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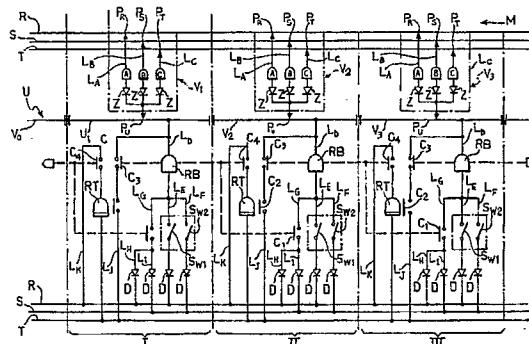
(54) **Equipment for controlling the movement of independent, motor-driven vehicles along a line of travel.**

(57) The line of travel of an overhead or other type of conveyor system includes three-phase electric power bars (R, S, T) and a control bar (U) divided into successive segments (U₁, U₂, U₃). Each vehicle has on-board control means, (A, B, C) for controlling the state of stoppage and at least one state of movement of the drive means. Each segment of the control bar has associated line control means (SW₁, SW₂) for controlling at least the said states of stoppage and of movement.

The on-board control means comprise an on-board circuit with three branches (L_A, L_B, L_C) which connect the respective power bars to the control bar. Each of these branches includes a respective on-board rectifier (Z). The on-board rectifiers are all oriented in the same sense. The on-board control

means are sensitive to the passage of current in one or more branches of the on-board circuit so as to control the said states of stoppage and movement.

The line control means associated with each segment of the control bar include a line circuit with a pair of branches (L_E, L_F) which the respective segments each to a respective power bar. Each of these branches includes a respective oriented line rectifier (D). The line rectifiers are all oriented in the opposite sense from that of the on-board rectifiers. The line control means also include settable switching means (SW₁, SW₂, C₁) for connecting one or other or both of the power bars (R, S) selectively to the control bar segment, such as to cause the passage and/or the stoppage of the current in the branches of the on-board circuit.



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EQUIPMENT FOR CONTROLLING THE MOVEMENT OF INDEPENDENT, MOTOR-DRIVEN VEHICLES ALONG A LINE OF TRAVEL

The present invention relates to control equipment for controlling the movement of independent, motor-driven vehicles along a line of travel, according to the introduction to Claim 1.

The invention has been developed for application to the control of conveyor carriages for an overhead conveyor system of the monorail type, but its application also extends to other systems, whether overhead or on the ground.

Equipment as defined in the introduction to Claim 1 is known from IT-B-1129163.

This known equipment makes use of the principle whereby a current which alternates sinusoidally may easily be split up, from the whole wave, into a positive half-wave and a negative half-wave. With the use of a control bar, this enables vehicles to be controlled so as to move at one or two speeds and to stop, and the presence of a vehicle on a following section of line to be signalled to stop a vehicle which is reaching a preceding section of line. This latter function also enables vehicles to be accumulated at a distance.

The equipment known from the document cited above has constituted a considerable progress over older control equipment but still has various limitations and/or defects, the main ones of which are as follows:

- The entire control system interacts through a single current collector or sliding contact on the control bar; if this contact is lost for any reason, as for example the breakage of the respective shoe or current collector, control is lost completely since the presence of the vehicle which has broken down is no longer signalled upstream of the line. This disadvantage may be eliminated only by doubling the control and operating system, with a considerable increase in investment costs.
- The control system is not able to control the presence of the three power phases needed to operate the vehicle motors correctly. Again in this case, it is necessary to add diagnostic and control apparatus, with associated costs, for complete safety.
- A further disadvantage of the known device is that the system for discriminating between the three pulsed sine wave signals, although being fairly simple, does however involve an electronic logic reading circuit with associated costs.
- Finally, the known equipment does not offer any means of allowing the current collector system of one vehicle to be replaced without loss of the signal indicating the presence of that vehicle, and hence loss of safety in the system.

The object of the invention is to provide equip-

ment of the type under consideration, which does not have the said disadvantages and, by virtue of its simplicity, is cheaper than the known equipment considered above.

According to the present invention, this object is achieved by means of equipment as defined in the characterising part of Claim 1 and in the following claims.

While in the equipment of the document IT-B-1129163, the operating principle was that of discriminating between at least three sine wave signals of the alternating current on a single reference conductor or control bar, the operating principle of the equipment of the present invention starts from the assumption of the use of the three reference phases of the three-phase alternating current and the exchange, according to need, of the reference phase on the fourth current collector which is suitably sectioned, that is on the segments of the control bar. By this device, one can obtain three separate current rings, usable as three distinct signals for the functions required for the first speed, the optional second speed, as well as the presence of the vehicles and their accumulation at a distance in safety.

A first advantage of the invention is that the three basic signals required for controlling the movement of the vehicles can be obtained without the use of electronic discriminatory circuits. Since only the closure of the three separate circuits need be detected, simple microrelays or other current detectors are needed for this purpose. The result is that maximum reliability can be achieved with a considerable reduction in the costs of production and performance of the system.

A further advantage of the invention is the fact that, in normal operation, the equipment interacts continuously with the three power phases so that their presence is always controlled. Should one of the current collectors of a vehicle break or even simply lose contact, the vehicle is stopped automatically but the presence of a vehicle which has broken down continues to be signalled, causing the stoppage of the following vehicles so as to avoid collisions.

Yet another advantage of the invention is that the equipment signals the presence of a vehicle which has broken down not only when one of the collectors has a fault but also when all of these collectors are faulty.

What this means is that, during maintenance of a vehicle which has broken down on the line, the whole system automatically remains safe. This enables a current collector unit to be replaced while

the vehicle is stopped on the line since, in this case, the presence of the vehicle being repaired continues to be signalled avoiding, among other things, the maintenance engineer being hit by a following vehicle.

The invention will be understood more clearly from a reading of the detailed description which follows, given with reference to the single appended drawing, which illustrates a simplified electrical diagram of a preferred embodiment, given by way of non-limiting example.

The upper part of the drawing shows three electrical power supply bars R, S and T of a travel line, such as a monorail. Each of these bars corresponds to one of the phases, also termed R, S and T, of a current which alternates at the usual frequency of 50Hz and preferably at a low tension, such as 40 volts.

The line also includes a control bar, generally indicated U, which runs parallel to the power bars R, S, T and is divided into segments U_1 , U_2 , U_3 ... which are insulated from each other. These segments may have a length of several metres but not such as to be engaged by more than one vehicle at a time.

As will be understood from the following, the segments of the control bar U correspond to an equal number of line sections or portions, three of which are shown at I, II and III in the lower part of the drawing.

The lower part of the drawing also shows three virtual bars R, S and T which are none other than conductors connected to the bars proper of the travel line.

The areas indicated V_1 , V_2 and V_3 represent symbolically three independent, motor-driven vehicles such as, for example, carriages of a monorail conveyor system. The direction of travel of the vehicles is indicated by the arrow M. It is supposed that the vehicles V_1 , V_2 and V_3 occupy the sections I, II and III respectively.

Each vehicle has its own three-phase electric motor such as a conventional pole-switching rotary motor. The motors could, however, be of a different type, such as, for example, the movable stator of a linear motor whose fixed rotor is carried by, or constituted by, the line of travel.

In a manner not shown, the motor of each vehicle receives its power supply from the bars R, S, T through respective sliding shoes or like current collectors P_R , P_S , P_T .

Each vehicle also has a sliding shoe or like current collector P_U which engages the successive segments of the control bar U.

On each vehicle, the current collectors P_R , P_S , P_T are connected to the current collector P_U by means of an on-board circuit which includes three branches L_A , L_B , L_C . Each of these branches incor-

porates respective on-board control means A, B, C and a respective diode or rectifier Z in series with each other. These rectifiers Z are all oriented in the same sense so as to avoid short-circuiting between the three phases R, S, T conveyed in the same conductor.

The on-board control means A, B, C are sensitive to the passage of current in their respective branches L_A , L_B , L_C . They may, for example, be relay windings. Alternatively they may be simple resistors the ends of which may supply a voltage.

In each case, the control means A, B and C are arranged so as to control the circuit which supplies the motor of the respective vehicle in such a manner as to make it operate at first and second speeds, through the switching of poles, as well as to cause its stoppage. This circuit has not been shown since it is within the capability of an expert in the art.

By way of example, the current detectors A, B, C (relay windings or resistors) are associated with a logic such as to fulfil the following functions:

F_1 - when B and C are passing current and A is not passing current, the motor is supplied at a first speed;

F_2 - when A and C are passing current and B is not passing current, the motor is supplied at a second speed;

F_3 - when A, B and C are all passing current, the motor is not supplied and the vehicle stops.

Each line section I, II and III etc, includes a circuit which interconnects the respective segment U_1 , U_2 , U_3 of the control bar U with the three phases R, S, T indicated in the lower part of the drawing.

Starting from one of segments U_1 , U_2 , U_3 , the line circuit includes a portion L_D including a block relay RB of which more will be said below.

The conductor L_D branches into three parallel branches L_E , L_F and L_G . The arms L_E and L_F are connected to the phases R and S respectively each with the interposition of a respective switch SW_1 , SW_2 and a respective diode D in series.

The branch L_G includes an auxiliary contact C_1 which is normally open and which forms part of the block relay RB of the next section with reference to the direction of motion M along the travel line. For example, the contact C_1 of the section II forms part of the block relay RB of the section I.

After the contact C_1 , the branch L_G again branches into two sub-branches L_H and L_I , each with a rectifier or diode D similar to the preceding ones.

All the line diodes or rectifiers D are oriented in the opposite sense from those of the on-board rectifier Z. Their function is again that of avoiding short-circuiting between the phases R, S, T.

The branches L_E and L_H terminate at the phase

R and the arms L_F and L_I terminate at the phase S.

Each section I, II, and III includes a second relay RT, called a transition relay, the function of which will be clarified below. The transition relay RT has an auxiliary contact C_2 which is normally closed. This is of the type in which, when its winding is conducting, the contact C_2 opens temporarily only to close after a very short period of time.

The contact C_2 is in series with an auxiliary contact C_3 which is normally open and which forms part of the block relay RB of the same section I, II or III. This series arrangement is in a line L_J which connects the phase T to the respective segment U_1 , U_2 or U_3 of the control bar U.

The supply for the winding of the security relay RT is taken from the phases R and T through a line L_K . This line L_K incorporates a further auxiliary contact C_4 which is normally open and which forms part of the block relay RB of the subsequent section. For example, the contact C_4 of the section II forms part of the block relay RB of the section I.

The switches SW_1 and SW_2 may be manual switches situated on a control panel or switches which are controlled by a control processor for the line. These serve as switching means for setting the states of movement and stoppage of the vehicles in the respective section of the line.

In particular, when SW_1 is closed and SW_2 is open, the said function F_1 (first speed) obtains; when, on the other hand, SW_1 is open and SW_2 is closed, the function F_2 (second speed) obtains; finally, when SW_1 and SW_2 are both closed, the function F_3 (stoppage) obtains.

Indeed, when SW_1 is closed, current passes through the on-board control means between the phase R, on the one hand, and the phases S and T, on the other, through the detectors B and C, while no current passes through the detector A which has the phase R across its ends. When SW_2 is closed and SW_1 is open, however, the current passes through the detectors A, C and not through the detector B for the same reasons. Finally, when both SW_1 and SW_2 are closed, the current passes through all three detectors A, B and C since each of these is affected by two of the three phases.

When the auxiliary contact C_1 is closed, the same function obtains as when the two switches S_1 , S_2 are both closed and thus again corresponds to the stoppage of a vehicle in the corresponding section. This function will be clarified below during the description of the operation of the device.

The operation will now be described in brief.

Supposing that the vehicle V_1 is moving in the section I and that this section is set for movement at the first speed (SW_1 closed, SW_2 open).

In these conditions, current passes through the winding of the block relay RB whereby its auxiliary

contacts C_1 , C_3 and C_4 are closed. More particularly, the closure of the contact C_3 automatically holds the block relay RB in the same section I, thus ensuring the closure of the auxiliary contact C_4 in the preceding section II. As will be understood, the block relay RB of the section I signals the presence of the vehicle V_1 in the section I to the section II. The automatic holding of the block relay RB, by virtue of the closure of the contact C_3 , signals this presence even if no current is passing through the segment U_1 and the phase R, for example because of a breakdown in one or more of the current collectors P_R , P_S , P_T , P_U . The presence of the vehicle V_1 in the section I also has the effect of closing the auxiliary contact C_1 in the preceding section II by means of the block relay RB. Thus, if there is a vehicle V_2 in the section II, the latter is prevented from moving since current flows through all three of its detectors A, B, C whatever the state of SW_1 and SW_2 .

The function of the transition relay RT will now be described. When the vehicle V_1 enters the section I from the section II with the resultant energisation of the block relay RB, the latter's auxiliary contact C_4 , which is in the preceding section II, closes, energising the transition relay RT of this same section II. This causes the temporary opening of the auxiliary contact C_2 with the interruption of the automatic holding of the block relay RB of the section II which had been caused by the arrival of the vehicle V_1 in the section II. Thus the section II is predisposed to receive a moving vehicle, such as V_2 , from the section III.

The presence of a vehicle V_2 in the section II will now be considered and one will suppose that SW_1 is open and SW_2 is closed. This corresponds to the second speed.

If there is no vehicle, such as V_1 , in the section I, the vehicle V_2 continues at the second speed into the section II. If, however, the vehicle V_1 is still present in the section I, the auxiliary contact C_1 in the section II is closed and the vehicle V_2 stops and remains stationary until the vehicle V_1 has freed the section I.

Clearly, the presence of the vehicle V_2 makes the auxiliary contact C_1 in the section III close, inter alia, making a vehicle V_3 which was reaching the latter section stop, and so on.

The drawing shows a succession of three circuits of the line with their switching means.

Three circuits of this type can conveniently be formed on a single printed circuit board. Naturally, a board of this type could, alternatively, include only a single circuit or more than three circuits. In each case, the entire line of the device could be formed as a battery of boards all interconnected like the circuits illustrated and including as many circuits as the number of sections into which the

plant is divided.

Claims

1. Equipment for controlling the movement of independent, motor-driven vehicles (V_1 , V_2 , V_3) along a line of travel provided with three-phase electrical power bars (R, S, T), in which each vehicle (V_1 , V_2 , V_3) has an electric motor supplied from the power bars (R, S, T) through current collectors (P_R , P_S , P_T), in which the line further includes a control bar (U) divided into successive segments (U_1 , U_2 , U_3), in which each vehicle (V_1 , V_2 , V_3) has on-board control means (A, B, C) for controlling the state of stoppage and at least one state of movement of the motor, interposed between the collectors (P_R , P_S , P_T) of current from the power bars (R, S, T) and a collector (P_U) of current from the control bar (U), and in which each segment (U_1 , U_2 , U_3) of the control bar (U) has associated line control means (SW_1 , SW_2) for controlling at least the said states of stoppage and movement, characterised in that each vehicle (V_1 , V_2 , V_3) includes an on-board circuit with three branches (L_A , L_B , L_C) which, through the respective current collectors (P_R , P_S , P_T , P_U), connect the respective power bars (R, S, T) to the control bar (U) and each of which includes a respective on-board rectifier (Z), the on-board rectifiers (Z) all being oriented in the same sense and the on-board control means (A, B, C) being disposed in the branches (L_A , L_B , L_C) in series with the rectifiers (Z) and being sensitive to the passage of current in one or more branches of the on-board circuit to control the said states of stoppage and movement of the motor of the vehicle, and in that the line control means associated with each segment (U_1 , U_2 , U_3) of the control bar (U) include a line circuit with a pair of branches (L_E , L_F) which connect the respective segment (U_1 , U_2 , U_3) each to a respective power bar (R, S) and each of which includes a respective line rectifier (D) oriented in the opposite sense from that of the on-board rectifiers (Z), and further include switching means (SW_1 , SW_2 , C_1) which can be set to connect one or other or both of the power bars (R, S) selectively to the control bar segment, all in such a manner as to cause the said passage and/or stoppage of current in the branches (L_A , L_B , L_C) of the on-board circuit.

2. Control equipment according to Claim 1, characterised in that, between its segment (U_1 , U_2 , U_3) of the control bar (U) and the said pair of branches (L_E , L_F), each line circuit includes a block relay (RB) which is sensitive to the passage and to the absence of current in the circuit itself and which has auxiliary contact means (C_1) interposed by way of further switching means in a line circuit of

which a preceding control bar segment, in the direction of movement of vehicles along the line, forms part, which auxiliary contact means (C_1) form part of the said switching means for this circuit and are thus arranged to input to the on-board control means of a following vehicle that it is in correspondence with the said following segment so as to cause, through the respective on-board control means (A, B, C), the stoppage of the motor of this following vehicle when the preceding vehicle is in correspondence with the preceding segment in the direction of movement.

3. Control equipment according to Claim 1, characterised in that the motor of each vehicle (V_1 , V_2 , V_3), is a two-speed motor of the pole-switching type or the like and the respective on-board control circuit, by way of on-board control means, includes a respective current detector (A, B, C) in each of the three branches (L_A , L_B , L_C) and a logic associated with the speed-change means of the motor, and such that, the detectors being indicated conventionally as A, B, C, these are so arranged as to fulfil the following functions:

F_1 - when current is passing through B and C and no current is passing through A, the motor is supplied at a first speed;

F_2 - when current is passing through A and C and no current is passing through B, the motor is supplied at a second speed;

F_3 - when current is passing through all three A, B, C, the motor is not supplied; and in that the settable switching means include a respective settable switch in each branch (L_E , L_F) of the line circuit, these switches being indicated conventionally as SW_1 and SW_2 , and these switches being so arranged as to fulfil the said functions as follows:

- function F_1 : SW_1 closed, SW_2 open;

- function F_2 : SW_1 open, SW_2 closed;

- function F_3 : SW_1 , SW_2 closed.

4. Control equipment according to Claim 2, characterised in that the motor of each vehicle (V_1 , V_2 , V_3) is a two-speed motor of the pole-switching type or the like and the respective on-board circuit includes, by way of on-board control means, a respective current detector (A, B, C) in each of the three branches (L_A , L_B , L_C) and a logic associated with the speed-change means of the motor, and such that, the detectors being indicated conventionally as A, B, C these are so arranged as to fulfil the following functions:

F_1 - when current is passing through B and C and no current is passing through A, the motor is supplied at a first speed;

F_2 - when current is passing through A and C and no current is passing through B, the motor is supplied at a second speed;

F_3 - when current is passing through all three A, B

and C, the motor is not supplied;

and in that the settable switching means include a respective settable switch in each branch (L_E , L_F) of the line circuit, these switches being indicated conventionally as SW_1 and SW_2 , and the switches being so arranged as to fulfil the said functions as follows:

- function F_1 : SW_1 closed, SW_2 open;

- function F_2 : SW_1 open, SW_2 closed;

- function F_3 : SW_1 , SW_2 closed;

and in that the said auxiliary contact means (C_1) are of the normally-open type and are so arranged as to short circuit both the switches SW_1 and SW_2 when the block relay (RB) of the said following segment is passing current in order to obtain the function F_3 in the preceding segment.

5. Control equipment according to Claim 4, characterised in that the logic circuit associated with the switching means (SW_1 , SW_2 , C_1) is so arranged that the said function F_3 is also obtained in the following conditions:

- SW_1 is closed, SW_2 is open and no current is passing through B or C or both B and C;

- SW_1 is open, SW_2 is closed and no current is passing through A or C or both A and C;

- SW_1 and SW_2 are closed, but no current is passing through at least A, at least B or at least C.

6. Control equipment according to any one of Claims 2-5, characterised in that the said block relay (RB) associated with each segment (U_1 , U_2 , U_3) of the control bar (U) includes an auxiliary holding contact (C_3) disposed in series with a temporarily-opening contact (C_2) controlled by the block relay (RB) associated with the following control-bar segment with reference to the direction of motion.

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