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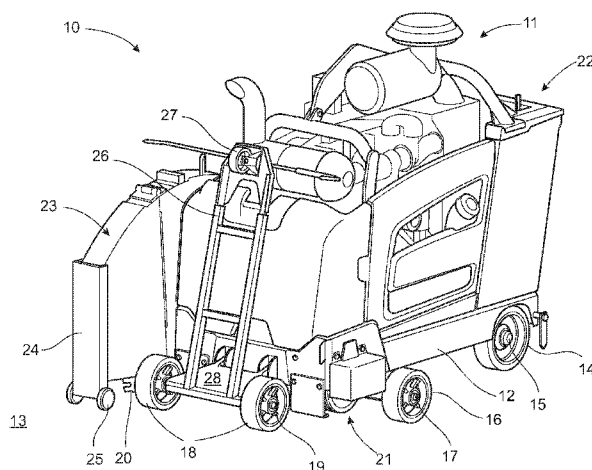


Fig. 1

(57) Abstract: The invention relates to a trench cutting machine (10) for making a cut in a surface (13). The trench cutting machine comprises a frame (12) comprising at least one rear axle (15) and at least one front axle (17); a rotatable circular blade (20) mounted to the frame (12). The front axle (17) is vertically adjustable relative to the frame (12) between a first position where the circular blade (20) is lifted clear of the surface (13), and a second position where the circular blade (20) is arranged to extend downwards from the frame (12) to cut a predetermined distance into the surface (13). The frame (12) comprises an auxiliary front axle (19) located in front of the axis of rotation of the circular blade (20), wherein the auxiliary front axle (19) and the rear axle (15) are arranged to support the frame (12) on the surface (13) during a cutting operation and to maintain a selected depth of cut. The invention further relates to a shroud assembly and a debris guiding device for such a machine.



TRENCH CUTTING MACHINE

TECHNICAL FIELD

The present invention relates to a trench cutting machine for cutting a narrow
5 trench prior to laying at least one flexible casing or tube, cable or wire, which
trench cutting machine including a circular blade arrangement for cutting a
trench into a surface that may comprise tarmac, concrete or similar. The
invention further relates to a shroud assembly and a debris guiding device for
such a trench cutting machine.

10 BACKGROUND ART

The use of trench cutting machines for laying flexible casings or tubes, e.g.
for optical fibers, as well as cables or wires for electrical or other installations
is becoming increasingly common. One reason for this is that a narrow trench
make less damage on e.g. a road and therefore provides less environmental
15 impact than a wider excavated channel. Furthermore, a narrow cut trench is
much easier to cover and can be made almost invisible as if no trenching had
been performed. Also, using a circular blade arrangement in a cutting
operation makes the side walls of the trench less likely to collapse, since
larger stones or roots are cut through. Finally, the material from the trench
20 when using a blade arrangement becomes fine debris which is more easily
handled than excavated material.

When performing a cutting operation, the circular blade can be rotated in two
alternative directions. A first direction involves rotating the circular blade in
the same direction as the ground contacting wheels of the machine, which
25 operation is commonly referred to as "down-cut". A problem with this
operation is that cut debris is drawn backwards into the trench by the blade
and will partially re-fill the trench unless steps are taken to remove the debris
immediately after the circular blade. A second direction involves rotating the

circular blade in the opposite direction as the ground contacting wheels of the machine, which operation is commonly referred to as “up-cut”. In this case, the problem of debris gathering in the cut trench is reduced, but debris can be thrown out in front of the machine as the cutting teeth of the blade cuts
5 through the surface. The latter is a particular problem when the circular blade begins its cut into the surface. Also, the cutting action of the blade can induce forces to the machine, which forces can make the machine unstable unless the weight on a rearmost axle of the machine is sufficient to counteract such forces.

10 Hence, there is a need for a trench cutting machine that solves the above problems. One object of the invention is to provide an improved trench cutting machine that can be operated in a stable manner during the entire cutting operation. A further object is to provide means for controlling the spread and deposition of debris during an up-cut operation.

15 DISCLOSURE OF INVENTION

The above problems are solved by a trench cutting machine as described in the attached claims.

In the subsequent text, the term “circular blade” denotes a blade assembly comprising one or more rotatable cutting blades mounted on a single axis,
20 wherein the number of blades can be selected to achieve a vertical cut having a desired, predetermined width in a surface. Terms such as “front”, “forwards”, “rear” and “rearwards” are defined in relation to the direction of movement of the a trench cutting machine during a cutting operation. Furthermore, the term “up-cut” refers to a direction of rotation of the circular
25 blade in the opposite direction as the ground contacting wheels of the machine, as defined above.

A circular blade for a trench cutting machine according to the invention can be in the form of a blade assembly for cutting into a work surface/area/structure. The blade assembly can include one single solid

blade but preferably include at least two blades, a first blade, a second blade, and possible additional blades, that are axially aligned, each blade having a working portion at the periphery of the blade and a central portion around the axial center of the blade for being operated on by a device for driving the blade assembly. A blade support structure extends between the working portion and the central portion and the blades are spaced apart by a spacer structure/-s. The spacer structure/s forms at least one compartment, between the blades, that is in contact with the central portion and extending towards the working portion, and at least at one radius of the spacer structure/s covering a significant part of the periphery at that radius of the spacer structure/s, said compartment/s having an inlet at the central portion.

More preferably the blade assembly includes three blades which are spaced apart by two spacer structures, said spacer structures each forming at least one compartment between the blades in contact with the central portion and extending towards the working portion and at least at one radius of the spacer structures covering a significant part of the periphery at that radius of the spacer structures, said compartment/s having an inlet at the central portion. The actual number and design of the blades making up such a blade assemble is not relevant for the current invention *per se*.

The invention relates to a trench cutting machine for making a cut in a surface comprising pavement, concrete and/or other hard materials. The trench cutting machine comprises a first frame having at least one front axle and at least one rear axle, wherein at least one of the front and rear axles has two wheels. The front and/or rear axles can comprise a single axle with one wheel, a single axle extending across the frame between a pair of wheels, or a separate axle for each individual wheel. For an arrangement with a pair of wheels with separate axles on opposite sides of the frame, the central axes of both axles are coinciding when moving straight forward or backward. A rotatable circular blade is mounted to the frame, which circular blade has an axis of rotation located parallel to and in front of the front axle

during a cutting operation. A prime mover is provided for driving at least the circular blade. The front axle is vertically adjustable relative to the frame between a first position where the circular blade is lifted clear of the surface, and a second position where the circular blade is arranged to extend
5 downwards from the frame to cut a predetermined distance into the surface.

The trench cutting machine further comprises an auxiliary front axle located in front of the axis of rotation of the circular blade, wherein the auxiliary front axle and the rear axle are arranged to support the frame on the surface during a cutting operation and to maintain a selected depth of cut into the
10 surface. As described above, the auxiliary front axle can comprise an axle with one wheel, a single axle extending between a pair of wheels, or a separate axle for each individual wheel. The prime mover can be arranged to drive one or more wheels on any one of the above-mentioned axles. Preferably, the prime mover is a combustion engine driving the cutting blade
15 via a belt transmission. The engine is preferably also used for powering a hydraulic pump coupled to at least one hydraulic motor for driving one or more wheels on any of above-mentioned axles. Preferably, there is an individual hydraulic motor for each of the driven wheels, and preferably the rear wheels are driven.

20 The direction of rotation of the circular blade when cutting is opposite to the direction of rotation of the wheels during forward movement of the trench cutting machine. This direction of rotation is hereafter termed an up-cut.

As indicated above, at least one of the auxiliary front axle and the rear axle has two wheels. According to the invention, the wheel or wheels on the rear
25 axle are preferably driven, as these will always be in contact with the ground. However, it is also possible to drive the wheel or wheels on either or both of the second and/or third axles.

The auxiliary front axle is preferably, but not necessarily, adjustable relative to the frame in order to set a predetermined depth of cut. According to one

example, the auxiliary front axle can be adjustable about a pivot relative to the frame. For instance, the auxiliary front axle can be mounted at the end of a sub-frame or an arm extending forwards, in front of the frame. When the trench cutting machine is performing a cutting operation, the front portion of the frame is supported by the wheel or wheels on the auxiliary front axle. In this position, the sub-frame or arm extends in the direction of a line between and at right angles to the axis of the pivot and the axis of the auxiliary front wheel or wheels. During the cutting operation this line is located at a predetermined angle relative to the plane of the substantially plane surface.

10 An actuator can be provided for adjusting the position of the sub-frame or arm prior to or during a cutting operation. The actuator can be controlled to act on the sub-frame or arm so that this angle is reduced, to increase the depth of cut, or increased, to reduce the depth of cut. Alternatively, the auxiliary front axle can be adjustable along a straight line, at right angles to or

15 at a predetermined angle relative to the main longitudinal direction of the frame. In this case the auxiliary front wheel can be mounted on a support at the front portion of the frame, which support is movable up and down for adjusting the position of the frame prior to or during a cutting operation. An actuator can be provided for adjusting the vertical position of the support

20 relative to the plane of the substantially plane surface to give a desired depth of cut. According to a further example, the auxiliary front axle can be steplessly adjustable relative to the frame. Alternatively, the auxiliary front axle can be adjustable in fixed steps relative to the frame. As an example, the support may be attachable to the frame by fasteners such as threaded

25 bolts and threaded bores. For instance, a plurality of threaded bores may be provided on the frame such that the operator can adjust the position of the auxiliary front axle by unengaging at least one threaded bolt from at least one threaded bore to loosen the support from the frame, vertically move the support to a desired position for the auxiliary axle and engage the at least

30 one threaded bolt with another at least one threaded bore to tighten the support to the frame.

The positioning of the auxiliary front axle can be carried out by a suitable actuator mounted to the frame or a chassis carried by the frame and be operated manually or by a mover for instance the prime mover. An actuator driven by the prime mover can comprise any suitable mechanically, hydraulically or electrically driven device and is controllable by an operator. Non-limiting examples of such suitable devices are e.g. ball-screw arrangement, hydraulic cylinders or electric servo motors. Unless it is desired to adjust the position of the sub-frame during a cutting operation, it can be advantageous that that actuator is self-locking or can be locked in a set position, in order to reduce the power output required from the prime mover to maintain the position. Alternatively, the actuator can be a suitable mechanical linkage or gearing that can be operated and set/locked manually by the operator. Non-limiting examples of such suitable devices are e.g. a hand-wheel connected to a self-locking screw mechanism or a hand cranked lever system.

As described above, the auxiliary front axle comprises at least one wheel arranged adjacent the circular blade. The circular blade can be arranged on the left or the right hand side of the frame, while maintaining the same auxiliary front axle arrangement. Alternatively, the circular blade can be located along or adjacent the central longitudinal axis of the trench cutting machine. In this case the auxiliary front axle can have at least one wheel arranged on either side of the circular blade.

The auxiliary front axle is located a predetermined distance in front of the axis of rotation of the circular blade. This distance is dependent on the size of the machine and the diameter of the circular blade and is selected so that the the auxiliary front axle can counteract the torque produced by the circular blade and prevent the wheel or wheels on the rear axle from slipping or lifting. The distance can also be selected so that at least one wheel on the auxiliary front axle is arranged in front of the outer periphery of the circular blade. According to the invention, the trench cutting machine is arranged to

be supported by the wheels of the rear axle and the auxiliary front axle during a cutting operation. An advantage with this solution is that the trench cutting machine is stabilized, as the supporting auxiliary front axle is located forward of the front axle and therefore increases the pressure on the rear axle and
5 therefore prevents the wheels on the rear axle from slipping or being lifted during the cutting operation.

The trench cutting machine further comprises a shroud assembly mounted on the frame to guide debris discharged from the circular blade. The shroud assembly comprises a first and second opposed and spaced apart side walls
10 joined along their rear, upper and front portions. The shroud assembly further has an open bottom portion and an at least partially open lower front portion. At least a portion of the circular blade is configured to be received within the shroud assembly. A movable front section is arranged at the front portion of the shroud assembly, which front section is arranged to cover the at least
15 partially open lower front portion and to extend to a position adjacent or in contact with the surface during a cutting operation.

One or both side portions of the movable front section can be attached onto the shroud assembly by a guide means, such as a sliding guide or a roller guide, allowing it to slide relative to a front surface of the shroud as the
20 distance between the surface and the lower portion of the shroud changes. For instance, the movable front section can be extended to its maximum extension in front of the shroud assembly when the frame is in its first position where the circular blade is lifted clear of the surface to allow transport of the machine. When the frame is lowered towards its second
25 position, the movable front section can be arranged to reach the surface at substantially the same time as the circular blade. An advantage with this solution is that debris can be prevented from being thrown forward by the cutting action. As the circular blade is lowered downwards to cut a predetermined distance into the surface, the movable front section will slide
30 relative to the front surface of the shroud as the distance between the surface

and the lower portion of the shroud is reduced. In this way the movable front section can be arranged to extend to a position adjacent the surface during the entire cutting operation. A lower end portion of the front section can be provided with a ground contacting member. The ground contacting member
5 can comprise one or more rotatable members, such as wheels, in contact with the surface. Alternatively, the ground contacting member can comprise one or more low friction components with a suitable rounded or curved lower surface.

For additional control of the debris from the cutting operation, the shroud can
10 be provided with a first deflector member arranged behind the circular blade. The first deflector member extends transversely from the first side wall at least up to a recess in the second side wall. Preferably, the first deflector member extends from a relatively higher position at the first side wall to a relatively lower position at the second side wall. For instance, the deflector
15 member can be arranged at an angle to form a downward angled surface from the first side wall towards the second side wall and its recess. Alternatively, the deflector member can be shaped as a curved surface suitable for guiding the debris towards the recess. A lower portion of the first deflector member adjacent the second side wall extends transversely outside
20 the second side wall, and thus outside the cut made by the circular blade in the surface. An advantage with this solution is that debris can be prevented from falling back into the cut in the surface. To ensure this function, the first deflector member can extend a distance out through the recess in the second side wall. The first deflector member can be arranged to deposit debris on
25 any one side of the cut.

According to a further example, a second deflector member can be arranged spaced from the first deflector member and facing the outer surface of the second side wall. The second deflector member extends away from the second side wall from a position above the recess and downwards past the
30 end of the first deflector member. In its simplest form the second deflector

member comprises a single angled surface extending downwards in front of the recess and below a lower portion of the first deflector member. Alternatively, the recess in the second side wall can be partially enclosed by a second deflector member in the form of a receptacle mounted on the outer surface of the second side wall. The receptacle can have an upper wall, an outer wall as well as a front and a rear wall. Debris exiting the recess along the first deflector member will be prevented from being thrown out of the recess in an uncontrollable manner, as it will strike one or more walls of the receptacle before falling out through the open bottom of the receptacle.

10 The invention further relates to a shroud assembly for a trench cutting machine, which shroud assembly is arranged to guide debris discharged from a circular blade of the trench cutting machine. The shroud assembly comprising a first and second opposed and spaced apart side walls joined along their rear, upper and front portions. The shroud assembly has an open bottom portion and an at least partially open lower front portion and is configured to receive a portion of the circular blade within said shroud assembly. A movable front section is arranged at the front portion of the shroud assembly, which front section is arranged to cover the at least partially open lower front portion and to extend to a position adjacent or in contact with the surface during a cutting operation.

At least one side portion of the movable front section is attached onto the shroud assembly by a guide means. A lower end portion of the movable front section can comprise a surface contacting member, which can comprise one or more rotatable members or a low friction member. Further details of the shroud assembly not described above can be found in the detailed description below.

The invention further relates to a debris guiding device for a shroud assembly. As described above, the shroud assembly comprises first and second opposed and spaced apart side walls joined along their rear, upper and front portions. The shroud assembly has an open bottom portion and

being configured to receive a portion of a circular blade within the shroud assembly. The debris guiding device comprises a first deflector member arranged behind the circular blade, which first deflector member extends transversely from the first side wall at least up to a recess in the second side wall.
5 wall.

Preferably, the first deflector member extends from a relatively higher position at the first side wall to a relatively lower position at the second side wall. A lower portion of the first deflector member located adjacent the second side wall extends transversely outside the second side wall, and thus
10 outside the cut made by the circular blade in the surface. Also, the first deflector member can extend out through the recess in the second side wall.

According to a further example, a second deflector member can be arranged spaced from the first deflector member and facing the outer surface of the second side wall. The second deflector member extends away from the
15 second side wall from a position above the recess and downwards past the end of the first deflector member. Further details of the shroud assembly not described above can be found in the detailed description below.

The invention will be described in further detail below applied to a trench cutting machine.

20 BRIEF DESCRIPTION OF DRAWINGS

In the following text, the invention will be described in detail with reference to the attached drawings. These schematic drawings are used for illustration only and do not in any way limit the scope of the invention. In the drawings:

Figure 1 shows a perspective front view of a self-propelled trench cutting machine according to a first embodiment of the invention;
25

Figure 2 shows a side view of the trench cutting machine in Fig.1 during a cutting operation;

Figure 3 shows a side view of the trench cutting machine in Fig.1 during transport;

Figure 4A shows a longitudinal cross-section through a shroud assembly of the trench cutting machine in Figure 1;

5 Figure 4B shows a transverse, vertical cross-section through the shroud assembly in Figure 4A; and

Figures 5A-F show a number of schematic plan views of alternative wheel arrangements for a trench cutting machine according to the invention.

10 EMBODIMENTS OF THE INVENTION

Figure 1 shows a perspective front view of a self-propelled trench cutting machine 10 powered by a prime mover 11, which in this example is an internal combustion machine. The trench cutting machine 10 includes a mobile frame 12 supported for movement across a substantially even surface 13 by a plurality of ground engaging wheels 14, 16, 18. Figure 1 shows a machine comprising a rear axle 15 provided with a first pair of wheels 14, a front axle 17 provided with a second pair of wheels 16, and an auxiliary front axle 19 provided with a third pair of wheels 18. In Figure 1, the first and second pairs of wheels 14, 16 are identical and located on opposite sides of the frame 12. During a cutting operation the frame 12 is supported by the rear axle 15 and the auxiliary front axle 19, as shown in Figures 1 and 2. During transport the frame 12 is supported by the rear axle 15 and the front axle 17, as shown in Figure 3. In order to displace the frame 12 between a first, cutting position into a second, transport position the front axle 17 can be displaced relative to the frame. This feature will be described in connection with Figure 3 below.

A rotatable circular blade assembly 20, hereinafter termed circular blade, is mounted to and extends forwardly of the frame 12. The circular blade 20 is rotated about an axis 21 located transverse to the frame 12 parallel to and

between the front axle 17 and the auxiliary front axle 19. At least a portion of the outer periphery of the circular blade 20 extends forwards of the frame 12 in the longitudinal direction thereof. The circular blade 20 can comprise one or more circular cutters mounted side by side to form an assembly having a size suitable for cutting a trench having a predetermined width and depth in the surface 13. The prime mover 11 is mounted in a chassis 22 on the frame 12 for providing motive power to the circular blade 20, via a gearbox (not shown), and at least one of the ground engaging wheels 14, 16, 18. In the example shown in Figure 1, the prime mover 11 is arranged to drive the wheels 14 of the rear axle 15. A pointer is shown folded up against the front of the chassis 22, which pointer is used for aiming the machine 10 along a line or marker on the surface 13 in front of the machine 10. In this example the pointer comprises a frame 26 and a guide wheel 27, wherein the frame 26 is pivotable between a folded up position, shown in Figure 1, and a folded down position, shown in Figure 2. Here, the frame 26 is mounted to the front of the machine adjacent the auxiliary front axle 19.

During a cutting operation the prime mover 11 is arranged to drive the rear axle 15 to propel the frame and the circular blade 20 to cut a vertical trench in the surface 13 at the front of the trench cutting machine 10. The circular blade 20 is rotated in a direction opposite to the direction of rotation of the wheels 14 18 during forward movement of the trench cutting machine 10. This direction of rotation is indicated by the arrow A1 in Figure 2, whereby the circular blade 20 performs a cutting action commonly referred to as "up-cut".

The trench cutting machine 10 further comprises a shroud assembly 23 mounted to the side of the frame 12, wherein a portion of the shroud extends in front of the frame 12. The shroud assembly 23 is arranged to collect debris discharged from the circular blade 20 and receives a portion of the circular blade 20 within enclosing wall portions. The shroud assembly 23 is described in further detail in connection with Figures 4A and 4B below. The shroud assembly 23 comprises a movable front section 24 arranged to cover an at

least partially open lower front portion in front of the circular blade 20. The movable front section 24 is mounted in a sliding guide or roller guide (not shown) on one or both sides, allowing it to slide relative to a front surface of the shroud 23 as the distance between the surface 13 and the lower portion of the shroud changes. Figure 1 indicates that the movable front section 24 can have longitudinal side edges extending over the side surfaces of the shroud assembly 23. The guides can be mounted inside and be protected by these side edges.

The movable front section 24 is arranged to extend to a position adjacent the surface 13 during a cutting operation. The embodiment in Figure 1 has a front section 24 provided with a pair of ground contacting wheels 25 in contact with the surface 13.

Figure 2 shows a side view of the self-propelled trench cutting machine 10 in Figure 1. As described above, the trench cutting machine 10 includes a mobile frame 12 supported for movement across a substantially even surface 13 by a plurality of ground engaging wheels 14, 16, 18. The figure shows the rear axle 15 provided with a first pair of wheels 14, the front axle 17 provided with a second pair of wheels 16, and the auxiliary front axle 19 provided with a third pair of wheels 18. During a cutting operation the frame 12 is supported by the rear axle 15 and the auxiliary front axle 19, wherein the auxiliary front axle is mounted to the front end of a sub-frame 28 attached to the frame 12. The sub-frame 28 can be pivoted about a pivot 29 attached to a front portion of the frame 12 as indicated by the arrow A2. In this way, the third pair of wheels 18 on the auxiliary front axle 19 can be adjusted between an upper position, for a maximum depth of cut for the circular blade 20, and a lower position, for a minimum depth of cut for the circular blade 20. The position of the third pair of wheels 18 can be adjusted in fixed steps or be set in any position between the upper and lower end positions. This adjustment is preferably, but not necessarily, performed prior to the start of a cutting

operation, the required depth of cut is usually known and as a rule constant during the operation.

- The positioning of the sub-frame 28 and the third pair of wheels 18 can be carried out by a suitable actuator (not shown) mounted to the frame 12 or chassis 22 and powered by the prime mover 11. The actuator can comprise
5 any suitable mechanically, hydraulically or electrically driven device and is controllable by an operator. Non-limiting examples of such suitable devices are e.g. ball-screw arrangement, hydraulic cylinders or electric servo motors. Unless it is desired to adjust the position of the sub-frame 28 during a cutting
10 operation, it can be advantageous that that actuator is self-locking or can be locked in a set position, in order to reduce the power output required from the prime mover to maintain the position. Alternatively, the actuator can be a suitable mechanical linkage or gearing that can be operated and set/locked manually by the operator.
- 15 During a cutting operation where the third pair of wheels 18 are in the lower position, the weight of the trench cutting machine 10 is taken up by the rear axle 15 and the auxiliary front axle 19. The second pair of wheels 16 on the front axle 17 can be located in contact with or adjacent the surface 13, but is not supporting the trench cutting machine 10.
- 20 Figure 2 further shows a side view of the shroud assembly 23 and the movable front section 24 arranged to cover an at least partially open lower front portion in front of the circular blade 20. As described above, the movable front section 24 is mounted in a sliding guide or roller guide (not
25 shown) on one or both sides, allowing it to slide relative to a front surface of the shroud 23 as the distance between the surface 13 and the lower portion of the shroud changes, as indicated by the arrow A3. Figure 2 also shows that the ground contacting wheels 25 are in contact with the surface 13 during a cutting operation.

Figure 3 shows a side view of the trench cutting machine 10 in Figure 1 during transport. In its transport position, the front part of the frame 12 of the trench cutting machine 10 is lifted until the circular blade 20 clears the ground and is positioned above the surface 13. When the front part of the frame 12 is lifted, the movable front section 24 is arranged to extend to its lower end position, as indicated by the arrow A3 in Figure 3. The front axle 17 is mounted to the front end of an arm 30 attached to the frame 12. The arm 30 can be pivoted about a pivot 31 attached to a lower portion of the frame 12 as indicated by the arrow A4. In this way, the second pair of wheels 16 on the front axle 17 can be adjusted between an extended, raised position, as shown in Figure 3, and a retracted, lowered position, as shown in Figure 2.

Consequently, in order to displace the frame 12 between a first, cutting position into a second, transport position the front axle 17 is displaced relative to the frame 12 by a pivoting movement of the arm 30 in the direction of the arrow A4, shown in Figure 3. Similarly, to displace the frame 12 between the second, transport position into the first, cutting position the front axle 17 is displaced relative to the frame 12 by a reversed pivoting movement of the arm 30 in the direction of the arrow A5, shown in Figure 2.

The raising and lowering of the frame 12 by the pivoting movement of the arm 30 can be carried out by a suitable actuator (not shown) mounted to the frame 12 or chassis 22 and powered by the prime mover 11. The actuator can comprise any suitable mechanically, hydraulically or electrically driven device and is controllable by an operator. Alternatively, the actuator can be a suitable mechanical linkage or gearing that can be operated and set/locked manually by the operator.

Figure 4A shows a shroud assembly 23 as indicated in Figure 1. As described above, the shroud assembly 23 is arranged to collect debris discharged from circular blade during a cutting operation and receives a portion of the circular blade 20 within enclosing wall portions. The shroud assembly 23 comprises a first and second opposed and spaced apart side

walls 41, 42 (see Figure 4B), which side walls are joined with transverse walls. The transverse walls comprise a rear portion 43, an upper portion 44 and a front portion 45. The shroud assembly 23 has an open bottom portion 46 and an at least partially open lower front portion 47, and is configured to receive a major portion of the circular blade 20 located above the surface 13 within said shroud assembly 23. The partially open lower front portion 47 is covered by a movable front section 48 mounted in a sliding guide or roller guide (not shown) on one or both sides, allowing the movable front section 48 to slide relative to the front portion 45 of the shroud 23 as the distance between the surface 13 and the lower portion of the shroud adjacent the open bottom portion 46 changes. The movable front section 48 is arranged to extend to a position adjacent the surface 13 during a cutting operation. In the same way as in the embodiment in Figure 1 the front section 48 is provided with a pair of ground contacting wheels 50 in contact with the surface 13.

Figure 4A further shows an arrangement for controlling the spread and deposition of debris during an up-cut operation performed by the circular blade. Debris cut by the circular blade is displaced out of the cut trench by cutting members along the outer periphery of the circular blade. The centrifugal forces created by the rotary movement of the circular blade will cause the debris to be displaced upwards and rearwards in a radial gap formed by the outer periphery of the circular blade and the inner surfaces of the rear, upper and front portions 43, 44, 45 of the shroud assembly 23, as shown by the arrow A6. Debris travelling along these surfaces, from the front towards the rear of the shroud assembly, will strike a deflector member 51 arranged behind the circular blade.

Figure 4B shows a transverse, vertical cross-section through the shroud assembly in Figure 4A. As seen in Figures 4A and 4B, the deflector member is arranged between the side walls 41, 42 and extends across the radial gap between the circular blade and the inner surfaces of the rear portion 43. According to the embodiment shown in Figure 4B it can be seen that the

deflector member 51 extends transversely from a first side wall 41, up to and through a recess 52 in the second side wall 42. Debris travelling through the shroud 23 will strike the deflector member 51 and be guided out through the recess 52, as shown by the arrow A7. In order to facilitate removal of debris, the deflector member 51 is arranged at an angle to form a downward angled surface from the first side wall 41 towards the second side wall 42 and its recess 52. Alternatively, the deflector member 51 can be shaped as a curved surface suitable for guiding the debris towards the recess 52. Preferably, a lower portion of the deflector member 51 adjacent the second side wall 42 extends a predetermined distance past the main extension of the second side wall 42. This ensures that debris is deposited to one side of an open trench cut in the surface 13, in order to prevent debris from falling back into the cut trench. In this example, the recess 52 in the second side wall 42 is partially enclosed by a receptacle 53 mounted on the outer surface of the second side wall 42. The receptacle 53 has an upper wall, an outer wall as well as a front and a rear wall. Debris exiting the recess 52 along the first deflector member 51 will be prevented from being thrown out of the recess 52 in an uncontrollable manner, as it will strike the walls of the receptacle 53 before falling out through the open bottom of the receptacle. This receptacle is an optional arrangement that can limit the spread of the debris and ensure a more controlled deposit along the cut trench.

Figures 5A-5F show a number of schematic plan views of alternative wheel arrangements for a trench cutting machine according to the invention. Figure 5A corresponds to the basic wheel arrangement for the first embodiment of the invention, as shown in Figure 1. The trench cutting machine 10a includes a mobile frame 12a supported for movement across a substantially even surface by a plurality of ground engaging wheels 14a, 16a, 18a. Figure 5A shows a machine comprising a rear axle provided with a first pair of wheels 14a and a front axle provided with a second pair of wheels 16a wherein both pairs of wheels 14a, 16a are located on opposite sides of the machine 10a. An auxiliary front axle is provided with a third pair of wheels 18a. In Figure

5A, at least the first pair of wheels 14a on the rear axle is driven, although it is also possible to drive either or both of the second and/or third pairs of wheels 16a, 18a. As indicated in Figure 5A, the wheels 18a of the auxiliary front axle are located in front of the rotary axle 21a of a circular blade 20a located within a shroud assembly 23a.

An alternative shroud assembly 23a' in Figure 5A shows that the circular blade can be located on either side of the machine 10a. This alternative location of the circular blade is applicable on each of the alternative embodiments shown in Figures 5A-5E.

10 Figure 5B shows the basic wheel arrangement for a second embodiment of the invention. The trench cutting machine 10b includes a mobile frame 12b supported for movement across a substantially even surface by a plurality of ground engaging wheels 14b, 16b, 18b. Figure 5B shows a machine comprising a rear axle provided with a first pair of wheels 14b and a front axle provided with a second pair of wheels 16b wherein both pairs of wheels 14b, 16b are located on opposite sides of the machine 10b. An auxiliary front axle is provided with a third, single wheel 18b located on the central longitudinal axis of the vehicle 10b. In Figure 5B, at least the first pair of wheels 14b on the rear axle are driven, although it is also possible to drive either or both of the second pairs of wheels 16b and/or the third, auxiliary wheel 18b. As indicated in Figure 5B, the wheel 18b of the auxiliary front axle is located in front of the rotary axle 21a of a circular blade 20a located within a shroud assembly 23a.

Figure 5C shows the basic wheel arrangement for a third embodiment of the invention. The trench cutting machine 10c includes a mobile frame 12c supported for movement across a substantially even surface by a plurality of ground engaging wheels 14c, 16c, 18c. Figure 5C shows a machine comprising a rear axle provided with a first pair of wheels 14c and a front axle provided with a second, single wheel 16c located on the central longitudinal axis of the vehicle 10c. The first pair of wheels 14c on the rear axle is located

on opposite sides of the machine 10c. An auxiliary front axle is provided with a third, single wheel 18c located on the central longitudinal axis of the vehicle 10c. In Figure 5C, at least the first pair of wheels 14c on the rear axle is driven, although it is also possible to drive either or both of the second and/or third wheels 16c, 18c. As indicated in Figure 5C, the wheel 18c on the auxiliary front axle is located in front of the rotary axle 21c of a circular blade 20c located within a shroud assembly 23c.

Figure 5D shows the basic wheel arrangement for a fourth embodiment of the invention. The trench cutting machine 10d includes a mobile frame 12d supported for movement across a substantially even surface by a plurality of ground engaging wheels 14d, 16d, 18d. Figure 5D shows a machine comprising a rear axle provided with a first pair of wheels 14d and a front axle provided with a second, single wheel 16d located on the central longitudinal axis of the vehicle 10d. The first pair of wheels 14d on the rear axle is located on opposite sides of the machine 10d. An auxiliary front axle is provided with a third pair of wheels 18d. In Figure 5D, at least the first pair of wheels 14d on the rear axle are driven, although it is also possible to drive either or both of the second wheel 16d and/or the third pair of wheels 18d. As indicated in Figure 5D, the wheels 18d of the auxiliary front axle are located in front of the rotary axle 21d of a circular blade 20d located within a shroud assembly 23d.

Figure 5E shows the basic wheel arrangement for a fifth embodiment of the invention. The trench cutting machine 10e includes a mobile frame 12e supported for movement across a substantially even surface by a plurality of ground engaging wheels 14e, 16e, 18e. Figure 5E shows a machine comprising a rear axle provided with a first, single wheel 14e and a front axle provided with a second pair of wheels 16e. The first, single wheel 14e is located on the central longitudinal axis of the vehicle 10c, while the second pair of wheels 16e is located on opposite sides of the machine 10a. An auxiliary front axle is provided with a third pair of wheels 18e. In Figure 5E, at

least the first, single wheel 14e on the rear axle is driven, although it is also possible to drive either or both of the second and/or third pairs of wheels 16e, 18e. As indicated in Figure 5E, the wheels 18e of the auxiliary front axle are located in front of the rotary axle 21e of a circular blade 20e located within a shroud assembly 23e.

Figure 5F shows the basic wheel arrangement for a sixth embodiment of the invention. The trench cutting machine 10f includes a mobile frame 12f supported for movement across a substantially even surface by a plurality of ground engaging wheels 14f, 16f, 18f. Figure 5F shows a machine comprising a rear axle provided with a first pair of wheels 14f and a front axle provided with a second pair of wheels 16f wherein both pairs of wheels 14f, 16f are located on opposite sides of the machine 10f. An auxiliary front axle is provided with a third pair of wheels 18f. In Figure 5F, at least the first pair of wheels 14f on the rear axle is driven, although it is also possible to drive either or both of the second and/or third pairs of wheels 16f, 18f. As indicated in Figure 5F, the wheels 18f of the auxiliary front axle are located in front of the rotary axle 21f of a circular blade 20f located within a shroud assembly 23f. As opposed to the embodiments in Figures 5A-5E, the wheels 18f of the auxiliary front axle are located on either side of the shroud assembly 23f, on opposite sides of the vehicle 10f. In an alternative embodiment of the vehicle 10f, the driven rear axle can be provided with a single wheel in the same way as illustrated in Figure 5E.

The invention is not limited to the above embodiments, but may be varied freely within the scope of the claims. For instance a consolidation and laying means according to the prior art may be arranged behind the blade, for clearing and safeguarding the trench from collapsing while laying at least one flexible casing or tube, cable or wire into the trench. The at least one flexible casing or tube, cable or wire can e.g. be rolled off from a reel/s mounted on the machine or from reels arranged on a reel trailer.

CLAIMS

1. A trench cutting machine (10) for making a cut in a surface (13) comprising pavement, concrete and/or other hard materials, said trench cutting machine comprising:
- 5 a frame (12) comprising at least one rear axle (15) and at least one front axle (17), wherein at least one of the rear and front axles (15, 17) has two wheels (14, 16);
- a rotatable circular blade (20) mounted to the frame (12), which circular blade (20) has an axis of rotation (21) located parallel to and in front of the front
- 10 axle (17) during a cutting operation,
- a prime mover (11) for driving at least the circular blade (20);
- wherein the front axle (17) is vertically adjustable relative to the frame (12) between a first position where the circular blade (20) is lifted clear of the surface (13), and a second position where the circular blade (20) is arranged
- 15 to extend downwards from the frame (12) to cut a predetermined distance into the surface (13);
- characterized in that the frame (12) comprises an auxiliary front axle (19) located in front of the axis of rotation of the circular blade (20), wherein the auxiliary front axle (19) and the rear axle (15) are arranged to
- 20 support the frame (12) on the surface (13) during a cutting operation and to maintain a selected depth of cut.
2. A trench cutting machine according to claim 1, characterized in that the direction of rotation of the circular blade (20) when cutting is opposite to the direction of rotation of the wheels during forward movement of the
- 25 trench cutting machine (10).
3. A trench cutting machine according to claim 1 or 2, characterized in that at least one of the rear axle (15) and the auxiliary front axle (19) has two wheels (14, 18).

4. A trench cutting machine according to any one of claim 1-3, characterized in that the auxiliary front axle (19) is adjustable relative to the frame (12) in order to set a predetermined depth of cut.
5. A trench cutting machine according to claim 4, characterized in that the auxiliary front axle (19) is adjustable about a pivot (29) relative to the frame (12).
6. A trench cutting machine according to claim 4, characterized in that the auxiliary front axle (19) is steplessly adjustable relative to the frame (12).
- 10 7. A trench cutting machine according to claim 4, characterized in that the auxiliary front axle (19) is adjustable in fixed steps relative to the frame (12).
8. A trench cutting machine according to any one of claims 1-7, characterized in that the auxiliary front axle (19) comprises at least
15 one wheel (18) arranged adjacent the circular blade (20).
9. A trench cutting machine according to any one of claims 1-7, characterized in that the auxiliary front axle (19) comprises at least one wheel (18) arranged on either side of the circular blade (20).
10. A trench cutting machine according to any one of claims 1-9,
20 characterized in that the auxiliary front axle (19) comprises at least one wheel (18) arranged in front of the outer periphery of the circular blade (20).
11. A trench cutting machine according to any one of claims 1-10, characterized in that the trench cutting machine is supported by
25 the wheels (14, 18) of the rear axle (15) and the auxiliary front axle (19) during a cutting operation.

12. A trench cutting machine according to any one of claims 1-11, which trench cutting machine further comprises a shroud assembly mounted on the frame (12) to guide debris discharged from the circular blade (20), the shroud assembly comprising a first and second opposed and spaced apart side walls (41, 42) joined along their rear, upper and front portions (43, 44, 45), the
5 shroud assembly (23) having an open bottom portion (46) and an at least partially open lower front portion (47), and being configured to receive a portion of the circular blade (20) within said shroud assembly (23), characterized in that a movable front section (48) is arranged at
10 the front portion (45) of the shroud assembly (23), which front section (48) is arranged to cover the at least partially open lower front portion (47) and to extend to a position adjacent or in contact with the surface (13) during a cutting operation.

13. A trench cutting machine according to claim 12,
15 characterized in that at least one side portion of the movable front section (48) is attached onto the shroud assembly by a guide means (49).

14. A trench cutting machine according to claim 12 or 13, characterized in that a lower end portion of the movable front section (48) comprises a surface (13) contacting member (25; 50).

20 15. A trench cutting machine according to any one of claims 12-14, characterized in that a lower end portion of the movable front section (48) comprises a rotatable member (25).

16. A trench cutting machine according to any one of claims 12-15, characterized in that a first deflector member (51) is arranged
25 behind the circular blade (20), which first deflector member (51) extends transversely from the first side wall (41) at least to a recess (52) in the second side wall (42).

17. A trench cutting machine according to claim 16, characterized in that the first deflector member (51) extends from

a relatively higher position at the first side wall (41) to a relatively lower position at the second side wall (42).

18. A trench cutting machine according to claim 16 or 17, characterized in that a lower portion of the first deflector member
5 (51) adjacent the second side wall (42) extends transversely outside the cut in the surface (13).

19. A trench cutting machine according to any one of claims 16-18, characterized in that the first deflector member (51) extends out through the recess (52) in the second side wall (42).

10 20. A trench cutting machine according to any one of claims 16-19, characterized in that a second deflector member (53) is arranged spaced from the first deflector member (51) and facing the outer surface of the second side wall (42).

21. A trench cutting machine according to claim 20,
15 characterized in that the second deflector member (53) extends away from the second side wall (42) from a position above the recess (52) and downwards past the end of the first deflector member (51).

22. A shroud assembly for a trench cutting machine, which shroud assembly is arranged to guide debris discharged from a circular blade (20) of the trench
20 cutting machine; the shroud assembly comprising a first and second opposed and spaced apart side walls (41, 42) joined along their rear, upper and front portions (43, 44, 45), the shroud assembly (23) having an open bottom portion (46) and an at least partially open lower front portion (47), and being configured to receive a portion of the circular blade (20) within said shroud
25 assembly (23), characterized in that a movable front section (48) is arranged at the front portion (45) of the shroud assembly (23), which front section (48) is arranged to cover the at least partially open lower front portion (47) and to extend to a position adjacent or in contact with the surface (13) during a cutting operation.

23. A shroud assembly according to claim 22, characterized in that at least one side portion of the movable front section (48) is attached onto the shroud assembly by a guide means (49).

24. A shroud assembly according to claim 22 or 23, characterized in
5 that a lower end portion of the movable front section (48) comprises a surface contacting member (25; 50).

25. A shroud assembly according to any one of claims 22-24, characterized in that a lower end portion of the movable front section (48) comprises a rotatable member (25).

10 26. A debris guiding device for a shroud assembly (23) the shroud assembly comprising a first and second opposed and spaced apart side walls (41, 42) joined along their rear, upper and front portions (43, 44, 45), the shroud assembly (23) having an open bottom portion (46) and being configured to receive a portion of a circular blade (20) within said shroud assembly (23),
15 characterized in that a first deflector member (51) is arranged behind the circular blade (20), which first deflector member (51) extends transversely from the first side wall (41) at least up to a recess (52) in the second side wall (42).

27. A debris guiding device according to claim 26, characterized in
20 that the first deflector member (51) extends from a relatively higher position at the first side wall (41) to a relatively lower position at the second side wall (42).

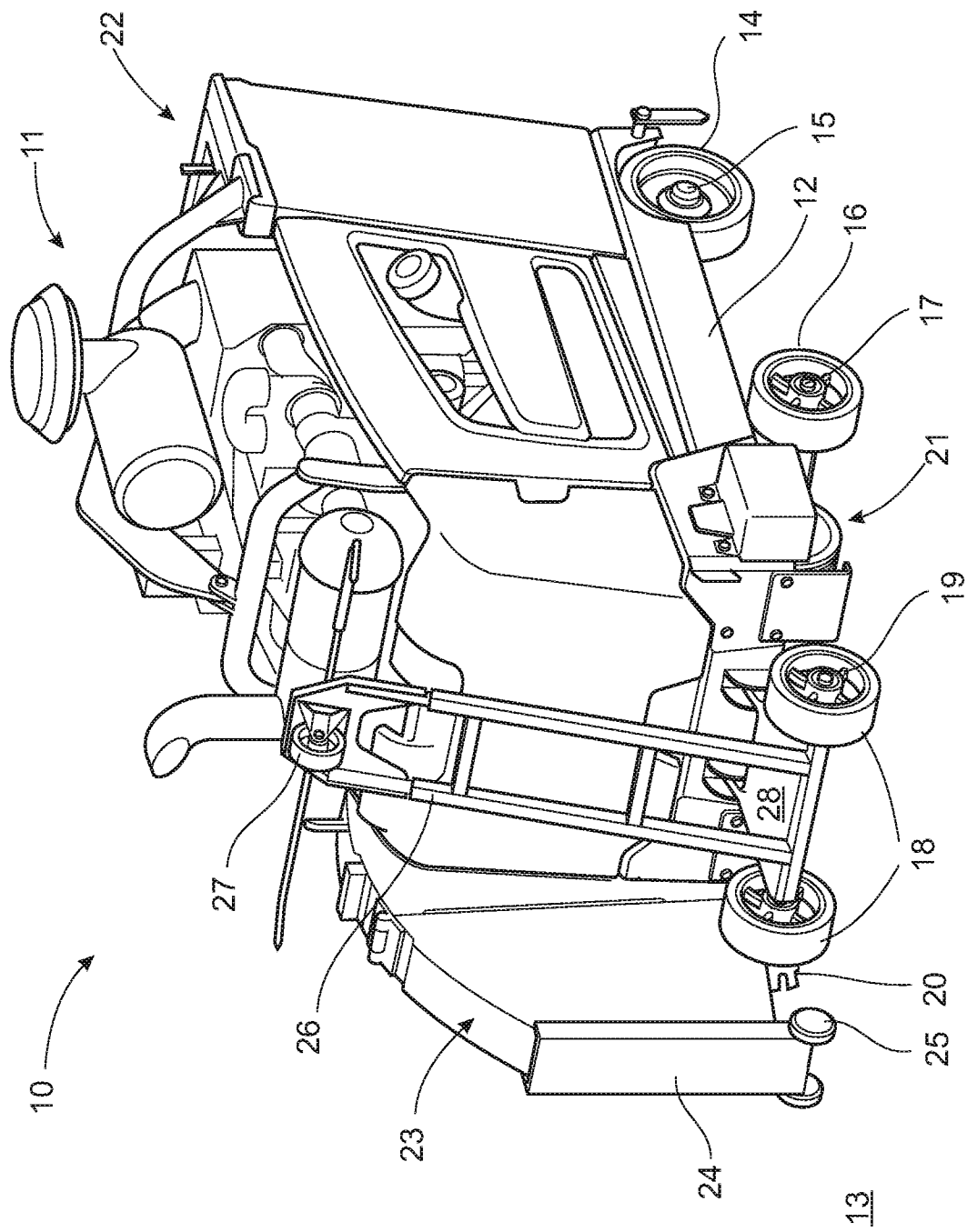
28. A debris guiding device according to claim 26 or 27, characterized in that a lower portion of the first deflector member
25 (51) adjacent the second side wall (42) extends transversely outside the cut in the surface (13).

29. A debris guiding device according to any one of claims 26-28, characterized in that the first deflector member (51) extends out through the recess (52) in the second side wall (42).

30. A debris guiding device according to any one of claims 26-29,
5 characterized in that a second deflector member (53) is arranged spaced from the first deflector member (51) and facing the outer surface of the second side wall (42).

31. A debris guiding device according to claim 30, characterized in
10 that the second deflector member (53) extends away from the second side wall (42) from a position above the recess (52) and downwards past the end of the first deflector member (51).

Fig.1



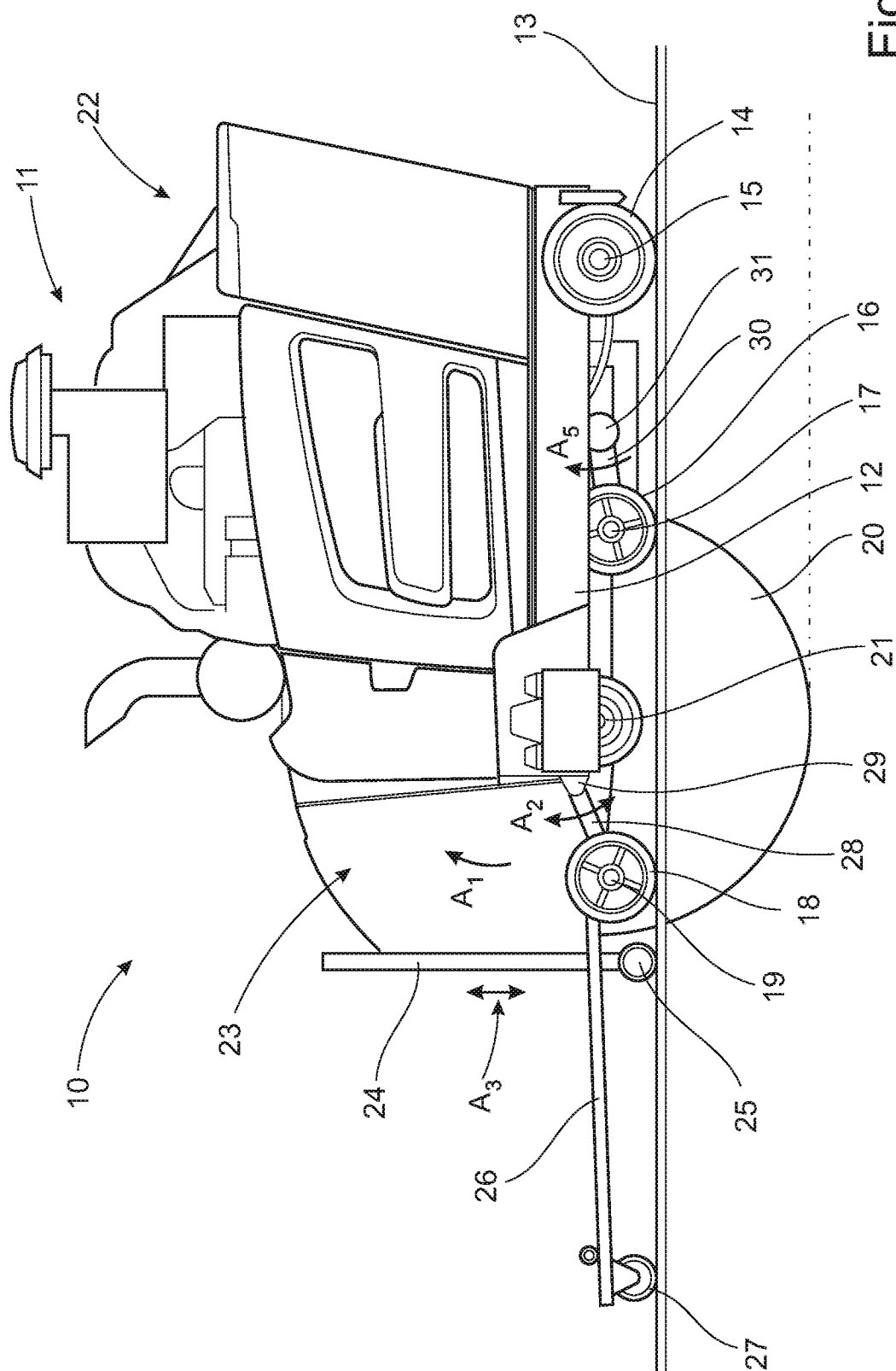


Fig. 2

3/7

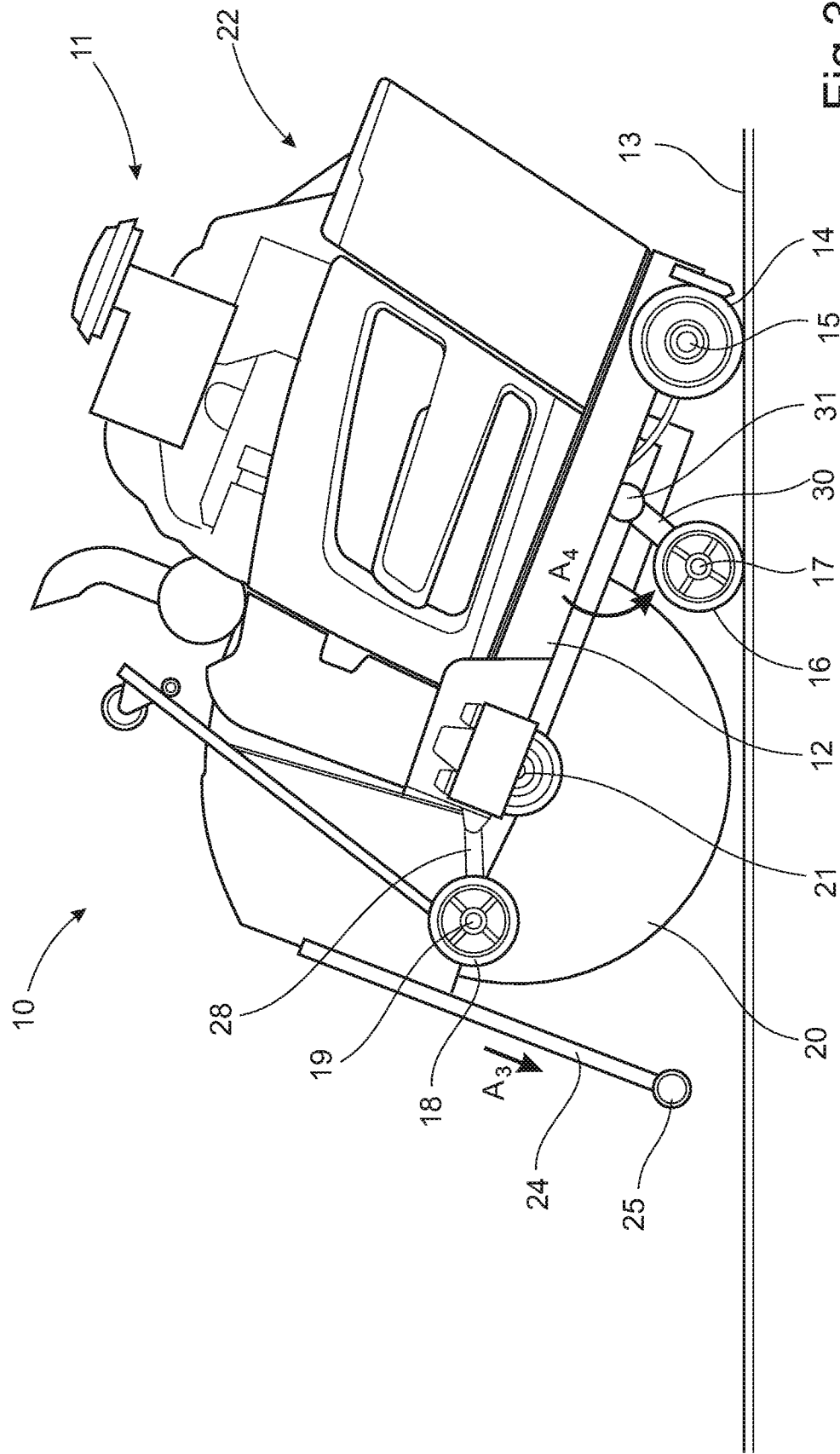


Fig. 3

4/7

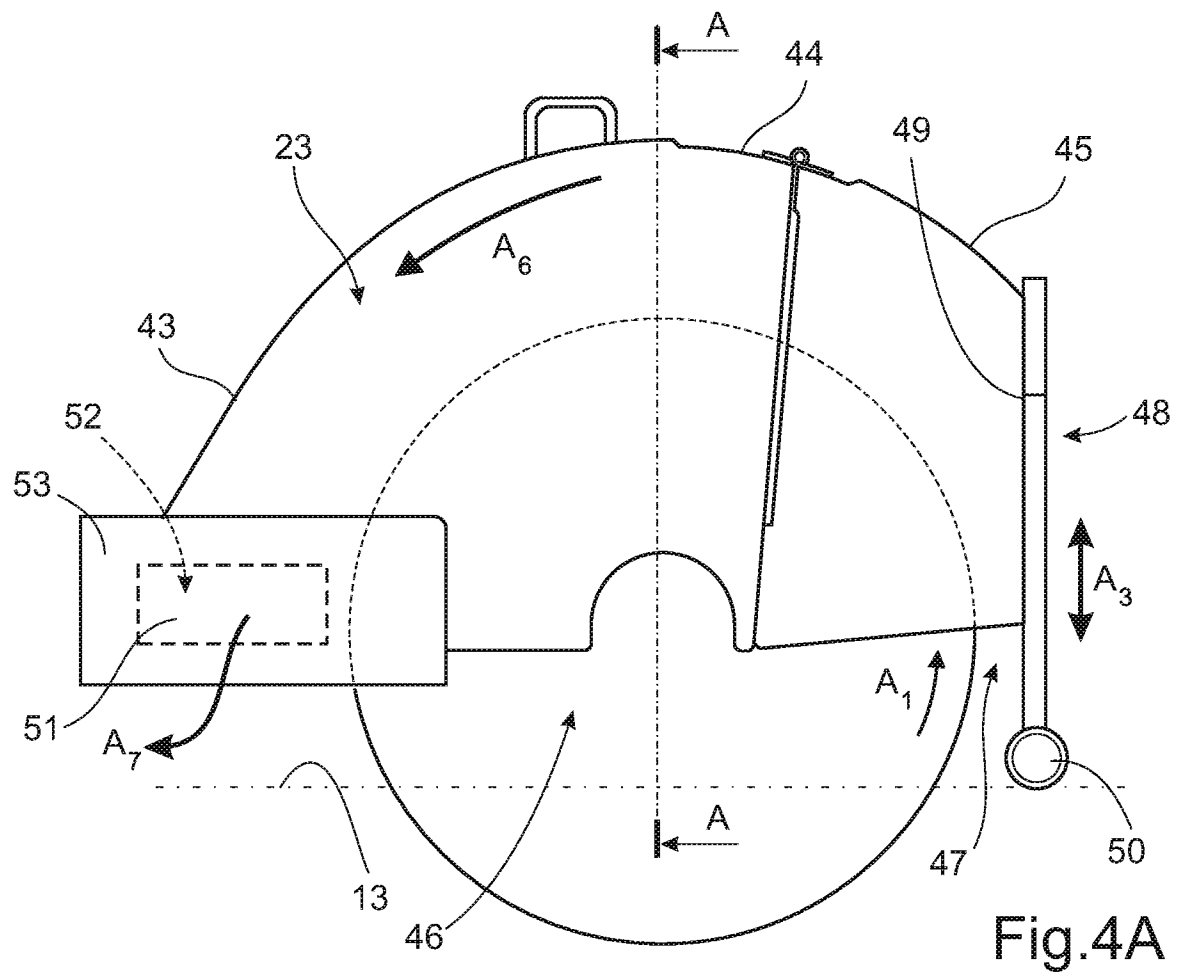


Fig.4A

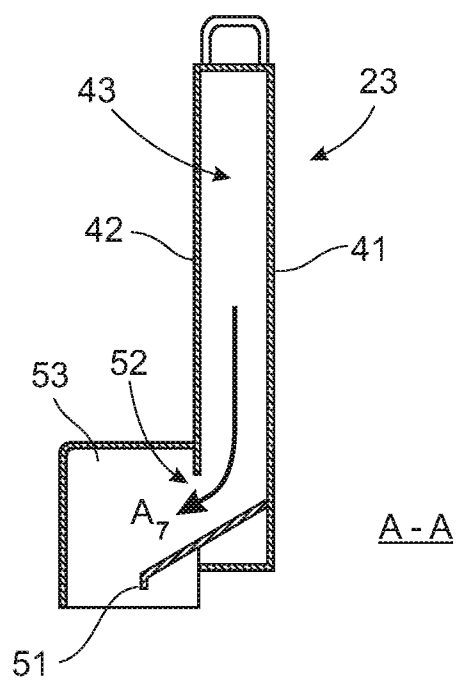


Fig.4B

5/7

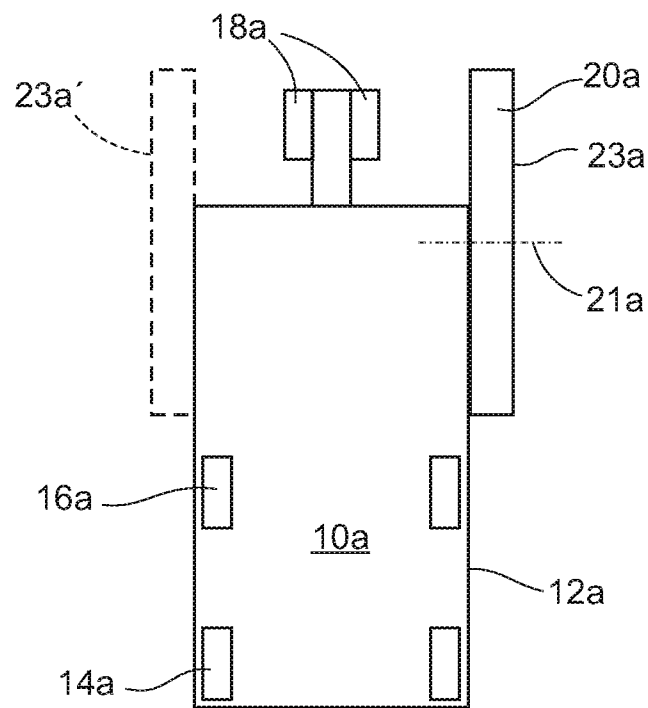


Fig.5A

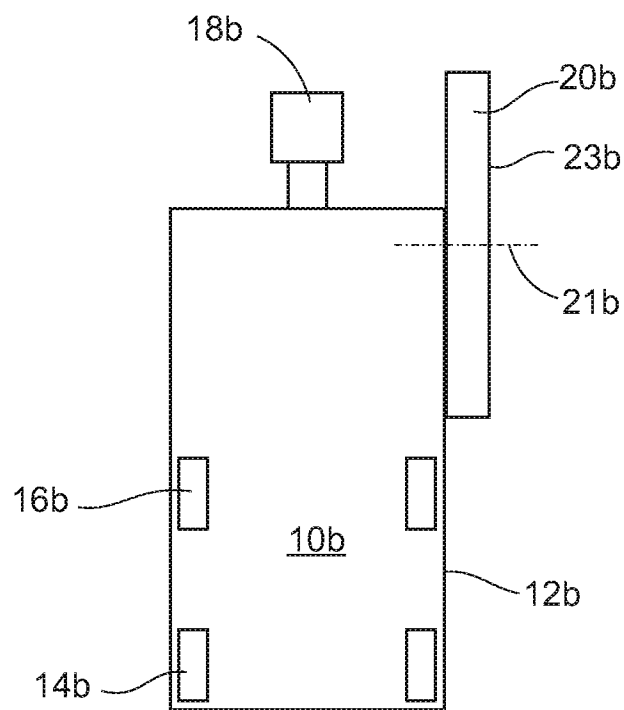


Fig.5B

6/7

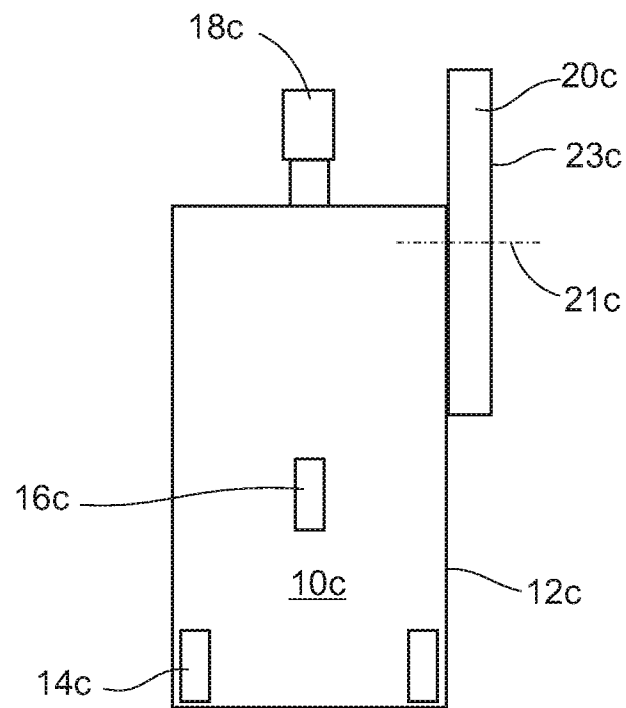


Fig.5C

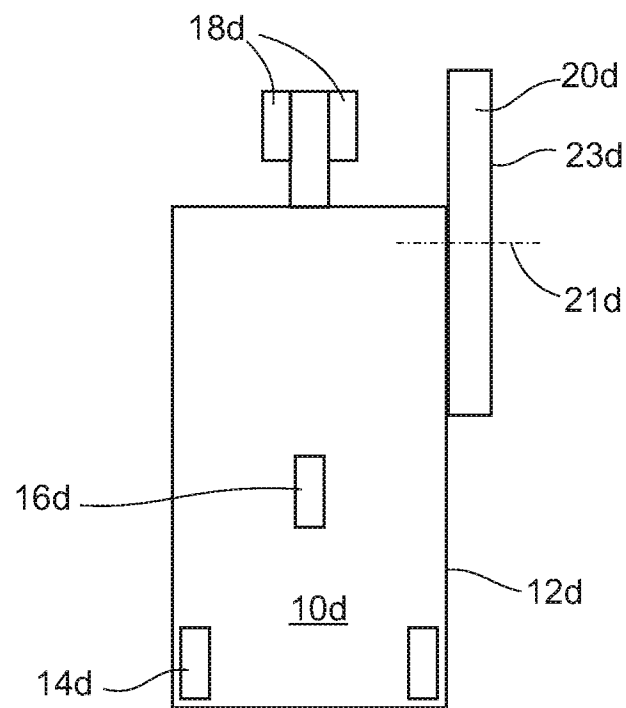


Fig.5D

7/7

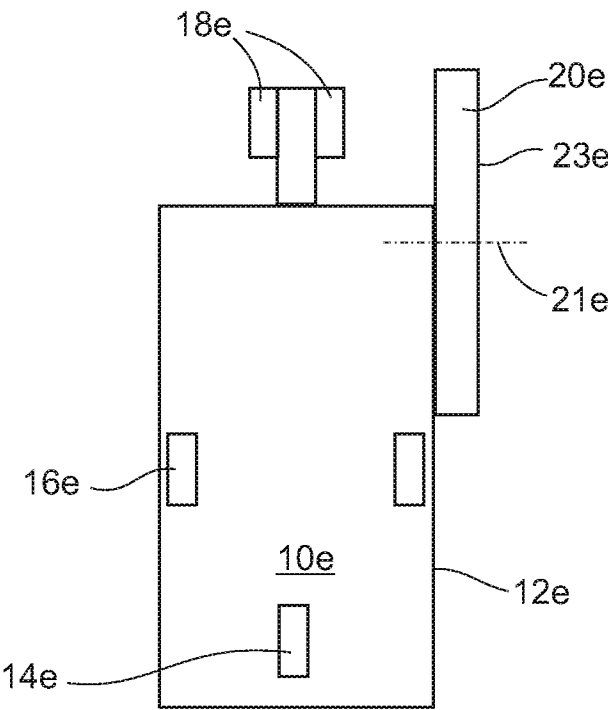


Fig.5E

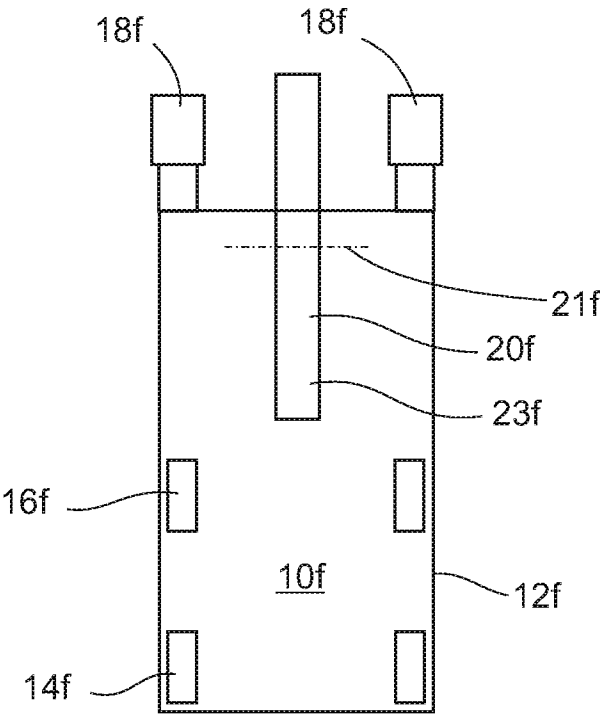


Fig.5F

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050204

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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: B23D, B27B, B28D, E02F, F16L, H02G

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

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, 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 20090263195 A1 (HORAN JEFF ET AL), 22 October 2009 (2009-10-22); abstract; column 0036; figures 1,3-4 --	1-11
A	US 5174686 A1 (RAYMOND GENE), 29 December 1992 (1992-12-29); abstract; figure 1 --	1-21
A	US 4503630 A1 (RILEY TERRENCE H), 12 March 1985 (1985-03-12); abstract; figure 1 --	1-21
A	US 2621427 A (WESLEY HULSE JOHN), 16 December 1952 (1952-12-16); figure 1 --	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

27-11-2015

Date of mailing of the international search report

27-11-2015

Name and mailing address of the ISA/SE

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050204

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1-21 directed to a trench cutting machine with an auxilliary front axle.

Claims 22-31 directed to a shroud assembly and a debris guiding device for a shroud assembly in connection with a trench cutting machine.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050204

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4958457 A (DOSKOCIL DAVID), 25 September 1990 (1990-09-25); abstract; figure 2 --	1-21
A	US 20110070030 A1 (MILLER DANIEL PAUL), 24 March 2011 (2011-03-24); abstract; paragraph [0020]; figures 5,6 --	22-31
A	WO 2014093625 A1 (VERMEER MFG CO ET AL), 19 June 2014 (2014-06-19); abstract; figure 1; claim 7 --	22-31
A	US 20140334878 A1 (MILLER DANIEL PAUL), 13 November 2014 (2014-11-13); abstract; paragraphs [0074], [0077]; figure 8b; claims 72-73 -- -----	22-31

Continuation of: second sheet

International Patent Classification (IPC)

E02F 5/10 (2006.01)

F16L 1/032 (2006.01)

H02G 1/06 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SE2015/050204

US	20090263195 A1	22/10/2009	US	8157477 B2	17/04/2012
US	5174686 A1	29/12/1992	NONE		
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			CR	20120199 A	17/07/2012
			DO	P2012000079 A	31/07/2012
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			GB	2516160 B	25/02/2015
			GT	201200088 A	10/09/2013
			HK	1175591 A1	30/10/2015
			HN	2012000594 A	16/06/2014
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			PE	14262012 A1	15/11/2012
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			US	8480332 B2	09/07/2013
			WO	2011038146 A2	31/03/2011
WO	2014093625 A1	19/06/2014	AU	2013359202 A1	02/07/2015
			CN	104981570 A	14/10/2015
			EP	2931980 A1	21/10/2015
			US	20150322634 A1	12/11/2015
US	20140334878 A1	13/11/2014	CA	2905800 A1	02/10/2014
			WO	2014159463 A3	11/12/2014