crossmember 6 by a pivot
15 connection about a pivot pin 40.

The roller cutter also permanently bears means of preloading it inside the housing.

20 These preloading means are preferably irreversible mechanical members such as bolts and/or jacks arranged between the locking member and the roller cutter crossmember.

25 In the present text, the term "irreversible" means that these members can not release the applied preload without a deliberate intervention using a dismantling device.

30 In the example illustrated here, these preloading means are screws 5 carried in a way that precludes loss on the bayonet 4 and which, when they are tightened to an appropriate torque, apply to the roller cutter locked into the housing a preload of the intensity
35 desired.

It is important to recognize that the set of components necessary for locking the roller cutter into the housing and for preloading the roller cutter (to wit mainly, in the example illustrated here, the bayonet 4 and the screws 5) are permanently born by the roller cutter, that is they are mechanically connected to the same with no possibility of removal without deliberate dismantling (for the purpose of repair, for example).

Further, these components can be immobilized with respect to one another for the purpose of constituting a rigid block allowing handling of the roller cutter.

It is self-evident that a person skilled in the art can contemplate a different roller cutter structure, also usable in the method described above, without thereby departing from the scope of the present invention.

For example, he could use a locking principle other than the bayonet 4, so long as the attachment elements were permanently born by the roller cutter and could constitute a rigid assembly for the handling of the roller cutter.

Likewise, the number of screws shown in these figure is only by way of indication, and a person skilled in the art can of course modify the number of screws and/or suggest other means of applying the preload without departing from the scope of the present invention.

Roller cutter handling device

Figure 9 illustrates an example of a handling device 3 for the roller cutter.

5 The device 3 includes a case 31 which supports the elements that allow it to be centered on the housing.

10 The centering elements are for example forms arranged on the frame which cooperate with complementary forms of the housing, thus fulfilling the function of guiding the device with respect to the housing.

15 In the example illustrated here, the clamping elements include four pins 33 having the shape of a quarter-circle and movable in rotation.

20 These pins 33 lodge themselves within grooves arranged on the housing so as to provide attachment of the frame 3 on the housing 2.

 The device 3 also includes an actuating device 36 housed in the case 31.

25 Here, the actuating member is movable in translation (by means of jacks 35) and in rotation with respect to the case 31.

30 The device 3 also includes a grasping element for holding the roller cutter, and more particularly the locking member of the same.

35 The grasping element is mounted on the actuating member 36, and can thus be driven both in translation to insert or extract the roller cutter from the housing

and in rotation to lock or unlock the roller cutter inside the housing.

In the example illustrated here, the grasping
5 element includes jaws 34 designed to seize the bayonet
4 of the roller cutter.

The jaws 34 can open to a distance greater than the width of the bayonet to allow it to be grasped or
10 released, and can be brought together to permanently hold the bayonet.

Thanks to their connection with the actuating member, the jaws 34 are also movable in rotation by at
15 least a quarter-turn between a position where the bayonet is in a position allowing the insertion of the roller cutter into the housing and a position where the bayonet is in a position locking the roller cutter into the housing.

20

The handling device 3 also includes means for applying or releasing the preload on the roller cutter, which cooperate with the preloading means of the roller cutter.

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These means include screwdriving heads 32 connected to screwdriver bodies 37 mounted in the actuating member 36 and designed to tighten or loosen the roller cutter preloading screws 5.

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The device 3 further includes roller cutter extraction elements.

In the example illustrated here, these extraction
35 means are jacks 35 arranged between the case 31 and the

actuating member 36.

In the situation illustrated in Figure 7A, where the roller cutter is in the operating position in the housing 2, the case 31 of the device 3 is clamped on the housing 2 by means of the pins 33 and the jacks 35 are in the retracted position, such that the actuating member 36, and hence the jaws 34 and the screwdriving heads 32 can respectively drive the bayonet and the roller cutter preloading screws.

In the situation illustrated in Figure 7B, where the roller cutter 1 is being extracted from the housing 2, the frame is still clamped to the housing 2 thanks to the pins 33, but the jacks 35 are in the deployed position, which has the effect of withdrawing the actuating member 36, and hence the jaws 34 that hold the bayonet.

The device 3 can also include any other component that a person skilled in the art deems useful.

Thus for example it includes means (not illustrated) for cleaning the housing after the extraction of the used roller cutter.

These means can consist in particular of high pressure water jets.

In the example illustrated in Figure 9 (as well as in Figure 10A, where it is shown in perspective with the roller cutter), the case 31 of the handling device is surrounded by an arch 38 which is designed to be hooked to a pulley block (not shown).

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This corresponds to a semi-automated embodiment, which can be implemented for example in degraded mode, during maintenance operations.

5 As for Figure 10B, it illustrates an embodiment of the handling device 3 designed to be mounted on the terminal part of a robotic handling effector, which is preferentially used for the operation of the tunnel boring machine.

10

Only a forward plate 42 of the handling robot is shown in this figure, which has a recess for receiving the handling device.

15 Said robot is particularly moved in translation along the axis of the housing, and has means for controlling the handling device.

20 The handling device 3 is connected with the plate 42 by a hexapod type jack assembly 41 which makes it possible to move the device 3 for the purpose of locking it on the housing, then withdrawing it.

25 The handling device which is illustrated in particularly suited to the roller cutter shown.

30 It is naturally understood that the shape of this handling device can vary according to the shape of the corresponding roller cutter without thereby departing from the scope of the present invention.

35 Finally, it is self-evident that the examples just given are only particular illustrations and are in no way limiting as regards the details of implementation of the invention.

CLAIMS

1. A method for replacing a roller cutter mounted with preload within a housing built into the cutting head of a tunnel boring machine, the method being implemented with a roller cutter bearing, permanently attached thereto, a member for locking it within the housing and means for applying said preload, and including the steps consisting of:

a) removal of a used roller cutter from said housing, comprising the following steps:

- clamping, onto the housing, of a handling device designed for grasping and guiding the roller cutter,
- grasping of the roller cutter by the handling device,
- release of the preload applied to the roller cutter,
- unlocking of the roller cutter from the housing,
- extraction of the roller cutter from the housing,
- unclamping the handling device from the housing,

b) installation in said housing of a replacement roller cutter, comprising the following steps:

- grasping of the roller cutter by the handling device,
- docking, then clamping of the roller cutter handling device on the housing,
- insertion of the roller cutter into the

housing, said roller cutter being guided by the handling device,

- locking the roller cutter into the housing,
- applying a preload to the roller cutter.

2. A method according to Claim 1, wherein the roller cutter is held by the handling device by its locking member.

3. A method according to one of Claims 1 or 2, wherein it is implemented by means of a mechanized roller cutter handling device.

4. A roller cutter suited for the implementation of the replacement process according to one of Claims 1 through 3, said roller cutter bearing, permanently attached thereto, a member for locking the roller cutter within the housing in the cutting head and means for applying a preload to the roller cutter when mounted in the housing.

5. A roller cutter according to Claim 4, wherein said locking member is designed to be immobilized, so that the roller cutter constitutes a rigid block.

6. A roller cutter according to one of Claims 4 or 5, wherein the locking member includes a bayonet movable in rotation between a position for inserting the roller cutter into the housing and a position for locking the roller cutter into the housing.

7. A roller cutter according to one of Claims 4 through 6, wherein the preloading means include screws.

8. A roller cutter according to Claims 6 and 7

combined, wherein the bayonet comprises said screws for preloading the roller cutter in a manner that precludes loss therefrom.

9. A device for handling the roller cutter in the implementation of the roller cutter replacement method according to one of 1 through 3, wherein it comprises:

- an element for clamping onto the housing,
- an element for grasping the roller cutter,
- means for releasing or applying preload to the roller cutter,
- an element for extracting the roller cutter,
- a member for actuating the locking member of the roller cutter.

10. A device according to Claim 9, wherein it includes means for cleaning the housing.

11. A device according to one of Claims 8 through 10, wherein it includes means of transporting, docking and/or clamping onto the housing by a robot.

12. A tunnel boring machine including a cutting head and a plurality of roller cutters according to one of claims 4 through 8 in housings built into the cutting head, said housings bearing contact surfaces for locking the roller cutters.

13. A tunnel boring machine according to Claim 12, wherein the housings have contact surfaces for docking and guiding a roller cutter

handling device according to one of Claims 9 through 11.

14. A tunnel boring machine according to one of Claims 12 or 13, wherein the roller cutters and the housings have respective complementary support contact surfaces for centering and guiding the roller cutter in the housing.