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(54) **Safety component**

(57) The invention relates to a safety component for controlling movements of machines, which movements are provided by a fluid system. The safety component (10) is arranged by means of at least one digital valve group (DV).

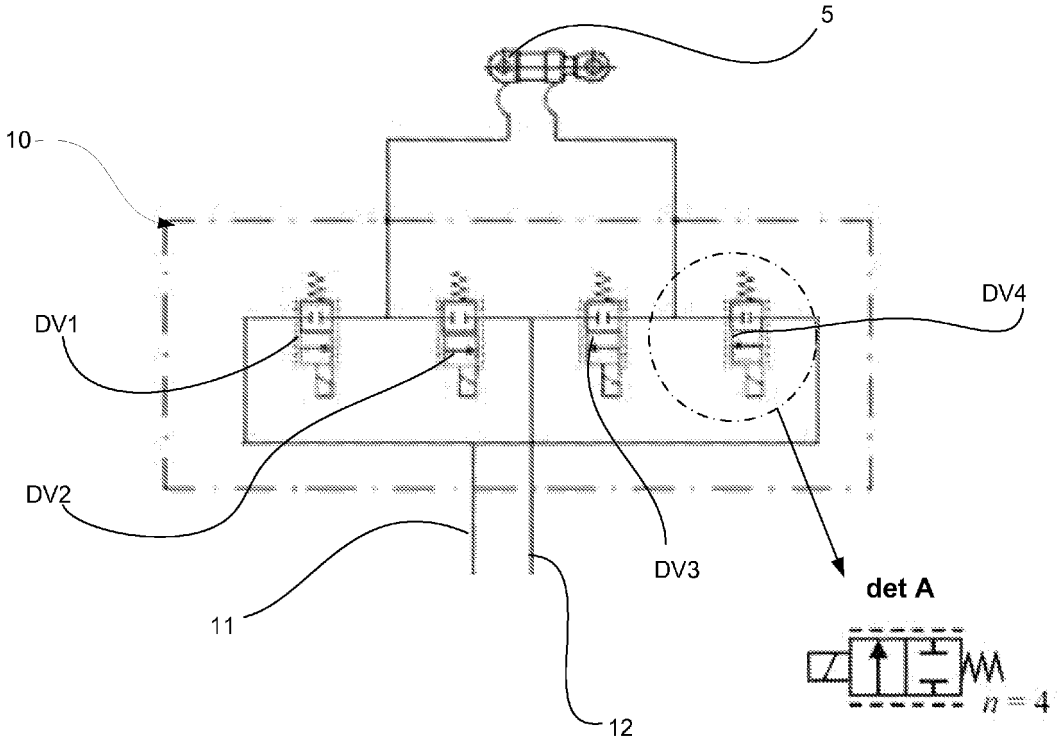


Fig. 1

EP 2 543 890 A1

Description

[0001] The invention relates to a safety component according to the preamble part of claim 1.

[0002] Recently more and more focus has been given to product and production safety due to new and modified legislation and standards relating to products and production of them due to the need to protect consumers and working personnel. Focus has also been given to safety of fluid systems for example systems based on hydraulics or pneumatics.

[0003] A safety component is a device or a part that forms one unit and that is exchangeable and that provides for a safety function and that when malfunctioning endangers persons within its working area and that is not needed for functioning of the machine or machinery that it is combined with and that could be replaced by a ordinary component for the machine or machinery to function. The functional components of machines or machinery are not considered as safety components but instead they are especially designed for providing a safety function. Safety components are defined in Machinery Directive 2006/42/EC. The present invention relates especially to safety components as defined in Appendix 5 item 5 Valves meant for controlling dangerous movements of machines that have a special function of detecting failure.

[0004] Hydraulic and pneumatic systems and actuators used in them are generally used for the generation of motions and forces. Actuators get their driving force from a hydraulic or pneumatic aggregate in the form of a pressure medium i.e. fluid that can be in form of gas, liquid, a mixture of gas and liquid and sometimes even comprising medium in solid form.

[0005] Safety design of machines and machinery is usually based on stopping movement of a moving machine part before someone is entering the area of danger due to this movement, for example gates with electric locks are provided. In prior art also different types of devices base on detecting a human are used as safety components but in practise many on them have deficiencies that make their use as safety components restricted to certain, limited uses as they seldom have properties that provide for fault tolerance.

[0006] Sometimes there exist needs for limiting movement speed of machine parts due to needs of process technique or maintenance even when someone is in the area of danger. In these cases in the prior art complicated and several instruments requiring systems are used in order to restrict the movement regulated by the fluid system safely enough. Typical objects are, for example, motions of different cars, levers, such as locking jaws or levers, rotating motions, such as rotating a primary wind-up device onto rails, etc. For example in maintenance stage of reel-ups or slitter-winders of fiber web machines the need for limiting the hydraulic movement speeds of machine parts is to limit the speed to level 5 % - 10 % of maximum speed. In prior art systems this is done by limiting a proportional valve control programmable.

[0007] Safety needs described above exist in many different fields of technology, for example energy production, mining, automation, production of products for example fiber web production lines, automation and refinery etc. Especially fiber web for example paper, tissue, pulp or carton web production lines have many process parts that need to be secured from anyone entering within the area of production when machinery is working at production speed but need to be accessed for maintenance or process technical steps when the machinery is working at low speed. This is due also of the fact that the production process start up after a break comprises step involving danger for example during tail threading of the web.

[0008] In prior art safety components have been designed as a separate devices or systems in addition to the components that provide the functional properties needed by the machine or machinery.

[0009] An object of the invention is to further develop the technology of safety components so that controllability and adjustability, and operational reliability would be improved, and the need for service of the functions or actuators would decrease.

[0010] It is also an object of the invention to achieve a device which would be robust and durable, among others, in surprising overload situations.

[0011] A non-limiting further object of the invention is to provide a safety component that reliably provides a slow movement that is safe when process or maintenance requires someone to be in an area of danger but does not allow anyone present i.e. provides safety when machine or machinery is working in fast speed.

[0012] It is also a non-limiting object of the invention to provide a safety component for a process or system that prevents danger by stopping the process or system but also provides the possibility of maintaining the process or system in low, safe speed when needed.

[0013] It is further a special object of the invention to considerably speed up response times for the fluid control system so that the adjustments of the said devices, such as reel-ups and slitter winders can be made especially fast and precisely, when desired.

[0014] It is characteristic of the apparatus of the invention that the safety component is arranged by means of at least one digital valve group. According to an advantageous embodiment of the invention the safety component is arranged bymeans of at least two digital valve groups.

[0015] According to the invention a valve for a fluid system is provided that utilises the digital technique and by which speed of a movement can be restricted with very high reliability. By the invention a safety component that combines safety to a component with a functional property is created.

[0016] According to an advantageous feature of the invention the digital valve functioning as safety component is two ways safe as substantially simultaneously both the work side flow and the return side flow back to the tank are limited.

[0017] According to one advantageous embodiment of the invention a digital valve group comprising at least two digital valves a safety component combines limiting of speed of a movement (flow) as required with chosen valve groups and coils and an electrically controllable group is created. Double control can be provided according to an advantageous feature by a safety relay. Thus by the invention the safety function is provided reliably as hardware.

[0018] According to an advantageous feature of the invention speed (flow of fluid) is defined by affecting the electrical connection of a valve. Thus more than one speed can be defined for the valve.

[0019] The present invention provides for many advantages. The fluid system is simplified which brings cost savings both in relation to the functional property and especially in relation to the safety properties in product and production safety and no more two separate component systems are needed. The invention provides for possibilities of creating safety function in combination with force, energy etc functions that are controllable by digital valve technique. As the system is simplified also testing, repairing and using is easier which all factors lower the production cost of machine as well as advance safety of the machine.

[0020] The digital valve technique is also known as being safe even when malfunctions occur. Also the possible malfunction is better controllable than in connection with prior art control valves since a problem in direction of working of shank does not stop functioning of the other valves. As a property of this digital valve technique is high level of fault tolerance and detecting of problems, one single failure does not in practice lead to non-functioning of safety properties.

[0021] Usability of digital valve technique is high and a fluid system based on it is easily designed as required by safety legislation as digital valve does not fail in a harmful way.

[0022] In the manner disclosed by the invention, this can be carried out using digital valve in the manner described later in connection with different embodiments, thus achieving several of the said pursued benefits.

[0023] Especially advantageous embodiments of the invention are such hydraulic systems for a slitter winder or reeler, in which big force and big position accuracy are needed simultaneously. Such embodiments typically comprise functions affecting the fibrous web of a wound fibrous web roll or starts, motions and stops of heavy machine parts. A feature common to all of these is that the processing efficiency of the fibrous web improves, the faster the function in question can be performed. Most often the function is related to a transaction outside the actual wind-up step, such as the beginning or end of the winding up, when the production speed has had to be reduced lower than normal in order to perform the function in question. The invention is advantageously used in connection with fiber web machine applications, for example in connection with secondary carriage of a reel-up, with rotating device of a tambour and in connection with maintenance stages of different machine parts of fiber web machines.

[0024] In connection with the description and claims the following terms are used for facilitating the explanation: the term liquid is mainly used of the pressure medium, but actually this is a fluid, the characteristics of which especially include flow-ability. This fluid can be liquid, gas or, for example, a mixture of liquid and gas or a mixture of some other, for example, solid component part. Digital hydraulics refers to a system, in which at least part of the components is based on digital valves. A digital valve group refers to a valve unit, in which there is at least one digital valve group, which again contains a number of digital valves connected in parallel in relation to the fluid flow passing through the digital valve group. A digital valve again refers to a valve intended for adjusting the fluid's volume flow, the valve having 2 — N different stepped discrete adjustment modes, especially 2 different discrete adjustment modes (open/closed), and for which the control signal to be brought from the control system has advantageously been digitalised, such as binary form. The digital valve has advantageously two modes; it is either fully open or fully closed. When the digital valve is open, the entire volume flow of liquid allowed by the digital valve passes through it, and when the digital valve is closed, no liquid at all passes through it. In this application, such a digitally controllable digital valve having two modes is also called an on/off valve and an on/off digital valve. The digital valve can also have more than two modes, in which case the valve is driven in a stepped manner from one mode to another. The digital valve can have three positions; it lets the liquid flow pass to a first or second direction, or then the valve does not allow any fluid to pass through it. The adjusting directive (control signal) is of a digital nature, such as binary. According to the adjusting directive, the volume flow from the digital valve group and the pressure caused by the flow are adjusted by opening a certain valve combination of the digital valve group so that a desired opening of the digital valve group and a desired volume flow of the fluid are achieved. Deviating from an analogue valve, each digital valve connected in parallel can only have a limited number of adjusting modes, i.e. the digital valve only has certain discrete flowing modes. In one digital valve form, it has three modes: open / closed / quick opening. However, each digital valve preferably has simply the on/off mode; when open, the valve lets a certain volume flow through it; when closed, it completely prevents the fluid from passing through. The digital valve group consists of digital valves with two modes (on/off). In this case, two successive digital valves with nominal volume flow amounts, the volume flow passing through the valve with bigger nominal volume flow in the open position is always two times bigger than the volume flow of the valve with smaller nominal volume flow. A binary control signal can then be brought to such a digital value group, in which the control signal's magnitude has been

converted into a binary number. As an exemplary comparison of differences in the adjustment method between an analogue valve and a hydraulic valve group, the following can be presented: if an analogue valve is adjusted with a control signal (adjusting directive), the magnitude of which is 12 units, the analogue valve stem moves a quantity comparable with 12 control units, in which case the valve lets through a volume flow that has increased respectively. Again, when a digital valve group consisting of five on/off digital valves connected in parallel to the input flow are controlled by a similarly dimensioned control signal (adjusting directive) of 12 units, in which the sizes of the volume flows the digital valves 1, 2, 3, 4, 5 let through are respectively 1, 2, 4, 8 and 16 units, the control signal is binary and sent into a control signal 01100 ($0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 = 12$) (corresponding to the valves 5, 4, 3, 2, 1), and the valves 3 and 4 are opened.

[0025] The invention will next be explained in more detail, referring to the enclosed drawings, in which:

Figure 1 illustrates schematically one example of one advantageous embodiment of the invention.

Figure 2 illustrates schematically one example of digital valve to be used in connection with one advantageous embodiment of the invention.

Figure 3 illustrates schematically one example of digital valve to be used in connection with one advantageous embodiment of the invention.

Figure 4 illustrates schematically one example of digital valve to be used in connection with one advantageous embodiment of the invention.

[0026] In figure a schematically presented example of an advantageous embodiment of the invention is illustrated. This example is based on that movements of a machine part are adjusted by a hydraulic or pneumatic actuator 5 giving the movement stroke. In the system the pressure line 11 is for to inlet fluid flow for providing the movement strokes and the return line 12 is for the fluid medium low to the tank. This example comprises a control valve 10 creating at the same time the safety component. In this example the safety component i.e. the control valve comprises four digital valve groups DV which simultaneously create functions for the safety component 10 (see examples in figure 2 -4). Digital valve group DV1 provides for the control of work movement of actuator 5 and digital valve group DV4 provides for control of return movement of actuator 5 and digital valve groups DV2 and DV3 provide for control return flow back to tank. The control messages used by the digital valve groups and transmitted by the adjusting system are both in digital form, which achieves the considerable benefit in relation to analogue valves that the adjusting information does not need to be converted from digital to analogue so that no information can disappear when converting the digital control message from the adjusting system into an analogue control message.

[0027] By using a digital valve groups DV in the control valve and safety component combination 10, it is possible to control the volume flow of the hydraulic or pneumatic actuator 5 in a very exact manner. In addition, the operation of the digital valve groups DV is considerably fast so that it is possible to control the same hydraulic or pneumatic actuator 5 with the same digital valve group both when changing from fast i.e. production speed required by a big change in volume flow and when changing to low speed for example for maintenance that requires a relatively small change in volume flow.

[0028] For safety component function the control valve 10 is provided by the control of both one digital valve group DV1; DV4 for work stroke and one return flow controlling digital valve group DV2; DV3 simultaneously and thus providing for strong double safety guard as needed.

[0029] In figure 1 also an enlargement of one digital valve group DV is shown as det A.

[0030] In figures 2-4 are illustrated examples for providing the control system for one digital valve group DV. In these figures only few examples of electrical control for one digital group are illustrated but it is clear to one skilled in the art that the possibilities have a large variety. The machine control system comprises single binary valves Q and in the example of figures 2-4 single binary valves Q5 — Q8 are provided with control devices K1, K2 that can be for example safety relays, safety logic units (safety PLCs), relay connections, safety controls built on relays etc. By the control devices K1, K2 safety function is created such that at least partly opening of binary valves connected, i.e. in this example binary valves Q5 — Q8 is prevented. And for the doubling control this is provided at least in two digital valve groups DV1, DV4 i.e. one controlling the work stroke of the actuator 5 and one controlling the return flow back to the tank. In this arrangement also the controllability remains in the desired control area. As shown in figures 2 — 4 the electrical control of one digital valve group can be created by breaking the electric inlet card of the output of logic, by breaking each output separately, by breaking one set of outputs.

[0031] The digital valve group DV can also consist of several on/off valves with different diameters or valves that otherwise let through different volume flows. These valves are controlled to open and close by a different control unit so that it is possible to achieve the desired pressure/flow on the side of the cylinder piston and arm. The valve response times are fast, typically 1 — 5 ms. Compared to the servo valve, at least the following advantages are achieved with the digital valve:

1. For power and/or pressure control, it is possible to achieve with the valve a pressure amplification curve of linear or desired form on a wide area,

2. An opening / flow relation of fully linear or desired form can be achieved by a suitably selected digital valve group for location control,

3. It is possible to generate fast and undisturbed controls (no exceeding as with servo valves),

4. No fine-mechanical stem, i.e. the valve characteristics stay the same upon changing the valve,

5. The digital valve is not sensitive to impurities,

6. Failure of one on/off valve or even several on/off valves does not make the whole digital valve group inoperative.

[0032] Figure 1 illustrates a general graph of a safety component 10 created by a control valve that is applicable in a variety of different kind of objects, in which there are two directions of movement and the component 10 comprises four individual digital valve groups DV. If only one direction of movement is applicable only two individual digital valve groups are needed. These arrangements are especially advantageously suited for basic level solutions, in which quite extreme resolution is not necessarily needed but by the same principles more complicated systems can be created if needed.

[0033] The invention is advantageously used in connection with fiber web machine applications, for example in connection with secondary carriage of a reel-up, with rotating device of a tambour and in connection with maintenance stages of different machine parts of fiber web. In connection with the example of the secondary carriage of a reel-up the movement is in two directions and four digital valves DV are needed and in connection with the example of the rotating device of a tambour when rotating in one direction two digital valves DV are needed. The maintenance application of the present invention could be for example pressure roll control and its maintenance stage.

Claims

1. A safety component for controlling movements of machines, which movements are provided by a fluid system, **characterised in that** the safety component (10) is arranged by means of at least one digital valve group (DV).

2. Apparatus according to claim 1, **characterised in that** the safety component (10) is arranged by means of at least two digital valve groups (DV).

3. Apparatus according to claim 1, **characterised in that** the safety component (10) comprises a control valve that comprises two digital valve groups (DV) for each movement direction.

4. Apparatus according to claim 1, **characterised in that** the digital valve group consists of several on/off valves with different diameters.

5. Apparatus according to claim 1, **characterised in that** the digital valve group consists of several on/off valves with identical diameters.

6. Apparatus according to claim 1, **characterised in that** the digital valve group consists of several on/off valves with different volume flows.

7. Apparatus according to claim 1, **characterised in that** the control signal for the digital valve group is digital, such as binary.

8. Apparatus according to claim 1, **characterised in that** the control signal of each digital valve in the digital valve group is binary so that the signal means 0 or 1.

9. Apparatus according to claim 1, **characterised in that** the safety component is provided in a fiber web machine.

10. Apparatus according to claim 1, **characterised in that** the digital valve is arranged to self observe its failure, to compensate the failure with other digital valves in the digital valve system, and to report the failure to the control system.

11. Apparatus according to claim 1, **characterised in that** the safety component is controlled substantially simultaneously by one digital valve group (DV1; DV4) for work side flow and one digital valve group (DV2; DV3) for the return side flow back to the tank.

12. Apparatus according to claim 1, **characterised in that** the safety component (10) comprises a control valve that comprises at least two digital valve groups and that he safety component control valve (10) has means for providing safety function and means for providing functional property, such as work function.

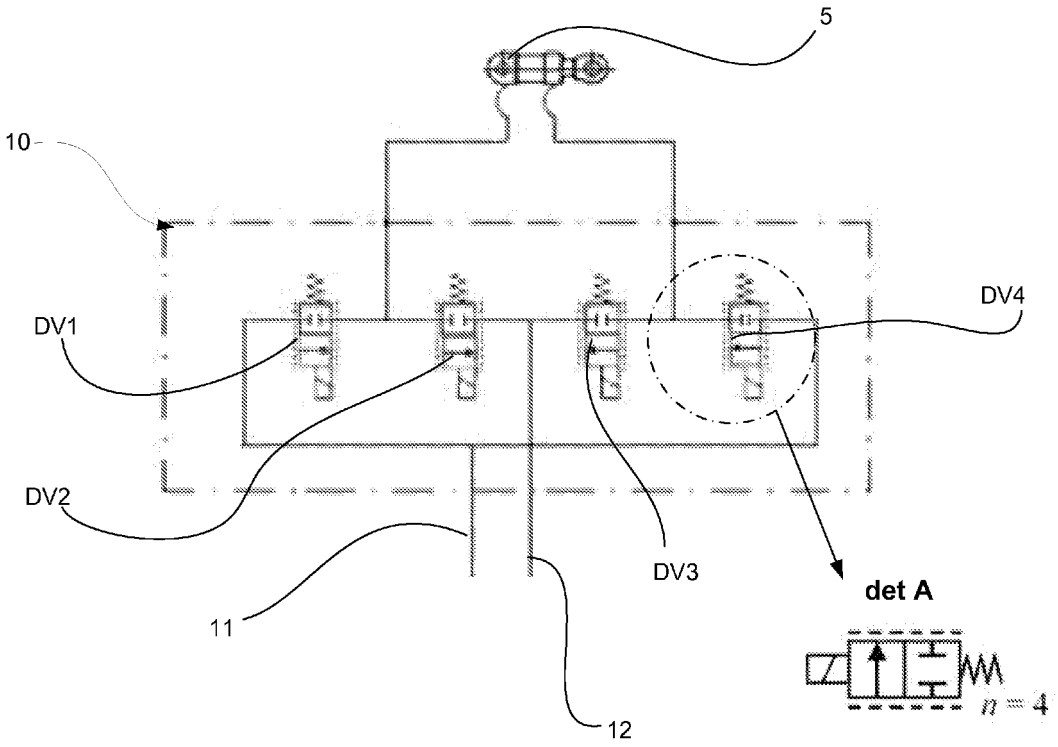


Fig. 1

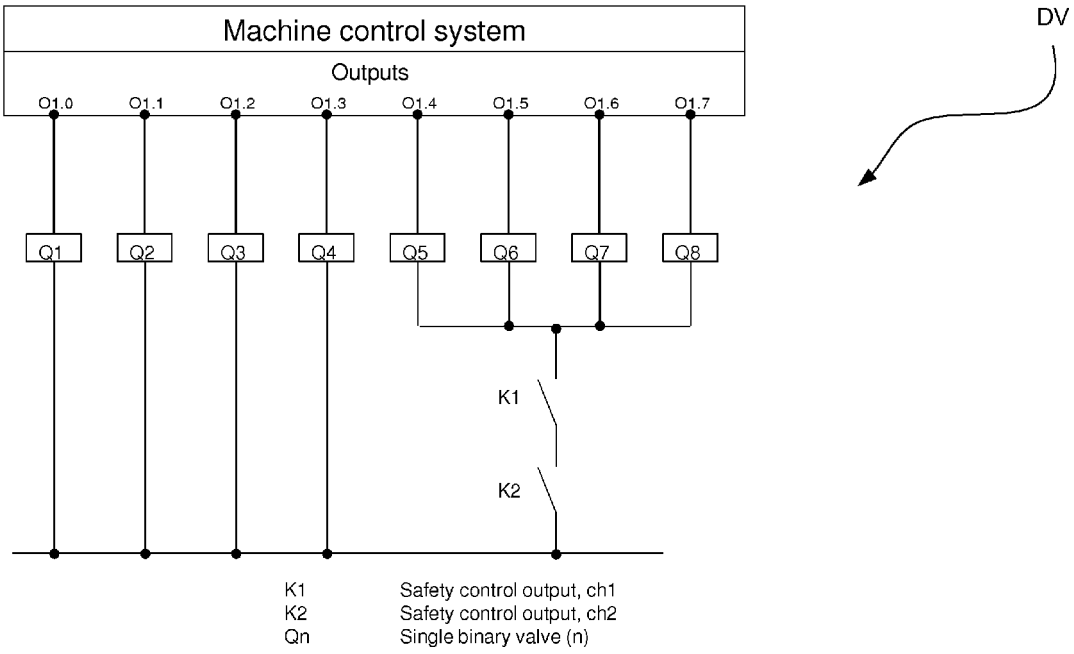
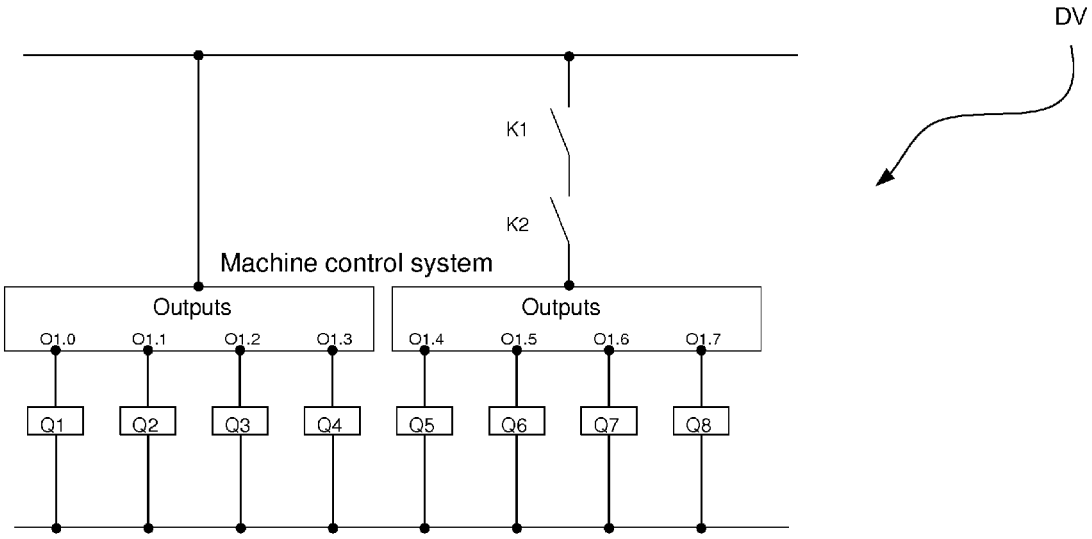

Machine control system
Outputs
O1.0
O1.1
O1.2
O1.3
O1.4
O1.5
O1.6
O1.7
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
K1
K2
DV
K1 Safety control output, ch1
K2 Safety control output, ch2
Qn Single binary valve (n)

Fig. 2



K1	Safety control output, ch1
K2	Safety control output, ch2
Qn	Single binary valve (n)

Fig. 3

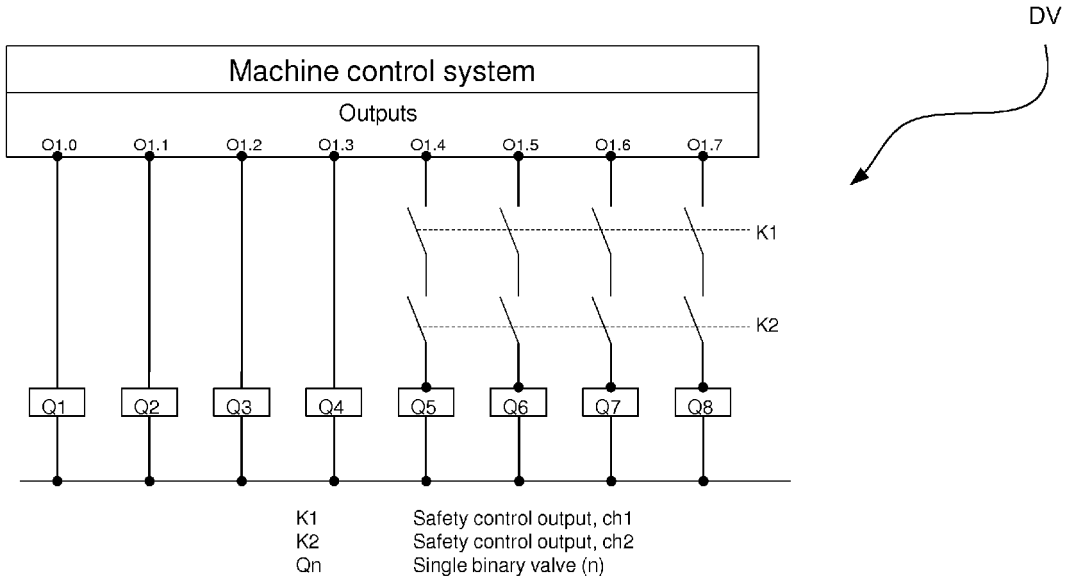

DV
Machine control system
Outputs
O1.0
O1.1
O1.2
O1.3
O1.4
O1.5
O1.6
O1.7
K1
K2
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
K1 Safety control output, ch1
K2 Safety control output, ch2
Qn Single binary valve (n)

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 11 17 2516

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2009/077650 A1 (METSO PAPER INC [FI]; IKONEN ARTO [FI]; SUOMI EERO [FI]; VANTOLA PEKKA) 25 June 2009 (2009-06-25) * page 14, lines 3-14 * * page 1, lines 7-8; figures 2b,2c,2d,3b,3d,3e,3f,6,7 * * page 3, lines 26-27 - page 4, lines 9-11 * * page 14, lines 15-18 * * page 18, line 29 - page 19, line 35 * * page 19, lines 29-31 * * page 44, lines 5-13 - page 45, lines 14-23 *	1-12	INV. F15B11/042
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 January 2012	Regaud, Christian

CATEGORY OF CITED DOCUMENTS

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