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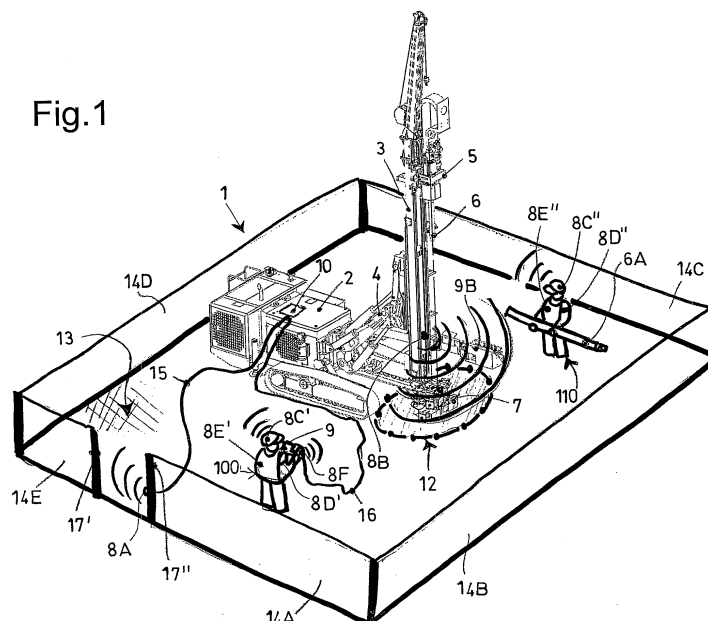
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(54) **SAFETY SYSTEM FOR EXCAVATION EQUIPMENT**

(57) The invention describes a safety system for controlling a dangerous area of excavation equipment provided with a guide antenna (3), as well as a rotary head (5) coupled in a sliding manner on the guide antenna (3) and arranged for supporting and moving an excavation battery (6). The dangerous area is delimited by a curve that develops at a predetermined distance from the excavation battery (6). The safety system comprises at least one pair of portable sensors (8C', 8D', 8E', 8F, 8C'',

8D'', 27) intended to be transported by the support personnel to the excavation equipment, wherein the two sensors of each pair are in communication with each other and at least one of such two sensors is capable of generating a signal further to the detection of the mutual presence of the two sensors themselves, and at least one receiving or individuation unit operatively connected to each pair of portable sensors, capable of receiving the signal emitted by at least one of such sensors.

Fig.1



Description

[0001] The present invention concerns a safety system for excavation equipment and, more specifically, a safety system used in excavation equipment for controlling the dangerous area surrounding a drilling machine and for interrupting dangerous manoeuvres of the machine itself. The safety system according to the present invention is used in order to prevent the operators from coming into contact with rotary or moving members of the drilling machine that are directly involved in the excavation process.

[0002] Indeed, the field of application of the present invention is that relating to drilling or excavation machines that, operating in several technological fields, can require the personnel in charge of the auxiliary services to carry out manual interventions in areas around the machine that are exposed to dangers, in particular close to the guide antenna or "mast" on which the driving head, also called "rotary", slides and close to the drilling axis on which the shafts used for the excavation, mixing, jetting and driving-in processes are located. Consequently, by dangerous area in the present description we mean the region of space around the guide antenna, where the rotary head slides, and the region of space close to the excavation area.

[0003] Drilling machines require interventions of the personnel that can be generally divided into three types: first mounting interventions, maintenance interventions and interventions simultaneous to the work manoeuvres. In the first two types of interventions, usually carried out in the factory, the experience of the trained personnel, the specificity of the problems and common practice lead to consider these intervention operations not to be particularly risky. In the third type of intervention, in which manual interventions are required during the work steps, for example to add or to remove the drilling shafts limited to the area close to the mast, the exposure to risk is very high since the operations are carried out on moving parts and are routine. This physiologically involves a drop in attention by those carrying out the same action repeatedly. Moreover, such interventions must be quick, so as to reduce as much as possible the intervention time and to increase productivity.

[0004] For these reasons, in order to allow the operator, during the normal operations of the drilling machine, to access the mobile parts of the machine itself that are directly involved in the excavation process, the presence of protections is suggested, such as fixed barriers (guards), mobile barriers with interblock, sensitive protection devices or a combination thereof around the dangerous area. Such protections must prevent access to the dangerous area during any dangerous movement.

[0005] For example, document WO 2011/051564 describes an excavation machine that comprises a protective structure or screen arranged at least partially around the antenna.

[0006] In the case in which the mobile barriers are opened or if the sensitive protection devices are activated

by the entry of a person or an object into the dangerous area, the dangerous drilling manoeuvres must be blocked quickly and safely. The standards require at least the rotation of the shaft to be simultaneously blocked and, alternatively, both the rotation and the translation movements of the driving head to be simultaneously and instantaneously blocked.

[0007] All the while that the mobile barriers remain open or that the sensitive devices remain activated, it is possible to reactivate the rotation of the shafts and the sliding of the rotary just by selecting, through a proper selector, a limited operating mode. In this limited operating mode all manoeuvres are properly slowed down up to values such as to eliminate the danger and to allow the inspection of the parts or the execution of the manual interventions. In order to go back to the normal operating mode, in other words the work mode, it is necessary to have closed and reset the interblocked mobile barriers or to have the sensitive protection devices no longer active and to have them reset, to have the normal operating mode of the machine selected, through a proper selector, and to have the start-up command actuated.

[0008] It is known in the field to use mobile barriers or guards with interblock, made in the form of containment cages, arranged around the work members of the machine to isolate the dangerous area. Such containment cages generally consist of one or more supporting frames, made through tubular elements or shaped plates that constitute the external shape thereof, as well as (metallic or plastic) grids, meshes or other screens that occupy the area enclosed by such a shape. The supporting frames can for example be hinged at points integral with the mast so that they can open by rotating on a horizontal plane, when the mast is arranged vertically, and leave free access to the dangerous area.

[0009] These types of barriers or "guards" in closed position, i.e. in work condition, have considerable bulks that generally are greater in the horizontal direction than the shape of the rotary head or of the clamps in order to be able to receive the rotary head itself inside the protected volume. Such bulks are linked to the need of delimiting a sufficiently large dangerous area, i.e. of keeping the operator sufficiently far away from the danger represented by the rotating shafts. Moreover, the possible presence of mechanical loading-aid means has to be provided, like for example automated loading arms, the so-called rack or revolver loaders, or the articulated cranes. These mechanical loading-aid means, in order to be able to operate correctly, should be contained inside the protected volume defined by the barriers.

[0010] The aforementioned considerable bulks, however, for various reasons, constitute a great limitation of the operating capabilities of the machine. In particular, such bulks do not allow performing drilling close to walls or corners formed by two walls, since by bringing the machine close to the walls a contact of the barriers with such walls occurs, preventing further approach of the drilling shafts. In this way, it would not be possible to carry

out any "wall-flush" drilling typical of consolidation and restructuring works. In the same way, in order to be possible to open the barriers, it is necessary to have enough space around the mast to allow the rotation or translation movement without interference with obstacles during the trajectory of the movement. The presence of the barriers, therefore, represents an obstacle to the manoeuvres and is limiting for the drilling that can be carried out.

[0011] The aforementioned limitations are not compatible with the confined spaces of building sites in which drilling machines generally work, in particular in an urban environment, in which the agility of the machine is essential. The bulk of the barriers, also in the open position, hinders the step of adding or removing shafts in the drilling battery. Moreover, the need to carry out continuous opening and closing of the barriers for loading the shafts determines an increase in work time and requires complication of the hydraulic and electrical systems to manage the actuation of such barriers.

[0012] A further limitation of this solution consists of the increased weight of the drilling machine, with a consequent reduction of the stability due to the frontally cantilevered positioning of the barriers. The use in horizontal drillings (tie rods) with very low heights, less than 1.6 metres, would also force to arrange barriers for the entire length of the mast, so as to always protect the operator in any position he is. In this case, however, these barriers would have points of contact and interference with the ground and would make the loading of the shafts awkward, since the mobile parts for the access to the shafts are considerably heavy, since the length of the shafts themselves can even reach ten metres.

[0013] An alternative known solution consists in using individuation sensitive devices, like for example electro-sensitive, photosensitive, laser, optical, radar, ultrasound or thermal devices. Such devices emit signals to generate barriers around the dangerous area. If a person or an object crosses such barriers, it will trigger the sensitive devices, causing the stop of the functions of the machine.

[0014] However, this solution also has some problems. Such problems arise in all cases for which the sensitive devices must register the approach of a building yard worker, carrying a sensor signalling the approach to a detection source. In particular, these types of sensors or tags are installed on clothing and are well detected by the individuation sensitive devices. However, in the case in which these clothes are not worn or are removed, the individuation device is no longer able to detect the presence of these types of sensors or tags, thus allowing the building site personnel to enter a forbidden area without being detected.

[0015] In addition, a person detecting device, operating with a visual/optical principle, may not be operating and effective in a working environment like that of drilling sites, where there is usually interference due to dust, water, mud, cement, debris and piles of soil that are projected from the excavation hole even to great height and long distances.

[0016] The purpose of the present invention is therefore that to make a safety system for excavation equipment and, more specifically, a safety system used in excavation equipment for controlling the dangerous area surrounding a drilling machine and for interrupting the dangerous manoeuvres of the machine itself, which is able to solve the aforementioned drawbacks of the prior art in a simple, cost-effective and functional manner.

[0017] In detail, a purpose of the present invention is to make a safety system for excavation equipment that is able to minimise the possibility of undesired stops of a drilling machine in the absence of dangerous conditions, whilst simultaneously maintaining the maximum reliability in detecting conditions of actual danger.

[0018] Another purpose of the present invention is to make a safety system for excavation equipment that is able to easily and safely detect the presence of personnel in predefined areas around the drilling machine.

[0019] The invention thus proposes to equip the personnel assigned to the drilling machine with portable sensors, so as to easily detect their presence. In particular, such a purpose is accomplished through a portable sensor that is combined with a second sensor so that, only when both sensors are close to each other, they are capable of transmitting a signal to an individuation unit. Moreover, such sensors are individuated by an entry barrier to the relevant area of the drilling machine, so that access is permitted to the area exclusively to people provided with the respective sensor. The barrier that encloses the drilling machine in its inside is connected to the machine itself, so as to interact with it, performing signalling and controls. In this way, the safety of the workplace is increased and access to the work areas or to the forbidden areas can be traced and prevented.

[0020] These purposes according to the present invention are accomplished by making a safety system for excavation equipment as outlined in claim 1.

[0021] Further characteristics of the invention are outlined by the dependent claims, which are an integral part of the present description.

[0022] The characteristics and advantages of a safety system for excavation equipment according to the present invention will become clearer from the following description, given as an example and not for limiting purposes, referring to the attached schematic drawings, in which:

figure 1 is a perspective view of excavation equipment provided with a safety system according to an embodiment of the present invention, shown in a vertical work configuration;

figure 2 is a perspective view of the excavation equipment of figure 1, shown in a horizontal work configuration;

figure 3 shows a first embodiment of sensors belonging to the safety system according to the present invention, transported or worn by a building site worker;

figure 4 shows a particular embodiment of a sensor belonging to the safety system according to the present invention; and

figure 5 shows a second embodiment of sensors belonging to the safety system according to the present invention, worn by a machine operator.

[0023] With reference to the figures, a safety system for excavation equipment 1 according to the present invention is shown. The excavation equipment 1, in a *per se* known way, consists of a drilling machine suitable for all digging technologies by rotation, rotopercussion, vibration, roto-driving and mixing and injection and can be of the type for making piles, micro piles, tie rods or mechanical mixing.

[0024] The drilling machine 1 comprises a machine-base 2, equipped with tracks or wheels, which allow the movement in the building site, a guide antenna or mast 3, on which the digging means slide, and a linkage 4 that allows the movement of the guide antenna 3 with respect to the machine-base 2 to take it reversibly from a closed configuration, used for transportation, to a work configuration, in which the guide antenna 3 can be arranged vertically, inclined or horizontal.

[0025] The guide antenna 3 is slidably coupled with at least one rotary table 5, or rotary, arranged to support and move a drilling or digging battery 6 that comprises at least one drilling segment or shaft 6A. In detail, the rotary head 5 is coupled with the guide antenna 3 so that it can slide along the guide antenna 3 itself to cause the excavation battery 6 to move forwards or backwards during drilling. On rotary head 5 an excavation battery 6 can also be mounted on it, which uses percussion and/or vibration in addition to rotation.

[0026] Preferably, the excavation battery 6 can comprise at least one supplementary drilling segment or shaft 6A that must be added during drilling, in particular when the excavation or treatment depth that is wished to be reached is greater than the stroke of the rotary head 5. In this case, during excavation, at the end of the first stroke of the rotary head 5, it is necessary to disconnect the rotary head itself from the last drilling driven in shaft 6A and to lift it in order to add one or more supplementary drilling shafts 6A that are screwed on those that have already been driven in. In order to allow such an operation, at the base of the guide antenna 3 there is at least one pair of clamps 7 that allow holding the last drilling driven in shaft 6A and disconnecting the rotary head 5 or another drilling shaft 6A from the shaft itself.

[0027] The pair of clamps 7 can comprise a pair of gripping clamps or, alternatively, a gripping clamp and an unscrewing device. The supplementary drilling shaft 6A is then connected to the excavation battery 6 at a predetermined height above the clamps 7. In the case of double-head drilling, both the drilling shafts 6A, and suitable coating tubes, externally coaxial with respect to such drilling shafts 6A, are used. The coating tubes require the application of three clamps 7, at least one of which con-

sists of an unscrewing device.

[0028] At the end of the excavation it is necessary to repeat the aforementioned operations in reverse in order to extract the excavation battery 6, unloading the drilling shafts 6A in sequence. The steps of loading and unloading the drilling shafts 6A can require, for their correct positioning, the intervention of an operator who must therefore get close to the drilling axis, in order to lift them or at least to direct them with respect to the drilling shafts 6A held by the clamps 7. The maintenance, inspection and replacement operations of the digging tool can also require the operator to get in said area. The area close to the guide antenna 3 and to the excavation battery 6 is considered dangerous, since the operator could come into contact with the rotary members and consequently could get caught in them and be dragged. Another danger can be caused by the movement of the rotary head along the guide antenna 3, which could hit or drag the operator.

[0029] In order to avoid the operator or other building site worker being exposed to dangers during the aforementioned steps, the safety system of the present invention is equipped with a first receiving or individuation unit 8B arranged close to the base of the guide antenna 3, when this is in the work configuration close to the vertical, as represented in figure 1. Such a first receiving or individuation unit 8B is capable of detecting the presence of a sensor within a predefined range of action that, can also be adjustable and that at least partially comprises the dangerous area around the guide antenna 3. The detection area of the first receiving or individuation unit 8B is defined in a first case by the volume of a sphere. Indicatively, the radius of this sphere could be variable from a few tens of centimetres to some metres. Alternatively, the individuation area can develop according to radial surfaces passing from the source, therefore in this case the volume would be a solid with vertical generatrices. In this way, in both variants, the first receiving or individuation unit 8B covers a volume, the projection of which to the ground is represented by the shape enclosed by the curve 12 of figure 1. Such a curve 12, that can coincide with a circumference, envelops the excavation battery 6 and is at a distance such as not to allow a contact between the building site workers and the rotary parts of the drilling machine 1, consisting of the excavation battery 6 itself. The first receiving or individuation unit 8B can operate on the basis of an electromagnetic waves technology (radio waves) or other equivalent systems (radar, magnetic, optical, etc.). The first receiving or individuation unit 8B, as stated earlier, is adjustable in the detection or individuation distance of the signal. In particular, such detection can be programmable and can assume composite geometrical shapes, such as to incorporate prismatic volumes of different shapes or local areas having different volumes. In a variant, the first receiving or individuation unit 8B is capable of discriminating a signal at two distances and therefore of detecting the approach of the support personnel to the drilling machine 1 and, in particular, to an area close to the danger-

ous area, the perimeter of which is formed by the curve 12. In this way, the detected approach can generate control and warning actions (light or sound) both by the same first receiving or individuation unit 8B, and communicating with an individuation and control/processing unit 10, described hereafter. Similarly, a double receiving unit programmed to detect two different distances allows discriminating and controlling two areas, the smallest of which, the dangerous one, is at least partially included in the larger one.

[0030] Figure 1 shows a first building site worker 100 who is the operator of the machine or drill. Increasingly frequently the operator 100 of the drilling machine 1 preferably uses remote-actuated control devices 9, equipped with a signalling and control cable 16 (wired controls) or with radio transmission (radio controls). These remote-actuated control devices 9 have developed in the field so as to no longer force the operator 100 to stay in a fixed location 9B on the side of the drilling machine 1, but rather, in certain cases, to leave him free to move around the machine 1 itself and find the most suitable and safe position in order to control, with maximum visibility, all the work steps, from the digging steps to the translation and positioning steps. The new problem that emerges is that with such devices the machine operator 100 as well, during the digging steps (thus with drilling battery 6 in movement, i.e. in rotation) can approach the forbidden area delimited by the curve 12 defined around the excavation battery 6.

[0031] The same problem also occurred in the past for the second building site worker, in general a helper 110 of the machine operator 100. Such a helper 110 amongst other things, provides for keeping the work area clean, coordinates the operations to be carried out during the drilling and in particular, if necessary, loads the drilling shafts 6A, feeding the drilling battery 6 and thus allowing the depth required by the project to be reached. Both operators 100 and 110 can thus be close to the drilling battery 6 during the digging steps, with the drilling shaft 6A in rotation, and possibly cross the forbidden area delimited by the curve 12.

[0032] With reference to figure 5, the machine operator 100 is shown equipped with the remote-actuated control device 9. The machine operator 100 wears a first sensor 8C', preferably but not necessarily fixed to own helmet 25. A second sensor 8F, on the other hand, is fixed to the remote-actuated control device 9.

[0033] When the operator 100 approaches the remote-actuated control device 9, the two sensors 8C' and 8F come into contact and detect the mutual presence. Such connection can preferably be made through a signal cable 23 that, through a pin 24, puts the two sensors 8C' and 8F in connection. Alternatively, the same sensors 8C' and 8F can come into contact through a radio connection or, in an equivalent manner, through wireless systems capable of ensuring the safety standard required for these types of transmissions. Advantageously, the enabling of the controls to use the remote-actuated con-

trol device 9 can be only given by the presence of the first sensor 8C', therefore only after having established the connection between such a first sensor 8C' and the second sensor 8F (via radio or via cable 23).

[0034] When the two sensors 8C' and 8F are in contact with each other, they are capable of transmitting their signal, preferably via radio, to the receiving or individuation units 8B, 10 and 8A (the latter described hereinafter). In this case the transmission could also occur through the cable 16 of the remote-actuated control device 9, or via radio through the remote-actuated control device 9 itself.

[0035] The first sensor 8C' can be worn on the helmet 25, could be made in the form of a bracelet 8D' and be inserted on the arm, or it could be inserted onto the high visibility jacket or onto the shoes of the operator 100. In any case, the first sensor 8C' should preferably be visible so that the other people present in the building site area can notice its presence or absence. Advantageously, such a sensor 8C' could also emit a light so as to be easily recognisable.

[0036] With reference to figure 3, the helper 110 is shown, wearing a first sensor 8C" analogous in functions, type and mode of installation to the first sensor 8C' of the machine operator 100. In this case, not having the remote-actuated control device 9, located at a distance from the first sensor 8C", the helper 110 will have a second sensor 8D", for example in the shape of a bracelet that can be worn on the arm and that, similarly to the two sensors 8C' and 8F of the machine operator 100, can enter into communication with the first sensor 8C" with the same modalities described for such two sensors 8C' and 8F of the machine operator 100. Also in this case the two sensors are transported or worn on different parts of the body, so as to generate the request for a connection between the two sensors themselves in order to establish a contact thereof. In this way, once established the connection between the first sensor 8C" and the second sensor 8D" of the helper 110, it is possible to send a signal towards the receiving or individuation units 8B, 10 and 8A. At least one of the two sensors 8C" and 8D" is capable of operating in data transmission mode. All sensors 8C', 8F, 8D', 8C" and 8D" so far described are equipped with a connection to a local energy source, consisting of a battery that advantageously will indicate its charge status through a visible luminous device (for example of the LED type).

[0037] The advantage of this system is that in the case in which:

- a sensor 8C', 8F, 8D', 8C" and/or 8D" breakage occurs;
- communication problems occur between the sensors of a single operator 100 or 110 that are placed at a distance from each other;
- one of the two sensors of a single operator 100 or 110 is too far from the other sensor;
- one of the two sensors of a single operator 100 or

110 is removed, for example because the operator 100 or 110 removes his helmet 25 and puts it down, forgetting it;

- the operator 100 leaves the remote-actuated control device 9 active (with levers in the active control position) in order to carry out other activities,

the safety system is capable of detecting it and therefore can have the emission signal missed, or even better, could send a breakdown signal, for example to an individuation and control/processing unit 10 positioned on the drilling machine 1, and integrated with the control circuit of the drilling machine 1 so as to be able to intervene on it. When the problem highlighted earlier occurs, the individuation and control/processing unit 10 receives a variation of the signal emitted by at least one of the sensors, or compares the presence and the absence over time of the signal itself, and is thus capable of activating certain signals or of carrying out command or control actions on the drilling machine 1 being connected to its control circuit.

[0038] A signal could be of the visual type inside the building site, like for example the switching on of a flashing danger device, or it could be of the sound type, with the activation of an alarm sound. An action, for example in the case in which the connection is missing between the first sensor 8C' and the second sensor 8F placed on the remote-actuated control device 9, i.e. in the most probable case in which the operator 100 has left such a remote-actuated control device 9 (deliberately disconnecting the connection 24 in the case of via cable connection or simply taking the control device away from the first sensor, thus making the radio connection lack) and has gone too far away from it, could be that of stopping the drilling manoeuvres and, in particular, the rotation of the drilling shaft 6A.

[0039] As illustrated so far, the advantages of the safety system for excavation equipment according to the present invention are already clear, both in terms of safety, and above all to avoid the possibility of tampering the sensors with or, starting from a certain moment, not being worn by the operators. A further variant provides to connect more than two sensors, for example also connecting sensors 8E' and 8E" (figure 1), still worn by the operators or present on the remote-actuated control device 9 to the previous sensors already described.

[0040] With reference to figure 4, a detail of installation of the first sensor 8C" is shown, preferably but not exclusively fixed on the protective helmet 25 of the operator 100 or of the helper 110, in which the second sensor 27 combined with it consists of an inertial device, preferably an accelerometer. Such sensors, connected to each other, equipped with a proper battery and installed in a fixed manner (but possibly interchangeable) on the helmet 25, are capable of transmitting information to the receiving or individuation units 8B, 10 and 8A according to the same modalities described previously. In this case, the second sensor 27 is capable of detecting sudden move-

ments of the helmet 25. In particular, when the helmet 25 is removed from the head of the operator, the accelerometer or the inertial device 27 would detect the variation of the acceleration and would be capable of communicating this variation to the first sensor 8C" and, therefore, to the receiving or individuation units 8B, 10 and 8A. In this case the action of removing the helmet 25, or slipping over and fall by a worker 100 and/or 110, would lead the safety system to signal the danger of the event and therefore the receiving or individuation unit 8B and/or 10 mounted on the drilling machine 1 could in turn send a signal, or act as described previously.

[0041] When the workers 100 and 110, also defined as support personnel to the drilling machine 1, approach the forbidden area 12, the receiving or individuation unit 8B, fixed on the drilling machine 1 itself or close to the excavation battery 6 (for example fixed to the ground and supported by a support), detects the presence of the sensors in connection with each other (8C', 8F, 8D', 8C", 8D", etc.) and consequently blocks the drilling, for example stopping at least the rotation or also the axial movement manoeuvres of the rotary head 5 along the guide antenna 3, preventing the contact of people with the rotating parts. In this way, it is ensured that the receiving or individuation unit 8B is capable of detecting the sensors and therefore people, because they could worn the sensors and not have removed them. Moreover, a further advantage is that of also preventing the machine operator 100 from coming into contact with the rotating parts (drilling shafts 6A), going beyond the forbidden limit delimited by the curve 12 and thus entering the forbidden area.

[0042] With reference to figure 2, a drilling machine 1 is shown that is totally analogous to the one described so far, except for the fact that it is equipped with a different linkage 4 that allows the movement of the guide antenna 3 with respect to the machine-base 2, as well as with an automatic loader to feed the drilling shafts 6A, in a horizontal drilling configuration. In this type of drilling machine 1, when the height of the drilling battery 6 can be reached by the workers, there is still the risk of coming into contact with rotating parts.

[0043] Therefore, in this case, it will be necessary to protect the event for the entire length of the drilling battery 6 and, consequently, to generate a forbidden area delimited by the curve 12 (broken line with dashes and dots in figure 2) that adequately incorporates the entire drilling battery 6 itself. In the case in which a single receiving or individuation unit 8B is not capable of covering the entire forbidden area 12, a plurality of receiving or individuation units 8B will be mounted, preferably integral with the guide antenna 3 or equivalently fixed to the ground or on the drilling machine 1, so as to cover the entire forbidden area 12 and to allow individuating the signal along the entire drilling battery 6. In the case of inclined drilling, the receiving unit or the receiving or individuation units 8B can be installed to cover all dangerous areas around the drilling battery 6 up to the heights that can be reached by the workers 100 and 110 (for example up to 2 metres

in height).

[0044] In order to further increase safety, the work area of the drilling machine 1 is shut off by a barrier consisting of different protective elements, here represented in figures 1 and 2 as 14A, 14B, 14C, 14D and 14E. Such a barrier can be of the physical or mechanical type, or it can in turn consist of sensitive devices. The main characteristic of such a barrier is however that of being closed around the drilling machine 1, identifying a work area 13 inside which access is only permitted to authorised personnel, i.e. the workers 100 and 110. In particular, the barrier has at least one access opening between two end elements 17' and 17" of the protective elements 14E and 14A. Such an access opening is in turn equipped with a receiving or individuation unit 8A of the sensors described previously.

[0045] In the example embodiment shown in the figures, the barrier consists of protective elements 14A-14E, that can be fixed to each other and interconnected, provided with an electric circuit. Once the complete mounting of the barrier has been carried out, the electric circuit is closed and the safety system will therefore be able to pass current and, therefore, to signal that the barrier is correctly closed.

[0046] The receiving or individuation unit 8A and the electric circuit of the barrier can be supplied by an autonomous energy source, or be connected and supplied by the drilling machine 1. A connection via cable 15 or via radio will allow the transmission of the data from the access opening, in particular from the individuation unit 8A towards the individuation and control/processing unit 10 positioned on the drilling machine 1, in order to process the signal received by the different receiving or individuation units 8A and 8B.

[0047] The passing of a person across the opening is detected by the receiving or individuation unit 8A that also detects the presence of the various sensors (8C', 8D', 8E', 8F, 8C", 8D", 8E", 27) and, consequently, only allows the passage to workers who possess such sensors, instead signalling the passage of people without the sensors (or having sensors not connected) and who therefore are not authorised to access the work area of the drilling machine 1.

[0048] The signal, reaching the individuation and control/processing unit 10, will be processed and can start off signals (visual, acoustic) or control actions (stop the rotation, stop the drilling, switch off the machine). It is therefore clear how the barrier can ensure that unauthorised people cannot enter the work area of the drilling machine 1.

[0049] The first time the safety system is switched on it is possible for the opening not to be active, so that, for example, the operator can enter the area (entering from the opening itself that could be locked by a gate) and enable the drilling machine 1 the first time it is switched on. The drilling machine 1 cannot be switched on until the operator has worn at least the device with the sensor and, consequently, the connection has been established

with the second sensor (generally the one placed on the remote-actuated control device 9 or worn) and, in addition for example, until the operator 100 himself has left the opening so as to make his first entry. Entering the active opening and having enabled the drilling machine 1, the latter having a signal recognising that the machine operator 100 has worn the safety system with sensor, the individuation and control/processing unit 10 can then allow the switching on and afterward the drilling.

[0050] As variants to the system and to the method described, it is possible to consider that the machine operator 100 does not have a remote-actuated control device 9, but just a fixed work station 9B (indicated in figure 1). In this case, the sensor 8F could be inserted on the drilling platform, or the machine operator 100 could have the same set-up of sensors as the helper 110.

[0051] In addition to the sensor or to the sensors described earlier, the safety system also includes a satellite position emitter, for example a GPS. The positions of all of the authorised workers present in the work area 13 are thus displayed on a monitor that localises their spatial position in the area of the building site 13. The monitor is placed close to the machine operator 100. When the drilling machine 1 is provided with a fixed control station with control seat, the monitor will be inserted into the cabin.

[0052] It is therefore intuitive for the system to detect the presence of the workers 100 and 110 provided with the relative safety devices and locate them with respect to the drilling machine 1, as well as display their position, warning about their dangerous approach to the forbidden area (thus already preparing the machine operator 100 to carry out safety manoeuvres like stopping the rotation of the shafts 6) or monitor waiting for the receiving or individuation unit 8B to detect the presence in a forbidden area, delimited by the curve 12.

[0053] The barriers can be extended as desired by adding more modular protective elements. Advantageously, the connections of the circuit between one protective element and another will be automatic, through the insertion of male-female connectors between the parts to be installed (for example between the protective elements 14A and 14B of figure 1) or through plugs to be connected. By adding more protective elements it is possible to enlarge the delimited area 13 as desired, allowing the drilling machine 1 to make more holes without having to remove or modify the geometric arrangement of the barrier.

[0054] In order to determine whether a person is entering or leaving the opening, the receiving or individuation units 8A can be a pair and the activation sequence identifies the movement direction. Or the receiving or individuation unit 8A can be combined with position sensors that determine the movement direction and the information is transmitted, together with the other signals, to the individuation and control/processing unit 10. Each sensor (8C', 8D', 8E', 8F, 8C", 8D", 8E", 27) can consist of a tag or a radio frequency identifier (RFID).

[0055] It has thus been seen that the safety system for excavation equipment according to the present invention achieves the purposes outlined earlier, obtaining in particular the following advantages:

- elimination of the bulk problems of the mechanical barriers (guards);
- use of individuation devices that detect a sensor, thus not influenced by the environmental conditions (dust, water, projection of debris or cement);
- certainty that the sensors stay worn or detected when no longer worn;
- safety against the danger that the operator with remote control approaches the dangerous and forbidden area;
- guarantee that inside the work area just authorised personnel provided with sensors that can be detected by the individuation devices is present, with the help of the barriers equipped with one or more access openings communicating with the drilling machine;
- visual signalling of the position of the workers preventing dangerous manoeuvres, like for example reversing the drilling machine with a person positioned at the back of the machine itself and not easily visible, or detecting the approach of a worker to the forbidden area, with the consequent possibility of preventing such action.

[0056] The safety system for excavation equipment of the present invention thus conceived can in any case undergo numerous modifications and variants, all of which are covered by the same inventive concept; moreover, all the details can be replaced by technically equivalent elements. In practice, the materials used, as well as the shapes and sizes, can be whatever according to the technical requirements.

[0057] The scope of protection of the invention is therefore defined by the attached claims.

Claims

1. Safety system for controlling a dangerous area of an excavation equipment (1) provided with a guide antenna (3), as well as a rotary head (5) coupled in a sliding manner on said guide antenna (3) and arranged for supporting and moving an excavation battery (6), said dangerous area being delimited by a curve (12) which develops at a predetermined distance from the excavation battery (6), said safety system being **characterized in that** it comprises:

- at least one pair of portable sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27) intended to be transported by the support personnel to said excavation equipment (1), wherein the two sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27) of each pair

of sensors are in communication with each other and at least one of said two sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27) is capable of generating a signal further to the detection of the mutual presence of said two sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27); and
 - at least one receiving or individuation unit (8A, 10, 8B) operatively connected to said at least one pair of portable sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27), said at least one receiving or individuation unit (8A, 10, 8B) being capable of receiving the signal emitted by at least one of said two sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27).

2. Safety system according to claim 1, **characterized in that** said at least one receiving or individuation unit (8B) is capable of receiving the signal emitted by at least one of said two sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27) within a predefined range of action at least partly comprising said dangerous area.
3. Safety system according to claim 1 or 2, **characterized in that** said at least one receiving or individuation unit (10) is a control/processing unit positioned on said excavation equipment (1), said control/processing unit (10) being capable of generating an alarm and/or of intervening on the operation of said excavation equipment (1) according to the information based on said signal.
4. Safety system according to any claim 1 to 3, **characterized in that** the operating connection between said at least one pair of portable sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27) and said at least one receiving or individuation unit (8A, 10, 8B) is carried out on the basis of an electromagnetic waves technology (radio waves).
5. Safety system according to any claim 1 to 3, **characterized in that** the operating connection between said at least one pair of portable sensors (8C', 8D', 8E', 8F; 8C", 8D", 8E", 27) and said at least one receiving or individuation unit (8A, 10, 8B) is carried out via cable (15).
6. Safety system according to any claim 1 to 5, **characterized in that** a first sensor (8C'; 8C") of each pair of sensors is fixed to a helmet (25) that can be worn by the support personnel to said excavation equipment (1).
7. Safety system according to claim 6, **characterized in that** a second sensor (27) of said helmet (25) is constituted by an inertial device, operatively connected to the first sensor (8C') of said helmet (25) and capable of detecting sudden movements of said

helmet (25).

8. Safety system according to claim 6, **characterized in that** a second sensor (8F) of each pair of sensors is fixed to a remote-actuated control device (9) for controlling said excavation equipment (1). 5
9. Safety system according to any claim 1 to 8, **characterized in that** said at least one receiving or individuation unit (8B) is located on the basis of said guide antenna (3). 10
10. Safety system according to any claim 1 to 8, **characterized in that** said at least one receiving or individuation unit (8B) is fixed on the ground close to said excavation battery (6). 15
11. Safety system according to any claim 1 to 8, **characterized in that** it comprises a plurality of receiving or individuation units (8B) integral with said guide antenna (3), said plurality of receiving or individuation units (8B) being capable of detecting the presence of at least one of said sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27) within a predefined range of action that coincides with said dangerous area, and wherein said dangerous area (12) extends by the entire length of said drilling battery (6). 20 25
12. Safety system according to any claim 1 to 11, **characterized in that** it comprises a barrier (14A, 14B, 14C, 14D, 14E) configured to delimit a work area (13) where the excavation equipment (1) operates, said barrier (14A, 14B, 14C, 14D, 14E) being closed around said excavation equipment (1) and provided with at least one access opening provided with a receiving or individuation unit (8A). 30 35
13. Method for controlling a dangerous area of an excavation equipment (1) provided with a guide antenna (3), a rotary head (5) coupled in a sliding manner on said guide antenna (3) and arranged to support and move an excavation battery (6), said dangerous area being delimited by a curve (12) that develops at a predetermined distance from the excavation battery (6), the method comprising the steps of: 40 45
 - generating a signal by at least one sensor (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27) of at least one pair of portable sensors intended to be transported by the support personnel to said excavation equipment (1), wherein said signal is generated further to the detection of the mutual presence of the two sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27) of each pair of sensors; and 50
 - receiving said signal by at least one receiving or individuation unit (8A, 10, 8B) operatively connected to said at least one pair of portable sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27), where- 55

in said at least one receiving or individuation unit (8A, 10, 8B) is capable of receiving said signal.

14. Method according to claim 13, wherein said signal is generated when the support personnel to said excavation equipment (1) is close to said dangerous area delimited by the curve (12), said reception of the signal implying a step of modifying the operation of said excavation equipment (1) comprising at least the stop of the excavation battery (6).
15. Method according to claim 13 or 14, wherein upon occurrence of at least one of the following situations:
 - breakage of at least one sensor (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27);
 - communication problems between the two sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27) of at least one pair of sensors; and/or
 - exceeding a predefined distance value between the two sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27) of at least one pair of sensors, the receiving or individuation unit (10) receives a signal variation, or compares the presence and the absence of said signal over time, and it is thus capable of activating certain signals and/or control actions on the excavation equipment (1).
16. Method according to any claim 13 to 15, comprising a controlling step, by at least one receiving or individuation unit (8A) installed on an access opening of a barrier (14A, 14B, 14C, 14D, 14E) configured for enclosing a work area (13) of the excavation equipment (1), of the passage of people through said access opening, so as to allow the access to the personnel provided with said portable sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27) and instead signalling the passage of people without said sensors and who are thus not authorized to access said work area (13).
17. Method according to any claim 13 to 16, comprising a preliminary step of controlling the ignition of the excavation equipment (1) by said receiving or individuation unit (10), wherein said ignition is prevented until the support personnel to said excavation equipment (1) is not provided with said portable sensors (8C', 8D', 8E', 8F; 8C'', 8D'', 8E'', 27).

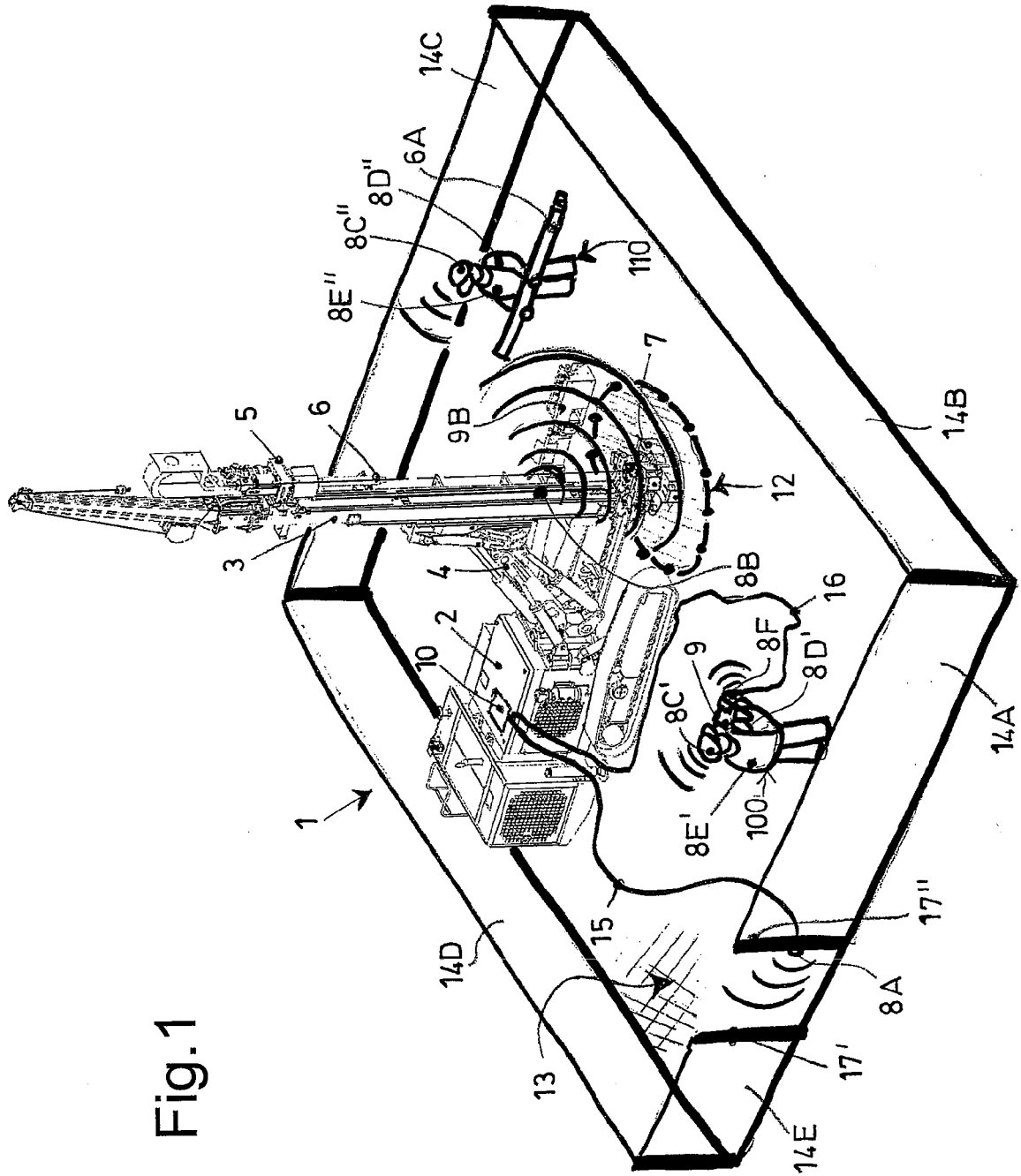


Fig. 1

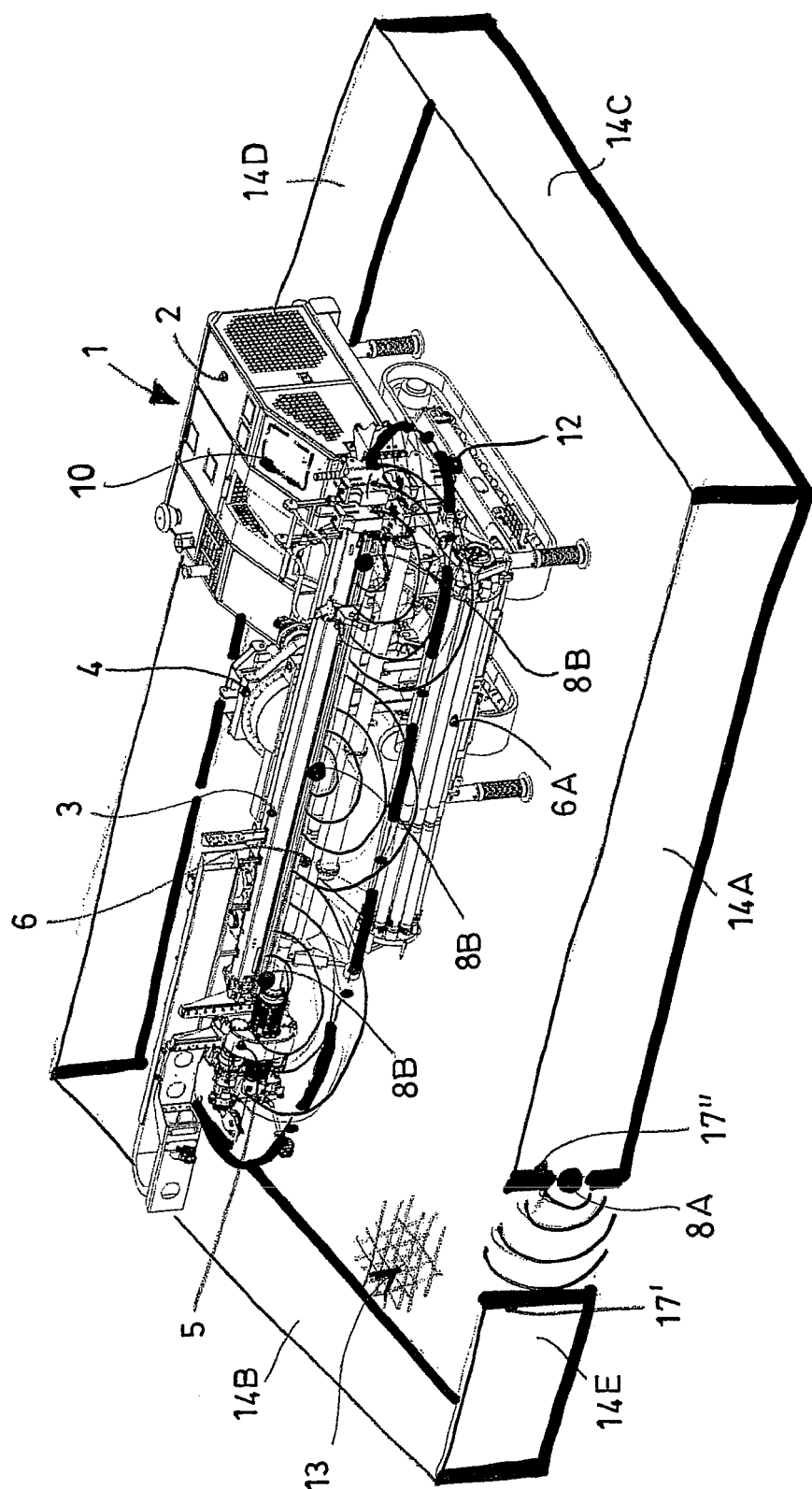


Fig.2

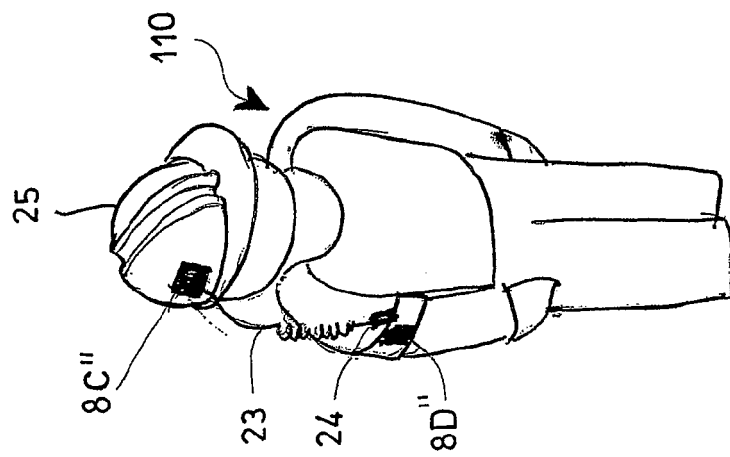


Fig.3

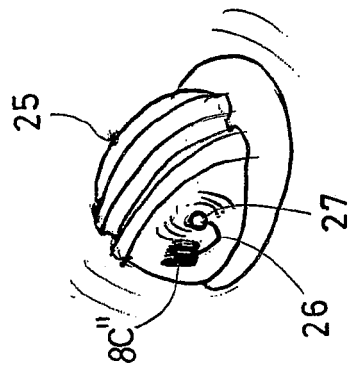


Fig.4

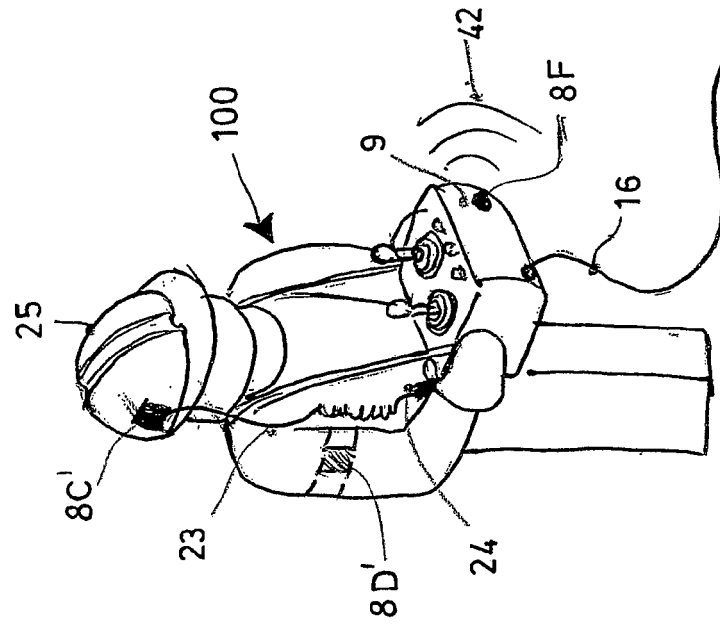


Fig.5



EUROPEAN SEARCH REPORT

Application Number
EP 15 17 0571

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			E21B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 28 September 2015	Examiner Manolache, Iustin
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