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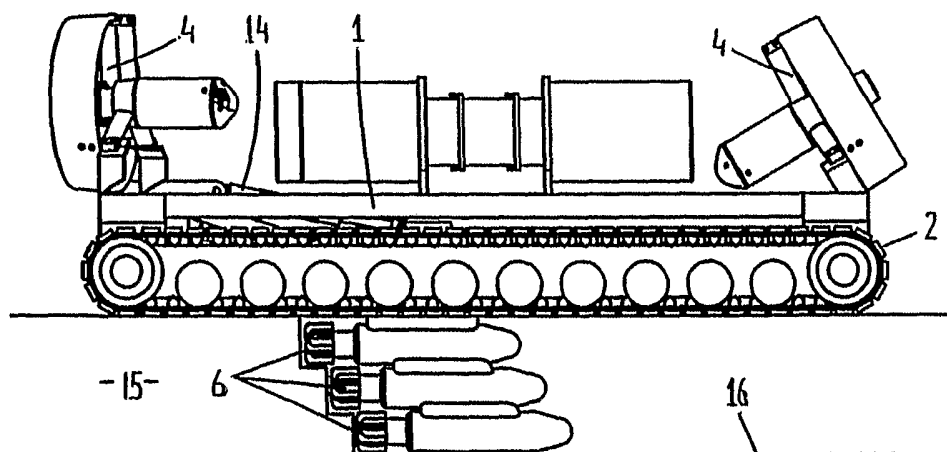
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(54) Title: APPARATUS FOR FORMING A TRENCH IN THE SURFACE OF THE EARTH



(57) Abstract: What is disclosed is an apparatus for forming a trench (16) in the surface of the earth (15), for example a trench for energy lines, communication lines, etc., which apparatus comprises a frame (1) provided with propulsion means (2, 3), on which frame at least one trench forming device (5) is mounted. The trench-forming device (5) comprises at least one driveable drill bit (6), whose axis of rotation is oriented substantially parallel to the direction of movement of the apparatus during operation of the apparatus.

Apparatus for forming a trench in the surface of the earth

The invention relates to an apparatus for forming a trench in the surface of the earth, for example a trench for energy lines, communication lines, etc., which apparatus comprises a frame provided with propulsion means, on which
5 frame at least one trench forming device is mounted.

Over the years a large number of cables and pipes have been laid in the ground, such as telephone cables, television cables and public utility lines. Also in the future a large number of such underground cables and pipes
10 will have to be laid. To that end, trenches are formed in the ground by means of apparatus especially intended for that purpose, the cables and pipes are laid in such trenches and subsequently the trenches are filled up again with the material that was initially removed therefrom.

15 The trenches being formed in the surface of the earth may be trenches on land or trenches in the seabed.

In a known apparatus of the type to which the present invention relates, the trench-forming device is made up of a rotating cutter, whose circumferential shape in principle defines the shape of the trench being formed. When such
20 a cutter is used, only part of the circumference of the cutter is in contact with the surface of the earth, which leads to major vibrations and shock loads being generated, and it is attempted to avoid said vibrations and shock loads by designing the apparatus to have a large weight. It stands to
25 reason that such a large weight is disadvantageous. In another known apparatus, the trench-forming device is made up of two circular saws arranged beside each other, by means of which the side walls of the trench are formed; the removal
30 of the material present between the cuts made by the circular saws must be removed in an additional operation so as to form the trench.

As it is to be expected that the number of underground cables and pipes will further increase in the future, regions of the earth's surface that were hitherto not considered suitable, such as regions having a hard, e.g. rocky
5 bottom, are presently being considered as locations for the trenches to be formed. It has become apparent that the aforesaid known apparatuses are hardly capable, if at all, to form the desired trenches in a hard bottom in a satisfactory manner (i.e. sufficiently quickly and at reasonable
10 cost, among other things).

In view of the foregoing it is an object of the present invention to provide an improved apparatus of the type referred to in the introduction.

According to the present invention, an apparatus
15 for forming a trench in the surface of the earth is to that end characterized in that the trench-forming device comprises at least one driveable drill bit, whose axis of rotation is oriented substantially parallel to the direction of movement of the apparatus during operation of the apparatus.

20 The applicant has found that, surprisingly, it appears to be possible to use a drill bit that is known per se, inter alia from the oil and gas exploration industries, in an apparatus for forming a trench in the surface of the earth. Suitable positioning of such a drill bit, with the
25 axis of rotation thereof being oriented substantially parallel to the direction of movement of the apparatus during operation of the apparatus, makes it possible to form a trench in the surface of the earth in an effective manner (quickly and at relatively low-cost), even if the surface of the
30 earth consists of a hard material (for example rocky bottom). Moreover, such a drill bit is in contact with the surface of the earth over its entire circumference, as a result of which vibrations and shock loads are prevented and the apparatus may have a lower weight, with all the attendant
35 advantages.

In a preferred embodiment of the apparatus according to the invention, the drill bit is movable between an operative position, in which the drill bit is in contact with the ground, and an inoperative position, in which the
5 drill bit is not in contact with the ground.

When such a construction of the apparatus according to the invention is used, the versatility and usability of the apparatus increase advantageously. Thus it is possible to move the apparatus over the bottom in the inoperative
10 position thereof, to a location where the trench is to start. The forming of the trench can be started by moving the drill bit to its operative position at that location. In the inoperative position of the apparatus, however, the apparatus can be moved without a trench being formed.

15 There are various possibilities of moving the drill bit between the aforesaid operative position and the aforesaid inoperative position. Thus the drill bit may be pivotable about a pivot axis extending substantially transversely to the aforesaid direction of movement. It is also
20 possible, however, for the transverse axis to be movable with respect to the frame. Furthermore it is possible to use a combination of said movements, so that it is possible to obtain an optimum movement of the drill bit, in particular when moving the drill bit from the inoperative position to
25 the operative position, which movement makes it easier to form the beginning of a trench, for example (when the drill bit must first be inserted into the ground).

In another, preferred embodiment of the apparatus according to the invention, the trench-forming device con-
30 sists of a number of drill bits with mutually overlapping operating ranges, which are arranged substantially side by side. The mutually overlapping operating ranges jointly define the cross-sectional shape of the trench being formed.

If the trench must be narrow yet deep, as is often
35 the case, it will be advantageous for the drill bits to be

arranged one above another, each drill bit taking up a forwardly staggered position, seen in the direction of movement, with respect to the drill bit positioned directly thereunder. If the drill bits are arranged in such a staggered position, one above another, it will be possible to
5 form a narrow, deep trench in a very effective manner.

As regards the propulsion of the apparatus according to the invention, the following can be noted. The propulsion means of the frame may include caterpillar tracks,
10 via which the apparatus can independently move over the bottom, thereby generating the driving force that causes the drill bit or drill bits to move through the surface of the earth. Especially in those cases in which the apparatus according to the invention is intended for forming a trench in
15 the seabed, the propulsion means may comprise at least one screw propeller mounted on the frame. Such a screw propeller may also be used in combination with the aforesaid caterpillar tracks, of course. The additional advantage of such
20 screw propellers is the fact that they are capable of generating a propulsion force that does not depend on the weight of the apparatus, which is advantageous in particular on a sloping surface. Moreover, said screw propellers may also be used for positioning the apparatus above a desired location before it is lowered onto the seabed.

25 The drivability of the apparatus can be further optimised if such a screw propeller is adjustable with respect to the frame, for example about a vertical axis and/or a lateral axis of the frame.

In a practical embodiment of the apparatus according to the invention, the apparatus comprises four screw
30 propellers disposed in the corner points of a rectangle.

If the apparatus is intended for forming a trench in the seabed, as noted above, the apparatus will generally co-operate with a mother ship and be connected thereto, in-
35 ter alia via control and communication lines. Cameras may be

mounted on the frame of the apparatus, for example, by means of which cameras operators present on the mother ship can view the working environment of the apparatus present on the seabed. Such connections between a mother ship and a device
5 present on the seabed are known per se and need not be explained in more detail herein.

It may furthermore be noted that the apparatus is generally provided with various driving means, which are likewise known per se, for carrying out its functions, which
10 may obtain the energy they require via an energy line that connects the apparatus to the aforesaid mother ship, but the apparatus may also have its own energy source.

The invention will be explained in more detail below with reference to the drawings, which show an embodiment
15 of the apparatus according to the invention.

Fig. 1 is a perspective view of an embodiment of the apparatus according to the invention;

Fig. 2 is a front view of the device of Fig. 1, showing the apparatus in an operative position thereof;

20 Fig. 3 is a partially cut-away side elevation of the apparatus of Fig. 1, showing the apparatus in an inoperative position thereof;

Figs. 4 and 5, similarly to Fig. 3, show the same apparatus during a transition phase from the inoperative position to the operative position; and
25

Fig. 6 is a view of the same apparatus in the operative position.

The figures show an embodiment of an apparatus for forming the trench in the surface of the earth that is
30 mainly intended for offshore applications, for example for forming a trench in the seabed. Although this is not shown in the drawings, such an apparatus may be connected to a mother ship by means of cables and/or pipes.

The apparatus comprises a frame 1 provided with a
35 left-hand caterpillar track 2 and a right-hand caterpillar

track 3. The frame 1, which is rectangular in this embodiment, is provided with screw propellers 4 in its four corner points, which are each adjustable, in a manner not shown, such that they can move both about a vertical axis and about
5 a lateral axis. The techniques that are used for this purpose are known per se and need not be explained in more detail herein.

The driving means used for driving the caterpillar tracks 2,3 and the screw propellers 4 are likewise comprised
10 in the prior art, and consequently they need not be explained in more detail herein, either. Nor will the energy source for such driving means be discussed in detail herein, which energy source may have any known form (on board the apparatus or on board a mother ship).

15 With reference in particular to Fig. 2, it is apparent from said figure that a supporting arm 5 is mounted on the frame 1 via an operating mechanism (yet to be described), which arm carries three drill bits 6 in the illustrated embodiment. Said drill bits, which are of conventional construction, are known from the gas and oil exploration industries, for example.
20

The operating mechanism 7 that is shown in front view in Fig. 2 will now be explained in more detail with reference to Fig. 3. Referring to Fig. 1, it is noted in
25 this connection that a number of the components of the operating mechanism to be described below are of dual construction in the illustrated embodiment. A pivoting arm 8 is pivotally connected to the frame 1 at a connecting point 9. The opposite end of the pivoting arm 8 is pivotally connected,
30 at the location of a pivot axis 10, to the supporting arm 5 that carries the drill bits 6 (and the driving units 6' thereof). Driving means, such as a cylinder-piston assembly 12, are disposed between a second connecting point 11 on the frame 1 and the pivoting arm 8 (in particular a bracket or
35 the like mounted thereon). The pivoting arm 8 can be pivoted

about the connecting point 9 with respect to the frame 1 by energizing said cylinder-piston assembly 12.

Referring also to Fig. 4, the figure shows that driving means, such as a cylinder-piston assembly 14, are arranged between a third connecting point 13 connected to the frame 1 and the supporting arm 5. The supporting arm 5 can be pivoted about the pivot axis 10 by energizing said cylinder-piston assembly 14.

The position and dimensions of the various components of the operating mechanism 7, as well as the moment of energizing the cylinder-piston assemblies 12 and 14, determine the pivoting of the pivoting arm 8 as well as the pivoting of the supporting arm 5 about the pivot axis 10 (and thus about the pivoting arm 8).

The operation of the apparatus will now be explained in more detail with reference to Figs. 3-6.

In figure 3, the operating mechanism 7 is positioned such that the drill bits 6 are positioned above the ground 15 in which a trench is to be formed. In this so-called inoperative position, the cylinder-piston assembly 12 is fully retracted and the cylinder-piston assembly 14 is extended. Important is that the drill bits 6 cannot come into contact with the ground 15 in this inoperative position; the spatial orientation of the drill bits is of minor importance in this connection.

Subsequently, the cylinder-piston assembly 12 is extended, whilst the cylinder-piston assembly 14 is retracted. This will cause the pivoting arm 8 to pivot in clockwise direction about the connecting point 9 (as a result of which the drill bits 6 will be directed towards the ground 15 with their operative front ends). In the meantime the drill bits 6 have been activated by their respective drive units 6', and with the drill bits penetrating the soil 15 deeper and deeper, the forming of a trench 16 in the ground is started.

Figure 5 shows a next situation, in which the pivoting arm 8 has been pivoted further about the connecting point 9, whilst the cylinder-piston assembly 14 has been slightly extended again, as a result of which the supporting arm 5 is pivoted in clockwise direction about the pivot axis 10 again relative to the position that is shown in Fig. 4.

Finally, a so-called operative position of the apparatus is reached in Fig. 6, in which position the axis of rotation of the drill bits 6 extends substantially in the direction of movement of the apparatus. A situation has now been reached in which a trench 16 having desired dimensions is formed while the apparatus is being moved ahead.

Fig. 6 clearly shows that the drill bits 6 are positioned one above another in the illustrated operative position, such that each drill bit 6 is staggered in forward direction, seen in the direction of movement (from the right to the left in Fig. 6) with respect to the drill bits 6 positioned directly thereunder.

The invention is not limited to the embodiment as described above, which can be varied in many ways within the scope of the invention as defined in the claims.

CLAIMS

1. An apparatus for forming a trench in the surface of the earth, for example a trench for energy lines, communication lines, etc., which apparatus comprises a frame provided with propulsion means, on which frame at least one trench forming device is mounted, **characterized in that** the trench-forming device comprises at least one driveable drill bit, whose axis of rotation is oriented substantially parallel to the direction of movement of the apparatus during operation of the apparatus.

2. An apparatus according to claim 1, wherein the drill bit is movable between an operative position, in which the drill bit is in contact with the ground, and an inoperative position, in which the drill bit is not in contact with the ground.

3. An apparatus according to claim 2, wherein the drill bit is pivotable about a pivot axis extending substantially transversely to said direction of movement.

4. An apparatus according to claim 3, wherein the transverse axis is movable with respect to the frame.

5. An apparatus according to claim 4, wherein the drill bit is pivotally connected to an arm, which arm itself is pivotable with respect to the frame.

6. An apparatus according to claim 1-5, wherein the trench-forming device consists of a number of drill bits having mutually overlapping operating ranges, which are arranged substantially side by side.

7. An apparatus according to claim 6, wherein the drill bits are arranged one above another, each drill bit taking up a forwardly staggered position, seen in the direction of movement, with respect to the drill bit positioned directly thereunder.

8. An apparatus according to any one of the preceding claims, wherein the propulsion means of the frame include caterpillar tracks.

5 9. An apparatus according to any one of the preceding claims, in particular intended for forming a trench in the seabed, wherein said propulsion means comprise at least one screw propeller mounted on the frame.

10 10. An apparatus according to claim 9, wherein said screw propeller is adjustable with respect to the frame, for example about a vertical axis and/or a lateral axis of the frame.

11. An apparatus according to claim 9 or 10, comprising four screw propellers disposed substantially at the corner points of a rectangle.

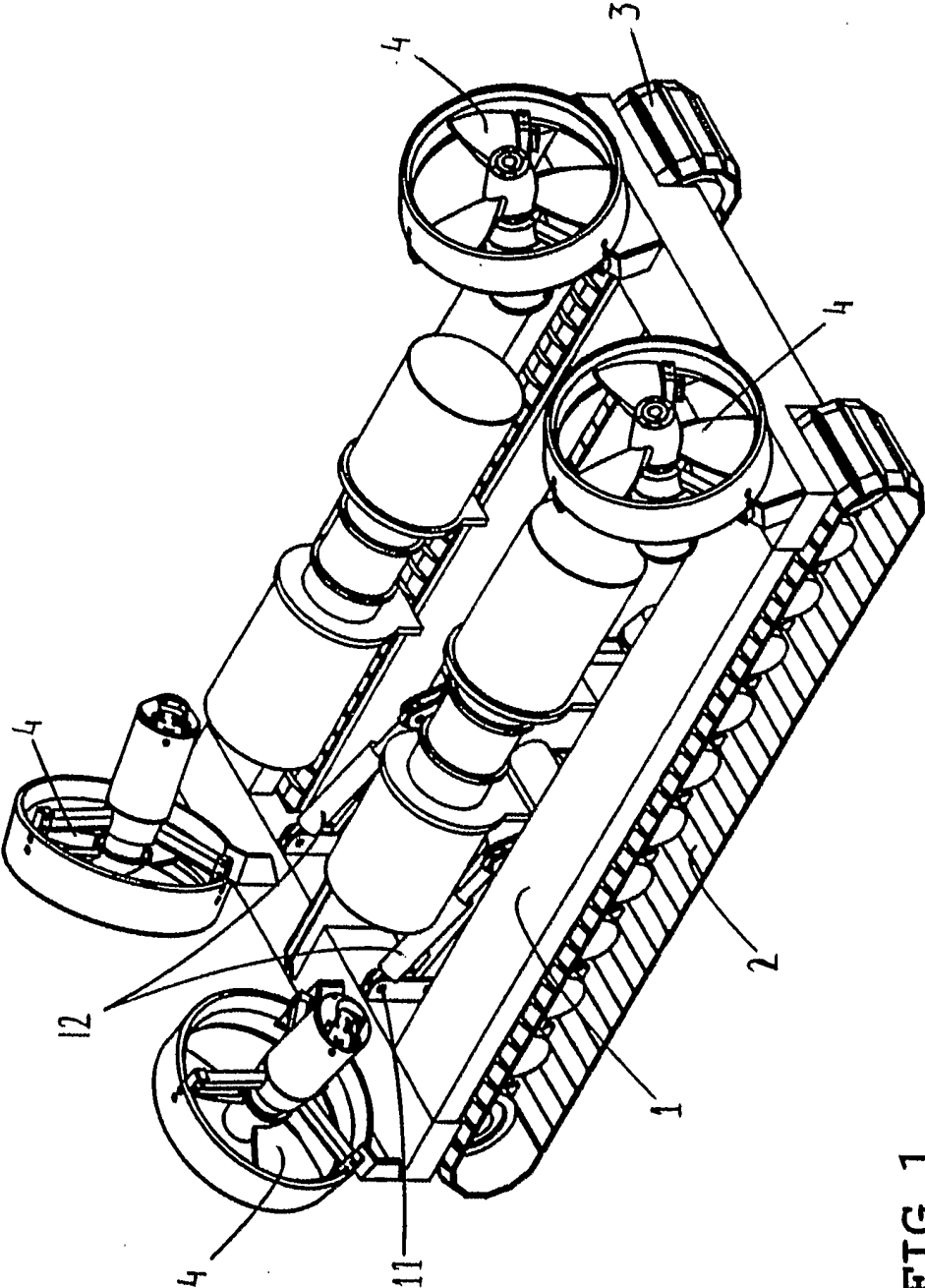


FIG. 1

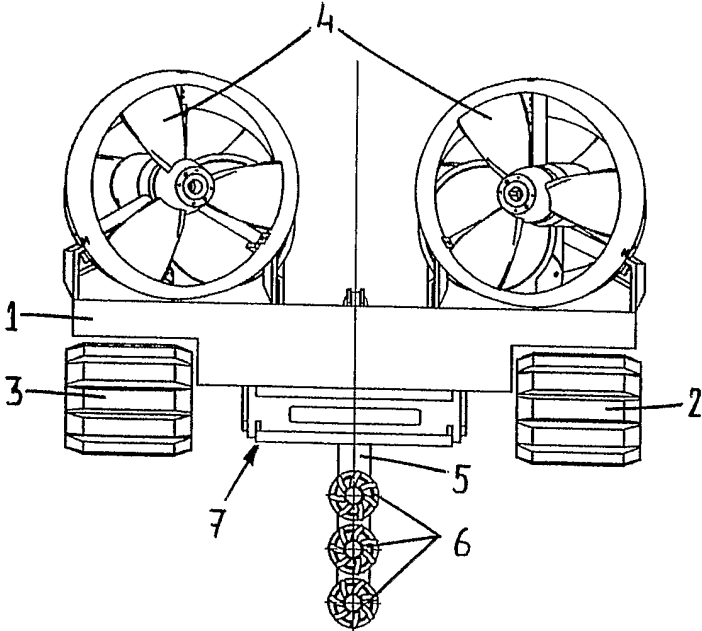


FIG. 2

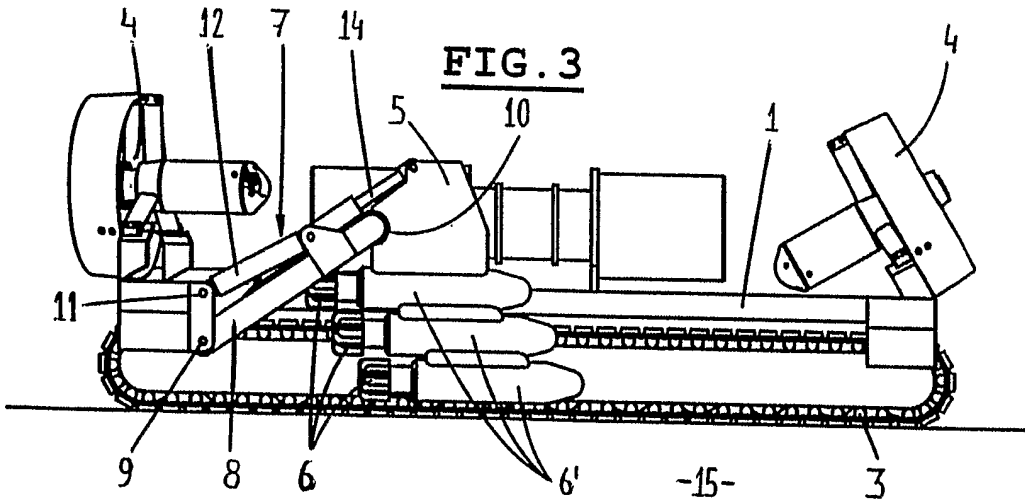
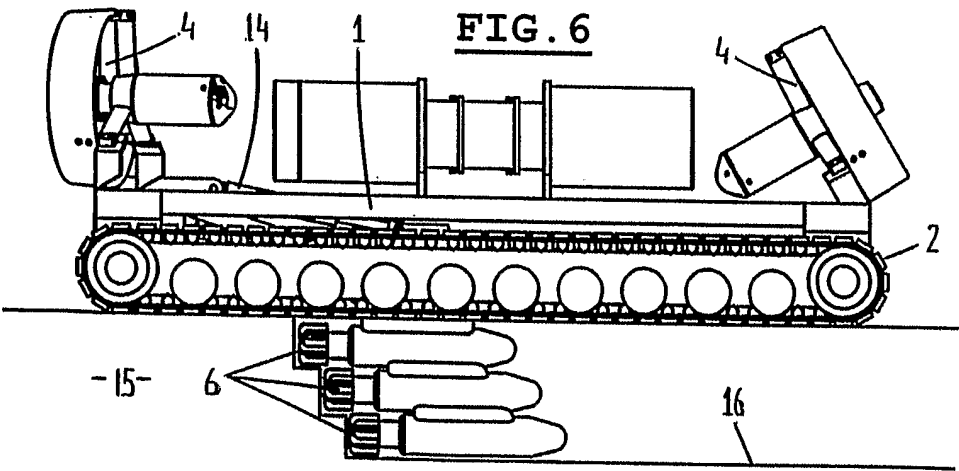
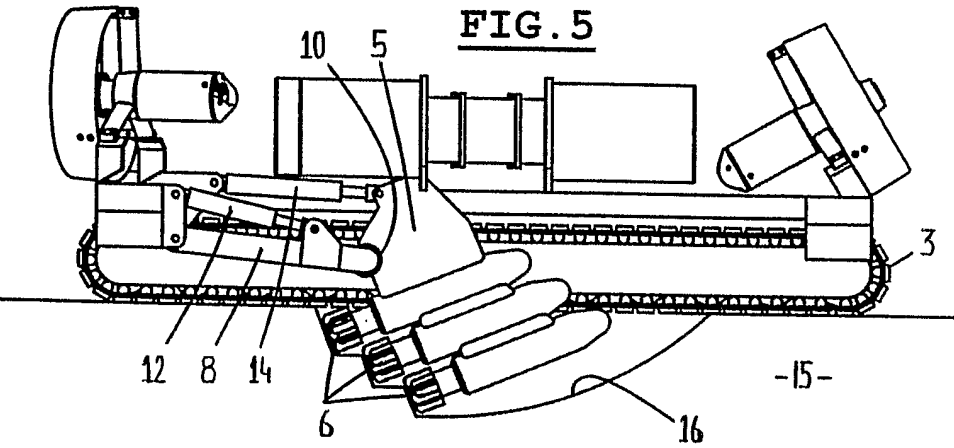
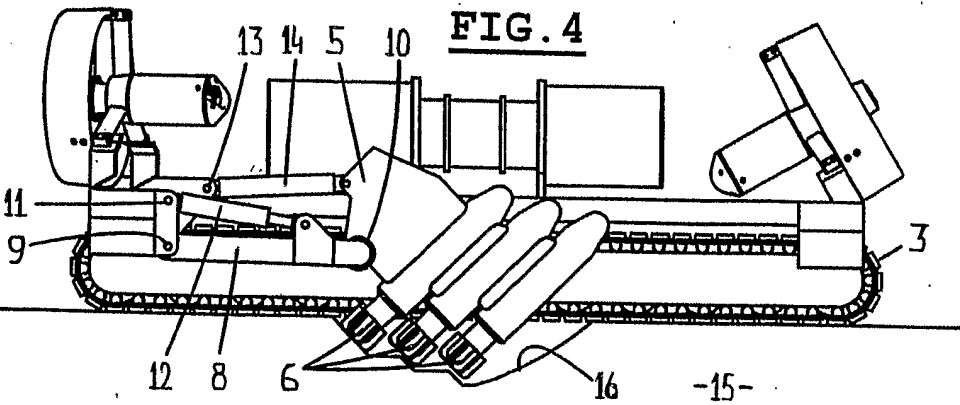


FIG. 3



INTERNATIONAL SEARCH REPORT

Internatj	Application No
PCT/NL	03/00908

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 E02F5/10

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)
 IPC 7 E02F

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 practical, search terms used)
 EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 010, no. 320 (M-530), 30 October 1986 (1986-10-30) -& JP 61 126229 A (TOSHIO TAWARA), 13 June 1986 (1986-06-13) abstract; figures 1,4-6 ---	1-5,8
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Internat Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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