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Description

The invention relates to an arrangement comprising a plurality of inductive lighting devices and a plurality of couplers for the contactless transmission of energy to the inductive lighting devices, wherein the couplers each have a transmitting inductor, in particular a transmitter coil, and an input for connection to an electrical supply line, and a device for generating a high-frequency voltage which is supplied to the transmitting inductor during operation of the coupler, and wherein the lighting devices each have a receiving inductor, in particular a receiver coil, and a light source, in particular with at least one LED, wherein the lighting devices can be electrically supplied via the receiving inductor. US2002008973 discloses a number of inductively coupled lighting devices 203 and 204 which are supplied with high-frequency alternating current via a supply line 201.

Inductive lighting devices in which the electrical energy required for operating a light source is transmitted contactlessly via an alternating magnetic field are known in the prior art. EP 335 447 B1 discloses such a system of inductive lighting devices for marking or illuminating a roadway. Thus, inductive lighting devices are arranged on the roadway surface while an inductive supply line is arranged below the inductive lighting devices in the floor of the roadway. Thus, the supply line is formed as an inductive supply line which is supplied with a high-frequency AC voltage along its entire length and therefore generates an alternating magnetic field which generates an induction voltage for operating the lighting device in a receiving inductor in the inductive lighting device. This has the advantage that in principle a lighting device can be arranged at each point above the inductive supply line. However, as the entire supply line serves as a transmitting inductor, wherein the high-frequency AC voltage is present along the entire supply line, the high-frequency voltage must have an extremely great amplitude, which brings with it exceptionally high losses so that longer sections of a roadway with such an inductive supply line and inductive lighting devices can only be realised with high losses or cannot be realised at all.

The object of the invention is to avoid this disadvantage and provide a device with which inductive lighting devices can also be operated easily along long sections, such as long tunnels.

This is achieved by an arrangement with the features of claim 1.

The couplers serve as transmitting devices for the transmission of energy to the inductive lighting devices without there needing to be an electrical connection between the couplers and the lighting devices. The energy transmission can therefore be carried out contactlessly. The couplers each comprise a transmitting inductor which generates a changing magnetic field. An inductive lighting device is arranged in the range of this magnetic field which can generate an induction voltage by means of the magnetic flow changing over time. The transmitting inductor is formed as a transmitter coil, for example, which can additionally include a core which increases permeability, such as an iron core. The couplers thus serve as an active and locally acting energy transmission unit.

The invention has thus realised that the high-frequency voltage required for operation of the transmitting inductor is generated locally in the coupler of the device for generating the high-frequency voltage with which the transmitting inductor is supplied during operation of the coupler. Due to the constantly changing high-frequency current direction, the magnetic field of the transmitting inductor constantly alternates its polarity, which is associated with a high rate of change of the magnetic flows in the transmission range of the transmitting inductor. An inductive lighting device in the influence range of the transmitting inductor can convert this high rate of change into an induction AC voltage with which a light source provided in the lighting device is operated.

The couplers thus also comprise an input for a connection to an electrical supply line with which the electrical energy required for the operation of the coupler is provided. In addition, a control device known per se can be provided with which the voltage or current supplied to the coupler via the supply line is controlled. It is also possible to transmit signals to the coupler via the control device relating to activation of the coupler or different parameters of the inductive lighting device such as brightness, colour, flashing function or similar. Methods and components known in the prior art are used for the transmission of these control signals.

For example, it is conceivable that the control device comprises a transformer, by means of which a slight AC voltage is coupled into the DC voltage or low-frequency AC voltage applied to the supply line, whereby a modulated DC current or low-frequency AC current results which can serve to encode a control signal. Thus, it can be provided that these control signals are transmitted to a local coupler via the supply line. As a plurality of such couplers is provided in a lighting installation, the control signal can comprise addressing so that the respective coupler to be controlled can be selected. In the case of local couplers, this control signal can be demodulated and at least temporarily stored. Subsequently, the control signal is coupled from a microcontroller (µC) arranged in the coupler, for example, or from a digital signal processor (DSP) by modulation into a high-frequency AC voltage which is generated by a device of the local coupler provided for this purpose. The modulated and encoded signal is transmitted to the inductive lighting device via a transmitting inductor, preferably a transmitter coil. For the encoding itself – as already mentioned – several methods, such as frequency-shift keying (FSK), amplitude-shift keying (ASK) or phase-shift keying (PSK) are conceivable. A control unit of the inductive lighting devices serves to control the light source according to the control signals. For the control of the inductive lighting device, the methods and components shown above with respect to the prior art discussed can be used.

The inductive lighting devices each have a receiving inductor with which the alternating magnetic field generated by the transmitting inductor can be converted into an induction AC voltage. The receiving inductor is in particular formed as a receiver coil, if necessary with a core which increases permeability, such as an iron core. The inductive lighting devices further each have a light source, in particular at least one LED which is electrically supplied with converted voltage via the receiving inductor.

If the receiving inductor is arranged closely enough to the transmitting inductor of the coupler assigned to the respective lighting device so that the changes in the magnetic flows can be detected by the receiving inductor, energy can be transmitted contactlessly. Thus, the orientation of the receiving inductor plays a role here with respect to the transmitting inductor.

If in each case, a local coupler is assigned to an inductive lighting device, the device of which coupler supplies the transmitting inductor for generating high-frequency voltage which in turn generates an alternating magnetic field which is received by the receiving inductor of the lighting device associated with the coupler and converted into electrical current for supplying the light source, the initial object can be achieved as just in the immediate area of the lighting device, a high-frequency AC voltage is generated, whereas the supply to the coupler can be carried out via the supply line with a voltage independent thereof.

Further advantageous embodiments of the invention are defined in the dependent claims.

In a particularly advantageous embodiment of the invention, a voltage with a frequency of more than 10 kHz, preferably of more than 30 kHz, can be generated by the device for generating a high-frequency voltage. In a specific embodiment of the invention, the device generates a voltage with a frequency of 38.5 kHz which is supplied to the transmitting inductor for generating an alternating magnetic field. However, other frequencies can be used for inductive energy transmission. As this AC voltage is only provided locally in the region of the coupler, only small amplitudes are required, whereby any impedance losses and further losses are kept within narrow limits.

In a preferred embodiment of the invention, the couplers formed as transmitting units have a clock generator which generates clock signals which correspond to a certain frequency. These clock signals are fed to the device for generating the high-frequency voltage during operation of the couplers so that the frequency of the high-frequency voltage can be precisely controlled: known electronic components can be used as a clock generator; however, quartz crystals can also be used.

In a further embodiment, the couplers have a microcontroller and/or a digital signal processor, wherein the clock generator can be a component of this microcontroller. It can also be provided that the clock generator is connected to a microcontroller or a digital signal processor. The microcontroller and/or the digital signal processor can thus be connected to the control unit, whereby the frequency, phase and amplitude of the high-frequency voltage can be controlled, and wherein depending on the frequency, phase or amplitude of the high-frequency voltage, the inductive lighting device can be controlled.

The couplers can serve as an information-transmitting station in two ways. On the one hand, control signals can be modulated and encoded on the high-frequency AC voltage generated by a device provided for this purpose via the transmitting inductor and thus be transmitted to the receiving inductor and subsequently processed by the control unit. On the other hand, the transmitting inductor can receive, i.e. demodulate and decode, the information transmitted by a transmitter unit of the lighting device. By means of a transformer, this information transmitted by the lighting device can be coupled to a DC voltage or low-frequency AC voltage present in the supply line, if necessary together with addressing, and transmitted to the control device. So as not to collide with the control signals for the control device, it can be provided that the control device transmits control signals for a certain period of time and is ready to receive information from the lighting device for a subsequent period of time. For this purpose, for example, the microcontroller of the coupler can have an electronic memory which stores the decoded and demodulated signals transmitted by the lighting device until the control device is ready to receive data. This is an asynchronous data transfer.

The decoding of the signals both in the couplers and also in the lighting device can be achieved by means of a microcontroller, for example with a zero-crossing detection of the voltage in connection with a measurement of the time passed between different zero crossings. The frequency-shift keying resulting from the modulation can be decoded by means of a transmission protocol of an FSK method stored in an electronic memory.

In an embodiment of the invention, the coupler comprises a DC-DC converter with which a DC voltage supplied via the electrical supply line can be transformed. For this purpose, DC regulators or DC voltage regulators and DC-DC converters known in the prior art are used. In particular with long supply lines which are connected to a DC power source, due to the ohmic resistance of the line, the DC voltage decreases as the distance from the couplers connected to the DC power source increases. However, it can also be provided that the devices for generating the high-frequency voltage with a DC voltage must be operated with a predetermined value. For this purpose, a DC-DC converter transforms the DC voltage present at the input to this value.

In another embodiment of the invention, the couplers have an AC-DC converter with which an AC voltage supplied via the supply line to the input at the coupler can be rectified and/or transformed to a desired value. Again, the AC-DC converter involves rectifiers known in the prior art such as various bridge circuits. The AC-DC converter may itself comprise the function for transforming the rectified voltage. However, it can also be provided that following an AC-DC converter which serves exclusively for rectifying an applied AC voltage, a DC-DC converter as described above is connected for transforming the rectified AC voltage. The AC voltage supplied via the supply line is preferably an AC voltage from the public power grid, i.e. a low-frequency AC voltage, for example 50 Hz or 60 Hz.

In a particularly preferred embodiment of the invention, the devices for generating the high-frequency voltage comprise a DC-AC inverter which is connected to the transmitting inductor during its operation so that the AC voltage generated by the device is present on the transmitting inductor. Electrical devices known in the prior art can again be used as a DC-AC inverter. Preferably, electronic systems are provided for this purpose which do not require rotating parts, such as different bridge circuits or inverters with a plurality of transistors. In addition, the DC-AC inverter can also provide the function of changing the AC voltage to another value, for example in that an AC-AC converter is coupled to the DC-AC converter.

The DC-AC inverter can thus be connected to a clock generator and/or a microcontroller, whereby the amplitude of the generated AC voltage and its frequency can be precisely controlled. In principle, an average value of the frequency generated by the device serves to transmit the energy to the inductive lighting device. In the amplitude, phase or frequency, control signals can be modulated via the clock generator or the microprocessor and additionally or alternatively via a digital signal processor which also include addressing of the coupler and the serve as special control of the lighting device, for example in relation to the brightness, the colour or a flashing function of the lighting device. For this purpose, the above-mentioned encoding and modulating methods can be used.

In an embodiment of the invention, the couplers comprise a demodulator which serves to demodulate the control signals transmitted via the control device. The demodulator is subsequently connected to the microcontroller to control the device for generating the high-frequency voltage.

In a preferred embodiment of the arrangement according to the invention, the inductive lighting devices comprise an AC-DC converter for rectifying and/or transforming an AC voltage induced from the receiving inductor. The AC-DC converter can thus be formed as described above. In particular, light sources with at least one LED must be operated with DC so that such a converter is required for this purpose. LEDs are thus preferably provided due to their low energy consumption, their long lifespan and their low heat build-up, as well as their flexibility.

In a further embodiment of the arrangement according to the invention, the inductive lighting devices comprise a microcontroller. This serves to implement control signals which are transmitted from the couplers, for example by modulating the frequency, phase or amplitude. The microcontroller thus controls the light source so that emits light at a different brightness, emits flashing light, emits light in different colours, is principally activated, etc.

The invention further relates to a lighting installation, in particular for marking roadways or tunnel walls having an arrangement as described above and a supply line which is connected to the input of the couplers. Thus, a plurality of such couplers and a plurality of inductive lighting devices are arranged along the supply line, whereby longer roadway areas or tunnels can also be illuminated or marked. Thus, it can be provided that the supply line and the coupler are both to be arranged in the floor of the roadway or within the tunnel wall. Inductive lighting devices, which may be formed as road studs, for example, are arranged on the roadway surface or the tunnel wall surface in the respective vicinity of the coupler. Another advantage of such a lighting installation is that, due to the lack of electrical connections between the supply line on the one hand and the lighting devices on the other hand, an improved sealing of the lighting device and the electrical supply against water inlet is provided.

In an embodiment of the lighting installation according to the invention, a DC power source is provided to which the supply line for supplying the couplers is connected.

It can also be provided that instead of the DC power source, a low-frequency alternating current source, for example with a frequency of 50 Hz or of 60 Hz, is provided for supplying the couplers. Such a lighting installation has the advantage that the AC power source can be formed in a simple manner by a connection to the public power grid. In addition, such an operation with alternating current leads to reduced galvanic corrosion.

In both cases, due to the active coupler, the supply line does not have to serve as a transmitting inductor so that impendence losses and further losses resulting from a longer supply line provided with high-frequency power are greatly limited and lighting installations can also be easily operated with longer supply lines.

In an embodiment of the invention, the inductive lighting device is situated at a distance of between 5 mm and 50 mm from the coupler arranged in the floor of the roadway, for example. This distance relates to the distance between the receiving inductor and the transmitting inductor.

If the lighting device comprises a receiver coil, preferably with a ferrous core, for example an iron core, and the coupler comprises a transmitter coil, preferably also with a ferrous core, in an embodiment of the lighting installation according to the invention, it is provided that the receiver coil and the transmitter coil are arranged substantially in parallel. In a lighting installation with a plurality of such couplers and lighting devices for marking a roadway, the couplers can be arranged along the edge of the roadway so that the transmitter coils are arranged parallel to the edge of the roadway. Thus, a simple arrangement of the lighting devices is possible on the roadway surface in that the receiver coils of the lighting devices are also parallel to the edge of the roadway. With such a parallel orientation, as much as possible of the alternating magnetic field generated by the transmitter coil is detected by the receiver coil and used to generate an induction voltage.

Further details and advantages of the present invention are described in detail in the following using the description of the figures with reference to the drawings.
Wherein:

Fig. 1 shows a schematic block diagram of a lighting installation according to the invention, and

Fig. 2 shows a schematic representation of a coupler.

Fig. 1 shows a schematic block diagram of the essential components of a lighting installation 16 according to the invention. A power source 18 is connected to a control device 17 via a supply line 3. The power source 18 can be formed as a DC power source or as a low-frequency AC power source. Furthermore, in this embodiment three couplers 1 for contactlessly transmitting energy, each having an input for connection to an electrical supply line 3, are connected to the control device 17 and the power source 18 via the supply line 3. The couplers 1 and the power source 18 can be connected in parallel. The couplers 1 themselves can be formed identically, wherein the control device 17 has means with which the couplers 1 can be addressed and thus individually controlled.

Thus, for example, the inductive lighting device 2 connected to a first coupler 1 can constantly emit light while an inductive lighting device 2 coupled via another coupler 1 emits flashing light to mark an accident site. For the purpose of this control, control signals are transmitted from the control device 17 to the couplers 1. As retransmission of information, for example of the present operating state of the couplers 1 or the inductive lighting devices 2 can also be provided to the control device 17, the information flow between the control device 17 and the coupler 1 is shown by a double arrow A. Corresponding double arrows between the control device 17 and the other couplers have been omitted for the sake of clarity.

The transmitting inductor 5 of the coupler 1 generates an alternating magnetic field 11 which is schematically represented in this figure by field lines. In the region of the receiving inductor 6 of the inductive lighting device 2, this alternating magnetic field 11 generates a temporally changing magnetic flow which in turn generates an induction AC voltage for the operation of the lighting device 2, in particular the light source 14. An electrical connection between the individual lighting devices 2 and between the lighting devices 2 and the couplers 1 are not required due to the contactless transfer of energy.

It can also be provided that control signals are transmitted from the couplers 1, for example via frequency, phase or amplitude modulations, to the inductive lighting devices 2. In the same way, it is also conceivable that the inductive lighting devices 2 transmit information relating to their operating state to the control device 17, for example by means of frequency, phase or amplitude modulation via the couplers 1 so that information flow between the couplers 1 and the inductive lighting devices 2 can run in both directions of the double arrow B.

Fig. 2 shows a schematic block diagram of a coupler 1 for contactless transmission of energy to an inductive lighting device 2 as it can be used for marking a roadway or a tunnel, for example. In this case, the couplers 1 are operated with direct current, i.e. the power source 18 is formed as a DC power source. For this purpose, a supply line 3 is connected to an input on the coupler 1 for this purpose. Further couplers 1 can be connected to the supply line 3. For the sake of clarity, this is not shown in this figure. At the input of the coupler 1, 48 volts, for example, are supplied from the DC power source as the coupler 1 is located in the vicinity of the DC power source. For lighting installations with shorter supply lines 3, a basic supply of 24 V could also be sufficient. As the voltage applied to other couplers 1 is lower DC voltage as a result of the resistance of the supply line 3, the coupler 1 can also be operated with lower voltages. For this purpose, a DC-DC converter 7 is provided for transforming the DC voltage applied to the input of the coupler 1 to a low value, for example 12 volts, with which a device for generating a high-frequency voltage is operated. For this DC-DC converter, which serves as a removal limiter for the tapped voltage, devices known in the prior art can be used.

The device for generating a high-frequency voltage comprises a DC-AC inverter 9 which generates a high-frequency AC voltage from the DC voltage made available from the DC-DC converter 7. At the same time, it can also be provided that the amplitude of the AC voltage is transformed. The frequency of the AC voltage is 38.5 kHz, for example. The timing of the device for generating the high-frequency voltage can be carried out by a microcontroller 12 and/or a separate clock generator 19. The clock generator 19 can be formed as a known electronic component or as a quartz crystal, its clock frequency being extremely stable. In contrast, the microcontroller 12 can, if necessary, receive and process control signals via a demodulator 10.

The demodulator 10 serves to decouple the control signals of the control device 17 coupled to the DC voltage or low-frequency AC voltage of the supply line 3. These control signals are tapped before the DC-DC converter 7 as the DC-DC converter 7 would cancel the modulations. The demodulator 10 has an electronic memory for storing the control signals as the control device 17 does not send continuous control signals but is activated for a certain period of time for receiving information from the lighting devices 2. Such a demodulator 10 is known in the prior art, for example from radio technology. Thus, various operating parameters of the inductive lighting device 2 can be controlled or regulated.

Depending on the control signals sent from the control unit 17, if necessary transformed via a demodulator 10, the microcontroller 12 can generate a slight frequency-shift keying of +/- 150 Hz, for example, or a slight amplitude modification and thus transmit information, in particular control signals, to the inductive lighting device 2. A transmitting inductor 5 formed as a transmitter coil with an iron core is connected the DC-AC inverter 9 which converts the high-frequency AC voltage into a rapidly changing magnetic field. This rapidly changing magnetic field also generates a high-frequency voltage in a receiving inductor 6 formed as a receiver coil with an iron core. As the lighting device 2 comprises a light source 14 formed as a light-emitting diode, an AC-DC converter 15 is provided to rectify the induction AC voltage into a DC voltage.

The light source 14 can thus consist of a plurality of light-emitting diodes (LEDs) in particular formed for the emission of different colours. In order to process the control signals transmitted by the control device 17, and if necessary to generate its own signals, which in turn can be transmitted back to the control device 17 by means of frequency modulation or amplitude modulation via the receiving or transmitting inductor 6, 5 the inductive lighting device 2 has its own microcontroller 13.

Not shown in this figure are devices with which information that is transmitted from the lighting device 2 to the coupler 1 and received by the transmitting inductor 5 is forwarded to the control device 17. For example, these devices include a transformer and can be formed in a similar manner to the devices of the control device 17 which serve to transmit the control signals to the couplers 1.

Further electronic components (partially not shown) are provided both in the coupler 1 and also in the inductive lighting device 2 which are required for the operation of the coupler 1 and the inductive lighting device 2. However, such electronic components are known in the prior arts and form the general knowledge of a person skilled in the art.

In addition to the inductive lighting devices 2, further lighting elements can also be connected directly via the supply line 3 and the control device 17 without inductive energy transmission. In this case, these further lighting elements are provided in addition to the inductive lighting devices 2 and the couplers 1 in a lighting installation, wherein these direct lighting elements can also have devices with which information about the operating state of the other lighting elements can be transmitted to the control device 17.

The electronic components not described in detail above, such as the microcontroller or the different converters and rectifiers can be formed as components known in the prior art.

Patentkrav

1. Anordning, omfattende et stort antal induktive belysningsindretninger (2) og et stort antal koblinger (1) til kontaktfri overførsel af energi til de induktive belysningsindretninger (2), idet af koblingerne (1) hver især har en sendeinduktivitet, især en sendespole, og en indgang til tilslutning til en elektrisk forsyningsledning og en indretning til frembringelse af en højfrekvent spænding, med hvilken sendeinduktiviteten (5) forsynes under koblingens (1) drift, og idet belysningsindretningerne (2) hver især har en modtageinduktivitet (6), især en modtagespole, og en lyskilde (14), især med mindst en LED, idet belysningsindretningerne (2) kan forsynes elektrisk over modtageinduktiviteten (6), idet der er tilordnet hver af de induktive belysningsindretninger (2) en egen kobling (1), **kendetegnet ved, at** hver af koblingerne (1) har en demodulator (10) til frakobling af de på forsyningsledningen (3) indkoblede styresignaler.

2. Anordning ifølge krav 1, **kendetegnet ved, at** en spænding med en frekvens på mere end 10 kHz, fortrinsvis på mere end 30 kHz, kan frembringes af indretningen til frembringelse af en højfrekvent spænding.

3. Anordning ifølge krav 1 eller 2, **kendetegnet ved, at** der i hver af koblingerne (1) er tilvejebragt en taktgiver (19), hvis taktsignaler tilføres indretningen til frembringelse den højfrekvente spænding.

4. Anordning ifølge krav 3, **kendetegnet ved, at** hver af koblingerne (1) og hver af belysningsindretningerne (1) har en mikrocontroller (12) og/eller en digital signalprocessor.

5. Anordning ifølge et af kravene 1 til 4, **kendetegnet ved, at** der i hver af koblingerne (1) er tilvejebragt en DC-DC-omformer (7) til at transformere en gennem den elektriske forsyningsledning (3) tilført jævnspænding.

6. Anordning ifølge et af kravene 1 til 5, **kendetegnet ved, at** der i hver af koblingerne (1) og i hver af belysningsindretningerne (2) er tilvejebragt en AC-DC-omformer (8) til at ensrette og/eller transformere en gennem den elektriske forsyningsledning (3) tilført vekselspænding.

7. Anordning ifølge et af kravene 1 til 6, **kendetegnet ved, at** indretningen til frembringelse af den højfrekvente spænding har en DC-AC-vekselretter (9).

8. Anordning ifølge et af kravene 1 til 7, **kendetegnet ved, at** hver af koblingerne (1) er anbragt i et særskilt hus.

9. Belysningsanlæg, især til markering af kørebaner og/eller tunnelvægge, med en anordning ifølge et af kravene 1 til 8 og en forsyningsledning (3), der er tilsluttet koblingens (1) indgang.

10. Belysningsanlæg ifølge krav 9, **kendetegnet ved, at** de lokale koblinger (1) er forbundet med en fælles forsyningsledning (3).

11. Belysningsanlæg ifølge krav 9 eller 10, **kendetegnet ved, at** der er tilvejebragt en jævnstrømskilde, til hvilken forsyningsledningen (3) til forsyning af den mindst ene kobling (1) er tilsluttet.

12. Belysningsanlæg ifølge krav 9 eller 10, **kendetegnet ved, at** der er tilvejebragt en lavfrekvent vekselstrømskilde, som er tilsluttet forsyningsledningen (3) til forsyning af den mindst ene kobling (1).

13. Belysningsanlæg ifølge et af kravene 9 til 12, **kendetegnet ved, at** den induktive belysningsindretnings (2) modtageinduktivitet (6) har en afstand til koblingens (1) sendeinduktivitet (5) på mellem 5 mm og 50 mm.

14. Belysningsanlæg ifølge et af kravene 9 til 13, **kendetegnet ved, at** belysningsindretningen (2) har en modtagespole (6), fortrinsvis med en jernholdig kerne, og at koblingen (1) har en sendespole, fortrinsvis med en jernholdig kerne, idet modtagespolen (6) og sendespolen i det væsentlige er orienteret parallelt.

Fig. 1

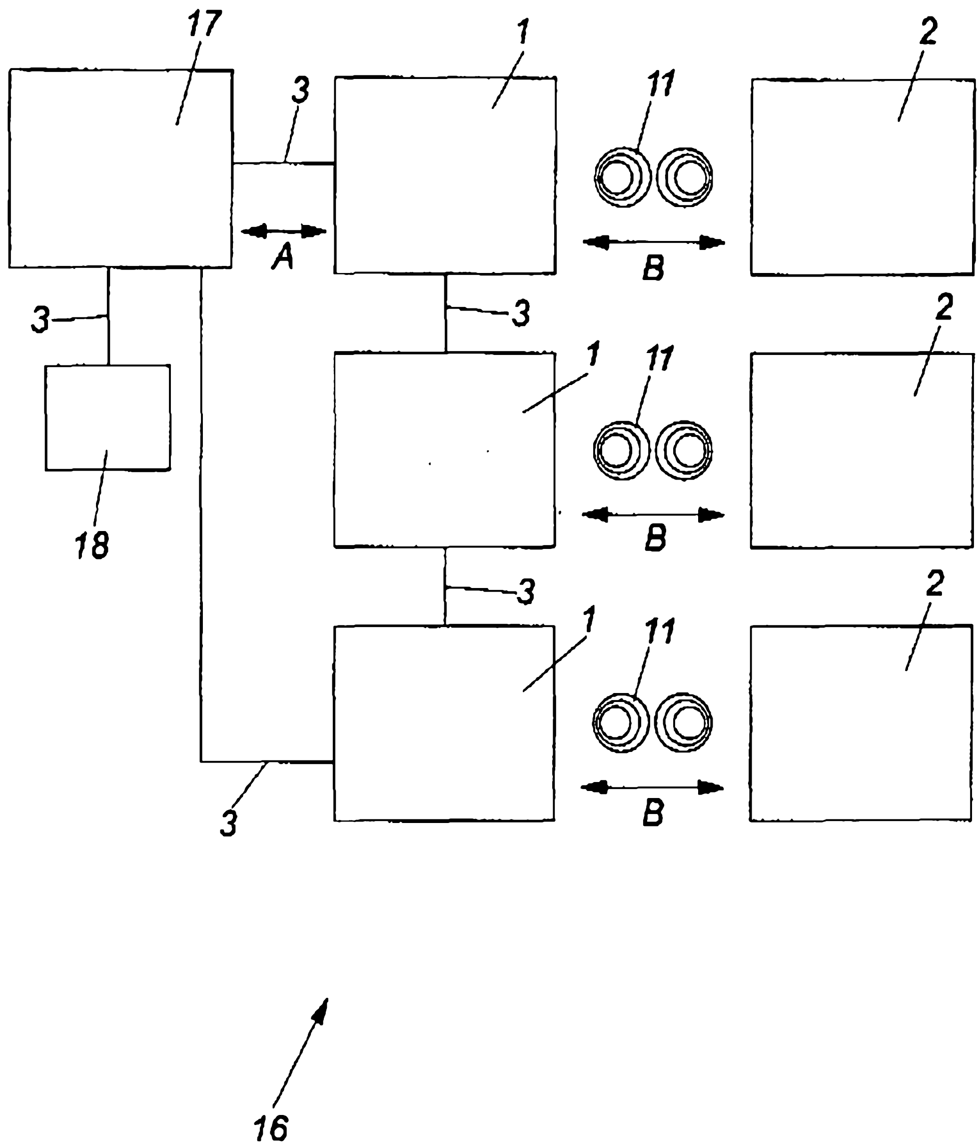

Fig. 2