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(54) **A multi-barrier operator system**

(57) Embodiments provide a multi-barrier operator system where the barriers can be operated in unison. The system comprises a master operator and one or more slave operators. The master operator and one or more slave operators each have an independent power supply, an independent motor for moving the related barrier, an independent communication device having a transmitter and a receiver, and an independent electric control circuit for controlling the related motor and barrier operation. The communication devices are configured to allow wireless control signals to be transmitted between the master operator and the one or more slave operators for wireless control of barrier operation.

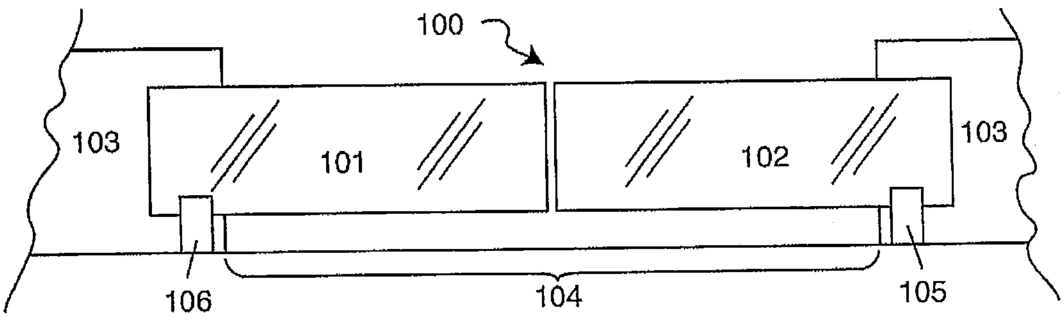

Fig. 1

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Description

[0001] This invention relates to a multi-barrier operator system and relates particularly but not exclusively to such for sliding gates or swing gates.

[0002] Hitherto, there have been many problems associated with providing operators for multi-barrier where the multiple barriers are intended to be operated in unison. A typical example of a multi-barrier installation where barriers are to be operated in unison is a pair of sliding gates that open and close across a driveway by sliding apart or towards one another. Another type is a swing gate. Other types of barriers are multiple roller or sectional or shutter type doors that are required to be operated in unison.

[0003] In known arrangements the barriers are divided into a master barrier, and one or more slave barriers. Typically an operator is provided at the master barrier and respective slave operators are provided at the one or more slave barriers. Each slave operator has its own dedicated motor however, power supply and data exchange is provided from the master operator by electrical interconnect wiring leads. Typically, such leads extend across a driveway in which the barriers are to close. The driveway can typically be concrete or the like which requires that a channel be cut in the concrete in order to accommodate the wiring. Once the wiring is inserted into the channel, the channel can be filled. The wiring is then exposed to the movement of the concrete or the like and rupturing of the wiring can occur. Further, there can be ingress of moisture to the wiring in the concrete which affects the operation of the system.

[0004] Limit sensor signals are detected locally at each slave operator concerning relative stop travel positions for the respective barriers but the actual control is from the master operator.

[0005] There is a real danger with the installations that the electrical wiring is incorrectly electrically wired to the operators. This, in turn, causes time wastage while the wiring problems are resolved. In some instances, the electrical components and the electrical control circuit boards have been destroyed because of incorrect wiring. In addition, normally the wires are not provided in a kit form owing to the wide variation in widths of barrier passageways. This, in turn, means that the installers usually purchase their own wire for this purpose. In some instances, the current carrying capacity of the wires purchased has been insufficient to allow for the necessary electric power to be provided to the slave units for the required operation. In some instances, the wires have been chosen of such small diameter and with an inappropriate number of strands that the wires break easily.

[0006] A further problem with such installations is that the wire extending across the driveway opening is of considerable length - perhaps four meters or more. Such wires present an aerial where induced signals from RF can be received. This, in turn, causes inappropriate operation of the operators due to the injection of unwanted RF signals which in some instances can cause dangerous operation of the operators.

[0007] Furthermore, in some installations, the respective operators become out of sync with each other. In other words, the operators may operate together but not in unison with an equal speed and distance of travel of one barrier with respect to the other. Such operation is undesirable.

[0008] Therefore, in accordance with a first broad aspect of the present invention there is provided a multi-barrier operator system where the barriers can be operated in unison comprising:

> a master operator and one or more slave operators, the master operator and one or more slave operators each having an independent power supply, an independent motor for moving the related barrier, an independent communication device having a transmitter and a receiver, and an independent electric control circuit for controlling the related motor and barrier operation, the communication devices being configured to allow wireless control signals to be transmitted between the master operator and the one or more slave operators to allow the barriers to be opened and closed, and each communication device permitting data about a current state of operation of a slave operator to be indicated to the master operator.

[0009] In an embodiment the master operator is configured to provide high level control instruction to each slave operator and the independent electronic control circuit of each slave operator is configured to control operation of the related barrier in response to the high level control instruction from the master operator.

[0010] Embodiments of the system can also comprise a memory related to each electric control circuit so barrier movement parameters can be stored therein, and wherein barrier movement parameters set at the master operator and stored in the memory therein can be promulgated to the one or more slave operators via the communication devices and stored in the memory therein.

[0011] In an embodiment each operator can be configured to operate as either a master or slave operator and one operator is designated as the master operator during installation and the remaining operators are subsequently designated as slave operators. In an embodiment, the master operator can configure the remaining operators as slave operators by data communication via the communication devices. In an embodiment one or more slave operators can be designated as a back up to the master operator and configured to assume the role of master operator in the event of a fault in the master operator.

[0012] In an embodiment of the system each slave operator is configured to transmit operation data to the master operator via the communication device and the master operator is configured to monitor operation of related barriers by each slave operator based on the received operation data and provide control instructions to the respective slave operator to control barrier movement.

[0013] In an embodiment the communication devices of one or more operators comprise more than one type of transmitter and receiver enabling more than one communication path to be used between operators. The operators can also be configured to use an alternative communication path in the event of failure of a communication path.

[0014] In an embodiment of the system the communication devices and the electronic control circuits of the one or more slave operators have a power conserving sleep mode, and wherein each comprises a polling function where the communication devices poll the master operator to determine a barrier movement operation of the master operator and if a movement operation is being invoked to wake the communication devices and the electric control circuit of the one or more slave operators to replicate the movement operations of the master operator of the slave operator.

[0015] In an embodiment the communication devices are tuneable to optimise transmission signal power for each communication path for power conservation.

[0016] In an embodiment the independent power supply of each operator includes a local power supply module not dependent on mains power, thereby enabling a wire free system installation.

[0017] In an embodiment the respective electric control circuits each comprise a barrier movement sensor so if a barrier movement does not occur as expected, control signals of such non occurrence can be exchanged between all operators and appropriate consequential barrier movement activated at all barriers.

[0018] In an embodiment the master operator is a master for receipt of barrier control signals sent from a remote control device, and wherein barrier control signals are then sent from the master operator to the one or more slave operators via the respective communication devices so all operators perform the same barrier control function.

[0019] In an embodiment one or more slave operators can be configured to receive a barrier control signal and relay the barrier control signal to the master via the communication device of the slave operator.

[0020] In order that the invention can be more clearly ascertained reference will now made to an embodiment as shown in the accompanying drawings wherein:

Figure 1 is a schematic diagram of a multi-barrier operator.

Figure 2 is a schematic block circuit diagram of one embodiment of the invention;

Figures 3, 4, 5 and 6 show firmware program steps for some of the functional features of the embodiment; and

Figure 7 is a flowchart of a transmission power tuning procedure of an embodiment.

[0021] Figure 1 is a schematic diagram of a multi-barrier operator system with particular application to a pair of sliding gates. As stated previously, the invention has application to barriers generally where there are multi-barriers which require to be operated in unison. Therefore, barriers such as swing gates roller doors, sectional doors, and tilt doors are all embraced. Other multi-barriers are also included. The invention can also be used with systems where combinations of different barriers are used in a coordinated manner, for example a roller door and sliding gate combination. In Figure 1, the installation 100 has a left hand barrier 101 and a right hand barrier 102. Each barrier is generally a planar type gate that is supported to slide apart or towards the other by suitable supporting means such as roller wheels on a track and guide means (not shown), all of which are known in this art. Typically, the barriers 101 and 102 are mounted adjacent a wall 103 that defines a barrier passageway 104. Each barrier 101, 102 has its own operator 105 and 106. One of the operators, such as operator 105, is designated as a master operator whilst the other operator 106 is dedicated as a slave. There may be a series of slave barrier operators connected with a single master barrier operator.

[0022] In known multi-barrier operators, electrical wiring in the form of cables must extend across the passageway 104 to interconnect the slave operators 106 with the master operator 105. As discussed previously, such wiring presents many problems. In the present invention, there is a wireless interconnect between the master operator 105 and the slave(s) operator 106. In this arrangement, electrical power is provided locally at each of the master operator(s) 105 and the slave operator(s) 106. In some arrangements, there will be AC mains power provided to each of the operators 105, 106. In some other installations, AC mains power may be provided to only one of the operators 105/106 whilst the other operators will have their power supplied locally such as from a DC battery source. Alternatively some or all operators may have a local power supply module, thus enabling a fully wireless installation embodiment where none of the master or slave operators are dependent on mains power supply. In some embodiments local power supply modules may have a DC battery power source. Other embodiments of local power supply modules may have renewable energy power generator and a power storage component, for example a local solar power module with photovoltaic cells or panels for conversion of solar energy to electricity and a battery for power storage and backup, or a local wind power module having a compact wind turbine and battery for power storage and backup, combinations and other alternatives are also contemplated. It should be appreciated that a combination of different power supply modules may be used for the master and slave operators. The choice of power supply module may vary depending on location or installation conditions. For example, wind and solar power supply modules may be highly suitable for use on a farm gate where mains power is not available or cost prohibitive to provide. Choice of wind or solar could also be based on local conditions, or a combination of wind and solar may be used to reduce risk of power failure if renewable energy is solely relied upon. For example, stored power of a wind power supply module may be exhausted during prolonged still conditions however, if a combination of wind and solar is used in a single power supply the likelihood of power failure is reduced. Alternatively if different types of power supplies are used the likelihood of all power supplies failing simultaneously is reduced, so if one power supply is exhausted the barrier may still be partially opened by a master or slave operator having power remaining, which may be sufficient for some purposes or minimise the manual effort required to fully open the barrier in the case of a power failure. Power supply modules of different types may be interchangeable to enable easy adaptation of operators for different installations.

[0023] In most installations however, all the operators will be powered from a mains power supply, and dedicated electrical power sockets and terminations will be made for each operator 105/106. In such arrangements there are prescribed regulations by electrical authorities to control the way mains power is supplied to exposed outside areas such as where the barriers are to operate. The wiring will be installed by a licensed electrician according to prescribed regulations. This contrasts with the providing of power to the operators by non-qualified electricians who may be installing the prior art operator system where electrical wires/cables are used to be extended across the driveway between each of the operators 105/106.

[0024] Figure 2 shows an example of an embodiment of the invention that uses a radio duplex communication system having respective radio communication devices 201 in the master operator 105 and 202 in the slave operator(s) 106. Figure 2 shows that each operator 105/106 has its own electric DC motor 203, its own electric control circuit 204 for controlling the operation locally, its own door position control sensing circuit 205 and its own power supply circuit. Each of the above components is independent of the components in the other operators. Each of the components is interconnected at the respective operators so the position of the respective barriers will be controlled locally by the respective operators in this embodiment. Typically each of the components shown will be provided as a module and there may be a motherboard (not shown) into which the respective modules can be attached by typically a plug and socket connection or some other connection such as direct mating contacts on one board into mating socket contacts on the other board.

[0025] The control circuit 204 may itself comprise the motherboard and have appropriate sockets for receipt of all other modules and components including a lead for supplying power to the motherboard electric motor 203. The door position sensing circuit 205 may comprise one of several alternatives types known in the art. Some of these include limit switches for sensing end positions of travel, angular position sensors for determining positions of ends of travel of the barrier for stopping the barrier movement at required set stop positions, and direction of movement sensors that may comprise shaft encoders.

[0026] In operation, a user person wishing to operate the barriers will typically initiate a signal that will be actioned upon at the master operator 105. Such signal may be input directly at the master operator 105 or from some remote location via a hard wire circuit. Alternatively, it may operate via a radio remote control device as is known in this art. In embodiments of the invention the communication device in each operator (master and slave) may receive the radio signal from the control device for operation of the door. In this case slave operators can signal to the mater operator that they have received the operation signal. In this manner the master can confirm that all slave operators are ready for operation and coordinate control of barrier operation. The operation signal can also be relayed to the master operator if it was not received by the master. For example for a wide barrier the master may be out of range of a remote control device, or a manual signal may be given at a slave operator such as pushing a button or scanning an access token/card and the signal received at the slave operator can be relayed to the master. For example a gate may have an access scanner/button on the operator on each side to enable a driver to operate the gate manually for both entry and exit without getting out of the vehicle, in this case one access scanner/button can be on the master operator and the other on a slave operator. Once the access scanner/button is activated on the slave operator the operation request is relayed wirelessly to the master operator by the slave. The relay signal can include encrypted identification/security information to enable the master operator to validate the operation request before operation of the barrier is allowed. Alternatively the access request may be validated at the slave operator.

[0027] In all such cases, the user person will provide a signal to request operation of the barrier which is either received directly by or communicated to the master operator 105 to coordinate barrier operation. The master operator 105 will, in turn, process that signal to operate the motor 103 associated with the master operator 105. Simultaneously or substantially simultaneously, the control circuit 204 which includes a micro controller processor will process the signal initiating movement of the barrier and provide an appropriate signal to the communication device 201. The communication device 201 will then by radio communication transmit a signal to a communication device 202 in the slave operator(s) 106. This signal will then be fed locally to the control circuit 204 to, in turn, cause the motor 103 at the slave operator 106 to commence barrier operation in unison with movement initiated at the master operator 105. Accordingly, for a sliding gate arrangement as shown in Figure 1, the master operator 105 will cause barrier 102 to move to close the passageway 104 and similarly, the barrier 101 in the slave 106 will also move in unison with barrier 102 to close the passageway 104. When the barrier is opening a similar reverse procedure will occur but again it will be initiated from the master operator 105. At the completion of travel of the barriers 102/101, the barriers will stop movement by virtue of the door position sensing circuit 205 operating locally to switch off the respective motors 103.

[0028] During the above movements, information about the current state position of the barrier(s) at the slave operator(s) 105 will be transmitted to the master operator 106 via the duplex communication device 202 so appropriate control instructions can be maintained to ensure that all barriers 101 and 102 move directly in unison. For example, if barrier 101 is moving too slowly, the master control circuit 204 can be signalled to slow down so that the two barriers 102 and 102 are moved in unison. Alternatively, the motor 103 in the slave 106 can be instructed to speed up to maintain an in unison movement of the barrier 101 relative to barrier 102.

[0029] The signalling between the master and slave operators can take any form suitable to the functionality of the control circuits of the respective master and slave operators. For example where the slave operators include a high level of control functionality and the slave operators perform monitoring of the operation of the slave operators, the master may provide the slave(s) with high level instruction as to the operation required which is then interpreted by the slave control circuit to perform appropriate motor control and slave operator may communicate status information back to the mater operator. Alternatively the slave operator may be configured to have minimal "intelligence" and depend on the master operator to determine the control commands required by the slave operator and communicate the control commands to the slave operator to, in turn, use to control the motor. In this embodiment the slave operator may be configured to send to the master operator as status information the outputs of sensors, such as position sensor data, and motor operating parameters, which are interpreted by the control circuit of the master operator to determine appropriate control commands to send to the slave operator. It should be appreciated that all alternative signalling regimes are contemplated within the scope of the present invention.

[0030] In a variation it may be intended through a control signal provided in the master operator 105 that only one of the barriers 101 or 102 is to operate. A control circuit 204 can control this function by duplex radio communication protocols provided by the communication devices 201 and 202. For example, where the barrier to be moved is the barrier operated by the slave operator, then the master operator 105 can signal the slave operator 106 to open the barrier while maintaining the other barrier stationary. Where the barrier to be opened is the barrier operated by the master operator 105, there may be no signalling to the slave operator 106 as this operator is not required to move its respective barrier.

[0031] An example of partial operation of a barrier is to enable pedestrian access without fully opening the barrier, this may be known as pedestrian mode. Pedestrian mode can be configured differently for different barrier types or installations. For example, pedestrian mode may be configured for full opening of one barrier only, partial opening of one barrier only, partial opening of two barriers, reversing direction (opening to closing) after a signal is received from a sensor or user controller before full opening of the barrier etc, and all possible variations are considered within the scope of the present invention. In some embodiments the pedestrian mode is indicated in a signal transmitted from a user controller, for example by pushing a "pedestrian" button on a hand held radio transmitter. Alternatively an operator may have an interface (for example a button, keypad or sensor) to enable a person to request pedestrian access and this may be provided on master or slave operators.

[0032] At the completion of barrier movement, the slave duplex communication device 202 can be put into a "sleep" mode. This will conserve power, and in the case of a battery source of power will aid in prolonging the time between battery replacement or re-charging. The communication device 201 at the master 105 can then "poll" the slave(s) 106 periodically to determine if the slave operators 106 are functioning correctly. For example, the slaves may periodically wake from the sleep state to communicate status information to the master. In another embodiment in the "sleep" mode the slave operators are configured to be able to receive poll signals from the master operator and reply with status information. This may not require the slave operator to fully transition from "sleep" mode to a "wake" mode wherein the operator operates the barrier, but rather an intermediate "semi-awake" mode may enable communication between the master and slave operators for polling purposes and a "wake" higher power consumption state only entered when necessary, for example to operate the barrier.

[0033] During polling status information for the slave operator can be communicated to the master operator. For example, if the power supply 206 in the slaves is a battery DC voltage source, then the communication devices 201/202 will communicate information about the battery status to the master controller 105 so that appropriate warnings can be provided to the user person that the battery may need replacement. The battery status may be determined by the controller of the slave operator, for example by sensing charge remaining, and communicated to the master in a status signal. Alternatively the master operator may determine the battery status based on communication signals from the slave operator. For example the master operator may assess signal power during polling or barrier operation and determining drop in signal power below a threshold level which indicates low battery power. Alternatively during barrier operation barrier speed may be monitored and slowing of the barrier between successive operations used as an indication of possible low battery power, or a motor problem. In such instance, a barrier controlled by a slave may be shut-down as a further visual indicator to the operator person that the battery may need replacement. In addition, if there are other circuit malfunctions in the slave operators 106 then appropriate data can be communicated back to the master operator 105 so that an appropriate alarm can be provided in order that corrective action may be taken. A problem with any of the operators can also be indicated to a user for action to be taken. For example, an LCD display on the master controller may provide a message indicating a problem, (for example, "low battery operator 2", "motor fault operator 3" or "obstruction detector fault zone 1"). In some embodiments data may be transmitted to a user remote control device to draw the user's attention to operator problems. In an example, a fault light may flash on a user device and the user look at the master operator for fault information. In another example the user device has a display on which messages may be displayed. Any fault identifiable by the operator controller may be reported in this manner, for example low battery, motor operation faults, communication faults, sensor faults/warnings, obstruction detection faults such as beam misalignment or low signal, etc. Messages may be displayed for any event that may be of relevant to the user, including faults and operational events. For example, messages may indicate restoration of correct operation after power failure, service reminders, manual operation occurrences, reversal of operation due to obstruction detection etc. In embodiments where messages are transmitted to remote user devices, the master operator may be configured to store some types of messages for transmission to a user device one it is in range, for example power failure and restoration messages or manual operation messages. It should be appreciated that such events may be of interest to the user but occur while the user controller is out of range of the operator. A list of messages may be displayed or scrolled where there is more than one message.

[0034] Other functions concerning states of movement of the barriers can be relayed between the master and slave operators by means of the communication devices. For example, if one of the barriers should strike an object during closing and stop due to the local control circuits being activated to stop the movement, then the communication devices can communicate that information back to the master operator which will, in turn, cause all barriers to cease movement. As a variation, the barriers may be stopped and then reversed in direction when an object is struck by one of the barriers. This may be replicated at each of the operators.

[0035] It should also be appreciated that the above arrangement provides many advantages not inherent with a locally hard wired installation which requires hard wiring between the master operator and the slave operators. For example, control parameters may be set by an installer person at the master controller and relayed to the slave operators via the communication devices so they are set at the slave operators as the inherent default parameters for the slave operators as well. Such information may relate to barrier states such as an obstruction force threshold setting which is used for detecting if the barriers strike an object during movement. The barriers are then reversed in direction when the threshold is reached. The intended speed of travel of the barriers can be set at the master operator 105 and relayed to the slave operators 106 as a desired barrier state movement speed. In addition, thresholds for opening and closing movement times can be set. In addition, particular zones for speeding up or slowing down movement of the barriers can be set and relayed to the slave operators. In addition, a start delay for operation of a slave or master operator can be set at the master operator, and sent to the slave operator(s) so all operators operate with the same delay. In this way, the parameters that are set at the master can be relayed to the slave operators and set as defaults for all operators in the system. The ways of sensing such thresholds and speeds of movement and zones are known per-se in this art for use with single door barrier operators and have not been replicated herein to aid brevity.

[0036] In an embodiment all operators may be capable of acting as either a master or slave operator and the status as master or slave configured on installation. For example, by setting a parameter value in the operator to be designated master and setting each other operator as slaves along with transmitting other operating parameters as described above. Alternatively a manual status selection means may be used such as a switch or changing a hardware component to distinguish the master from slave operators. It should be appreciated that having operators adapted to be used as either a master or a slave can reduce the inventory required for installers. Further, a slave operator may also be designated as a back-up master and able to switch from the role of a slave to the role of the master automatically if there is a failure in the master operator, to enable at least partial operation of the barrier in the case of a fault in the master.

[0037] In alternative embodiments slave operators may be configured to have limited control functionality and simply respond to commands of the master operator. In such an embodiment the slave operators can transmit to the master operator status data from sensors such as barrier position sensors or motor operation data such as speed and power consumption. Instead of the slave operator assessing operation of the operator and determining when speed thresholds of different zones are met, the master operator determines these from the status information and provides any control instructions required to the slave operator. In this embodiment the processing required at the slave operators is simplified which, in turn, can reduce the processing capacity required at the slave operators enabling the slave units to be cheaper and potentially lower power consumption than the master operator. This can be advantageous in embodiments where slave units are powered by battery or solar power supply. Another potential advantage is the software and firmware required at the slave operators is also simplified. In some cases upgrades or modification to operating parameters may be made in software of the master operator but avoided in slave operators, thus simplifying the modification/upgrade.

[0038] In some embodiments the communication device may comprise more than one transmitter and receiver or transceiver and different modes of transmission may be used. For example, in an embodiment the communication devices each include both radio frequency (RF) and optical (for example, infra red (IR) or laser) transceivers. In this embodiment different transmission modes can be used for different information or at different times, for example, the slave may be configured to power down the RF transceiver in "sleep" mode only receive IR signals for polling or to wake. For example, an IR beam incident on the IR receiver may indicate a poll and status information transmitted in an IR bean in response. Alternatively, the IR beam may instruct the slave operator to "wake" and a reply transmitted via the RF transceiver to indicate the wake state and readiness to operate the barrier. In alternative embodiment one mode of communication may be used to transmit signals to the slave operators and an alternative mode used to reply. For example, the slave operator communication device may have an RF receiver only and communication status information back to the master operator using an IR transmitter. All alternatives are contemplated within the scope of the present invention. It should be appreciated that, in addition to the advantages for managing power consumption that may be enabled, using more than one communication mode can provide security advantages. For example, if instructions are transmitted using one communication mode, say IR, and acknowledgements of instructions are transmitted using a different mode, say RF or acoustic signalling, then if an attempt is made to send a false open instruction to a slave operator, then the acknowledgement of the fraudulent instruction will be received by the master operator using the second communication mode and appropriate action taken, for example, an override instruction sent and alarm raised. Further, redundancy in communication capability allows signalling via a backup mode to at least operate the barrier to a safe or secure position if there is failure of one communication mode.

[0039] In an embodiment the communication devices can be configurable to adjust signal power level in order to optimise power usage. In embodiments where at least some operators are battery or renewable energy powered there is a risk that the operators may exhaust their power supply. For example, batteries may go flat or where renewable energy generation is relied upon and the barrier is operated frequently when power is not being generated (for example at night for a solar generator) stored energy may be exhausted, so power conservation is desirable to maximise the duration of operation. In some embodiments of the invention the signal power of the communication devices can be adjusted to reduce transmission power in order to reduce power consumption. The signal transmission power can be adjusted to only that necessary for reception by other operators in the system using a tuning process. As the communication devices are configured to transmit and receive the tuning process can utilise handshaking between two operators at different power levels to determine the lowest power level at which the two operators can reliably establish communication. In an embodiment the master operator is tuned for reliably communicate with each slave operator and each slave operator is tuned for reliable communication with the master operator. In an alternative embodiment slave operators may be tuned to communicate where at least one of the slave operators is also configured to relay signals to the master operator. The tuning process can be manually executed or automatic.

[0040] An example of an embodiment of the tuning process is shown in Figure 7. The tuning process takes place between two operators, for example a master and slave. The example of Figure 7 shows the tuning steps executed in one operator only. The tuning process starts at step 701 where the transmission power level is set to an initial power level. The initial power level may be the maximum or minimum power level or any power level therebetween and may be a preset power level. A signal is transmitted using the set power level at step 702 and the operator then waits to receive a reply or acknowledgement signal at step 703. A timer may be set for a reasonable time period in which as reply is expected, for example a 20 millisecond countdown timer. If a reply is not received at step 704 then it is assumed that the transmission power level was too low to be received. The power level is then incremented to increase transmission power at step 706 and another signal sent at step 702 and the process repeats from step 702 until a reply is received.

[0041] When a reply is received at step 704 it is determined whether or not a reply was received to the previous signal at step 705, if no reply was received previously then it is determined tat the current power level is the lowest power level that may be used for the communication path between the two operators. Thus the signal power level is set at this level at step 708 and the tuning process ends at step 709.

[0042] If this is the first iteration or the previous reply signal was also received at step 705 it is determined that the power level may be decreased at step 707 and the process repeated with signal sent at the new power level at step 702. The process repeats until a reply signal is not received, indicating that the transmission signal power has dropped too low to be received. The signal power is then incremented and a final signal can be sent to check that the signal power is sufficient. Alternatively the signal power can be set to the power of the last successfully received signal.

[0043] An alternative question at step 705 may be whether the power level is being incrementally increased or decreased. If the power level is being increased and a reply signal is received this can be set as the power level. If the power level is being decreased, increments can continue until a reply signal is not received, indicating the power level is too low. The power level can then be increased to a power level that can be received as set at that level for continued operation. It should be appreciated that this configuration of power level can be performed for each operator and each transmitter/receiver pair between operators. The tuning process may be performed controlled by software or firmware of the operator. The tuning process may be performed automatically on installation or in response to a manual command. In some embodiments the operators may be configured to periodically execute the tuning process to re-tune the communication devices, for example to compensate for changes in environmental conditions which may affect communication. For example, the operators maybe configured to retune every 6 months, every one thousand operations, or in response to user commands such as pushing a button or selecting retune from an operator control menu. Alternatively or additionally the operator may be configured to retune in response to operational events, such as battery replacement, after detection of a communication fault etc.

[0044] Once one operator is tuned the process can be repeated with the other operator to tune the communication device transmission power. Alternatively one operator may be tuned, say the master operator tuned to determine a minimum power level required for communication with the slave operator, and the determined power level transmitted to the slave operator to configure the slave operator to transmit at the same power level. For example, the power level may be transmitted as signal data to configure the slave operator.

[0045] The above communication system tuning procedure can be used for any type of communication path. For example, the tuning procedure may be used to tune optical (IR and laser) transmitter and receiver pairs or RF transmitter and receiver pairs. It should be appreciated that the above tuning procedure can be used for tuning wireless receiver and transmitter pairs for any operator and is not limited to use on the multi barrier operator system described above.

[0046] In an embodiment the above described tuning system can be used to tune communication systems used in a wireless obstruction detection system, such as disclosed in Australian innovation patent no. 2012101044 which relates to a beam protection system and is incorporated herein by reference in its entirety. In and embodiment of this obstruction detection system a beam transmitter and beam receiver unit are placed in either side of the access way closed by the barrier to project an optical beam across the access way during opening or closing of the barrier and obstruction detection is based on disruption of the beam. The units of the beam protection system communicate wirelessly with each other and with a controller of the barrier operator. The above tuning process can use utilised in embodiments of this beam protection system to tune each communication path to reduce communication signal power and improve battery life in battery powered units. The power level of the optical beam used for obstruction detection may also be tuned to optimise power consumption using this tuning process.

[0047] It should be appreciated that such a beam protection system can be used with a multi-barrier operator as described above. The communication system of the beam protection system can communicate wirelessly with the master controller to inform the master controller of obstruction detection. In this embodiment the communication system of the beam protection system sends signals to the master operator, for example RF signals receivable by the communication device of the master operator. Thus the communication system of the beam protection system can be tuned to optimise the signal power for transmission to the master operator. The master operator can also transmit signals to the beam protection system. It should be appreciated that in this embodiment the master operator will transmit control signals to both slave operators and the beam protection system, in this case, where there is more than one receiver of signals, the communication device of the master operator can be tuned to use a signal power sufficient for reception by all slave operators and the beam protection system. It should be appreciated that for some operators the signal power may be higher than the minimum required for reception. In this embodiment the tuning process can be performed between the master operator and each of the slave operators and beam protection system and the lowest signal power receivable by all devices selected for use by the master operator. The master operator may be configured to store the lowest required signal power for each device and select the highest of these for use. Alternatively during as the tuning process is performed with each operator the master operator can store a signal power value for a first tuning in memory and compare the stored signal power with a signal power used for a second tuning, if the power required for the second tuning is higher, then this power level can replace the stored power level. Therefore on completion of tuning for each communication path the stored power level should be the lowest power level that is receivable by all communication devices. When performing this tuning process between a plurality of operators, after tuning with the first operator, the initial signal power may be set to the stored power level and the tuning process move on to the next operator if a signal at this initial power is successfully received. The tuning process can be used for any wireless communication between operator components.

[0048] In most circumstances the barrier operators are installed relatively close to each other, on either side of the access way closed by the barrier for the current embodiment. In embodiments where a local wireless communication system is used to communicate with separates modules of a single operator, the transmitter and receiver pairs may be located even closer. Further most operators are installed in fixed positions so there is little change in transmission conditions for the wireless communication paths. It should therefore be appreciated that very low transmission power may be sufficient for reliable operation. Using lower transmission power can improve battery life.

[0049] In an embodiment the above tuning procedure can be used to configure a communication path between a barrier operator controller and a wireless user remote control device configured for two way communication between the operator controller and remote device. In most installations, although the user remote control device is portable, the user typically operates the remote control device to open or close the barrier from reasonably close proximity to the barrier. For example a person will typically press the button on their remote device to request opening of a garage door or gate as they approach the driveway in their car, within a range of around 10 meters or less. This is a reasonably close proximity for communication between the remote device and door operator and therefore transmitting the open signal by the remote control device at full power may not be necessary. The above tuning procedure can be used to reduce the transmit power of the remote control device to conserve energy and improve battery life for the remote control device.

[0050] In an embodiment the tuning process can be performed during operation of the barrier. For example, a user will typically hold down the operation button for a second or so when requesting the barrier to open or close. During this time the remote device may send a sequence of control signals or signal pulses at decreasing power levels. Each signal or pulse that is received by the operation can be acknowledged with a reply signal or pulse. When the transmission signal power becomes too low for reception by the operator controller nor acknowledging signal will be received. The remote control device control circuit can record the signal power of the last signal that was acknowledged and set a transmit signal power based on this minimum power level. For example, the remote control device transmit power may be set to the minimum power level or to a level above the minimum power level, for example the minimum power level plus a percentage of the minimum power level (e.g. 10% or 20%) to provide a tolerance for variation in distance from the operator at which the remote control device may be activated.

[0051] In an alternative embodiment the tuning process may be performed for each of a set number of barrier open and close operations and the minimum received power level recorded for each operation, for example 10 or 15 operations. At the conclusion of this set number of operations the tuned transmit power level can be set based on the recorded minimum power levels. For example, configuration rules in software or firmware of the remote control device may cause the transmit power level to be set to the maximum of the recorded minimum power levels, at an average power level of the recorded minimum power levels, a median of the average power levels, the minimum power level plus a percentage of the minimum power level etc. It should be appreciated that the configuration rules may vary for different embodiments and the choice of configuration rules may be based on the type of barrier operator and installation environment. For example different rules may be used for domestic and industrial operator installations or based on variations in vehicle size that must be accommodated. For example different configuration rules may be applied for an installation accommodating both cars and trucks to a domestic operator accommodating cars only. It should be appreciated that the tuning of transmit power for remote control devices can be automatic and transparent to the user. In another embodiment the user may initiate a tuning process, for example by standing at a distance from the barrier operator where the remote device would typically be used and pressing a combination of buttons or selecting a menu item to initiate tuning. The remote control device may also be retuned periodically. Where power conservation is desirable for the barrier operator or barrier operator component communicating with the remote device, the transmit power for signals from the barrier operator controller to the remote device may also be tuned using the above described tuning process.

[0052] In an embodiment the tuning process using any of the options described above can be performed by the barrier operator controller to determine the signal power required for signals to be reliably transmitted between operator and remote control device. In this embodiment the barrier operator controller transmits a signal to set the transmit power for the remote control device to the determined tunes signal power. It should be appreciated that in this embodiment the remote control device software or firmware need not be configured to perform the tuning process, simply to configure the transmit signal power in accordance with the instruction from the barrier operator, thus the programming for the remote control device is simplified.

[0053] It should be appreciated that any variation in initiating tuning is contemplated within the scope of embodiments of the invention.

[0054] In some embodiments slave operators having local (non-mains) power supplies may be configured to enable operation under local power supply in the event of mains power failure. For example, to enable pedestrian access or to reduce manual operation required if mains power fails. The slave operator may receive an operation signal and identify the power failure from absence of communication from the master. In some embodiments an additional user input maybe required to enable the slave to operate the barrier in absence of control from the mater, for example holding the open button on a remote transmitter or pushing a manual operation button on the operator. It should be appreciated that in the prior art when power failure occurs for a multi barrier a user will need to manually move each barrier to open or close the access way. In embodiments of the present invention, if some operators are not dependent on main power, then these may still be operated if there is a failure to mains power to reduce the manual operation required. If there is more than one slave operator a slave may be configured as a master back-up for emergency operation. The slaves may be configured in a back up hierarchy to ensure coordinated operation of barriers. Data from position sensors in master and slave operators can be used for re-synchronisation of barrier movement by the master once power is restored.

[0055] Figure 3 is a functional block diagram of an embodiment of firmware at the operators showing operation of the system. Here at step 300 a question is asked if a movement is occurring at the master. At step 301 an instruction is sent to a slave operator. The instruction is received at a slave operator at step 302 and the barrier at the slave is moved according to the instruction at step 303. Note that the movement of the barrier in step 303 may include exchange of data between the master and slave operators as each barrier is moved to enable the master to control the position of each barrier, for example in embodiments where the slave operator has minimal control functionality. At step 304 the barrier state position is confirmed to all of the operators, for example confirming all barriers are at a fully open position. At step 305 a question is asked if there is a need to change the barrier state movement, for example to close the barriers. If the answer is NO then the process finishes at step 306. If the answer is YES, the program proceeds to step 307 which requires a change to the barrier state movement at a slave. Alternatively, if there is a change in the slave barrier state movement this can be relayed via the communication devices to the master operator so that the master operator can take appropriate action, for example to stop or reverse the movement of the barriers if an obstruction is detected. The process finishes at step 308.

[0056] Figure 4 shows the basics associated with firmware program steps for programming of an installation. Here, at step 400 an operator installer person will initiate a programming mode. This is performed at the master operator 105. The program settings are stored in memory as parameters at the master operator at step 401. The programming is completed at the master operator at step 402. At step 403 the parameters stored in memory at the master operator are communicated to the slave(s) and the process finishes at step 404. When the parameters are relayed to the slave(s) the parameters are stored at the slave(s) in memory locally resident therein.

[0057] Figure 5 shows process steps associated with firmware steps of a slave recovering from a "sleep" mode and moving the slave barrier. Here, at step 500 the slave operator is in a "sleep" mode. At step 501 a poll from the master controller "wakes" the slave controller. A question is then asked "is master moving" at step 502. If the answer is NO then the slave is able to go back to sleep at step 503. If the answer is YES, then the barrier at the slave is moved in accordance with the movement of the barrier at the master at step 504. At completion of movement of the barrier a slave barrier movement finish is detected at step 505, and then the slave is able to go back to sleep at step 506.

[0058] The slaves may also automatically poll the master at regular intervals without being instructed to "wake" by the master. Data about the state of the slave can then be sent to the master. This duplex transmission of data between operator devices allows the master operator to have complete knowledge and therefore control of the whole system at all times.

[0059] Figure 6 shows an example of operation where an operation command (in this case an open command) is received by a slave operator. A slave operator received an open command at step 601. A question is asked at step 602 whether the request is to operate a sing barrier, for example pedestrian mode, which would be that operated by the slave in this case. If the answer is NO then the slave operator relays the open request to the master operator in step 603. At step 604 the master instructs the slaves to move their respective barriers in accordance with the request. The barriers are operated 605 and barrier state confirmed to the master by each slave operator in step 606 to finish 607. It should be appreciated that the operation of the barriers under control of the master can be as discussed above with reference to Figure 3. If the answer to the question at step 602 is YES and only a single barrier is to be operated, for example if the open request is a pedestrian mode request made by pushing a button on the slave operator, then the slave operator operates the barrier at step 608. The barrier state is reported to the master at step 609 to finish 610. The master may then control a change in barrier state, for example to instruct the slave operator to close the barrier after a set time period or in response to a received close request. It should be appreciated that this is one example of operation and variations are contemplated within the scope of the present invention.

[0060] It should be appreciated that a photoelectric beam or IR beam circuit or similar may be associated with the passageway 104 to interact with the master operator. In this way, if there is an object in the presence of the barriers as detected by interruption of the beam, then the whole system may be halted with regard to future movement until the object is removed. The subject matter of our prior Australian innovation patent no. 2012101044 which relates to a beam protection system is incorporated herein by reference in its entirety. In some embodiments the IR beam may also provide an alternative or backup communication channel between the master and slave operators.

[0061] It should also be appreciated that any one or more of the inventions disclosed in our prior patent application may be incorporated herein in the operator system. Details of such patent applications may be found by searching the IP Australia Patent Office database records under our name. The subject matter of those specifications is incorporated herein by reference in their entirety.

[0062] It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

[0063] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

[0064] These and other modifications may be made without departing from the nature of the invention as determined from the above description.

Claims

1. A multi-barrier operator system where the barriers can be operated in unison comprising:

a master operator and one or more slave operators, the master operator and one or more slave operators each having an independent power supply, an independent motor for moving the related barrier, an independent communication device having a transmitter and a receiver, and an independent electric control circuit for controlling the related motor and barrier operation, the communication devices being configured to allow wireless control signals to be transmitted between the master operator and the one or more slave operators to allow the barriers to be opened and closed, and each communication device permitting data about a current state of operation of a slave operator to be indicated to the master operator.

2. A system as claimed in claim 1, wherein the master operator is configured to provide high level control instruction to each slave operator and the independent electronic control circuit of each slave operator is configured to control operation of the related barrier in response to the high level control instruction from the master operator.

3. A system as claimed in claim 2, comprising a memory related to each electric control circuit so barrier movement parameters can be stored therein, and wherein barrier movement parameters set at the master operator and stored in the memory therein can be promulgated to the one or more slave operators via the communication devices and stored in the memory therein.

4. A system as claimed in claim 3, wherein each operator is configured to operate as either a master or slave operator and one operator is designated as the master operator during installation and the remaining operators are subsequently designated as slave operators.

5. A system as claimed in claim 4 wherein the master operator configures the remaining operators as slave operators by data communication via the communication devices.

6. A system as claimed in claim 5 wherein one or more slave operators can be designated as a back up to the master operator and configured to assume the role of master operator in the event of a fault in the master operator.

7. A system as claimed in claim 1 wherein each slave operator is configured to transmit operation data to the master operator via the communication device and the master operator is configured to monitor operation of related barriers by each slave operator based on the received operation data and provide control instructions to the respective slave operator to control barrier movement.

8. A system as claimed in claim 1 wherein the communication devices of one or more operators comprise more than one type of transmitter and receiver enabling more than one communication path to be used between operators.

9. A system as clamed in claim 8 wherein the operators are configured to use an alternative communication path in the event of failure of a communication path.

10. A system as claimed in any one of the preceding claims, wherein the communication devices and the electronic control circuits of the one or more slave operators have a power conserving sleep mode, and wherein each comprises a polling function where the communication devices poll the master operator to determine a barrier movement operation of the master operator and if a movement operation is being invoked to wake the communication devices and the electric control circuit of the one or more slave operators to replicate the movement operations of the master operator of the slave operator.

11. A system as claimed in any one of the preceding claims wherein the communication devices are tuneable to optimise transmission signal power for each communication path for power conservation.

12. A system as claimed in any one of the preceding claims wherein the independent power supply of each operator includes a local power supply module not dependent on mains power, thereby enabling a wire free system installation.

13. A system as claimed in any one of the preceding claims, wherein the respective electric control circuits each comprise a barrier movement sensor so if a barrier movement does not occur as expected, control signals of such non occurrence can be exchanged between all operators and appropriate consequential barrier movement activated at all barriers.

14. A system as claimed in any one of the preceding claims, wherein the master operator is a master for receipt of barrier control signals sent from a remote control device, and wherein barrier control signals are then sent from the master operator to the one or more slave operators via the respective communication devices so all operators perform the same barrier control function.

15. A system as claimed in any one of the preceding claims wherein one or more slave operators are configured to receive a barrier control signal and relay the barrier control signal to the master via the communication device of the slave operator.

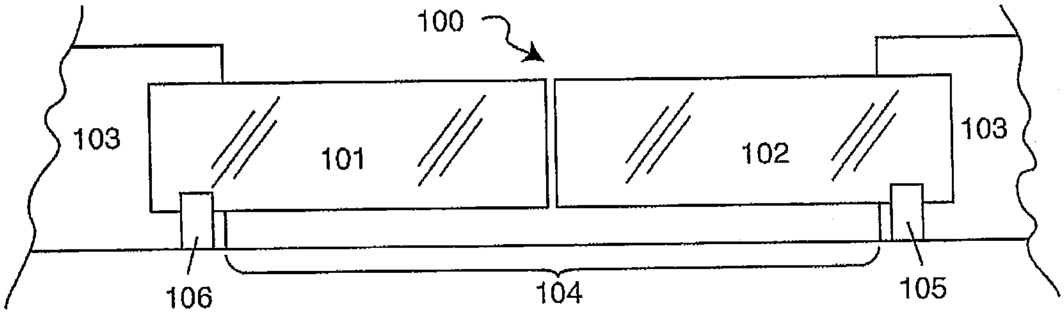
100
103
101
102
103
106
104
105

Fig. 1

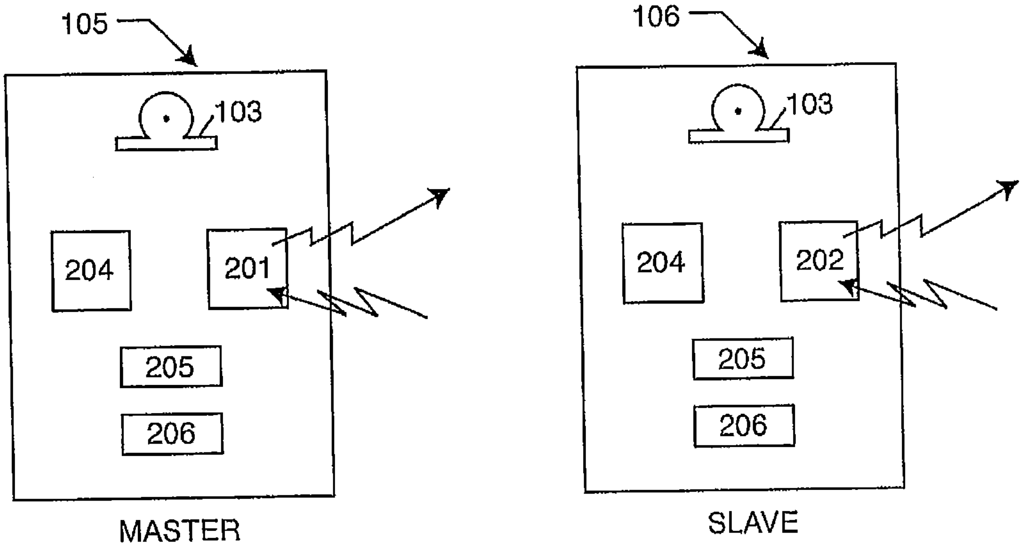
105
103
204
201
205
206
MASTER
106
103
204
202
205
206
SLAVE

Fig. 2

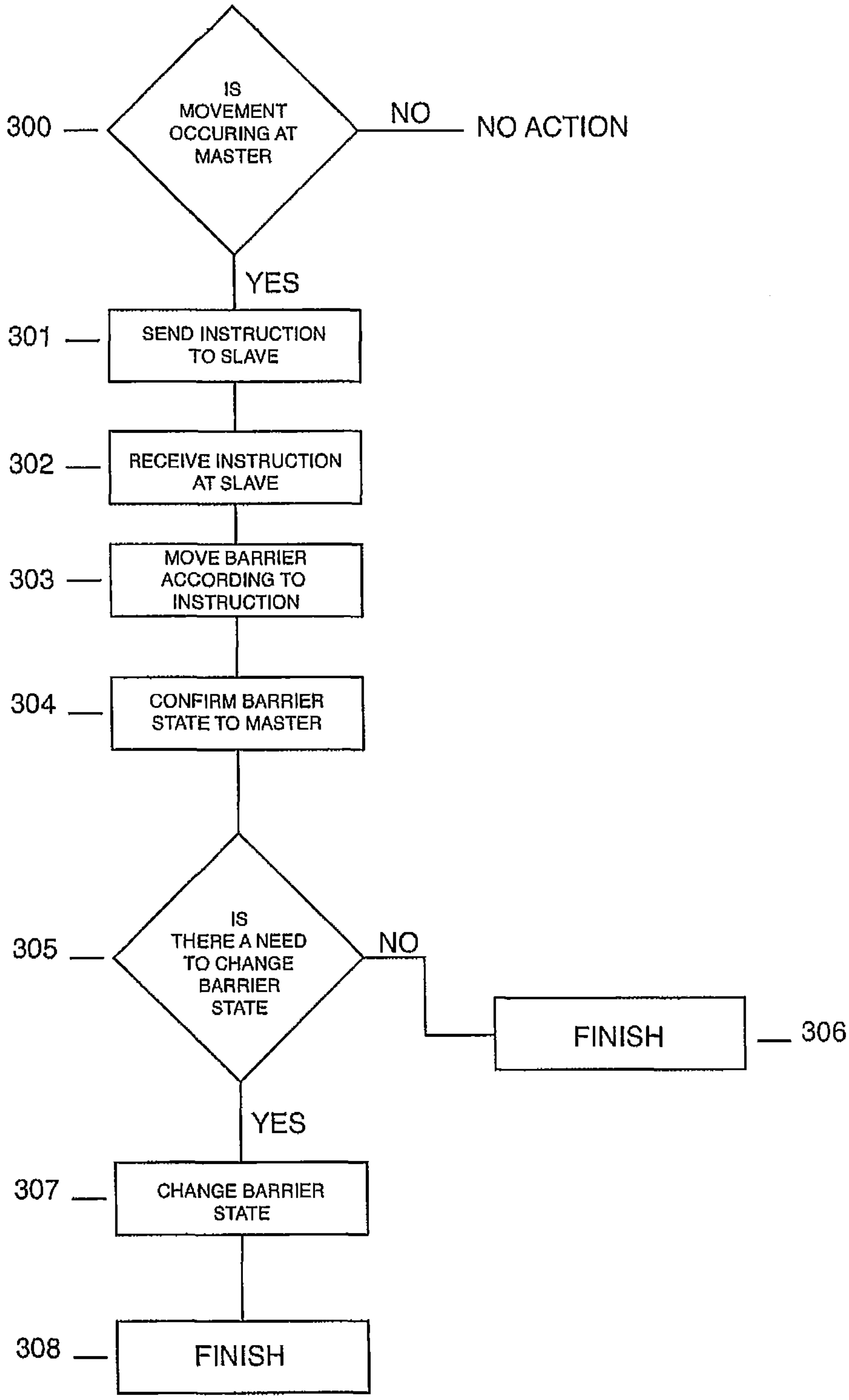
300
IS MOVEMENT OCCURING AT MASTER
NO
NO ACTION
YES
301
SEND INSTRUCTION TO SLAVE
302
RECEIVE INSTRUCTION AT SLAVE
303
MOVE BARRIER ACCORDING TO INSTRUCTION
304
CONFIRM BARRIER STATE TO MASTER
305
IS THERE A NEED TO CHANGE BARRIER STATE
NO
FINISH
306
YES
307
CHANGE BARRIER STATE
308
FINISH

Fig. 3

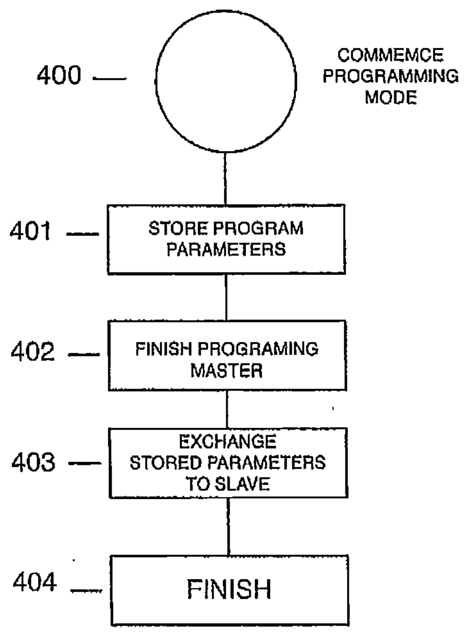
400
COMMEMCE PROGRAMMING MODE
401
STORE PROGRAM PARAMETERS
402
FINISH PROGRAMING MASTER
403
EXCHANGE STORED PARAMETERS TO SLAVE
404
FINISH

Fig. 4

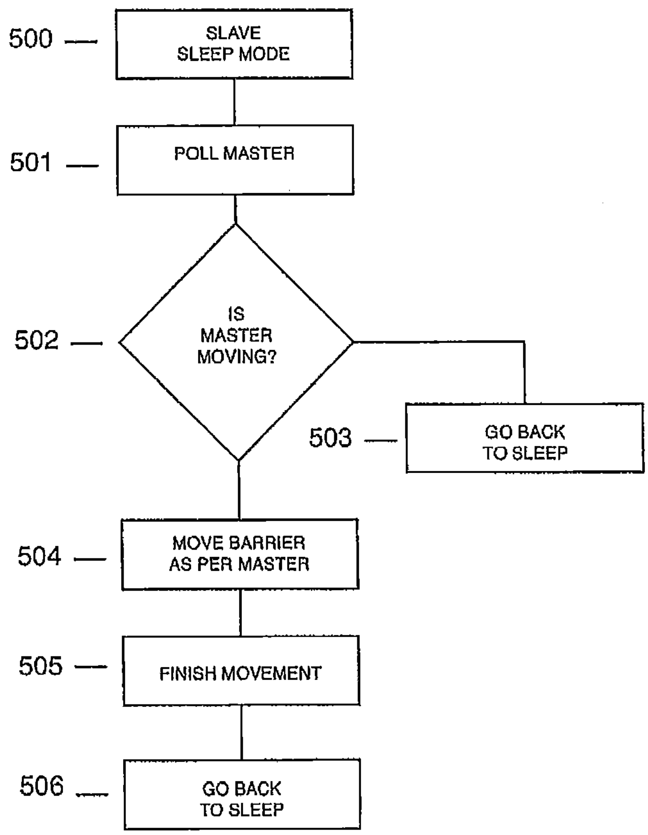
500
SLAVE SLEEP MODE
501
POLL MASTER
502
IS MASTER MOVING?
503
GO BACK TO SLEEP
504
MOVE BARRIER AS PER MASTER
505
FINISH MOVEMENT
506
GO BACK TO SLEEP

Fig. 5

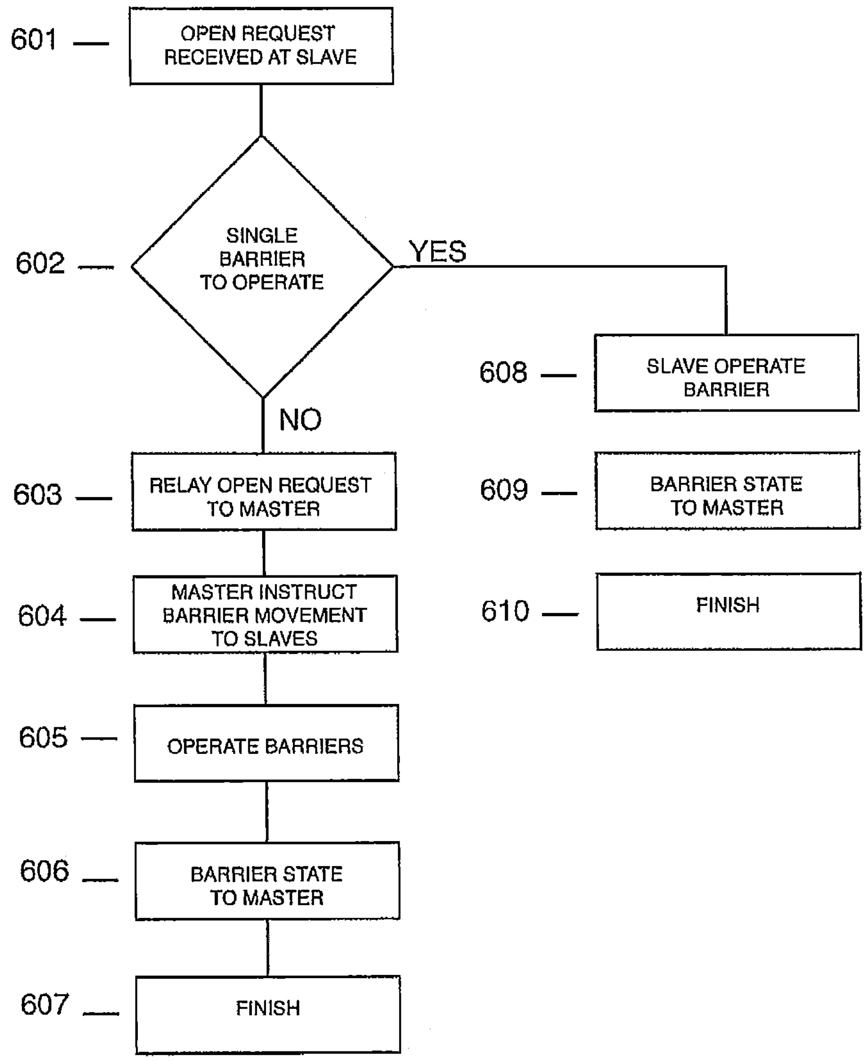
601
OPEN REQUEST RECEIVED AT SLAVE
602
SINGLE BARRIER TO OPERATE
YES
NO
603
RELAY OPEN REQUEST TO MASTER
604
MASTER INSTRUCT BARRIER MOVEMENT TO SLAVES
605
OPERATE BARRIERS
606
BARRIER STATE TO MASTER
607
FINISH
608
SLAVE OPERATE BARRIER
609
BARRIER STATE TO MASTER
610
FINISH

Fig. 6

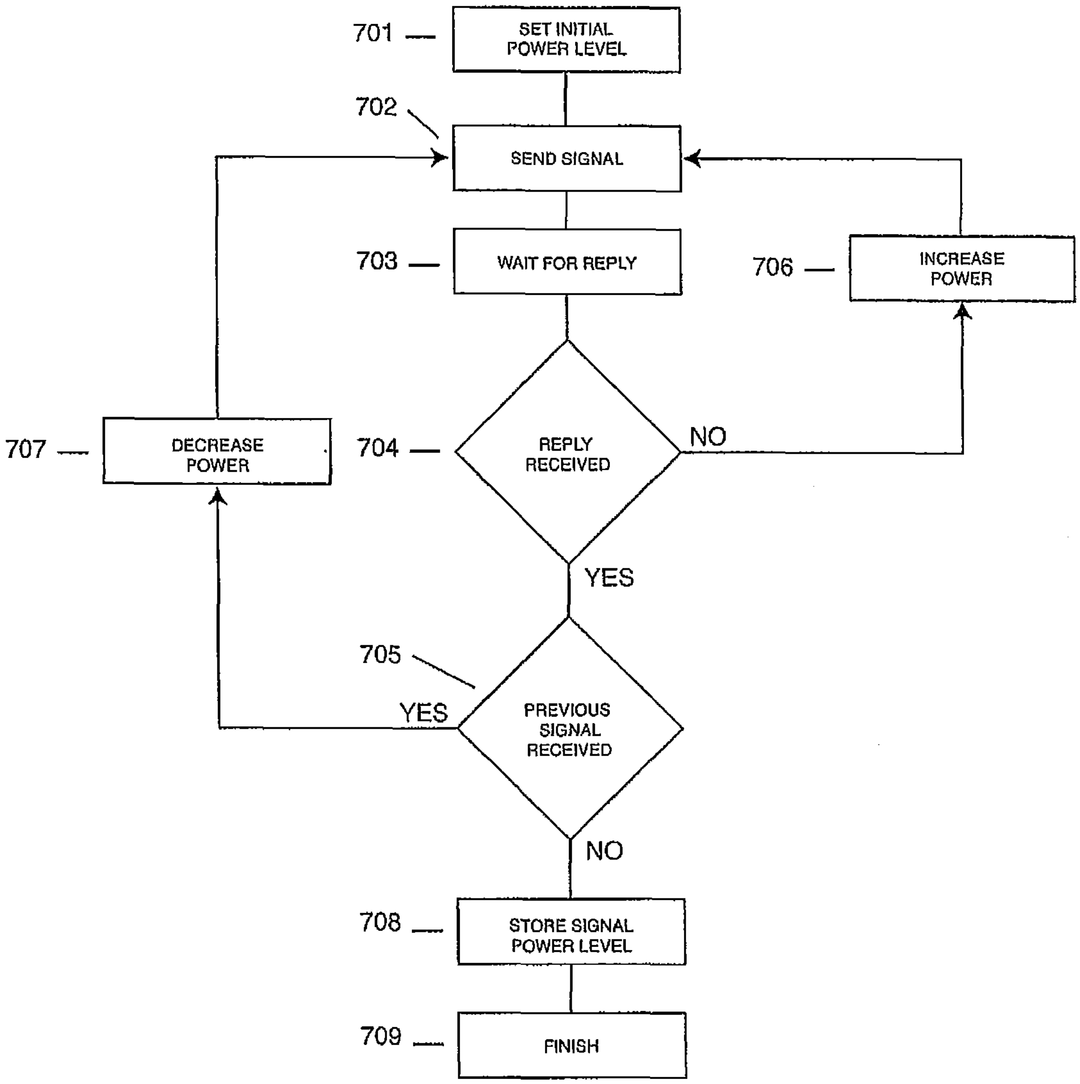
701
SET INITIAL POWER LEVEL
702
SEND SIGNAL
703
WAIT FOR REPLY
706
INCREASE POWER
707
DECREASE POWER
704
REPLY RECEIVED
NO
YES
705
YES
PREVIOUS SIGNAL RECEIVED
NO
708
STORE SIGNAL POWER LEVEL
709
FINISH

Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- AU 2012101044 **[0046] [0060]**