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(54) **Mobile work platform**

(57) A mobile work platform includes an operator platform (6), a base (2) and a lift mechanism (4) for lifting the operator platform relative to the base. A hydraulic drive system for the mobile work platform includes an

internal combustion engine (14), an electric motor (24) and a hydraulic pump (26). The internal combustion engine (14) and the electric motor (24) are constructed and arranged so as to be capable of driving the hydraulic pump (26) either separately or together.

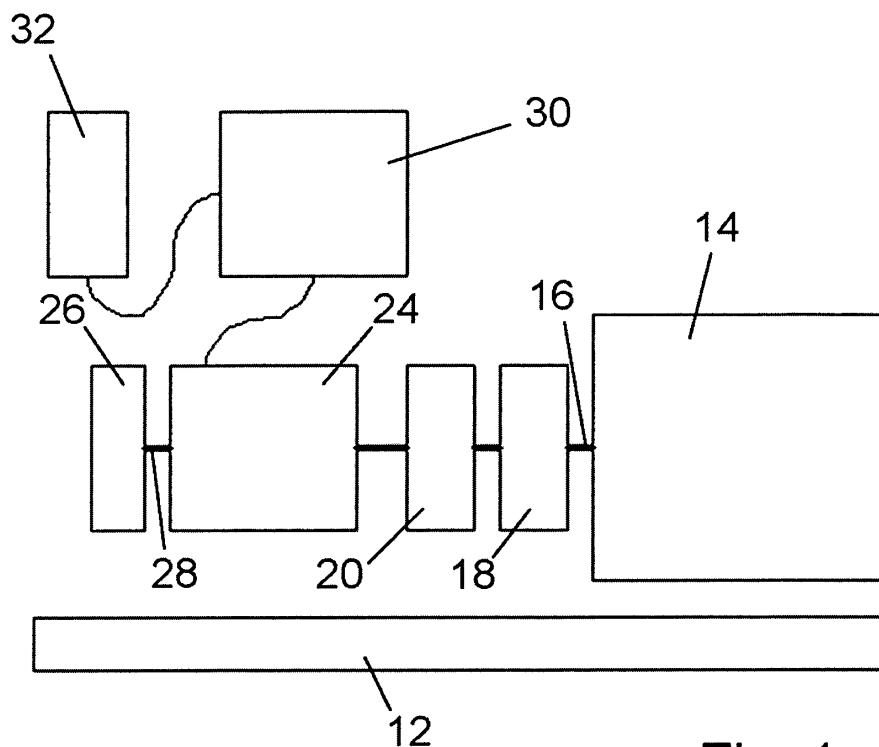


Fig. 1

Description

[0001] The present invention relates to a mobile work platform and a drive system for a mobile work platform.

[0002] Mobile work platforms typically include a cage or platform that is designed to receive one or more human operators. The cage is mounted on a lift mechanism, such as a hydraulic boom or a scissor lift mechanism, that allows its height to be adjusted. The mobile work platform also includes a wheeled or tracked chassis, which allows it to be moved easily to a desired location. Various types of mobile work platform are available, including self-propelled, self-drive, trailer and vehicle-mounted platforms.

[0003] The present invention is concerned in particular, but not exclusively, with larger mobile work platforms, for example having a working height of 14m or more (typically up to 30-40m) and a load carrying capacity of over 200kg (typically up to 1000kg). However, it is also applicable to smaller mobile work platforms, such as those with a load carrying capacity of less than 200kg and a working height in the range 9-12m.

[0004] Most mobile work platforms have a hydraulic drive system. In smaller platforms (for example those with a working height of less than 15m), it is common to use two fixed displacement hydraulic pumps, one of which is driven by an internal combustion (IC) engine (for example a diesel engine) and the other being driven by a DC electric motor, powered from batteries. Either pump may be used to operate the hydraulic drive system. For example, it may be preferable to use the electrically driven pump when the mobile work platform is being operated indoors, where the noise and exhaust fumes of the internal combustion engine might be undesirable. At other times, for example when the mobile work platform is being operated outdoors, it may be preferable to use the pump driven by the internal combustion engine, since this can provide continuous operation for a much longer period of time than the battery powered electric motor. When the IC engine is operating, it may also be used to recharge the batteries, using its alternator.

[0005] With larger mobile work platforms (for example those with a working height of 14m or more and a load carrying capacity greater than 200kg), a more complicated variable displacement hydraulic pump is generally required. Variable displacement pumps are much more expensive than fixed displacement pumps and generally it is not commercially viable to employ a two pump system as described above. Larger platforms therefore usually have only one pump, which is driven directly by an internal combustion engine. The internal combustion engine must of course have sufficient capacity to meet the peak power requirement of the hydraulic drive system. For example, a mobile work platform with a carrying capacity of 200kg may typically require a peak input power of 10kW. Most of the time, the power requirement will be much lower than this. As IC engines are inefficient when operating at low power or when idling, this leads to unnecessarily high fuel consumption and high levels of

noise and exhaust emissions. Larger IC engines also have higher capital cost and higher maintenance charges.

[0006] It is an object of the present invention to provide a mobile work platform and a drive system for a mobile work platform that mitigates at least some of the aforesaid disadvantages.

[0007] According to one aspect of the present invention there is provided a hydraulic drive system for a mobile work platform, the system including an internal combustion engine, an electric motor and a hydraulic pump, wherein the internal combustion engine and the electric motor are constructed and arranged so as to be capable of driving the hydraulic pump either separately or together.

[0008] The system provides the advantage that it is possible to select the drive motor according to the circumstances. Thus, for example, the electric motor may be used to drive the pump during indoor operation (when exhaust fumes may be unacceptable), and the internal combustion engine may be used to drive the pump during operation outdoors, or to recharge the batteries when the platform is outside (for example during a break). Alternatively, for maximum power, both the internal combustion engine and the electric motor may be used in tandem to drive the pump. This means that a less powerful internal combustion engine can be used, while still meeting the peak power requirement of the pump. This provides savings both in the capital and maintenance costs of the IC engine, and in its fuel consumption. Exhaust emissions and noise may also be reduced. Only one pump is required, providing further cost savings.

[0009] Advantageously, the system includes a clutch mechanism for disconnecting the internal combustion engine from the pump, so that it can be driven by the electric motor when the IC engine is inoperative. Preferably, the clutch is designed to disconnect the IC engine automatically when it is inoperative.

[0010] The system may include a battery for powering the electric motor. Advantageously, the electric motor is operable as a generator to charge the battery. This allows any spare capacity of the IC engine, for example when it is idling or the load on the pump is low, to be put to useful purpose, so improving fuel efficiency. The stored energy may subsequently be used to drive the electric motor, so reducing the load on the internal combustion engine or allowing it to be turned off.

[0011] Advantageously, the hydraulic drive system includes a control device for controlling the transfer of power between the internal combustion engine, the electric motor and the hydraulic pump. Preferably, the control device has a plurality of selectable operational modes, including at least one of an electric mode in which power is supplied to the pump exclusively from the electric motor, an IC engine mode in which power is supplied to the pump exclusively from the IC engine, and a boost mode in which power is supplied to the pump from both the electric motor and the IC engine. The control device may

be constructed and arranged to select boost mode when the power requirement of the pump exceeds a predetermined value.

[0012] Advantageously, the control device has a regeneration mode in which the electric motor is driven by the IC engine and operates as a generator to charge the battery. Preferably, the control device controls the transfer of electric power between the battery and the motor.

[0013] Advantageously, the internal combustion engine has a power in the range 5-50kW, preferably approximately 10-20kW.

[0014] The internal combustion engine may for example be a diesel engine, a petrol engine or an engine that runs on liquified petroleum gas (LPG).

[0015] The pump is preferably a variable displacement pump.

[0016] The internal combustion engine, the electric motor and the hydraulic pump may be arranged co-axially. This provides a compact and mechanically simple arrangement.

[0017] Alternatively, the pump and the electric motor may be mounted on a common drive shaft, which is offset from an output shaft of the internal combustion engine, the drive shaft and the output shaft being connected by a drive transfer mechanism. This arrangement may be preferred in certain circumstances, for example when packaging requirements do not permit a coaxial arrangement.

[0018] According to a further aspect of the invention there is provided a mobile work platform that includes an operator platform, a base and a lift mechanism for lifting the operator platform relative to the base, and a hydraulic drive system according to any one of the preceding claims for operating the lift mechanism.

[0019] The operator platform preferably has a working height of 10m or more and a load capacity in the range 100-1000kg, and more preferably 200-500kg, the drive system being particularly well suited to larger mobile work platforms having a load carrying capacity in this range.

[0020] Certain embodiments of the invention will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram illustrating the components of a mobile work platform drive system according to a first embodiment of the invention;

Figure 2 is a block diagram of a mobile work platform drive system according to a second embodiment of the invention, and

Figure 3 is a front elevation of a mobile work platform according to an embodiment of the invention, in various operating configurations.

[0021] Figure 3 shows a typical mobile work platform according to an embodiment of the invention, which includes a wheeled base unit 2, a lift mechanism compris-

ing a hydraulically operated boom 4 and a platform (or cage) 6 for a human operator 8. The boom 4, which is shown here in various operating configurations, may be retracted and folded onto the base unit 2 for transportation or storage. Movement of the boom 4 is controlled by various hydraulic cylinders 10, which are connected by hydraulic hoses (not shown) to a hydraulic drive system. Hydraulic motors may also be provided for driving the wheels. The components shown in Figure 3 are all conventional and will not therefore be described in detail. It should be understood that the mobile work platform may take various alternative forms. For example, it may include a scissor lift mechanism.

[0022] A hydraulic drive system according to a first embodiment of the invention is shown in Figure 1. This includes a support frame 12 on which is mounted an internal combustion (IC) engine 14, for example a diesel engine, having an output shaft 16, which is connected via a clutch 18 and a flexible coupling 20 to a drive shaft 28, on which is mounted an electric motor/generator 24 and a variable displacement hydraulic pump 26. The drive shaft 28 is coaxial with the internal combustion engine output shaft 16. The pump 26 is connected via hydraulic pipes (not shown) to other components of the hydraulic system, which are all conventional.

[0023] The clutch 18 is designed to disengage the IC engine 14 automatically from the drive shaft 28 whenever the engine is inoperative, to allow free rotation of the drive shaft. The flexible coupling 20 is designed to absorb misalignments and transient shocks when engaging or disengaging the clutch 18.

[0024] The electric motor/generator 24 may be used either as a motor or as a generator, which can be used to generate electricity by driving the rotor mechanically through the drive shaft 28. The motor/generator 24 is electrically connected via a control device 30 to a battery 32 of electric cells. The control device 30 controls operation of the motor/generator 24, either supplying electrical power to the battery 32 to recharge it when the motor/generator is in generator mode, or supplying electrical power from the battery 32 to the motor/generator 24 when it is in motor mode. The control device 30 controls the voltage supply to the battery 32 during recharging, and controls the speed of the motor when it is being driven by electric power drawn from the battery 32. The control device 30 is preferably located adjacent the motor/generator 24, while the battery 32 may be located remotely.

[0025] The hydraulic drive system has various operational modes, including IC engine operation mode, electrical operation mode, regeneration mode and boost mode. Each of these operational modes will now be described.

[0026] During IC engine operation, the internal combustion engine 14 drives the pump 26 via the output shaft 16, the clutch 18 and the drive shaft 28. The pump 26 provides hydraulic fluid to the drive components (for example the hydraulic cylinders and motors) of the system so as to operate the lift and drive functions of the mobile

work platform. During this operational mode, the rotor of the electric motor/generator 24 rotates with the drive shaft 28 but it does not generate electricity, this function being controlled by the control device 30.

[0027] During electrical operation mode, the pump 26 is driven directly by the electric motor/generator 24, which operates in motor mode and draws power from the battery 32. The pump 26 thus provides hydraulic fluid to operate the lift and drive functions of the mobile work platform. The control device 30 controls the power delivered to the motor. During electrical operation, the internal combustion engine 14 is inoperative and the clutch 18 is automatically disengaged to disconnect the output shaft 16 of the IC engine 14 from the drive shaft 28.

[0028] During regeneration mode, the IC engine 14 drives the electrical motor/generator 24 via the clutch 18 and the drive shaft 28, to generate electricity which is stored in the battery 32. The control device 30 controls the delivery of current to the battery 32 and prevents overcharging. Regeneration may take place either when the hydraulic system is idle and the pump 26 is inoperative, or when the pump 26 is operating at a low output level. In the latter case, the spare output capacity of the IC engine 14, beyond that required to operate the pump 26, is used to generate electricity. This excess energy is stored in the battery and saved for later use during electric operation, thus improving fuel efficiency.

[0029] In certain circumstances, more power may be required by the hydraulic pump 26 than can be supplied individually by either the IC engine 14 or the electric motor 24. In this case, the drive system enters boost mode, in which the IC engine 14 and the electric motor 24 operate in tandem to drive the pump 26. The electric motor 24 therefore supplements the power output of the IC engine 14, thereby providing a greater output power than can be supplied by the IC engine 14 operating on its own. This in turn allows a smaller capacity IC engine to be used, which is smaller and lighter, less expensive, more economical and causes less noise and pollution. The system may be designed to enter boost mode automatically whenever the power requirement of the pump exceeds a certain predetermined level.

[0030] A second embodiment of the invention is shown in Figure 2. In this embodiment, the hydraulic drive system is similar in most respects to the first drive system described above, and where appropriate like reference numbers have been used to indicate equivalent components. The main difference is that the drive shaft is divided lengthwise into two parts 28a, 28b. The first part 28a of the drive shaft is coaxial with the output shaft 16 of the IC engine and is connected to the clutch 18 and the flexible coupling 20. The second part 28b of the drive shaft carries the electric motor/generator 24 and the pump 26, and is offset from the axis of the IC engine output shaft 16. Drive is transferred from the first part 28a of the drive shaft to the second part 28b of the drive shaft by a drive transfer mechanism 34, which in this case consists of a drive belt mounted on a pair of pulleys.

[0031] Various alternative drive transfer mechanisms may of course be used, including gears, toothed belts or a chain and sprockets, and this mechanism may be located at different positions within the drive chain, such as between the IC engine 14 and the clutch 18. The second part of the drive shaft may also be set at an angle relative to the first part of the shaft (for example, it may be perpendicular). These arrangements may be useful where packaging requirements prevent the use of the co-axial drive system of the first embodiment described above. Operation of the second drive system is essentially identical to that of the first drive system, as described above.

[0032] Numerous modifications of the drive system are of course possible. For example, the drive system may include a charging circuit that is designed to recharge the battery 32 or operate the electric motor 24 directly from a mains electricity supply, where one is available. Various alternative kinds of clutch may be used including, for example, an electrically actuated clutch. The system may also be reconfigured, for example so that the pump is located between the IC engine and the electric motor.

Claims

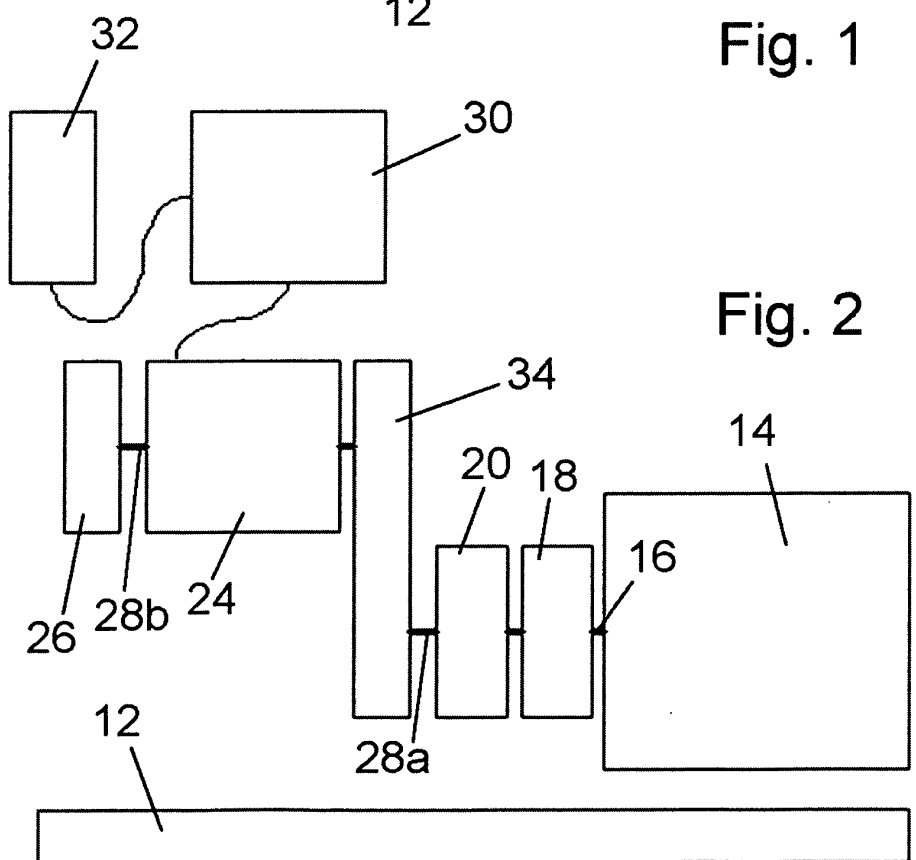
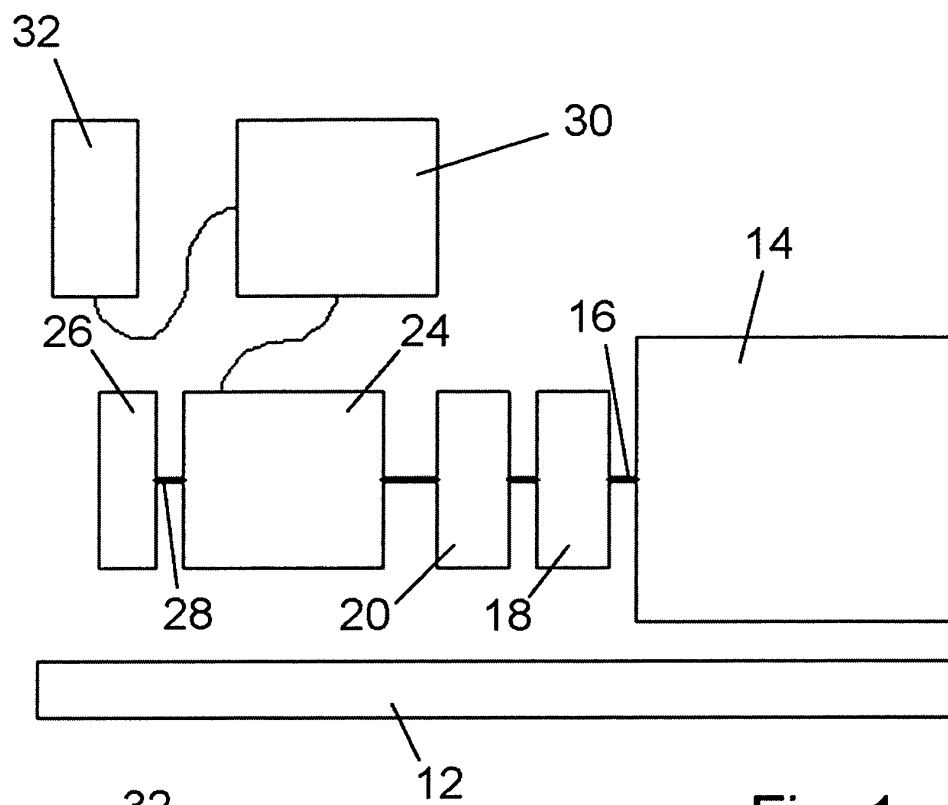
1. A hydraulic drive system for a mobile work platform, the system including an internal combustion engine, an electric motor and a hydraulic pump, wherein the internal combustion engine and the electric motor are constructed and arranged so as to be capable of driving the hydraulic pump either separately or together.
2. A hydraulic drive system according to claim 1, including a clutch mechanism for disconnecting the internal combustion engine from the pump.
3. A hydraulic drive system according to claim 1 or claim 2, including a battery for powering the electric motor.
4. A hydraulic drive system according to claim 3, wherein the electric motor is operable as a generator to charge the battery.
5. A hydraulic drive system according to any one of the preceding claims, including a control device for controlling the transfer of power between the internal combustion engine, the electric motor and the hydraulic pump.
6. A hydraulic drive system according to claim 5, wherein the control device has a plurality of selectable operational modes, including at least one of an electric mode in which power is supplied to the pump exclusively from the electric motor, an IC engine mode in which power is supplied to the pump exclusively from the IC engine, and a boost mode in which power is

supplied to the pump from both the electric motor and the IC engine.

7. A hydraulic drive system according to claim 6, wherein the control device is constructed and arranged to select boost mode when the power requirement of the pump exceeds a predetermined value. 5
8. A hydraulic drive system according to claim 6 or claim 7 when dependent upon claim 3 or claim 4, wherein the control device has a regeneration mode in which the electric motor is driven by the IC engine and operates as a generator to charge the battery. 10
9. A hydraulic drive system according to claim 8, in which the control device controls the transfer of electric power between the battery and the motor. 15
10. A hydraulic drive system according to any one of the preceding claims, wherein the internal combustion engine has a power in the range 5-50kW. 20
11. A hydraulic drive system according to any one of the preceding claims, wherein the pump is a variable displacement pump. 25
12. A hydraulic drive system according to any one of the preceding claims, wherein the internal combustion engine, the electric motor and the hydraulic pump are arranged co-axially. 30
13. A hydraulic drive system according to any one of claims 1 to 11, wherein the pump and the electric motor are mounted on a common drive shaft, which is offset from an output shaft of the internal combustion engine, the drive shaft and the output shaft being connected by a drive transfer mechanism. 35
14. A mobile work platform that includes an operator platform, a base and a lift mechanism for lifting the operator platform relative to the base, and a hydraulic drive system according to any one of the preceding claims for operating the lift mechanism. 40
15. A mobile work platform according to claim 14, wherein the operator platform has a working height of 10m or more and a load capacity in the range 100-1000kg. 45

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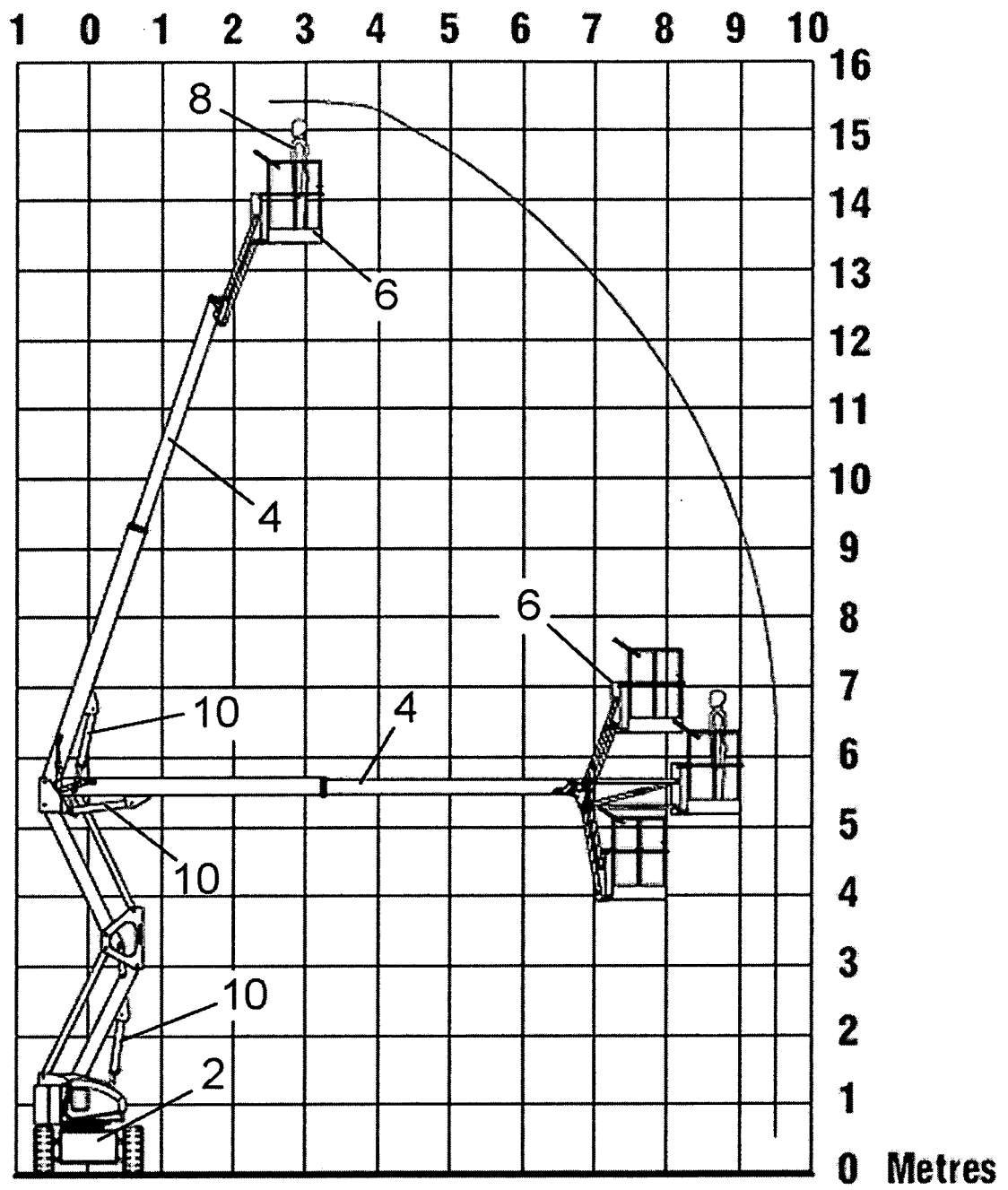


Fig. 3



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 4188

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 July 2008	Examiner Faymann, L
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 00 4188

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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