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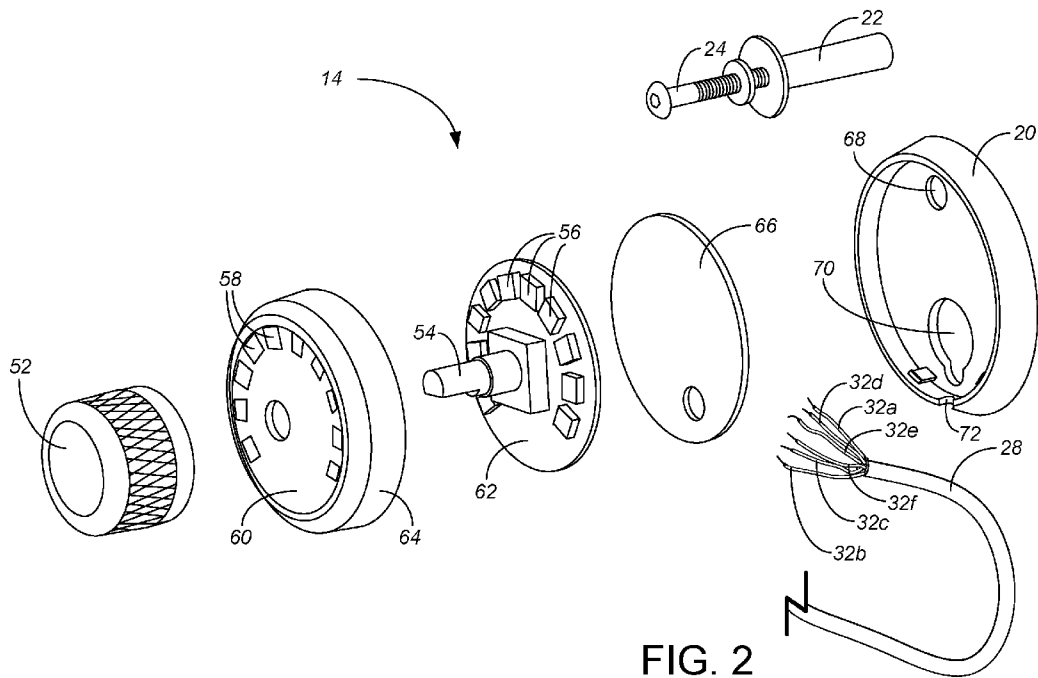


FIG. 2

(57) Abstract: A brake controller has a control dial with a series of full color LEDs arranged around the dial. The dial with its LEDs is in a module mounted on the dash of the towing vehicle and connected by a cable to a main module mounted out of sight. The dial is a rotary encoder pushbutton mounted on the same circuit board as the LED chips. Status information is output using the LEDs primarily based on color. Substantially all setting input is provided solely by user manipulation of the dial, pushing the dial in to change setting input mode, with the value of the input reflected in the number of LEDs being lit in a color corresponding to the brake controller setting being changed, as the user rotates the dial either clockwise or counterclockwise to change setting values.



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## BRAKE CONTROLLER INTERFACE

### CROSS-REFERENCE TO RELATED APPLICATION(S)

5 The present application claims priority from U.S. Provisional Application No. 62/541,947 entitled BRAKE CONTROLLER INTERFACE filed August 7, 2017, incorporated herein by reference.

### BACKGROUND OF THE INVENTION

10 The present invention relates to brake controllers used in towing, and particularly to the interface on the exterior of a housing, such as for mounting relative to a dashboard on a towing vehicle, to communicate information to and from the brake controller.

15 Brake controllers are devices used in towing a trailer, towed vehicle or similar load having brakes behind a towing vehicle. The brake controllers use various strategies and components to activate the trailer brakes at an appropriate rate and time relative to the driver's control of brakes on the towing vehicle. Exemplary brake controllers are disclosed in U.S. Pat. Nos. 6,012,780, 6,068,352, 7,058,499, 8,463,519, 9,150,201, 9,315,173 and 9,446,747 and U.S. Pat. Pub. No. 2010/0152920, each incorporated by reference.

20 Some brake controllers include a display and all control buttons on a single package or housing that contains all of the integrated circuit control electronics. Other brake controllers, such as disclosed in U.S. Pat. No. 9,150,201, separate the display and/or control buttons on a housing which is different from the housing containing the integrated circuit control electronics. In both types of configurations as presently on the brake controller market, the display (to communicate from the unit to the person  
25 operating the vehicle) typically includes one or two seven-segment units, and perhaps a plurality of LEDs 56 or other lights. At the same time, the control buttons (for the person operating the vehicle to input settings into the brake controller) can include one or more push buttons, slider controls, and one or more dials. Generally speaking, both the display and the control buttons of prior art brake controllers are not intuitive or easy to  
30 understand. A numerical display is often used to communicate brake controller setting values. If LEDs 56 or other lights are used, they are generally not associated with the position of the controls or the settings of the brake controller, but instead are used to communicate connection status and/or error messages. Better interfaces with brake controllers are needed.

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### SUMMARY OF THE INVENTION

The present invention is a brake controller in which a control dial is provided with lights or similar controllable indicators around the dial to provide feedback to the user regarding the operational input to the brake controller. In its preferred embodiment, the  
40 dial can be a rotary dial which allows continuous rotation, with ten full color Red-Green-Blue (RGB) light emitting diodes (LEDs) arranged in an arc around the dial. The dial with its LEDs can be provided as a small assembled package to be mounted as a single unit in a location readily accessible to the driver, such as on the dashboard of the towing vehicle. Meanwhile, the preferred embodiment includes a separate electronics unit that  
45 communicates with the input dial but can be mounted in a different location, such as

under the dashboard of the towing vehicle. With a minimal change to the dashboard of the towing vehicle including adding only the small dial with LEDs, the user interface provided by the present invention can communicate more simply and intuitively with the driver, both for input from the driver and feedback to the driver regarding the brake controller settings and indicators. At the same time, the brake controller as a whole has lower component costs as compared to prior art brake controllers with the same electronic capabilities.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described with reference to the attached drawing sheets, in which:

FIG. 1 is a perspective view of the primary components that make up the preferred brake controller of the present invention.

FIG. 2 is an exploded perspective view of the preferred interface of FIG. 1.

FIG. 3 is an enlarged view of the interface module of FIG. 2.

FIG. 4 is a schematic view showing wiring of the brake controller of the present invention in a towing vehicle.

FIG. 5 is a schematic view of the electronics within the interface module.

FIG. 6 is a schematic view indicating the preferred display communication of the present invention.

While the above-identified drawing figures set forth a preferred embodiment, other embodiments of the present invention are also contemplated, some of which are noted in the discussion. In all cases, this disclosure presents the illustrated embodiments of the present invention by way of representation and not limitation. Numerous other minor modifications and embodiments can be devised by those skilled in the art which fall within the scope and spirit of the principles of this invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, the brake controller 10 of the preferred embodiment includes a main module 12 and a display/knob module 14, as well as various components to make installation and assembly of the main module 12 and the display/knob module 14 easier. In the preferred embodiment, the logic implementation of the brake controller 10 occurs within the main module 12, while the display/knob module 14 provides the substantially entire interface between the brake controller 10 and the user, communicating inputs from the user to the brake controller 10 and communicating information back to the user.

The most preferred embodiment includes two alternative ways of mounting the main module 12, either using a mounting flange 16 and/or using a main module adhesive pad 18. The most preferred embodiment also includes two alternative ways of mounting the display/knob module 14, including a base plate 20, well nut 22 and screw 24 and/or a display/knob adhesive pad 26. Use of the base plate 20 in mounting the display/knob module 14 to the dash board (not shown) or instrument panel (not shown) of a towing vehicle (not shown) better allows the cable 28 for the display/knob module 14 to be inserted through a hole drilled in the dash board or instrument panel. After this cable 28 is routed as desired, a plug 30 connected is attached to the wires 32 on the end of the cable 28 so these wires 32 can be plugged into and communicate with the main module 12.

The main module 12 communicates with the towing vehicle and the trailer or towed vehicle (not shown) as well known in the prior art, which could include wireless communications but more preferably includes a four wire connection 34, 36, 38, 40. As shown in the wiring diagram of FIG. 4, two of the wires are used as power wires 34, 36 from the towing vehicle's power system, typically a nominal 12 volt direct current system using an automotive battery 42. A fuse or circuit breaker 44 (preferably 30 Amp) may be added or included as part of the power connection. Using coloring typical of vehicle power systems and brake controllers, the "hot" power wire 34 is preferably black and the neutral or ground power wire 36 is preferably white. Alternatively, a different power source could be used to make wiring and installation easier, such as from a replaceable or rechargeable battery (not shown) in the main module 12. However, the main module 12 is made simpler and more reliable by omitting a separate power source and avoiding any need to replace or recharge that separate power source or otherwise access the main module 12 during use of the brake controller 10. A third wire 38, preferably colored red, taps into the brake light signal, activating the brake controller 10 whenever the driver steps on the brake pedal 46 of the towing vehicle. The fourth wire 40, preferably colored blue, provides the output of the brake controller 10, a signal indicative of braking power to be applied to the towed trailer or towed vehicle brakes. For instance, the blue output signal wire 40 may be routed to a trailer connector 48, to be plugged in to the plug (not shown) of the control and power wiring of the trailer as widely known in the towing art. A universal pigtail harness 50 or similar extension wires may be used for making the wiring connections.

As known in the brake controller art, the main module 12 includes circuitry to determine the braking power output. In general, the application and timing of braking force to the trailer as determined within the main module 12, based on operation of the towing vehicle brake pedal 46 in conjunction with the sensor(s) and settings of the main module 12, is within the prior art. In the preferred embodiment, in addition to the brake light signal input 38, the main module 12 houses an inertial sensor (not separately shown), such as a digital three-axis accelerometer, with the most preferred embodiment employing a ADXL345 three-axis accelerometer chip available from Analog Devices of Norwood, Massachusetts. A microcontroller (not separately shown) in the main module 12 preferably controls the operation of the brake controller 10, such as a LPC1111/12/13/14 32 bit microcontroller chip from NXP Semiconductor of Eindhoven, Netherlands. When the brake pedal 46 is pressed, the main module 12 combines readings from the three-axis accelerometer with settings input through the knob 52 to electrically output a value on the blue output signal line 40 which controls how hard and fast the trailer brakes are activated.

The display/knob module 14 communicates with the main module 12. In the preferred embodiment, this communication occurs through a cable 28 that includes six separate wires 32a-f, though in other embodiments the communication could occur wirelessly or with a different number of wires. For reasons similar to the main module 12, two of the six wires 32 connecting the main module 12 to the display/knob module 14 are power wires, including a hot wire 32a and a ground wire 32b. For convenience of circuitry and components, the preferred power system for the display/knob module 14 is a 5 V DC system. The main module 12 includes electronic power component circuitry (not separately shown) to derive a smooth, stable 5 V DC power for the display/knob module

14. The other four wires 32c-f in the preferred connection between the display/knob module 14 and the main module 12 are data wires, three wires 32c-e providing input data to the main module 12 and one wire 32f providing output data from the main module 12 for display to the user.

5           The primary reason for separating the main module 12 and the display/knob module 14 is to make the display/knob module 14 smaller and more readily mounted in the vehicle. The display/knob module 14 should be mounted in a location where it is easily reached, such as by the driver of the vehicle while driving, and can be easily seen at a glance without obstructing the view of the driver on the road or causing the driver to  
10           turn significantly away from the road. As power supplies, accelerometers, microcontrollers and other components become smaller, alternative embodiments may combine the main module electronics into the display/knob module 14. In the current most preferred embodiments, the main module 12 can be securely mounted at virtually any location in the towing vehicle, such as under the dash, without banging the driver's  
15           knees but while still allowing relatively short wiring runs both to the vehicle battery 42 or fuse box, to the towing vehicle brake light circuit, to the display/knob module 14, and to the trailer plug 48.

          The display/knob module 14 of the present invention is best seen in FIGS. 1-3. Instead of having the myriad of different buttons, knobs, sliders, input screens or other  
20           controls of prior art brake controllers, the present invention uses a single knob 52 that allows a user to input substantially all the input information to the brake controller 10 which is needed for ordinary operation of the brake controller 10. This knob 52 permits two separate input movements, either pressing the knob 52 axially inward to overcome its spring force and act as a pushbutton, or rotating the knob 52 clockwise or  
25           counterclockwise. Both of these types of inputs, pushing the knob 52 in and rotating the knob 52, are inherently understood by users; many radio sound systems in today's motor vehicles utilize the identical types of controls, such as pushing a knob in to turn the radio on or off, and rotating the knob to increase or decrease radio volume. As will be explained in more detail, the fact that the single knob 52 allows two very distinct and  
30           separate movements to allow distinct and separate input commands is important, not only toward increasing the amount and type of information that can be readily input, but as providing a safety factor that information will not be inadvertently entered.

          The most preferred knob input is a combination rotary encoder/pushbutton 54. Examples of such devices are explained in U.S. Pat. Nos. 4,599,605, 4,866,219 and  
35           6,462,677, all incorporated by reference. One of the data wires 32c combines, opposite either the power input or the ground, to act as a switch across pins 1 and 2 as schematically represented in FIG. 5. When the knob 52 is pushed in, pins 1 and 2 are closed; otherwise pins 1 and 2 are open. By correctly wiring this to the microcontroller in the main module 12, the main module 12 knows whenever the knob 52 is pushed.

40           Two 32d, 32e of the data wires 32 output a two bit quadrature code on pins A and B, allowing four unique values schematically represented in FIG. 5. Rotation of the knob 52 clockwise proceeds through one sequence, while rotation of the knob 52 counter-clockwise proceeds through the opposite sequence. Thus, correct wiring the output of pins A and B to the micro-controller allows the main module 12 to know whether the  
45           knob 52 is being rotated clockwise and its general speed of rotation, or whether the knob

52 is being rotated counterclockwise and its general speed of rotation, or whether the knob 52 is not being rotated.

In the most preferred embodiment, the knob input is provided by a PEC11L series low profile encoder 54 available from Bourns Pro Audio of Riverside, California. Rotationally, it has a shaft with soft detents every 18° of rotation. There are no stops and no reason why the dial cannot be rotated endlessly either clockwise or counter-clockwise. It has a maximum operational speed of 60 RPM and a maximum contact bounce at 60 RPM of 10ms, with the quadrature code outputting 15 pulses per 360° of rotation. As a pushbutton, it has a push travel distance about 0.5mm and a required push actuation force of about 600 gf, and requires a few milliseconds to debounce (such as 4ms at make and 10ms at break). Resistors R3 and R4 (10kΩ) and capacitors C1 and C2 (0.1μF) are included within the display/knob module 14 on the rotary data lines 32d, 32e as shown in FIG. 5.

Unlike many prior art microprocessor-based brake controllers, there is no display screen to output numbers or letters to be read and translated into meaning by the user. Instead, the output communicated to the user is entirely through a series of multi-color lights 56, situated around the dial input in a way that makes intuitive sense. The preferred display/knob module 14 includes ten such lights 56, mounted so as each to be viewable through its own translucent light-diffusing window 58. Other embodiments include a different number of lights or different types of lights, provided there are enough lights to be interpreted by the user as a series indicating movement of the input along a range.

With the input being a knob 52, the lights 56 are mounted in a circumferential series, extending about 240° around the shaft axis. The about 120° gap 60 in the circumference is preferably below the knob 52 as mounted in the towing vehicle. In the most preferred embodiment, the lights 56 are provided by are WS2812B-Mini intelligent external control LED chips commercially available from Shenzhen LED Color Opto Electronic Co. Ltd. of Shenzhen, China. Each of these LED chips 56 has a quite small footprint, square with dimensions of about 3.5 x 3.5mm, allowing them to be positioned next to each other close in to the dial 52. For instance, the preferred knob 52 has a knurled outer surface diameter of about 20mm, with the ten LED chips 56 placed around the dial 52 to define an arc with a diameter of only about 30mm. As best shown in FIG. 2, even though each LED chip 56 is individually just about a square, the LED chips 56 are mounted angularly offset from each other, in a circular arc rather than a rectangular pattern. Each preferred LED chip 56 actually includes three separate LEDs (not separately shown), one red, one green and one blue, additive to produce a broad array of colors and intensity. The three primary colors of each chip 56 can achieve 256 level grayscale. Preferably each window 58 only covers and provides visibility over the portion of the LED chip 56 that contains the three additive LEDs. Particularly with window coverage over the LEDs, the user perceives the three monochrome LEDs as a single light of selectable color and intensity.

In the preferred embodiment, the series of LED chips 56 are wired in a cascade as shown in FIG. 5, with each chip 56 having its power-in supported by a capacitor C3 - C12 (0.1μF). The data transfer protocol of the preferred LED chips 56 uses a single NZR communication mode, allowing each chip 56 in the series to collect initial 24 bit data through its data in port and then reshape the 24 bit data sent to the next chip 56 in the

cascade through its data out port. Other methods of cascading the lights 56 could be used, including allowing the microprocessor to individually control each light 56 rather than output a single 24 bit data stream that controls all the lights 56. The important concept is that the multiple lights 56 act collectively rather than individually to communicate information to the user. The preferred logic scheme utilizes both which colors are used and which lights are lit to convey different information to the user.

In the preferred embodiment, both the knob 52 and the LEDs 56 are mounted, together with the other electronic components of FIG. 5, on a single circuit board 62 as shown in FIG. 2. The cable 28 for the display/knob module 14 includes six wires 32 electrically connected as known in the art (such as by soldering) to the circuit board 62. After the electrical components are mounted on the circuit board 62 and the cable wires 32a-f are connected to the circuit board 62, the circuit board 62 is preferably sealed within the housing front 64 and the housing back 66 as part of the manufacturing process for the brake controller 10, i.e., the user is not permitted access to the circuit board 62 shown in FIG. 2. The housing front 64 and the housing back 66 protect the electrical components and the entire circuit of FIG. 5 from moisture, dirt and human/exterior object contact, and the preferred display/knob module 14 is amply robust for its environment of use in the cab of the towing vehicle.

This series of lights 54 of the preferred display/knob module 14 intuitively provides a number of advantages. Firstly, in most mounting locations and dashboard orientations, the knob 52 will be mounted so as to be directed lower than the line of sight of the driver. Having the gap 60 below the knob 52 places the lights in a position where they will be least likely to be obstructed by the existence of the knob 52, and the least likely to be obstructed when the user reaches with his or her hand and arm to turn the knob 52. Secondly, the gap 60 presents a logical beginning and end for the data/information being conveyed. The user inherently expects that the first light in the series - mirroring low volume on the car stereo - is to the far left, and the last light in the series - mirroring high volume on the car stereo - is to the far right. Thirdly, the arc of lights 56 clearly indicates and reflects the rotational motion of the knob 52, intuitively indicating to the user that the knob 52 should be turned clockwise or counterclockwise to control the lights 56 and to control the brake controller 10. In an alternative embodiment where the control is a slider rather than a rotational knob 52, the lights should be linearly arranged relative to the slider so as to intuitively indicate that the slider should be slid in a direction to control the lights and to likewise control the brake controller 10 with more or less power.

The preferred installation method for the present invention involves mounting the LED display rotary knob module 14 before mounting the main module 12. The LED display rotary knob module 14 is preferably mounted in a suitable location where it is securely attached to a solid surface which can be easily reached by the driver of the vehicle, such as in the dashboard of the vehicle adjacent the radio controls, adjacent the HVAC controls, adjacent the lighting controls, or adjacent the instrument panel. If drilling is to occur for either a mounting screw 24 or for the cable 28 to extend through the dashboard, the area behind the mounting location must be clear to avoid damage while drilling. The installer holds the base plate 20 in the selected position, and marks two hole locations through the base plate 20, and then drills two holes through the dash panel at the marked locations. The installer inserts the well nut 22 into the outer hole 68



of the base plate 20, securing the base plate 20 with the screw 24 to the dash panel. Once the base plate 20 is secured to the dash panel, the installer feeds the cable 28 of the LED display rotary knob module 14 through the center hole 70, and then positions the LED display rotary knob module 14 into the base plate 20 with the LEDs 56 in the upright position, pressing down until it clicks past detents in peripheral prongs of the base plate 20. After the LED display rotary knob module 14 is in place, the installer attaches the plug connector terminal 30 to the end of the cable wires 32, and routes the cable 28 toward the main module location.

As an alternative to drilling through the dash panel, the LED display knob module 14 can be mounted to the dashboard in the vehicle using the circular adhesive pad 26. Either the back of the module 14 or more preferably the back of the base plate 20 is adhered to the dash panel. When the back of the base plate 20 is adhered to the dash panel, the cable 28 can be routed downward out a gap 72 in the base plate 20 and in front of the dash panel toward the main module location.

Like the LED display rotary knob module 14, the main module 12 must be mounted securely to a solid surface of the towing vehicle. But unlike the LED display rotary knob module 14, the main module 12 does not need to be within sight lines and reach of the driver. Instead, the main module 12 is preferably mounted by tightening screws through openings in the mounting flange 16 into a mounting location, such as the kick plate or console side surfaces around the driver's feet or legs or the bottom or back of the dash panel. As an alternative to using screws and the mounting flange 16, the main module 12 may be adhesively mounted using the rectangular adhesive pad 18, and/or may be securely tied in place using zip ties (not shown). Once the wiring distance between the main module 12 and the display/knob module 14 is established and the cable 28 is run, the cable 28 can be cut to length with the installer installing the plug 30 on the end of the six wires 32a-f of the cable 28. Then the installer inserts the plug connector 30 of the cable 28 into the mating receptor plug 74 of the main module 12.

The main module 12 is wired into the towing vehicle as shown in FIG. 4, providing power 34, 36 to the brake controller 10, providing the brake light signal 38 to the brake controller 10, and providing the brake control output signal 40 to the towed vehicle or trailer brakes. If desired, the main module 12 can be plugged in to the pigtail harness or vehicle-specific quick plug 50. If such a harness or plug 50 is unavailable, hard wiring may be necessary.

After both the main module 12 and the LED display rotary knob module 14 are mounted and the wiring connected, the brake controller 10 is ready to be calibrated and used in accordance with the logic sequence of the system. The LED display provides two distinct types of information, schematically represented in FIG. 6. First, it indicates status information useful in calibration and troubleshooting the brake controller setup. Second, it indicates the value setting and setting mode when the knob 52 is moved.

Calibration and status information is communicated using the series of LEDs 56 primarily based on the color palette being displayed, with a flashing pattern/number of LEDs being lit that indicates the importance of the information. In the preferred embodiment, the calibration indicator is communicated entirely in green, inherently indicating to the user that everything is fine and calibration is a normal part of operation of the brake controller 10. Whenever power is first applied to the brake controller 10 (usually by starting the engine of the towing vehicle) and a trailer is connected, the brake

controller 10 self-calibrates prior to braking operation. Calibration should be performed while parked on a level surface, with the vehicle in park or neutral with the parking brake applied, foot off of the brake pedal 46, and no manual control actuation. The preferred calibration indicator is a series of increasing from one green light at left to all ten green lights 56, occurring multiple times during the self-calibration over the time required for self-calibration. For instance, the preferred embodiment self-calibrates for about 5 seconds. During this 5 second time period, the display sequences, from one to ten green lights, seven times. The direction of the increasing number of green lights of the calibration indicator inherently indicates to the user which way to turn the dial to adjust (increase the volume of) various brake controller settings.

An overload status indicator is provided by flashing half of the LEDs 56 in one color and flashing the other half of the LEDs 56 in a second color. For instance, the preferred embodiment, when displaying the overload status indicator, flashes every other LED 56 (the first, third, fifth, seventh and ninth LED) in red, and flashes the remaining LEDs 56 in yellow. The overload status indicator indicates when the brake control is in an overload or short-circuit condition. The LEDs 56 flash red and yellow in sequence until the overload condition is removed. The flashing red and yellow does not indicate a direction of movement or otherwise suggest any movement of the dial 52. The red and yellow color and flashing inherently indicates that the overload or short circuit condition is an alarm condition that needs to be rectified to avoid potential damage to the brake controller 10 or braking system, or worse yet, to avoid a dangerous brake failure situation.

A miswired status indicator is provided by showing all ten LEDs 56 on in a particular color for an extended period of time, such as in red for in excess of 10 seconds. The miswired status is most commonly caused by having the red wire of the brake controller main module 12 connected to ground side of stoplight pedal switch or shorted to ground, or a miswired trailer connector. The red color inherently indicates that the miswired status needs to be corrected for the trailer or towed vehicle brakes to function.

A disconnect status indicator is provided by flashing LEDs 56 in a particular color, preferably not a color within the red, yellow, green palette of a common stoplight. The preferred embodiment uses blue flashing LEDs 56 as the disconnect indicator. One embodiment flashes all ten LEDs 56 in the selected color, while the embodiment depicted in FIG. 6 only flashes the first, second, ninth and tenth LEDs 56. If desired, for any of the status indicators, more information can be conveyed by the number of LEDs 56 that are flashing or by which LEDs 56 in the series are flashing. A blue display thus indicates when the trailer has been disconnected (flashing blue) or if the brakes are pressed with no trailer connected (steady on blue as long as brake pedal 46 is held). The blue color inherently indicates that the disconnect status is not an alarming condition, but that the brake controller 10 is functioning but not actively controlling the brakes of the trailer or towed vehicle.

An accelerometer error status indicator is provided by displaying a color not otherwise used, and preferably not a color within the red, yellow, green palette of a common stoplight. The preferred embodiment uses purple in a ramp pattern on the ten LEDs 56 as the accelerometer error indicator. The accelerometer error condition is most commonly rectified by unplugging the trailer connector and plugging it back in.

In inputting control information, there are four modes of operation: brightness, manual control, brake output control, and sensitivity control. Pressing the knob 52 inward (toward the dashboard) switches between these four modes. Each mode of operation occurs in a distinct color profile of the LED display, so the user can immediately determine which mode the input is in by looking at the color of the LED display. For inputting control information, the number of LEDs 56 being lit (in the preferred embodiment, generally from a minimum or zero or one to a maximum of ten) is generally indicative of the value being selected by the user for the particular setting being controlled.

The default or initial mode of operation of the control knob 52 is brightness control. In the preferred embodiment, brightness control is displayed with white colors on the series of ten LEDs 56 (actually, with illuminating all three of the additive red-green-blue LEDs on any LED chip 56 at the same time, so the output is viewed by the user as showing a white light through its window 58). While in brightness control mode, rotating the knob 52 clockwise increases the brightness or luminosity of however many white lights are showing, at the same time as it increases the number of windows 58 which are lit, from dimly lighting one window 58 to brightly lighting ten windows 58. While in brightness control mode, rotating the knob 52 counter-clockwise decreases the brightness or luminosity of however many white lights are showing, at the same time as it decreases the number of windows 58 which are lit. Based on the brightness setting selected (from one to ten), any time the LEDs 56 are lit (in any color) they will illuminate with a brightness consistent with a brightness setting. The brightness setting thus enables the user to select how brightly the display appears whenever it illuminates during driving or braking, in a way similar to the way some vehicles allow the user to select how bright or dim dash lighting should be. The brightness setting is particularly beneficial for the contrast between sunlit daytime driving, when maximum brightness may be needed to adequately notice or see the output of the LEDs 56, and dark night-time driving, when a much dimmer display is desired so as to not "blind" or otherwise overly distract the driver and so as to not overly illuminate the cab of the towing vehicle.

One beneficial aspect of the control logic is that the control knob 52 returns to the brightness control mode whenever the knob 52 has not been pressed in or rotated for a threshold period of time, in the preferred embodiment about 10 seconds. Because of this, the only way the other three modes of control operation can be reached and the brake controller settings changed is by first depressing the knob 52 and then, before the threshold time period is reached, either holding the knob 52 in or rotating the knob 52. The required input provides a beneficial safety feature that inadvertent contact with the brake controller knob 52 will only rarely result in changing any of the brake control operational settings, but instead will only adjust or change the brightness of the LEDs 56 in the display.

Depressing the control knob 52 and holding it in for a period of time (such as in excess of 0.5 seconds) changes the input to manual brake output control. In the preferred embodiment, manual brake output control is displayed with entirely red colors on the series of LEDs 56. Manual brake activation is typically used by a driver in situations where a slow reduction in speed is desirable. In manual brake output control mode, the brake controller 10 begins to apply the trailer or towed vehicle brakes, increasing braking pressure by ramping over time. The red LEDs 56 light up in sequence, with the number

of LEDs 56 being lit being proportional to how long the knob 52 has been held in during the ramp-up and simultaneously proportional to the brake output. The maximum output of the manual brake output control is adjustable by, while the knob 52 is being pushed down, rotating the knob 52 clockwise to increase the maximum manual brake output and rotating the knob 52 counter-clockwise to decrease the maximum manual brake output.

From the default or brightness control mode, depressing the control knob 52 and releasing it changes the input to brake output control. The brake output control determines how hard to apply the trailer brakes for a given accelerometer reading when the brake pedal 46 of the towing vehicle is being pushed. The output control also generally establishes the maximum amount of power available to the trailer brakes when braking. The output control is most commonly adjusted during initial setup, when trailer load changes, when different trailers are used or when adjustment is needed for changing road or driving conditions. In the preferred embodiment, brake output control is displayed with green colors on the left side of the series of ten LEDs 56 shifting toward red colors on the right side of the series of ten LEDs 56. While in brake output control mode, rotating the knob 52 clockwise increases the braking output and the number of windows 58 which are lit, and rotating the knob 52 counter-clockwise decreases the braking output and the number of windows 58 which are lit. After 10 seconds of no user input, the interface reverts to brightness mode and the display goes to sleep.

From the default or brightness control mode, depressing the control knob 52 and releasing it twice changes the input to sensitivity control. The sensitivity control adjusts trailer brake aggressiveness. Sensitivity adjustment has no effect on the manual control. The sensitivity control can be adjusted for individual driver preference, trailer load changes or changing road conditions. In the preferred embodiment, sensitivity control is displayed with blue colors on the left side of the series of ten LEDs 56 shifting toward red colors on the right side of the series of ten LEDs 56. While in sensitivity control mode, rotating the knob 52 clockwise increases the sensitivity and the number of windows 58 which are lit, and rotating the knob 52 counter-clockwise decreases the sensitivity and the number of windows 58 which are lit. After 10 seconds of no user input, the interface reverts to brightness mode and the display goes to sleep.

As described above, all of the primary operational controls of the brake controller 10 are operated by manipulation of a single input dial 52. However, the preferred embodiment includes switch controls 76, 78 on the main module 12 which are intended to never be used when driving the towing vehicle or adjusting the brakes, but rather to change the control logic within the main module 12 particularly for the manual output mode. Specifically, there are two small switches 76, 78 located at the front of the unit, next to the port 74 on the main module 12 and shown in FIG. 1. Once accessed, the switch positions can be changed using a small pointed tool (not shown), but are quite difficult or impossible to change by hand.

The switch 76 on the right controls the level of output available to the trailer brakes when using the manual control. The factory default setting is the 'ON' position with the switch 76 down. This setting limits the manual control output to the level set using the output control mode. As noted previously, the output control mode generally establishes the maximum amount of power available to the trailer brakes when braking. The only exception is when the manual control is set up for 100% braking. Moving this

switch 76 up to the 'OFF' position allows 100% of the output to the brakes when the manual control is actuated regardless of the output control setting.

5 The switch 78 on the left controls the unit's brake light activation feature. The factory default setting is the 'ON' position with the switch 78 is down. This setting activates the tow vehicle and trailer brake lights when the manual control is actuated. Some tow vehicle circuits do not allow power for brake lights from a second source. In these applications, the brake light feature can be switched off using this second small switch 78 at the rear of the unit 12. The brake light connection (red wire 38) is still required to activate the brake controller 10 with the switch 78 in either position. Moving the switch 78 up to the 'OFF' position turns off the brake light activation feature and the  
10 brake lights are not activated when the manual control is actuated.

Like the preferred embodiment of the present invention, prior art brake controllers included a control input for determining the maximum output of the trailer brakes, a separate control input for determining the aggressiveness of the trailer brakes, and a  
15 separate control input for manual operation of the trailer brakes. However, the four modes of operation (the fourth mode being control of the brightness of the ten LEDs 56, for better viewing in the light conditions present at the time in the cab of the towing vehicle), all controlled by the single continuous rotation dial 52 and as explained above, are entirely new and different. The series of full color LEDs 56 are used in gradations to  
20 intuitively represent the various operational settings of the brake controller 10, while providing direct feedback to the dial input rather than the confusing feedback of the prior art displays.

Although the present invention has been described with reference to preferred  
embodiments, workers skilled in the art will recognize that changes may be made in form  
25 and detail without departing from the spirit and scope of the invention.

## CLAIMS

1. A brake controller comprising:
  - 5 a micro-processor based control module having a plurality of settings which control functions of the brake controller output for use in controlling brakes of a trailer or towed vehicle; and
  - 10 an input having at least first and second distinct types of control motion, in communication with the micro-processor based control module, which enables control of the settings of the brake controller, wherein the first type of control motion switches between input modes, with different input modes controlling different settings of the brake controller, wherein the second type of control motion allows user selection of a value for the setting being controlled in that input mode.
- 15 2. The brake controller of claim 1, wherein the input is on an input module which is separately mounted relative to the micro-processor based control module.
3. The brake controller of claim 1, wherein the first distinct type of control motion is pushing a control switch.
- 20 4. The brake controller of claim 3, wherein the control switch is a rotary dial, wherein the second distinct type of control motion is rotation of the rotary dial.
- 25 5. The brake controller of claim 4, wherein one of the input modes is manual brake output control accessed by depressing the rotary dial and holding it in to increase braking pressure by ramping over time, wherein rotating the rotary dial clockwise increases the maximum manual brake output and rotating the rotary dial counter-clockwise decreases the maximum manual brake output.
- 30 6. The brake controller of claim 4, wherein the rotary dial is a rotary encoder.
7. The brake controller of claim 1, wherein one of the input modes is brake output control, and another of the input modes is sensitivity control.
- 35 8. The brake controller of claim 1, wherein one of the input modes is brightness control over a display of the brake controller.
9. A brake controller comprising:
  - 40 a micro-processor based control module having a plurality of settings which control functions of the brake controller output for use in controlling brakes of a trailer or towed vehicle;
  - 45 an input in communication with the micro-processor based control module, which enables control of at least some of the settings of the brake controller; and
  - a display comprising a plurality of light elements in a sequence, with sequential lighting of the light elements indicating a value for the setting being controllable by the input.

10. The brake controller of claim 9, wherein the input is based on motion of a hand operated control element, and wherein the plurality of light elements are disposed relative to the hand operated control element to be lit in correspondence with motion of the hand operated control element.

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11. The brake controller of claim 10, wherein the hand operated control element is a rotary dial, wherein the plurality of light elements are arranged in an arc around the dial.

12. The brake controller of claim 9, wherein the light elements are multicolor, wherein color being shown by the light elements indicates status information of the brake controller.

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13. The brake controller of claim 12, wherein red shown by the light elements indicates an alarm condition, and wherein green shown by the light elements indicates a calibration condition.

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14. The brake controller of claim 9, wherein the light elements are multicolor, wherein color being shown by the light elements indicates mode of the input, and wherein the number of light elements being lit indicates the value of the setting being controllable in that mode of the input.

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15. The brake controller of claim 9, wherein the setting being controllable by the input is brightness of the light elements.

16. The brake controller of claim 9, wherein the light elements further indicate status information of the brake controller.

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17. A method of inputting settings into a brake controller, comprising:  
moving a hand operated control element to input a value for a first setting;  
changing input mode of the hand operated control element; and  
moving the hand operated control element to input a value for a second setting.

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18. The method of claim 17, wherein the first setting is display brightness, and wherein, after a period of time elapses since the last setting change, the input mode reverts to brightness control mode.

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19. The method of claim 17, wherein the first setting is display brightness, wherein the second setting is manual brake control output based on time of ramp up, and further comprising:

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again changing input mode of the hand operated control element; and  
moving the hand operated control element to input a value for a third setting, the third setting being brake output based on accelerometer output combined with the third setting;

once again changing input mode of the hand operated control element; and  
moving the hand operated control element to input a value for a fourth setting, the fourth setting being sensitivity.

45

20. The method of claim 17, further comprising:

5           lighting a plurality of light elements of the brake controller in a sequence about  
            the hand operated control element, with sequential lighting of the light  
            elements indicating a value for the setting being controllable by the hand  
            operated control element.



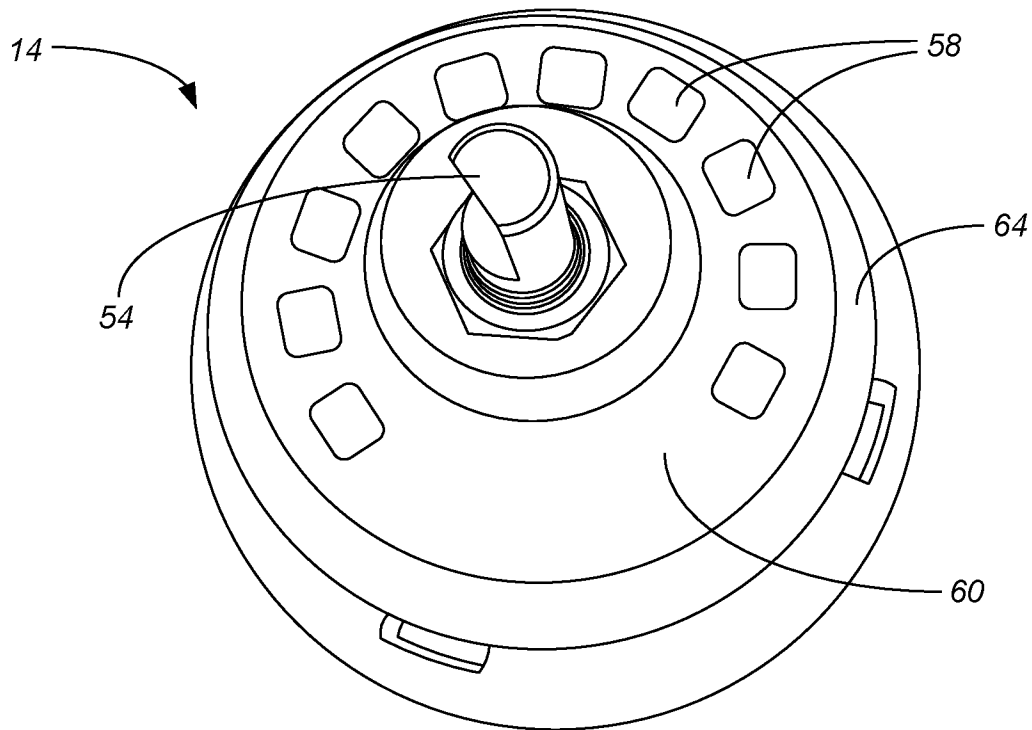


FIG. 3

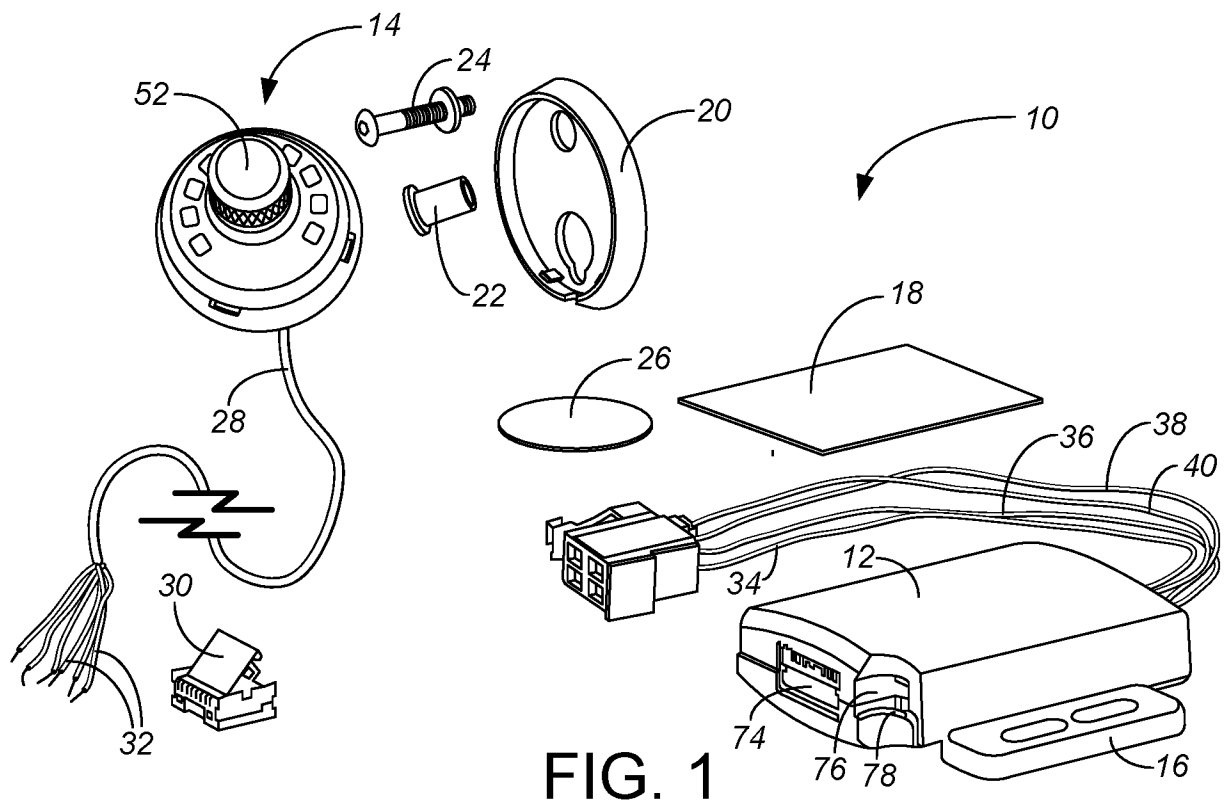


FIG. 1

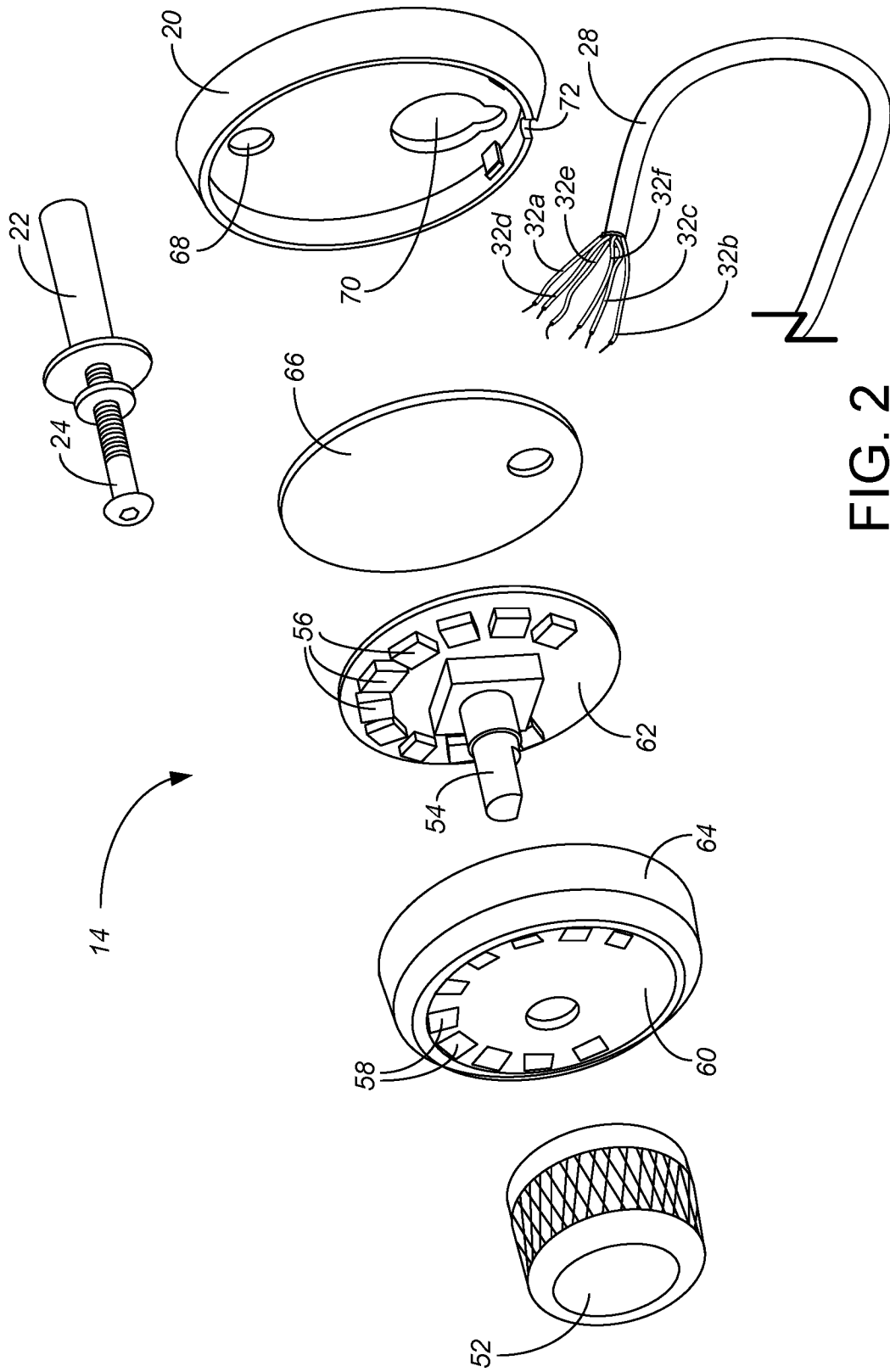


FIG. 2

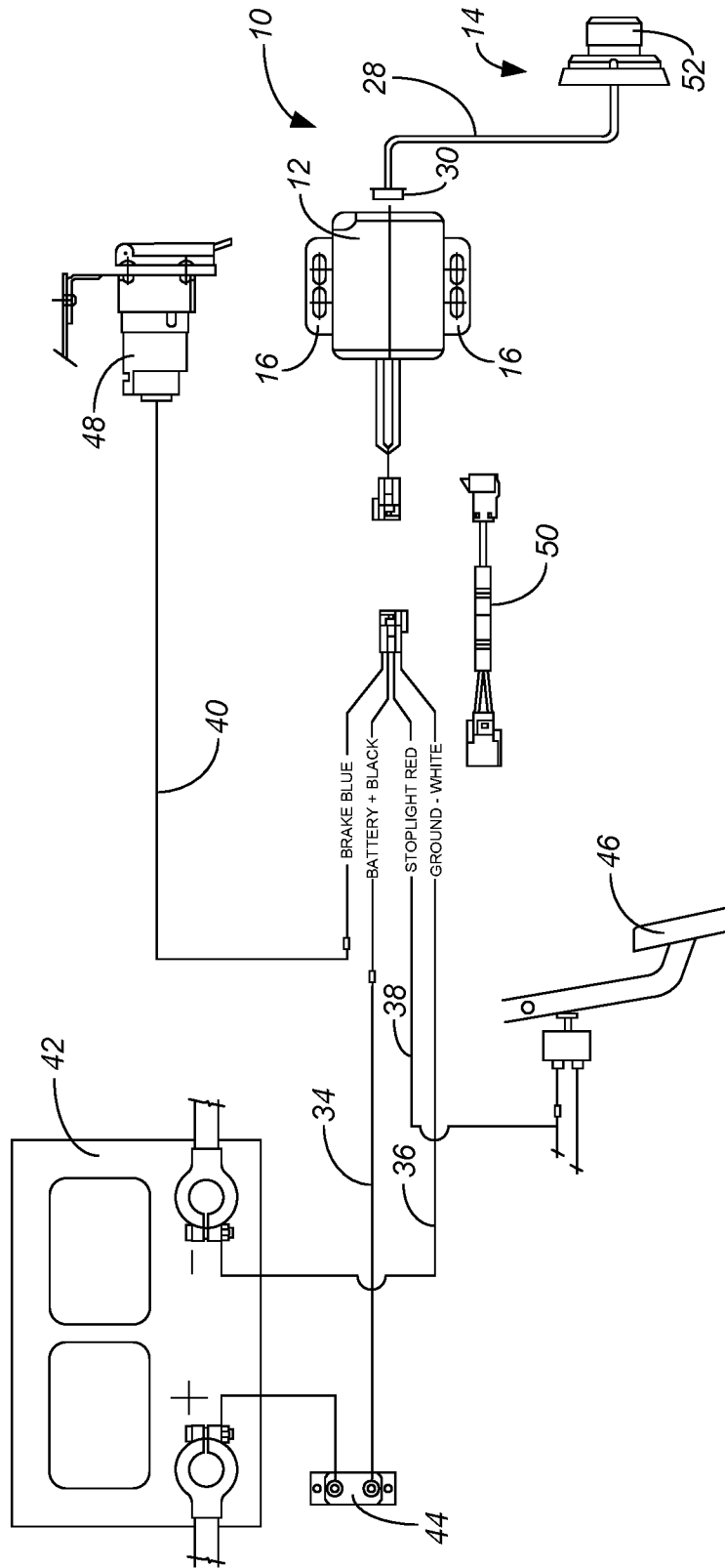


FIG. 4

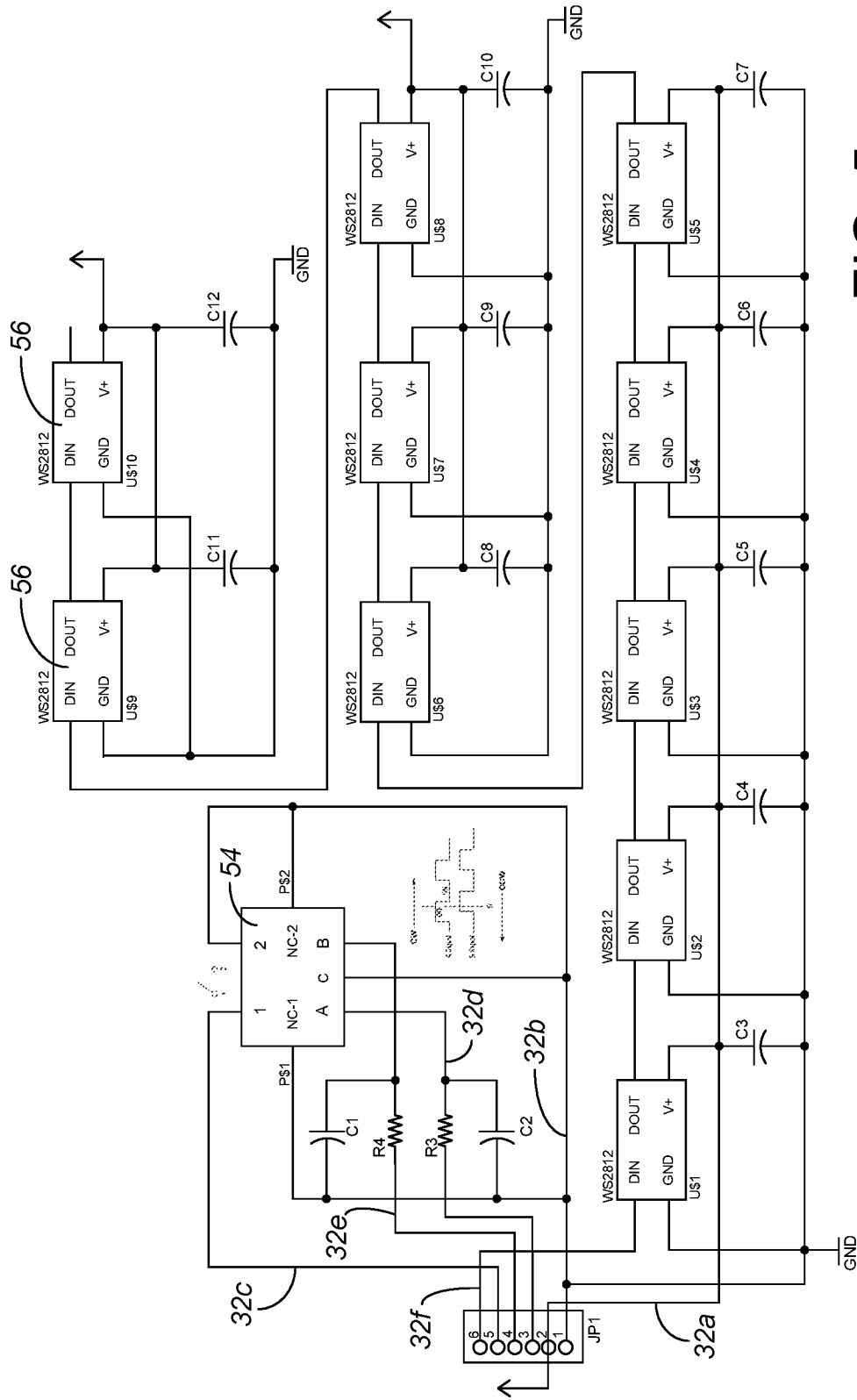
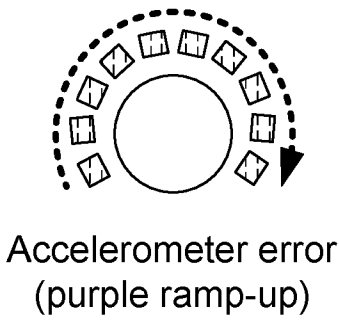
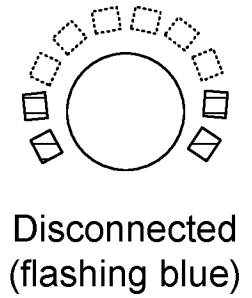
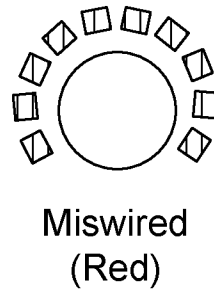
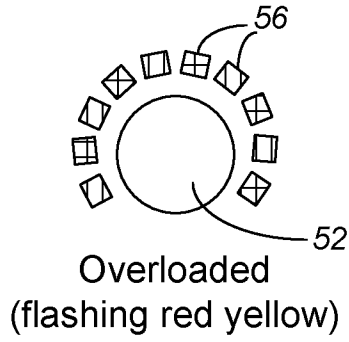
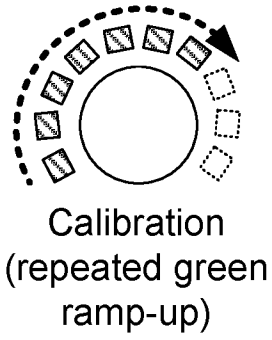
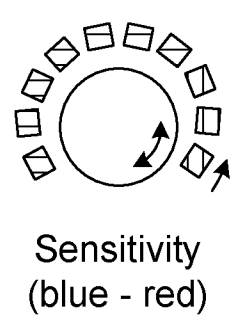
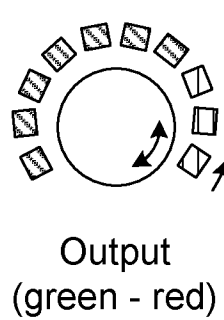
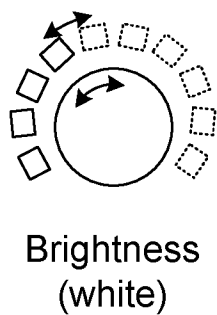
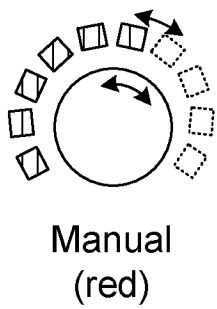


FIG. 5

**INDICATORS**



**MODES**



**FIG. 6**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/45642

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

-see extra sheet-

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-8, 17-20

**Remark on Protest**

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 18/45642

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC(8) - B60T 7/00 (2018.01)  
 CPC - B60T 7/20, B60T 8/1708, B60T 7/085

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 9,150,201 B2 (Smith et al.) 06 October 2015 (06.10.2015) entire document ( especially col. 4, ln 59-64, col. 5, ln 3-5; col. 6, ln 36-41; col. 9, ln 66 to col. 10, ln 5; col. 6, ln 50-56)	1-5, 7, 17 ----- 6, 8, 18-20
Y	US 2008/0224640 A1 (Itoh et al.) 18 September 2008 (18.09.2008) (para [0065])	6
Y	US 2007/0241874 A1 (Okpysh et al.) 18 October 2007 (18.10.2007) (para [0043]-[0045], [0065]-[0069])	8, 19-20
Y	US 2005/0127747 A1 (Robertson) 16 June 2005 (16.06.2005) (para [0067], [0090])	18
A	US 2007/0063581 A1 (Teifke et al.) 22 March 2007 (22.03.2007) (para [0051], [0059])	1-8, 17-20
A	US 2017/0190283 A1 (Thunder Power Hong Kong Ltd.) 06 July 2017 (06.07.2017) entire document	1-8, 17-20

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

05 December 2018 (05.12.2018)

Date of mailing of the international search report

18 DEC 2018

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents  
 P.O. Box 1450, Alexandria, Virginia 22313-1450  
 Facsimile No. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300  
 PCT OSP: 571-272-7774

## Continuation of Box III: Lack of Unity

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-8 and 17-20 are drawn to a brake controller comprising a microcontroller, an input, and a first and second control motions that switch between input modes and controls different settings of the brake controller.

Group II: claims 9-16 are drawn to a brake controller comprising a microcontroller, an input, and a display comprising a plurality of light elements in a sequence, with sequential lighting of the light elements indicating a value for the setting being controllable by the input.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

**Special Technical Features:**

The special technical feature of Group I is a brake controller comprising a micro-processor, an input, and a first and second control motions that switch between input modes and controls different settings of the brake controller, not required by Group II.

The special technical feature of Group II requires a brake controller comprising a micro-processor, an input, and a display comprising a plurality of light elements in a sequence, with sequential lighting of the light elements indicating a value for the setting being controllable by the input, not required by Group I.

**Common Technical Features:**

Groups I through II share the technical feature of a micro-processor based control module having a plurality of settings which control functions of the brake controller output for use in controlling brakes of a trailer or towed vehicle; and an input in communication with the micro-processor based control module, which enables control of at least some of the settings of the brake controller; a value for the setting being controlled in that input. However, these shared technical features do not represent a contribution over US 9,150,201 B2 Smith et al. (hereinafter 'Smith') 06 October 2015 (06.10.2015).

Smith discloses a micro-processor based control module having a plurality of settings which control functions of the brake controller output for use in controlling brakes of a trailer or towed vehicle ("A trailer mounted proportional brake controller (brake controller) 10 is shown in FIGS. 1-9. The brake controller 10 may be an electronic control device that may provide braking power to brakes on a towed vehicle (not shown) that may be proportional to the level of braking effort supplied by the towing vehicle (not shown).", col 3, ln 16-21; "The microprocessor 40 may receive, Store and transmit the gain control settings from the user's adjustment of the wheel 22 to the power control module 50 via a communications link between the respective RF modules 42,72" col 4, ln 33-36);

and an input in communication with the micro-processor based control module, which enables control of at least some of the settings of the brake controller ("The manual control or knob 26 of the hand control unit 10 may be operable to actuate the towed vehicle's brakes when the user moves the knob 26 from a rest position. This may allow the user to manually apply the towed vehicle's brakes without having to depress the towing vehicle's brake pedal. The manual knob 26 may be of any appropriate type, such as a spring-loaded, linear -travel potentiometer, whereby the further the knob 26 is moved from the rest position, the greater the braking force (i.e., brake output Voltage) applied by the towed vehicle's brakes.", col 4, ln 37-47).  
a value for the setting being controlled in that input ("values may be used to set the minimum and maximum limits," col. 5, ln 10-12).

As the technical features were known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups.

Groups I though II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.