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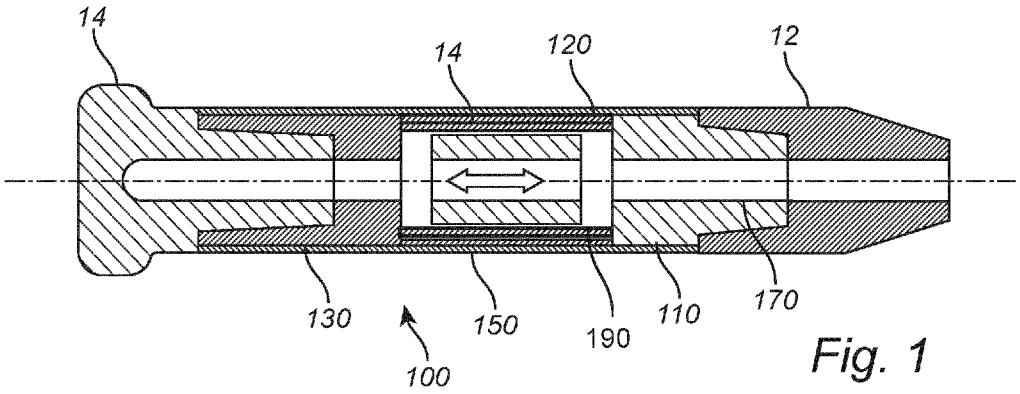


Fig. 1

(57) Abstract: A percussive drilling assembly (100) configured to form part of a drill string is disclosed. The drilling assembly comprises a top element (110) and a piston case (120), wherein the top element is configured to be connected to the piston case, a bottom element (130) provided at an end of the piston case, opposing the top element, wherein the top element and the bottom element are configured to couple the drilling assembly to respective sections of the drill string and a piston (140) arranged inside the piston casing and configured to reciprocate in the piston casing to generate a percussive action. The assembly further comprises a protective sleeve (150) configured to protect an outside surface of the piston casing, wherein the protective sleeve elongates at least from the top element to the bottom element.

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PROTECTIVE SLEEVE FOR PERCUSSIVE DRILLING ASSEMBLY

Technical field

The present invention relates to a percussive drilling assembly, such as a down-the-hole hammer assembly, comprising a sleeve for protecting an outside surface of a piston casing of the assembly.

Background

Percussive drilling, such as down-the-hole (DTH) drilling, is typically performed by a hammer comprising a piston casing extending between a top element, also referred to as a top sub, and a bottom element, also referred to as a drive sub or chuck, which is releasably coupled to a drill bit. Drilling may be achieved via a combination of rotation and axial percussive action of the drill bit. The rotation may be imparted to the drill bit from the drive sub via intermediate engaging splines, whereas the axial percussive action may be generated by means of a reciprocating piston shuttling back and forth within the piston casing.

A pressurized fluid may be supplied to the drill bit located at the bottom of the bore hole and act to both drive the reciprocating movement of the piston and to evacuate cuttings rearwardly through the bore hole. The fluid, together with cuttings entrained therein, is conducted upwardly through an annular space formed between the outer surface of the drilling assembly and the inside wall of the hole being drilled. As a result, the outer surface of the assembly, and particularly that of the piston case, is subjected to wear due to the abrasive contact with the cuttings.

Eventually, the excessively worn piston case needs to be replaced, resulting in lost drilling time and added cost of a replacement piston case and the work associated therewith. It would therefore be desirable to provide an improved drilling assembly enabling a reduced cost and improve uptime of the drilling equipment.

Summary

To better address one or more of these concerns a percussive drilling assembly, having the features defined in the independent claim, is provided. Preferable embodiments are defined in the dependent claims.

Hence, according to an aspect, a percussive drilling assembly configured to form part of a drill string is provided. The drilling assembly comprises a top element and a piston case, wherein the top element is configured to be connected to the piston case. Further, a bottom element is provided at an end of the piston case, opposing the top element. The top element and the bottom element are configured to couple the drilling assembly to respective sections of the drill string. The assembly also comprises a piston arranged inside the piston case and configured to reciprocate in the piston casing to generate a percussive action, as well as a protective sleeve configured to protect an outside surface of the piston casing, wherein the protective sleeve elongates at least from the top element to the bottom element.

Conventionally, replacing a worn piston case is expensive and time consuming as the drilling operation needs to be disrupted, the hammer disassembled, and the worn piston case replaced with a new one. This adds cost in terms of replacement materials and downtime of the drilling equipment. The inventors have realized that by arranging a protective sleeve to protect an outside of the piston casing, the casing may be at least partly protected from wear induced by the abrasive cuttings entrained in the passing fluid. Advantageously, the protective sleeve may be easier to replace as it does not require the piston case to be disassembled from the hammer. Further, the design of the protective sleeve may be less complex than the design of the piston case, and therefore cheaper to produce. The protective sleeve may for instance have a design allowing it to be extruded. The protective sleeve may therefore reduce the downtime of the drilling equipment as well as the material costs for the replacement.

The percussive drilling assembly may in some examples be referred to as a hammer, or percussive drilling hammer.

The top element and the bottom element may be understood as a part or portion of the percussive drilling assembly by which the assembly can be coupled to other elements of the drill string. Each of the top element and the bottom element may be configured to be coupled to a drill rod, a drill tube, a drill bit, a shank adaptor, a thread adaptor or a shaft. The coupling may preferably be releasable to allow the drill string to be disassembled and the drilling assembly removed for service and repair. The top element may also be referred to as a top sub, whereas the bottom element may be referred to as a drive sub or chuck. In further options the bottom element may comprise or be formed of the drill bit.

It will be understood that a drill string may comprise a variety of elements, also referred to as segments or sections, including the above-mentioned rods, adaptors, tubes, and bits. The drill tubes may also be referred to as extension rods, extension tubes, extension drill steel, extension drill rods and extension drill tubes. The elements may be coupled to each other to transfer torque and drilling fluid to the drill bit. For instance, the percussive drilling assembly disclosed herein may form part of the drill string and may at its top end be coupled to a drill rod or a drill tube via the top element and at its bottom end be coupled to a drill bit via the bottom element.

Further, it is appreciated that the protective sleeve may extend between the top and bottom element such that it covers at least the piston case. However, in other options the protective sleeve may as well cover at least part of the top element and/or bottom element, as will be apparent from the detailed description.

The protective sleeve may be secured, or fixed, at its intended position relative the piston case in a way that prevents the protective sleeve from being displaced during use while still allowing the protective sleeve to be replaced when worn. This may be understood as the protective sleeve being secured or retained at the outer surface of the piston case. The protective sleeve may for instance be secured in a way that hinders it from rotating relative piston case and/or sliding axially along at least one direction along the piston case. In the following, various examples of how to secure or restrain the protective sleeve will be discussed.

Preferably, the protective sleeve may be configured to engage another structure, such as the top or bottom element, the piston case, or a section of the drill string coupled to the percussive drilling assembly, in a way that allows it to be maintained in its intended position during operation. The engagement may for instance hinder the protective sleeve from sliding along the piston case, along the axial direction, and/or rotating around the piston case.

Thus, in some embodiments, the protective sleeve is configured to engage the top element or a first section of the drill string to which the top element is configured to be coupled. Alternatively, or additionally, the protective sleeve may be configured to engage the bottom element or a second section of the drill string to which the top element is configured to be coupled.

In a further option, the protective sleeve may be configured to be clamped between at least one of the top element and the first section of the drill string, and at least one of the bottom element and the second section of the drill string. Hence, in an embodiment, the top and bottom elements may be arranged to rest against a respective end surface of the protective sleeve to hinder it from sliding axially between the top and bottom elements. This may in some embodiments be achieved by reducing a diameter, or cross-sectional width of the piston case, such that it is smaller than a corresponding measure of the top and bottom elements. The protective sleeve, on the other hand, may have an outer diameter or cross-sectional width corresponding to the one of the top and bottom elements. Put differently, an outer diameter of the top and bottom elements may correspond to the outer diameter of the protective sleeve. This allows for the resulting assembly to have a relatively uniform diameter along its entire length, i.e., along the top element, the protective sleeve, and the bottom element.

In some embodiments, the percussive drilling assembly may comprise a stopping element, or restraining element, configured to secure the protective sleeve around the piston case. The stopping element may for instance be an inwardly protruding member arranged at the protective sleeve and oriented towards a center of the piston case. The stopping member may be arranged to engage an interlocking

structure of the piston case, top element, or bottom element, such as a groove, a gap or a correspondingly protruding member. In different words, the stopping element of the protective sleeve may be adapted to engage with at least one of the piston case, top element, or bottom element to prevent the protective sleeve from being displaced during the drilling operation.

The stopping element may for instance be configured to engage a structure between the bottom element and the piston case and/or the top element and the piston case. The structure may for example be formed by a gap, spacing or groove formed at the interface between the piston case and the top/bottom element, such as and end portion of the piston case and the top/bottom element. In further embodiments, the stopping element may be configured to engage a structure between the top element and another element of the drill string coupled to the top element, such as for instance an adapter or a drill rod. Similarly, the stopping element may in some examples be configured to engage a structure between the bottom element and another element coupled to the bottom element, such as a drill bit. Further, it should be noted that the protective sleeve may be arranged to protect more than one element of the drill string, such as for instance one or more adapters and/or one or more drill rods or drill tubes. The stopping element may then be arranged to engage such an element, for example at a position between adjacent elements. Thus, in a specific, non-limiting example the drill string may comprise a sequence of adjacent elements coupled to each other, wherein the sequence comprises a bit coupled to a hammer as outlined above, coupled to a first adapter, coupled to a drill tube, coupled to a second adapter, and a stopping element in form of a protruding member arranged to be fitted between the drill tube and the second adapter.

It will be appreciated that the above stopping element may be arranged to secure the protective sleeve axially along at least one direction, such as preventing it from sliding towards the bottom of the hole during the drilling operation. In some examples, the stopping element may be adapted to allow the sleeve to slide upwards, in a direction away from the drill bit, to facilitate replacement of the

protective sleeve. In yet further options the stopping element may be arranged to secure the protective sleeve rotationally to prevent it from rotate relative the piston case, around a length axis of the piston case. This may facilitate disassembling of the percussive drilling assembly, as torque may be transmitted to the piston case or top/bottom element via the protective sleeve.

In some embodiments, the stopping element may be configured to engage at least one of a bottom end and a top end of the protective sleeve. The stopping element may for instance be formed of an outwardly protruding member arranged at on at least one of the top element, bottom element, piston case and a drill string section coupled, directly or indirectly, to such a top or bottom element. The outwardly protruding member may thus be arranged to extend in a direction away from a center line of the drill string and configured to abut or engage an end portion of the protective sleeve. Similar to what is described above, the outwardly protruding stopping element may be configured to secure the protective sleeve rotationally along the center line of the drill string to prevent the protective sleeve from rotating relative the piston case.

The stopping element, irrespectively of it being an inwardly protruding member of the protective sleeve or an outwardly protruding member of any of the other parts of the assembly, may have a shape conforming to a washer, a ring, a flange, a plate or an insert.

According to an embodiment, at least a part of the protective sleeve comprises a coating. The coating may for instance be formed of an anti-corrosion material or a wear-reducing material. Further, the protective sleeve may comprise a region or layer which is heat-treated to further increase strength and wear resistance. Examples of coatings including carbide coatings, such as tungsten carbide/cobalt, tungsten carbide/nickel-chromium, chromium carbide/nickel-chromium, and tungsten carbide/cobalt/chromium. The carbide coating may for instance be applied by means of thermal spraying.

Further objective of, features of, and advantages with the present invention will become apparent when studying the following detailed disclosure, the drawings,

and the appended claims. Those skilled in the art will realize that different features of the present invention can be combined to create embodiments other than those described in the following.

Brief description of drawings

This and other aspects of the present invention will now be described in more detail, with reference to the appended drawing showing embodiments of the invention.

Figures 1 and 2 are a schematic cross sections of percussive drilling assemblies according to some embodiments.

Figure 3a is a schematic cross section of a percussive drilling assembly according to an embodiment, when arranged between two sections of a drill string.

Figures 3b and c show examples of stopping element configurations for securing the protective sleeve around the piston case.

Figure 4 is a cross section of a percussive drilling assembly according to another embodiment.

Figure 5 is an illustration of a flange-shaped stopping element according to an embodiment of the percussive drilling assembly.

Figure 6 illustrates a piston case according to an embodiment of the percussive drilling assembly.

Figure 7 illustrates a protective sleeve according to an embodiment.

Detailed description

Figure 1 is a schematic cross section of a percussive drilling assembly 100 according to some embodiments. The percussive drilling assembly 100, which in the following description also may be referred to as a hammer 100, comprises a top element 110, a bottom element 130 and a piston case 120 extending therebetween. Thus, the top and bottom elements 110, 130 may be arranged at opposing end portions of the piston case 120, relative to a length direction or center axis of the drill string of which the hammer 100 may form part. Disposed within the piston case 120 is an inner cylindrical sleeve 190.

The top element 110, which also may be referred to as a top sub, may be configured to be releasably coupled to a first section 12 of the drill string, such as a sub, a thread adapter or a drill tube. Similarly, the bottom element 130, which also may be referred to as a drive sub, may be configured to be releasably coupled to a second section 14 of the drill string, such as a drill bit.

The piston case 120 may be releasably attached to the each of the top element 110 and the bottom element 130 to facilitate disassembly and replacement of the piston case 120. However, as this is known to be a work- and time-consuming process it is desirable to avoid disassembling the elements of the hammer 100 whenever possible. As illustrated in the present figure, the piston case 120 may have a substantially cylindrical shape which its length axis oriented along the length direction of the drill string. The piston case 120 may further be adapted to accommodate a piston 140 arranged inside the piston casing 120 and configured to reciprocate back and forth in the casing 120 to generate a percussive action. The piston action may for instance be hydraulically or pneumatically actuated, using technologies that are known in the art and therefore not described in further detail herein. It should also be noted that figures 1 and 2 show simplified configurations in which the piston 140 impacts the bottom element 130, which in turn transfers the percussive action to the drill bit 14. It may however be preferable to arrange the piston 140 to act directly on the drill bit 14, as illustrated in figures 3a-c and 4.

The elements of the drilling assembly 100, such as the top element 110, the piston 140 and the bottom element 130 may form a fluid channel 170 through which a fluid may be supplied through the drill string all the way down to the bottom of the drill hole that is being formed. The fluid channel 170 may for instance run along a center axis of the drill string, passing through the interior of the hammer 100.

Further, the hammer 100 may comprise a protective sleeve 150 arranged to protect an outside surface of the piston casing 120. The protective sleeve 150 may preferably have a shape conforming to a cylinder or a tube with a circular cross section and may be provided with an inner width or diameter that allows it to be fitted around the piston casing 120. In the present example, the outer width or

diameter of the protective sleeve 150 may correspond to the outer width or diameter of the sections 12, 14 of the drill string to which the hammer 100 is coupled via the top and bottom elements 110, 130. Other configurations are however also conceivable, as will be discussed below.

Preferably, the protective sleeve 150 extends at least between the top element 110 and the bottom element 130 to protect the entire piston case 120. Further, the protective sleeve 150 may form a continuous surface covering the entire outer surface of the piston case 120. However, a wear-reducing effect may still be achieved should the protective sleeve 150 comprise through-holes or other structures leaving portions of the underlying piston case surface exposed.

As indicated in the present figure, the protective sleeve 150 may extend beyond the outer surface of the piston case 120 such that it covers at least part of the outer surface of the top element 110, the bottom element 130 or both. In the illustrated embodiment the protective sleeve 150 has a length allowing it to extend along the entire length of the hammer 100, including the top element 110 and the bottom element 130, thereby covering the entire outer surface between the first and second sections 12, 14 of the drill string to which the hammer 100 is attached. In further embodiments, the protective sleeve 150 may extend to cover also one or several sections of the drill string coupled, directly or indirectly, to the top and/or bottom elements 110, 130.

The protective sleeve 150 may be axially and/or rotationally secured around the piston case 120 to prevent relative motion between the protective sleeve 150 and the piston case 120. The protective sleeve 150 may for example be configured to be retained by the first and second sections 12, 14, which may be arranged to abut the end portions of the protective sleeve 150 to prevent it from sliding along its axial direction. Thus, the protective sleeve 150 may be clamped between the respective section 12, 14 to which the top and bottom elements 110, 130 are coupled. In further embodiments a rotation blocking element may be provided to prevent rotation relative the piston case 120. Examples of such rotation blocking elements are discussed in connection with figures 6 and 7.

Advantageously, the protective sleeve 150 may be replaced at the same time as any of the drill string sections 12, 14, such as the drill bit 14, is replaced.

Figure 2 shows another example of a percussive drilling assembly 100, which may be similarly configured as the hammer 100 in figure 1. However, in the present example one or several stopping elements 160 may be provided to axially secure the protective sleeve 150 around the piston case 120. Several different configurations of the stopping elements 160 may be considered. The stopping element may for instance comprise a protruding member 160 arranged to protrude jut out from an outer surface of the top or bottom element 110, 130 (or a drill string section coupled, directly or indirectly, to such an element). In the present example, the hammer comprises two different types of stopping elements 160: a first one, formed by a separate (and possibly replaceable) element attached to the top element 110 and arranged to extend outwards to form an abutment with the protective sleeve 150, and a second one formed by a protrusion or shoulder of the bottom element 130. The protective sleeve 150 may be removed from the hammer 100 by removing the stopping element 160 at the top element 110, or by removing the entire top element 110. Thereafter, the protective sleeve 150 may be slid off the piston case 120 in the direction towards the top element 110. Similar to the embodiments of figure 1, the protective sleeve 150 may further comprise a rotation blocking element for preventing a relative rotational movement between the protective sleeve 150 and the piston case 120. The rotation blocking element may for instance be formed of an indentation or recess extending into the protective sleeve 150 in the axial direction and adapted to engage the stopping element 160. Hence, the rotational movement may be hindered by providing mutually engaging, or interlocking, structures at the protective sleeve 150 and at least one of the top and bottom elements 110, 130.

Figure 3a shows a hammer 100 which may be similar to the ones disclosed in connection with figures 1 and 2. Thus, the hammer 100 may comprise a top element 110, a bottom element 130 and an intermediate piston 140 arranged to shuttle, along a length direction between the top and bottom elements 110, 130, in a piston

case 120. In the present example the top element 110 is coupled to a first section 12 of the drill string and the bottom element 130 to a second section 14 of the drill string, in this case a drill bit 14. Further, a protective sleeve 150, for instance formed as a metal tube, is arranged around the piston case 120 such that it covers the entire length of the piston case 120 and, in the present example, the entire outer surface of both the top element 110 and the bottom element 130. The extent by which the protective sleeve 150 covers also the top and/or bottom elements 110, 130 may vary between different embodiments.

As mentioned above, there are several different ways of ensuring that the protective sleeve 150 is maintained in its intended position around the piston case 120 during operation of the hammer 100. A few, illustrating and non-limiting examples and combinations will now be discussed with reference to figures 3a-c and 4.

Figure 3a shows a hammer 100 wherein the protective sleeve 150 is prevented from sliding along the axial direction of the piston case 120 by means of a stopping element 161 engaging an interface between the top element 110 and the first section 12 of the drill string, which is coupled to the top element 110. The stopping element 161 may be formed as an inwardly protruding member of the protective sleeve 150. The stopping member 161 may thus be formed of an integral portion of the of the protective sleeve 150 or of a separate element that has been attached to the protective sleeve 150 and arranged to be interlocked with a corresponding receiving structure of the top element 110 and/or first section 12. It should however be noted that this is merely an illustrating example, and that other configurations also are possible. The stopping element 161 may for instance be configured to engage a structure further up the drill string, such as between a drill tube and an adapter, or further down, such as between the top element 110 and the piston case 120.

Figure 3a further illustrates an example wherein the protective sleeve 150 is arranged to engage, or abut, a shoulder 163 of a drill bit 14 coupled to the bottom element 130.

Figure 3b illustrates a further option, wherein an inwardly protruding member 162 is arranged to protrude from an inner surface of the protective sleeve 150 and engage a corresponding, interlocking structure between the piston case 120 and the bottom element 130. This structure may be combined with the shoulder 163 in the drill bit 14. The shoulder 163 may for example be arranged to support the protective sleeve along the axial direction of the piston case 120, whereas the protruding member 162 may hinder the protective sleeve 150 from rotating relative the piston case 120.

Alternative arrangements of the attachment of the protective sleeve 150 at its lower end are however conceivable. One example is shown in figure 3c, wherein the stopping element 162 is interposed between the second section (i.e., the drill bit 14 in the present example) and the bottom element 130. In this arrangement, the shoulder 163 may hinder the protective sleeve 150 from sliding towards the drill bit 14, whereas the inwardly protruding member 162 may hinder it from sliding in a direction away from the drill bit 14.

In further configurations the stopping element 162 may be configured to engage other elements as well, such as interlocking structures in the piston case 120.

As illustrated in figures 3a and b, the stopping element may be arranged within the protective sleeve 150 and at a position distant from the end portion of the protective sleeve 110. Such a stopping element 161, 162 may for instance be formed of a protruding member fitting in an axial groove (not shown) in the top element 110 or bottom element 130, in which the protruding member may slide to facilitate assembling and disassembling.

Figure 4 shows the hammer 100 of figures 3a-c, wherein the protective sleeve 150 is secured around the piston case 120 by means of engaging structures 163, 164 protruding in an outward direction from a center of the hammer 100. The engaging structures 163, 164 may be arranged at the top element 110, the bottom element 130, or at sections 12, 14 of the drill string to which the hammer 100 is coupled. In the present figure the engaging structures 163, 164 are formed as a first

shoulder 163 or protrusion of a drill bit 14 coupled to the bottom element 130 and a second shoulder 164 or protrusion of a drill tube 12' indirectly attached to the top element 110 via a thread adapter 12''. Similar to what is described with reference to figure 2, the protective sleeve 150 may be clamped axially between the first and second shoulders 163, 164. The engaging structures 163, 164, which may be considered as examples of stopping elements 160 as discussed above, may in some options be formed by an end portion of a section of the drill string (such as an adapter, drill tube or drill bit), wherein the engaging structure is enabled by a the end portion having a slightly larger diameter compared to an inner diameter of the protective sleeve 150. The protective sleeve 150 may hence be arranged to abut or rest against, in the axial direction, an end portion of such an adapter, drill tube, or drill bit.

It will be appreciated that the protective sleeve 150 in some configurations may be supported at both ends, and in other configuration only at one end, such as the bottom end facing the drill bit 14. In the latter case, the protective sleeve 150 may be easier to remove from the hammer 100 by pulling it in a direction away from the drill bit 14.

Figure 5 shows an end portion of a protective sleeve 150, which may be similarly configured as the protective sleeve 150 disclosed above in connection with figure 3c. Thus, the protective sleeve 150 may have a shape conforming to a cylinder and an inner diameter allowing it to be fitted around the piston case 120. Further, the protective sleeve 150 may be formed of a metal, such as steel, which may be heat-treated to further increase strength and resistance to abrasive wear from debris and cuttings entrained in the passing drilling fluid. In some examples, the protective sleeve may be provided with a wear-reducing coating, such as a carbide coating, which preferably may be applied by means of thermal spraying.

The protective sleeve 150 may comprise a stopping element 160, which in the present example is arranged at the end portion of the sleeve 150. The stopping element 160 may be formed as a flange or washer extending in a plane orthogonal to the length axis of the protective sleeve 150 and protruding towards the interior of

the sleeve 150. The protective sleeve 150 may preferably be formed by extrusion, whereas the flange or washer 160 may for instance be welded onto the extruded sleeve 150.

Figures 6 and 7 show examples of a portion of a piston case 120 and a protective sleeve 150, respectively, similar to the one in figure 3b. Figures 6 and 7 illustrate an example of stopping elements configured as mutually engaging rotation blocking structures, in which protruding elements 180'' of the protective sleeve 150 are arranged to interlock with corresponding recesses 180' of an end portion of the piston case 120 for preventing relative, rotational movement between the protective sleeve 150 and the piston case 120. The recesses 180' protrude from an end portion of the piston case 120, in the axial direction of the case 120, and are distributed along a circumference of the piston case 120.

In figure 7 the blocking elements 180'' are arranged on an interior of the protective sleeve 150, and similar to figure 6 distributed radially along a periphery of the sleeve. The blocking elements 180'' may be formed as protrusions directed in the axial direction and configured to engage the corresponding recesses at the end portion of the piston case 120 to secure the protective sleeve 150 rotationally and/or axially around the piston case 120.

The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims.

CLAIMS

1. A percussive drilling assembly (100) configured to form part of a drill string, the drilling assembly comprising:

a top element (110) and a piston case (120), wherein the top element (110) is configured to be connected to the piston case (120);

a bottom element (130) provided at an end of the piston case (120), opposing the top element (110), wherein the top element (110) and the bottom element (130) are configured to couple the drilling assembly to respective sections of the drill string (12, 14);

a piston (140) arranged inside the piston casing (120) and configured to reciprocate in the piston casing (120) to generate a percussive action; and

a protective sleeve (150) configured to protect an outside surface of the piston casing (120), wherein the protective sleeve (150) elongates at least from the top element (110) to the bottom element (130).

2. The percussive drilling assembly (100) according to claim 1, wherein the protective sleeve (150) is configured to engage the top element (110) or a first section (12) of the drill string to which the top element (110) is configured to be coupled.

3. The percussive drilling assembly (100) according to claim 1 or 2, wherein the protective sleeve (150) is configured to engage the bottom element (130) or a second section (14) of the drill string to which the bottom element (130) is configured to be coupled.

4. The percussive drilling assembly (100) according to claim 2 or 3, wherein the protective sleeve (150) is configured to be clamped between at least one of the top element (110) and the first section (12) of the drill string, and at least one of the bottom element (130) and the second section (14) of the drill string.

5. A percussive drilling assembly (100) according to any of the preceding claims, further comprising a stopping element (160) configured to secure the protective sleeve (150) around the piston case (120).

6. A percussive drilling assembly (100) according to claim 5, wherein the stopping element (160) is an inwardly protruding part of the protective sleeve (150) configured to engage at least one of the top element (110) and the first section (12) of the drill string.

7. A percussive drilling assembly (100) according to claim 5 or 6, wherein the stopping element (160) in an inwardly protruding part of the protective sleeve (150) configured to engage at least one of the bottom element (130) and the second section (14) of the drill string.

8. A percussive drilling assembly (100) according to claim 5, wherein the stopping element (160) is configured to engage at least one of a bottom end (130) and a top end of the protective sleeve (150).

9. A percussive drilling assembly (100) according to claim 8, wherein the stopping element (160) is a protruding part of at least one of the piston case (120), the top element (110) and the bottom element (130).

10. A percussive drilling assembly (100) according to claim 8, wherein the stopping element (160) is a protruding part of at least one of the first section (12) of the drill string and the second section (14) of the drill string.

11. A percussive drilling assembly (100) according to any of claims 5-10, wherein the stopping element (160) comprises a shape conforming to a washer, a ring or an insert.

12. A percussive drilling assembly (100) according to claim 1, wherein the protective sleeve (150) is further configured to be removable from the percussive drilling assembly.

13. A percussive drilling assembly (100) according to claim 1, wherein the section (12, 14) of the drill string to which the top element (110) is configured to be coupled is at least one of a drill rod, a drill tube, a shank adapter, an adapter, a shaft, a thread adapter, and a shock absorber.

14. A percussive drilling assembly (100) according to claim 1, wherein the section (12, 14) of the drill string to which the bottom element is configured to be coupled is at least one of a drill rod, a drill tube, a shank adapter, a drill bit, an adapter, a shaft, and a thread adapter.

15. A percussive drilling assembly (100) according to claim 1, wherein the protective sleeve (150) comprises at least one of an anti-corrosion material, a wear reducing coating, a heat-treated material.

16. A percussion drill string comprising at least one percussive drilling assembly (100) as claimed in any one of the preceding claims.

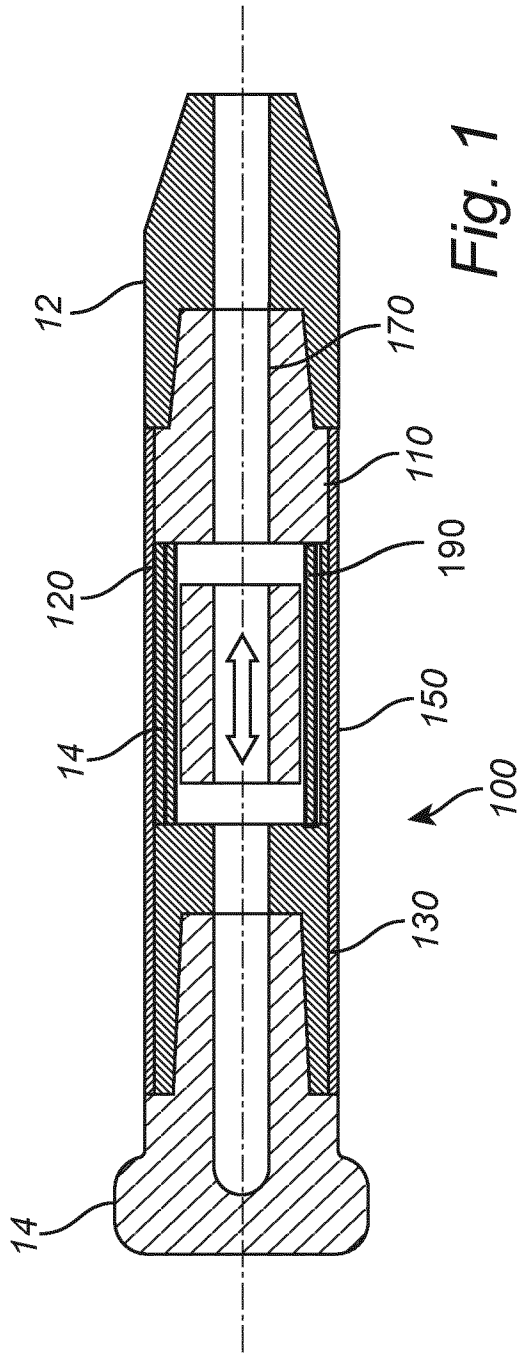

12
170
110
190
120
150
14
100
130
14

Fig. 1

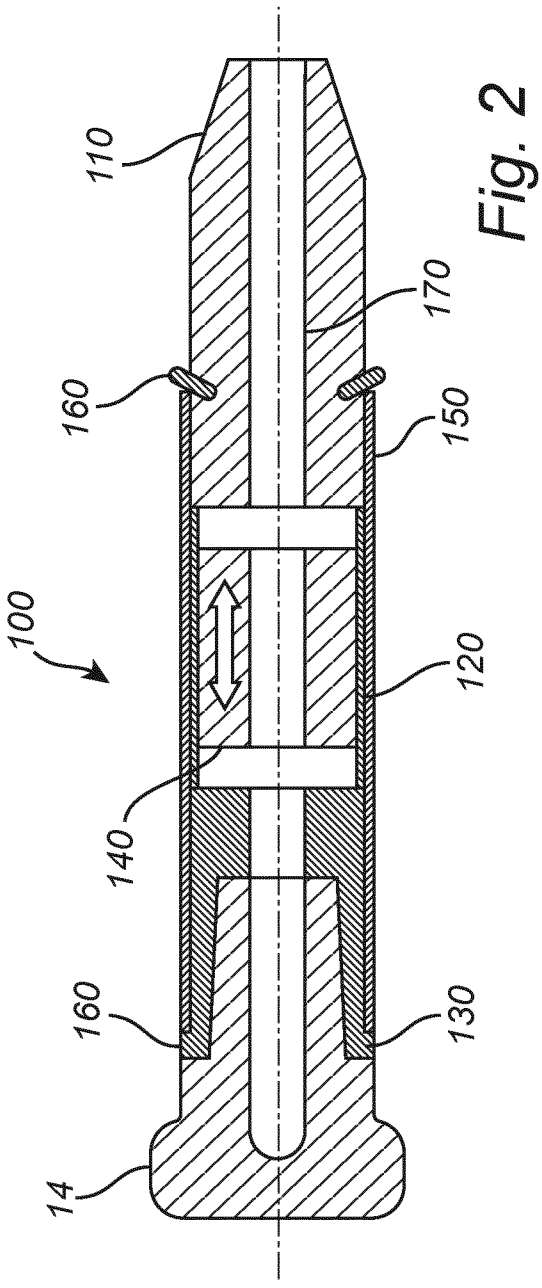

110
170
160
150
100
120
140
160
130
14

Fig. 2

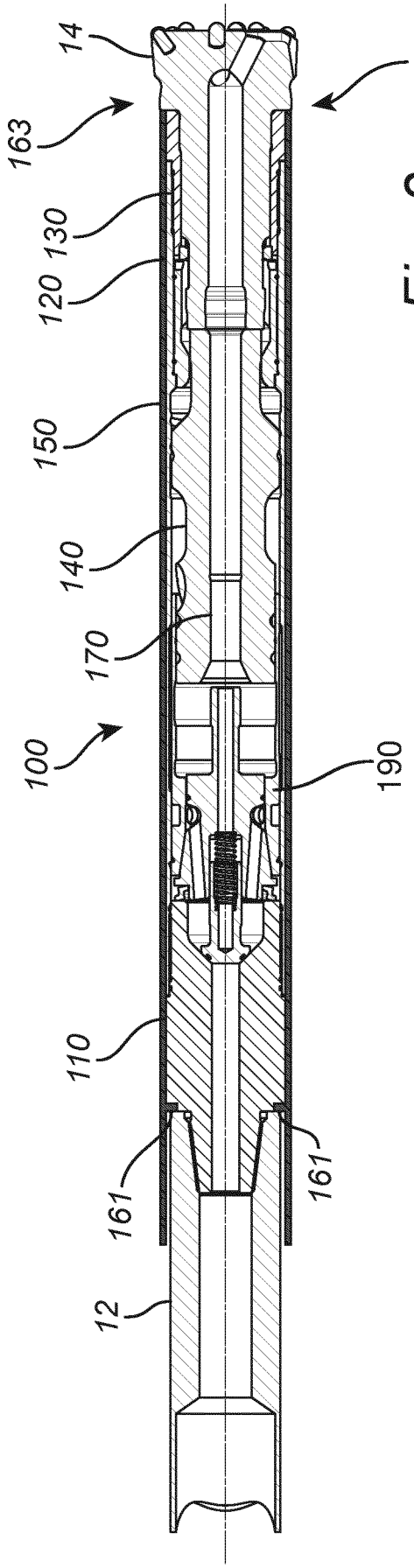

14
163
163
130
120
150
140
170
100
190
110
161
161
12

Fig. 3a

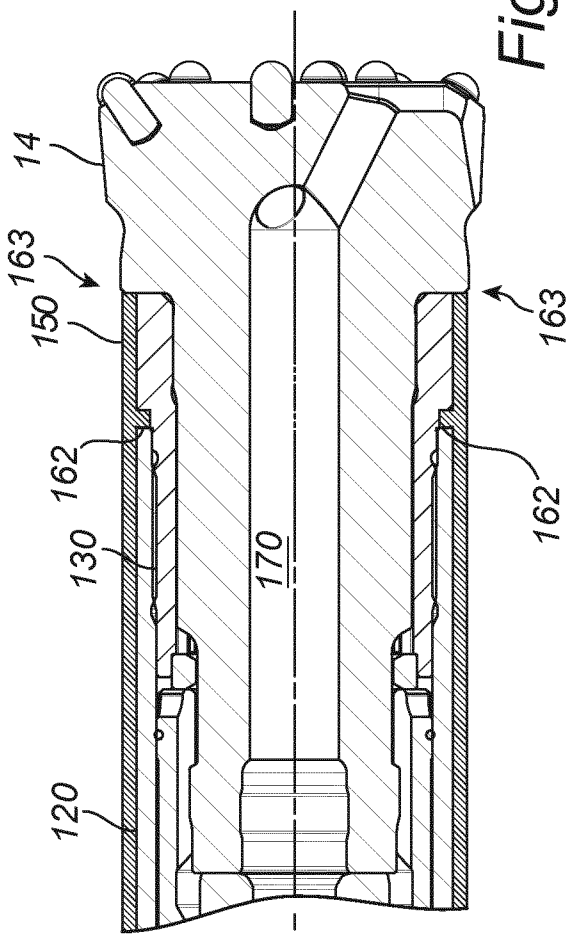

14
163
150
163
162
162
130
170
120

Fig. 3b

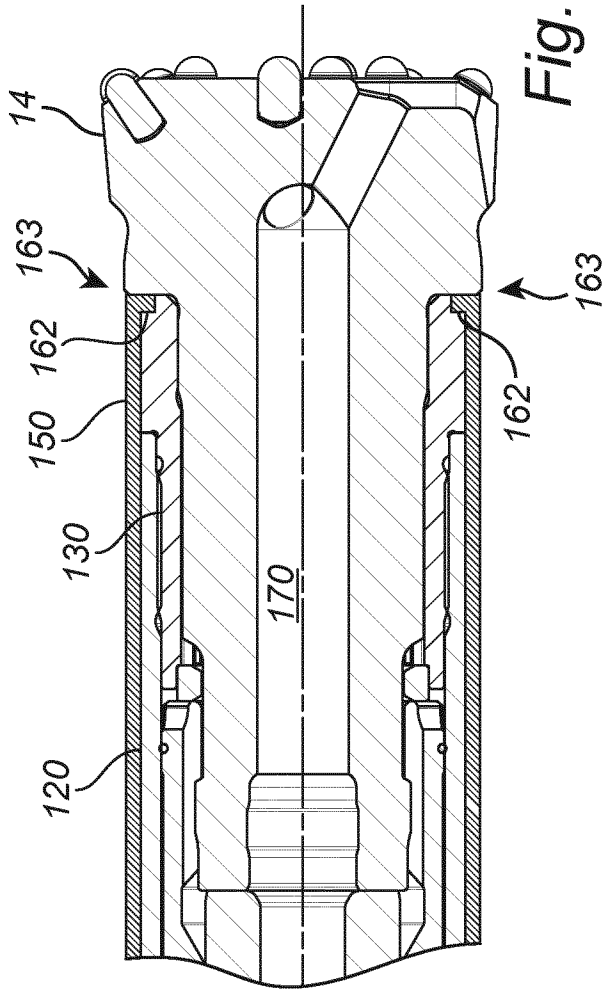

14
163
162
150
130
120
170
163
162

Fig. 3c

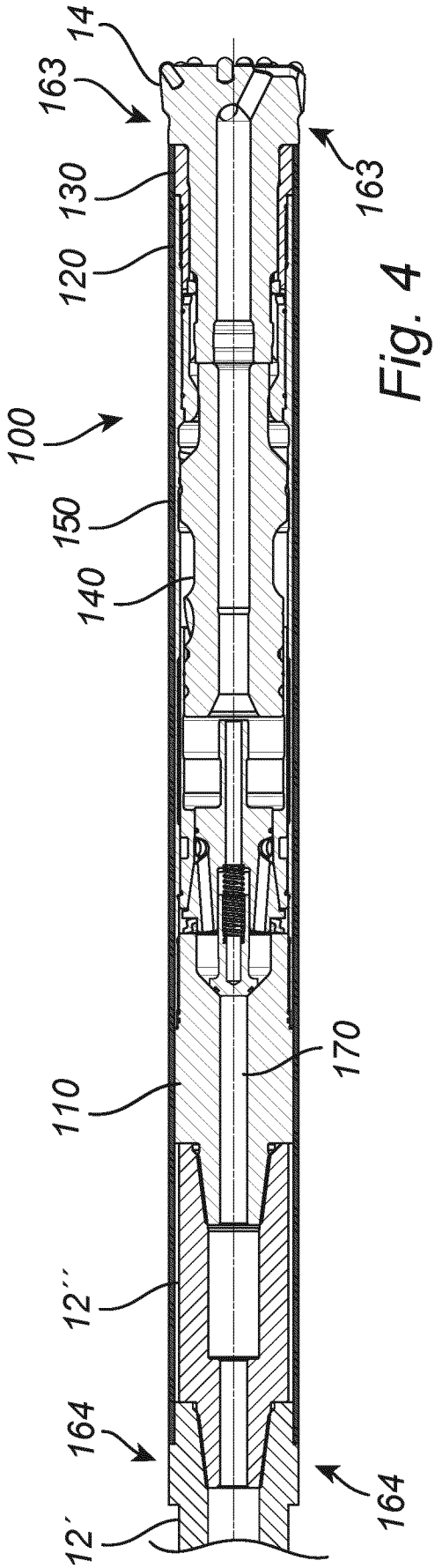

14
163
130
120
100
150
140
163
110
170
12''
164
12'
164

Fig. 4

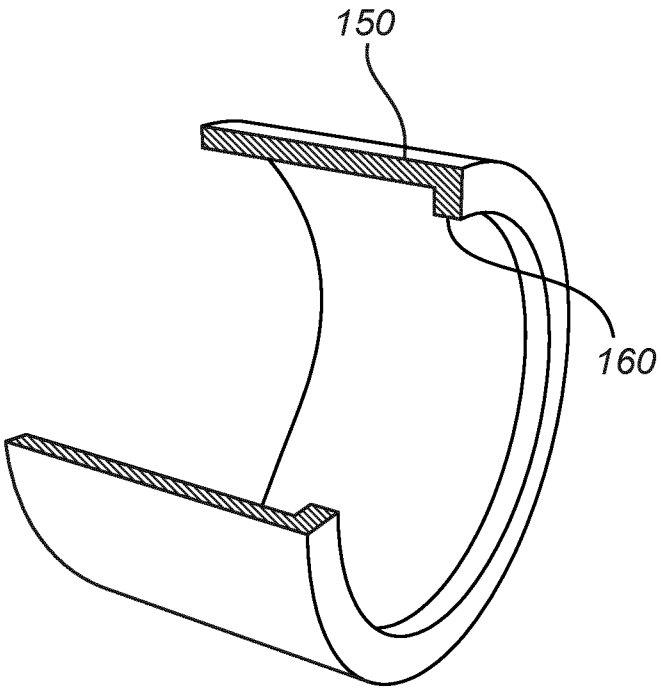


Fig. 5

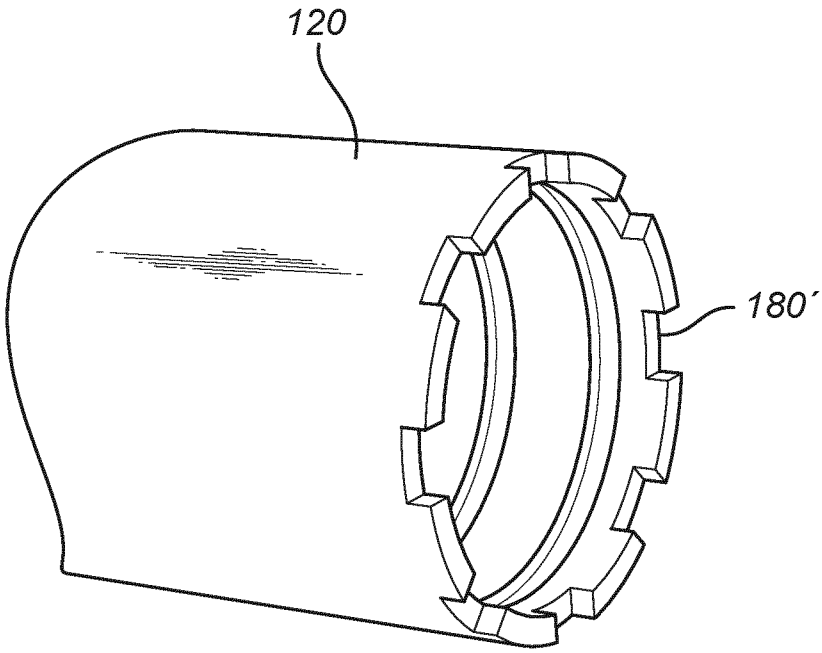


Fig. 6

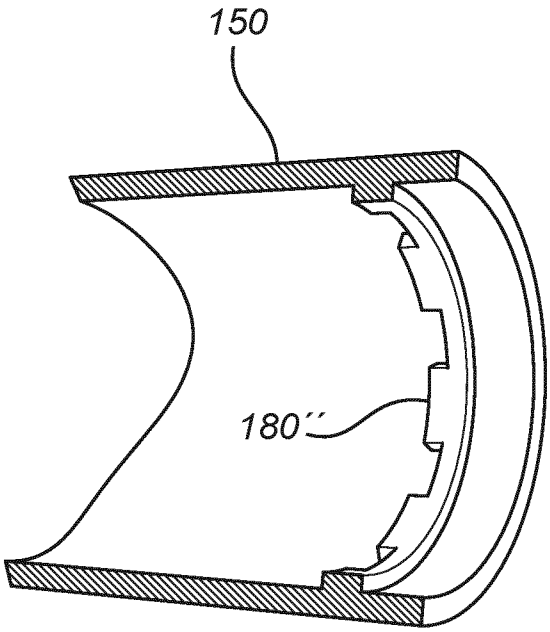


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/059077

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B4/14 E21B10/36 E21B10/46 E21B10/62
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 090 500 A (YOUSEF FAISAL J [US] ET AL) 25 February 1992 (1992-02-25) column 3, line 39; figure 1	1-16
X	US 5 957 220 A (COFFMAN JAMES E [US] ET AL) 28 September 1999 (1999-09-28) the whole document	1-14,16
X	EP 0 204 243 A2 (WEAVER & HURT LTD [GB]) 10 December 1986 (1986-12-10) the whole document	1-14,16
X	EP 0 081 897 A1 (WEAVER & HURT LTD [GB]) 22 June 1983 (1983-06-22) the whole document	1-5, 8-14,16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 July 2023	14/07/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ott, Stéphane

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2023/059077

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5090500 A	25-02-1992	AU 662718 B2	14-09-1995
		CA 2097307 A1	31-05-1992
		IE 914152 A1	03-06-1992
		JP H06503615 A	21-04-1994
		US 5090500 A	25-02-1992
		WO 9209782 A1	11-06-1992
US 5957220 A	28-09-1999	NONE	
EP 0204243 A2	10-12-1986	AU 5805286 A	11-12-1986
		EP 0204243 A2	10-12-1986
		GB 2175941 A	10-12-1986
EP 0081897 A1	22-06-1983	AT E19130 T1	15-04-1986
		EP 0081897 A1	22-06-1983