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(71) Applicant: **Brokk Aktiebolag**
931 27 Skelleftea (SE)

(72) Inventors:
- **Andersson, Stefan**
  931 52 SKELLEFTEÅ (SE)
- **Bystedt, Gunnar**
  931 91 SKELLEFTEÅ (SE)

(74) Representative: **Norman, Pia Christiane**
Albihns.Zacco AB
Patent Department
P.O. Box 5581
114 85 Stockholm (SE)

(54) **Control system for a remote-controlled working machine equipped with a manoeuvrable arm**

(57) The invention concerns a control system for a remote-controlled working machine (1) equipped with a manoeuvrable arm (10), in particular a demolition robot for demolition work, that is intended to carry at the free end of its arm a tool (14, 16), whereby the control system comprises a control unit (4) intended for the remote control of the working machine, whereby an operator (3) is in connection, either by cable or wirelessly, with a control computer (25) that is a component of a hydraulic control circuit (22) for the working machine, and which control unit includes a pair of control sticks (4a, 4b) and associated buttons and knobs that through their influence allow the working machine to be switched into different functional or working modes, whereby the manoeuvrable arm can be caused to carry out desired motions through a number of operating means (31, 32, 33, 34) that are driven hydraulically, that are arranged at the manoeuvrable arm, and that can be influenced by means of the said control sticks (4a, 4b). For an improved efficiency and ease of use, the working machine (1) can be switched through the control unit (4) between two different working modes, including:
a first mode for manual operation in which the operator (3) controls the motion of the manoeuvrable arm (10) through direct influence of the relevant control sticks (4a, 4b) of the control unit (4), and
a second mode for semi-automatic or fully automatic operation in which the operator (3), on influence of any one of the control sticks (4a, 4b), causes the manoeuvrable arm to move following a predetermined course through the synchronised control of at least two of the operating means (31, 32) of the manoeuvrable arm following a valve control curve (26a, 26b) for each one of these and stored as software in the control computer (25).

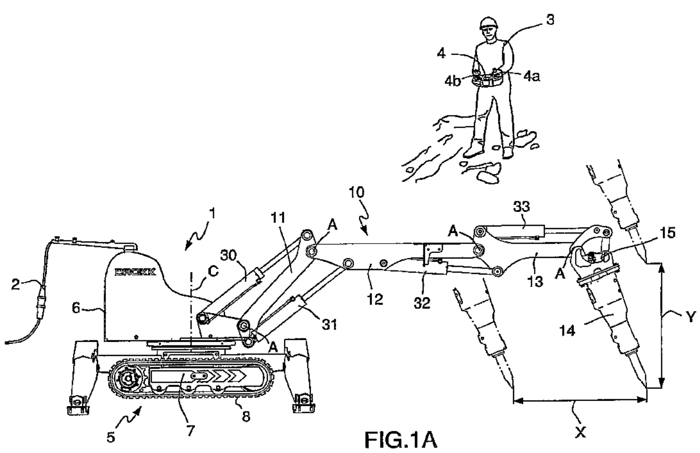


FIG.1A

EP 2 508 680 A1

Description

[0001] The present invention concerns a control system for a working machine equipped with a manoeuvrable arm intended to support a tool.

[0002] This type of remote-controlled working machine is intended for various types of task, not only specific industrial applications and work to be carried out with high precision but also more general applications with more heavy-duty work that is carried out on site, and that can most closely be compared with excavation of the type that is normally carried out with conventional excavators. The most common task of the working machine is, however, destruction and demolition and the displacement of freed material, whereby the operator walks beside the machine and controls its various motions with a control unit of the type that is intended to be carried on the body of the operator using a harness, waist belt or similar. The working machine has various types of working mode that can be selected through the control unit. The operator is in connection with the machine by cable or by wireless communication, for example Bluetooth or radio control. The control unit comprises two control sticks and a series of button and knobs that through their influence and settings can cause the manoeuvrable arm to carry out the desired motions. The working machine can be set into various functional or working modes through the control unit. During exchange of working mode, the control unit is set into what is known as "setup mode". Exchange of working mode can take place only when the control unit is in the said setup mode, whereby the selected working mode is displayed with the aid of symbols that are illuminated on a screen or display on the control unit. By setting the working machine into various working modes, the working machine can carry out a number of different motions with only the two control sticks.

[0003] The working machine generally comprises a chassis with an upper part and a lower part. The upper part is mounted in bearings on the lower part such that it can be rotated in a horizontal plane around a vertical axis. The lower part of the working machine is provided with a propulsion means that includes continuous tracks. The manoeuvrable arm of the working machine is supported at the rotatable upper part and is relatively complicated in its design in that it includes four hydraulic functions that include, when viewed from the chassis of the working machine, pivoting of a first arm section (known as the "boom" or the "lifting arm"), pivoting of a second arm section, pivoting of a third arm section, and pivoting of a tool supported at the end of the third arm section. The working machine is equipped with a hydraulic pump with which the operating means of the machine for the manoeuvrable arm, which means comprises a first cylinder (the boom cylinder), a second and a third arm cylinder, and a fourth cylinder that constitutes a breaker or pivot cylinder for the supported tool, is driven by hydraulic fluid that is supplied by the pump. Between each operating means and the pump there is placed a control valve that controls the hydraulic fluid from the pump to the operating means such that the displaceable arm of the working machine can be manoeuvred in the desired manner through the influence of the two control sticks. Thus the flow to each of the operating means is determined by the position of the control stick.

[0004] As has been mentioned above, working machines of this type have a wide range of application and the manoeuvrable arm of the working machine is therefore intended to support many types of tool at its free end, in a manner that allows them to be exchanged, for example concrete crushers, demolition hammers, and various types of bucket for excavation work and for the displacement of material. It is possible in certain cases for the user to tailor the hydraulic system to user-specific tools, known as "special tools". Some of these tools are relatively heavy, while others are light, and this influences the behaviour of the manoeuvrable arm during operation. Certain operations of a more industrial nature require that the tool be operated with high precision during what is known as "parallel displacement" across a large working area. This is necessary, not least during different types of the industrial operations that are to be carried out in, for example, a nuclear power station, whereby the working machine is operated from a control room, monitored by digital cameras. During, for example, the sorting and packaging of contaminated material, large demands are placed on the motion precision of the working machine, whereby it must be possible to displace the current tool in a linearly parallel manner along selected axes, normally along horizontal axes, although displacement along vertical axes may be necessary. Even if an operator is highly skilled, it is generally not possible to regulate by means of the control sticks, manually, the pivot mechanisms that arise at the manoeuvrable arm in such a manner that a tool can follow an exactly linear course, i.e. it is not possible to achieve completely parallel guidance of the tool along a course in the horizontal or the vertical direction. Various types of system solution in order to achieve semi-automatic or fully automatic parallel guidance are known, which solutions are generally mechanically based with link arm mechanisms designed for the purpose. Hydraulic systems that use hydraulic flow dividers are also known, with the help of which flow dividers it is ensured that a given pressure medium flows in the desired amounts, independently of the pressure of the load, across several hydraulic consumers that are arranged parallel to each other and that are used for the manoeuvring of the relevant arm sections of a manoeuvrable arm. Each flow valve at a flow divider comprises a flow constrictor and a pressure regulator, and the flow valve makes it possible to regulate the flow to each consumer individually. When using, for example, an arm, parallel displacement is achieved through the allocation of a determined amount of driving fluid to the hydraulic consumers, divided into suitable partial amounts. In order to achieve parallel displacement, in a predetermined manner, of the arm in the horizontal plane at a known working machine of the present type, the amount of flow is distributed between the first hydraulic cylinder, which is used for the raising and lowering of the first arm section (the lifting arm), and the second hydraulic cylinder, which is used for the manoeuvring of a second arm section. Thus, a constant horizontal longitudinal extent of the manoeuvrable arm is achieved through interaction between the first and second cylinders of the working machine.

[0005] When working with working machines of the present type, it is common that not only the tasks are changed but also the other operating conditions of the working machine, which means that not only the fact that the manoeuvrable arm supports different tools, but also the different weights of the tools and the different viscosity of the hydraulic fluid under variations in temperature will influence how the manoeuvrable arm behaves and how it moves during operation. The above-mentioned effect also makes it difficult to make general recommendations for how the hydraulic system of the working machine is to be set and operated, particularly during accurate parallel guidance of the tool while the control flows in the hydraulic system will vary, depending on the task chosen and the operating conditions under which it is carried out. It should be understood that tools with considerably different weights and hydraulic fluids with considerably varying viscosities influence the motions of the operating means and, as a result of this, these motions will influence the behaviour of the manoeuvrable arm and thus also that of the tool, and the possibility of achieving the precision in motion required, in particular the possibility of achieving accurate parallel guidance. It should further be understood that there is always an aspiration to make all sticks and knobs as easy to operate as possible for the operator: the more the operator is able to concentrate on the task, the safer and more efficient will be the use of the working machine. Thus, it is a natural step to try to reduce the number of sticks and knobs that must be influenced for the operation of the working machine.

[0006] The purpose of the present invention, therefore, is to achieve a control system for a working machine of the present type that solves the above-mentioned problems and that makes the working machine more efficient by increasing its ease of use and flexibility. This is achieved through a working machine being equipped with a control system that demonstrates the distinctive features and characteristics that are specified in claim 1.

[0007] The insight that forms the basis of the invention is that of assigning to the working machine the ability to be switched between different working modes, in particular a mode that includes a mode for manual operation in which the operator controls the motions of the manoeuvrable arm by direct influence on the control sticks, and a mode for semi-automatic or fully automatic operation (automatic motion control stick mode) whereby the working machine, when a control stick is operated, follows a course determined in advance based on synchronisation of the operating means of the manoeuvrable arm being carried out through the use of software that is stored in a computer. The working machine is this way able to be switched by the control unit between a first working mode known as "manual control stick mode" and an automatic control stick mode, whereby the manoeuvrable arm moves along a course under control of the software of the computer.

[0008] When the working machine has been switched to the manual control stick mode, the operating means carry out their motions for the manoeuvring of the displaceable arm by direct manual influence of the operating means of the control unit, i.e. through influence of the two control sticks. When the working machine has been switched to the automatic control stick mode, the operating means carry out their motions in a manner that has been mutually preprogrammed in order to carry out motion that has been determined in advance.

[0009] This motion, that has been determined in advance includes the manoeuvring of the displaceable arm, can include any suitable courses of motion at all, but it includes two linear motions of particular interest, namely a first denoted by "horizontal parallel guidance" and a second denoted by "vertical parallel guidance". In horizontal parallel guidance, the operating means are synchronised through following a control curve that has been developed for each one of these operating means, such that a tool supported at the free end of the manoeuvrable arm moves linearly along a horizontal axis. In vertical parallel guidance, the operating means are so synchronised that the tool at the end of the arm moves linearly along a vertical axis and the hydraulic control circuit is equipped with means for the adjustment of the parameters of the synchronous electronic (electrohydraulic) control of the operating means of the manoeuvrable arm, depending on the weight of the selected tool.

[0010] In a second embodiment of the invention, the hydraulic control circuit is equipped with means for the adjustment of the parameters of the synchronous electronic (electrohydraulic) control of the operating means of the manoeuvrable arm, depending on the apparent temperature, and thus viscosity, of the hydraulic medium.

[0011] In one embodiment, the system comprises means for the identification of the selected tool and for automatic adjustment of the parameters of the electronic (electrohydraulic) control of the operating means of the manoeuvrable arm, depending on the weight of the selected tool.

[0012] In a second embodiment, the system includes the possibility of selecting the operating specifications of the hydraulic system through a choice of the tool by means of the control unit for the remote control of the working machine.

[0013] The invention will be described below in more detail with reference to the attached drawings, of which:

Figure 1A shows a side view of a remote-controlled working machine set into an automatic control stick mode and during the execution of linear longitudinal extension of the manoeuvrable arm of the working machine in a horizontal plane through interaction between the operating cylinders of the manoeuvrable arm,

Figure 1B shows a side view of a part of the remote-controlled arm of the working machine equipped with a tool in the form of a bucket and set into a manual control stick mode for the direct influence of control sticks and displacement of freed material by means of the bucket,

Figure 1C shows a side view of the manoeuvrable arm in a dash-dot contour, starting at a withdrawn position, and ready to be parallel displaced by moving forwards,

Figure 2 shows schematically a circuit diagram of a hydraulic system that is a component of a control system according to the present invention,

Figure 3 shows in more detail the principle of the function of the hydraulic system and its associated regulator structure for the adjustment of the parameters of the motion in automatic control stick mode,

Figure 4A shows a perspective view from above of a control unit such as it is seen by an operator during operation of the working machine,

Figure 4B shows in the form of a summary the functions of the control unit in its working mode and the symbols of the control unit for the switching of the working machine between the manual control stick mode and the fully automatic or semi-automatic control stick mode,

Figure 5A shows a side view of a third arm section (the shaft) with a quick-release coupling arranged at the end of it for the attachment of tools at the end of the manoeuvrable arm,

Figure 5B shows a side view of a first tool in the form of a hydraulically powered impact hammer,

Figure 5C shows a side view of a second tool in the form of a bucket for excavation work, and

Figure 6 shows in the form of a summary the control unit set in a mode for the selection of tool, i.e. the choice of the tool, and the symbols associated with this.

[0014] Figure 1 A shows a remote-controlled electrically driven working machine 1 designed as a demolition robot that is supplied with power through a cable 2. Such a remote-controlled working machine is manufactured and sold under the trademark "BROKK", and is such a working machine at which an operator 3 walks beside the machine and controls and operates it by means of a portable control unit 4 or remote-control unit that is carried on the body by means of a belt or harness. The control unit 4 comprises two control sticks, one of which 4a is located at the left and the other of which 4b is located at the right, and the control unit has a series of buttons and knobs that through their influence and settings can cause the working machine to carry out the desired motions, or through the input of data the working machine is provided with the required instructions. The working machine 1 can be set into different types of working mode that can be selected by means of the control unit, see also Figures 4A and 4B. When the control unit is set into the setting mode and position for "Tool choice", different types of tool can be selected, see Figure 6, whereby the selection of the following tools is illustrated: hydraulic hammer, hydraulic cutter, bucket, and two user-specific tools denoted by "Special 1" and "Special 2".

[0015] The operation of the working machine 1 takes place with the aid of controls that can be influenced for each relevant function, whereby functions are included that are arranged through the control system for fully automatic or semi-automatic synchronisation of the motions of the operating means. The term "fully automatic control" is used below to denote the process in which, when a control stick is influenced, there is initiated and executed a complete work cycle as a motion along a course that has been determined in advance, while "semi-automatic control" is used to denote a process in which the motion along the course continues only for as long as the control stick is influenced. When the control stick is subsequently released, the motion stops immediately, i.e. the manoeuvrable arm 10 stops moving. The operator 3 is in connection with the machine through the control unit 4 by cable or in a wireless manner, for example through Bluetooth or radio control. The working machine 1 can be set through the control unit 4 into different working modes as is illustrated in Figure 5B. The control unit 4 is set into what is known as "setup mode" during the switching of the working mode. Exchange of working mode can take place only when the control unit 4 is in the said setup mode, whereby the selected working mode is displayed with the aid of symbols that are illuminated on a screen 4c or display on the control unit 4. By setting the working machine into various working modes, the working machine can carry out a number of different motions with the two control sticks 4a, 4b. The working machine is shown in Figure 1A during the execution of work with a demolition hammer for the freeing and crushing of material, and it is shown in Figure 1 B during excavation and the removal of free material, whereby the working machine is equipped with a bucket 16.

[0016] The working machine 1 generally comprises a chassis 5 with an upper part 6 and a lower part 7. The upper part 6 is mounted to rotate in bearings on the lower part 7 for rotation in a horizontal plane around a vertical axis C. The lower part 7 of the working machine 1 is provided with a propulsion means that includes continuous tracks 8. The working machine 1 has a manoeuvrable arm 10 that is supported at the rotatable upper part 6 and including four hydraulic functions that include, when viewed from the chassis of the working machine, pivoting of a first arm section 11 (known as the "boom" or the "lifting arm"), pivoting of a second arm section 12, pivoting of a third arm section 13, and pivoting of a tool 14 supported at the end of the third arm section. What is known as a "quick-release coupling" 15 for the attachment of different types of tool is present at the free end of the manoeuvrable arm 10. The said sections pivot mutually around essentially horizontal axes A. The working machine 1 is equipped with a hydraulic pump 20 with which the operating means of the machine for the manoeuvrable arm 10 is driven by hydraulic fluid that is supplied by the pump. The operating means include a first hydraulic cylinder 31 [here and elsewhere - the cylinder numbers in Figure 1A are 30, 31, 32, 33] (the boom cylinder), a second 32 and a third 33 hydraulic cylinder (arm cylinders), and a fourth hydraulic cylinder 34 (the breaker or pivot cylinder) for the tool. Between each operating means 31, 32, 33, 34 and the pump there is placed a control valve 21a, 21b that controls the hydraulic fluid from the hydraulic pump 20 to the operating means such that the working machine can be manoeuvred in the desired manner through the influence of the two control sticks 4a, 4b of the control unit 4.

[0017] According to the invention, the working machine 1 is provided with means that make it possible to set the hydraulic system into different working modes in order to make it easier for the operator 3 to carry out specific tasks. It is thus possible to select through the control unit 4 in association with this different types of tool, whereby the working machine is placed into the mode for tool selection.

[0018] As is made clear by Figures 4A and 4B these two different working modes include a first mode for manual operation in which the operator 3 controls the motions of the manoeuvrable arm 10 through direct influence of the control sticks 4a, 4b, and a second mode for automated operation, whereby the motion is fully or partially controlled by software in a computer such that the tool 14 that is suspended at the manoeuvrable arm 10 of the working machine carries out a defined motion along a course following a linear course that has been determined in advance, but stops at a freely chosen position along the course as soon as the influence of the control stick ceases. The working machine 1 has, in this way, the advantage that the manoeuvrable arm 10 can be assigned through rules and control technical measures a course of motion that has been determined in advance, for example, as is shown in Figure 1 A, that of causing a tool 14 supported by the manoeuvrable arm 10 to follow an exact linear horizontal course denoted by "X", i.e. to achieve complete parallel guidance of a supported tool 14 along the course. It is appropriate that the control system be so designed that the deviation of the position of the control sticks 4a, 4b from their central points influences the speed of motion of the manoeuvrable arm 10, such that a small deviation results in the manoeuvrable arm moving slowly. A vertical course is denoted by "Y" in Figure 1A. As a part of the invention, the operating means 31, 32, 33, 34 of the manoeuvrable arm are synchronised to carry out motions that ensure that the manoeuvrable arm as a unit carries out the desired motion along a course in space. The technology will be described below for the sake of simplicity following an embodiment that concerns only parallel guidance of the tool in a horizontal plane X, while this simple case means that essentially only two operating means need to be controlled when the working machine is driven in automated operating, namely the first 31 and second 32 hydraulic cylinders of the manoeuvrable arm 10, as should be realised if the final position in Figure 1 A is compared with the withdrawn initial position of the manoeuvrable arm that is shown with dash-dot contour lines in Figure 1C.

[0019] Figure 2 shows a circuit diagram for a control arrangement 22 intended for the control of the working machine 1. Furthermore, the hydraulic system 23 is shown schematically with its associated regulator structure for the control of the operating means of the working machine, i.e. the first cylinder 31 (the boom cylinder), the second 32 and the third 33 cylinders, and the fourth cylinder 34 that constitutes the breaker or pivot cylinder for the supported tool 14. The full lines denote hydraulic lines, while the dashed lines denote lines for electrical signals. As has been described above, the hydraulic pump 20 is arranged to supply the operating means 31, 32, 33, 34 of the manoeuvrable arm 10 with hydraulic fluid. It is the task of the first flow-regulating valve 22a in Figure 3 of the hydraulic system 23 to regulate the hydraulic flow to a hydraulically powered tool, for example a demolition hammer, and the valve is connected hydraulically to the pump 20 through a valve 24 that sets priorities, and electrically to a computer unit 25. In the embodiment of the invention described here, the tool that is supported by the manoeuvrable arm 10 includes a demolition hammer 14, but it could, however, be constituted by any tool that is available, such as, for example, a bucket 16 (see Figure 1 B). The valve 24 that sets priorities in the present embodiment is set to always give priority to the hydraulic flow to the tool (the hydraulic demolition hammer), before other consumers. This means that if the demolition hammer 14 and the operating means 31, 32, 33, 34 of the manoeuvrable arm 10 are used at the same time, it is the demolition hammer that will dominate, or that will have priority. The operating means are activated slowly, and the manoeuvrable arm will move somewhat more slowly. The setting of priorities takes place fully hydraulically.

[0020] The hydraulic system 23 in Figure 3 comprises further a second flow-regulating valve 22b in the form of a manoeuvrable arm valve that is set to regulate the hydraulic flow to the operating means of the working machine, i.e. to the first cylinder 31 (the boom cylinder), the second 32 and the third 33 cylinders, and the fourth cylinder 34 that constitutes the breaker or pivot cylinder for the supported tool 14. The computer unit 25 is connected to the said first and second valves 21a, 21b for the regulation of these. The control arrangement 22 comprises further influenceable control means in the form of the said sticks 4a, 4b, which, as has been described above, are arranged on the control unit 4 that is carried by the operator 3. The sticks 4a, 4b, are connected to the computer unit 25, as is the control unit in its entirety. The hydraulic system 23 is of the type that senses the load applied, and this means that the pump 20 supplies fluid only when it is required and only to the locations at which it is required. This means that motor power is available to power particularly demanding tools, for example a hydraulic demolition hammer 14.

[0021] As has been mentioned above, the present working machine 1 has a broad field of use in which the manoeuvrable arm is intended to support many different types of tool 14, 16 at its free end, and these tools may also be selected in the control unit 4 of the working machine, whereby the control arrangement 22 of the hydraulic system is adapted by the control computer 25 in a pre-determined manner for the tool selected. This adaptation may concern, for example setting the priority for the hydraulic flow to the hydraulically powered tool. It would be an advantage during certain operations of a more industrial nature if the tool could be manoeuvred with high precision during what is known as "parallel displacement", and displaced linearly while maintaining its orientation across a large working area. Other operations that are carried out can be compared most closely with conventional excavation using an excavator, whereby it must be possible to remove the freed material in a rapid and flexible manner. In order to aid in this, the present working machine is assigned a control system that makes it possible directly through the control unit to switch between a first working mode denoted the "manual control stick mode" and a second working mode denoted the "automatic control stick mode". For this, the computer 25 comprises software with a regulatory structure that can control in a synchronised manner each one of the operating means that are used for the motions of the manoeuvrable arm 10. The working machine 1 is this way able to be switched by the control unit 4 between a first working mode known as "manual control stick mode" and an "automatic control stick mode". During influence on the control stick in the said automatic control stick mode, a tool 14 that is suspended at the manoeuvrable arm 10 moves along a course in space under the control of the software of the computer.

[0022] Figure 3 shows the principle for the automatic control stick mode in more detail and, as the drawing makes clear, electrohydraulic valve blocks are denoted by 22a which valve blocks are equipped with electrohydraulic pilot valves (not shown in the drawing) and which valve blocks control and regulate the motion of the first and second operating means of the working machine, i.e. the first cylinder 31 (the boom cylinder) and the second arm cylinder 32. The electrical operation of the valves 21a, 21b is carried out by the computer unit 25. Any other hydraulic cylinders that are components of the manoeuvrable arm 10, i.e. in this case the operating means 33 and 34 of the manoeuvrable arm, are controlled in a similar manner by further valve sections in the block, which further blocks are suggested by dash-dot contour lines in Figure 3. A first signal transmitter connected to the control arrangement 22 and comprising a control stick 4a (or 4b) that is a component of the control unit is arranged such that the operator can give orders to the control arrangement. The control signals required are produced in the electronic control stick 4a in order subsequently to be led onwards to the computer unit 25 of the working machine and from this unit to the relevant operating means 31, 32 that is required in order for the tool 14 to carry out the desired linear displacement. The control stick 4a communicates with the control unit 22 and with relevant other components through an integrated CAN interface. In a similar manner, parameter determination of programmed functions occurs through the CAN interface, using, for example, a portable service computer. The special functions and the switching between the operating modes, manual and automatic working modes, is activated by the operator with the aid of buttons on the control unit 4 and the signals are received by digital inputs to the control computer 25. The CAN signals and the signals at the digital inputs (push buttons) are processed in task and maintask, and they start and dismiss control routines. The program routines control through PWM outputs proportional magnets in the electrohydraulic pilot valves in the control valves 21, 21b. Valve control curves 26a, 26b are available in the computer unit 25 in the form of software for each one of the relevant operating means 31, 32 and for any other operating means that are necessary in order to carry out the required functional cycle for the motion of the manoeuvrable arm 10. Furthermore, correction factor curves 27a, 27b and 28a, 28b are available that, based on external circumstances that are related to the weight of the selected tool 14 (curves 27a, 27b) or related to the viscosity of the hydraulic fluid (curves 28a, 28b), compensate and correct the valve control curves 26a, 26b such that the manoeuvrable arm 10 and thus also the tool 14 always carry out the desired linear motion, for example parallel displacement along a horizontal course as is shown in Figure 1 A, independently of the weight of the current tool and of the instantaneous viscosity of the hydraulic fluid. It is appropriate that light-emitting diodes on the control unit 4 indicate the condition of the various units.

[0023] The control process for automatic control stick mode is divided into two groups, namely one group with preprogrammed fixed valve control curves 26a, 26b, for the relevant operating cylinder 31, 32, and one group with the said correction factor curves 27a, 27b; 28a, 28b that are determined by the condition and that are selected by the control system depending on data that has been obtained from a set of sensors connected to the computer unit 25. The control arrangement 22 comprises thus means 40 for the detection of the weight of the selected tool 14, 16 and means 41 for the detection of the temperature, and thus the viscosity, of the hydraulic fluid. A suitable correction factor curve 27a, 27b for the weight correction is selected using information about the weight of the tool 14, 16. The computer unit can subsequently determine the viscosity of the hydraulic fluid based on the temperature of the fluid and select, based on this, a suitable correction factor curve 28a, 28b. The preprogrammed fixed valve control curves 26a, 26b for the relevant operating cylinder are determined at a certain temperature, for example room temperature at 20 °C.

[0024] The working machine is shown with symbols in Figure 4 set into different working modes including manual working mode, automatic horizontal motion inwards and outwards, automatic vertical motion upwards and downwards. When the working machine 1 has been switched to the manual control stick mode the operating means 31, 32, 33, 34 carry out their motions for the manoeuvring of the displaceable arm 10 by direct manual influence of the operating means 4a, 4b of the control unit 4, i.e. through influence of the two control sticks 4a, 4b. The control signals for the basic functions raising and lowering the manoeuvrable arm 10 and the supported tool 14 takes place through the crosswise operation of what is known as a "multifunction control stick". With the aid of a number of buttons 4d, 4e arranged at the top of the control sticks special functions can be activated and signals can be transferred to the control unit for the motion of the working machine. In the embodiment of the invention described here, the motion of the manoeuvrable arm 10 is controlled in manual working mode through operation of the control sticks 4a, 4b. When in the automatic working mode for horizontal motion outwards and inwards, the control takes place by means of the control stick 4a in combination with the influence of the upper button 4d of the control stick 4a. When in the automatic working mode for vertical motion upwards and downwards, the control takes place by means of the control stick 4b in combination with the influence of the upper button 4e of the control stick 4b. It should be understood that the choice of the combination of control stick 4a, 4b and the buttons 4d and 4e is purely a matter of programming technicalities that does not in itself have anything to do with the invention.

[0025] As is shown in Figure 6, the operator 3 through the control unit 4 specifies the choice of a specific tool, for example a hydraulic hammer, hydraulic cutter or bucket, through symbols on the control unit. In this embodiment of the invention the hydraulic control circuit 22 is assigned means 40 for the parameter adjustment of the valve control curves 26a, 26b through the influence of correction factor curves 27a, 27b that, stored as software in the control computer 25, are selected depending on the specified tool 14, 16 that is supported by the working machine and that has been specified by the operator.

[0026] In an alternative embodiment, the operator does not need to specify which tool the working machine is supporting: this can take place fully automatically. For this, the system includes means that automatically identify identification data of the selected tool 14, 16, and when the working machine 1 has been switched into the automatic control stick the valve control curves 26a, 26b of the operating means are adapted automatically through the choice of suitable correction factor curves 27a, 27b. Another method, of course, is that the operator manually inputs into the control computer 25 through the buttons of the control unit 4 data that concerns the type or weight of the tool when the tool is changed. Although it is true that this method functions well, it is time-consuming and it is not very reliable.

[0027] Thus, the present control system comprises wireless identification means in which a receiver 50 is arranged to receive identification information from identification means 51. The system is further arranged to adapt and adjust at least one operating parameter of the working machine 1 on the basis of an identified tool, for example a demolition hammer 14 or a bucket 16. By comparing the identification information that has been received by the identification means 50 with identification information that is stored in memory, the system can detect also tools that do not provide a reply to the receiver. If the selected tool does not respond, i.e. does not transmit the expected identification information, information about the weight of the tool must be manually input into the control computer 25 through the control unit 4.

[0028] As is made clear by Figures 5A-5C, the identification means 51 may be attached to the outer surface of the tool while the receiver is arranged at the working machine 1, in this case given as an example, on the manoeuvrable arm 10. The identification means 51 operates wirelessly and may include a passive radiolabel known as a "radio frequency identification" tag, or "RFID" tag. An RFID tag consists of an RFID chip with an identification number and an aerial. The passive RFID tag is supplied with power from an electromagnetic field that is transmitted from an RFID receiver. When the transponder is supplied with power, it transmits its identification number. The identification number is subsequently read by the RFID receiver. RFID technology is well-known to one skilled in the arts and will not, therefore, be described in more detail.

[0029] Different types of tool, such as demolition hammers 14 and buckets 16, intended to be supported in an exchangeable manner by the present working machine 1 are provided during manufacture with a passive radiolabel, an RFID tag, containing identification information, and thus also containing information about the weight of the tool, and possibly other information that may be significant for the functional adaptation of the hydraulic control system 22 of the working machine 1. During choice of the tool that the working machine is to support for the current task, the receiver 50 that is arranged at the working machine 1 reads identification information from the identification means, the radiolabel, what is known as an "RFID tag", which information is addressed to the computer unit 25 of the control system 22. On the basis of the tool that has been identified, the software in the computer unit 25 ensures that the identification information that has been received is used for the adaptation and adjustment of at least one operating parameter of the working machine 1. This adaptation concerns the control process during automatic control stick mode, whereby in which a correction factor curve 27a, 27b that is stored in the computer unit 25 and that has been appropriately prepared is selected on the basis of the identification information concerning the weight of the current tool that has been received, for the adjustment of the different program loops from the group of preprogrammed fixed valve control curves 26a, 26b that are used for the synchronised control of the relevant operating means 31, 32, in order to achieve the desired linear motion of the manoeuvrable arm 10.

[0030] As has been described in the present embodiment, the manoeuvrable arm 10 and a tool 14 that is supported by it can in this way be caused to carry out the desired linear motion along a course, for example in order to achieve horizontal parallel guidance. For this, the two operating means 31, 32 of the manoeuvrable arm 10 each follows a valve control curve 26a, 26b that has been developed for each one of these operating means and that has been adjusted by a suitable correction factor curve 27a, 27b, selected on the basis of the identification information received from the identification means 51, i.e. from the RFID tag, and concerning the weight of the current tool.

[0031] The invention is not limited to that which has been described above and shown in the drawings: it can be changed and modified in several different ways within the scope of the innovative concept defined by the attached patent claims.

Claims

1. A control system for a remote-controlled working machine (1) equipped with a manoeuvrable arm (10), in particular a demolition robot for demolition work, that is intended to carry at the free end of its arm a tool (14, 16), whereby the control system comprises a control unit (4) intended for the remote control of the working machine, whereby an operator (3) walks next to the working machine and is in connection, either by cable or wirelessly, with a control computer (25) that is a component of a hydraulic control circuit (22) for the working machine, and which control unit includes a pair of control sticks (4a, 4b) and associated buttons (4d, 4e) and knobs that through their influence allow the working machine to be switched between different functional or working modes, whereby the manoeuvrable arm can be caused to carry out desired motions through a number of operating means (31, 32, 33, 34) that are driven hydraulically, that are arranged at the manoeuvrable arm, and that can be influenced by means of the said control sticks (4a, 4b), **characterised in that** the working machine (1) can be switched through the control unit (4) between two different working modes that are present in the system, including:

    a first mode for manual operation in which the operator (3) controls the motion of the manoeuvrable arm (10) through direct influence of the relevant control sticks (4a, 4b) of the control unit (4), and

    a second mode for semi-automatic or fully automatic operation in which the operator (3), on influence of one of the control sticks (4a, 4b), causes the manoeuvrable arm (10) to move under parallel guidance along a determined linear course in the horizontal or vertical direction through synchronised control of at least two of the operating means (31, 32) of the manoeuvrable arm following a valve control curve (26a, 26b) for each one of these that is stored in the control computer (25) as software, whereby the hydraulic control circuit (22) is assigned means (40) for the adjustment of the parameters of the valve control curves (26a, 26b) during the said operation through the influence of correction factor curves (27a, 27b) that, stored as software in the control computer (25) are selected depending on the weight of the tool (14, 16) that is supported by the working machine.

2. The control system according to claim 1, whereby when the system is arranged for semi-automatic operation, the forward end of the manoeuvrable arm (10) carries out a motion along a course that has been predetermined by the control computer (25) on influence of the control stick (4a, 4b), and in that the motion is stopped as soon as the influence ceases and the control stick returns to a central position.

3. The control system according to claim 1, whereby when the system is arranged for fully automatic operation the forward end of the manoeuvrable arm (10) carries out a motion along a course that has been predetermined in the control computer (25), on influence of the control stick (4a, 4b), and the motion is stopped when the forward end of the manoeuvrable arm has reached a position in space that has been predetermined.

4. The control system according to claim 1 or 2, whereby the system is so designed that the deviation of the position of the control stick (4a, 4b) from its central position during semi-automatic operation influences the speed of motion of the manoeuvrable arm (10), such that a small deviation from the central position results in the manoeuvrable arm moving more slowly.

5. The control system according to any one of claims 1-4, whereby the hydraulic control circuit (22) is assigned means (41) for the measurement of the temperature of the hydraulic fluid and, on the basis of the measurement result obtained, to achieve adjustment of the parameters of the valve control curves (26a, 26b) through the influence of correction factor

curves (28a, 28b) that are stored as software in the control computer (25) and are selected depending on the calculated viscosity of the hydraulic fluid.

6. The control system according to any one of claims 1-5, whereby the system is arranged to adapt and adjust at least one operating parameter of the working machine (1) on the basis of an identified tool (14, 16).

7. The control system according to claim 6, including wireless identification means in the form of a receiver (50) arranged to receive identification information from an identification means (51).

8. The control system according to claim 7, whereby the receiver (50) is supported by the working machine (1) and the identification means (51) is supported by the tool (14, 16).

9. The control system according to claim 8, whereby the identification means (51) is of passive type.

10. The control system according to claim 9, whereby the identification means (51) comprises what is known as a "radio frequency identification tag", abbreviated as "RFID tag".

11. The control system according to any one of claims 1-10, whereby switched into semi-automatic or fully automatic operation including two linear motions, namely
a first motion denoted by "horizontal parallel guidance", whereby the operating means (31, 32) are synchronised through following a control curve (26a, 26b) that has been developed for each one of these operating means, such that the free end of the manoeuvrable arm (10) moves linearly along a horizontal axis (X), and
a second motion denoted by "vertical parallel guidance" whereby the operating means (31, 32, 33) are so synchronised that the end of the arm moves linear along a vertical axis (Y).

12. The control system according to any one of claims 1-11, whereby the hydraulic control circuit (22) is assigned means (40) for the adjustment of parameters of the valve control curves (26a, 26b) through the influence of correction factor curves (27a, 27b) that are stored as software in the control computer (25) and are selected depending on the tool (14, 16) that is supported by the working machine, which is set by the operator through the selection of symbols at the control unit (4).

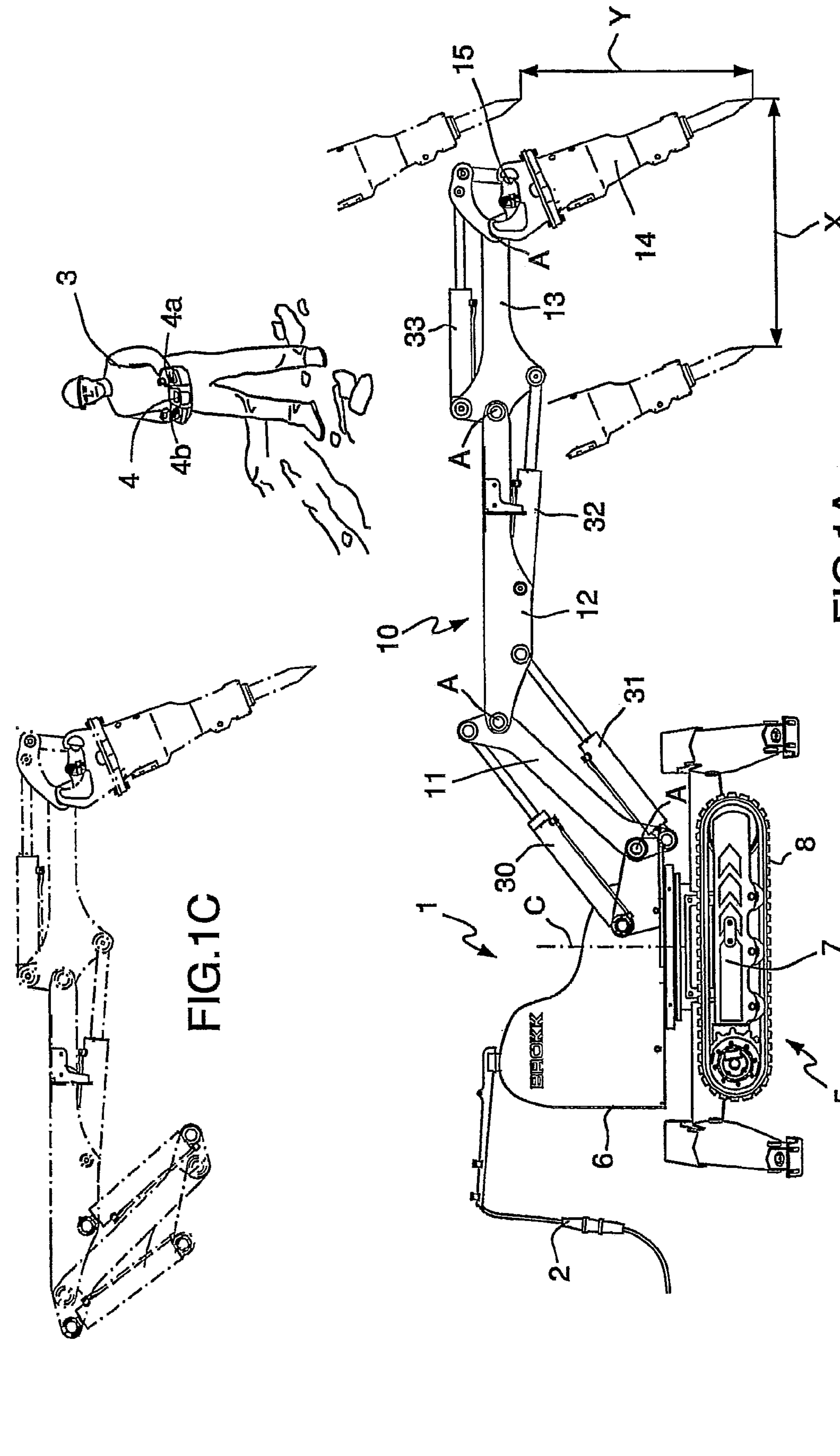


FIG.1C

FIG.1A

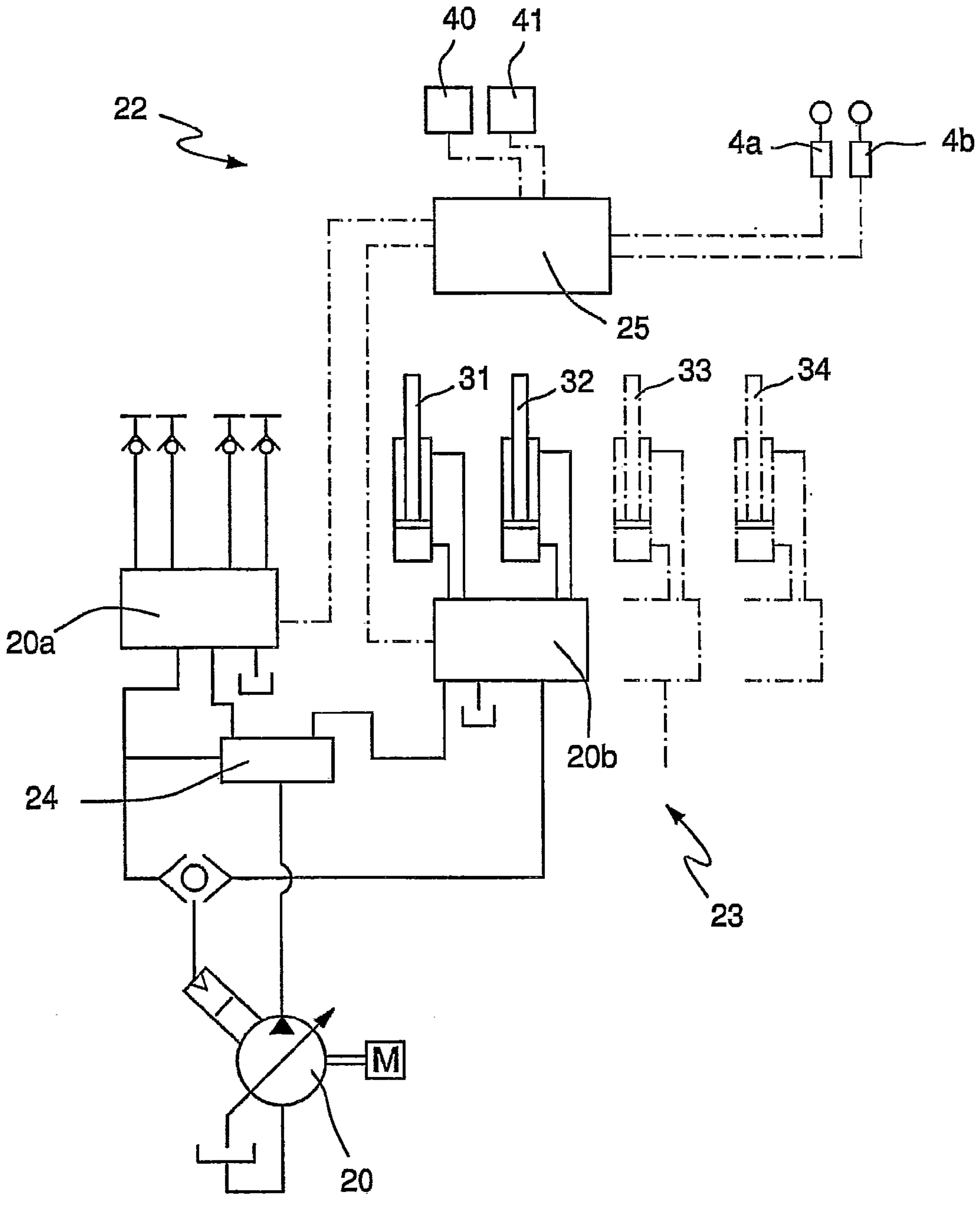


FIG.2

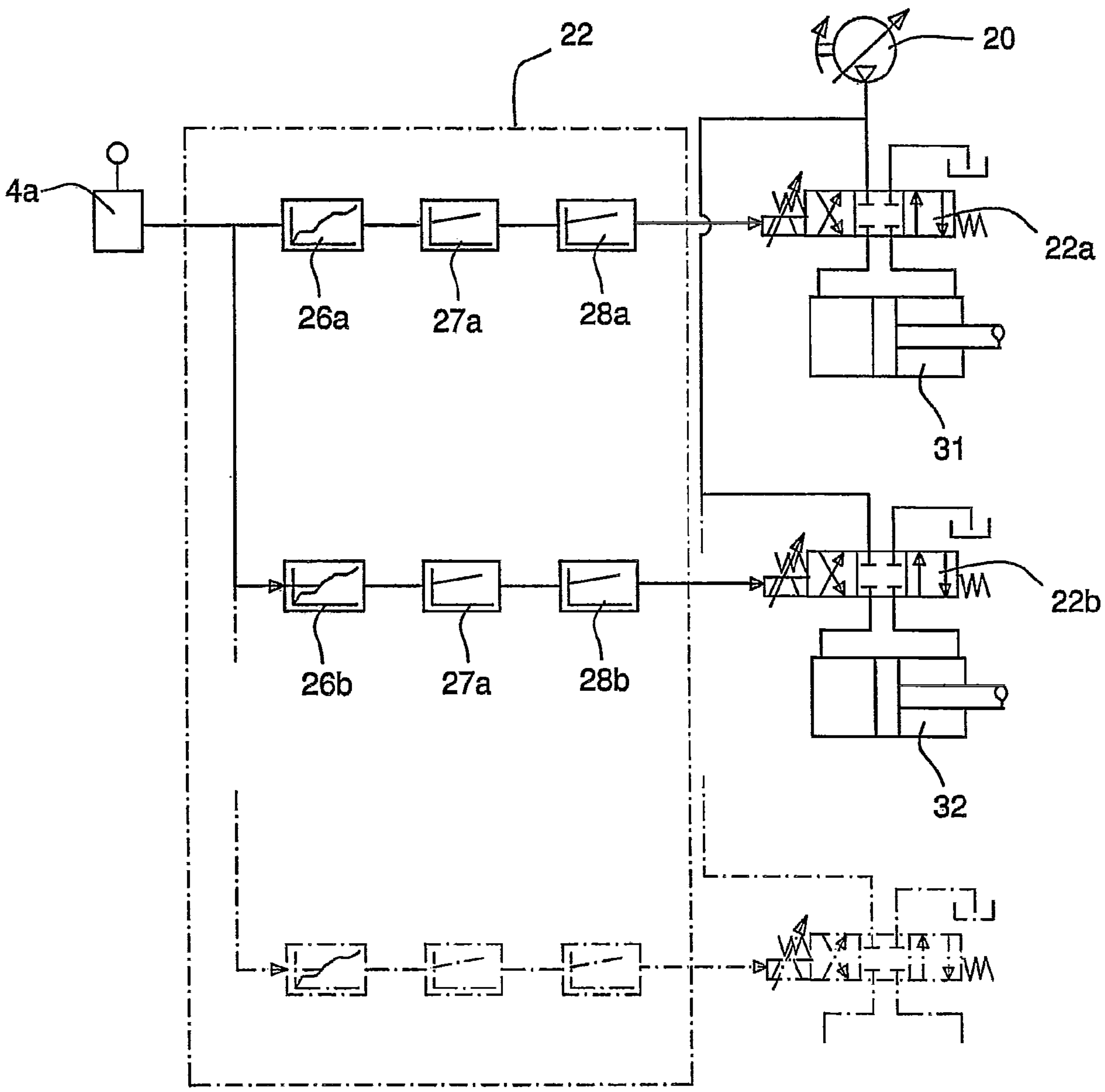


FIG.3

FIG.4A

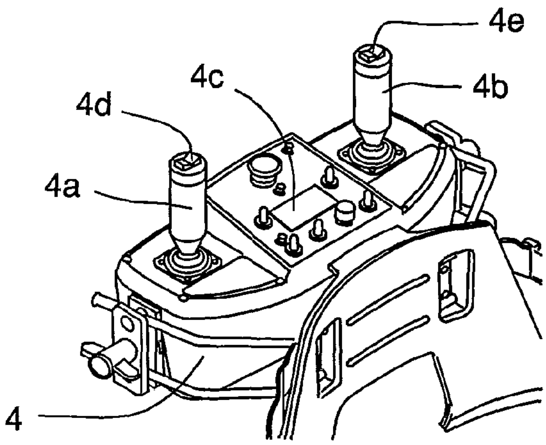
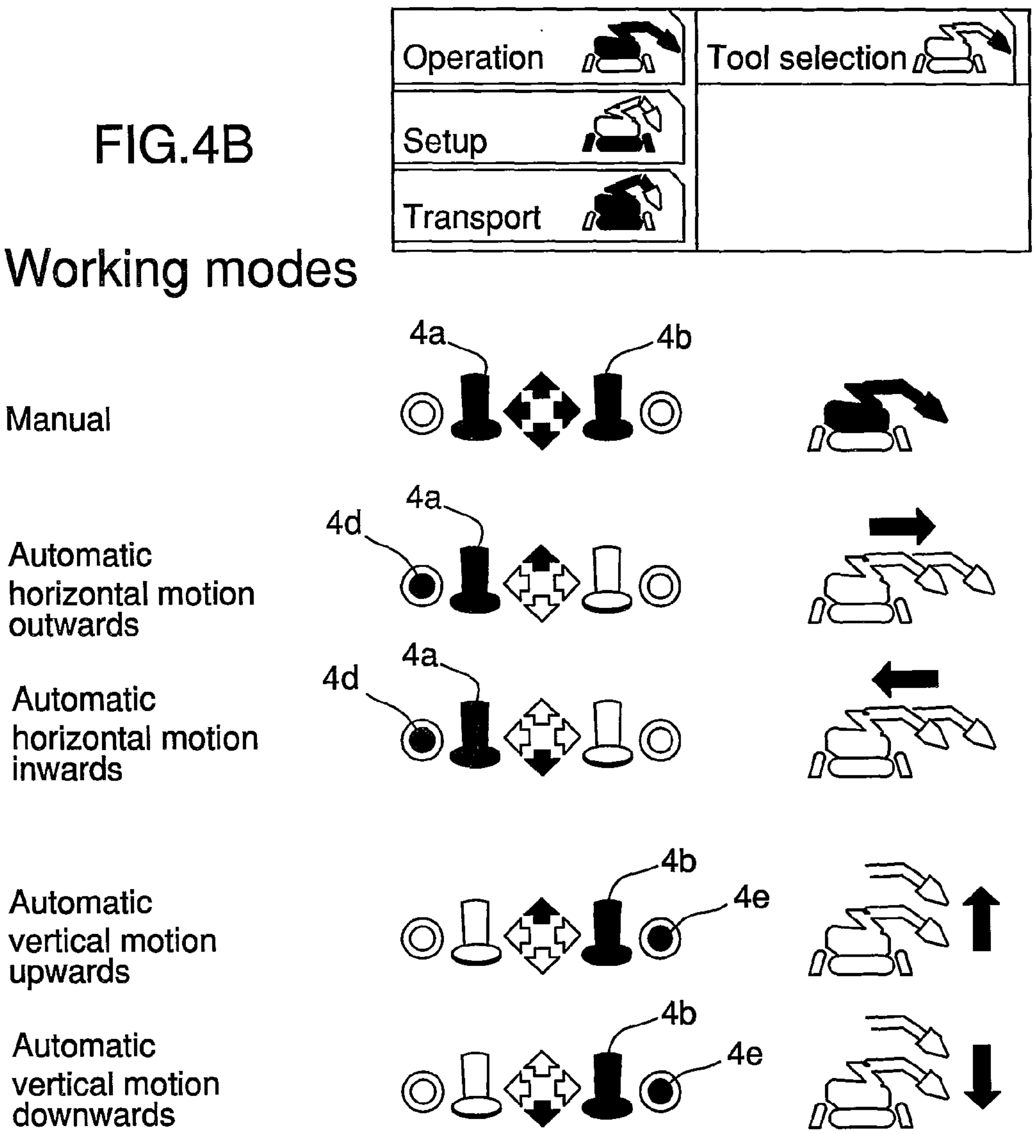

4e
4c
4b
4d
4a
4

FIG.4B


Operation
Tool selection
Setup
Transport
Working modes
Manual
4a
4b
Automatic horizontal motion outwards
4d
4a
Automatic horizontal motion inwards
4d
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Automatic vertical motion upwards
4b
4e
Automatic vertical motion downwards
4b
4e

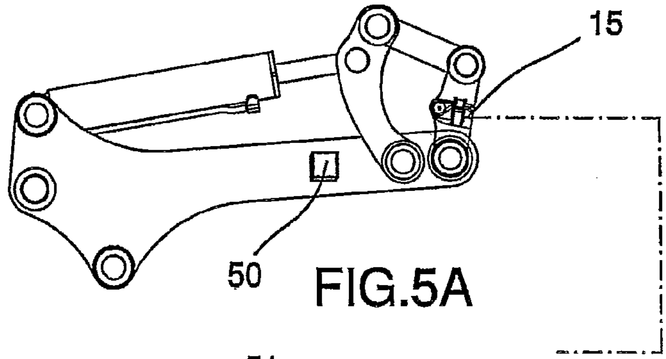


FIG.5A

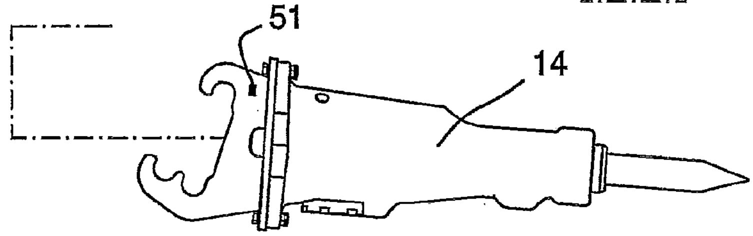


FIG.5B

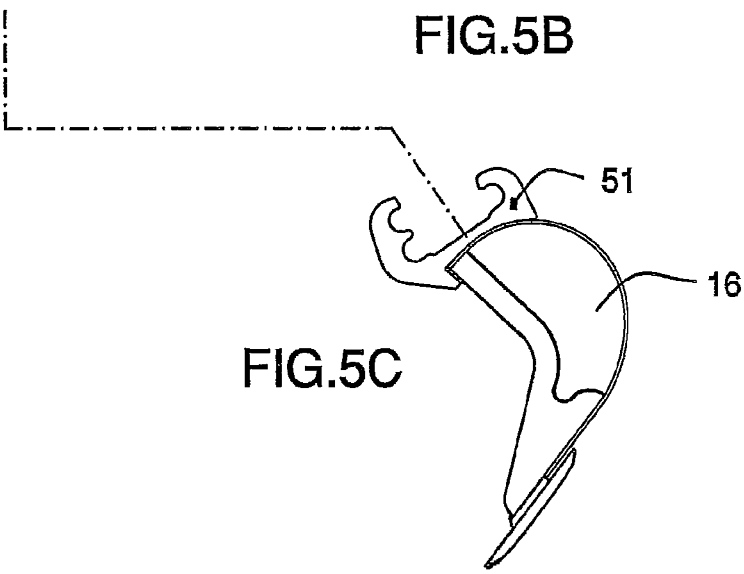


FIG.5C

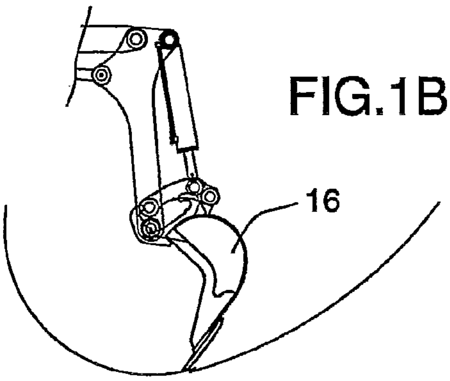
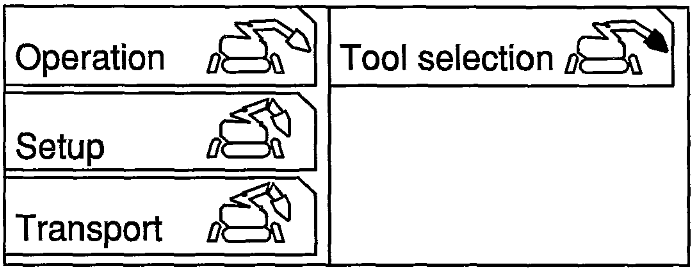
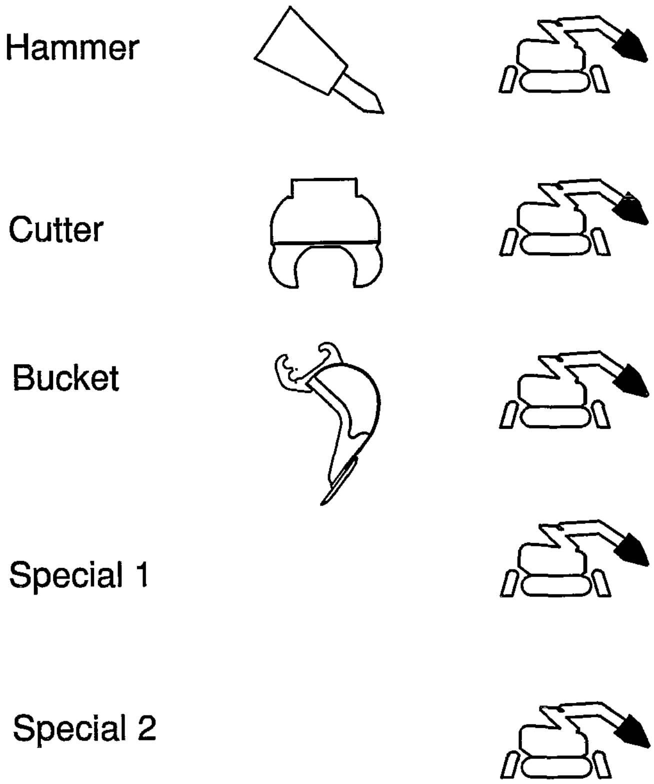


FIG.1B

FIG.6

Working modes





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EUROPEAN SEARCH REPORT

Application Number
EP 12 44 6501

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