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(54) **Configuration of a train control system**

(57) The invention relates to the configuration of a train control system, wherein the system is able to control trains comprising a variable number of consists (C), which are rolling units that can be coupled together to form a train, wherein each consist, from a leading consist (C1) to a last consist (C3) in the train, has a first electric line which is connected to a corresponding first electric line in any following consist in the train, wherein each of the consists has a second electric line which is connected to a corresponding second electric line in any following consist in the train, wherein the first electric line and the second electric line in the last consist are connected to each other, wherein one of the first and second electric lines in each of the consists, which is referred to as the switch line (D1, D2) of the consist, comprises a switch (S) which is controlled by a control device (COM) of the consist (C), wherein the other one of the first and second electric lines in each of the consists is referred to as the continuous line (D3) and wherein the method comprises:
a) the switches (S), which are located in the switch line (D1, D2) in each of the consists (C), are opened or are kept in the open state,
b) starting at a leading consist (C1), a signal is applied

to one of the first and second electric lines in the leading consist, wherein the line which the signal is applied to is referred to as the active line (SL) of the consist and the other one of the first and second electric lines in the consist is referred to as the passive line (PL),
c) the control device (COM) of the consist (C) closes the switch (S) in the switch line (D1, D2) of the consist (C),
d) it is determined if the signal can be detected at both the active and the passive line,
e) if the signal cannot be detected at both the active and the passive line steps c), d) and e) are repeated for the following consist (C2, C3), the following consist comprising an active line (SL), which is the one of the first and second electric line that is connected to the active line of the preceding consist (C1, C2), and the following consist (C2, C3) comprising the other one of the first and second electric lines which is referred to as the passive line (PL),
f) If the signal can be detected at both the active (SL) and the passive line (pal) the last consist (C3) in the train is reached and, as a result, there is no following consist,
g) determining the number of performances of steps c), d) and e), including the first performance for the leading consist, as the number of consists in the train.

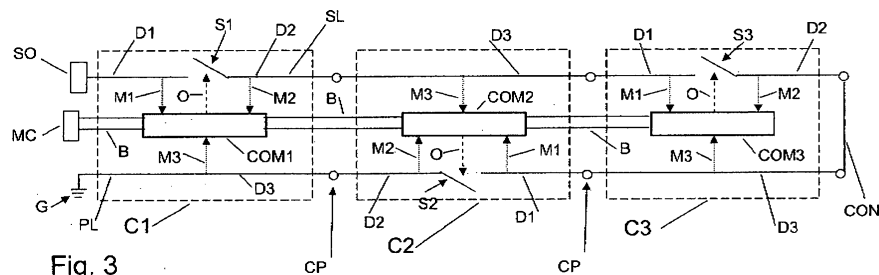


Fig. 3

Description

[0001] The present invention relates to a method for configuration of a train control system, wherein the system is able to control trains comprising a variable number of consists. Consists are rolling train units (such as wagons with and without an own propulsion unit and groups of wagons which are permanently connected to each other) and can be coupled with other train units to form a train. In particular, a consist is the smallest unit of a train which can automatically be coupled with or decoupled from other units of a train.

[0002] Furthermore, the invention relates to an arrangement for configuration of a train control system, relates to a train control system and relates to a train comprising a number of consists.

[0003] During the last years, train control system have been developed which are able to perform many control and management functions. Examples are: controlling the opening of at least one passenger door according to a selection made by the driver (especially the selection that the door can be opened on a particular side of the train the correct side), monitoring the air pressure status of each consist, controlling and monitoring the operational status of pantographs on the train.

[0004] Typically, the train control system comprises one computer or more than one computer which perform (s) the control and/or management functions. These computers are connected to devices which are distributed all over the train. The computer or computers on one hand and the devices on the other hand are connected to each other via data transmission buses. Examples of these buses are the WTB (wire train bus) and the MVB (multifunction vehicle bus). However, other types of connections can also be used, such as Ethernet busses using IP (internet protocol).

[0005] In many cases, at least some of the functions of the train control system are safety-relevant for the operation of the train. For example, the braking system which has components typically in each consist of the train may be controlled by the train control system. Another safety-relevant function is the control of doors where passengers can enter and leave the train.

[0006] In order to guarantee a reliable and safe operation of the train control system, the train control system must be aware of the actual configuration of the train. In particular, the number of consists, the sequence of the consists in the train and the orientation of each consist in the train should be known to the system.

[0007] When consists are coupled together or when one or more consist is decoupled from the train, the new train configuration has to be updated in the train control system. For example, the driver may type in the relevant information to the system or the corresponding data may be transferred to the system by the driver or automatically. However, this information may not correspond to the actual train configuration.

[0008] It may be possible to implement an automatic

procedure which recognizes the actual configuration of the train and provides the necessary information to the train control system. However, since such an automatic procedure must be free of any error, the effort and costs for developing, homologating and maintaining such a procedure are high.

[0009] It is an object of the present invention to provide a method for providing train configuration data to the train control system which is reliable and safe. Preferably, it should be possible to use the configuration data in an existing train configuration data procedure, without any modification of the procedure. A further object of the present invention is to provide a corresponding arrangement, a corresponding train control system and/or a train comprising the arrangement and/or the train control system.

[0010] The present invention can use information about the desired configuration of the train and can perform a verification procedure to verify if the actual train configuration corresponds to the desired configuration. The desired configuration can be provided to the system as mentioned above, for example. Alternatively, there might be an automatically operating system or arrangement which generates the information about the desired configuration. The desired configuration may be the outcome of this automatic procedure. Therefore, the term "desired" denotes simply the state which is to be verified by the verification procedure, in particular according to the present invention. The desired state may be defined in advance, e.g. by the driver or the operator of the train, but there are also cases where the driver or operator does not plan the configuration of a train in advance, before the consists are coupled or decoupled.

[0011] It is a basic idea of the present invention to collect information about the actual configuration of the train in order to verify the desired train configuration, wherein the verification procedure does not rely on the same arrangement of units or devices as the procedure of the present invention.

[0012] Therefore, the verification procedure can be performed to verify the train configuration information which are given in advance or independent of the actual train configuration or is performed as a redundant procedure.

[0013] The present invention does not necessarily require any additional safety tested component for determining the desired train configuration, i.e. components which are classified according to a safety standard. On the other hand, if the train comprises such safety tested components or arrangement anyway, the present invention may use these components.

[0014] The outcome of the method or the arrangement of the present invention is information which can be used to verify other train configuration information as mentioned above. However, the information produced according to the present invention can alternatively be used to check if the train configuration has changed. In this case, the invention may be performed two times or more

than two times (twice or multiple times). Furthermore, it is possible to perform the method of the present invention repeatedly, e.g. by opening all switches, as explained later and by sequentially closing the switches, as explained later. Then, all switches can be opened again and can be sequentially closed again and so on. This embodiment can be used, for example, to detect a failure in the train communication system. In case of such a failure, a part of train communication system can be bypassed, in order to establish an emergency operation. Consequently, the method of the present invention will produce different train configuration information and, therefore, the failure can be detected.

[0015] It is therefore an advantage of the present invention that existing train control systems do not need to be reconstructed to become safe. "Safe" means that the configuration is highly reliable and that failures can be detected. The implementation of an additional function according to the present invention is sufficient. As will be described in the following, simple hardware components and a simple logical structure, which may be implemented as software, can be used to perform the invention. The software may run on a computer with the necessary safety integrity (e.g. a computer with a high certified safety level) of the train control system. Alternatively, it may run on an additional computer with the necessary safety integrity, separate from the train control system, but this is not preferred, since it would require additional hardware.

[0016] According to an essential concept of the present invention a switch is provided in each consist of the train or an existing switch in the consist is used. The switch is not a type of switch in the meaning of a data transfer network, but is a switch (such as a relay) which can open and close an electric line. The switch or relay is preferably a component which corresponds to high certified level of safety, i.e. the operation is highly reliable. Preferably, the initial state of the switch, e.g. the non-powered state of the relay is the open state. Therefore, the method starts from a defined, fail-safe state.

[0017] The electric line, which can be opened and closed by the switch, extends through the consist and is electrically connected to each neighbouring consist which is coupled to the consist. For example, three consists may be coupled together to form a train. In this case, the electric line extends through all three consists. Furthermore, there is a second electric line which also extends through each consist of the train and is connected to a corresponding second electric line in each neighbouring consist which is coupled to the consist. Furthermore, at the last consist of the train, the first and second electric lines are connected to each other, preferably in a safe way according to a defined safety standard. In other words, the first and second electric lines are shorted at the end of the train. Each consist comprises the switch mentioned above. Depending on the orientation of the consist, the switch may be located in the first or second electric line. For example, if one of the consists would be

decoupled and would be re-coupled to the neighbouring consist or neighbouring consists in opposite orientation, the switch of the re-coupled consist would be connected to the other electric line of the other consists.

[0018] The first and second electric lines in the consist which are coupled together may be electric lines which are used for other purposes in the train or may be electric lines which may serve for the purpose of verification only.

[0019] Switches and electric lines are simple and highly reliable electric components. Therefore, the present invention produces reliable and safe results for a verification procedure and does not need additional expensive components.

[0020] An initial step of the method is to produce a predefined switching state of all the switches in the first and second electric lines and/or to check that the switching state is achieved. In the predefined state, the switch in each consist is open. There are different possibilities to obtain this defined state. For example, each switch may be open or may be checked to be open. Alternatively, all switches may be closed first and may then be opened. The closed state can be detected by applying a signal to one of the first and second electric lines and the other electric line, which is not the line which is the signal applied to, must also carry the signal, if all switches are closed. Then, all switches are opened. The advantage of first closing, then testing the closed state and then opening the switches is that the closed state and the opened state cannot be mixed up. However, there are other possibilities to detect or measure all switches are in the opened state at the beginning of the verification procedure.

[0021] The main part of the method starts with applying (preferably, in a safe way) a signal to one of the first and second electric lines in a leading consist of the train. The term "leading" does not necessarily mean that this consist is the first consist in the direction of travel. Rather, it may be the last consist in the direction of travel or an additional part of the train, for example a locomotive, may be coupled to the leading consist, but is not part of the train configuration verification procedure. Therefore, more generally speaking, the signal is applied to any consists which is the first in a sequence of consists in a train which consist can be for example at the end of the train where the train was started-up. The number of consists in the sequence may be one or any higher integer.

[0022] The signal may be any signal which is able to be transferred by the electric lines. For example, a frequency signal may be applied by varying the voltage or current at a voltage or current source. The signal may be, alternatively, a coded signal such as a number of current pulses of defined lengths and distances. However, it is preferred to apply a defined electric potential to the line, for example by connecting the electric line to one pole of a voltage source. The other pole of the voltage source may be connected to the other electric line.

[0023] It was mentioned above that the signal is applied either to the first electric line or to the second electric

line in the leading consist. The electric line which the signal is applied to is called the active line. The other line is called the passive line.

[0024] When applying the signal to the first or second electric line in the leading consist, the signal is applied in a section of the line which is distant to the end of the signal line which is coupled to the next following consist, if there is such a consist. If there is not such following consist, the section which the signal is applied to is distant to the connection to the passive line. This means that if the switch is located in the active line the signal cannot be detected in the following consist or in the passive line as long as the switch is open.

[0025] According to a preferred embodiment of the invention, it is measured or detected that the signal is not carried by the passive line before the switch in the leading consist is closed. Preferably, the same applies to any following consist, before the switch in this consist is closed. An advantage of this embodiment will become apparent later from the description of the figures.

[0026] Now, the switch in the leading consist is closed, i.e. this is the first switch which is closed. It is then evaluated if the signal can be detected in the passive line of the consist. If this is the case, the verification procedure has detected that the leading consist is the last and only consist.

[0027] If there is a following consist, the procedure continues with this consist. This means that there is an active line and a passive line in this consist, since either the first or the second electric line is connected to the active line of the leading consist and since the switch is still open in this consist and, therefore, the other electric line (or at least not all parts of the other line) does not carry the signal yet.

[0028] Then, the switch in this consist is closed. It is then evaluated if the signal can be detected in the passive line of the consist. If this is the case, the verification procedure has detected that the consist is the last and only consist. If not, the procedure continues with the next following consist in the same manner until the last consist is reached.

[0029] This basic principle of the invention will be described with respect to figures 5 to 8 later. Also, preferred embodiments will be described there, in order to detect the number, orientation and sequence of the consists.

[0030] In particular, the following steps are performed:

- a) the switches, which are located in the switch line in each of the consists, are opened or are kept in the open state,
- b) starting at a leading consist, a signal is applied to one of the first and second electric lines in the leading consist, wherein the line which the signal is applied to is referred to as the active line of the consist and the other one of the first and second electric lines in the consist is referred to as the passive line.
- c) the control device of the consist closes the switch in the switch line of the consist,

d) it is determined if the signal can be detected at both the active and the passive line,

e) if the signal cannot be detected at both the active and the passive line steps c), d) and e) are repeated for the following consist, the following consist comprising an active line, which is the one of the first and second electric line that is connected to the active line of the preceding consist, and the following consist comprising the other one of the first and second electric lines which is referred to as the passive line, f) if the signal can be detected at both the active and the passive line the last consist in the train is reached and, as a result, there is no following consist, g) determining the number of performances of steps c), d) and e), including the first performance for the leading consist, as the number of consists in the train.

[0031] It should be mentioned that in step b), the signal is only applied to the active line and is not directly applied to the passive line. The only possibility that the application of the signal to the active line makes the signal available at the passive line is that the consist is the last consist and, therefore, the first and second electric lines of the consist are connected to each other.

[0032] For each consist, step c) is performed after step b). In addition, step d) is performed after step c) for each consist. Step e) is a step in which a decision is made, but no further action is taken with the exception of repeating steps b), c) and d) for the following consist, if there is such a following consist. If the decision or detection in step e) does not result in a repetition of steps b), c) and d), step f) is performed after step e). In this step, no action is taken except for the decision. It is just detected that the signal is available both at the active and the passive line. In other words, steps e) and f) correspond to the two branches in a flow chart at a point where a decision is made and depending on the yes- or no-decision either the first branch is followed or the second branch. Therefore, steps e) and f) can also be considered as parts of the same step. Step g) can be omitted or replaced by another step in which just the information about the detected last consist in the train is output.

[0033] If step g) is performed the determined number of consists in the train may be compared with information about a desired number of consists which shall form the train in order to verify if the number of consists is equal to the desired number of consists. The information about the desired number of consists may be received as explained before.

[0034] In many cases, each consist in a fleet of rail vehicles has a unique identifier which is assigned to the consist. Furthermore, it may be essential for proper function of the train control system to know the unique identifiers of each consist in the train and, optionally, as well the sequence of the consists in the train. One reason for the use of unique identifiers may be that the train control system performs a monitoring of the consists in the train in order to decide if the respective consist is expected to

work reliably or if maintenance is needed. Alternatively or in addition, the train control system may be come aware of a fault in one of the consists and needs to pass the information to a stationary control centre for controlling the vehicle fleet.

[0035] Therefore it is preferred that the unique identifiers of the consists are verified and, optionally, compared with information about the consists which are expected to be part of the train. In particular, there are two ways to obtain the required information from the actual train. First, for each consist in the train, the respective unique identifier, which is stored in the consist, is retrieved. For example, a central control unit in the train may retrieve and collect the unique identifiers of the consists. According to another embodiment, information about the expected unique identifiers in the train is used to instruct the control devices or the consists to close the switch, for example according to the step c) in the list of steps stated above. It may then be checked, as soon as the switch in the last consist is closed, if any of the first or second lines in the consists forming the train is interrupted by an open switch. If this is the case, there are two possibilities. First, the consists are not in the expected sequence. Optionally, the remaining unique identifiers can be used to instruct the control devices of the respective consists to close the switch or switches. If there is still one of the first or second lines interrupted by an open switch, there is either a malfunction or there is a consist in the train which has a unique identifier that is not expected to be there.

[0036] More generally speaking, embodiments of the present invention may be designed to retrieve the unique identifiers of all consists in the train and/or to provide the information which consist is coupled to any other consist in the train and the information at which position each consist in the train is located. In both cases, unique identifiers of the consists in the train or of the consists which are expected to be in the train can be used as mentioned above. In particular, the unique identifiers which may be retrieved from the consists in the train are used to verify if the consists are coupled together according to an expected sequence. The retrieval of the unique identifier is preferably done at the beginning of the validation procedure. The unique identifier is unambiguously linked to the consist.

[0037] According to a preferred embodiment, it is evaluated before closing the switch in a particular consist (e.g. before step c) in the list of steps above) if the signal can be detected at the continuous line and it is decided that the continuous line is the active line if the signal can be detected at the continuous line and it is decided that the switch line is the active line if the signal cannot be detected at the continuous line. Preferably, this decision is used to verify if the consist is oriented in a desired manner.

[0038] Evaluating or detecting if the signal is applied to the continuous line before closing the switch in the consist, can easily be performed in the procedure of de-

termining the number of consists and/or determining the last consist.

[0039] The invention also relates to an arrangement for configuration of a train control system, wherein the system is able to control trains comprising a variable number of consists, which are rolling units that can be coupled together to form a train, wherein the arrangement comprises in each consist within the train:

- 10 • a first electric line which is connected to a corresponding first electric line in any following and preceding consist in the train,
- a second electric line which is connected to a corresponding second electric line in any following and preceding consist in the train,
- 15 • an electric connection between the first electric line and the second electric line in the last consist
- a switch in one of the first and second electric lines, which is referred to as the switch line of the consist, wherein the other one of the first and second electric lines in each of the consists is referred to as the continuous line,
- 20

wherein the arrangement comprises at least one control device adapted to control the switches in the consists of the train and wherein the arrangement is adapted to sequentially, starting with a leading consist, close the switches.

[0040] Modifications and features of further embodiments of the arrangement follow from the description of embodiments of the method according to the present invention.

[0041] In particular,

- 35 • the arrangement may further comprise one control device (preferably a device which corresponds to a defined safety integrity) in each consist of the train, each control device being adapted to control the switch in the consist and/or
- 40 • the arrangement may comprise a central control unit (preferably a unit which corresponds to a defined safety integrity) which is adapted to instruct the at least one control device to open the switches, which are located in the switch lines or to keep the switches in the open state, before sequentially closing the switches, wherein the central control unit instructs the at least one control device or the respective control device of a particular consist to close the switch in the switch line of the consist, and/or
- 45 • the arrangement may comprise a signal generation device and a signal connection (preferably a connection which is adapted to transfer signals corresponding to a defined safety integrity) which are adapted to, starting at a leading consist, apply a signal to one of the first and second electric lines in the leading consist, wherein the line which the signal is applied to is referred to as the active line of the consist and the other one of the first and second electric
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- 55

lines in the consist is referred to as the passive line, and/or

- the arrangement may comprise at least one determining device adapted to determine if the signal can be detected at a section of the passive line of a consist, after the switch of the consist has been closed, wherein the determination starts at a leading consist and repeatedly continues with any following consist until the signal is detected at the section of the passive line of the consist, and
- the arrangement may comprise a verification device being adapted to compare the determination results determined by the at least one determining device with expected results obtained using the information about the desired number of consists, thereby verifying if the number of consists from the leading consist to the last consist is equal to the desired number of consists, and/or
- the arrangement may be adapted to receive information about a unique identifier for each consist which shall be part of the train, each unique identifier being assigned to one particular consist, wherein for each consist in the train

1. either the arrangement is adapted to obtain a unique identifier, which is stored in the consist, and is adapted to compare the unique identifier with the information about the unique identifier or
2. the at least one central control unit mentioned above is adapted to use the information about the unique identifier to instruct the at least one control device or of the respective control device of the consist to close the switch,

and

- the arrangement may be adapted to verify if each existing consist in the train is expected to be in the train and/or if the consists are coupled together in an expected sequence, and/or
- the arrangement may be adapted to receive information about an orientation of each consist which shall be part of the train, wherein the arrangement is adapted to use for each consist in the train the determination results determined by the determining device mentioned above to identify if the active line is the switch line or if the passive line is the switch line and wherein the verification device is adapted to verify based on the result of the identification if the consist is oriented in a desired manner.

[0042] Furthermore, the present invention includes a train control system adapted to control trains comprising a variable number of consists, which are rolling units that can be coupled together to form a train, wherein the train control system comprises the arrangement in one of the embodiments described above and/or below.

[0043] Furthermore, the present invention includes a train comprising a number of consists, which are rolling

units that are coupled together to form the train, and further comprising the arrangement in one of the embodiments described above and/or below.

[0044] Preferred embodiments of the present invention will be described with reference to the attached drawing. Furthermore, some basic principals will be illustrated in connection with the drawings.

Fig. 1 shows a train having three consists,

Fig. 2 shows the train of Fig. 1, wherein the second consist has been decoupled and the first and the third consist have been coupled together,

Fig. 3 schematically shows electric lines, switches and control devices for controlling the switches for a sequence of three consists in a train, for example for the three consists of Fig. 1,

Fig. 4 schematically shows electric lines, switches and control devices for controlling the switches in two consists coupled together, for example for the train shown in Fig. 2,

Fig. 5 - 8 show a consist in different position within a train and with different orientations.

[0045] The train T1 shown in Fig. 1 comprises three consists C1, C2, C3 which are coupled together. The first consist C1 and third consist C3 are designed to travel as the front part of the train T1, i.e. the driver may drive the train T1 using a control desk in the consist C1, C3. The consist C2 in the middle of the train T1 has no driver desk. It is coupled to the consists C1, C3 in regions denoted by CP.

[0046] In the train T2 shown in Fig. 2, the second consist C2 of Fig. 1 is missing. The first consist C1 and the third consist C3 are directly coupled together in a region CP.

[0047] A train control system may be provided as a distributed system in the train T1 or T2. For example, a master computer of the train control system may be located in the first consist C1 or in the third consist C3, depending on the direction of travel, in the leading consist. If train T1 of Fig. 1 would travel to the left, the master computer may be located in consist C1. If train T1 would travel in the opposite direction, the master computer may be located in consist C3. The consist comprising the master computer and the other consists in the train may comprise further computers (slave computers) or other devices which are connected to the master computer by data transfer connections. The master computer controls the operation of all other devices in the system. In addition, sensors and actuators may be distributed all over the train which are connected to at least one of the computers, devices or data switches of the train control system via data transfer connections and/or electric lines.

[0048] Alternatively, instead of using one computer in the leading consist as master computer, a particular computer in the train can be used as master computer, no

matter if the train travels in one direction or in the opposite direction.

[0049] Figures 5 - 8 show a consist at different locations and having different orientations in the train.

[0050] The consist C comprises a switch line D1, D2, wherein the two sections D1 and D2 of the switch line are separated from each other by a switch S which can be opened and closed. The control device which controls the opening or closing of the switch S is, for example, a computer COM which is connected to the switch S via a control line O (dashed arrow). The consist C also comprises a continuous line D3 having no switch or any switch in the line is permanently closed while the procedure is performed.

[0051] The control device COM is connected to other devices, in particular to the control devices in other consists of the train, via a data bus B.

[0052] In the example and for better illustration of the invention, each section D1, D2 of the switch line and the continuous line D3 comprises a location (i.e. a point in the line) at which a signal on the line can be detected. These locations are connected in Fig. 5 - 8 with the control device COM via a measurement / detection connection M1, M2, M3. Therefore, the computer COM can detect or measure if the signal is present or not at the respective location.

[0053] The measurement can be performed in practice in a different manner. For example, a measurement sensor (e.g. a resistor in the section or line) can be located in the section or line or near the section or line and a corresponding number of measurement lines may be connected to the control device COM where a measurement unit is located. For example, in the case of the resistor, two measurement lines connect the resistor with the measurement unit so that the voltage across the resistor can be measured. Alternatively, the resistor may be located within a line connecting the measurement location with a reference potential, such as ground potential. In this case, two measurement lines leading to the measurement unit at the computer COM are provided and are connected to measure the voltage across the resistor in order to detect if the potential at the measurement location is at the ground potential or at a different potential which corresponds to the signal. In this preferred case, the different potential is produced by a voltage source and is applied to the active line as indicated by device SO in Fig. 5 - 8.

[0054] The ground potential is also indicated in Fig. 5 - 8. However, not all components are shown, such as a resistor connecting the passive line to ground potential.

[0055] Other ways of performing the invention are also possible. Fig. 5 - 8 serve to illustrate basic principals of the invention, but these basic principals also apply to other embodiments of the arrangement. For example, the computer COM may be located in a different part of the train, such as in the leading consist only or in a locomotive. Alternatively, or in addition, the signal may not be a voltage signal, but a frequency signal. In this case,

the measurement connections M1, M2, M3 may comprise a band pass filter which is adapted to let pass the frequency signal produced by the signal source SO.

[0056] Fig. 5 shows the consist C in a situation in which the consist C is not the last consist in the train. The signal is applied to the switch line. In the situation shown in Fig. 6, the consist C is the last consist in the train, since the switch line D1, D2 and the continuous line D3 are connected to each other at the end of the train via a connection CON.

[0057] In the situation depicted in Fig. 7, the continuous line D3 is the active line and the consist C is not the last consist in the train.

[0058] According to the state shown in Fig. 8, the consist C is again (as in Fig. 6) the last consist in the train, but the continuous line D3 is the active line as in Fig. 7.

[0059] Before closing the switch S, the signal can be detected only at the location of M1 (Fig. 5), the location of M1 (Fig. 6), the location of M3 (Fig. 7) and the locations of M3, M2 (Fig. 8).

[0060] After closing the switch S, the signal can be detected at the locations of M1, M2 (Fig. 5), at the locations of M1, M2, M3 (Fig. 6), the location of M3 (Fig. 7) and the locations of M3, M2, M1 (Fig. 8). In the case that the consist C is the last consist (Fig. 6 and 8), this means, that closing the switch applies the signal to all sections and lines, no matter if the switch line or the continuous line is the active line.

[0061] Therefore, detecting the signal at the passive line (the continuous line D3 in Fig. 6 or the switch line D1, D2 in Fig. 8) means that the consist C is the last consist in the train. While closing the switch S in the case of Fig. 6 applies the signal to the passive line, the closing of the switch S in the situation of Fig. 8 does not change the situation in section D2, but does change the situation in section D1. However, since the connection CON is the reason for the fact that the signal can be detected in the passive line, detecting the signal in the passive line after closing the switch S is a reliable proof. Therefore, only one measurement / detection location in the switch line is sufficient to perform the verification procedure regarding the detection of the last consist in the train. This means that only two measurement locations are needed for this purpose, one in the switch line and one in the continuous line.

[0062] In order to detect the number of consists from the leading consist to the last consist in the train, it may be counted how often a switch in the switch line of a consist is closed until the last consist is reached and can be detected as the last consist. This counting may be performed, for example by the computer COM in the leading consist or in a locomotive which is connected to the computers COM in the other consists C via the data bus B which extends through the whole train.

[0063] Another possibility to detect the number of consists in the train is to retrieve a unique identifier from each consist which is stored in the consist. For example, the unique identifier of the leading consist is transmitted to

a central control unit controlling the process of verifying the configuration information. Alternatively, the computer COM in the leading consist may be the central control unit itself. Another alternative may be that the computer COM in another consist of the train is the central control unit. Preferred is that the computer in the leading consist is the central control unit, since this saves costs for expensive computers having high safety levels. Safety tested computers are usually part of the train control system. They can be used for the purpose of the present invention.

[0064] The central control unit may then retrieve the unique identifiers from each consist. For example, the central control unit may broadcast a corresponding retrieval request to all computers COM connected to the bus B. If only one computer having access to a unique identifier of a consist exists in each consist, the number of retrieved unique identifiers is equal to the number of consist.

[0065] It is also possible, that the number of consist in the train is not only determined by performing one procedure, but performing a plurality of procedures, such as counting the switching actions (see above) and counting the number of retrieved unique identifiers.

[0066] Further information which is in most cases essential for a train control system is the orientation of each consist in the train. For each consist, there are two possible orientations. The basic principal of identifying the orientation is to detect whether the switch line or the continuous line is the active line or, alternatively, which of the switch line and continuous line is the passive line. A requirement for performing the verification procedure is that the active line would change if the consist would be decoupled from the train and re-coupled to the train in opposite orientation. This requirement can be fulfilled, for example, by using electric connectors at the opposite ends of the consist, wherein a first pole of the connector at the first end of the consist is connected to the continuous line and a second pole at the same connector is connected to the switch line and wherein, at the opposite end of the consist, the continuous line is connected to the second pole and the switch line to the first pole. Furthermore, the information about the desired orientation corresponds to this basic concept of detecting the orientation using the verification procedure. For example, a side of the consist which is defined as the "right" side should be assigned to either the continuous line or the switch line being the active line and the person or system which produces the information about the desired orientation should know about this assignment. For example, the correct orientation of each consist guarantees that the driver will open the doors on the correct side of the train.

[0067] There are different possibilities to identify which line, the continuous line or the switch line, is the active line. All these possibilities must fulfil the requirement that the procedure does not depend on the question if the consist is the last consist or not.

[0068] Coming back to the illustration of Fig. 5 to 8: Since the signal can be detected at all three locations M1, M2, M3 after closure of the switch S, if the consist is the last consist in the train (see Fig. 6 and 8), at least some information before closing the switch should be collected. One possibility is to detect, before closing the switch S, if the continuous line carries the signal. If this is the case, the continuous line is the active line and vice versa. The computer COM in the consist should know (i.e. corresponding data is available to the computer) which measurement point belongs to which line or line section in the consist.

[0069] If a central control unit is used to instruct the switch control devices in different consists, and if the sequence (in which the switches in the different consists are closed) must correspond to a desired sequence, it is preferred to either guarantee that

- the switches in the consists are closed in the actual order of the consisting consist or
- that the unique identifiers of the consists are used to instruct the control device to close the switch.

[0070] In the first case, a procedure is required which guarantees that the switches are sequentially closed in the order of the existing consists. One possible procedure is to use point to point connections from the control device or computer in the leading consist to the next following consist and so on between each consist and the next following consist. This means that the instruction sent from the central control unit to a particular control device in a consist must pass all control devices in between the consist and the leading consist. Therefore, a control device which has not performed the action of closing the switch in the consist can block instructions to other control devices in any following consist. The central control unit can therefore issue one instruction signal and the next control device in the sequence of the consist, which has not performed the switching action, will be addressed and will close its switch. In particular, the expected unique identifiers of the consists can be used to address the control devices of the respective consist.

[0071] Fig. 3 shows three consists C1, C2, C3, which are coupled together in the sequence C1, C2, C3. The regions where the middle consist C2 is coupled to the leading consist C1 and to the last consist C3 are denoted by CP. In these coupling regions CP, a first electric line extending through the leading consist C1 is coupled to a first electric line in the middle consist C2 and this first electric line in the middle consist C2 is coupled to a first electric line in the last consist C3. In the example shown, the first electric line is constituted by sections D1, D2 in consist C1, by a continuous line D3 in the middle consist C2 and by sections D1, D2 in the last consist C3. The first electric line is connected either within the leading consist C1 or, alternatively, by connecting section D1 to an external device, to a signal source SO which may be a frequency generator or a plus pole of a voltage source,

for example.

[0072] The sections D1, D2 in the leading consist C1 and in the last consist C3 are separated from each other by a switch S1 in consist C1 or by a switch S3 in consist C3. The middle consist C2 also has a switch line with sections D1, D2 which are separated from each other by a switch S2. but the switch line is not part of the first electric line. Rather the switch line of consist C2 is part of a second electric line extending through the sequence of the three consists C1, C2, C3. The other parts of the second electric line are a continuous line D3 in the leading consist C1 and a continuous line D3 in the last consist C3. These parts of the second electric line are electrically connected (i.e. coupled) together in the coupling regions CP. Furthermore, the end regions of the first electric line and the second electric line in the last consist C3 are electrically connected to each other via a connection CON. The beginning of the second electric line in consist C1 (i.e. the section which is not connected to the second line in consist C2) at the front end (left side in Fig. 3) is, for example, connected to ground potential G, wherein details, such as a high ohmic resistor, are not shown in the schematic drawing of Fig. 3.

[0073] In the same manner as described with respect to Fig. 5 - 8, each consist C1, C2, C3 comprises a control device or computer COM having at least one measurement connection to the switch line in the consist and one measurement connection to the continuous line in the consist. Not both of the measurement connections M1, M2 shown in each of the consists are required within the same consist. Fig. 3 just illustrates that these two locations are possible for the measurement at the switch line. Measurement, which may also be called detection, serves to detect if the signal produced by the signal source SO is present at the measurement location.

[0074] In the example shown in Fig. 3, there is an additional computer, the master computer MC which is not the control device or computer COM1 in consist C1. Signal source SO and master computer MC may be located, for example, in a locomotive which is not shown in Fig. 3 and which is coupled to the leading consist C1 (on the left side in Fig. 3). However, as shown in Fig. 4 for a different example, signal source SO and master computer MC may be located in one of the consists or preferably in the leading consist. Other embodiments are also possible, for example that the signal source is located within the leading consist, but the master computer is not located in the leading consist and vice versa.

[0075] The control devices or computers COM within the consists C1, C2, C3 are connected to each other via a data bus B. If there is an additional master computer MC, it is also connected to the data bus B.

[0076] In the following, a preferred embodiment of the present invention is described based on the arrangement shown in Fig. 3. However, the number of consists is just an example. The train may comprise any other number of consists.

[0077] The master computer MC which may also be

the computer COM1 in the leading consist C1 starts the procedure by checking that each switch S1, S2, S3 in the consists is open. If one of the switches is not open, it will be opened. For example, the master computer instructs the control devices COM2 in the middle consist C2 and COM3 in the last consist C3 via the data bus B to open their switch S2, S3 or to check if their switch S2, S3 is open.

[0078] A signal generated by the signal source SO is applied to the first line in the leading consist C1. Since this first line is the switch line, the signal is applied to section D1. If the first line would be the continuous line (as shown in the example of Fig. 4), the signal would be applied to the continuous line.

[0079] In the next step, information is collected about the orientation of the consist C1, the leading consist. Before closing the switch S1, it is measured or detected if the signal is applied to the continuous line D3 of the leading consist C1. In the example of Fig. 3, this is not the case (in the example of Fig. 4 it is the case). Therefore, the switch line is the active line in Fig. 3 and this information is equivalent to the information that the leading consist C1 is oriented in the direction shown in Fig. 3 (and is not oriented in the opposite direction, as in the example shown in Fig. 4).

[0080] Then, the switch S1 is closed by the master computer MC. If the master computer is not the control device within the consist C1, the master computer issues a command via data bus B to the control device COM1. The control device issues a command to the switch or applies, for example, the appropriate voltage to control the closure of the switch S1. The control connection between the control device COM1 and the switch S1 is schematically indicated by the dashed arrow denoted with reference sign O. Thereby, switch S1 is closed. Therefore, the sections D1, D2 of the switch line are electrically connected to each other and the signal from the signal source SO is also detectable at section D2. This status of being the active line is denoted by SL. The passive line is denoted by PL. According to the preferred embodiment, the first line is always the active line and the second line is always the passive line.

[0081] In the example shown in Fig. 4, closing the switch S1 connects the sections D1, D2 of the switch line, but the switch line of the leading consist C1 is the passive line. Therefore (and since the consist is not the last consist), the signal is not available at the section D1 nor at the section D2.

[0082] Coming back to the example of Fig. 3, the signal is not available at the continuous line D3 by closing switch S1. This is detected using measurement line M3. In the example of Fig. 4, this could be detected either by measurement line M1 or by measurement line M2.

[0083] Since, in both cases, the signal cannot be detected after closing the switch S1 in the passive line, it is decided by the master computer or by the control device COM1 that the consist is not the last consist in the train.

[0084] In order to count the number of consists in the

train, a counter is set to "1" before, while or after closing the switch S1 in the leading consist C1 (i.e. the first switch in the train).

[0085] Furthermore, the master computer MC retrieves a unique identifier of the leading consist C1. This retrieval may be initiated by sending a request to transmit the unique identifier. For example, the request may be sent together with the command to close the switch S1. If the control device COM1 is the master computer it can retrieve the unique identifier of the consist by reading the content of a corresponding data storage which is combined with the master computer.

[0086] The retrieved unique identifier may be used to check if a consist having this particular unique identifier is expected to be within the train. In addition, optionally, the retrieved unique identifier is used to check if a consist having this unique identifier is expected to be the leading consist in the train.

[0087] Generally speaking, not only in context with the verification of the unique identifier, any difference between the expected train configuration and the information collected with the arrangement or method of the present invention, may automatically result in a warning to the driver or to the operator of the train. For example, it would also result in such a difference if a switch cannot be closed or if the parts of the first line in the different consist would not be connected to each other. As an alternative to a warning, any difference may prohibit the operation of the train. For example, the master computer which performs the verification may produce the warning signal or may block the operation of the train.

[0088] The next step in the procedure is to check for the next following consist (consist C2 in the example of Fig. 3 and consist C3 in the example of Fig. 4) if the signal can be detected in the continuous line D3. This is the case for consist C2 in the example of Fig. 3 and this is not the case in consist C3 in the example of Fig. 4. In the manner as described above for consist C1, this information is used to determine the orientation of the consist.

[0089] Next, the switch in the consist (S2 of consist C2 or S3 of consist C3) is closed, for example the master computer MC or COM1 issues a corresponding command to the control device COM2 or COM3 in the consist.

[0090] The value of the counter counting the number of consists in the train is increased by one before, while or after closing the switch.

[0091] Next, it is evaluated if the signal is applied to the passive line PL in the consist C2 in the example of Fig. 3 or C3 in the example of Fig. 4. The passive line is the switch line in consist C2 and the continuous line in consist C3. Therefore, the signal cannot be detected in the example of Fig. 3 and can be detected in the example of Fig. 4, since the consist C2 in Fig. 3 is not the last consist and since the consist C3 in Fig. 4 is the last consist and the continuous line D3 is connected to the switch line D1, D2 by connection CON.

[0092] Furthermore, in the same manner as described above for consist C1, the unique identifier is retrieved

from consist C2 (in the example of Fig. 3) and of consist C3 (in the example of Fig. 4). Again, it can be verified if the consist with this unique identifier is expected to be within the train or is expected to be at this position in the sequence of consists.

[0093] In the example of Fig. 4 relevant information about the train configuration has been collected and it is not necessary to continue. However, optionally, final checks can be performed, such as checking if the signal can be detected at the front end of the passive line in the leading consist C1, i.e. in section D2 of consist C1. If this would not be the case, there would be a malfunction, for example due to a loose connection of the second lines of consists C3 and C1, or a defect switch in the passive line.

[0094] When all necessary information has been collected, the whole procedure or parts of the procedure may be repeated.

[0095] In the example of Fig. 3, the procedure continues with

- checking if the signal can be detected in the continuous line of the next following consist (consist C3), in order to collect information about the orientation of the consist,
- the counter value of the counter for counting the number of consists in the train is increased by one,
- the switch in the switch line is closed and it is checked if the signal can be detected in the passive line, in order to determine if the consist is the last consist,
- retrieving a unique identifier of the consist in order to verify if the consist is expected to be in the train or is expected to be at this position in the sequence of consists.

[0096] In the following, general aspects of the invention and features of embodiments of the invention are discussed.

[0097] The invention solves the problem that existing train configuration systems cannot rely safely on information about the number of consists in the train, about the orientation of the consists and about the sequence of the consists which is defined using their unique identifier.

[0098] Furthermore, existing train control systems can be used as they are or can be extended by implementing the present invention. Therefore, the present invention can be performed also separately from any existing train control system. The arrangement according to the present invention can transfer or broadcast safely the collected information to any device within the train or outside of the train. Any verification using the collected information, in particular by comparing with expected train configuration, can be performed by the arrangement according to the present invention and/or by any other device within the train or outside of the train.

[0099] Each consist may comprise a plurality of rolling units, for example cars. However, these units cannot be

coupled or decoupled automatically. Correspondingly, a consist may be defined as the smallest unit of the train which can be coupled and/or uncoupled automatically. The leading consist may be detected using the fact that the driver or another responsible person of the staff has operated a key within the consist, for example within the driver compartment. The key may be operated by using a mechanical key or by providing a coded set of data.

[0100] According to an embodiment of the present invention, the switch in any consist, in particular in the leading consist, is opened and is kept open (which means that it is prevented that the switch can be closed) if the arrangement detects any malfunction of components which are necessary for the arrangement of the present invention and/or are necessary for the operation of the train control system. For example, a so called heartbeat signal which is received by the arrangement may indicate that any needed component is operating without fault. If the heartbeat signal is no longer received, the switch is kept open as mentioned. As a result, the information about the actual configuration of the train cannot be obtained or collected and the arrangement may output, for example, that no valid configuration of the train can be confirmed. In turn, this may result in a warning message or blocking the operation of the train.

[0101] By repeating the procedure of collecting the configuration information according to the present invention, any change in the configuration can be detected and corresponding information can be transferred to any other system in the train, in particular to the train configuration system.

Claims

1. Method for configuration of a train control system, wherein the system is able to control trains comprising a variable number of consists (C), which are rolling units that can be coupled together to form a train, wherein

- each consist, from a leading consist (C1) to a last consist (C3) in the train, has a first electric line which is connected to a corresponding first electric line in any following consist in the train,
- each of the consists has a second electric line which is connected to a corresponding second electric line in any following consist in the train,
- the first electric line and the second electric line in the last consist are connected to each other,
- one of the first and second electric lines in each of the consists, which is referred to as the switch line (D1, D2) of the consist, comprises a switch (S) which is controlled by a control device (COM) of the consist (C),
- the other one of the first and second electric lines in each of the consists is referred to as the

continuous line (D3) and wherein the method comprises:

- a) the switches (S), which are located in the switch line (D1, D2) in each of the consists (C), are opened or are kept in the open state,
- b) starting at a leading consist (C1), a signal is applied to one of the first and second electric lines in the leading consist, wherein the line which the signal is applied to is referred to as the active line (SL) of the consist and the other one of the first and second electric lines in the consist is referred to as the passive line (PL),
- c) the control device (COM) of the consist (C) closes the switch (S) in the switch line (D1, D2) of the consist (C),
- d) it is determined if the signal can be detected at both the active and the passive line,
- e) if the signal cannot be detected at both the active and the passive line steps c), d) and e) are repeated for the following consist (C2, C3), the following consist comprising an active line (SL), which is the one of the first and second electric line that is connected to the active line of the preceding consist (C1, C2), and the following consist (C2, C3) comprising the other one of the first and second electric lines which is referred to as the passive line (PL),
- f) if the signal can be detected at both the active (SL) and the passive line (PL) the last consist (C3) in the train is reached and, as a result, there is no following consist,
- g) determining the number of performances of steps c), d) and e), including the first performance for the leading consist, as the number of consists in the train.

2. The method of the preceding claim, wherein the method comprises receiving information about a desired number of consists (C) which shall form the train and comparing the number of consists determined according to claim 1, thereby verifying if the number of consists from the leading consist to the last consists is equal to the desired number of consists.

3. The method of one of the preceding claims, wherein a unique identifier is assigned to or has been assigned to each consist (C), wherein for each consist in the train

- the unique identifier, which is stored in the consist (C) is retrieved, and
- an expected unique identifier is used to instruct the control device (COM) of the consist to close

the switch (S) in step c) of claim 1, wherein it is checked, as soon as the switch (S3) in the last consist (C3) is closed, if any of the first or second lines in the consists forming the train are interrupted by an open switch (S)

and thereby verifying if each existing consist (C) in the train is expected to be in the train.

4. The method of the preceding claim, wherein the unique identifiers retrieved from the consists (C) in the train are used to verify if the consists (C) are coupled together according to an expected sequence.

5. The method of one of the preceding claims, wherein it is evaluated before step c) in claim 1 if the signal can be detected at the continuous line (D3) and wherein it is decided that the continuous line (D3) is the active line (SL) if the signal can be detected at the continuous line (D3) and it is decided that the switch line (D1, D2) is the active line (SL) if the signal cannot be detected at the continuous line (D3).

6. The method of the preceding claim, wherein the decision is used to verify if the consist (C) is oriented in a desired manner.

7. Arrangement for configuration of a train control system, wherein the system is able to control trains comprising a variable number of consists (C), which are rolling units that can be coupled together to form a train, wherein the arrangement comprises in each consist (C) within the train:

- a first electric line which is connected to a corresponding first electric line in any following and preceding consist in the train,
- a second electric line which is connected to a corresponding second electric line in any following and preceding consist in the train,
- an electric connection (CON) between the first electric line and the second electric line in the last consist (C3)
- a switch (S) in one of the first and second electric lines, which is referred to as the switch line (D1, D2) of the consist (C), wherein the other one of the first and second electric lines in each of the consists is referred to as the continuous line (D3),

wherein the arrangement comprises at least one control device (COM) adapted to control the switches (S) in the consists (C) of the train and wherein the arrangement is adapted to sequentially, starting with a leading consist (C), close the switches (S).

8. The arrangement of the preceding claim, wherein the arrangement comprises one control device (COM) in each consist of the train, each control device (COM) being adapted to control the switch (S) in the consist (C).

9. The arrangement of one of the preceding claims, wherein the arrangement comprises a central control unit (COM1, MC) which is adapted to instruct the at least one control device (COM) to open the switches, which are located in the switch lines (D1, D2) or to keep the switches (S) in the open state, before sequentially closing the switches (S), wherein the central control unit (COM1, MC) instructs the at least one control device or the respective control device (COM) of a particular consist (C) to close the switch (S) in the switch line (D1, D2) of the consist (C).

10. The arrangement of one of the preceding claims, wherein the arrangement comprises a signal generation device (SQ) and a signal connection which are adapted to, starting at a leading consist (C1), apply a signal to one of the first and second electric lines in the leading consist (C1), wherein the line which the signal is applied to is referred to as the active line (SL) of the consist (C) and the other one of the first and second electric lines in the consist (C) is referred to as the passive line (PL).

11. The arrangement of the preceding claim, wherein the arrangement comprises at least one determining device (COM) adapted to determine if the signal can be detected at a section of the passive line (PL) of a consist (C), after the switch (S) of the consist (C) has been closed, wherein the determination starts at a leading consist (C1) and repeatedly continues with any following consist (C2, C3) until the signal is detected at the section of the passive line (PL) of the consist (C).

12. The arrangement of one of the preceding claims, wherein the arrangement is adapted to receive information about a unique identifier for each consist (C) which shall be part of the train, each unique identifier being assigned to one particular consist, wherein for each consist (C) in the train

- the arrangement is adapted to obtain a stored unique identifier, which is stored in the consist (C), and is adapted to compare the unique identifier with an expected unique identifier and
- the at least one central control unit (MC, COM1) of claim 9 is adapted to use the expected unique identifier to instruct the at least one control device (COM) or the respective control device (COM) of the consist (C) to close the switch (S),

and wherein the arrangement is adapted to verify if

each existing consist (C) in the train is expected to be in the train and/or if the consists are coupled together in an expected sequence.

13. The arrangement of one of the preceding claims, wherein the arrangement is adapted to receive information about an orientation of each consist (C) which shall be part of the train, wherein the arrangement is adapted to use for each consist (C) in the train the determination results determined by the determining device to identify if the active line (SL) is the switch line (D1, D2) or if the passive line (PL) is the switch line and wherein a verification device is adapted to verify based on the result of the identification if the consist (C) is oriented in a desired manner. 5 10 15
14. A train control system adapted to control trains comprising a variable number of consists (C), which are rolling units that can be coupled together to form a train, wherein the train control system comprises the arrangement of one of claims 8 to 15. 20
15. A train comprising a number of consists (C), which are rolling units that are coupled together to form the train, and further comprising the arrangement of one of the claims 8 to 15. 25

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Fig. 1

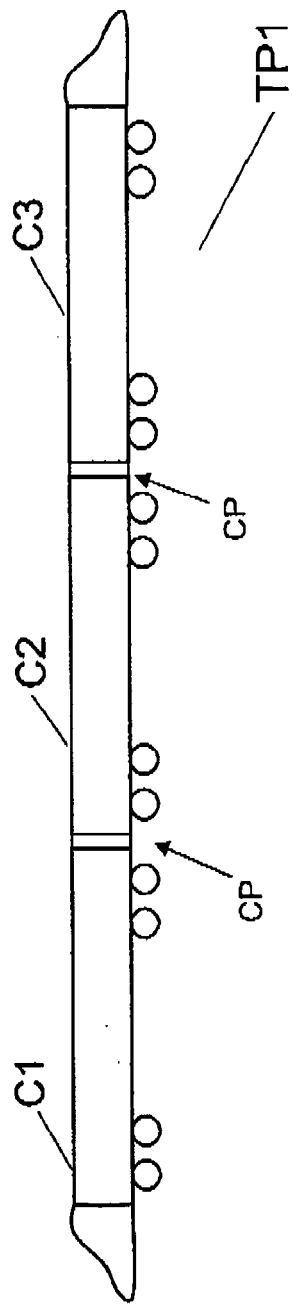
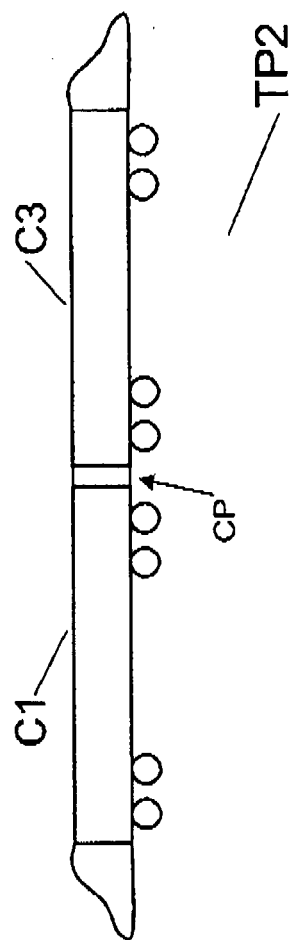
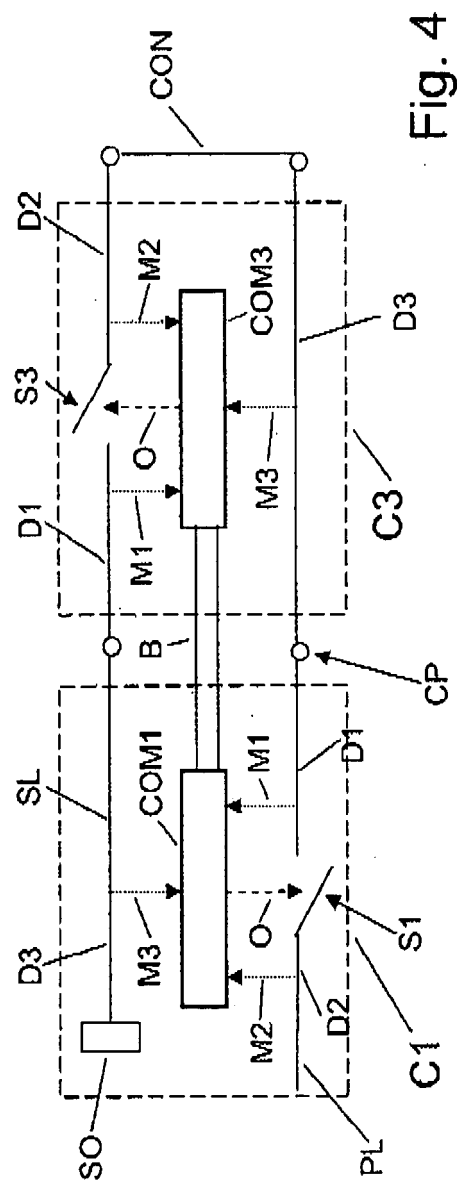
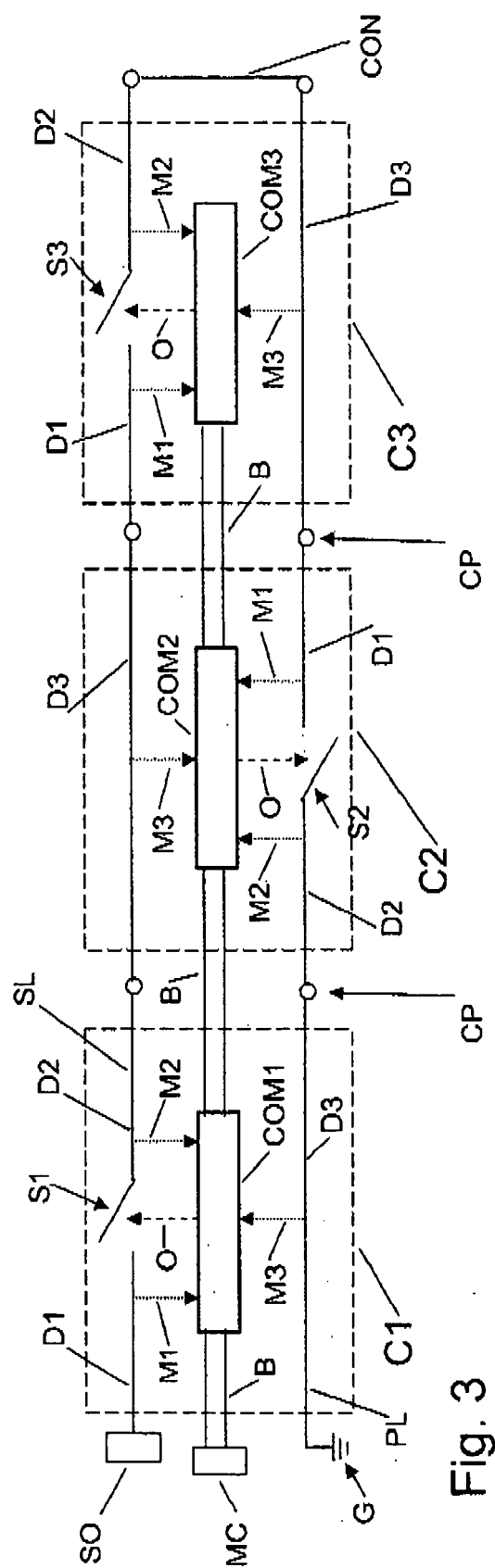


Fig. 2





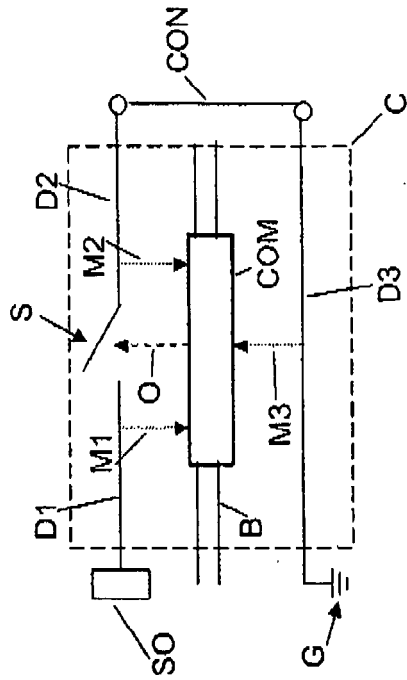


Fig. 5

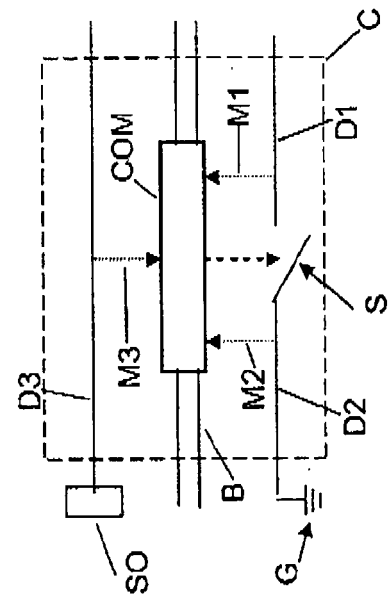


Fig. 6

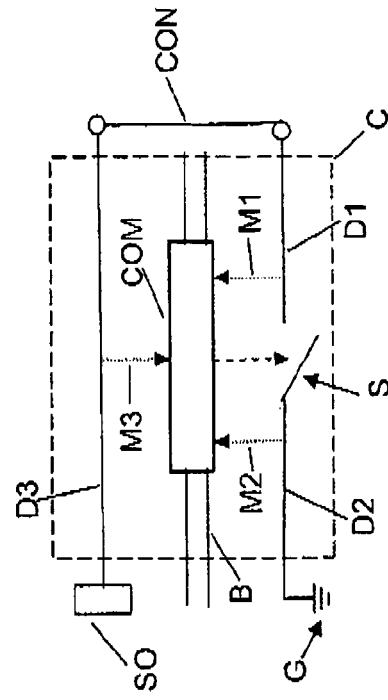


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 09 00 8055

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 1 065 128 A1 (DEUTSCHE BAHN AG [DE] RAILION DEUTSCHLAND AG [DE]) 3 January 2001 (2001-01-03) * paragraphs [0013] - [0022]; figures 1-3 *	1-15	INV. B61L15/00
A	WO 2009/069328 A1 (MITSUBISHI ELECTRIC CORP [JP]; HOMMA HIDETOSHI [JP]; TAKEYAMA MASAYUKI) 4 June 2009 (2009-06-04) * abstract; figures 2,3,4 *	1-15	
A	EP 1 306 283 A2 (DEUTSCHE BAHN AG [DE] DB REGIO AG [DE]; DB REISE & TOURISTIK AG [DE]) 2 May 2003 (2003-05-02) * paragraphs [0008] - [0014] *	1-15	
A	WO 2009/000544 A1 (BOMBARDIER TRANSP GMBH [DE]; DE COEN LUC [BE]; HANS GERNOT [DE]) 31 December 2008 (2008-12-31) * page 7, line 18 - page 10, line 8; figure 1 *	1,7, 14-15	
A	EP 1 422 833 A2 (HITACHI LTD [JP]; HITACHI INF & CONTROL SYST [JP]) 26 May 2004 (2004-05-26) * paragraphs [0014], [0015]; figures 1,2 *	1,7, 14-15	TECHNICAL FIELDS SEARCHED (IPC) B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 December 2009	Examiner Massalski, Matthias
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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

EP 09 00 8055

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