

**An excavating tool for a tunnel boring machine and boring machine
comprising such a tool**

The present invention relates to an excavating tool for a mole, as well as to a mole comprising such an excavating tool.

5 A mole, otherwise called a tunnel boring machine, comprises a tubular casing at the front of which is provided a shield, the outer diameter of which corresponds to the diameter of the bored tunnel. The front part of the shield which comes into contact with the cutting front for boring the land crossed by the mole, includes a cutting head which is driven into rotation on itself around an axis corresponding to the central longitudinal axis
10 of the mole. The cutting down of the land is obtained by rotation of the cutting head and simultaneous advance of the latter generated by a strong thrust against the cutting front. On the rear of the front shield, the casing of the mole is interiorly equipped with means for moving the mole forwards, with a system for discharging the cuttings resulting from the cutting down of the land and a device for laying voussoirs inside the bored tunnel in order
15 to gradually make a tube lining the inside of the tunnel.

 The cutting head comprises radial arms which support excavating tools intended for cutting down the land. A distinction is made between the tools which freely rotate on themselves on a shaft secured to the cutting head and which are typically disc cutters rolling on the cutting front for cutting it, and tools which, when operating are provided
20 attached on the cutting head and which attack the cutting front by scraping. The invention is interested in these last excavating tools, which, conventionally include a drag bit for attacking the land to be excavated, sometimes called a pick, a plough or a knife. This drag bit is subject, because of the geological nature of the crossed land, to strong mechanical stresses and to abrasion, so that it wears out or even breaks and that it therefore has to
25 be replaced periodically. In line with this, the drag bit is mounted interchangeably on a dedicated mounting bracket, permanently fixed, generally by welding, on the arms of the cutting head. In practice, the drag bit is retained on the mounting bracket by removable attachment means, which should allow disassembling of the worn drag bit and mounting again a new drag bit, both easily, while using portable and usual tooling, and fast in order
30 to avoid too long immobilization of the mole. Of course, these attachment means have to be adapted to the conditions of use of the excavating tool, notably to the forces and impacts to which the tool is subject, as well as to the presence of cuttings and water. Further, in principle, these attachment means should be provided for limiting the constraints of use and minimizing the weight of tooling to be handled by the operators
35 having to carry out maintenance operations of the excavating tool, notably the operation

for replacing its drag bit: indeed, these operations are carried out under difficult conditions for the operators, from an often over-pressurized chamber, between the cutting head and a fixed vertical partition positioned behind this head.

5 A first solution which is the most widespread, consist of attaching the drag bit to the mounting bracket with several screws, for example four screws or even more, which cross a smooth bore hole of the drag bit so as to be screwed into additional tapped holes of the mounting bracket, until they clamp the drag bit against the mounting bracket. This solution has drawbacks. Indeed, the accessibility of the screw heads is delicate while these screws have to be associated with nuts and ideally tightened with a torque wrench, 10 which implies long and tedious manipulations for the operator, with the risk of loosening or losing screws. Further, these screws directly support the essential part of the applied forces on the drag bit. Moreover, in the long run, the tapping holes of the mounting bracket tend to be damaged because of the forces and of corrosion.

A second solution consist of blocking the drag bit on the mounting bracket so that, 15 during operation, the forces applied to the drag bit are essentially directly absorbed by the mounting bracket, while providing the possibility of disengaging the drag bit with respect to the mounting bracket in at least one predetermined disengagement direction. In order to prevent this disengagement as long as this is not desired, a screw crosses both the drag bit and the mounting bracket and tightens them against each other by adding a tightening 20 nut to the end of the screw, opposite to its head. This solution also has drawbacks. Indeed, it is necessary, both for mounting and disassembling, to handle approximately in the same time the screw and its associated nut: under the maintenance conditions mentioned above, and by taking account of the fact that, regarding the diverse possible orientations of the tool related to the angular position of the cutting head, the screw most 25 often extends in a tilted way with respect to the horizontal, it is understood that these handling operations require two operators, except incurring the high risk of losing the screw and/or the nut.

Moreover, both for either one of these solutions, the disengagement of the drag bit with respect to the mounting bracket requires that the screws be totally separated from the 30 drag bit and the mounting bracket, if necessary, after having been released from their nut: it is understood that the movements engaged in the corresponding operations are numerous and complex, which in practice results in these operations which cannot, with reasonable costs, be applied by robot manipulators.

A third solution was proposed by EP-1 253 286-A1. Like in the second solution 35 mentioned above, the drag bit in operation is blocked on the mounting bracket in all the

directions of space except in a disengagement direction. In order to prevent the drag bit from disengaging from the mounting bracket during the rotation of the cutting head, a screw attaches the drag bit to the mounting bracket removably: in a mounted configuration of this excavating tool, the threaded end of the screw is screwed into a tapped hole of the drag bit, the central axis of which is parallel or slightly tilted with respect to the disengagement direction, while the head of the screw is supported on a wall of the mounting bracket through which extends the screw. In order to disengage the drag bit from the mounting bracket while maintaining the screw secured to this drag bit, the screw is partly unscrewed, and it is then necessary to move the drag bit first along a first translational movement of the disengagement direction, and then along a second translational movement in a direction perpendicular to this disengagement direction: the first movement gives the possibility of only partly disengaging the drag bit with respect to the mounting bracket, the continuation of this first movement being impossible because of the interference in the disengagement direction, between the head of the screw and the aforementioned wall of the mounting bracket. The movement of the drag bit according to the second movement is that the stem of the screw crosses the aforementioned wall of the mounting bracket through a slot of this wall, this slot being oriented in the direction of the second translational movement and opened at its end so as to let the stem of the screw move out and thus allow effective disengagement of the drag bit and of the screw with respect to the mounting bracket. The successive application of the first and second aforementioned movements may prove to be delicate, in particular for a robot manipulator.

Embodiments of the present invention seek to propose an excavating tool of the type mentioned above, for which the mounting and the attachment of the drag bit are efficient and fast, as well as particularly simple to apply, potentially automatically by a robot.

For this purpose, embodiments of the invention seek to provide an excavating tool for a tunnel boring machine as defined in claim 1.

According to a first aspect of the present invention, there is provided an excavating tool for a tunnel boring machine, comprising:

- a drag bit for attacking the land to be excavated,
- a mounting bracket for mounting the drag bit, the mounting bracket being provided so as to be permanently fixed to a cutting head of the tunnel boring machine, the mounting bracket and the drag bit being shaped so as to be engaged with each other so as to fixably bind the drag bit with the mounting bracket in all the directions of space except in a disengagement direction, and

- a screw for removably attaching the drag bit to the mounting bracket, the screw being provided with threading which is screwed into a tapped hole of the drag bit, the disengagement direction being transverse to the central axis of this tapped hole,

5 wherein, in a mounted configuration of the excavating tool, the drag bit is in direct mechanical engagement with the mounting bracket in the directions other than the disengagement direction and the screw interferes with the mounting bracket in the disengagement direction for blocking the drag bit with respect to the mounting bracket, and

10 wherein the tapped hole of the drag bit and the threading of the screw are designed for, by screwing-unscrewing, maintaining the drag bit and the screw secured to each other while having the excavating tool pass between the mounted configuration and a disassembled configuration in which the screw does not interfere with the mounting bracket in the disengagement direction so that, by driving only in the disengagement direction, the drag
15 bit and the screw are disengaged from the mounting bracket, while by driving only in a direction opposite to the disengagement direction, the drag bit and the screw are mounted on the mounting bracket.

According to embodiments of the invention, the attachment of the drag bit on the mounting bracket is achieved with at least one screw which, both when the drag bit is
20 mounted on the mounting bracket and the tool is thus in an operating condition, and when the drag bit is disassembled with respect to the mounting bracket and the tool is thus in a maintenance condition for purposes of repair or of changing the drag bit, it is physically maintained secured to the drag bit, while remaining screwed into this drag bit. Therefore, there is no risk of loosening or losing the screw during the handling operations of the drag
25 bit. The passage of the tool according to embodiments of the invention between its mounted and disassembled configurations is carried out by relative screwing-unscrewing between the screw and the

drag bit. Further, once the tool is in a disassembled configuration, the joint drive of the drag bit and of the screw exclusively in the disengagement direction gives the possibility of completely disengaging this drag bit and this screw with respect to the mounting bracket; the mounting of the assembly « drag bit + screw » on the mounting bracket is, as for it, totally obtained by driving this assembly exclusively in a direction opposite to the disengagement direction. Thus, the movements engaged for mounting and disassembling the tool, i.e. the screwing-unscrewing of the screw and the rectilinear drive of the « screw + drag bit » assembly parallel to the engagement direction, are limited, constant and repetitive, the assembly « drag bit + screw » remaining entire and secured: the mounting and disassembling operations are facilitated and shortened for a human operator, these operations being even easily adaptable to automatic application by a robot manipulator.

Further, in the mounted configuration of the tool, the screw only supports few, or even no forces exerted by the land on the drag bit during the scraping action of the latter on the cutting front: indeed, because of the direct engagement between the drag bit and the mounting bracket, notably by blocking, these forces are in majority absorbed or even exclusively absorbed by the mounting bracket, except in the disengagement direction of the drag bit with respect to the mounting bracket, a direction in which the screw ensures the blocking of the drag bit with respect to the mounting bracket while interfering with the latter. In practice, the proportion of the forces specifically applied in this disengagement direction is small, or even marginal with respect to the whole of the forces which, upon accumulation, are exerted on the drag bit, these forces being oriented in a very large number of directions, depending on the irregularities of the cutting front and gradually during the rotation of the cutting head. It is understood that the screw of the excavating tool according to embodiments of the invention may advantageously be dimensioned accordingly to a minimum and only be provided in a single version, which reinforces the handling facility, while guaranteeing the reliability of the operating excavating tool.

Advantageous additional features of the excavating tool according to embodiment of the invention are specified in claims 2 to 10.

According to a second aspect of the present invention, there is provided a tunnel boring machine, comprising a cutting head and at least one excavating tool, as defined in the first aspect and the mounting bracket of which is permanently fixed to the cutting head.

The invention will be better understood upon reading the description which follows, only given as an example and made with reference to the drawings wherein:

- Fig. 1 is a front face of a mole according to the invention;

- Fig. 2 is a perspective view of an excavating tool according to the invention, in the mounted configuration;

- Fig. 3 is a perspective exploded view of the tool of Fig. 2;

- Fig. 4 is a perspective view, under an observation angle different from that of Fig. 3, of the tool of Fig. 2, in the disassembled configuration;

- Figs. 5 to 7 are sectional views along the planes V, VI and VII of Fig. 2, respectively; and

- Fig. 8 is a view similar to Fig. 7, showing the tool in a disassembled configuration.

In Fig. 1, is schematically illustrated a mole 1 for which the tubular casing with a substantially circular base includes a front shield including in its front part, a cutting head 2 coming into contact with the cutting front excavated by the mole. In a way known *per se*, the cutting head 2, sometimes call the boring head, is designed so as to be driven into rotation on itself around an axis 2A substantially corresponding to the central longitudinal axis of the tubular casing of the mole 1. In Fig. 1, the mole 1 is observed from the front and in the axis 2A, so that only its cutting head 2 is visible, the remainder of the mole extending rearwards and in the axial extension of the head.

As explained in the introductory part of the present document, the mole 1 excavates land by cutting down the latter under the action of the rotation of the cutting head 2 and the simultaneous advance of this head, generated by a strong thrust against the cutting front. In the exemplary embodiment considered in Fig. 1, the cutting head 2 includes arms 3 extending radially to the axis 2A. These radial arms 3 delimit together apertures opening, towards the rear of the head 2, into a cutting-down chamber from which the cuttings taken away from the cutting front by the head 2 are discharged. Each of the radial arms 3 bears excavating tools 4 designed for cutting down the land by scraping, one of these tools 4 being illustrated alone and at a larger scale in Figs. 2 to 8. Of course, the cutting head 2 may be equipped with excavating tools other than the tools 4: thus, in the embodiment considered in Fig. 1, each of the radial arms 3 also bears disc cutters 5, which freely rotate on themselves on a shaft secured to the arm and which, during operation roll on the cutting front for cutting it.

In order to facilitate the description of the excavating tool 4 which will follow, this description is oriented with respect to a spaced reference system consisting of three geometrical axes X, Y, Z, drawn in Figs. 2 to 4 and orthogonal with each other. By convenience, the axis Z is associated with the vertical, by considering that its direction is directed upwards when it points towards the upper portion of Figs. 2 to 6, while it is directed downwards in the opposite direction. The axes X and Y define a horizontal

geometrical plane, the axis X being associated with an antero-posterior direction which is oriented towards the front when it points towards the right portion of Figs. 2 and 4 to 6, while it is oriented rearwards in the opposite direction.

As well visible in Fig. 3, the excavating tool 4 comprises, or even consists of three
5 main components which are a mounting bracket 10, a drag bit 20 and a screw 30.

As well visible in Figs. 3 and 4, the mounting bracket 10 includes a lower base 11
which, in its rear portion, is surmounted with two branches 12 and 13. The branches 12
and 13 are distant from each other in the direction of the Y axis. As well visible in Figs. 4
and 6, the rear of the base 11 is notched between the branches 12 and 13, and this over
10 the whole separation extent, along the Y axis, between these branches. The base 11 thus
delimits an upper surface 11A, which is included in a plane perpendicular to the Z axis
and which, in the relevant example in the figures, extends both between the branches 12
and 13 and towards the front of each of them. At its rear notch, the base 11 delimits a rear
surface 11B, which is included in a plane perpendicular to the X axis and which in the
15 relevant example in the figures, extends between the branches 12 and 13.

The base 11 is designed so as to be permanently fixed to the cutting head 2, in
particular to one of its radial arms 3, like in the example shown in Fig. 1. This definitive
attachment is achieved by any suitable means, for example by welding of the lower face
of the base 11 to a side wall of the relevant arm 3. In practice, the orientation of the
20 mounting bracket 10 with respect to the relevant arm 3 or, more generally relatively to the
cutting head 2 is not a limitation of the invention.

On its side turned towards the branch 13, the branch 12 delimits a lateral surface
12A, which is included in a plane perpendicular to the Y axis and which, in the relevant
example in the figures, extends over the whole extent of the branch 12 along the X and Z
25 axes. In the same way, on its side turned towards the branch 12, the branch 13 delimits a
side surface 13A, which is included in a plane perpendicular to the Y axis and which, in
the relevant example in the figures extends over the whole extent of the branch 13 along
the X and Z axes. As well visible in Figs. 7 and 8, the side surface 12A and 13A are thus
facing each other along the Y axis.

On its lateral side opposite to its surface 12A, the branch 12 delimits a housing 14
30 which is cylindrical, with a circular base and centered on an axis Y1 parallel to the Y axis.
The housing 14 is thus recessed in the side face of the branch 12, opposite to the branch
13. As well visible in Figs. 3 and 4, the branch 12 also delimits a slot 15 which, both
connects, along the Z axis, the housing 14 to the upper face of the branch 12 and
35 connects, along the Y axis, the bottom of the housing 14 to the side surface 12A of the

branch 12. This slot 15 is with a smooth wall and has a width, i.e. a dimension along the X axis, which is strictly less than the diameter of the housing 14.

5 The branch 13, as for it, delimits a through-hole 16, with a smooth wall and connecting the side surface 13A to the side face of the branch 13, opposite to the branch 12. This through-hole 16 extends along the Y axis, while being centered on the axis Y1, as well visible in Figs. 7 and 8.

10 Further, as well visible in Figs. 3 and 5, the branches 12 and 13 delimit respective front surfaces 12B and 13B, which are included in a same plane perpendicular to the X axis and which, in the relevant example in the figures, extend over and upper portion of these branches.

As well visible in Figs. 3 and 4, the drag bit 20 comprises a front head 21 extended rearwards with a body 22, by giving the drag bit 20 a « T » shape when it is observed along the Z axis.

15 On its front side, the head 21 is designed so as to attack the land to be excavated, by scraping for removing the cuttings. For this purpose, in a way known *per se* and not limiting the invention, the front of the head 21 is rigidly provided with inserts 23 in a hard material, such as carbide, or more generally with similar functionally resistant elements with view to intensifying the scraping action of the drag bit 20 against the cutting front.

20 On the rear, the head 21 delimits, on either side along the Y axis, of the body 22, rear surfaces 21A and 21B which are included in a same plane perpendicular to the X axis and which, in the relevant exemplary embodiment here, occupy the whole rear face of the head 21 outside the hold of the body 22. Also, as indicated in Figs. 5 and 6, the head 21 delimits, on its lower side, a lower surface 21C, which is included in a plane perpendicular to the Z axis and which, in the relevant exemplary embodiment here, occupies a front portion of the lower face of the head.

25 As well visible in Figs. 3, 4 and 6, the body 22 is provided, at its rear end, with a lower heel 24 which, at the junction with the remainder of the body 22 forms a bend turned downwards. The heel 24 thus delimits a front surface 24A, which is included in a plane perpendicular to the X axis and which, in the relevant exemplary embodiment here, extends over substantially the whole front face of the heel.

30 The body 22 delimits side surfaces 22A and 22B, opposite to each other along the Y axis, which are each included in planes perpendicular to the Y axis and which, in the relevant exemplary embodiment here, substantially occupy the whole extent of the corresponding side faces of the body 22.

The mounting bracket 10 and the drag bit 20 are shaped so as to be engaged with each other so as to block to within functional plays, any relative movement between them except for an upward movement along the Z axis of the drag bit with respect to the mounting bracket. To do this, as illustrated in Figs. 2 and 5 to 8, the drag bit 20 is designed so as to be mounted on the mounting bracket 10 so that its body 22 is received between the branches 12 and 13 and its head 21 is received at the front of these branches while its heel 24 is received in the rear notch of the base 11. In this mounted condition of the drag bit 20 on the mounting bracket 10, the lower surface 21C of the head 21 is in planar contact against the upper surface 11A of the base 11 so that the drag bit is blocked downwards along the Z axis with respect to the mounting bracket 10. Further, the distance, along the X axis, between the rear surfaces 21A and 21B of the head 21 and the front surface 24A of the heel 24 is equal, to within a functional play, to the distance, along the X axis, between the rear surface 11B of the base 11 and the front surfaces 12B and 13B of the branches 12 and 13: in the mounted condition of the drag bit 20 on the mounting bracket 10, the surfaces 24A, 21A and 21B are, to within the aforementioned play, in planar contact with the surfaces 11B, 12B and 13B respectively so that the drag bit 20 and the mounting bracket 10 are blocked relatively to each other towards the front and towards the rear along the X axis, as shown in Figs. 5 and 6. Moreover, the dimension, along the Y axis, of the body 22 is equal to within a functional play, to the separation, along this Y axis, between the branches 12 and 13: in the mounted condition of the drag bit 20 on the mounting bracket 10, the side surfaces 22A and 22B of the body 22 are, to within the aforementioned play in planar contact with the side surfaces 12A and 13A of the branches 12 and 13 respectively so that the drag bit 20 and the mounting bracket 10 are blocked relatively to each other in both directions, opposite to each other, extending along the Y axis.

Thus, in the mounted condition of the drag bit 20 on the mounting bracket 10, the drag bit 20 and the mounting bracket 10 cooperate, in all the directions of space except upwards along the Z axis, by shape-mating so as to be fixably bound to each other, by blocking between the surfaces 21A, 21B, 21C, 22A, 22B and 24A and the surfaces 11A, 11B, 12A, 13A, 12B and 13B. It is also understood that moving away the drag bit 20 from the mounting bracket 10 for purposes of disassembling the drag bit is only possible in one disengagement direction D, which is rectilinear and oriented in one direction, and which, in the relevant example here and as indicated by an arrow in Fig. 4, extends along the Z axis and is oriented upwards.

Moreover, as shown in Figs. 3, 7 and 8, the body 22 of the drag bit 20 delimits a through-hole 25 which extends along the Y axis, while connecting the lateral surfaces 22A and 22B with each other. This hole 25 is centered on an axis Y2 and is provided with a tapped hole 26 which, in the relevant exemplary embodiment here, extends over the whole axial length of the hole 25. In the mounted condition of the drag bit 20 on the mounting bracket 10, the hole 25 extends in the extension, along the Y axis, of the housing 14 and of the hole 16 of the branches 12 and 13, the axes Y1 and Y2 then substantially coinciding, as shown in Figs. 7 and 8.

As shown in Fig. 3, the screw 30 defines a central longitudinal axis Y3 which, during operation, extends along the Y axis. This screw 30 includes in a centered way on the axis Y3:

- at one longitudinal end 30A, a screw 31 provided with an imprint for receiving tooling, not shown, for driving the screw 30 into rotation on itself around the axis Y3;

- at its opposite longitudinal end 30B, a pin 32 with a screw surface, in particular not threaded; and

- in its current part 30C, a connecting rod 33 between the head 31 and the pin 32, which is provided with threading 34, extending over the essential part of this rod, and which has a diameter both strictly less than that of the head 31 and strictly greater than that of the pin 32.

The threading 34 of the screw 30 is complementary to the tapped hole 26 of the drag bit 20, so that, as shown in Fig. 4, the hole 25 of the drag bit 20 is designed for movably receiving the screw 30, by screwing-unscrewing between the threading 34 and the tapped hole 26, the axes Y2 and Y3 the coinciding. Thus, while remaining secured to the drag bit 20, the screw 30 is displaceable relatively to the drag bit along the Y axis, in return for its driving into rotation on itself.

The screw 30 is provided for attaching the drag bit 20 to the mounting bracket 10, and not in the sense when this screw 30 would rigidly bind together the drag bit 20 and the mounting bracket 10 by transmitting the forces between them in every direction, but in the sense when the screws 30 is designed for blocking the drag bit 20 with respect to the mounting bracket 10 only in the disengagement direction D, thereby setting the mounted condition of the drag bit 20 on the mounting bracket 10. To do this, while the drag bit 20 is in the mounted condition on the mounting bracket 10, the head 31 of the screw 30 is designed so as to be received inside the housing 14, the latter being provided complementarily to the head 31, and the pin 32 of the screw 30 is designed so as to be received in the hole 16, the latter being provided complementarily to the pin 32: by shape

complementarity between the head 31 and the housing 14 on the one hand and the pin 32 and the hole 16 to within the functional plays, on the other hand, the screw 30 being in potential interference with the mounting bracket in all the radial directions to the axes Y1 and Y3 then substantially coinciding with each other. However, because of the engagement, by blocking, between the mounting bracket 10 and the drag bit 20, described above, the screw does not mechanically interfere with the mounting bracket 10 only in the disengagement direction D, i.e. upwards along the Z axis, this interference in the disengagement direction D being moreover exclusively between the screw and the mounting bracket in the sense when, in this disengagement direction D, the mounting bracket and the drag bit are not directly engaged with each other.

The relative arrangement which has just been described, between the mounting bracket 10, the drag bit 20 and the screw 30, corresponds to a mounted configuration of the excavation tool 4, illustrated by Figs. 2 and 5 to 7: in this mounted configuration, as explained above, the screw 30 begins to interfere with the mounting bracket 10 only in the disengagement direction D in order to block the drag bit 20 with respect to the mounting bracket, while, in the directions other than this disengagement direction D, the drag bit is in direct mechanical engagement with the mounting bracket. In this way, the forces exerted on the drag bit 20 when the tool 4 scrapes the cutting front against which is applied the cutting head 2, are directly transmitted to the mounting bracket 10, without passing through the screw 30, except for the forces strictly oriented in the disengagement direction D. It is understood that, without the attachment of the drag bit 20 to the mounting bracket 10 being a penalty and, more generally, the reliability of the excavating tool 4, the screw 30, even provided in a single version within this excavating tool, is sufficient, no attachment means other than this single screw being advantageously necessary.

In order to have the tool 4 pass from its mounted configuration to a disassembled configuration, as illustrated in Figs. 4 and 8, the screw 30 by driving its head 21 by means of ad hoc tooling not shown, is unscrewed with respect to the drag bit 20 so as to extract the head 31 along the Y axis from the housing 14 and the pin 32 from the hole 16. This unscrewing of the screw 30 continued until the head 31 from the housing 14 and the pin 32 from the hole 16 come out in totality, as illustrated in Fig. 8, without however extracting the screw 30 from the tapped hole 25 of the drag bit 20, while maintaining a part of the threading 34 engaged with a part of the tapped hole 26. The drag bit 20 and the screw 30 may then be disengaged together in totality from the mounting bracket 10, by being driven, either manually or with suitable tooling, upwards along the Z axis, in other words, only in the disengagement direction D as shown in fig. 4. Of course, in order that the

screw 30 does not block the relative disengagement between the mounting bracket 10 and the assembly consisting of the drag bit and of the screw 30, the latter should not interfere with the mounting bracket 10 in the disengagement direction D, which requires ad hoc dimensioning of its slot 15, the width of this slot, i.e. its dimension along the X axis, being greater, at least to within a functional play, than the diameter of the rod 33, as well visible in fig. 5.

The passing of the tool 4 from the disassembled configuration to the mounted configuration is carried out in an opposite way as to what has been described for the passing from the mounted configuration to the disassembled configuration, successively in return for the complete mounting of the assembly, consisting of the drag bit 20 and of the screw 30, on the mounting bracket 10 by driving this assembly exclusively in a direction opposite to the disengagement direction D, and then the screwing of the screw 30, until complete penetration of its head 31 into the housing 14 and of its pin 32 into the hole 16. In practice, this screwing is applied until the head 31 along the Y axis is in abutment against the bottom of the housing 14. The continuation of this screwing is prevented, to within a functional play, by blocking, in the Y axis, the surface 22A of the body 22 against the surface 12A of the branch 12 of the mounting bracket 10, but advantageously gives the possibility of jamming the screw 30 because of the tightening of the branch 12 between the head 31 of the screw and the body 22 of the drag bit: the risk of untimely unscrewing of the screw 30 is thus limited since an unblocking force on the screw is required for initiating its unscrewing with purposes for having the tool 4 pass into the disassembled configuration.

In all the cases, the passing of the excavating tool 4 between its mounted and disassembled configurations is simply achieved by screwing-unscrewing of the screw 30, while maintaining it secured of the drag bit 20: the corresponding handling operations are rapid and easy to apply, if necessary automatically by a robot manipulator, without incurring the risk of loosing the screw. Also, once the excavating tool 4 is in the disassembled configuration, the complete disengagement, with respect to the mounting bracket 10 of the drag bit 20 and of the screw 30 which remains partly screwed thereto, just like the mounting on the mounting bracket of this assembly consisting of the drag bit and of the screw, are achieved by exclusively driving this assembly parallel to the disengagement direction D, respectively in the sense of this disengagement direction and in the opposite sense: the respective handling operations are there again fast and easy to apply, if necessary automatically by a robot manipulator.

Finally, various arrangements and alternatives to the excavating tool 4 and to the mole 1 described up till now, may moreover be contemplated. As examples:

- rather than being a through-hole, the hole 16 may be provided as a blind hole, only opening onto the side surface 13A of the branch 13;

5 - for facilitating the setting into place of the assembly, consisting of the drag bit 20 and of the screw 30, with respect to the mounting bracket 10, certain edges of the mounting bracket, of the drag bit and/or of the screw are advantageously chamfered; in the exemplary embodiment illustrated in the figures, this is notably be the case for the upper edge of the side surfaces 12A and 13A, the lower edge of the side surfaces 22A
10 and 22B, the upper edge of the rear surface 11B, the lower edge of the front surface 24A, the upper edge of the edges of the slot 15 and the extreme peripheral edge of the pin 32, as well as the periphery of the housing 14 and of the hole 16; and/or

- rather than being strictly perpendicular like in the exemplary embodiment considered in the figures, the disengagement direction D may more generally be
15 transverse to the central axis Y2 of the tapped hole 25.

CLAIMS

1.- An excavating tool for a tunnel boring machine, comprising:

- a drag bit for attacking the land to be excavated,
- 5 - a mounting bracket for mounting the drag bit, the mounting bracket being provided so as to be permanently fixed to a cutting head of the tunnel boring machine, the mounting bracket and the drag bit being shaped so as to be engaged with each other so as to fixably bind the drag bit with the mounting bracket in all the directions of space except in a disengagement direction, and
- 10 - a screw for removably attaching the drag bit to the mounting bracket, the screw being provided with threading which is screwed into a tapped hole of the drag bit, the disengagement direction being transverse to the central axis of this tapped hole, wherein, in a mounted configuration of the excavating tool, the drag bit is in direct mechanical engagement with the mounting bracket in the directions other than the
- 15 disengagement direction and the screw interferes with the mounting bracket in the disengagement direction for blocking the drag bit with respect to the mounting bracket, and
- wherein the tapped hole of the drag bit and the threading of the screw are designed for, by screwing-unscrewing, maintaining the drag bit and the screw secured to each other while
- 20 having the excavating tool pass between the mounted configuration and a disassembled configuration in which the screw does not interfere with the mounting bracket in the disengagement direction so that, by driving only in the disengagement direction, the drag bit and the screw are disengaged from the mounting bracket, while by driving only in a direction opposite to the disengagement direction, the drag bit and the screw are mounted
- 25 on the mounting bracket.

2.- The excavating tool according to claim 1, wherein the threading of the screw is located in a current part of the screw.

- 30 3.- The excavating tool according to one of claims 1 or 2, wherein, in the mounted configuration of the excavating tool, the screw interferes with the mounting bracket in the disengagement direction at both opposite longitudinal ends of the screw.

- 35 4.- The excavating tool according to claim 3, wherein a first of both ends of the screw forms a head for driving the screw in screwing-unscrewing relatively to the tapped

hole of the drag bit, this head being connected to the second end of the screw by a stem of the screw, the diameter of which is strictly less than that of the head, and wherein the mounting bracket delimits a housing:

- 5 - inside which the head of the screw is received in a complementary way in the mounted configuration of the excavating tool,
- from which the head of the screw comes out in totality during the unscrewing of the screw for having the excavating tool pass from its mounted configuration to its disassembled configuration, and
- 10 - which is connected to an outer face of the mounting bracket in the disengagement direction through a slot of the mounting bracket, the width of which is both less than the diameter of the head of the screw and greater than the diameter of the stem of the screw.

5.- The excavating tool according to claim 4, wherein the slot of the mounting bracket also connects the housing to a surface, delimited by the mounting bracket, for
15 blocking the drag bit in a direction parallel to the central axis of the tapped hole.

6.- The excavating tool according to one of claims 4 or 5, wherein the second end of the screw forms a smooth pin, and wherein the mounting bracket delimits a smooth hole, inside which the pin of the screw is
20 received in a complementary way into the mounted configuration of the excavating tool, and from which the pin of the screw comes out in totality during the unscrewing of the screw for having the excavating tool pass from its mounted configuration to its disassembled configuration.

25 7.- The excavating tool according to any of the preceding claims, wherein, in the mounted configuration of the excavating tool, the drag bit and the mounting bracket are in directions other than the disengagement direction, in mechanical engagement with each other by contact between blocking surfaces respectively delimited by the drag bit and the mounting bracket.

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8.- The excavating tool according to claim 7, wherein said blocking surfaces include:

- a surface of the drag bit and a surface of the mounting bracket, which, in the mounted configuration of the excavating tool, are in contact with each other for blocking

the drag bit with respect to the mounting bracket in the direction opposite to the disengagement direction,

5 - surfaces of the drag bit and surfaces of the mounting bracket, which, in the mounted configuration of the excavating tool, are in contact with each other for blocking the drag bit and the mounting bracket with respect to each other in directions opposite to one another, which are parallel to the central axis of the tapped hole, and

10 - surfaces of the drag bit and surfaces of the mounting bracket, which, in the mounted configuration of the excavating tool, are in contact with each other for blocking the drag bit and the mounting bracket with respect to each other in directions opposite to one another which are both perpendicular to the disengagement direction and to the central axis of the tapping hole.

15 9.- The excavating tool according to any of the preceding claims, wherein the screw is provided in a single version, and in that the excavating tool is without any means for attachment of the drag bit to the mounting bracket other than this single screw.

10.- A tunnel boring machine, comprising:

20 - a cutting head, and
 - at least one excavating tool, which is according to any of the preceding claims and the mounting bracket of which is permanently fixed to the cutting head.