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(54) **A multifunction device for remote maintenance and remote control, in particular for cranes**

(57) A multifunction device for remote maintenance and remote control applications for cranes, in which a crane is provided with a plurality of motors (5, 8) for driving mobile parts of the crane, each of the plurality of motors (5, 8) being commanded by a respective electronic control unit (6, 9). The multifunction device comprises at least a control module (14) connected, via at least a commu-

nications port (15, 16, 19), to the electronic control units (6, 9), the at least a control module (14) gathering data associated to controlling functions of the crane, and further comprising at least a communications module (20) associated to the control module (14), which communications module (20) transmits and receives via radio data packets of information relating to functioning of the crane.

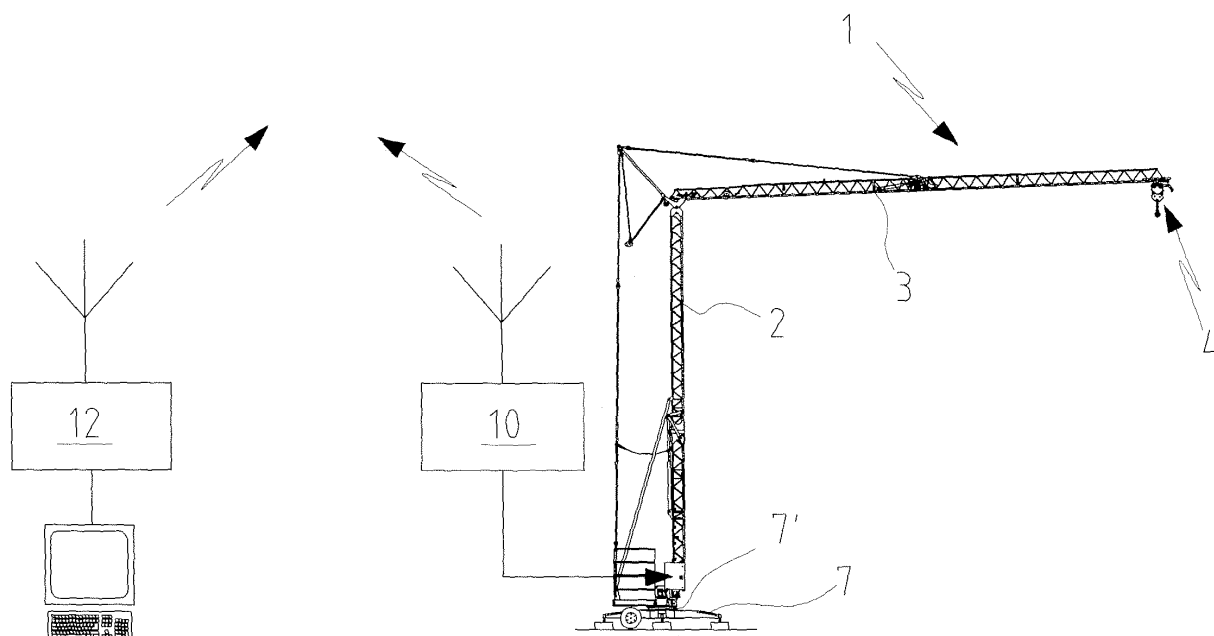


FIG.1

Description

[0001] The invention concerns a multifunction device for maintenance and remote control applications, in particular for cranes.

[0002] As is known, cranes used for lifting in the construction sector are constituted by a fixed structure upon which a vertical first member is mounted to support a horizontal second member, the second member being provided with a sliding carriage which is provided with load lifting means, and being rotatable relative to the vertical member, for example by the interposition of a fifth wheel coupling.

[0003] Apparatus of this kind usually exhibit a lifting motor group which is powered by inverters and provided with programmable functions and appropriate safety systems, including maximum load and maximum moment limiters, and ascent and descent limit stops. At least one motor is provided to drive the carriage, and a further motor group is provided to rotate the member supporting the carriage, both groups also being programmable and powered by respective inverters.

[0004] In use, it is of fundamental importance to be able to control the functioning of a crane so as to identify any breakdowns or faults, or vary and re-program all the crane's setting parameters according to requirements.

[0005] However, to solve problems caused by breakdowns and anomalies so that the crane may become operational again, or to re-program the crane's parameters, direct intervention by an operator is necessary. This gives rise to travel expenses and labour costs, and intervention times are relatively slow.

[0006] The invention primarily seeks to solve an initial technical problem of a general nature, that is, to provide the crane with a remote maintenance service which does not require continuous on-site intervention by a specialist operator.

[0007] The second technical problem, which is subordinate to the first, is to obtain this control activity by means of a multifunction device using a type of communications protocol which is known in the industrial field. At present in fact, known communications protocols are not easily applied to the remote control of cranes and give rise to a series of technical drawbacks.

[0008] In particular, the Modbus ASCII protocol and the Modbus RTU protocol are among the communications protocols used in industrial applications, both of which are suitable for communication, via a serial port, between a control and information requesting device, known as the Master, and a plurality of devices, known as Slaves, which receive, and respond to, the commands of the Master device.

[0009] In the ASCII protocol, all characters which convey information from one device to another are converted into ASCII characters, a number of control characters being left to define the beginning and the end of a data packet, or string.

[0010] This however entails the drawback of signifi-

cantly increasing the number of bytes which must be transmitted from one apparatus to another, compared with the actual amount of information transmitted, therefore the ASCII protocol is not suited to the remote maintenance application of the invention, since communication becomes too slow.

[0011] As regards the Modbus RTU protocol, a binary protocol in which all 256 values of a byte convey information, all the data can be transmitted without conversion to ASCII and so the number of bytes for each data packet is significantly reduced, the resulting communication being more rapid.

[0012] The beginning and the end of a data packet is identified by measuring the pause between one data packet and the subsequent one and between one character and the subsequent one. In particular, if a pause of 3.5 times the transmission time of a character over the serial line is detected, it means that the data packet has ended and its analysis can therefore begin.

[0013] The Slave's response takes place after a minimum pause of 3.5 characters between the data packet it has received and the data packet which it must transmit.

[0014] Further, if a pause of 1.5 characters is detected between one character and the next, the present message is discarded and reception of a new message begins.

[0015] For this reason, the Modbus RTU protocol, unlike the ASCII version, does not tolerate interruption of data packet strings during a transmission and is therefore not used in communications via modem; it is therefore not suitable for use as a protocol for managing a remote maintenance device for a crane via radio.

[0016] An aim of the invention is to obviate the above-mentioned drawbacks, by providing a multifunction device for remote maintenance and remote control applications, in particular for cranes.

[0017] A further aim of the invention is to provide a device for remote maintenance and remote control of cranes which functions reliably and safely and is capable of using a communications protocol of the Modbus RTU type.

[0018] These aims are achieved by a multifunction device for remote maintenance and remote control applications for cranes, in which the crane is provided with a plurality of motor groups to power its moving parts, each of the motor groups being controlled by a respective electronic power unit, the multifunction device being **characterised in that** it exhibits at least a control module which is connected to the electronic power units via at least a communications port, and which is capable of detecting data pertinent to monitoring and controlling the crane's functions, and at least a communications module, associated to the control module and capable of receiving and transmitting data packets of information relative to the crane's functions via radio. The data packets of information are received by, and transmitted to, a remote maintenance and control station by means of which an operator can check and if necessary modify the crane's op-

erating parameters.

[0019] In particular, according to the invention, communications via radio between the remote maintenance and control station and the communications module on board the crane take place via the GSM or GPRS network; communication between the monitoring module and the electronic power units of the motors takes place instead via the RS 486 and/or RS 232 serial port(s), depending on the electronic devices which are installed on the crane.

[0020] According to the invention, the control module comprises means for managing the information received from the remote maintenance station via the communications module. The means for managing use the Modbus RTU protocol to send data packets of information between the control module and the electronic power units of the motors.

[0021] In particular, the means for managing comprise that before being sent on to the electronic power units of the motors, the data packets constituting the information are stored temporarily in a memory unit subsequent to reception of the last piece of data for a much longer period of time than the time specified in Modbus RTU specifications, which period of time is sufficient to be certain that the data packet has been concluded. According to the invention this time varies between 80 and 120 ms and is preferably 100 ms.

[0022] In a preferred embodiment, the information management means are integrated in the firmware which manages the operations of the control module and the memory unit is a buffer memory integrated in the control module.

[0023] According to the invention, the control module is also provided with analogue and digital outputs, which are connected to sensors and actuators to control certain functions of the crane. In this case, the data packet requesting information, sent by the remote station to the control module over the communications module, can be in the form of an SMS message.

[0024] Finally, the monitoring module can also be provided with serial communications port of the RS 232 type which can be connected to a PLC (programmable logic controller) by means of which it is possible to control and manage some of the operating parameters of the crane.

[0025] Further characteristics of the invention will emerge from the dependent claims.

[0026] The characteristics and the advantages of the invention will emerge from the following description, which is provided by way of a non-limiting example, with the aid of the appended figures of the drawings, in which:

figure 1 diagrammatically illustrates the operating principle of the system of remote maintenance for a crane according to the invention.

figure 2 shows a block diagram of the invention for managing remote maintenance functions for a crane.

[0027] With reference to figure 1, a crane 1 of known type comprises a vertical member 2 which at an upper end thereof supports a horizontal member 3 to which a lifting organ 4 is associated, which lifting organ 4 is supported by a carriage of a usual type (not shown), which carriage translates the lifting organ 4 on the horizontal member 3; the lifting organ 4 is driven by an electric motor 5 powered by an electronic unit 6 of the AC/AC inverter type. The vertical member 2 rests on a support platform 7 through interposing of a fifth wheel coupling 7' which enables the member 2 to rotate. Rotation of the member 2 takes place thanks to an electric motor 8 which is powered an electronic unit 9 of the AC/AC inverter type.

[0028] A multifunction device 10, described in more detail herein below, is installed on the crane, and an aerial 11 is associated thereto in order to transmit and receive data. Data transmission and reception are performed by the base station 12, which is provided with appropriate hardware and software means and with an antenna 13.

[0029] The base station 12 is of the remote type and can be installed for example on the premises of the company running the remote maintenance service, or it can be located on a mobile station.

[0030] In figure 2, the multifunction device 10 comprises a control module 14 to which a communications module 20 is associated, in this case a GSM/GPRS modem, which receives and transmits data packets from and to the base station via a GSM/GPRS network.

[0031] The control module is provided with a first serial communications port 15, of the RS 485 type, connected to the electronic units 6 and 9 (figure 2) of the respective electric drive motors 5 and 7. In this embodiment, the electronic units 6 and 9 are usual inverters of the AC/AC type which are provided with RS 485 serial ports. Thanks to this connection at least the following crane functions can be controlled and/or modified:

- monitoring inverter alarm history
- monitoring inverter input and output signals
- modifying parameters and re-programming the inverter
- modifying working speed
- modifying acceleration and deceleration times.

[0032] Data is transmitted from the control module to the devices connected to the RS 485-type communications port 15 using the Modbus RTU protocol.

[0033] In particular, the control module 14 comprises means (not illustrated) which manage the received data packets, storing them in a memory unit associated to the control module 14, and subsequently sending the data packets to the electronic units 6 and 9 via the communications port 15. In this embodiment the data managing means are integrated in the management firmware of the control module 14, while the memory unit is integrated in the control module 14. Upon receipt of a data packet, the control module stores the incoming data in the buffer memory and waits 100 ms before sending the data packet

received from the base station to the electronic devices. Tests carried out have shown that this time interval is sufficient to ensure that all the data of the packet has been received by the monitoring module before transmission to the electronic units powering the motors takes place.

[0034] This detail therefore enables the entire received data packet to be sent to the electronic units 6 and 9 which power the motors 5 and 8, thus obviating the intrinsic drawback of the Modbus RTU protocol consisting in this protocol's limited tolerance to interruption of data packets during transmission, which makes it intrinsically unfit for applications such as that of the invention.

[0035] The time of 100 ms is *per se* extremely long compared with the times which are at present handled in electronic communications, but this time was chosen on purpose, overcoming a technical prejudice, in order to solve the problem of adapting the known Modbus RTU protocol to the particular application of the invention.

[0036] The control module is also provided with a second serial communications port, of the RS 232 type, for connecting to a PLC which is installed on board the electronic control units 6 and 9, that is, the two AC/AC inverters. Via this connection it is possible to take the following actions regarding the crane:

- checking functioning of the limit stops
- checking the mains supply to the electrical system
- resetting the lifting and carriage limit stops
- resetting load cell and weight reading
- monitoring the hours of operation and the lifting, rotation, carriage translation groups and work cycles of the crane
- modifying the operating configuration parameters of the machine (load, outreach height, setting the parking brakes timer).

[0037] Finally the control module is also provided with analogical and digital input and output ports 19, through which it is possible to monitor/control the following crane functions:

- check if crane is locked/unlocked
- check if crane is powered up or not
- check for any inverter errors
- check automatic/manual mode
- check load cell signal
- check the limit stop mains supply signal.

[0038] Note that through the analogue and digital ports 19 the above-listed functions can also be controlled by sending the data packets in SMS (Short Message Service) form. Instead, transmission and reception of the data packets addressed to the communications ports 15 and 16, respectively RS 485 and

[0039] RS 232, takes place using the communications module 20, which in this case is the GSM/GPRS modem in dial-up mode.

[0040] From the foregoing description it is clear that use of the device of the invention enables operations of remote maintenance to the crane to be performed from a remote station in a simple way. The operator at the base station 12 need only send a data packet to the control module 14 via the communications module 20; the control module 14 first of all stores the received data packet in a buffer memory and then transfers it to the communications ports 15 and 16. If instead the incoming data packet is in the form of an SMS text message, the monitoring module 14 ascertains that the data packet is in the form of an SMS text message and implements the instructions contained in the message through the analog and digital ports 19.

[0041] The invention provides a series of important advantages, including being able to identify breakdowns and anomalies from a remote and/or portable station, or vary and re-program the setting parameters of the crane by acting on the PLC or the inverters of the crane.

[0042] Further, in many cases it is possible to solve breakdowns and faults, resuming crane operation without any direct intervention from an operator, thus economising on travel expenses and labour costs.

[0043] Finally, note that the above list of remote maintenance functions is a non-limiting example of the invention's possibilities.

[0044] Obviously modifications or improvements springing from contingent or particular causes could be introduced to the invention as it is described, without thereby abandoning the ambit of the invention as claimed below.

Claims

1. A multifunction device for remote maintenance and remote control applications for cranes, in which a crane is provided with a plurality of motors (5, 8) for driving mobile parts of the crane, each of the plurality of motors (5, 8) being commanded by a respective electronic control unit (6, 9), the multifunction device also comprising at least a control module (14) connected, via at least a communications port (15, 16, 19), to the electronic control units (6, 9), the at least a control module (14) gathering data associated to controlling functions of the crane, and further comprising at least a communications module (20) associated to the control module (14), which communications module (20) transmits and receives via radio data packets of information relating to functioning of the crane, **characterised in that** communication of the information between the control module (14) and the electronic control units (6, 9) of the motors is made using a Modbus - RTU protocol and **in that** the transmission of the data packets between the control module (14) and electronic control units (6, 9) of the motors is made in a much longer period of time than the time specified in Modbus RTU speci-

fications from reception of a most recent piece of information by the control module.

2. The device for remote control of a crane of claim 1, **characterised in that** the radio-transmitted information is transmitted to and received from a base station (12) for remote maintenance and remote control. 5
3. The device of claim 2, **characterised in that** communications via radio between the communications module (20) and the base station (12) take place using a GSM/GPRS network. 10
4. The device of claim 1, **characterised in that** means for managing the data packets, and a memory unit for storing the received information are associated to the control module (14). 15
5. The device of claim 4, **characterised in that** the means for managing the data packets are integrated in management firmware of the control modules. 20
6. The device of claim 4, **characterised in that** the memory unit is a buffer memory unit. 25
7. The device of claim 1, **characterised in that** the at least a communications port is a serial port of an RS 485 type and/or an RS 232 type. 30
8. The device of claim 7, **characterised in that** the serial ports RS 485 and/or RS 232 can interface with the electronic control units of the motors.
9. The device of claim 1, **characterised in that** the electronic control units of the motors comprise an AC/AC inverter. 35
10. The device of claim 9, **characterised in that** the communication is made via the communications port (15) of the RS 485 type. 40
11. The device of claims 1, **characterised in that** the transmission of the data packets between the control module (14) and electronic control units (6, 9) of the motors is made in an interval of between 80 and 120 ms from reception of a most recent piece of information by the control module. 45
12. The device of claim 11, **characterised in that** the transmission communication takes place 100 ms after the most recent piece of data has been received by the control module. 50
13. The device of claim 1 **characterised in that** it comprises a plurality of analogue and digital ports (19). 55

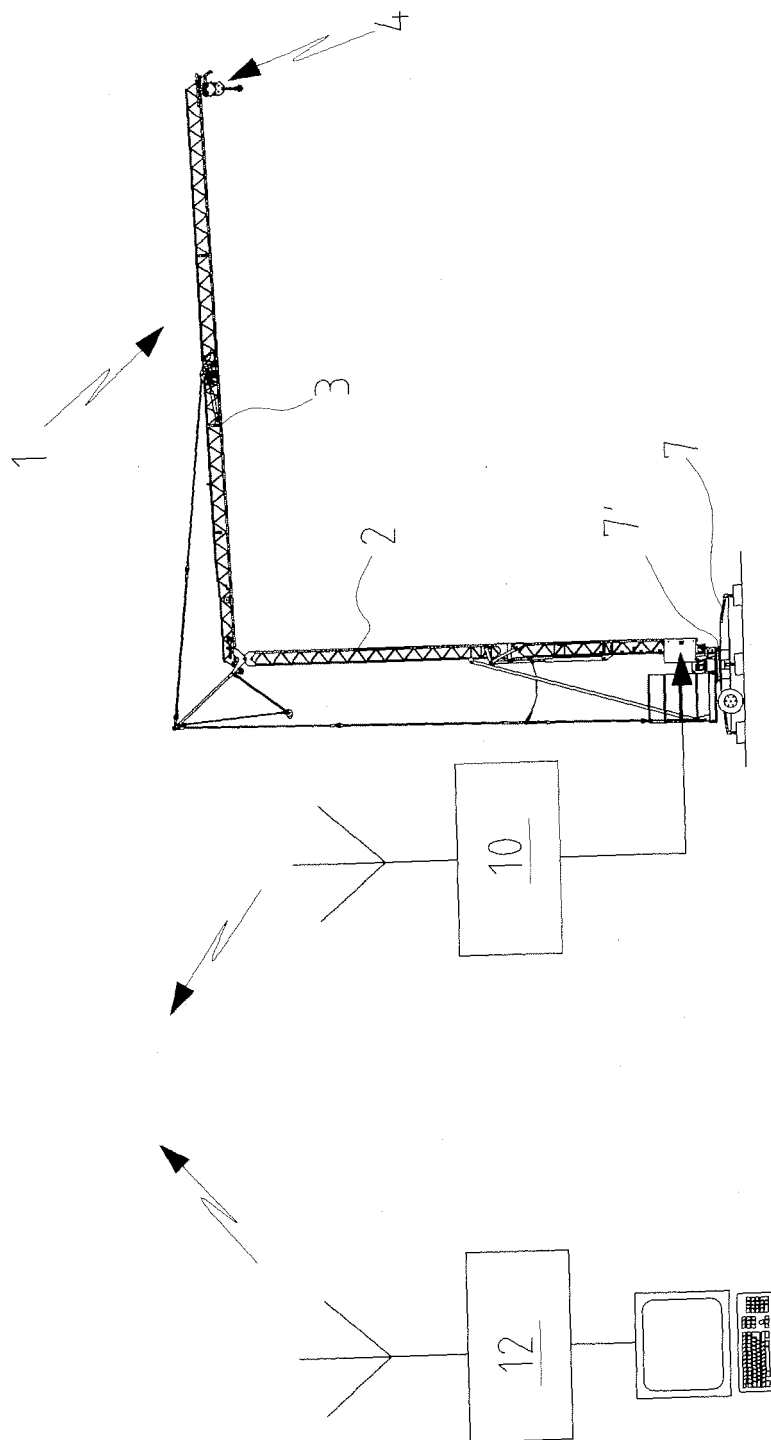


FIG.1

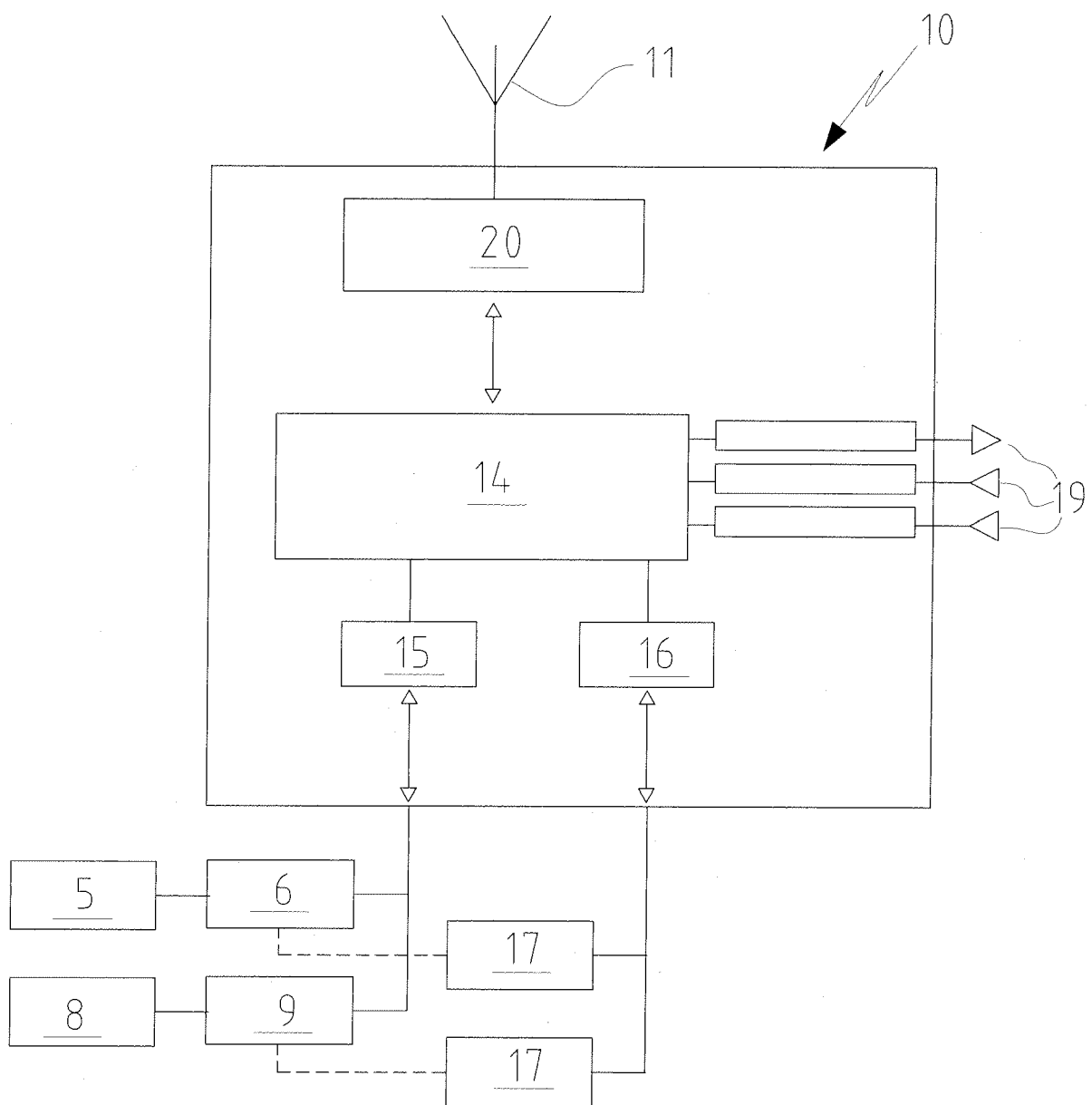


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 09 17 1508

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 281 656 A (VOITH WERKE [AT]) 5 February 2003 (2003-02-05) * the whole document * * paragraphs [0001], [0007], [0014], [0034], [0038] * -----	1-13	INV. B66C13/40
A	JP 2001 328792 A (MITSUBISHI HEAVY IND LTD) 27 November 2001 (2001-11-27) * abstract * -----	1-13	
A	WO 2008/111907 A (BROMMA CONQUIP AKTIEBOLAG [SE]; LEWIS ANDREAS [SE]) 18 September 2008 (2008-09-18) * the whole document * -----	1-13	
			TECHNICAL FIELDS SEARCHED (IPC)
			B66C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 8 December 2009	Examiner Faymann, L
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EPO FORM 1503 03.82 (P04C01)

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

EP 09 17 1508

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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08-12-2009

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