

Alexis Adian Smith (State Bar No. 274429)
asmith@JonesDay.com
JONES DAY
555 S. Flower Street, 50th Floor
Los Angeles, CA 90071-2452
Telephone: (213) 489.3939
Facsimile: (213) 243.2539

Meredith M. Wilkes (*pro hac vice*)
mwilkes@JonesDay.com
David B. Cochran (*pro hac vice*)
dcochran@JonesDay.com
John C. Evans (*pro hac vice*)
jcevans@JonesDay.com
JONES DAY
North Point
901 Lakeside Avenue
Cleveland, OH 44114.1190
Telephone: (216) 586.7231
Facsimile: (216) 579.0212

Attorneys for Plaintiff
THE NOCO COMPANY

UNITED STATES DISTRICT COURT
CENTRAL DISTRICT OF CALIFORNIA

THE NOCO COMPANY,
Plaintiff,

v.

WINPLUS NORTH AMERICA, INC.,
WINPLUS NA, LLC, AND ADC
SOLUTIONS AUTO LLC
Defendants.

Case No. 8:23-cv-00269-CJC-DFM
FIRST AMENDED COMPLAINT
FOR PATENT INFRINGEMENT
DEMAND FOR JURY TRIAL

1 Plaintiff The NOCO Company (“NOCO” or “Plaintiff”) for its First Amended Complaint
2 against Defendants Winplus North America, Inc., Winplus NA, LLC, and ADC Solutions Auto
3 LLC (collectively, “Winplus” or “Defendants”) alleges as follows:

4 **INTRODUCTION**

5 1. NOCO, a designer of consumer electronics headquartered in the greater Cleveland,
6 Ohio area, has set a new standard in the performance, design and safety of portable jump starters.
7 An unfortunate by product of NOCO’s tremendous success has been widespread copycats
8 entering the market from outside of the U.S. seeking to trade off of NOCO’s substantial
9 investment in its research, design and marketing. These knockoff and copycat products are
10 pouring into the United States from overseas infringing NOCO’s valuable intellectual property
11 rights.

12 2. This is an action to cease the unlawful and infringing activities of Defendants in
13 the manufacture and sale of their jump starter products. As set forth more fully below, NOCO
14 seeks damages, costs and attorneys’ fees and permanent injunctive relief as authorized by the
15 Patent Act.

16 **THE PARTIES**

17 3. NOCO is a corporation organized under the laws of the State of Ohio, with its
18 principal place of business in Glenwillow, Ohio.

19 4. Upon information and belief, Defendant Winplus North America, Inc. is a
20 California company having a principal place of business at 2975 Red Hill Avenue, Suite 100
21 Costa Mesa, CA, 92626-1201, as registered with the California Secretary of State.

22 5. Upon information and belief, Defendant Winplus NA, LLC is a Delaware
23 company registered to do business in California, having a principal place of business at 2975 Red
24 Hill Avenue, Suite 100 Costa Mesa, CA, 92626-1201, as registered with the California Secretary
25 of State.

26 6. Upon information and belief, Defendant ADC Solutions Auto LLC is a
27 corporation incorporated under the laws of California with its principal place of business located
28

1 at 2975 Red Hill Ave. #100, Costa Mesa, CA 92626.

2 **JURISDICTION AND VENUE**

3 7. This action involves statutory questions and claims arising under the laws of the
4 United States. This Court has jurisdiction over the subject matter of this action pursuant to
5 35 U.S.C. § 271, *et. seq.*, and 28 U.S.C. §§ 1331 and 1338.

6 8. Personal jurisdiction exists over Defendants. Defendants share and maintain a
7 principal place of business in the State of California within this District. Defendants also have
8 minimum contacts with this the State of California and this District as a result of substantial
9 business regularly conducted or solicited within the State of California and this District.
10 Moreover, Defendants have placed its products within the stream of commerce, which stream is
11 directed to residents of the State of California and this District. Defendants are causing harm to
12 NOCO as a result of tortious activity occurring in the State of California and in this District.

13 9. Venue is proper in this Court under 28 U.S.C. §§ 1391 and 1400, as Defendants
14 reside in this District and wrongful acts giving rise to NOCO's claims have occurred in this
15 District.

16 **BACKGROUND**

17 10. Founded in the greater Cleveland, Ohio area in 1914, and continuously owned and
18 managed by the same family since then, NOCO is a power supply and consumer electronics
19 company. Among other things, NOCO is in the business of designing and marketing innovative,
20 premium battery products including jump starters, battery chargers, cables and accessories.

21 11. NOCO's patents asserted in this matter generally relate to technologies
22 implemented in portable battery jump starters. They concern technologies related to specific
23 circuitry for improving the performance and safety of these devices.

24 12. Since the early days of automobiles in the 1900s, car batteries have provided
25 power to start engines. Batteries, however, lose charge over time, and eventually lack sufficient
26 power to start the car. When a car battery dies, the engine can be started using an external current
27 source, a process known as "jump starting." The conventional way to jump start a dead car
28 battery has been through the use of "jumper cables," where two cables run from the positive and

1 negative terminals of a live battery (usually in a running car) to the corresponding terminals of the
2 dead battery.

3 13. Using jumper cables to provide the current needed to start a car with a dead battery
4 has long been problematic, even dangerous. This method can entail, among other things, a
5 second car with a live battery or a heavy and bulky lead-acid battery system to provide the current
6 boost. The method also presents a risk that the cables are improperly connected to either battery,
7 which may cause sparks and short circuits that damage the car and potentially injure those
8 performing the process.

9 14. NOCO solved the safety problems presented by jump starting a car with jumper
10 cables in 2014 and introduced what is now known as the NOCO BOOST® line of jump starter
11 products.

12 15. NOCO's NOCO BOOST® products are tremendously popular and are the market-
13 leading compact lithium-ion battery-based jump starters in the United States. The NOCO
14 BOOST® products have become known for safety, ease of use, and reliability.

15 16. NOCO is an innovator and has made substantial investments in research and
16 development resulting in NOCO having been awarded numerous utility and design patents,
17 including the asserted patents identified below, that cover the key safety and performance features
18 of NOCO's NOCO BOOST® products.

19 17. Some of NOCO's game-changing patented inventions deliver enhanced battery
20 life, safety, and performance thanks to dedicated circuits that equalize the charging process.
21 Lithium-ion battery-based jump starters generally include a bank of individual battery cells that
22 store enough charge to jump start a depleted 12-volt car battery. Batteries lose charge over time
23 and with each use, and so they need to be re-charged. NOCO's patented solutions improve the re-
24 charging process by equalizing the charges and charging rates of the individual battery cells,
25 resulting in a more efficient and effective charging process that increases battery life as well as
26 jump starting performance. The two asserted patents relating to NOCO's equalization circuits are
27 United States Patent Nos. 10,981,452 ("the '452 Patent") and 11,254,213 ("the '213 Patent").

28 18. The '452 Patent is entitled "Portable or Hand Held Vehicle Battery Jump Starting

1 Apparatus with Battery Cell Equalization Circuit.” The ’452 Patent was duly and legally issued
2 on April 20, 2021 by the United States Patent and Trademark Office (USPTO), a true and correct
3 copy of which is attached hereto as Exhibit A and by reference is herein incorporated. NOCO is
4 the assignee and owner of all right, title and interest, including the right to recover for past
5 infringement, in the ’452 Patent.

6 19. The ’213 Patent is entitled “Portable or Hand Held Vehicle Battery Jump Starting
7 Apparatus with Battery Cell Equalization Circuit.” The ’213 Patent was duly and legally issued
8 on February 22, 2022 by the USPTO, a true and correct copy of which is attached hereto as
9 Exhibit B and by reference is herein incorporated. NOCO is also the assignee and owner of all
10 right, title and interest, including the right to recover for past infringement, in the ’213 Patent.

11 20. NOCO’s patented technology also relates to flexible and convenient ways to re-
12 charge jump starters using a USB input charging interface. Previously, re-charging a jump starter
13 powerful enough to jump start a 12-volt car battery frequently required a high-power charger
14 through a non-standard or proprietary plug. NOCO engineers devised a new way to re-charge
15 using low-voltage inputs through standardized, convenient, and (now) widely-used USB plugs.
16 The asserted patents relating to NOCO’s USB charging inventions is United States Patent Nos.
17 11,447,023 (“the ’023 Patent”) and 11,584,243 (“the ’243 Patent”).

18 21. The ’023 Patent is entitled “Portable Vehicle Battery Jump Start Apparatus with
19 Safety Protection and Jumper Cable Device Thereof.” The ’023 Patent was duly and legally
20 issued on September 20, 2022 by the USPTO, a true and correct copy of which is attached hereto
21 as Exhibit C and by reference is herein incorporated. NOCO is the assignee and owner of all
22 right, title and interest, including the right to recover for past infringement, in the ’023 Patent.

23 22. The ’243 Patent is entitled “Jump Starting Device With USB.” The ’243 Patent
24 was duly and legally issued on February 21, 2023 by the USPTO, a true and correct copy of
25 which is attached hereto as Exhibit D and by reference is herein incorporated. NOCO is the
26 assignee and owner of all right, title and interest, including the right to recover for past
27
28

1 infringement, in the '243 Patent.

2 **DEFENDANTS' INFRINGING ACTIVITIES**

3 23. Unfortunately, the success and popularity of NOCO's BOOST® products has
4 resulted in imitation, copying, and unlawful piggybacking off of NOCO's substantial investment
5 in its intellectual property rights, including the asserted patents.

6 24. Upon information and belief, Defendants develop, import, distribute, offer to sell,
7 sell, and/or use jump starter products within the state of California, within this District, and
8 elsewhere around the country.

9 25. More particularly, Winplus offers for sale and sells at least the following jump
10 starter products (collectively, "Winplus jump starters"):

- 11 • TYPE S 12V 6.0L Battery Jump Starter with Qi Wireless Charging, JumpGuide™
12 and 8,000 mAh Power Bank – Black (<https://typesauto.com/products/type-s-wireless-jump-starter-8000mah-with-lcd-ac530013>)
- 13 • TYPE S 12V 6.0L Battery Jump Starter with JumpGuide™ and 10,000 mAh
14 Power Bank – Black (<https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>)
- 15 • TYPE S 12V 6.0L Battery Jump Starter with Built-in USB-C Cable & LCD
16 Display and 8,000mAh Qi Power Bank – Black
(<https://typesauto.com/products/type-s-12v-6-0l-battery-jump-starter-with-built-in-usb-c-cable-lcd-display-and-8-000mah-qi-power-bank-ac532671>)
- 17 • TYPE S 12V 6.0L Battery Jump Starter with Built-in MFi Certified Lightning
18 Cable & LCD Display and 8,000mAh Qi Power Bank - Black
(<https://typesauto.com/products/type-s-12v-6-0l-battery-jump-starter-with-built-in-lightning-cable-lcd-display-and-8-000mah-power-bank-ac532777>)
- 19 • TYPE S 12V 9.0L ProJump™ Battery Jump Starter with JumpGuide™ and 18,000
20 mAh Power Bank (<https://typesauto.com/products/type-s-12v-9-0l-projump-18000-jump-starter-ac530017>)
- 21 • TYPE S 12V 9.0L ProJump™ Battery Jump Starter with JumpGuide™ and 26,000
22 mAh Power Bank (<https://typesauto.com/products/type-s-12v-9-0l-projump%E2%84%A2-battery-jump-starter-with-jumpguide%E2%84%A2-and-26000-mah-power-bank-ac530020>)
- 23 • TYPE S 12V 7.0L Battery Jump Starter with USB C Charging and 10,000 mAh
24 Power Bank – Blue (<https://typesauto.com/products/type-s-10000mah-jump-starter-and-portable-power-bank-ac56789>)
- 25 • TYPE S 12V 6.0L Battery Jump Starter Power Bank with Dual USB Charging and
26 8,000 mAh Power Bank – Titanium (<https://typesauto.com/products/type-s->
- 27
- 28

[8000mah-car-jump-start-and-portable-power-bank-ac56388\)](https://typesauto.com/products/type-s-12v-6-0l-jump-starter-power-bank-with-jump-guide-gen-2-ac532632)

- TYPE S 12V 6.0L Battery Jump Starter with JumpGuide™ and 8,000 mAh Power Bank (<https://typesauto.com/products/type-s-12v-6-0l-jump-starter-power-bank-with-jump-guide-gen-2-ac532632>)
- TYPE S 12V 8.0L ProJump™ Battery Jump Starter with JumpGuide™ and 15,000 mAh Power Bank (<https://typesauto.com/products/type-s-12v-8-0l-projump%E2%84%A2-battery-jump-starter-with-jumpguide%E2%84%A2-and-15-000-mah-power-bank-ac532780>)
- TYPE S Jump Starter & Power Bank (<https://typesauto.com/products/type-s-jump-starter-power-bank-ac532806>)

26. Upon information and belief, as set forth more fully below, the Winplus jump starters infringe one or more claims of the '452, '213, and '023 Patents.

The '452 Patent

27. Upon information and belief, as set forth more fully below, the Winplus jump starters infringe one or more claims of the '452 Patent.

28. The '452 Patent is generally directed to a portable vehicle battery jump starting device comprising a battery pack with multiple individual battery cells and a battery cell equalization circuit.

29. Exemplary Independent claim 1 of the '452 Patent recites:

A portable or hand held jump starting apparatus, comprising:

a battery comprising a plurality of individual battery cells connected together in series;

a battery cell equalization circuit connected to the battery, the battery cell equalization circuit comprising:

an individual battery cell equalization circuit provided for each of the plurality of individual battery cells; and

a load resistor provided for each of the individual battery cell equalization circuits,

wherein the individual battery cell equalization circuits are configured to discharge a respective individual battery cell using a respective load resistor upon the respective individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the respective cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the battery charging process is terminated, and

wherein the individual battery cell equalization circuits are

configured to charge lower voltage individual battery cells at a higher rate allowing lower voltage individual battery cells to catch up in voltage to an individual battery cell having a highest voltage.

30. On information and belief, Defendants offer to sell and sell Winplus jump starters within this District and throughout the United States that infringe one or more claims of the '452 Patent.

31. For example, the Winplus jump starters are portable or hand held jump starting apparatuses, as shown in the following representative image from Defendants' website:



(Excerpted from <https://typesauto.com/collections/portable-jump-starters>).

32. Upon information and belief, each of the Winplus jump starters contain a battery comprising a plurality of individual battery cells connected together in series. For example, the Type S 12V 6.0L Battery Jump Starter with JumpGuide™ and 10,000 mAh Power Bank has a "Battery Capacity" of "10,000mAh @ 3.7V." (See <https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>).

33. Upon information and belief, the Winplus jump starters contain a battery cell equalization circuit connected to the battery that comprises an individual battery cell equalization circuit for each of the individual battery cells, and a load resistor for each of the individual battery cell equalization circuits.

34. Upon information and belief, in each of the Winplus jump starters, the individual battery cell equalization circuits discharge a respective individual battery cell using a load resistor upon the individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the respective cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the battery charging process is terminated.

35. Upon information and belief, in each of the Winplus jump starters, the individual

1 battery cell equalization circuits are configured to charge lower voltage individual battery cells at
 2 a higher rate allowing lower voltage individual battery cells to catch up in voltage to an individual
 3 battery cell having a highest voltage. For example, the Winplus website explains the Winplus
 4 jump starters have “Safe & Smart Jump-Starting Technology” including “Polarity Protection,”
 5 “Over-discharge Protection,” “Low Voltage Protection,” “Reverse Charging Protection,” “Short-
 6 circuit Protection,” “Overheat Protection,” “Timeout Protection,” “Temperature Control
 7 Protection,” and “Spark-proof Clamps.” See [https://typesauto.com/products/type-s-jump-starter-
 8 10-000mah-with-lcd-and-emergency-light-ac532781](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781).

9 ***The '213 Patent***

10 36. Upon information and belief, as set forth more fully below, the Winplus jump
 11 starters infringe one or more claims of the '213 Patent.

12 37. The '213 Patent is generally directed to a portable vehicle battery jump starting
 13 device comprising a battery pack with multiple individual battery cells and a battery cell
 14 equalization circuit.

15 38. Exemplary Independent claim 1 of the '213 Patent recites:
 16 A portable or hand held jump starting apparatus, comprising:

17 a battery comprising a plurality of individual battery cells
 18 connected in series;

19 a battery cell equalization circuit connected to the battery,
 20 the battery cell equalization circuit comprising:

21 a plurality of individual battery cell equalization
 22 circuits each provided for each respective battery cell; and

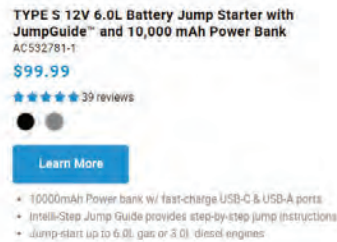
23 a plurality of load resistors each provided for each
 24 respective battery cell,

25 wherein the individual battery cell equalization circuits are
 26 configured to discharge an individual battery cell by its particular
 27 load resistor upon the individual battery cell reaching a cell voltage
 28 exceeding a pre-determined upper voltage threshold until the
 individual battery cell reaches a pre-determined lower voltage level
 below the upper voltage threshold or until the individual battery cell
 charging process is terminated.

39. On information and belief, Defendants offer to sell and sell Winplus jump starters
 within this District and throughout the United States that infringe one or more claims of the '213

1 Patent.

2 40. For example, the Winplus jump starters are portable or hand held jump starting
3 apparatuses, as shown in the following representative image from Defendants' website:



8 (Excerpted from <https://typesauto.com/collections/portable-jump-starters>).

9 41. Upon information and belief, each of the Winplus jump starters contain a battery
10 comprising a plurality of individual battery cells connected together in series. For example, the
11 Type S 12V 6.0L Battery Jump Starter with JumpGuide™ and 10,000 mAh Power Bank has a
12 “Battery Capacity” of “10,000mAh @ 3.7V.” (See [https://typesauto.com/products/type-s-jump-](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781)
13 [starter-10-000mah-with-lcd-and-emergency-light-ac532781](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781)).

14 42. Upon information and belief, the Winplus jump starters contain a battery cell
15 equalization circuit connected to the battery that comprises a plurality of individual battery cell
16 equalization circuits for each respective battery cell, and a plurality of load resistors for each
17 respective battery cell.

18 43. Upon information and belief, in each of the Winplus jump starters, the individual
19 battery cell equalization circuits discharge an individual battery cell by its particular load resistor
20 upon the individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage
21 threshold until the individual battery cell reaches a pre-determined lower voltage level below the
22 upper voltage threshold or until the individual battery cell charging process is terminated. For
23 example, the website explains the Winplus jump starters have “Safe & Smart Jump-Starting
24 Technology” including “Polarity Protection,” “Over-discharge Protection,” “Low Voltage
25 Protection,” “Reverse Charging Protection,” “Short-circuit Protection,” “Overheat Protection,”
26 “Timeout Protection,” “Temperature Control Protection,” and “Spark-proof Clamps.” See
27 <https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light->
28

[ac532781](#).

The '023 Patent

44. On information and belief, as set forth more fully below, the Winplus jump starters infringe one or more claims of the '023 Patent.

45. The '023 Patent is generally directed to a hand held jump starter comprising a USB input port and circuit for charging or recharging an internal power supply.

46. Exemplary Independent claim 1 of the '023 Patent recites:

A jump starting apparatus configured for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starting apparatus comprising:

a power supply;

a positive polarity battery terminal connector configured for connecting the jump starting apparatus to the positive polarity battery terminal of the depleted or discharged battery;

a negative polarity battery terminal connector configured for connecting the jump starting apparatus to the negative polarity battery terminal of the depleted or discharged battery;

a power switch or circuit configured to turn on power from the power supply to the positive and negative polarity battery terminal connectors;

a control system or circuit connected to and controlling the power switch, the control system or circuit configured to detect whether the positive and negative polarity battery terminal connectors have a correct polarity connection with the positive and negative polarity battery terminals of the depleted or discharged battery prior to turning on the power switch or circuit;

a USB input circuit connected to the power supply, the USB input circuit comprising a DC/DC converter, the USB input circuit configured for converting power from a USB power source to increase power voltage to the power supply; and

a USB input connector connected to the USB input circuit, the USB input connector configured for connecting to the USB power source and providing power input from the USB power source through the USB input connector and the USB input circuit to the power supply.

47. On information and belief, Defendants offer to sell and sell Winplus jump starters within this District and throughout the United States that infringe one or more claims of the '023

1 Patent.

2 48. For example, the Winplus jump starters are jump starting devices for boosting or
3 charging a depleted or discharged battery having a positive polarity battery terminal (**red**) and a
4 negative polarity battery terminal (**black**), as in the following representative image:



13 [https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781)
14 [ac532781](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781).

15 49. Each of the Winplus jump starters comprises a power supply. For example, the
16 Type S 12V 6.0L Battery Jump Starter with JumpGuide™ and 10,000 mAh Power Bank has a
17 “Battery Capacity” of “10,000mAh @ 3.7V.” (See [https://typesauto.com/products/type-s-jump-](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781)
18 [starter-10-000mah-with-lcd-and-emergency-light-ac532781](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781)).

19 50. Each of the Winplus jump starters also comprises a positive polarity battery
20 terminal connector (**red**) and a negative polarity battery terminal connector (**black**) that connects
21 the jump starting apparatus to the positive polarity battery terminal and the negative polarity
22 battery terminal of the depleted or discharged battery, respectively, as shown in the following
23 representative image:
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27
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<https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>.

51. Upon information and belief, each of the Winplus jump starters comprises a power switch or circuit configured to turn on power from the power supply to the positive and negative polarity battery terminal connectors. For example, upon information and belief, the Winplus jump starters comprise a power relay or switch internal to the jump starters that turns on power from the power supply to the positive and negative polarity battery terminal connectors.

52. Upon information and belief, the Winplus jump starters further comprise a control system or circuit that controls the power switch and detects whether the positive and negative polarity battery terminal connectors have a correct polarity connection with the positive and negative polarity battery terminals of the depleted/discharged battery prior to turning on the power switch or circuit. For example, the website explains the Winplus jump starters have “Safe & Smart Jump-Starting Technology” including “Polarity Protection,” “Over-discharge Protection,” “Low Voltage Protection,” “Reverse Charging Protection,” “Short-circuit Protection,” “Overheat Protection,” “Timeout Protection,” “Temperature Control Protection,” and “Spark-proof Clamps.” See <https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>.

53. Upon information and belief, the Winplus jump starters comprise a USB input circuit connected to the power supply. For example, the website refers to a “high-speed USB-C input/output port,” as shown in the following representative image:

USB-C Charging Goes Both Ways

Rapid charge mobile devices AND recharge the TYPE S 12V 6.0L Battery Jump Starter Power Bank With Jump Guide (Gen 2) through the high-speed USB-C input/output port. USB-C charging is up to 20 times faster than standard USB.



<https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>.

54. Upon information and belief, the Winplus jump starters comprise a USB input circuit that includes a DC/DC converter and is configured for converting power from a USB power source to increase power voltage to the power supply. For example, upon information and belief, each of the Winplus jump starters is configured to be charged through a USB input port described and shown above.

55. Upon information and belief, the Winplus jump starters comprise a USB input connector connected to the USB input circuit, where the USB input connector is configured to connect to the USB power source and provide power from the USB power source through the USB input connector and the USB input circuit to the power supply. For example, upon information and belief and as described and depicted above, the power supply in each of the Winplus jump starters is charged/provided power through a USB input connection.

The '243 Patent

56. Upon information and belief, as set forth more fully below, the Winplus jump starters infringe one or more claims of the '243 Patent.

57. The '243 Patent is generally directed to a jump starting device comprising a USB input connector and circuit for charging or recharging an internal power supply.

58. Exemplary Independent claim 1 of the '243 Patent recites:

A jump starting device for boosting or charging a depleted or discharged battery having a positive battery terminal and a negative battery terminal, the jump starting device comprising:

a power supply;

1 a positive battery connector for electrically connecting the
2 jump starting device to the positive battery terminal of the
depleted or discharged battery;

3 a negative battery connector for electrically connecting the
4 jump starting device to the negative battery terminal of the
depleted or discharged battery;

5 a power switch or switch circuit connected in circuit with
6 the power supply and the positive and negative battery connectors,
7 the power switch or switch circuit configured to switch power on
8 from the power supply to boost or charge the depleted or
discharged battery when connected between the positive and
negative battery connectors;

9 a USB input connector; and

10 a USB charge circuit electrically connecting the USB
11 input connector to the power supply, the USB charge circuit
comprising a DC-DC converter configured to upconvert voltage
from the USB input connector to the power supply.

12 59. Upon information and belief, Defendants offer to sell and sell Winplus jump
13 starters within this District and throughout the United States that infringe one or more claims of
14 the '243 Patent.

15 60. For example, the Winplus jump starters are jump starting devices for boosting or
16 charging a depleted or discharged battery having a positive battery terminal (**red**) and a negative
17 battery terminal (**black**), as in the following representative image:



26 [https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781)
27 [ac532781](https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781).

28 61. Additionally, each of the Winplus jump starters comprises a power supply. For

example, the Type S 12V 6.0L Battery Jump Starter with JumpGuide™ and 10,000 mAh Power Bank has a “Battery Capacity” of “10,000mAh @ 3.7V.” (See <https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>).

62. Each of the Winplus jump starters also comprises a positive battery connector (**red**) and a negative battery connector (**black**) that electrically connects the jump starting device to the positive battery terminal and the negative battery terminal of the depleted or discharged battery, respectively, as shown in the following representative image:



<https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>.

63. Upon information and belief, each of the Winplus jump starters comprises a power switch or switch circuit connected in circuit with the power supply and battery connectors configured to switch power on from the power supply to boost or charge the depleted or discharged battery when connected between the positive and negative battery connectors. For example, upon information and belief, the Winplus jump starters comprise a power relay or switch internal to the jump starters that turns on power from the power supply to the positive and negative battery connectors.

64. Upon information and belief, the Winplus jump starters also comprise a USB input connector. For example, the website refers to a “high-speed USB-C input/output port,” as shown in the following representative image:

USB-C Charging Goes Both Ways

Rapid charge mobile devices AND recharge the TYPE S 12V 6.0L Battery Jump Starter Power Bank With Jump Guide (Gen 2) through the high-speed USB-C input/output port. USB-C charging is up to 20 times faster than standard USB.



<https://typesauto.com/products/type-s-jump-starter-10-000mah-with-lcd-and-emergency-light-ac532781>.

65. Upon information and belief, the Winplus jump starters also comprise a USB charge circuit that electrically connects the USB input connector to the power supply. For example, upon information and belief, each of the Winplus jump starters is configured to be charged through a USB input port described and shown above.

66. Upon information and belief, each of the Winplus jump starters' USB charge circuit comprises a DC-DC converter configured to upconvert voltage from the USB input connector to the power supply. For example, upon information and belief and as described and depicted above, the power supply in each of the Winplus jump starters is charged/provided power through a USB input connection.

COUNT ONE – INFRINGEMENT OF U.S. PATENT NO. 10,981,452

67. NOCO realleges, adopts, and incorporates by reference the allegations included within paragraphs 1-66 as if fully set forth herein.

68. Upon information and belief, Defendants have directly infringed the '452 Patent by importing, offering to sell, selling, and/or using the Winplus jump starters in the United States, without authority, in a manner that infringes at least claim 1 of the '452 Patent to the injury of NOCO both literally and under the doctrine of equivalents.

69. Defendants are liable for infringement of the '452 Patent pursuant to 35 U.S.C. § 271.

70. Upon information and belief, Winplus has willfully infringed the '452 Patent. Among other things, Winplus competes with NOCO. NOCO's portfolio of issued patents is

1 public knowledge and, upon information and belief, Winplus has actually known about the '452
2 Patent and their infringement thereof since prior to this lawsuit.

3 71. As a result of Defendants' infringement of the '452 Patent, NOCO has suffered
4 and will continue to suffer monetary damages, including lost profits and/or a reasonable royalty,
5 that are compensable under 35 U.S.C. § 284 in an amount to be determined at trial. NOCO
6 complied with the patent marking statute, 35 U.S.C. § 287(a), by providing an address of a
7 posting on the Internet, accessible to the public without charge for accessing the address, that
8 associates the patented article with the number of the patent (<https://no.co/intellectual-property>,
9 <https://no.co/patents>, and <https://npats.co>).

10 72. Unless an injunction is issued enjoining Defendants and their officers, agents,
11 servants, employees, attorneys, representatives, affiliates, and all others acting on their behalf
12 from infringing the '452 Patent, NOCO will continue to be greatly and irreparably harmed and
13 has no adequate remedy at law.

14 **COUNT TWO – INFRINGEMENT OF U.S. PATENT NO. 11,254,213**

15 73. NOCO realleges, adopts, and incorporates by reference the allegations included
16 within paragraphs 1-72 as if fully set forth herein.

17 74. On information and belief, Winplus has directly infringed the '213 Patent by
18 importing, offering to sell, selling, and/or using the Winplus jump starters in the United States,
19 without authority, in a manner that infringes at least claim 1 of the '213 Patent to the injury of
20 NOCO both literally and under the doctrine of equivalents.

21 75. Defendants are liable for infringement of the '213 Patent pursuant to 35 U.S.C.
22 § 271.

23 76. Upon information and belief, Winplus has willfully infringed the '213 Patent.
24 Among other things, Winplus competes with NOCO. NOCO's portfolio of issued patents is
25 public knowledge and, upon information and belief, Winplus has actually known about the '213
26 Patent and their infringement thereof since prior to this lawsuit.

27 77. As a result of Defendants' infringement of the '213 Patent, NOCO has suffered
28 and will continue to suffer monetary damages, including lost profits and/or a reasonable royalty,

1 that are compensable under 35 U.S.C. § 284 in an amount to be determined at trial. NOCO
 2 complied with the patent marking statute, 35 U.S.C. § 287(a), by providing an address of a
 3 posting on the Internet, accessible to the public without charge for accessing the address, that
 4 associates the patented article with the number of the patent (<https://no.co/intellectual-property>,
 5 <https://no.co/patents>, and <https://npats.co>).

6 78. Unless an injunction is issued enjoining Defendants and their officers, agents,
 7 servants, employees, attorneys, representatives, affiliates, and all others acting on their behalf
 8 from infringing the '213 Patent, NOCO will continue to be greatly and irreparably harmed and
 9 has no adequate remedy at law.

10 **COUNT THREE – INFRINGEMENT OF U.S. PATENT NO. 11,447,023**

11 79. NOCO realleges, adopts, and incorporates by reference the allegations included
 12 within paragraphs 1-78 as if fully set forth herein.

13 80. On information and belief, Winplus has directly infringed the '023 Patent by
 14 importing, offering to sell, selling, and/or using the Winplus jump starters in the United States,
 15 without authority, in a manner that infringes at least claim 1 of the '023 Patent to the injury of
 16 NOCO both literally and under the doctrine of equivalents.

17 81. Defendants are liable for infringement of the '023 Patent pursuant to 35 U.S.C.
 18 § 271.

19 82. Upon information and belief, Winplus has willfully infringed the '023 Patent.
 20 Among other things, Winplus competes with NOCO. NOCO's portfolio of issued patents is
 21 public knowledge and, upon information and belief, Winplus has actually known about the '023
 22 Patent and their infringement thereof since prior to this lawsuit. In fact, NOCO has previously
 23 accused Winplus (and others) of infringing a related patent (U.S. Patent No. 9,007,015) in earlier
 24 litigation. *See, e.g., Certain Portable Battery Jump Starters & Components Thereof*, Inv. No.
 25 337-TA-1256 (U.S. Int'l Trade Comm'n).

26 83. As a result of Defendants' infringement of the '023 Patent, NOCO has suffered
 27 and will continue to suffer monetary damages, including lost profits and/or a reasonable royalty,
 28 that are compensable under 35 U.S.C. § 284 in an amount to be determined at trial. NOCO

1 complied with the patent marking statute, 35 U.S.C. § 287(a), by providing an address of a
 2 posting on the Internet, accessible to the public without charge for accessing the address, that
 3 associates the patented article with the number of the patent (<https://no.co/intellectual-property>,
 4 <https://no.co/patents>, and <https://npats.co>).

5 84. Unless an injunction is issued enjoining Defendants and their officers, agents,
 6 servants, employees, attorneys, representatives, affiliates, and all others acting on its behalf from
 7 infringing the '023 Patent, NOCO will continue to be greatly and irreparably harmed and has no
 8 adequate remedy at law.

9 **COUNT FOUR – INFRINGEMENT OF U.S. PATENT NO. 11,584,243**

10 85. NOCO realleges, adopts, and incorporates by reference the allegations included
 11 within paragraphs 1-84 as if fully set forth herein.

12 86. On information and belief, Winplus has directly infringed the '243 Patent by
 13 importing, offering to sell, selling, and/or using the Winplus jump starters in the United States,
 14 without authority, in a manner that infringes at least claim 1 of the '243 Patent to the injury of
 15 NOCO both literally and under the doctrine of equivalents.

16 87. Defendants are liable for infringement of the '243 Patent pursuant to 35 U.S.C.
 17 § 271.

18 88. Upon information and belief, Winplus has willfully infringed the '243 Patent.
 19 Among other things, Winplus competes with NOCO. NOCO's portfolio of issued patents is
 20 public knowledge and, upon information and belief, Winplus has actually known about the '243
 21 Patent and their infringement thereof the issuance of the '243 Patent on February 21, 2023. In
 22 fact, NOCO has previously accused Winplus (and others) of infringing a related patent (U.S.
 23 Patent No. 9,007,015) in earlier litigation. *See, e.g., Certain Portable Battery Jump Starters &*
 24 *Components Thereof*, Inv. No. 337-TA-1256 (U.S. Int'l Trade Comm'n).

25 89. As a result of Defendants' infringement of the '243 Patent, NOCO has suffered
 26 and will continue to suffer monetary damages, including lost profits and/or a reasonable royalty,
 27 that are compensable under 35 U.S.C. § 284 in an amount to be determined at trial. NOCO
 28 complied with the patent marking statute, 35 U.S.C. § 287(a), by providing an address of a

1 posting on the Internet, accessible to the public without charge for accessing the address, that
2 associates the patented article with the number of the patent (<https://no.co/intellectual-property>,
3 <https://no.co/patents>, and <https://npats.co>).

4 90. Unless an injunction is issued enjoining Defendants and their officers, agents,
5 servants, employees, attorneys, representatives, affiliates, and all others acting on its behalf from
6 infringing the '243 Patent, NOCO will continue to be greatly and irreparably harmed and has no
7 adequate remedy at law.

8 **PRAYER FOR RELIEF**

9 NOCO respectfully requests the following relief:

- 10 (a) Judgment for NOCO and against Defendants on all Counts asserted herein;
- 11 (b) Permanent injunctive relief enjoining Defendants and their officers, agents,
12 servants, employees, attorneys, representatives, affiliates, and all others acting on their behalf or
13 in active concert or participation with them from infringement of the '452, '213, '023, and '243
14 Patents;
- 15 (c) Damages to which NOCO is entitled including without limitation as
16 provided under 35 U.S.C. § 284;
- 17 (d) Actual, statutory, and compensatory damages as proven at trial;
- 18 (e) Enhanced damages in an amount equal to three times NOCO's damages for
19 Defendants' willful infringement of the '452, '213, '023, and '243 Patents pursuant to 35 U.S.C.
20 § 284;
- 21 (f) Pre-judgment and post-judgment interest;
- 22 (g) That the Court find that this is an exceptional case within the meaning of
23 35 U.S.C. § 285;
- 24 (h) NOCO's costs, expenses, and reasonable attorneys' fees and litigation
25 expenses incurred in this action; and
- 26 (i) Such other relief as the Court may deem just and proper.
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Dated: March 13, 2023

Respectfully submitted,

JONES DAY

By: /s/ Alexis A. Smith

Alexis Adian Smith (State Bar No. 274429)
asmith@JonesDay.com
JONES DAY
555 S. Flower Street, 50th Floor
Los Angeles, CA 90071-2452
Telephone: (213) 489.3939
Facsimile: (213) 243.2539

Meredith M. Wilkes (*pro hac vice*)
mwilkes@JonesDay.com
David B. Cochran (*pro hac vice*)
dcochran@JonesDay.com
John C. Evans (*pro hac vice*)
jcevans@JonesDay.com
JONES DAY
North Point
901 Lakeside Avenue
Cleveland, OH 44114.1190
Telephone: (216) 586.7231
Facsimile: (216) 579.0212

Attorneys for Plaintiff
THE NOCO COMPANY

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JURY TRIAL DEMAND

Pursuant to Rule 38(b) of the Federal Rules of Civil Procedure, The NOCO Company demands a trial by jury of all issues triable of right by jury.

Dated: March 13, 2023

Respectfully submitted,

JONES DAY

By: /s/ Alexis A. Smith

Alexis Adian Smith (State Bar No. 274429)
asmith@JonesDay.com
JONES DAY
555 S. Flower Street, 50th Floor
Los Angeles, CA 90071-2452
Telephone: (213) 489.3939
Facsimile: (213) 243.2539

Meredith M. Wilkes (*pro hac vice*)
mwilkes@JonesDay.com
David B. Cochran (*pro hac vice*)
dcochran@JonesDay.com
John C. Evans (*pro hac vice*)
jcevans@JonesDay.com
JONES DAY
North Point
901 Lakeside Avenue
Cleveland, OH 44114.1190
Telephone: (216) 586.7231
Facsimile: (216) 579.0212

Attorneys for Plaintiff
THE NOCO COMPANY

EXHIBIT A



US010981452B2

(12) **United States Patent**
Nook et al.

(10) **Patent No.:** **US 10,981,452 B2**

(45) **Date of Patent:** ***Apr. 20, 2021**

(54) **PORTABLE OR HAND HELD VEHICLE BATTERY JUMP STARTING APPARATUS WITH BATTERY CELL EQUALIZATION CIRCUIT**

(71) Applicant: **THE NOCO COMPANY**, Glenwillow, OH (US)

(72) Inventors: **Jonathan Lewis Nook**, Gates Mills, OH (US); **William Knight Nook, Sr.**, Shaker Heights, OH (US); **James Richard Stanfield**, Peoria, AZ (US); **Derek Michael Underhill**, Tempe, AZ (US)

(73) Assignee: **THE NOCO COMPANY**, Glenwillow, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/587,624**

(22) Filed: **Sep. 30, 2019**

(65) **Prior Publication Data**
US 2020/0028368 A1 Jan. 23, 2020

Related U.S. Application Data
(63) Continuation of application No. 16/461,562, filed as application No. PCT/US2018/050243 on Sep. 10, (Continued)

(51) **Int. Cl.**
B60L 3/00 (2019.01)
H01M 10/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **B60L 3/0046** (2013.01); **B60L 50/60** (2019.02); **F02N 11/12** (2013.01); (Continued)

(58) **Field of Classification Search**
CPC H02J 7/0016; B60L 53/14; B60L 3/0046 (Continued)

(56) **References Cited**

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Primary Examiner — Richard V Muralidar

(74) Attorney, Agent, or Firm — Vorys, Sater, Seymour & Pease LLP; William Klima

(57) **ABSTRACT**

A portable or handheld device or apparatus for jump starting a vehicle engine having a depleted or discharged starting battery. The portable or handheld device or apparatus for jump starting a vehicle engine includes a rechargeable lithium-ion (Li-ion) battery pack and a battery cell equalization circuit configured to prevent overcharging of one or more individual lithium-ion battery cells, which can cause fire, damage to the battery pack and device or apparatus for jump starting a vehicle, or personal injury to a user.

16 Claims, 15 Drawing Sheets

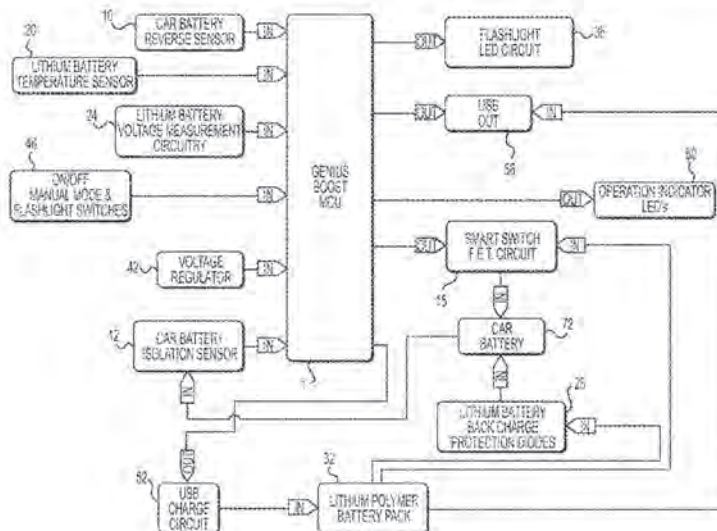


Exhibit A

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(52)	U.S. Cl.			320/105	
	CPC <i>H01M 10/0525</i> (2013.01); <i>H01M 10/425</i>	9,525,298 B1 *	12/2016	Pham H02J 7/007	
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	<i>7/0016</i> (2013.01); <i>H02J 7/0021</i> (2013.01);	2012/0074907 A1	3/2012	Roeper	
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	(2013.01); <i>B60L 53/18</i> (2019.02); <i>H01M</i>	2015/0380952 A1	12/2015	Brandt et al.	
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(58)	Field of Classification Search	2018/0345803 A1 *	12/2018	Nook H02J 7/342	
	USPC 320/105, 116–123	2020/0259340 A1 *	8/2020	Nook B60L 3/0046	
	See application file for complete search history.	* cited by examiner			

* cited by examiner

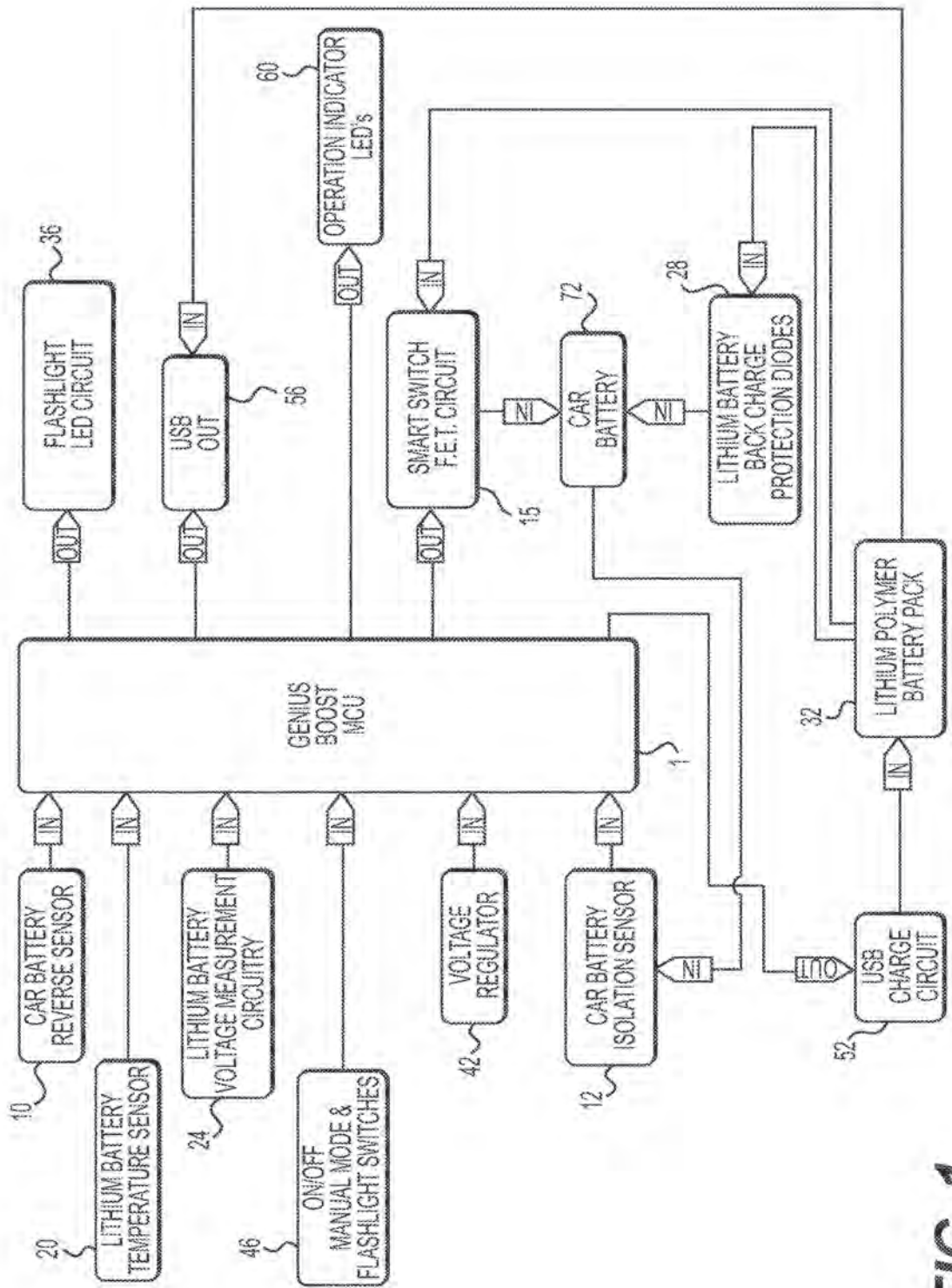


FIG. 1

Exhibit A
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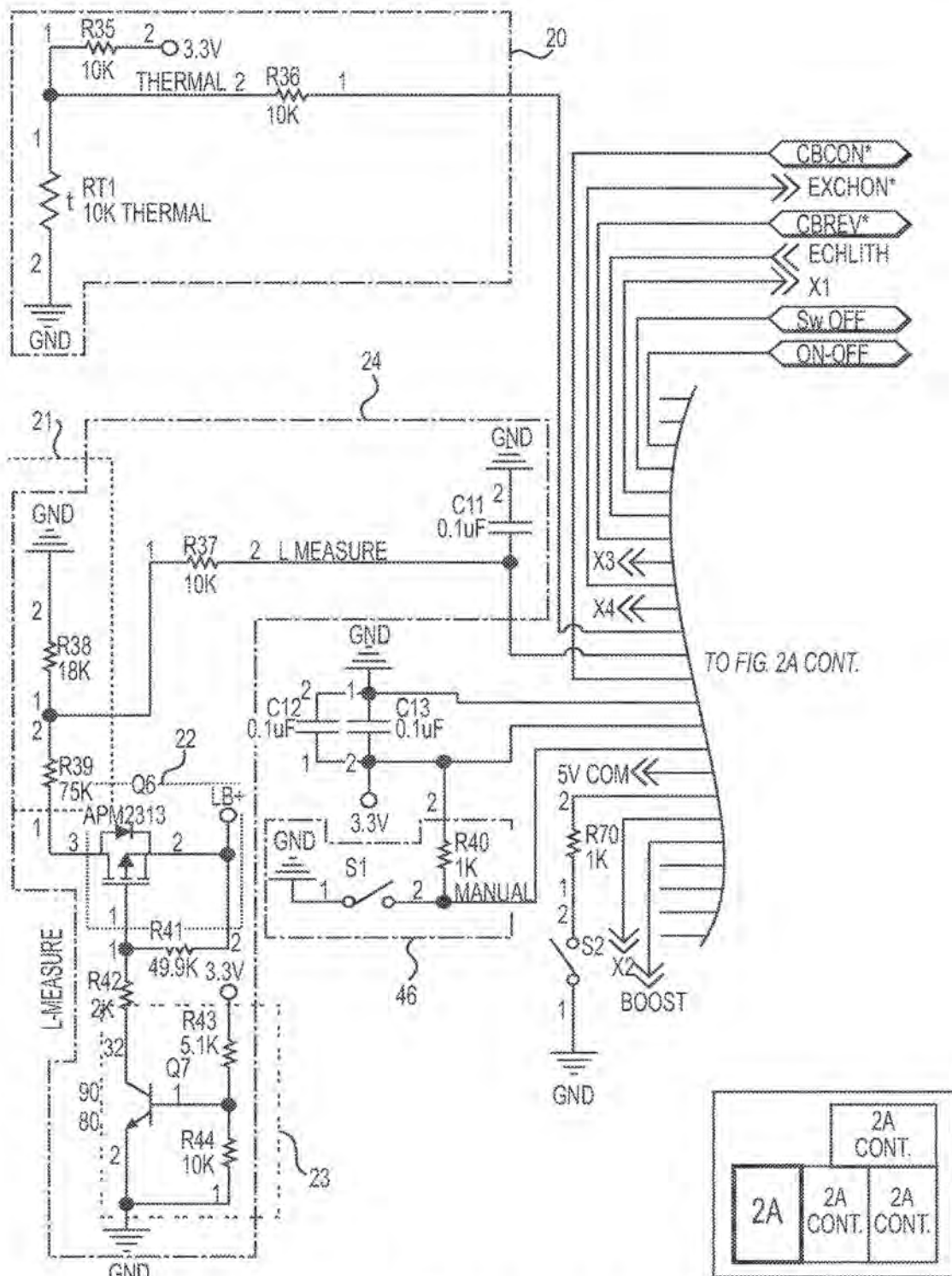


FIG. 2A

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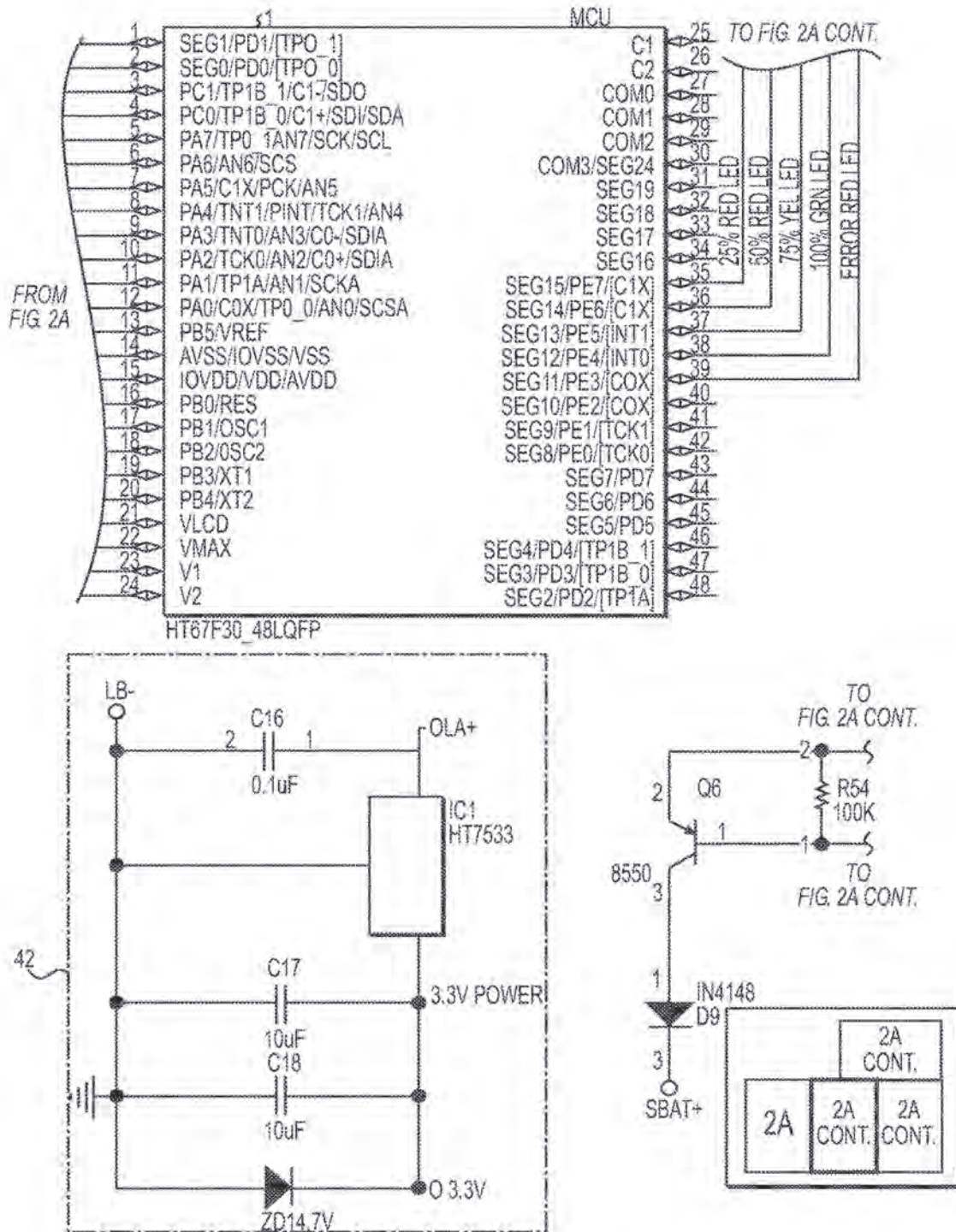
**FIG. 2A CONT.**

Exhibit A

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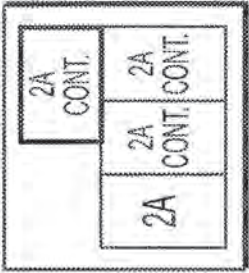
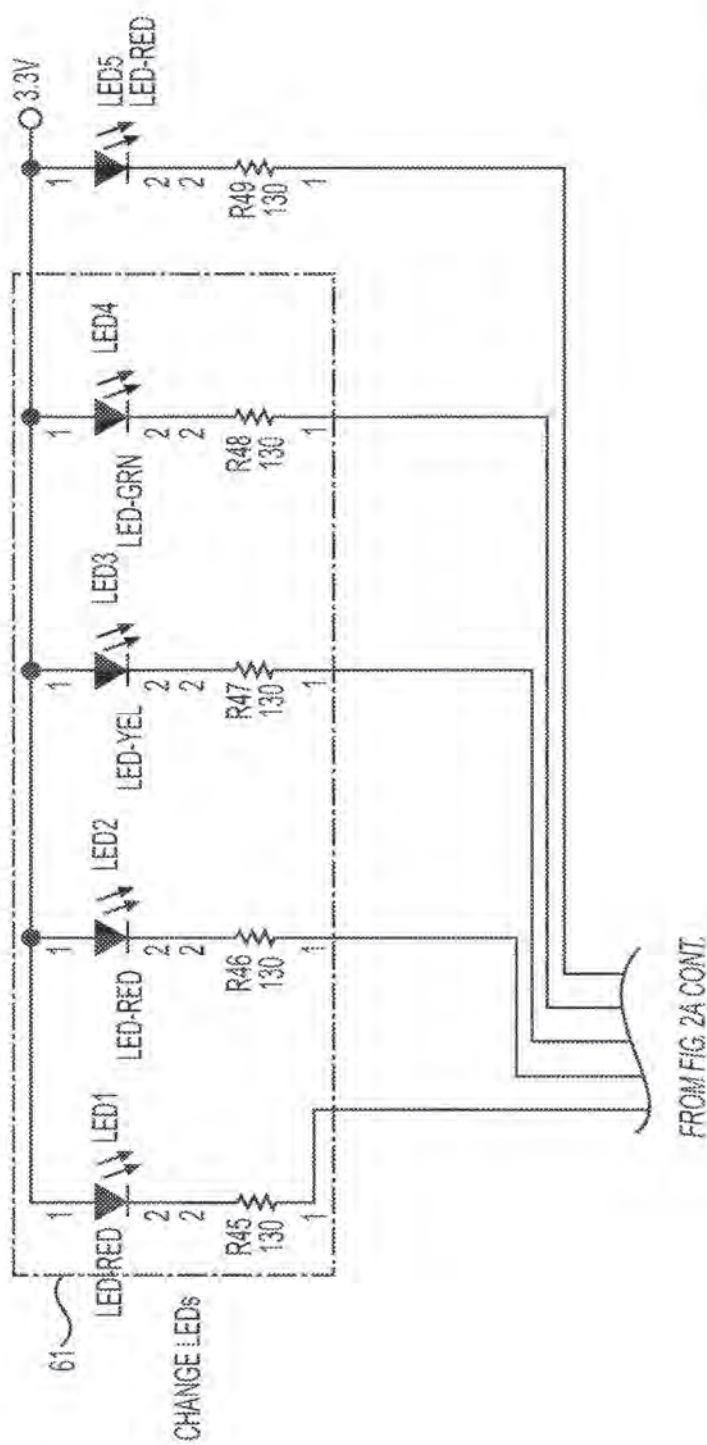


FIG. 2A CONT.

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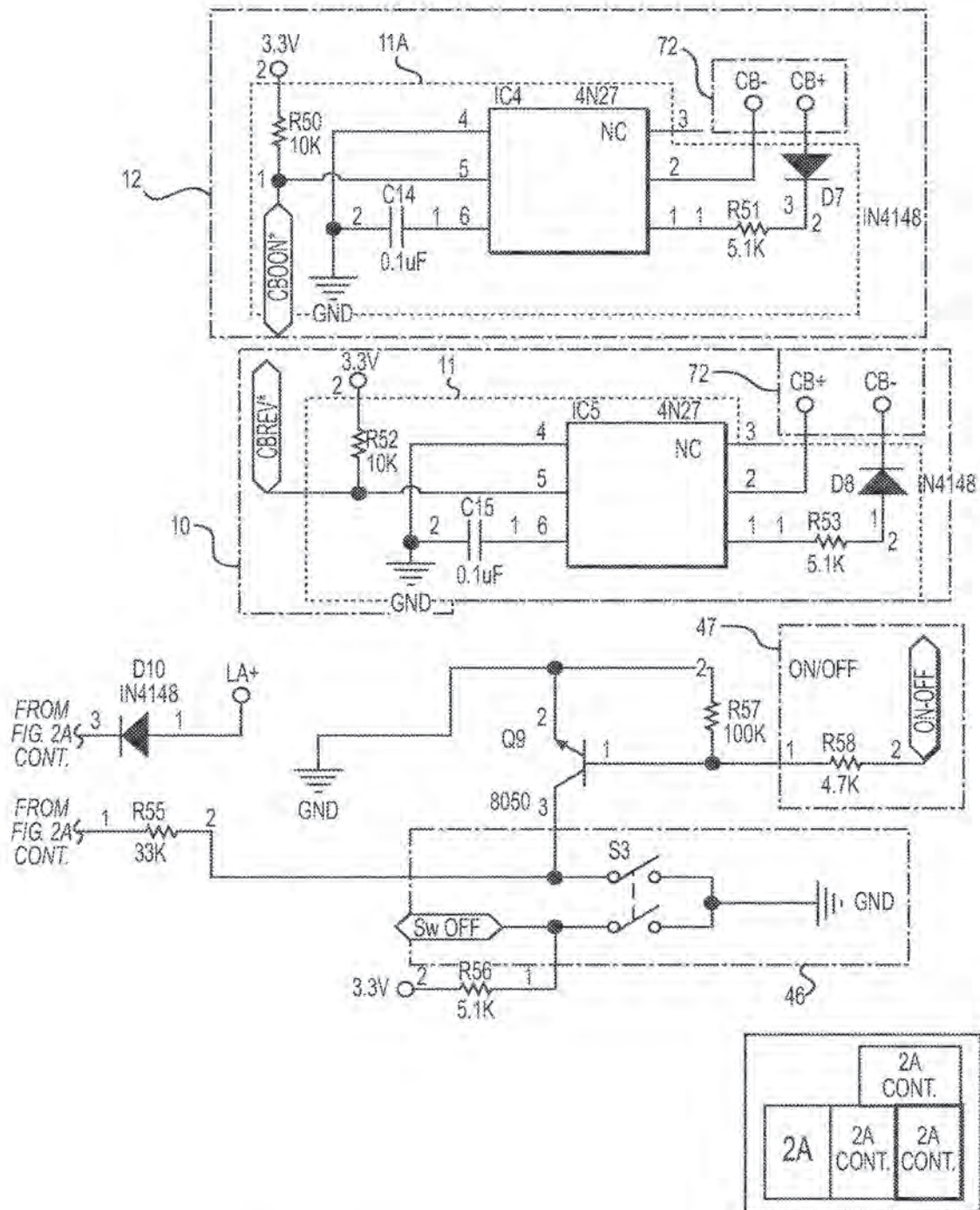
**FIG. 2A CONT.**

Exhibit A

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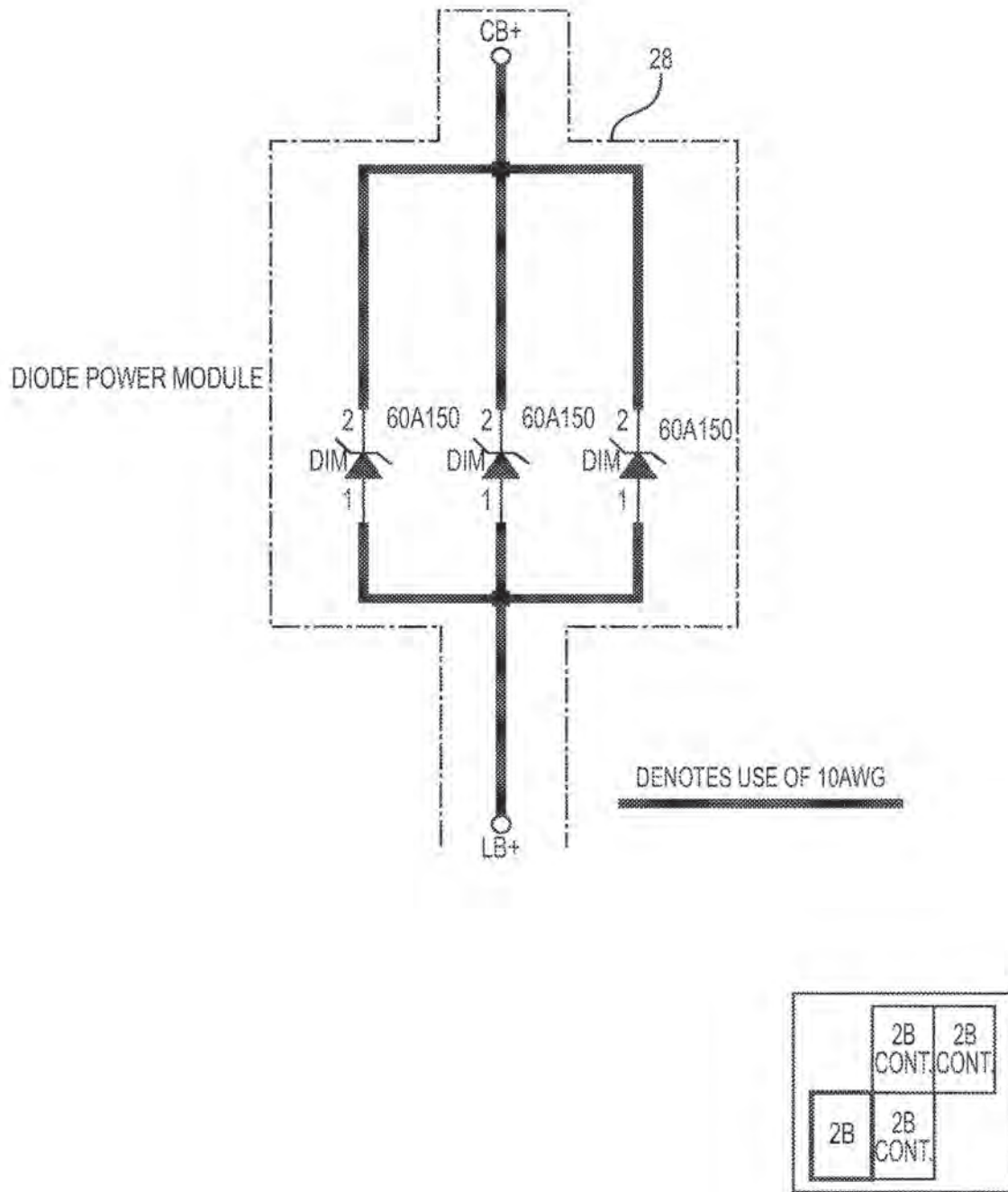


FIG. 2B

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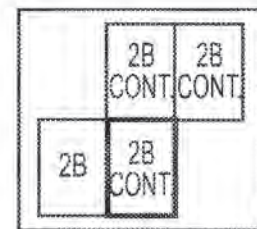
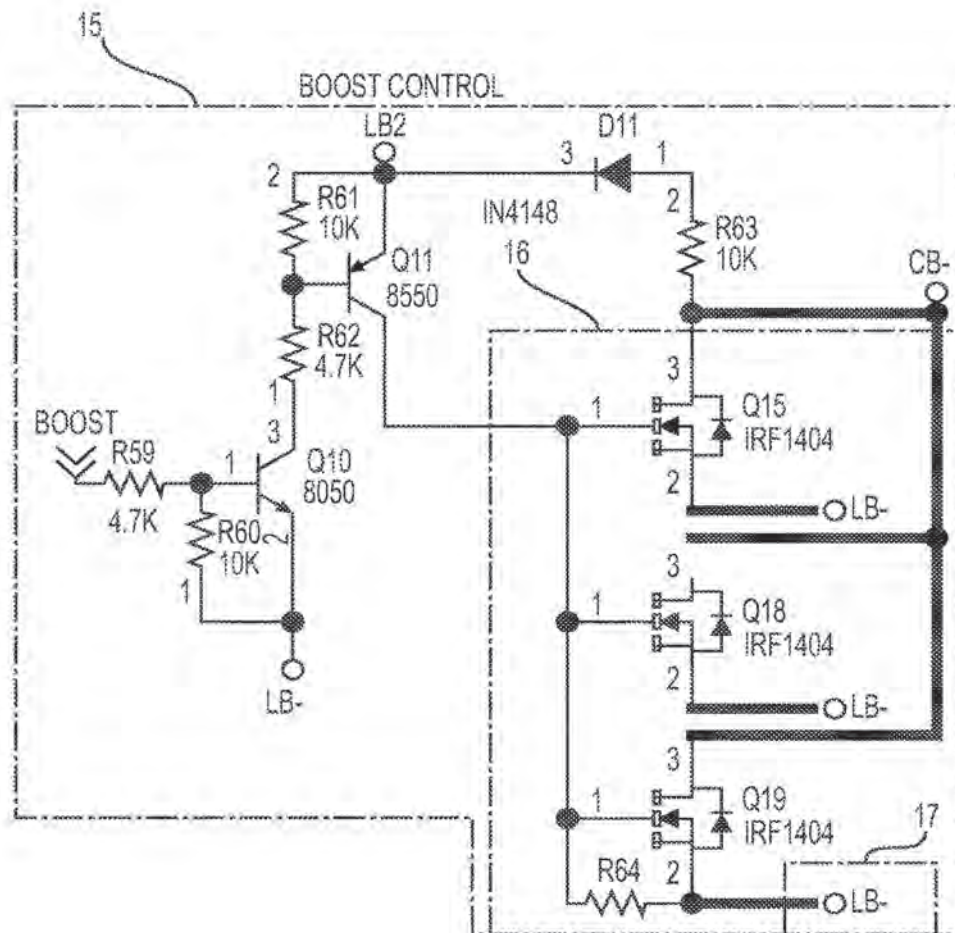


FIG. 2B CONT.

Exhibit A

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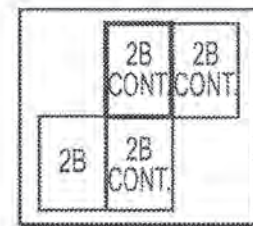
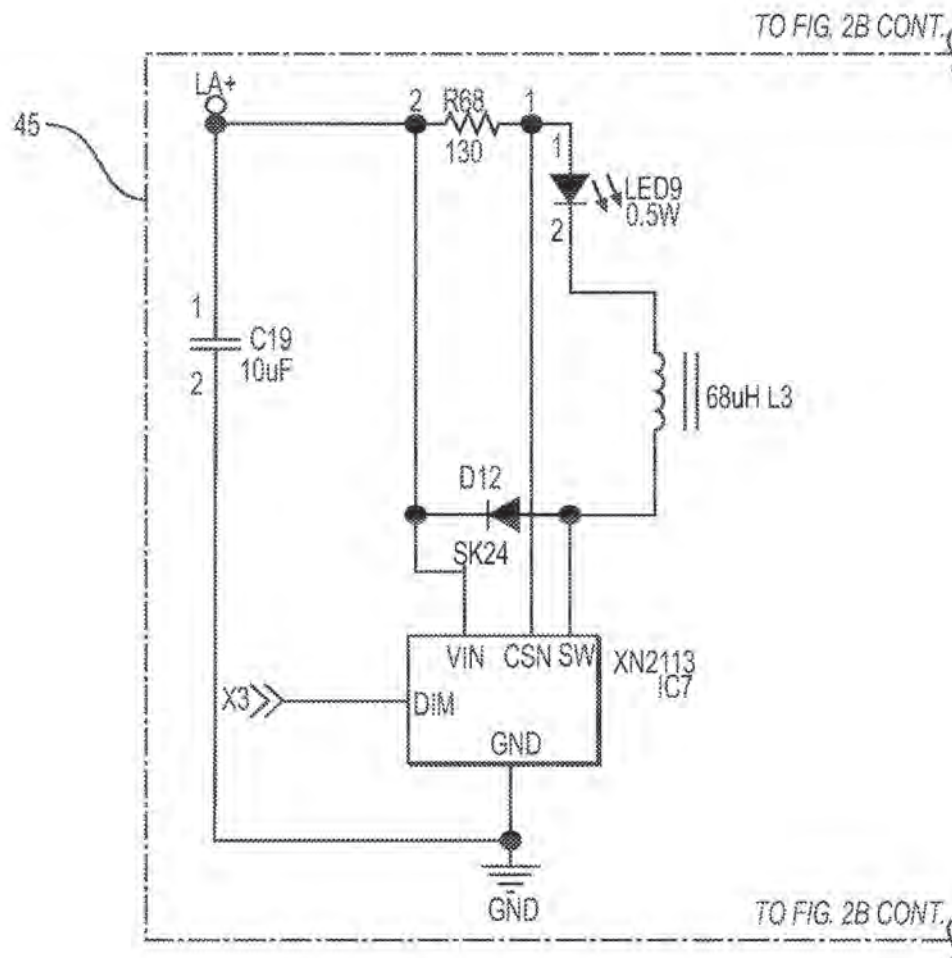


FIG. 2B CONT.

Exhibit A

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EXHIBIT 1010
Petitioner ADC (IPR2024-00671)

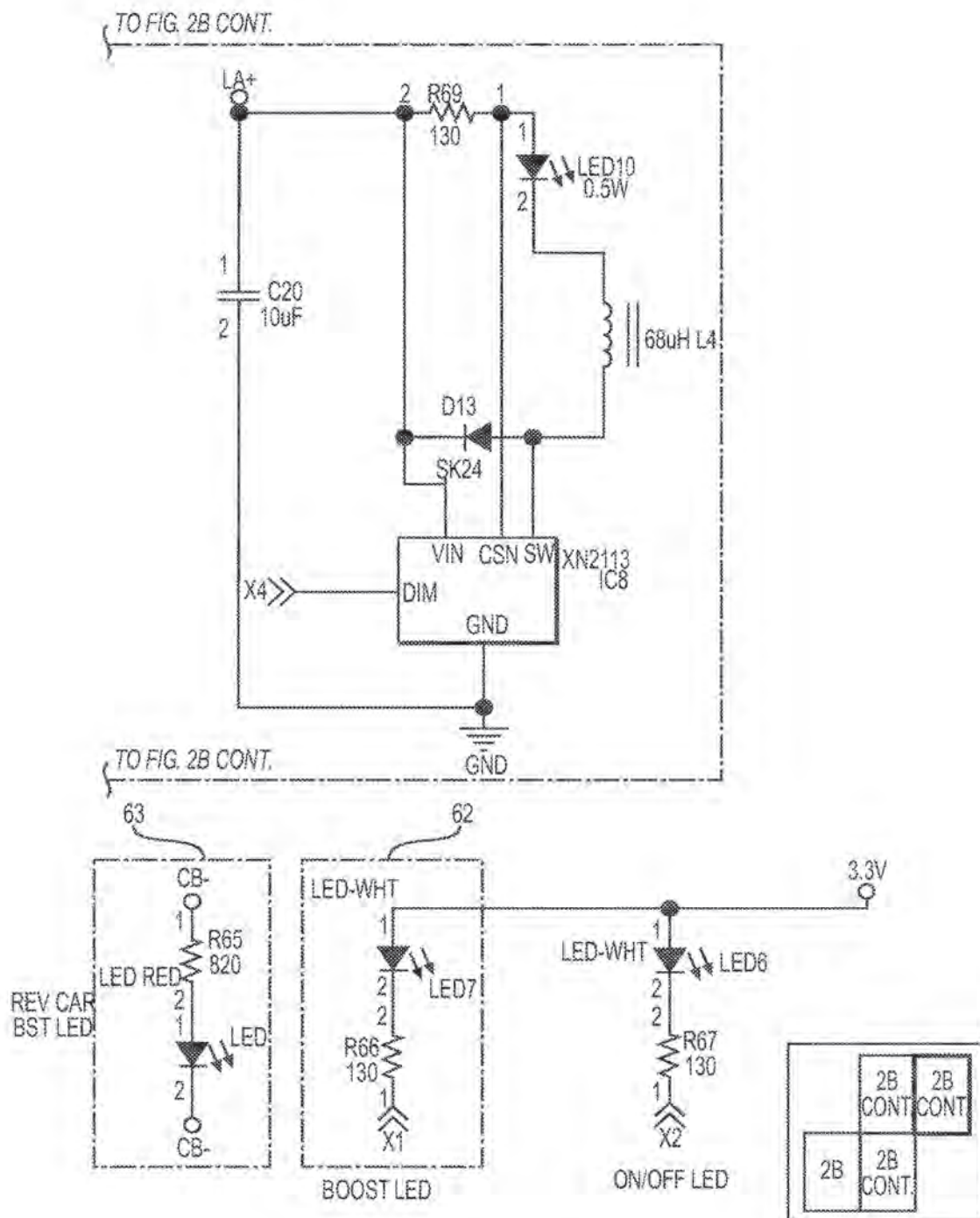


FIG. 2B CONT.

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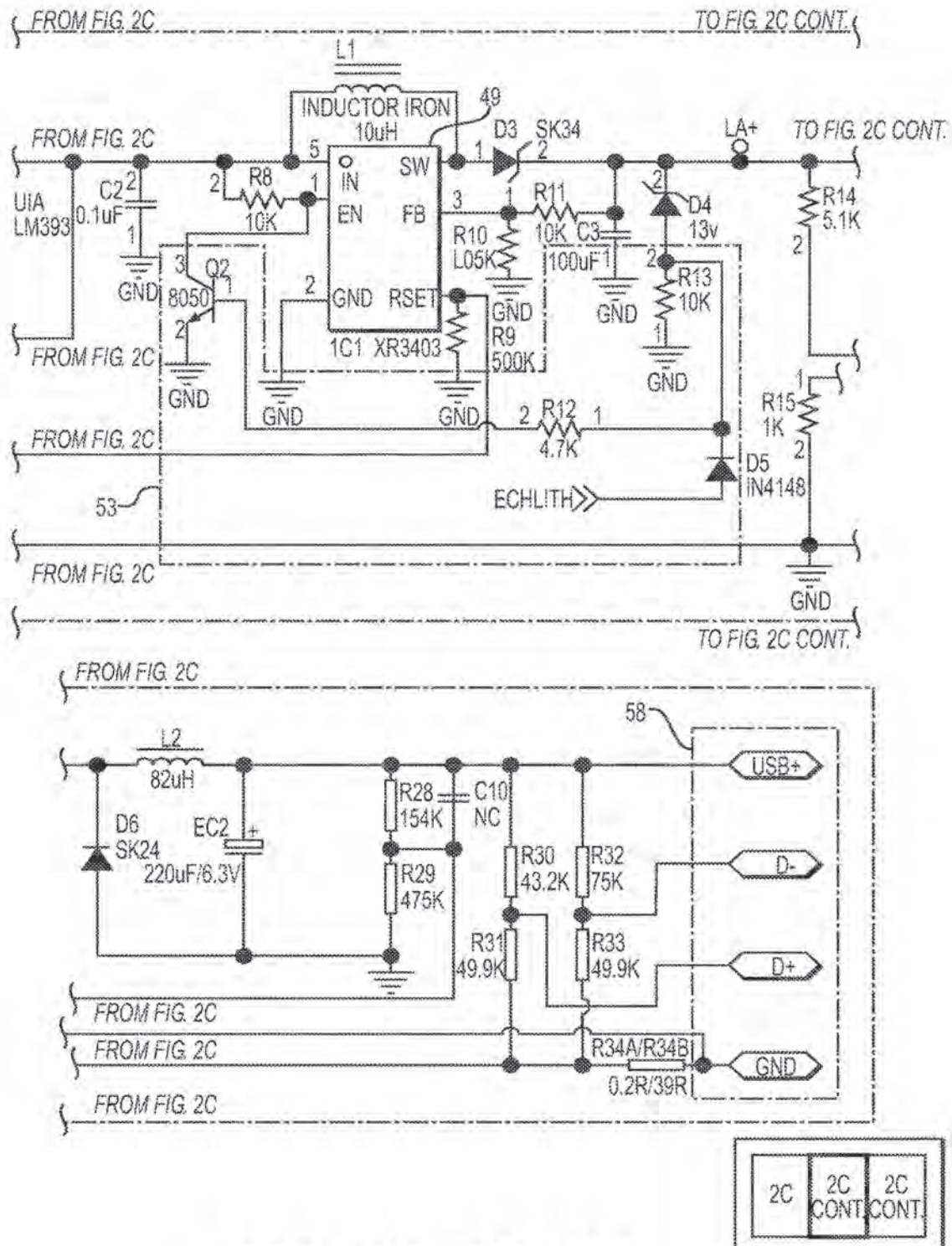


Exhibit A

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EXHIBIT 1010

Petitioner ADC (IPR2024-00671)

U.S. Patent

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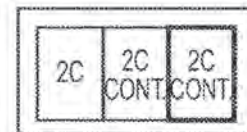
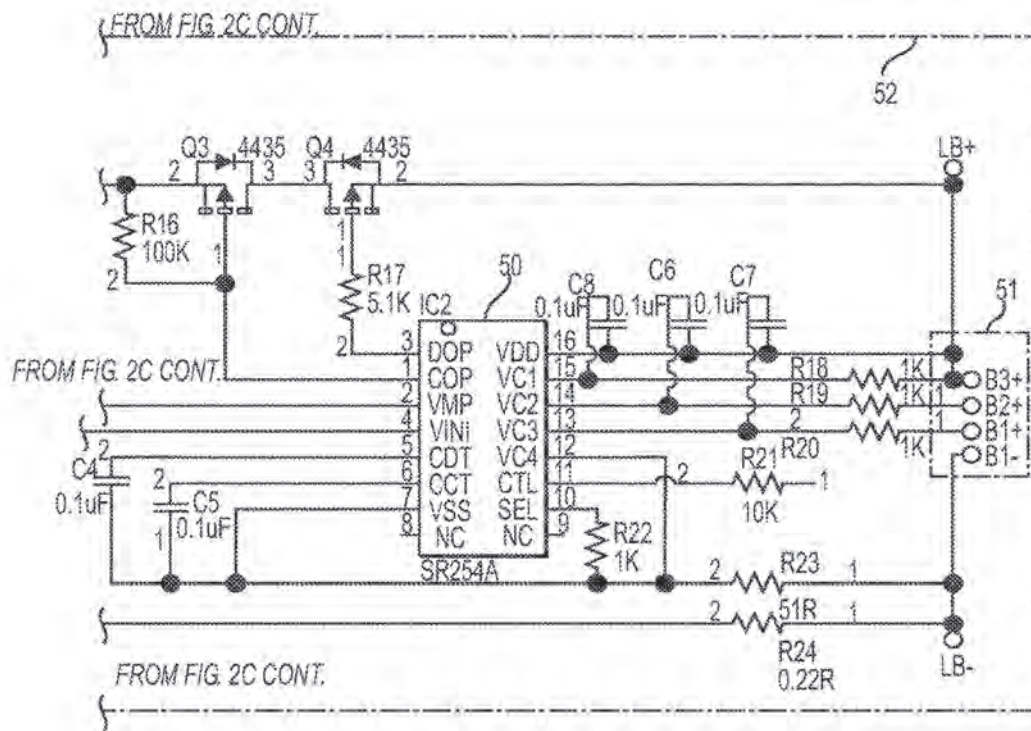


FIG. 2C CONT.

U.S. Patent

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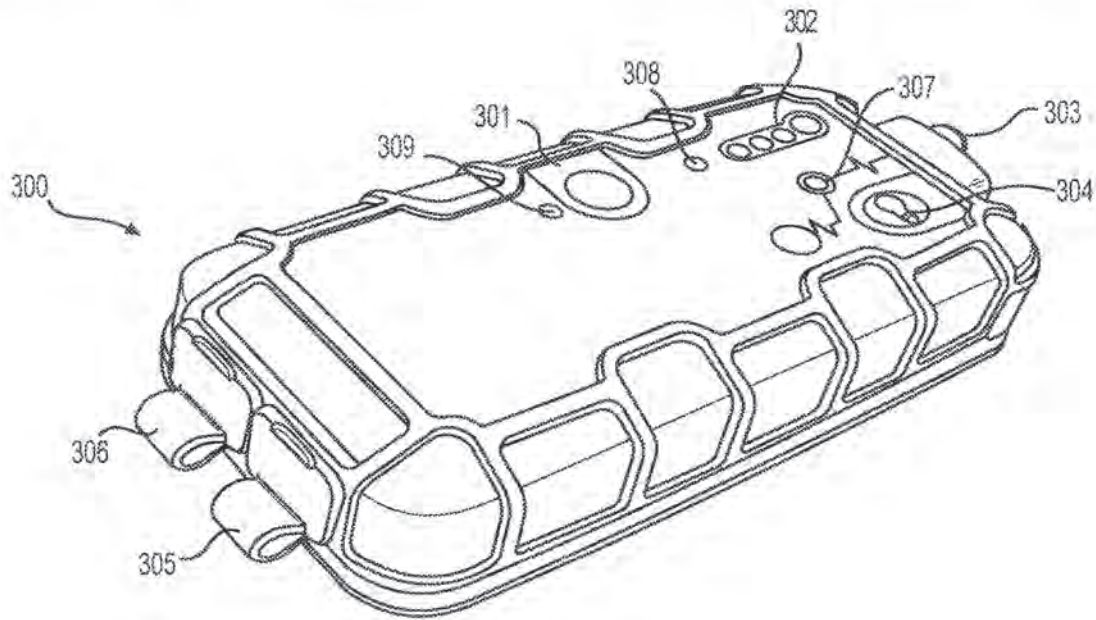


FIG. 3

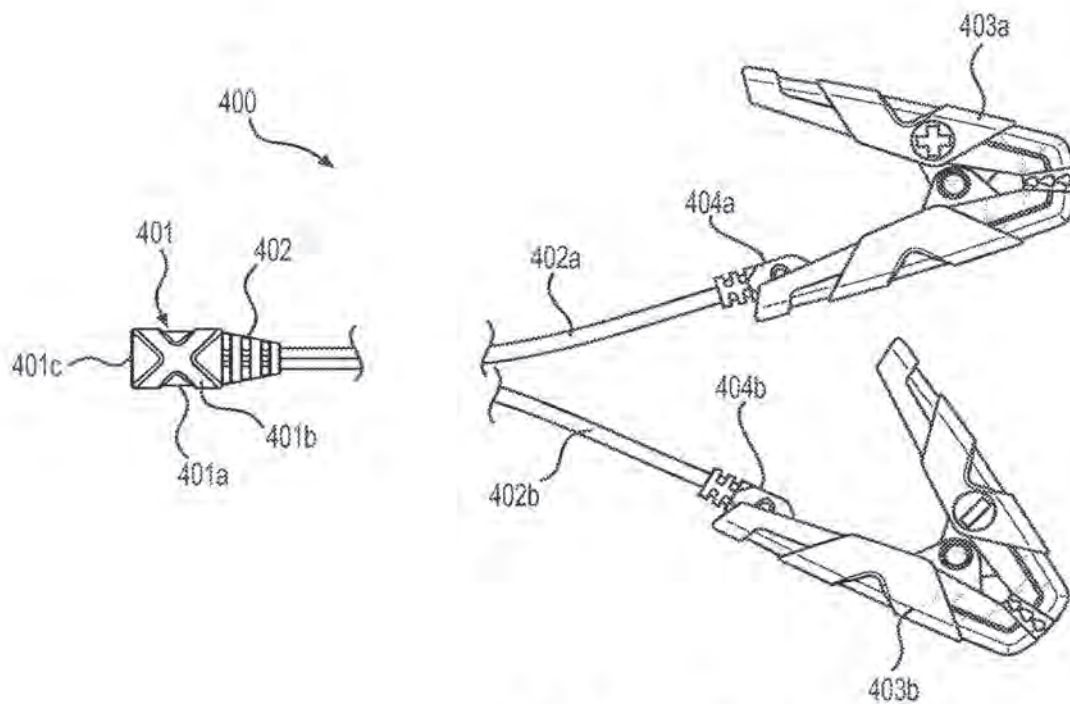


FIG. 4

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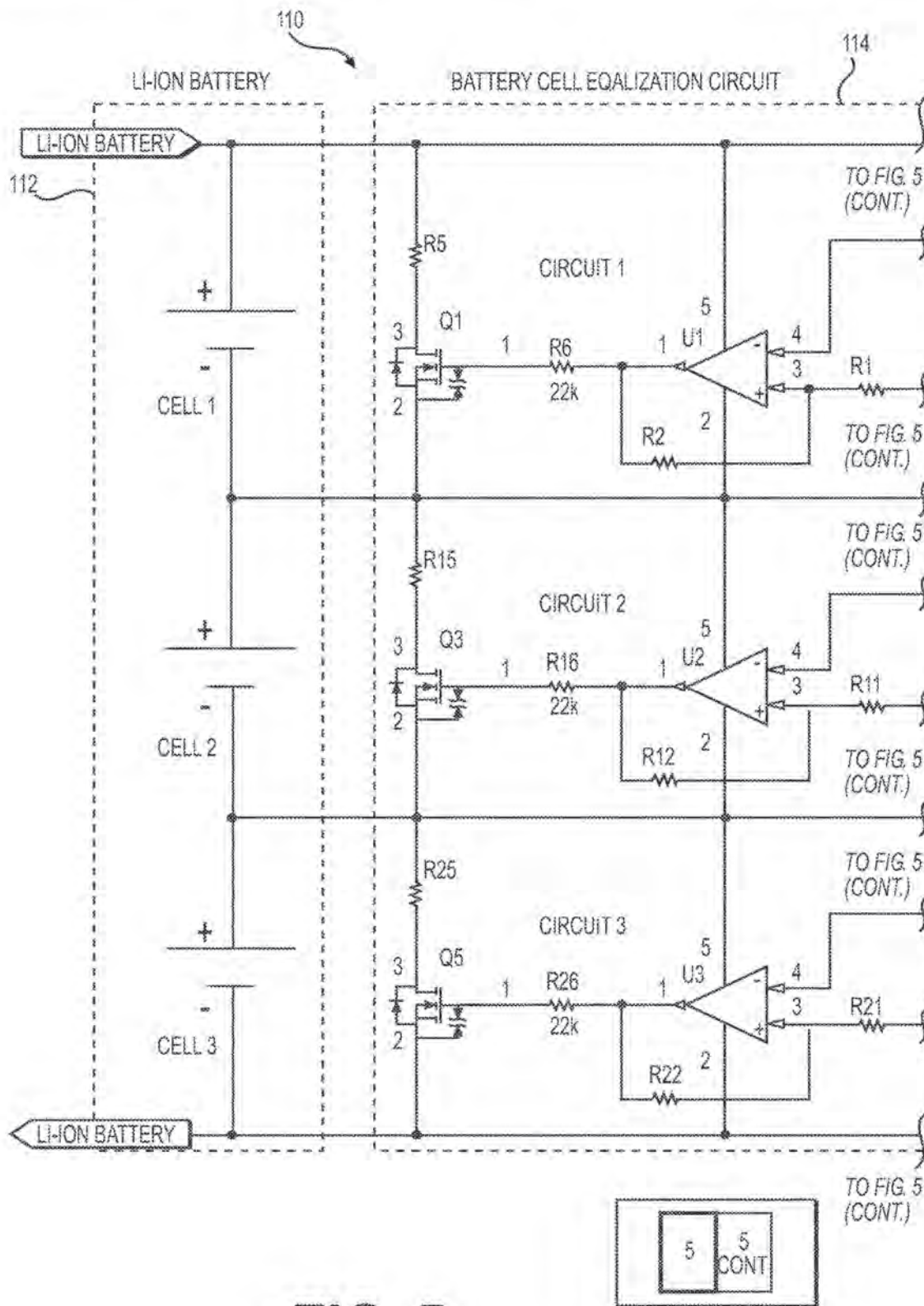


FIG. 5

Exhibit A

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EXHIBIT 1010
Petitioner ADC (IPR2024-00671)

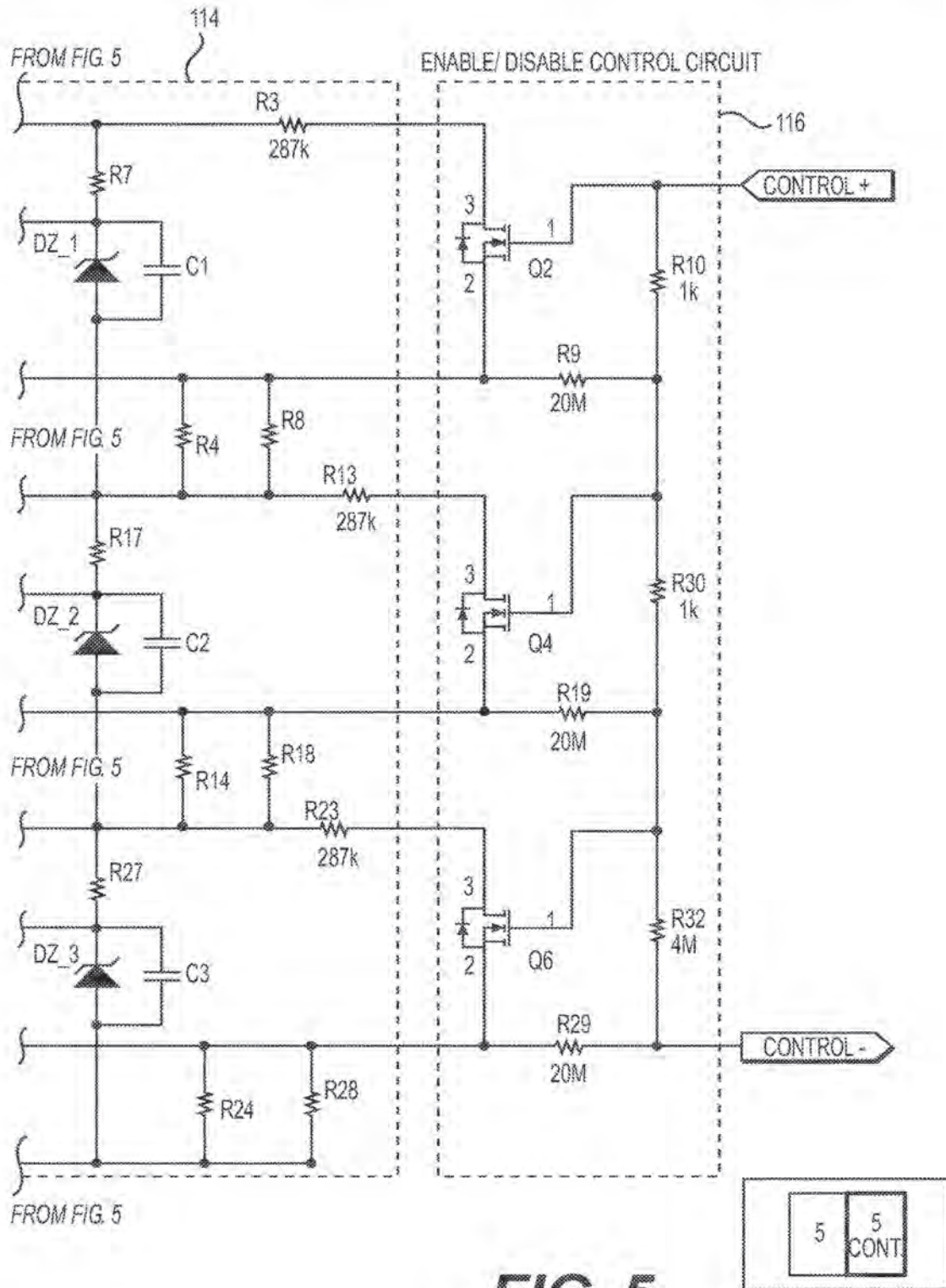


FIG. 5
(CONT.)

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**PORTABLE OR HAND HELD VEHICLE
BATTERY JUMP STARTING APPARATUS
WITH BATTERY CELL EQUALIZATION
CIRCUIT**

**CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application is a Continuation Application of U.S. patent application Ser. No. 16/461,562, filed May 16, 2019, which was a 371 of International Application PCT/US2018/050243, filed Sep. 10, 2018, which is a continuation in part of International Application No.: PCT/US2018/025424, filed Mar. 30, 2018, which claims benefit of priority to U.S. Provisional Application No. 62/480,082, filed Mar. 31, 2017 which are hereby incorporated by reference herein in their entirety.

FIELD

The present invention relates generally to an electronic device or apparatus having multiple batteries or a battery pack having multiple battery cells provided with a battery cell equalization circuit. For example, the apparatus is a portable vehicle battery jump starting apparatus for jump starting a vehicle having a depleted or discharged battery. The portable vehicle battery jump starting device comprises a battery pack having multiple individual battery cells and a battery cell equalization circuit.

BACKGROUND

Prior art devices are known, which provide either a pair of electrical connector cables that connect a fully-charged battery of another vehicle to the engine start circuit of the dead battery vehicle, or portable booster devices which include a fully-charged battery which can be connected in circuit with the vehicle's engine starter through a pair of cables.

Problems with the prior art apparatus arose when either the jumper terminals or clamps of the cables were inadvertently brought into contact with each other while the other ends were connected to or being power, or when the positive and negative jumper terminals or clamps were connected to the opposite polarity terminals in the vehicle to be jumped, thereby causing a short circuit resulting in sparking and potential damage to batteries and/or bodily injury. Various attempts to eliminate these problems have been made in the prior art.

U.S. Pat. No. 6,212,054 issued Apr. 3, 2001, discloses a battery booster pack that is polarity sensitive and can detect proper and improper connections before providing a path for electric current flow. The device uses a set of LEDs connected to optical couplers oriented by a control circuit. The control circuit controls a solenoid assembly controlling the path of power current. The control circuit causes power current to flow through the solenoid assembly only if the points of contact of booster cable clamp connections have been properly made.

U.S. Pat. No. 6,632,103 issued Oct. 14, 2003, discloses an adaptive booster cable connected with two pairs of clips, wherein the two pairs of clips are respectively attached to two batteries to transmit power from one battery to the other battery. The adaptive booster cable includes a polarity detecting unit connected to each clip, a switching unit and a current detecting unit both provided between the two pairs of clips. After the polarity of each clip is sensed by the

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polarity detecting unit, the switching unit generates a proper connection between the two batteries. Therefore, the positive and negative terminals of the two batteries are correctly connected based on the detected result of the polarity detecting unit.

U.S. Pat. No. 8,493,021 issued Jul. 23, 2013, discloses apparatus that monitors the voltage of the battery of a vehicle to be jump started and the current delivered by the jump starter batteries to determine if a proper connection has been established and to provide fault monitoring. Only if the proper polarity is detected can the system operate. The voltage is monitored to determine open circuit, disconnected conductive clamps, shunt cable fault, and solenoid fault conditions. The current through the shunt cable is monitored to determine if there is a battery explosion risk, and for excessive current conditions presenting an overheating condition, which may result in fire. The system includes an internal battery to provide the power to the battery of the vehicle to be jump started. Once the vehicle is started, the unit automatically electrically disconnects from the vehicle's battery.

U.S. Pat. No. 5,189,359 issued Feb. 23, 1993, discloses a jumper cable device having two bridge rectifiers for developing a reference voltage, a four-input decoder for determining which terminals are to be connected based on a comparison of the voltage at each of the four terminals to the reference voltage, and a pair of relays for effecting the correct connection depending on the determination of the decoder. No connection will be made unless only one terminal of each battery has a higher voltage than the reference voltage, indicating "positive" terminals, and one has a lower voltage than the reference voltage, indicating "negative" terminals, and that, therefore, the two high voltage terminals may be connected and the two lower voltage terminals may be connected. Current flows once the appropriate relay device is closed. The relay device is preferably a MOSFET combined with a series array of photodiodes that develop MOSFET gate-closing potential when the decoder output causes an LED to light.

U.S. Pat. No. 5,795,182 issued Aug. 18, 1998, discloses a polarity independent set of battery jumper cables for jumping a first battery to a second battery. The apparatus includes a relative polarity detector for detecting whether two batteries are configured cross or parallel. A three-position high current capacity crossbar pivot switch is responsive to the relative polarity detector for automatically connecting the plus terminals of the two batteries together and the minus terminals of the two batteries together regardless of whether the configuration detected is cross or parallel, and an under-current detector and a delay circuit for returning the device to its ready and unconnected state after the device has been disconnected from one of the batteries. The crossbar pivot switch includes two pairs of contacts, and a pivot arm that pivots about two separate points to ensure full electrical contact between the pairs of contacts.

The present invention can also be used to produce a battery charger that may be connected to a battery without regard to the polarity of the battery.

U.S. Pat. No. 6,262,492 issued Jul. 17, 2001, discloses a car battery jumper cable for accurately coupling an effective power source to a failed or not charged battery, which includes a relay switching circuit connected to the power source and the battery by two current conductor pairs. First and second voltage polarity recognition circuits are respectively connected to the power source and the battery by a respective voltage conductor pair to recognize the polarity of the power source and the battery. A logic recognition circuit

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produces a control signal subject to the polarity of the power source and the battery, and a driving circuit controlled by the control signal from the logic recognition circuit drives the relay switching circuit, enabling the two poles of the power source to be accurately coupled to the two poles of the battery.

U.S. Pat. No. 5,635,817 issued Jun. 3, 1997, discloses a vehicle battery charging device that includes a control housing having cables including a current limiting device to prevent exceeding of a predetermined maximum charging current of about 40 to 60 amps. The control housing includes a polarity detecting device to verify the correct polarity of the connection of the terminals of the two batteries and to electrically disconnect the two batteries if there is an incorrect polarity.

U.S. Pat. No. 8,199,024 issued Jun. 12, 2012, discloses a safety circuit in a low-voltage connecting system that leaves the two low-voltage systems disconnected until it determines that it is safe to make a connection. When the safety circuit determines that no unsafe conditions exist and that it is safe to connect the two low-voltage systems, the safety circuit may connect the two systems by way of a "soft start" that provides a connection between the two systems over a period of time that reduces or prevents inductive voltage spikes on one or more of the low-voltage systems. When one of the low-voltage systems has a completely-discharged battery incorporated into it, a method is used for detection of proper polarity of the connections between the low-voltage systems. The polarity of the discharged battery is determined by passing one or more test currents through it and determining whether a corresponding voltage rise is observed.

U.S. Pat. No. 5,793,185 issued Aug. 11, 1998, discloses a hand-held jump starter having control components and circuits to prevent overcharging and incorrect connection to batteries.

Further, there exists a problem with the prior art electronic devices or apparatus having multiple batteries or a battery pack with multiple battery cells.

For example, lithium-ion (Li-ion) batteries have been known to explode or catch fire due to overheating when individual battery cells get overcharged. The battery life also decreases, if individual battery cells are not equally charged, causing significantly unequal voltages across the individual battery cells.

Currently, portable or hand-held vehicle jump starters using Li-ion batteries do not include battery equalization circuits. Thus, Li-ion batteries can suffer from the above overcharging problems. An example of such a hand-held vehicle jump starter is disclosed in U.S. Pat. No. 9,007,015, which is incorporated herein by reference.

A battery cell equalization circuit according to the present invention can be applied or incorporated into the portable or hand-held vehicle jump starter device disclosed and claimed in U.S. Pat. No. 9,007,015.

There exists a need to provide battery equalization circuits, for example, with electronic apparatus having multiple Li-ion batteries or Li-ion battery packs having multiple battery cells, for example, in rechargeable electronic devices such as the portable or hand-held vehicle jump starter device according to the present invention.

While the prior art attempted to provide solutions to one or more of the above-mentioned problem(s) as discussed above, each of the prior art solutions suffers from other shortcomings, either in complexity, cost and/or has potential for malfunction. Accordingly, there exists a need in the art for further improvements to electronic devices or apparatus

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having multiple batteries or battery packs having multiple battery cells such as used in vehicle jump starting devices or apparatus.

SUMMARY

In accordance with an aspect of the invention, an electronic device or apparatus is provided for jump starting a vehicle engine, including: an internal power supply; an output port having positive and negative polarity outputs; a vehicle battery isolation sensor connected in circuit with the positive and negative polarity outputs, configured to detect presence of a vehicle battery connected between the positive and negative polarity outputs; a reverse polarity sensor connected in circuit with the positive and negative polarity outputs, configured to detect polarity of a vehicle battery connected between the positive and negative polarity outputs; a power FET switch connected between the internal power supply and the output port; and a microcontroller configured to receive input signals from the vehicle isolation sensor and the reverse polarity sensor, and to provide an output signal to the power FET switch, such that the power FET switch is turned on to connect the internal power supply to the output port in response to signals from the sensors indicating the presence of a vehicle battery at the output port and proper polarity connection of positive and negative terminals of the vehicle battery with the positive and negative polarity outputs.

In accordance with another aspect of the invention, the internal power supply is a rechargeable lithium-ion (Li-ion) battery pack.

In accordance with yet another aspect of the invention, a jumper cable device is provided with a plug configured to plug into an output port of a handheld battery charger booster device having an internal power supply; a pair of cables integrated with the plug at one respective end thereof; the pair of cables being configured to be separately connected to terminals of a battery at another respective end thereof.

The present invention also provides a battery cell equalization circuit for an electronic device or apparatus having multiple battery cells (e.g. Li-ion batteries) or a battery pack having multiple battery cells (e.g. Li-ion battery cells). For example, the batteries or battery pack can comprise or consist of multiple batteries connected to a battery cell equalization circuit. The battery cell equalization circuit (e.g. circuit board) can be packaged internally with the batteries or battery pack, or can be an electronic circuit or component separate from the battery pack installed in the electronic device or apparatus powered by the battery pack (e.g. circuit board within electronic device, but not packaged with battery pack). The batteries or battery packs can be rechargeable using lithium-ion, nickel cadmium, or rechargeable batteries or battery cells.

The battery cell equalization circuit according to the present invention, for example, can be applied or implemented in a rechargeable electronic device or apparatus such as a tool, portable or hand-held vehicle jump starter, vehicle, electrical vehicle (e.g. electric car, electric truck, electric bus, electric golf cart, electric utility cart, motorcycle, mini bike, scooter, go kart), radio, electronic player, radio controlled device, radio controlled toy (e.g. R/C airplane, R/C boat, R/C car, R/C truck), game, or other numerous other rechargeable electronic devices, apparatus, or applications.

The battery cell equalization circuit can be applied to or used in a portable or hand-held jump starter. This type of electronic device conveys a significant amount of energy or

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power from the rechargeable batteries or battery pack to a deplete or discharged battery being jump started in a short amount of time requiring the batteries or batter cells to all be fully charged and balanced.

The battery cell equalization circuit according to the present invention can be configured to be simple, safe, effective, low cost, and can include a controllable mechanism to enable or disable itself from trying to sense the cell voltages and trying to equalize them.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of a handheld vehicle battery boost apparatus in accordance with one aspect of the present invention;

FIGS. 2A-2C are schematic circuit diagrams of an example embodiment of a handheld vehicle battery boost apparatus in accordance with an aspect of the invention;

FIG. 3 is a perspective view of a handheld jump starter booster device in accordance with one example embodiment of the invention; and

FIG. 4 is a planar view of a jumper cable usable with the handheld jump starter booster device in accordance with another aspect of the invention.

FIG. 5 is a schematic circuit diagram of a battery cell equalization circuit according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 is a functional block diagram of a handheld battery booster according to one aspect of the invention. At the heart of the handheld battery booster is a lithium polymer battery pack 32, which stores sufficient energy to jump start a vehicle engine served by a conventional 12 volt lead-acid or valve regulated lead-acid battery. In one example embodiment, a high-surge lithium polymer battery pack includes three 3.7V, 2666 mAh lithium polymer batteries in a 351P configuration. The resulting battery pack provides 11.1V, 2666 Ah (8000 Ah at 3.7V, 29.6 Wh). Continuous discharge current is 25 C (or 200 amps), and burst discharge current is 50 C (or 400 amps). The maximum charging current of the battery pack is 8000 mA (8 amps).

A programmable microcontroller unit (MCU) 1 receives various inputs and produces informational as well as control outputs. The programmable MCU 1 further provides flexibility to the system by allowing updates in functionality and system parameters, without requiring any change in hardware. According to one example embodiment, an 8 bit microcontroller with 2K.times.15 bits of flash memory is used to control the system. One such microcontroller is the HT67F30, which is commercially available from Holtek Semiconductor Inc.

A car battery reverse sensor 10 monitors the polarity of the vehicle battery 72 when the handheld battery booster device is connected to the vehicle's electric system. As explained below, the booster device prevents the lithium battery pack from being connected to the vehicle battery 72 when the terminals of the battery 72 are connected to the wrong terminals of the booster device. A car battery isolation sensor 12 detects whether or not a vehicle battery 72 is connected to the booster device, and prevents the lithium battery pack from being connected to the output terminals of the booster device unless there is a good (e.g. chargeable) battery connected to the output terminals.

A smart switch FET circuit 15 electrically switches the handheld battery booster lithium battery to the vehicle's

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electric system only when the vehicle battery is determined by the MCU 1 to be present (in response to a detection signal provided by isolation sensor 12) and connected with the correct polarity (in response to a detection signal provided by reverse sensor 10). A lithium battery temperature sensor 20 monitors the temperature of the lithium battery pack 32 to detect overheating due to high ambient temperature conditions and overextended current draw during jump starting. A lithium battery voltage measurement circuit 24 monitors the voltage of the lithium battery pack 32 to prevent the voltage potential from rising too high during a charging operation and from dropping too low during a discharge operation.

Lithium-ion battery back-charge protection diodes 28 prevent any charge current being delivered to the vehicle battery 72 from flowing back to the lithium battery pack 32 from the vehicle's electrical system. Flashlight LED circuit 36 is provided to furnish a flashlight function for enhancing light under a vehicle's hood in dark conditions, as well as providing SOS and strobe lighting functions for safety purposes when a vehicle may be disabled in a potentially dangerous location. Voltage regulator 42 provides regulation of internal operating voltage for the microcontroller and sensors. On/Off manual mode and flashlight switches 46 allow the user to control power-on for the handheld battery booster device, to control manual override operation if the vehicle has no battery, and to control the flashlight function. The manual button functions only when the booster device is powered on. This button allows the user to jump-start vehicles that have either a missing battery, or the battery voltage is so low that automatic detection by the MCU is not possible. When the user presses and holds the manual override button for a predetermined period time (such as three seconds) to prevent inadvertent actuation of the manual mode, the internal lithium ion battery power is switched to the vehicle battery connect port. The only exception to the manual override is if the car battery is connected in reverse. If the car battery is connected in reverse, the internal lithium battery power shall never be switched to the vehicle battery connect port.

USB charge circuit 52 converts power from any USB charger power source, to charge voltage and current for charging the lithium battery pack 32. USB output 56 provides a USB portable charger for charging smartphones, tablets, and other rechargeable electronic devices. Operation indicator LEDs 60 provide visual indication of lithium battery capacity status as well as an indication of smart switch activation status (indicating that power is being provided to the vehicle's electrical system).

Detailed operation of the handheld booster device will now be described with reference to the schematic diagrams of FIGS. 2A-2C. As shown in FIG. 2A, the microcontroller unit 1 is the center of all inputs and outputs. The reverse battery sensor 10 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D8 in the lead conductor of pin 1 (associated with the negative terminal CB-), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11 will not conduct current, and is therefore turned off, providing a "1" or high output signal to the MCU 1. The car battery isolation sensor 12 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D7 in the lead conductor of pin 1 (associated with the positive terminal CB+), such that if the battery 72 is connected to the terminals of the booster device with the

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correct polarity, the optocoupler LED 11A will conduct current, and is therefore turned on, providing a “0” or low output signal to the MCU, indicating the presence of a battery across the jumper output terminals of the handheld booster device.

If the car battery 72 is connected to the handheld booster device with reverse polarity, the optocoupler LED 11 of the reverse sensor 10 will conduct current, providing a “0” or low signal to microcontroller unit 1. Further, if no battery is connected to the handheld booster device, the optocoupler LED 11A of the isolation sensor 12 will not conduct current, and is therefore turned off, providing a “1” or high output signal to the MCU, indicating the absence of any battery connected to the handheld booster device. Using these specific inputs, the microcontroller software of MCU 1 can determine when it is safe to turn on the smart switch FET 15, thereby connecting the lithium battery pack to the jumper terminals of the booster device. Consequently, if the car battery 72 either is not connected to the booster device at all, or is connected with reverse polarity, the MCU 1 can keep the smart switch FET 15 from being turned on, thus prevent sparking/short circuiting of the lithium battery pack.

As shown in FIG. 2B, the FET smart switch 15 is driven by an output of the microcontroller 1. The FET smart switch 15 includes three FETs (Q15, Q18, and Q19) in parallel, which spreads the distribution of power from the lithium battery pack over the FETs. When that microcontroller output is driven to a logic low, FETs 16 are all in a high resistance state, therefore not allowing current to flow from the internal lithium battery negative contact 17 to the car battery 72 negative contact. When the micro controller output is driven to a logic high, the FETs 16 (Q15, Q18, and Q19) are in a low resistant state, allowing current to flow freely from the internal lithium battery pack negative contact 17 (LB-) to the car battery 72 negative contact (CB-). In this way, the microcontroller software controls the connection of the internal lithium battery pack 32 to the vehicle battery 72 for jumpstarting the car engine.

Referring back to FIG. 2A, the internal lithium battery pack voltage can be accurately measured using circuit 24 and one of the analog-to-digital inputs of the microcontroller 1. Circuit 24 is designed to sense when the main 3.3V regulator 42 voltage is on, and to turn on transistor 23 when the voltage of regulator 42 is on. When transistor 23 is conducting, it turns on FET 22, thereby providing positive contact (LB+) of the internal lithium battery a conductive path to voltage divider 21 allowing a lower voltage range to be brought to the microcontroller to be read. Using this input, the microcontroller software can determine if the lithium battery voltage is too low during discharge operation or too high during charge operation, and take appropriate action to prevent damage to electronic components.

Still referring to FIG. 2A, the temperature of the internal lithium battery pack 32 can be accurately measured by two negative temperature coefficient (NTC) devices 20. These are devices that reduce their resistance when their temperature rises. The circuit is a voltage divider that brings the result to two analog-to-digital (A/D) inputs on the microcontroller 1. The microcontroller software can then determine when the internal lithium battery is too hot to allow jumpstarting, adding safety to the design.

The main voltage regulator circuit 42 is designed to convert internal lithium battery voltage to a regulated 3.3 volts that is utilized by the microcontroller 1 as well as by other components of the booster device for internal operating power. Three lithium battery back charge protection diodes 28 (see FIG. 2) are in place to allow current to flow

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only from the internal lithium battery pack 32 to the car battery 72, and not from the car battery to the internal lithium battery. In this way, if the car electrical system is charging from its alternator, it cannot back-charge (and thereby damage) the internal lithium battery, providing another level of safety. The main power on switch 46 (FIG. 2A) is a combination that allows for double pole, double throw operation so that with one push, the product can be turned on if it is in the off state, or turned off if it is in the on state. This circuit also uses a microcontroller output 47 to “keep alive” the power when it is activated by the on switch. When the switch is pressed the microcontroller turns this output to a high logic level to keep power on when the switch is released. In this way, the microcontroller maintains control of when the power is turned off when the on/off switch is activated again or when the lithium battery voltage is getting too low. The microcontroller software also includes a timer that turns the power off after a predefined period of time, (such as, e.g. 8 hours) if not used.

The flashlight LED circuit 45 shown in FIG. 2B controls the operation of flashlight LEDs. Two outputs from the microcontroller 1 are dedicated to two separate LEDs. Thus, the LEDs can be independently software-controlled for strobe and SOS patterns, providing yet another safety feature to the booster device. LED indicators provide the feedback the operator needs to understand what is happening with the product. Four separate LEDs 61 (FIG. 2A) are controlled by corresponding individual outputs of microcontroller 1 to provide indication of the remaining capacity of the internal lithium battery. These LEDs are controlled in a “fuel gauge” type format with 25%, 50%, 75% and 100% (red, red, yellow, green) capacity indications. An LED indicator 63 (FIG. 2B) provides a visual warning to the user when the vehicle battery 72 has been connected in reverse polarity. “Boost” and on/off LEDs 62 provide visual indications when the booster device is provide jump-start power, and when the booster device is turned on, respectively.

A USB output 56 circuit, as shown in FIG. 2C is included to provide a USB output for charging portable electronic devices such as smartphones from the internal lithium battery pack 32. Control circuit 57 from the microcontroller 1 allows the USB Out 56 to be turned on and off by software control to prevent the internal lithium battery getting too low in capacity. The USB output is brought to the outside of the device on a standard USB connector 58, which includes the standard voltage divider required for enabling charge to certain smartphones that require it. The USB charge circuit 52 allows the internal lithium battery pack 32 to be charged using a standard USB charger. This charge input uses a standard micro-USB connector 48 allowing standard cables to be used. The 5V potential provided from standard USB chargers is up-converted to the 12.4 VDC voltage required for charging the internal lithium battery pack using a DC-DC converter 49. The DC-DC converter 49 can be turned on and off via circuit 53 by an output from the microcontroller 1.

In this way, the microcontroller software can turn the charge off if the battery voltage is measured to be too high by the A/D input 22. Additional safety is provided for helping to eliminate overcharge to the internal lithium battery using a lithium battery charge controller 50 that provides charge balance to the internal lithium battery cells 51. This controller also provides safety redundancy for eliminating over discharge of the internal lithium battery.

FIG. 3 is a perspective view of a handheld device 300 in accordance with an exemplary embodiment of the invention. 301 is a power on switch. 302 shows the LED “fuel gauge” indicators 61. 303 shows a 12 volt output port connectable

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to a cable device 400, described further below. 304 shows a flashlight control switch for activating flashlight LEDs 45. 305 is a USB input port for charging the internal lithium battery, and 306 is a USB output port for providing charge from the lithium battery to other portable devices such as smartphones, tablets, music players, etc. 307 is a "boost on" indicator showing that power is being provided to the 12V output port. 308 is a "reverse" indicator showing that the vehicle battery is improperly connected with respect to polarity. 309 is a "power on" indicator showing that the device is powered up for operation.

FIG. 4 shows a jumper cable device 400 specifically designed for use with the handheld device 300. Device 400 has a plug 401 configured to plug into 12 volt output port 303 of the handheld device 300. A pair of cables 402a and 402b are integrated with the plug 401, and are respectively connected to battery terminal clamps 403a and 403b via ring terminals 404a and 404b. The port 303 and plug 401 may be dimensioned so that the plug 401 will only fit into the port 303 in a specific orientation, thus ensuring that clamp 403a will correspond to positive polarity, and clamp 403b will correspond to negative polarity, as indicated thereon. Additionally, the ring terminals 404a and 404b may be disconnected from the clamps and connected directly to the terminals of a vehicle battery. This feature may be useful, for example, to permanently attach the cables 302a-302b to the battery of a vehicle. In the event that the battery voltage becomes depleted, the handheld booster device 300 could be properly connected to the battery very simply by plugging in the plug 401 to the port 303.

Battery Cell Equalization

A battery cell equalization circuit 110 is shown in FIG. 1. The battery cell equalization circuit 110 comprises a Li-ion battery 112 having three (3) cells having a nominal battery rating of 12V, a battery cell equalization circuit 114 having three (3) individual battery cell equalization circuits, and an enable/disable control circuit 116. Each cell has its own independent battery cell equalization circuit, which are essentially identical.

The battery cells are "equalized" using the principle that if any cell voltage exceeds a certain pre-determined upper voltage threshold, it will be discharged through its own load resistor (R5, R15, and R25), until it reaches a certain pre-determined level below that threshold or until the battery charging process is terminated.

Bleeding the charge of a cell through its load resistor may not always result in the net discharge of that cell. For example, if the (externally supplied) charging current through the Li-ion battery 112, which is the same through each cell, is higher than the discharge or bleed current of that cell, it will slow down the effective charging rate of that cell while charging the lower voltage cells at a higher rate allowing them to catch up to the highest voltage cell.

The battery cell equalization circuit 110 is enabled or disabled using a single control signal, which may be generated after evaluating user affected settings or various operational conditions within the jump starter. Disabling the equalization circuit during active cell discharge stops the discharge of the cell(s). Enabling the equalization circuit may or may not cause the cell(s) to be discharged, as that decision depends on the cell voltages.

Operation

Enabling the equalization circuit involves turning ON the MOSFET switches Q2, Q4, Q6, electrically connecting the

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voltage divider resistors (R3, R4), (R13, R14) and (R23, R24) that scale down the individual cell voltages and feed them to the non-inverting inputs of their respective comparators, allowing them to sense the individual cell voltages. Disabling the equalization circuit turns OFF MOSFET switches Q2, Q4, Q6, disconnecting the resistors (R3, R4), (R13, R14) and (R23, R24) and preventing the cell voltages reaching the comparators' non-inverting inputs. That essentially presents zero voltage to the comparators' non-inverting inputs, causing their output voltages to be zero, which prevents the load resistors R5, R15, R25 from being connected across the cells.

Semiconductor voltage references DZ_1, DZ_2, DZ_3 in series with biasing resistors R7, R17, R27, provide a reference voltage signal to the inverting input of comparators U1, U2, U3, respectively. The resistor divider R3, R4 (or R13, R14 or R23, R24) values are chosen such the scaled cell voltage equals the reference voltage when the cell voltage reaches the upper voltage threshold at which the discharge process needs to be started. If any scaled cell voltage being fed to the non-inverting input of its respective comparator exceeds the corresponding reference voltage present at the inverting input, then the comparator's output voltage will be high, exceeding the gate-source threshold voltage of the enhancement mode MOSFET switch Q1 (or Q3, Q5), causing it to turn ON and connecting load resistor R5 (or R15, R25) across the corresponding battery cell.

Resistor R8 (or R18, R28) lies in parallel with R4 (or R14, R24) and allows fine tuning of the voltage division, allowing the use of cheaper, commonly available mass produced resistors, instead of a single specific non-standard value. Further consideration in choosing the value of the voltage divider resistors is to minimize the current drawn by these resistors to avoid draining the battery cells, while at the same time keeping their value small enough to allow enough current through these voltage divider resistors that is significantly greater than the comparators' input bias current, so as to effectively not load the voltage divider.

R1, R2 (R11, R12 or R21, R22) control the "hysteresis" band that determines the lower cell voltage level to which the cell(s) needs to be discharged, once the discharge process has been started.

Li-ion battery 112 can store a significant amount of energy, which can cause high current in the cells, if their terminals get short-circuited un-intentionally, resulting in excessive heat generation and damage to the jump starter unit or other undesired catastrophic consequences. High valued resistors R6, R16, R26 have been added between the output of comparator U1 (or U2, U3) and the switches Q1, Q3, Q5 to limit the amount of current through each cell to a safe value, in the case when somehow the output of U1 (or U2, U3) gets clamped to its cell voltage and the gate-source terminals of Q1 (or Q3, Q5) get short-circuited.

The gate-source threshold voltage of MOSFETs Q1, Q3, Q5 has been chosen to be a minimum of 1.2V, as opposed to a few tenths of a volt, in order to prevent their spurious turning ON due to stray voltages present between their gate-source terminals. The comparators and voltage references used are of the "nano power" category to not drain the battery cells significantly over time, thus maintaining its jump starting capacity.

Capacitors C1, C2, C3 are kept to allow stable operation of the voltage references DZ_1, DZ_2, DZ_3.

Enable/Disable Control Circuit Operation

Turning ON enhancement mode MOSFET switches Q2, Q4, Q6 enables the battery cell equalization circuit 110.

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Turning them OFF, disables the battery cell equalization circuit 110. The switches Q2, Q4, Q6 are turned ON simultaneously by applying a nominal 12V control voltage signal between the terminals marked "Control +", "Control -". They are simultaneously turned OFF by applying a nominal zero volt control signal. In this implementation, the control voltage needed to be greater than or equal to the nominal voltage of the battery whose cells are being equalized. The nominal 12V control voltage level was chosen due to its availability within, for example, a hand-held jump starter unit, as it is readily obtained via the external charge port or from the Li-ion battery 112 itself.

Placement of the voltage divider resistor R3 (or R13, R23) on the drain (terminal 3) side of MOSFET switches Q2 (Q4 or Q6), instead of on the source (terminal 2) side, is critical to the proper operation of the enable/disable circuit 116. If it is desired to keep Q2 (Q4, Q6) turned ON, it is essential to maintain its gate-source voltage at a level higher than its gate-source threshold voltage. When Q2 (Q4, Q6) gets turned on, the voltage drop across R3 (R13, R23) causes its source terminal to be pulled below its corresponding positive cell terminal potential, enabling a gate to source voltage at a level higher than its chosen gate-source threshold voltage. To allow a larger voltage drop across R3 (R13, R23), its value is kept much larger than R4 (R14, R24), such that it would allow a standard valued, readily available voltage reference DZ_1 (DZ_2, DZ_3) to be chosen.

The gate-source threshold voltage of MOSFETs Q2, Q4, Q6 has been chosen to be a minimum of 1.1V, as opposed to a few tenths of a volt, in order to prevent their spurious turning ON due to stray voltages present between their gate-source terminals. This in turn imposes a higher voltage requirement across the gate-source voltage of Q2, Q4, Q6 in order to turn them ON and keep them in that state. It can be seen that if R3 were kept on the source (terminal 2) side of Q2, then the source terminal of Q2 would be pulled to the nominal 12V battery potential as soon as Q2 were turned ON with a 12V control signal. However, this would result in a zero voltage applied between the gate-source of Q2, immediately turning it back OFF.

The values of R10, R30, R32 have been chosen to allow an equitable distribution of the applied voltages between the gate-source terminals of Q2, Q4, Q6 when the 12V control voltage is present. R10, R32 are kept much smaller than R32 to allow similar amounts of current to reach the gates of Q2, Q4, Q6. Large valued resistors R9, R19 act as another layer of safety by further introducing electrical resistance between the individual battery cells 112 as well as between the battery and the control voltage source by limiting fault current in case of short circuits across multiple components of the circuit. Value R32 needs to be kept large enough so that most of the control voltage drops across it, in case the control voltage source has significant resistance in series with it.

Example #1

The battery cell equalization circuit 110 can be applied or installed into the battery jump start boost device disclosed in U.S. Pat. No. 9,007,015, which is incorporated herein by reference.

The invention having been thus described, it will be apparent to those skilled in the art that the same may be varied in many ways without departing from the spirit or scope of the invention. Any and all such variations are intended to be encompassed within the scope of the following claims.

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The invention claimed is:

1. A portable or hand held jump starting apparatus, comprising:

a battery comprising a plurality of individual battery cells connected together in series;

a battery cell equalization circuit connected to the battery, the battery cell equalization circuit comprising:

an individual battery cell equalization circuit provided for each of the plurality of individual battery cells; and

a load resistor provided for each of the individual battery cell equalization circuits,

wherein the individual battery cell equalization circuits are configured to discharge a respective individual battery cell using a respective load resistor upon the respective individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the respective cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the battery charging process is terminated, and

wherein the individual battery cell equalization circuits are configured to charge lower voltage individual battery cells at a higher rate allowing lower voltage individual battery cells to catch up in voltage to an individual battery cell having a highest voltage.

2. The apparatus according to claim 1, wherein the battery cell equalization circuits are configured to slow a charging rate upon the particular cell a cell voltage approaching the pre-determined upper voltage threshold while charging the lower voltage individual battery cells at a higher rate, allowing the lower voltage individual battery cells to catch up to the particular individual battery cell having the highest voltage.

3. The apparatus according to claim 1, wherein the battery cell equalization circuit is configured to be enabled or disabled using a single control signal.

4. The apparatus according to claim 3, wherein disabling the battery cell equalization circuit during active battery cell discharge stops the discharge of the battery cells.

5. The apparatus according to claim 3, wherein the battery cell equalization circuit comprises MOSFET switches and voltage divider resistors, and wherein enabling the battery cell equalization circuit involves turning on the MOSFET switches electrically connecting the voltage divider resistors that scale down individual cell voltage of the battery cells and feed them to non-inverting inputs of respective comparators, allowing them to sense the individual cell voltages.

6. The apparatus according to claim 5, wherein disabling the battery cell equalization circuit turns off the MOSFET switches disconnecting the resistors and preventing cell voltages reaching the comparators' non-inverting signals and presenting zero voltage to the comparator's non-inverting inputs, causing their output voltages to be zero, which prevents the load resistors from being connected across the cells.

7. The apparatus according to claim 1, wherein the battery is a Li-ion battery pack comprising a plurality of Li-ion battery cells.

8. The apparatus according to claim 1, further comprising an output port having positive and negative polarity outputs; a vehicle battery isolation sensor connected in circuit with the positive and negative polarity outputs, configured to detect presence of a vehicle battery connected between the positive and negative polarity outputs; a reverse polarity sensor connected in circuit with the positive and negative polarity outputs, configured to detect polarity of a vehicle battery connected between the positive and negative polarity

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outputs and to provide an output signal indicating whether positive and negative terminals of the vehicle battery are properly connected with the positive and negative polarity outputs of the output port; a power switch connected between the internal power supply and the output port; and a microcontroller configured to receive input signals from the vehicle isolation sensor and the reverse polarity sensor, and to provide an output signal to the power switch, such that the power switch is turned on to cause the internal power supply to be connected to the output port in response to signals from the sensors indicating the presence of a vehicle battery at the output port and proper polarity connection of positive and negative terminals of the vehicle battery with the positive and negative polarity outputs, and is not turned on when signals from the sensors indicate either the absence of a vehicle battery at the output port or improper polarity connection of positive and negative terminals of the vehicle battery with the positive and negative polarity outputs, wherein the battery equalization circuit is a separate isolated circuit relative to the circuit with the positive and negative polarity outputs, and wherein the microcontroller is connected to and controls the battery equalization circuit.

9. The apparatus according to claim 8, wherein the power switch comprises a plurality of FETs connected in parallel.

10. The apparatus of claim 8, wherein the vehicle isolation sensor and reverse polarity sensor comprise optically coupled isolator phototransistors.

11. The apparatus of claim 8, further comprising a plurality of power diodes coupled between the output port and the internal power supply to prevent back-charging of the internal power supply from an electrical system connected to the output port.

12. The apparatus of claim 8, further comprising a temperature sensor configured to detect temperature of the internal power supply and to provide a temperature signal to the microcontroller.

13. The apparatus of claim 8, further comprising a voltage measurement circuit configured to measure output voltage of the internal power supply and to provide a voltage measurement signal to the microcontroller.

14. The apparatus of claim 8, further comprising a voltage regulator configured to convert output voltage of the internal power supply to a voltage level appropriate to provide operating power to internal components of the apparatus.

15. A portable or hand held jump starting apparatus, comprising:

- a Li-ion battery comprising a plurality of individual Li-ion battery cells connected together in series;
- a battery cell equalization circuit connected to the battery, the battery cell equalization circuit comprising:

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a plurality of individual battery cell equalization circuits, the plurality of individual battery cell equalization circuits arranged with one individual battery cell equalization circuit provided for each respective individual battery cell; and

a plurality of load resistors, the plurality of load resistors arranged with one load resistor provided for each respective individual battery equalization circuit resistor provide of each respective battery cell equalization circuit,

wherein the individual battery cell equalization circuits are each configured to discharge a respective individual battery cell using a respective load resistor upon the respective individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the particular cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the battery charging process is terminated, and

wherein the individual battery cell equalization circuits are configured to charge lower voltage individual battery cells at a higher rate allowing the lower voltage individual battery cells to increase in voltage to catch up to the respective cell having a highest voltage.

16. A portable or hand held jump starting apparatus, comprising:

a battery comprising a plurality of individual battery cells connected together in series;

a battery cell equalization circuit connected to the battery, the battery cell equalization circuit comprising:

an individual battery cell equalization circuit provided for each of the plurality of individual battery cells; a load resistor provided for each of the individual battery cell equalization circuits; and

a MOSFET switch and a voltage divider resistor provided for each of the individual battery cell equalization circuits,

wherein the individual battery cell equalization circuits are each configured to discharge a particular individual battery cell using the respective load resistor upon the particular individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the particular cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the battery charging process is terminated, and

wherein the individual battery cell equalization circuits are configured to charge lower voltage individual battery cells at a higher rate allowing lower voltage individual battery cells to catch up to the individual battery cell having a highest voltage.

* * * * *

EXHIBIT B



US011254213B2

(12) **United States Patent**
Nook et al.

(10) **Patent No.: US 11,254,213 B2**

(45) **Date of Patent: Feb. 22, 2022**

(54) **PORTABLE OR HAND HELD VEHICLE BATTERY JUMP STARTING APPARATUS WITH BATTERY CELL EQUALIZATION CIRCUIT**

(71) Applicant: **THE NOCO COMPANY**, Glenwillow, OH (US)

(72) Inventors: **Jonathan Lewis Nook**, Gates Mills, OH (US); **William Knight Nook, Sr.**, Shaker Heights, OH (US); **James Richard Stanfield**, Peoria, AZ (US); **Derek Michael Underhill**, Tempe, AZ (US)

(73) Assignee: **THE NOCO COMPANY**, Glenwillow, OH (US)

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PCT Pub. Date: **Oct. 3, 2019**

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H02J 7/00 (2006.01)
B60L 3/00 (2019.01)

(Continued)

(52) **U.S. Cl.**

CPC **B60L 3/0046** (2013.01); **B60L 50/60** (2019.02); **F02N 11/12** (2013.01); (Continued)

(58) **Field of Classification Search**

CPC **H02J 7/0016**
See application file for complete search history.

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Primary Examiner — Robert Grant

(74) *Attorney, Agent, or Firm* — Vorys, Sater, Seymour and Pease LLP; William L. Klima

(57) **ABSTRACT**

A portable or handheld device or apparatus for jump starting a vehicle engine having a depleted or discharged starting battery. The portable or handheld device or apparatus for jump starting a vehicle engine includes a rechargeable lithium-ion (Li-ion) battery pack and a battery cell equalization circuit configured to prevent overcharging of one or more individual lithium-ion battery cells, which can cause fire, damage to the battery pack and device or apparatus for jump starting a vehicle, or personal injury to a user.

16 Claims, 15 Drawing Sheets

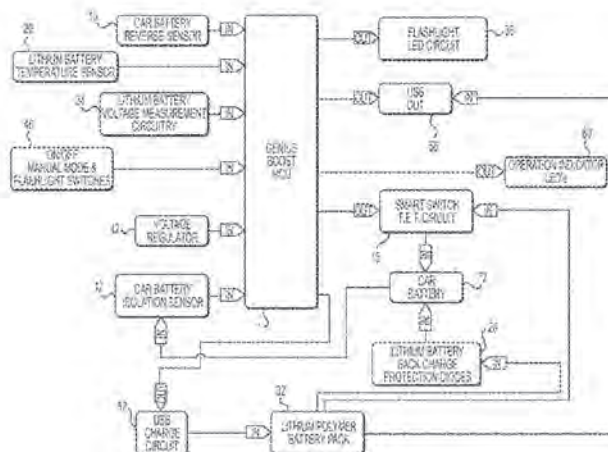


Exhibit B

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(52)	U.S. Cl.		
	CPC <i>H01M 10/0525</i> (2013.01); <i>H01M 10/425</i> (2013.01); <i>H01M 10/441</i> (2013.01); <i>H02J 7/0016</i> (2013.01); <i>H02J 7/0021</i> (2013.01); <i>H02J 7/0029</i> (2013.01); <i>H02J 7/0047</i> (2013.01); <i>B60L 53/18</i> (2019.02); <i>H01M 2010/4271</i> (2013.01); <i>H01M 2220/30</i> (2013.01)		
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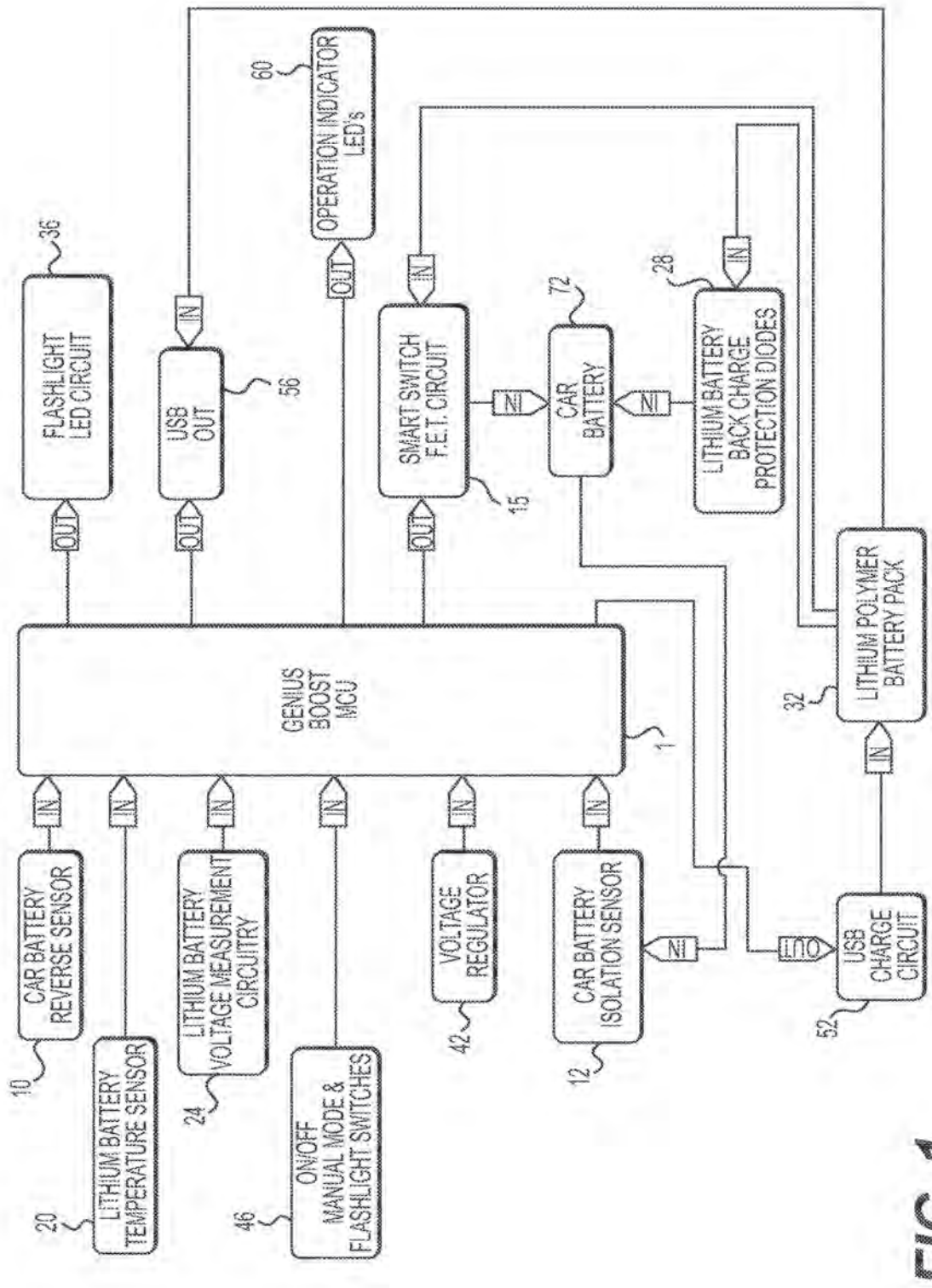


FIG. 1

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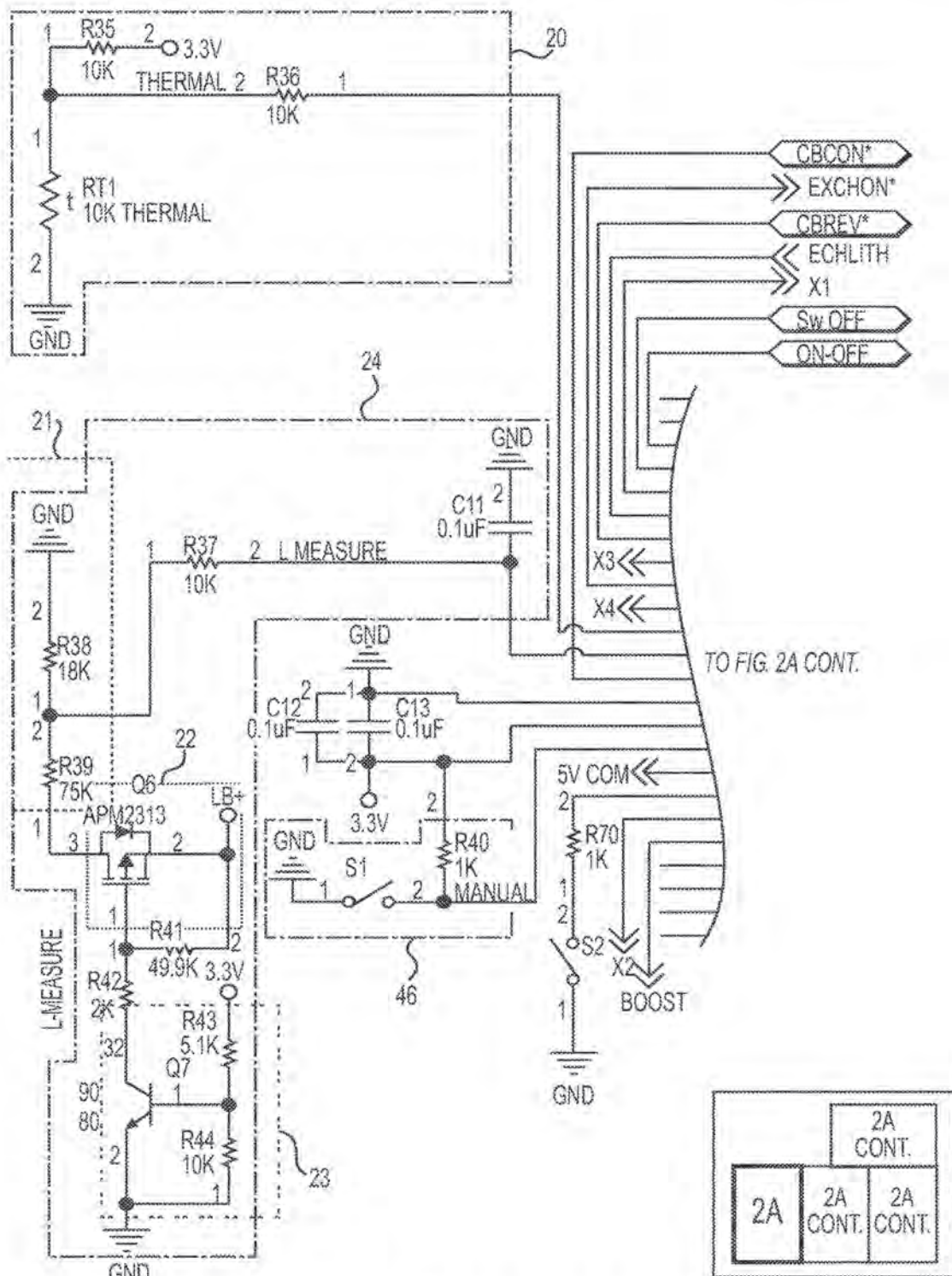


FIG. 2A

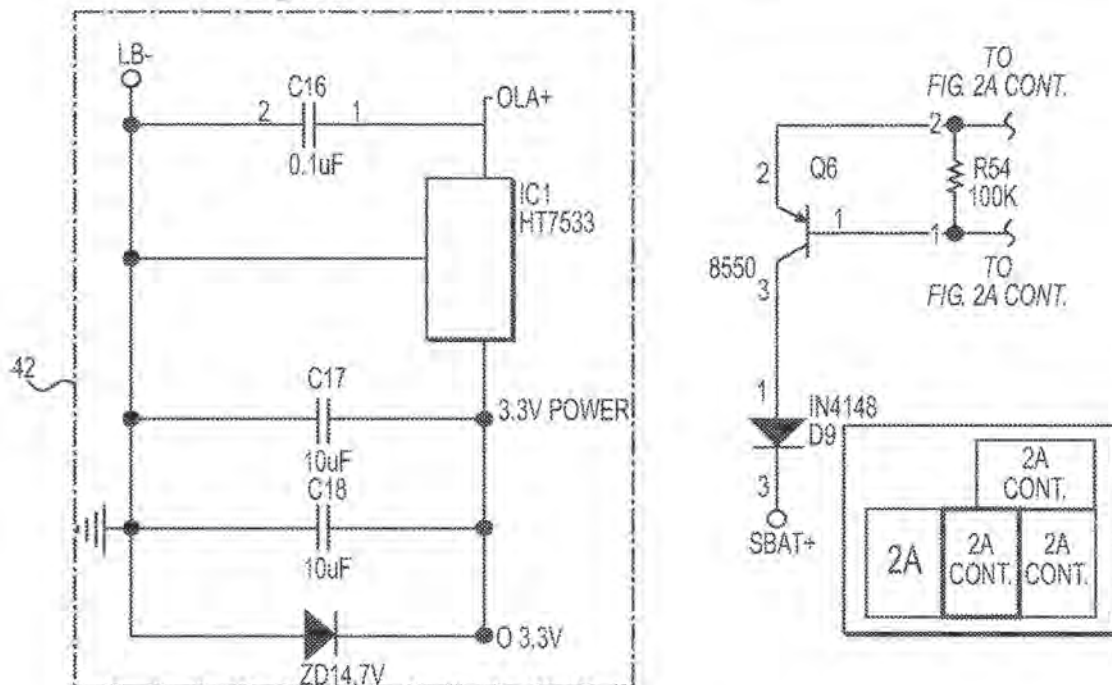
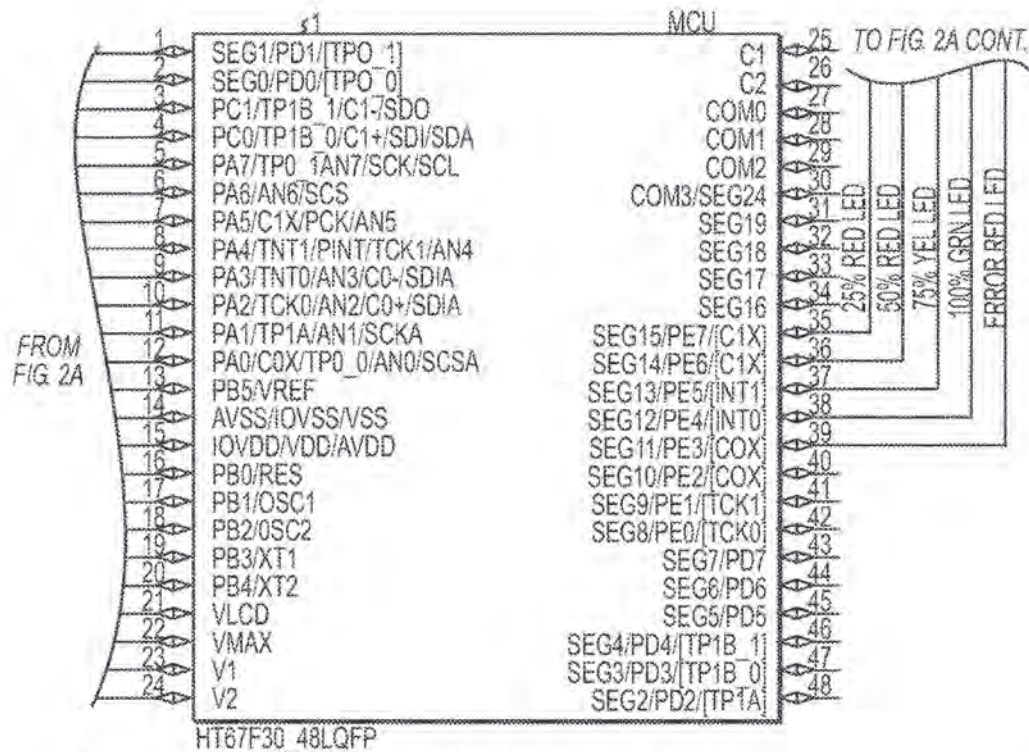


FIG. 2A CONT.

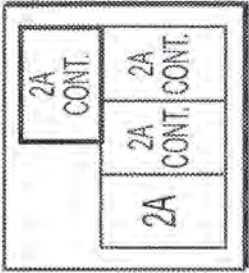
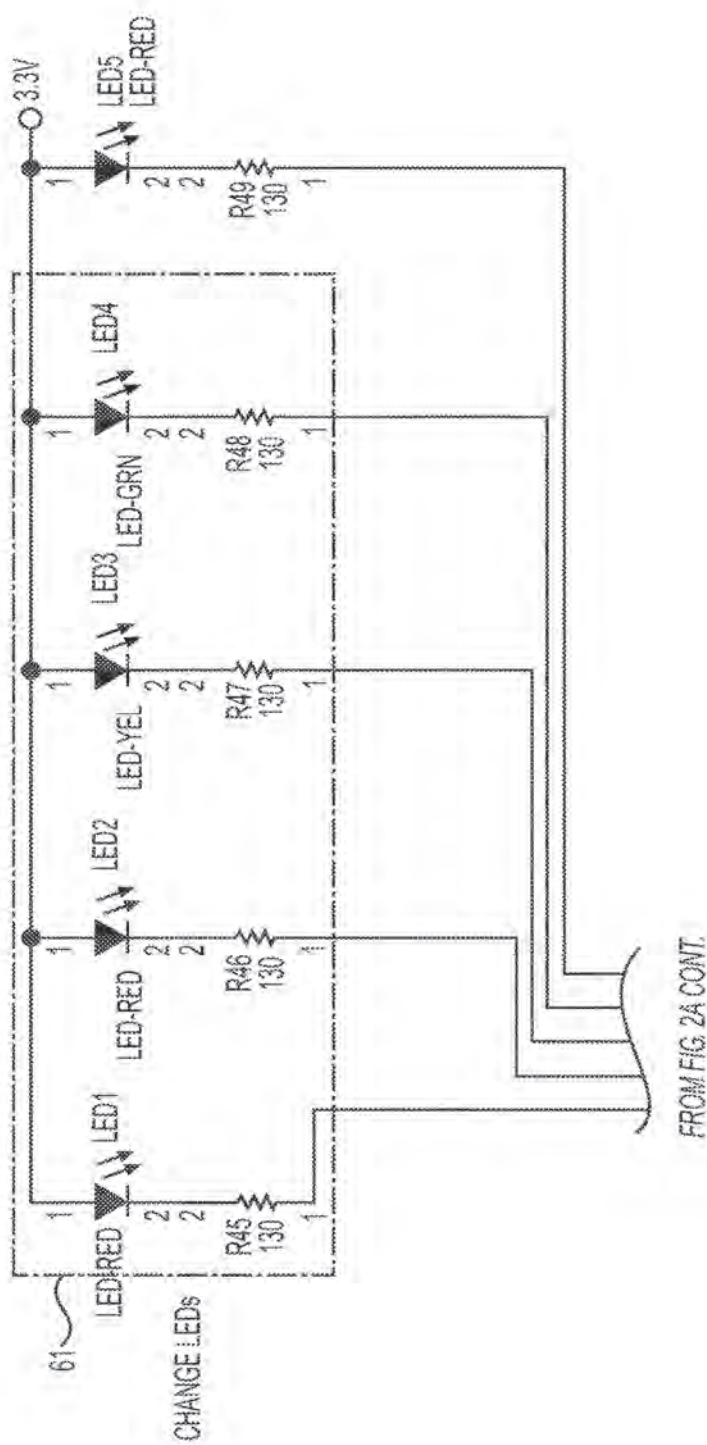


FIG. 2A CONT.

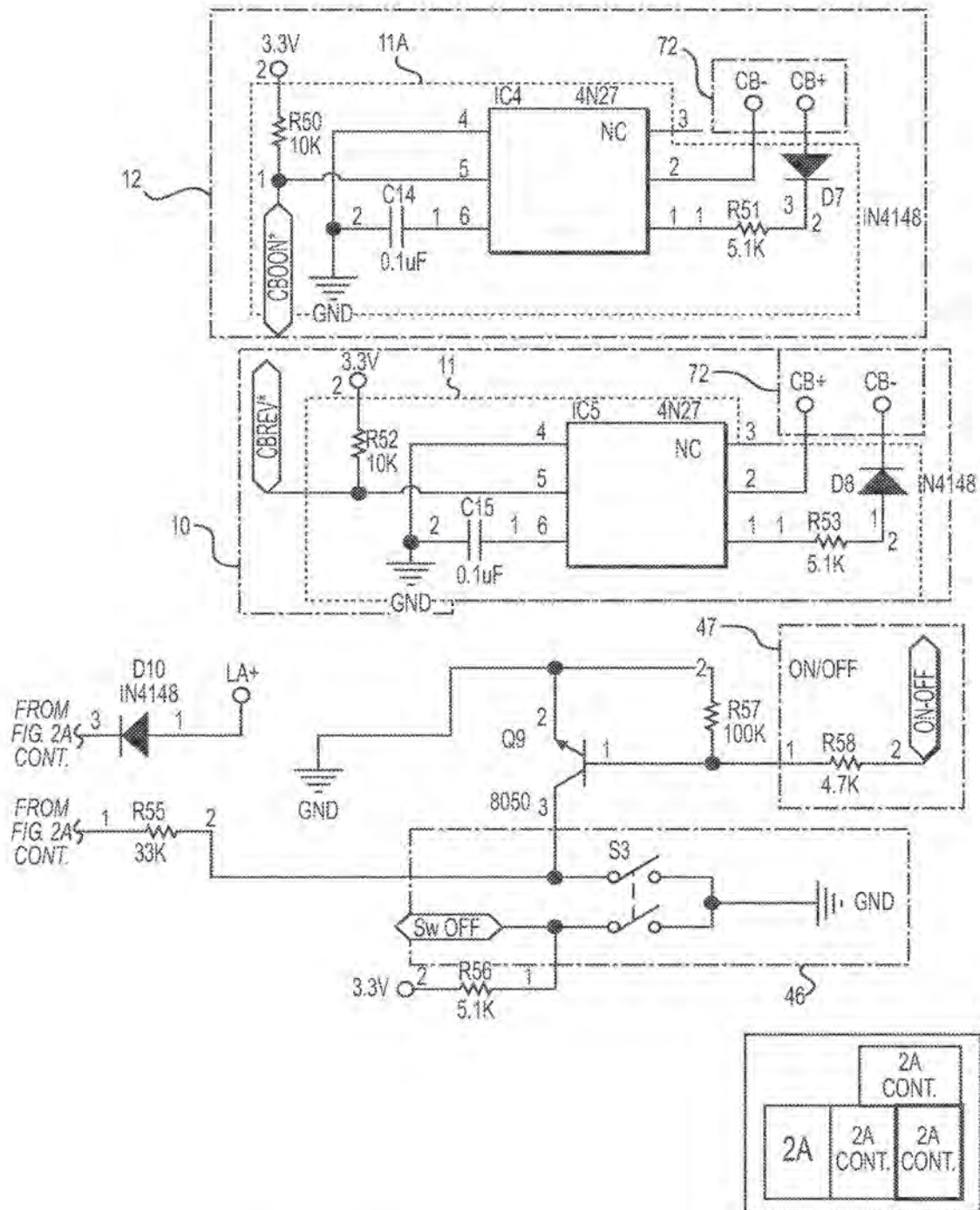


FIG. 2A CONT.

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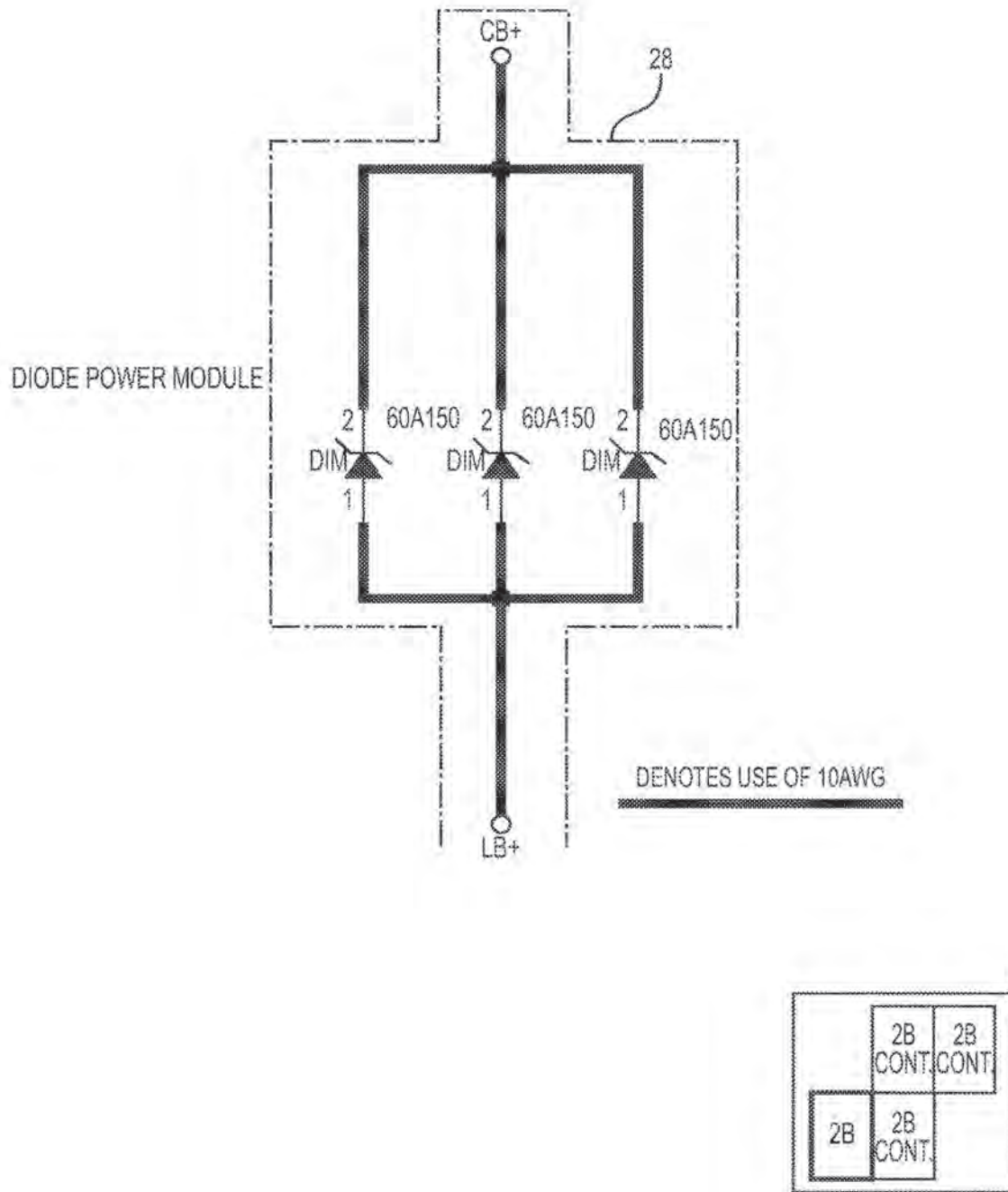


FIG. 2B

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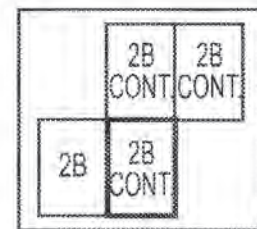
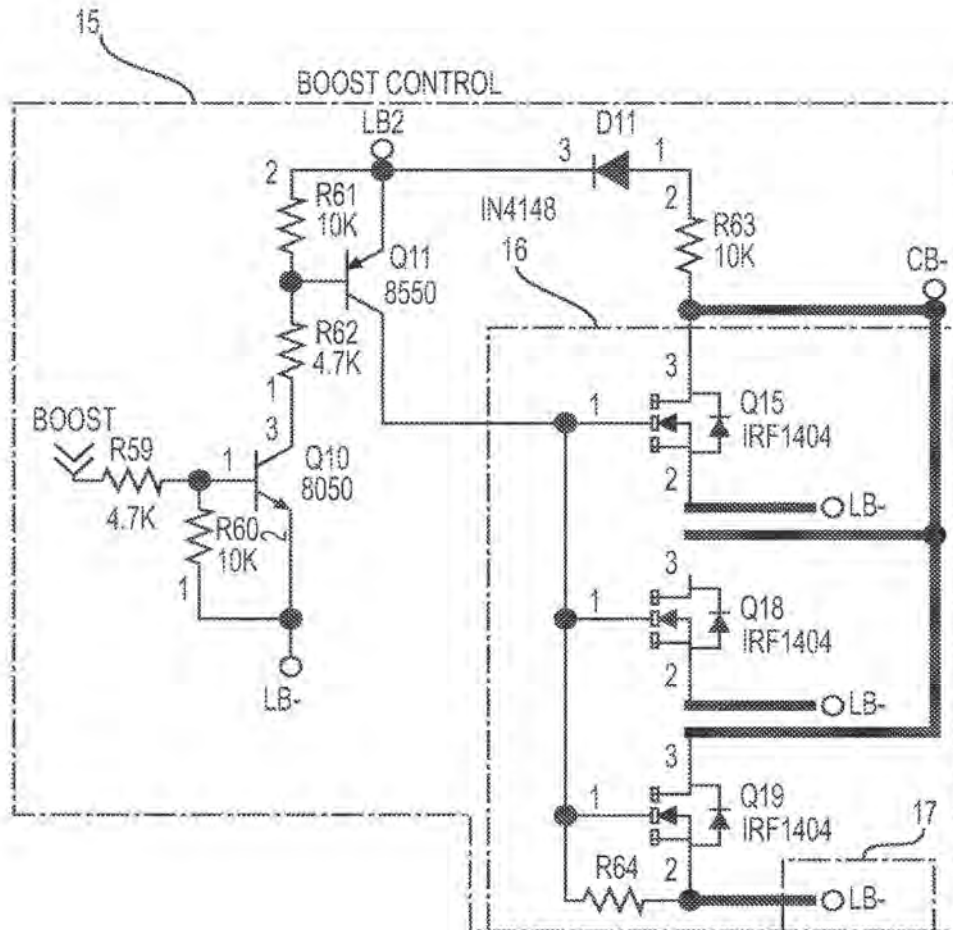


FIG. 2B CONT.

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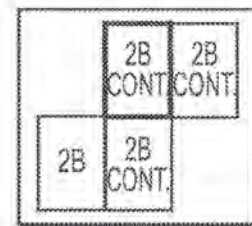
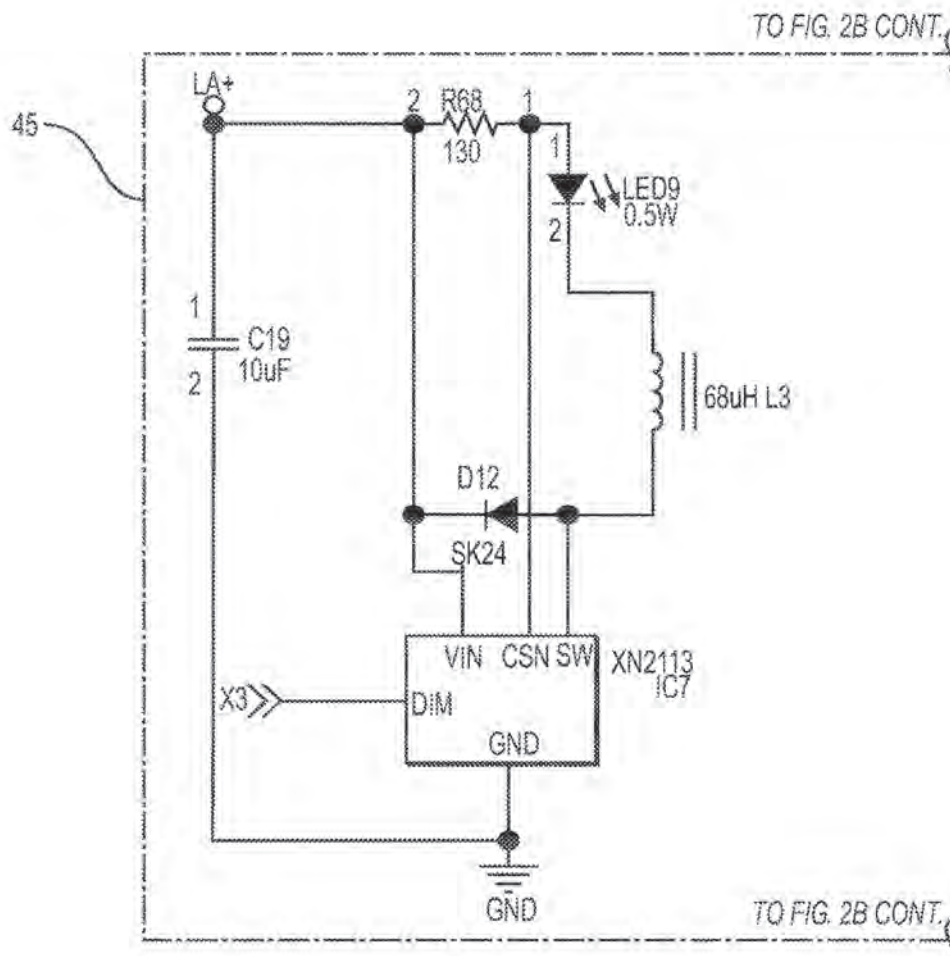


FIG. 2B CONT.

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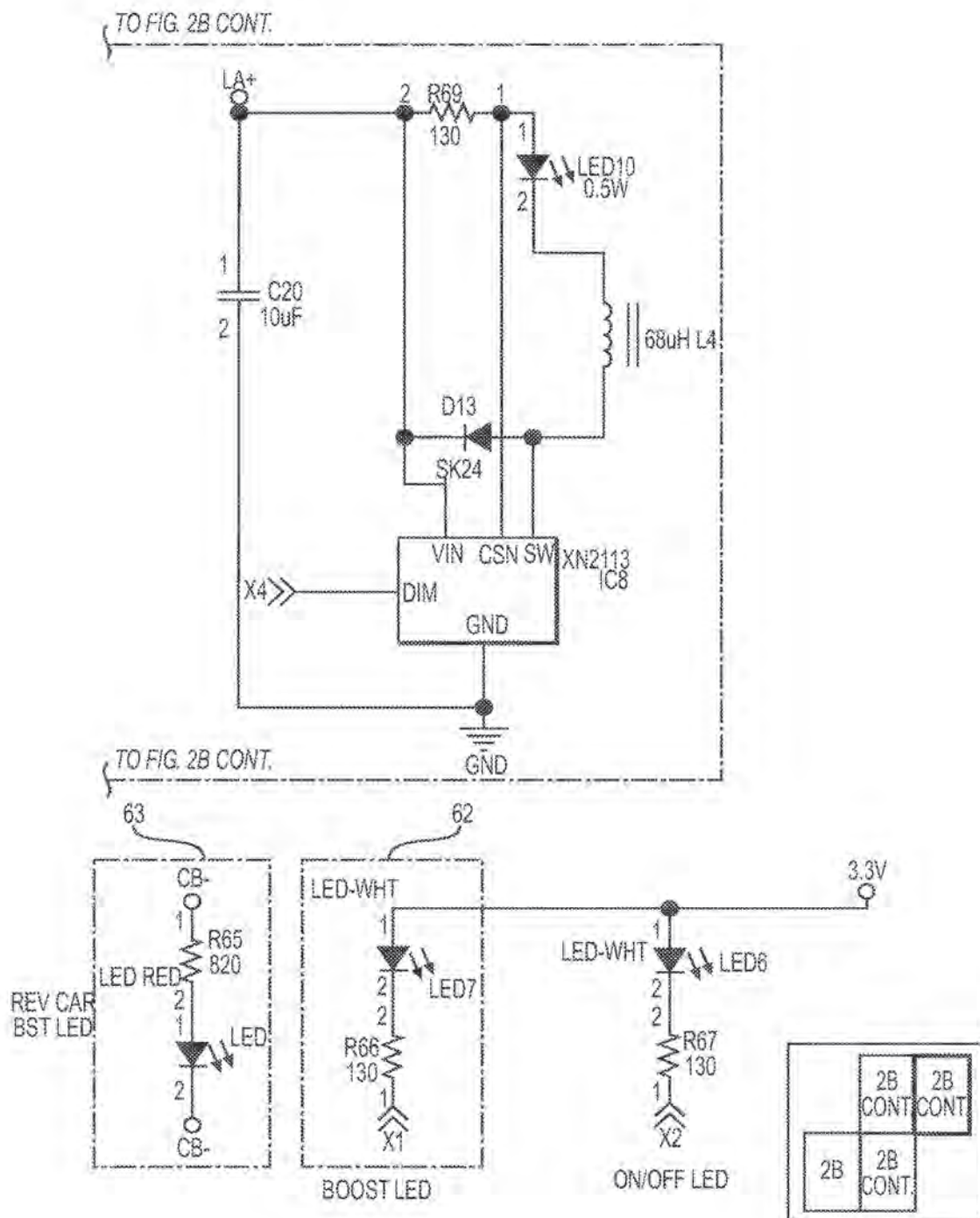


FIG. 2B CONT.

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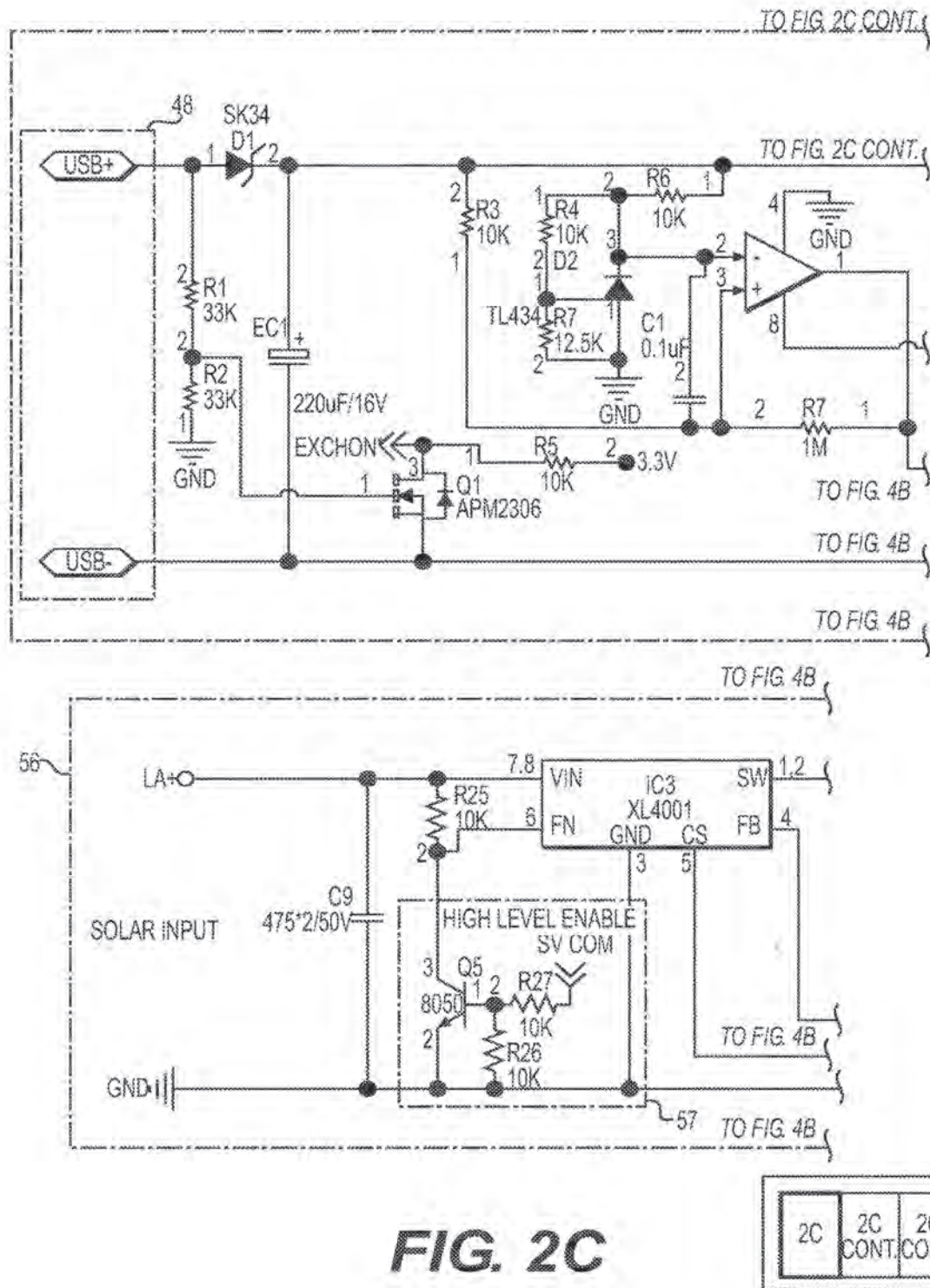


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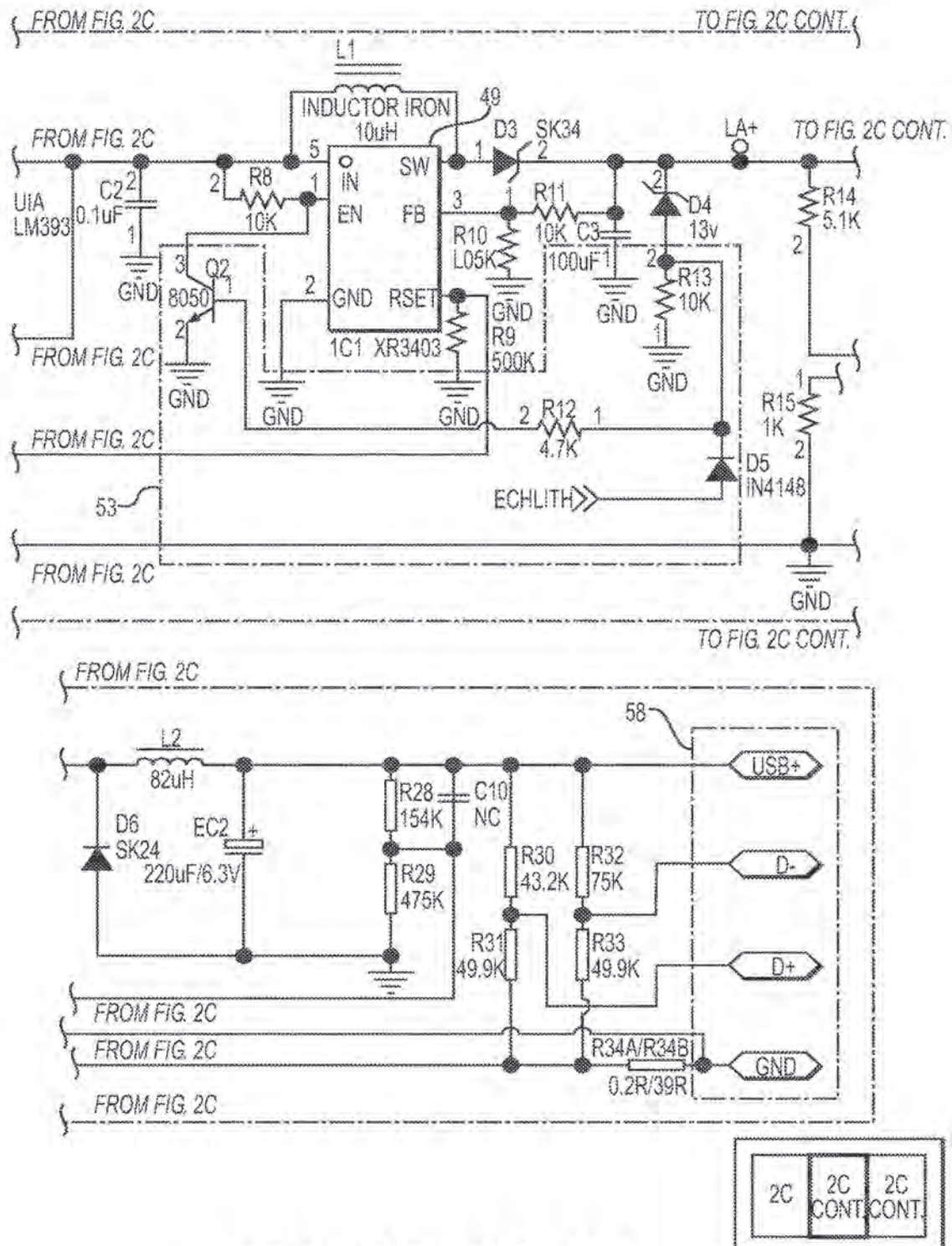


FIG. 2C CONT.

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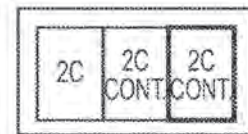
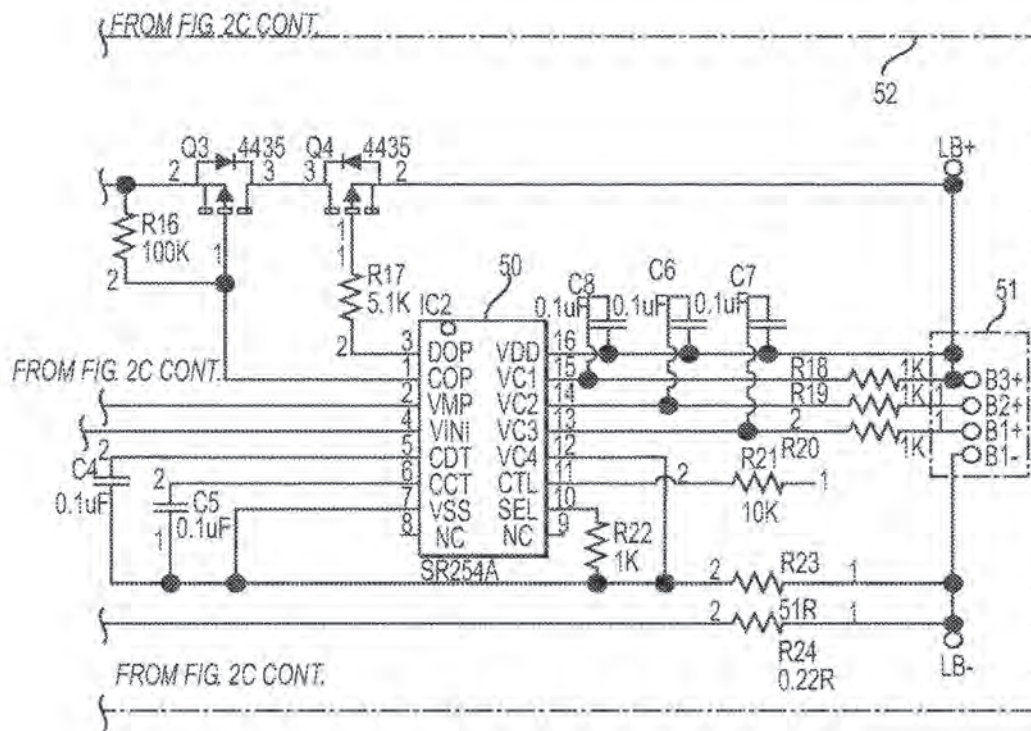


FIG. 2C CONT.

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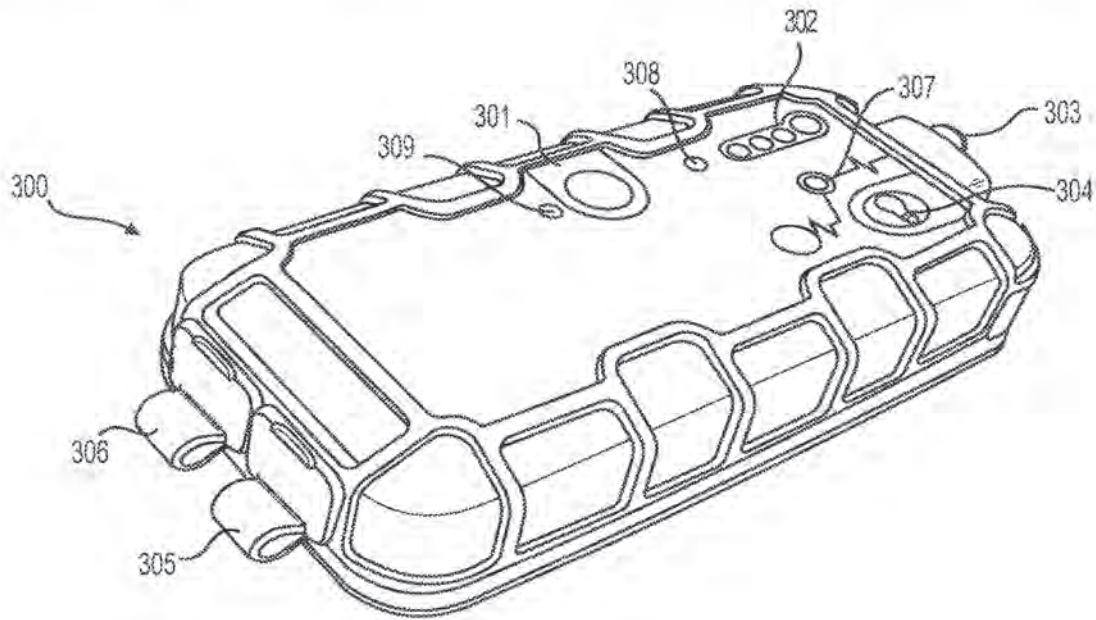


FIG. 3

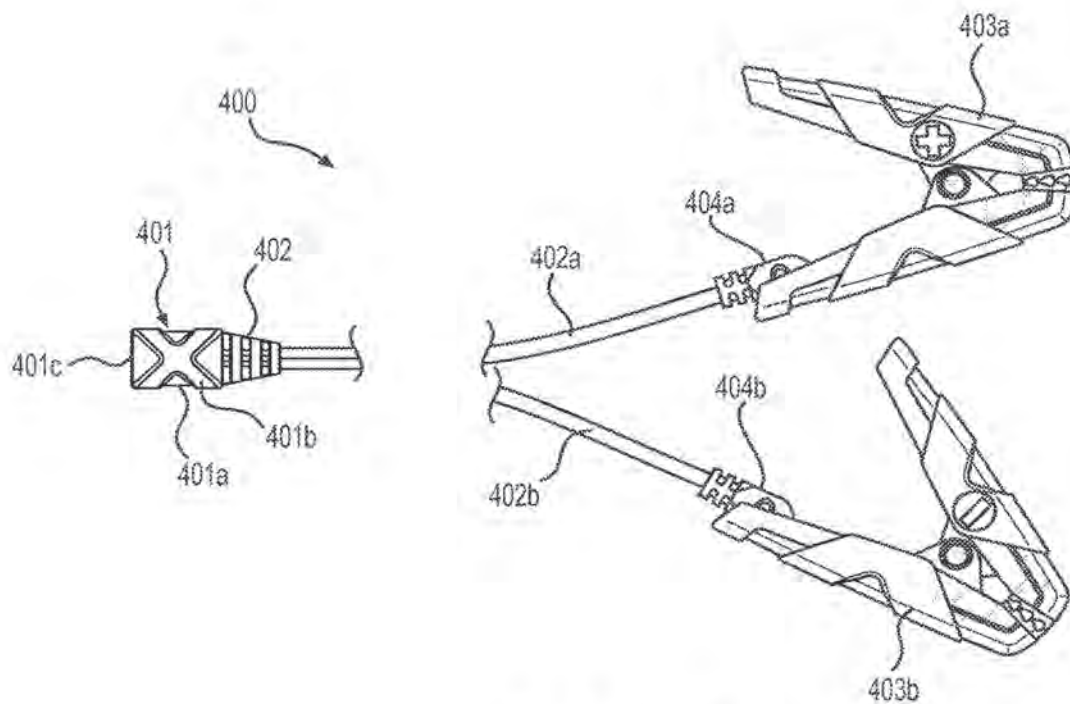


FIG. 4

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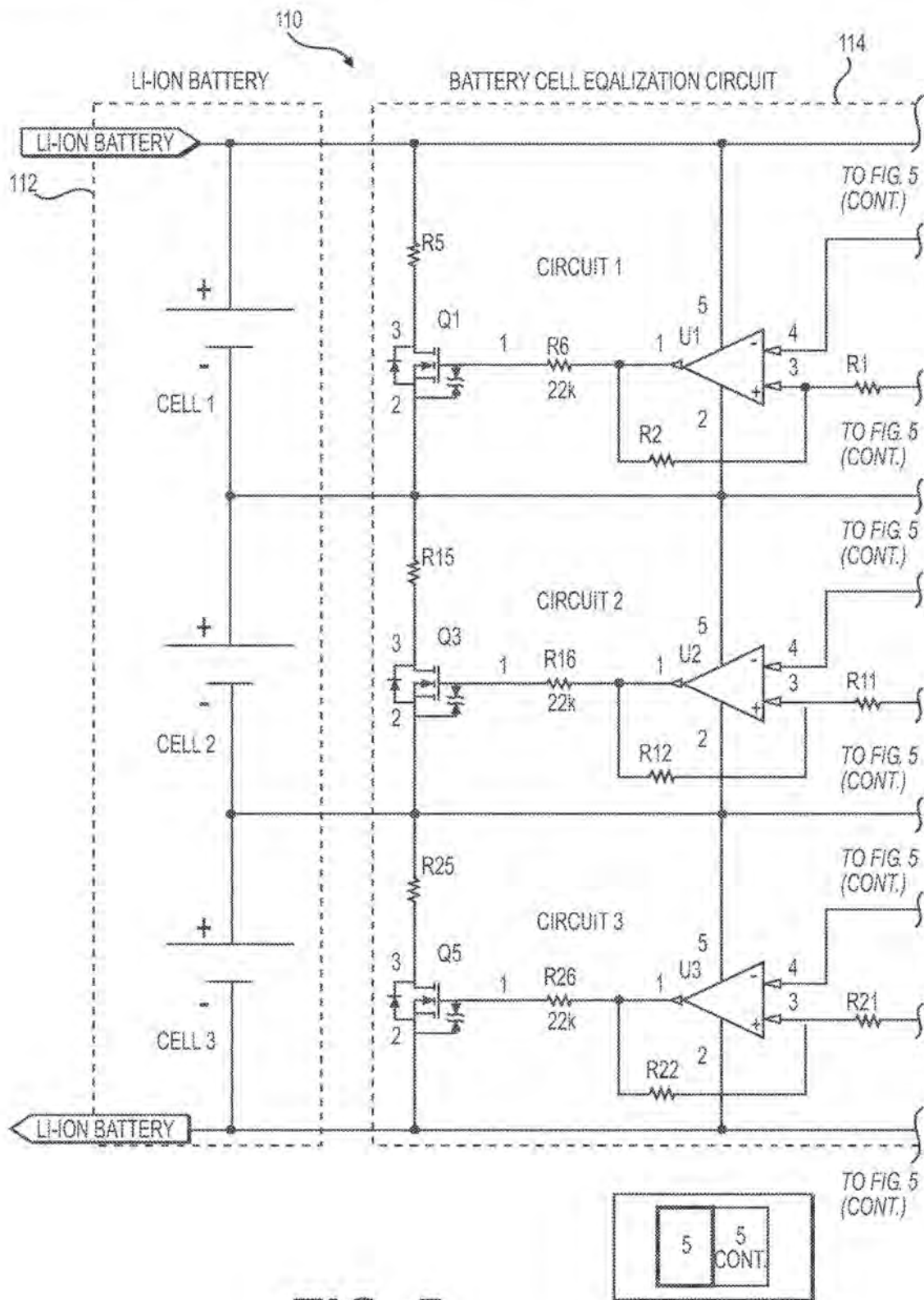


FIG. 5

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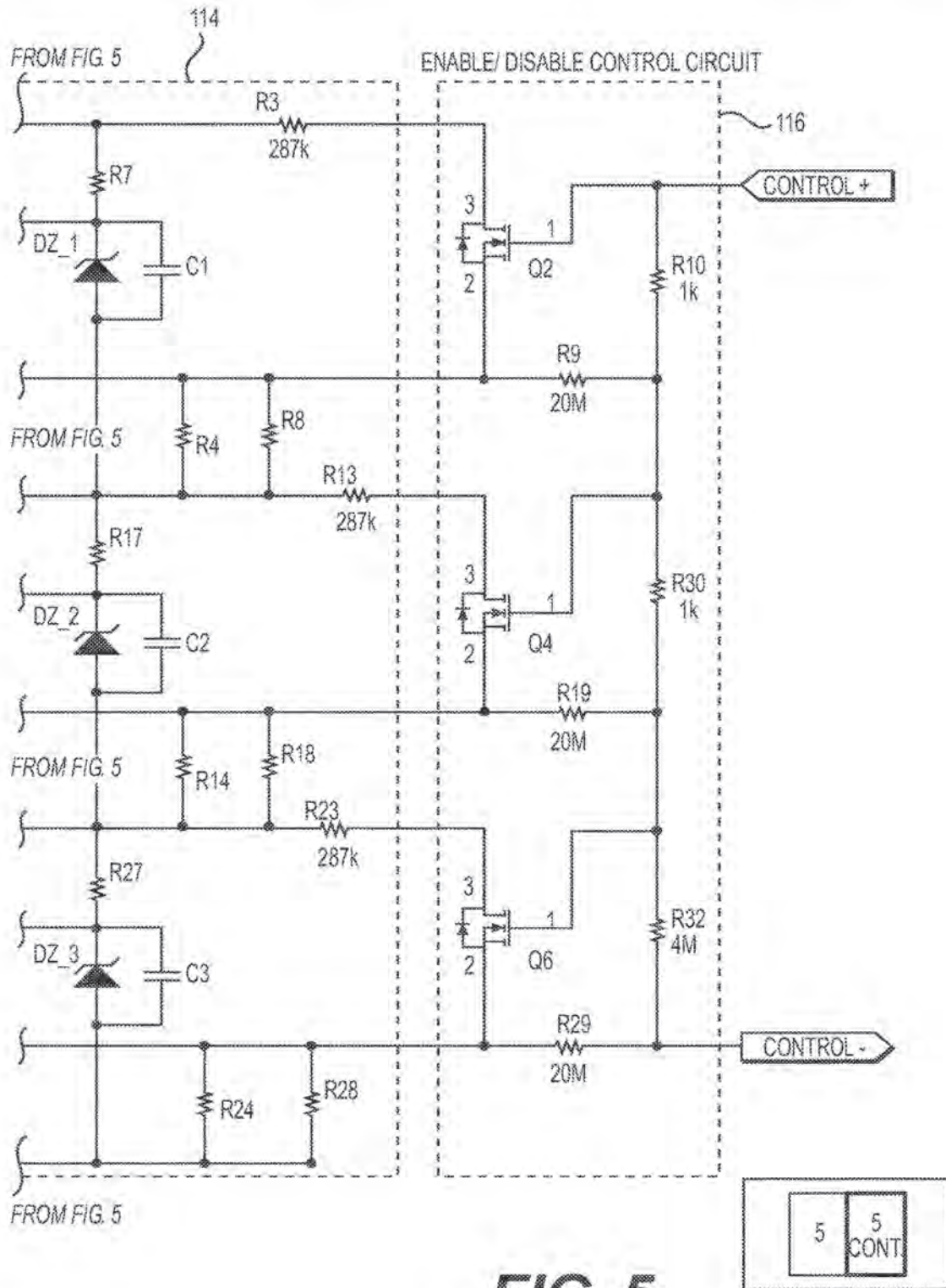


FIG. 5
(CONT.)

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**PORTABLE OR HAND HELD VEHICLE
BATTERY JUMP STARTING APPARATUS
WITH BATTERY CELL EQUALIZATION
CIRCUIT**

RELATED APPLICATIONS

This PCT application claims priority to PCT/US18/25424 filed on Mar. 30, 2018, which is hereby incorporated by reference herein in its entirety.

FIELD

The present invention relates generally to an electronic device or apparatus having multiple batteries or a battery pack having multiple battery cells provided with a battery cell equalization circuit. For example, the apparatus is a portable vehicle battery jump starting apparatus for jump starting a vehicle having a depleted or discharged battery. The portable vehicle battery jump starting device comprises a battery pack having multiple individual battery cells and a battery cell equalization circuit.

BACKGROUND

Prior art devices are known, which provide either a pair of electrical connector cables that connect a fully-charged battery of another vehicle to the engine start circuit of the dead battery vehicle, or portable booster devices which include a fully-charged battery which can be connected in circuit with the vehicle's engine starter through a pair of cables.

Problems with the prior art apparatus arose when either the jumper terminals or clamps of the cables were inadvertently brought into contact with each other while the other ends were connected to or being power, or when the positive and negative jumper terminals or clamps were connected to the opposite polarity terminals in the vehicle to be jumped, thereby causing a short circuit resulting in sparking and potential damage to batteries and/or bodily injury. Various attempts to eliminate these problems have been made in the prior art.

U.S. Pat. No. 6,212,054 issued Apr. 3, 2001, discloses a battery booster pack that is polarity sensitive and can detect proper and improper connections before providing a path for electric current flow. The device uses a set of LEDs connected to optical couplers oriented by a control circuit. The control circuit controls a solenoid assembly controlling the path of power current. The control circuit causes power current to flow through the solenoid assembly only if the points of contact of booster cable clamp connections have been properly made.

U.S. Pat. No. 6,632,103 issued Oct. 14, 2003, discloses an adaptive booster cable connected with two pairs of clips, wherein the two pairs of clips are respectively attached to two batteries to transmit power from one battery to the other battery. The adaptive booster cable includes a polarity detecting unit connected to each clip, a switching unit and a current detecting unit both provided between the two pairs of clips. After the polarity of each clip is sensed by the polarity detecting unit, the switching unit generates a proper connection between the two batteries. Therefore, the positive and negative terminals of the two batteries are correctly connected based on the detected result of the polarity detecting unit.

U.S. Pat. No. 8,493,021 issued Jul. 23, 2013, discloses apparatus that monitors the voltage of the battery of a

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vehicle to be jump started and the current delivered by the jump starter batteries to determine if a proper connection has been established and to provide fault monitoring. Only if the proper polarity is detected can the system operate. The voltage is monitored to determine open circuit, disconnected conductive clamps, shunt cable fault, and solenoid fault conditions. The current through the shunt cable is monitored to determine if there is a battery explosion risk, and for excessive current conditions presenting an overheating condition, which may result in fire. The system includes an internal battery to provide the power to the battery of the vehicle to be jump started. Once the vehicle is started, the unit automatically electrically disconnects from the vehicle's battery.

U.S. Pat. No. 5,189,359 issued Feb. 23, 1993, discloses a jumper cable device having two bridge rectifiers for developing a reference voltage, a four-input decoder for determining which terminals are to be connected based on a comparison of the voltage at each of the four terminals to the reference voltage, and a pair of relays for effecting the correct connection depending on the determination of the decoder. No connection will be made unless only one terminal of each battery has a higher voltage than the reference voltage, indicating "positive" terminals, and one has a lower voltage than the reference voltage, indicating "negative" terminals, and that, therefore, the two high voltage terminals may be connected and the two lower voltage terminals may be connected. Current flows once the appropriate relay device is closed. The relay device is preferably a MOSFET combined with a series array of photodiodes that develop MOSFET gate-closing potential when the decoder output causes an LED to light.

U.S. Pat. No. 5,795,182 issued Aug. 18, 1998, discloses a polarity independent set of battery jumper cables for jumping a first battery to a second battery. The apparatus includes a relative polarity detector for detecting whether two batteries are configured cross or parallel. A three-position high current capacity crossbar pivot switch is responsive to the relative polarity detector for automatically connecting the plus terminals of the two batteries together and the minus terminals of the two batteries together regardless of whether the configuration detected is cross or parallel, and an under-current detector and a delay circuit for returning the device to its ready and unconnected state after the device has been disconnected from one of the batteries. The crossbar pivot switch includes two pairs of contacts, and a pivot arm that pivots about two separate points to ensure full electrical contact between the pairs of contacts.

The present invention can also be used to produce a battery charger that may be connected to a battery without regard to the polarity of the battery.

U.S. Pat. No. 6,262,492 issued Jul. 17, 2001, discloses a car battery jumper cable for accurately coupling an effective power source to a failed or not charged battery, which includes a relay switching circuit connected to the power source and the battery by two current conductor pairs. First and second voltage polarity recognition circuits are respectively connected to the power source and the battery by a respective voltage conductor pair to recognize the polarity of the power source and the battery. A logic recognition circuit produces a control signal subject to the polarity of the power source and the battery, and a driving circuit controlled by the control signal from the logic recognition circuit drives the relay switching circuit, enabling the two poles of the power source to be accurately coupled to the two poles of the battery.

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U.S. Pat. No. 5,635,817 issued Jun. 3, 1997, discloses a vehicle battery charging device that includes a control housing having cables including a current limiting device to prevent exceeding of a predetermined maximum charging current of about 40 to 60 amps. The control housing includes a polarity detecting device to verify the correct polarity of the connection of the terminals of the two batteries and to electrically disconnect the two batteries if there is an incorrect polarity.

U.S. Pat. No. 8,199,024 issued Jun. 12, 2012, discloses a safety circuit in a low-voltage connecting system that leaves the two low-voltage systems disconnected until it determines that it is safe to make a connection. When the safety circuit determines that no unsafe conditions exist and that it is safe to connect the two low-voltage systems, the safety circuit may connect the two systems by way of a "soft start" that provides a connection between the two systems over a period of time that reduces or prevents inductive voltage spikes on one or more of the low-voltage systems. When one of the low-voltage systems has a completely-discharged battery incorporated into it, a method is used for detection of proper polarity of the connections between the low-voltage systems. The polarity of the discharged battery is determined by passing one or more test currents through it and determining whether a corresponding voltage rise is observed.

U.S. Pat. No. 5,793,185 issued Aug. 11, 1998, discloses a hand-held jump starter having control components and circuits to prevent overcharging and incorrect connection to batteries.

Further, there exists a problem with the prior art electronic devices or apparatus having multiple batteries or a battery pack with multiple battery cells.

For example, lithium-ion (Li-ion) batteries have been known to explode or catch fire due to overheating when individual battery cells get overcharged. The battery life also decreases, if individual battery cells are not equally charged, causing significantly unequal voltages across the individual battery cells.

Currently, portable or hand-held vehicle jump starters using Li-ion batteries do not include battery equalization circuits. Thus, Li-ion batteries can suffer from the above overcharging problems. An example of such a hand-held vehicle jump starter is disclosed in U.S. Pat. No. 9,007,015, which is incorporated herein by reference.

A battery cell equalization circuit according to the present invention can be applied or incorporated into the portable or hand-held vehicle jump starter device disclosed and claimed in U.S. Pat. No. 9,007,015.

There exists a need to provide battery equalization circuits, for example, with electronic apparatus having multiple Li-ion batteries or Li-ion battery packs having multiple battery cells, for example, in rechargeable electronic devices such as the portable or hand-held vehicle jump starter device according to the present invention.

While the prior art attempted to provide solutions to one or more of the above-mentioned problem(s) as discussed above, each of the prior art solutions suffers from other shortcomings, either in complexity, cost and/or has potential for malfunction. Accordingly, there exists a need in the art for further improvements to electronic devices or apparatus having multiple batteries or battery packs having multiple battery cells such as used in vehicle jump starting devices or apparatus.

SUMMARY

In accordance with an aspect of the invention, an electronic device or apparatus is provided for jump starting a

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vehicle engine, including: an internal power supply; an output port having positive and negative polarity outputs; a vehicle battery isolation sensor connected in circuit with the positive and negative polarity outputs, configured to detect presence of a vehicle battery connected between the positive and negative polarity outputs; a reverse polarity sensor connected in circuit with the positive and negative polarity outputs, configured to detect polarity of a vehicle battery connected between the positive and negative polarity outputs; a power FET switch connected between the internal power supply and the output port; and a microcontroller configured to receive input signals from the vehicle isolation sensor and the reverse polarity sensor, and to provide an output signal to the power FET switch, such that the power FET switch is turned on to connect the internal power supply to the output port in response to signals from the sensors indicating the presence of a vehicle battery at the output port and proper polarity connection of positive and negative terminals of the vehicle battery with the positive and negative polarity outputs.

In accordance with another aspect of the invention, the internal power supply is a rechargeable lithium-ion (Li-ion) battery pack.

In accordance with yet another aspect of the invention, a jumper cable device is provided with a plug configured to plug into an output port of a handheld battery charger booster device having an internal power supply; a pair of cables integrated with the plug at one respective end thereof; the pair of cables being configured to be separately connected to terminals of a battery at another respective end thereof.

The present invention also provides a battery cell equalization circuit for an electronic device or apparatus having multiple battery cells (e.g. Li-ion batteries) or a battery pack having multiple battery cells (e.g. Li-ion battery cells). For example, the batteries or battery pack can comprise or consist of multiple batteries connected to a battery cell equalization circuit. The battery cell equalization circuit (e.g. circuit board) can be packaged internally with the batteries or battery pack, or can be an electronic circuit or component separate from the battery pack installed in the electronic device or apparatus powered by the battery pack (e.g. circuit board within electronic device, but not packaged with battery pack). The batteries or battery packs can be rechargeable using lithium-ion, nickel cadmium, or rechargeable batteries or battery cells.

The battery cell equalization circuit according to the present invention, for example, can be applied or implemented in a rechargeable electronic device or apparatus such as a tool, portable or hand-held vehicle jump starter, vehicle, electrical vehicle (e.g. electric car, electric truck, electric bus, electric golf cart, electric utility cart, motorcycle, mini bike, scooter, go kart), radio, electronic player, radio controlled device, radio controlled toy (e.g. R/C airplane, R/C boat, R/C car, R/C truck), game, or other numerous other rechargeable electronic devices, apparatus, or applications.

The battery cell equalization circuit can be applied to or used in a portable or hand-held jump starter. This type of electronic device conveys a significant amount of energy or power from the rechargeable batteries or battery pack to a deplete or discharged battery being jump started in a short amount of time requiring the batteries or battery cells to all be fully charged and balanced.

The battery cell equalization circuit according to the present invention can be configured to be simple, safe, effective, low cost, and can include a controllable mecha-

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nism to enable or disable itself from trying to sense the cell voltages and trying to equalize them.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of a handheld vehicle battery boost apparatus in accordance with one aspect of the present invention;

FIGS. 2A-2C are schematic circuit diagrams of an example embodiment of a handheld vehicle battery boost apparatus in accordance with an aspect of the invention;

FIG. 3 is a perspective view of a handheld jump starter booster device in accordance with one example embodiment of the invention; and

FIG. 4 is a planar view of a jumper cable usable with the handheld jump starter booster device in accordance with another aspect of the invention.

FIG. 5 is a schematic circuit diagram of a battery cell equalization circuit according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 is a functional block diagram of a handheld battery booster according to one aspect of the invention. At the heart of the handheld battery booster is a lithium polymer battery pack 32, which stores sufficient energy to jump start a vehicle engine served by a conventional 12 volt lead-acid or valve regulated lead-acid battery. In one example embodiment, a high-surge lithium polymer battery pack includes three 3.7 V, 2666 mAh lithium polymer batteries in a 3S1P configuration. The resulting battery pack provides 11.1 V, 2666 Ah (8000 Ah at 3.7 V, 29.6 Wh). Continuous discharge current is 25 C (or 200 amps), and burst discharge current is 50 C (or 400 amps). The maximum charging current of the battery pack is 8000 mA (8 amps).

A programmable microcontroller unit (MCU) 1 receives various inputs and produces informational as well as control outputs. The programmable MCU 1 further provides flexibility to the system by allowing updates in functionality and system parameters, without requiring any change in hardware. According to one example embodiment, an 8 bit microcontroller with 2 Kbytes, 15 bits of flash memory is used to control the system. One such microcontroller is the HT67F30, which is commercially available from Holtek Semiconductor Inc.

A car battery reverse sensor 10 monitors the polarity of the vehicle battery 72 when the handheld battery booster device is connected to the vehicle's electric system. As explained below, the booster device prevents the lithium battery pack from being connected to the vehicle battery 72 when the terminals of the battery 72 are connected to the wrong terminals of the booster device. A car battery isolation sensor 12 detects whether or not a vehicle battery 72 is connected to the booster device, and prevents the lithium battery pack from being connected to the output terminals of the booster device unless there is a good (e.g. chargeable) battery connected to the output terminals.

A smart switch FET circuit 15 electrically switches the handheld battery booster lithium battery to the vehicle's electric system only when the vehicle battery is determined by the MCU 1 to be present (in response to a detection signal provided by isolation sensor 12) and connected with the correct polarity (in response to a detection signal provided by reverse sensor 10). A lithium battery temperature sensor 20 monitors the temperature of the lithium battery pack 32 to detect overheating due to high ambient temperature

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conditions and overextended current draw during jump starting. A lithium battery voltage measurement circuit 24 monitors the voltage of the lithium battery pack 32 to prevent the voltage potential from rising too high during a charging operation and from dropping too low during a discharge operation.

Lithium-ion battery back-charge protection diodes 28 prevent any charge current being delivered to the vehicle battery 72 from flowing back to the lithium battery pack 32 from the vehicle's electrical system. Flashlight LED circuit 36 is provided to furnish a flashlight function for enhancing light under a vehicle's hood in dark conditions, as well as providing SOS and strobe lighting functions for safety purposes when a vehicle may be disabled in a potentially dangerous location. Voltage regulator 42 provides regulation of internal operating voltage for the microcontroller and sensors. On/Off manual mode and flashlight switches 46 allow the user to control power-on for the handheld battery booster device, to control manual override operation if the vehicle has no battery, and to control the flashlight function. The manual button functions only when the booster device is powered on. This button allows the user to jump-start vehicles that have either a missing battery, or the battery voltage is so low that automatic detection by the MCU is not possible. When the user presses and holds the manual override button for a predetermined period time (such as three seconds) to prevent inadvertent actuation of the manual mode, the internal lithium ion battery power is switched to the vehicle battery connect port. The only exception to the manual override is if the car battery is connected in reverse. If the car battery is connected in reverse, the internal lithium battery power shall never be switched to the vehicle battery connect port.

USB charge circuit 52 converts power from any USB charger power source, to charge voltage and current for charging the lithium battery pack 32. USB output 56 provides a USB portable charger for charging smartphones, tablets, and other rechargeable electronic devices. Operation indicator LEDs 60 provide visual indication of lithium battery capacity status as well as an indication of smart switch activation status (indicating that power is being provided to the vehicle's electrical system).

Detailed operation of the handheld booster device will now be described with reference to the schematic diagrams of FIGS. 2A-2C. As shown in FIG. 2A, the microcontroller unit 1 is the center of all inputs and outputs. The reverse battery sensor 10 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D8 in the lead conductor of pin 1 (associated with the negative terminal CB-), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11 will not conduct current, and is therefore turned off, providing a "1" or high output signal to the MCU 1. The car battery isolation sensor 12 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D7 in the lead conductor of pin 1 (associated with the positive terminal CB+), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11A will conduct current, and is therefore turned on, providing a "0" or low output signal to the MCU, indicating the presence of a battery across the jumper output terminals of the handheld booster device.

If the car battery 72 is connected to the handheld booster device with reverse polarity, the optocoupler LED 11 of the

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reverse sensor 10 will conduct current, providing a “0” or low signal to microcontroller unit 1. Further, if no battery is connected to the handheld booster device, the optocoupler LED 11A of the isolation sensor 12 will not conduct current, and is therefore turned off, providing a “1” or high output signal to the MCU, indicating the absence of any battery connected to the handheld booster device. Using these specific inputs, the microcontroller software of MCU 1 can determine when it is safe to turn on the smart switch FET 15, thereby connecting the lithium battery pack to the jumper terminals of the booster device. Consequently, if the car battery 72 either is not connected to the booster device at all, or is connected with reverse polarity, the MCU 1 can keep the smart switch FET 15 from being turned on, thus prevent sparking/short circuiting of the lithium battery pack.

As shown in FIG. 2B, the FET smart switch 15 is driven by an output of the microcontroller 1. The FET smart switch 15 includes three FETs (Q15, Q18, and Q19) in parallel, which spreads the distribution of power from the lithium battery pack over the FETs. When that microcontroller output is driven to a logic low, FETs 16 are all in a high resistance state, therefore not allowing current to flow from the internal lithium battery negative contact 17 to the car battery 72 negative contact. When the micro controller output is driven to a logic high, the FETs 16 (Q15, Q18, and Q19) are in a low resistant state, allowing current to flow freely from the internal lithium battery pack negative contact 17 (LB-) to the car battery 72 negative contact (CB-). In this way, the microcontroller software controls the connection of the internal lithium battery pack 32 to the vehicle battery 72 for jumpstarting the car engine.

Referring back to FIG. 2A, the internal lithium battery pack voltage can be accurately measured using circuit 24 and one of the analog-to-digital inputs of the microcontroller 1. Circuit 24 is designed to sense when the main 3.3 V regulator 42 voltage is on, and to turn on transistor 23 when the voltage of regulator 42 is on. When transistor 23 is conducting, it turns on FET 22, thereby providing positive contact (LB+) of the internal lithium battery a conductive path to voltage divider 21 allowing a lower voltage range to be brought to the microcontroller to be read. Using this input, the microcontroller software can determine if the lithium battery voltage is too low during discharge operation or too high during charge operation, and take appropriate action to prevent damage to electronic components.

Still referring to FIG. 2A, the temperature of the internal lithium battery pack 32 can be accurately measured by two negative temperature coefficient (NTC) devices 20. These are devices that reduce their resistance when their temperature rises. The circuit is a voltage divider that brings the result to two analog-to-digital (A/D) inputs on the microcontroller 1. The microcontroller software can then determine when the internal lithium battery is too hot to allow jumpstarting, adding safety to the design.

The main voltage regulator circuit 42 is designed to convert internal lithium battery voltage to a regulated 3.3 volts that is utilized by the microcontroller 1 as well as by other components of the booster device for internal operating power. Three lithium battery back charge protection diodes 28 (see FIG. 2) are in place to allow current to flow only from the internal lithium battery pack 32 to the car battery 72, and not from the car battery to the internal lithium battery. In this way, if the car electrical system is charging from its alternator, it cannot back-charge (and thereby damage) the internal lithium battery, providing another level of safety. The main power on switch 46 (FIG. 2A) is a combination that allows for double pole, double

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throw operation so that with one push, the product can be turned on if it is in the off state, or turned off if it is in the on state. This circuit also uses a microcontroller output 47 to “keep alive” the power when it is activated by the on switch. When the switch is pressed the microcontroller turns this output to a high logic level to keep power on when the switch is released. In this way, the microcontroller maintains control of when the power is turned off when the on/off switch is activated again or when the lithium battery voltage is getting too low. The microcontroller software also includes a timer that turns the power off after a predefined period of time, (such as, e.g. 8 hours) if not used.

The flashlight LED circuit 45 shown in FIG. 2B controls the operation of flashlight LEDs. Two outputs from the microcontroller 1 are dedicated to two separate LEDs. Thus, the LEDs can be independently software-controlled for strobe and SOS patterns, providing yet another safety feature to the booster device. LED indicators provide the feedback the operator needs to understand what is happening with the product. Four separate LEDs 61 (FIG. 2A) are controlled by corresponding individual outputs of microcontroller 1 to provide indication of the remaining capacity of the internal lithium battery. These LEDs are controlled in a “fuel gauge” type format with 25%, 50%, 75% and 100% (red, red, yellow, green) capacity indications. An LED indicator 63 (FIG. 2B) provides a visual warning to the user when the vehicle battery 72 has been connected in reverse polarity. “Boost” and on/off LEDs 62 provide visual indications when the booster device is provide jump-start power, and when the booster device is turned on, respectively.

A USB output 56 circuit, as shown in FIG. 2C is included to provide a USB output for charging portable electronic devices such as smartphones from the internal lithium battery pack 32. Control circuit 57 from the microcontroller 1 allows the USB Out 56 to be turned on and off by software control to prevent the internal lithium battery getting too low in capacity. The USB output is brought to the outside of the device on a standard USB connector 58, which includes the standard voltage divider required for enabling charge to certain smartphones that require it. The USB charge circuit 52 allows the internal lithium battery pack 32 to be charged using a standard USB charger. This charge input uses a standard micro-USB connector 48 allowing standard cables to be used. The 5 V potential provided from standard USB chargers is up-converted to the 12.4 VDC voltage required for charging the internal lithium battery pack using a DC-DC converter 49. The DC-DC converter 49 can be turned on and off via circuit 53 by an output from the microcontroller 1.

In this way, the microcontroller software can turn the charge off if the battery voltage is measured to be too high by the A/D input 22. Additional safety is provided for helping to eliminate overcharge to the internal lithium battery using a lithium battery charge controller 50 that provides charge balance to the internal lithium battery cells 51. This controller also provides safety redundancy for eliminating over discharge of the internal lithium battery.

FIG. 3 is a perspective view of a handheld device 300 in accordance with an exemplary embodiment of the invention. 301 is a power on switch. 302 shows the LED “fuel gauge” indicators 61. 303 shows a 12 volt output port connectable to a cable device 400, described further below. 304 shows a flashlight control switch for activating flashlight LEDs 45. 305 is a USB input port for charging the internal lithium battery, and 306 is a USB output port for providing charge from the lithium battery to other portable devices such as smartphones, tablets, music players, etc. 307 is a “boost on” indicator showing that power is being provided to the 12 V

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output port. 308 is a "reverse" indicator showing that the vehicle battery is improperly connected with respect to polarity. 309 is a "power on" indicator showing that the device is powered up for operation.

FIG. 4 shows a jumper cable device 400 specifically designed for use with the handheld device 300. Device 400 has a plug 401 configured to plug into 12 volt output port 303 of the handheld device 300. A pair of cables 402a and 402b are integrated with the plug 401, and are respectively connected to battery terminal clamps 403a and 403b via ring terminals 404a and 404b. The port 303 and plug 401 may be dimensioned so that the plug 401 will only fit into the port 303 in a specific orientation, thus ensuring that clamp 403a will correspond to positive polarity, and clamp 403b will correspond to negative polarity, as indicated thereon. Additionally, the ring terminals 404a and 404b may be disconnected from the clamps and connected directly to the terminals of a vehicle battery. This feature may be useful, for example, to permanently attach the cables 302a-302b to the battery of a vehicle. In the event that the battery voltage becomes depleted, the handheld booster device 300 could be properly connected to the battery very simply by plugging in the plug 401 to the port 303.

Battery Cell Equalization

A battery cell equalization circuit 110 is shown in FIG. 1. The battery cell equalization circuit 110 comprises a Li-ion battery 112 having three (3) cells having a nominal battery rating of 12 V, a battery cell equalization circuit 114 having three (3) individual battery cell equalization circuits, and an enable/disable control circuit 116. Each cell has its own independent battery cell equalization circuit, which are essentially identical.

The battery cells are "equalized" using the principle that if any cell voltage exceeds a certain pre-determined upper voltage threshold, it will be discharged through its own load resistor (R5, R15, and R25), until it reaches a certain pre-determined level below that threshold or until the battery charging process is terminated.

Bleeding the charge of a cell through its load resistor may not always result in the net discharge of that cell. For example, if the (externally supplied) charging current through the Li-ion battery 112, which is the same through each cell, is higher than the discharge or bleed current of that cell, it will slow down the effective charging rate of that cell while charging the lower voltage cells at a higher rate allowing them to catch up to the highest voltage cell.

The battery cell equalization circuit 110 is enabled or disabled using a single control signal, which may be generated after evaluating user affected settings or various operational conditions within the jump starter. Disabling the equalization circuit during active cell discharge stops the discharge of the cell(s). Enabling the equalization circuit may or may not cause the cell(s) to be discharged, as that decision depends on the cell voltages.

Operation

Enabling the equalization circuit involves turning ON the MOSFET switches Q2, Q4, Q6, electrically connecting the voltage divider resistors (R3, R4), (R13, R14) and (R23, R24) that scale down the individual cell voltages and feed them to the non-inverting inputs of their respective comparators, allowing them to sense the individual cell voltages. Disabling the equalization circuit turns OFF MOSFET switches Q2, Q4, Q6, disconnecting the resistors (R3, R4), (R13, R14) and (R23, R24) and preventing the cell voltages reaching the comparators' non-inverting inputs. That essen-

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tially presents zero voltage to the comparators' non-inverting inputs, causing their output voltages to be zero, which prevents the load resistors R5, R15, R25 from being connected across the cells.

Semiconductor voltage references DZ_1, DZ_2, DZ_3 in series with biasing resistors R7, R17, R27, provide a reference voltage signal to the inverting input of comparators U1, U2, U3, respectively. The resistor divider R3, R4 (or R13, R14 or R23, R24) values are chosen such the scaled cell voltage equals the reference voltage when the cell voltage reaches the upper voltage threshold at which the discharge process needs to be started. If any scaled cell voltage being fed to the non-inverting input of its respective comparator exceeds the corresponding reference voltage present at the inverting input, then the comparator's output voltage will be high, exceeding the gate-source threshold voltage of the enhancement mode MOSFET switch Q1 (or Q3, Q5), causing it to turn ON and connecting load resistor R5 (or R15, R25) across the corresponding battery cell.

Resistor R8 (or R18, R28) lies in parallel with R4 (or R14, R24) and allows fine tuning of the voltage division, allowing the use of cheaper, commonly available mass produced resistors, instead of a single specific non-standard value. Further consideration in choosing the value of the voltage divider resistors is to minimize the current drawn by these resistors to avoid draining the battery cells, while at the same time keeping their value small enough to allow enough current through these voltage divider resistors that is significantly greater than the comparators' input bias current, so as to effectively not load the voltage divider.

R1, R2 (R11, R12 or R21, R22) control the "hysteresis" band that determines the lower cell voltage level to which the cell(s) needs to be discharged, once the discharge process has been started.

Li-ion battery 112 can store a significant amount of energy, which can cause high current in the cells, if their terminals get short-circuited un-intentionally, resulting in excessive heat generation and damage to the jump starter unit or other undesired catastrophic consequences. High valued resistors R6, R16, R26 have been added between the output of comparator U1 (or U2, U3) and the switches Q1, Q3, Q5 to limit the amount of current through each cell to a safe value, in the case when somehow the output of U1 (or U2, U3) gets clamped to its cell voltage and the gate-source terminals of Q1 (or Q3, Q5) get short-circuited.

The gate-source threshold voltage of MOSFETs Q1, Q3, Q5 has been chosen to be a minimum of 1.2 V, as opposed to a few tenths of a volt, in order to prevent their spurious turning ON due to stray voltages present between their gate-source terminals. The comparators and voltage references used are of the "nano power" category to not drain the battery cells significantly over time, thus maintaining its jump starting capacity.

Capacitors C1, C2, C3 are kept to allow stable operation of the voltage references DZ_1, DZ_2, DZ_3.

Enable/Disable Control Circuit Operation

Turning ON enhancement mode MOSFET switches Q2, Q4, Q6 enables the battery cell equalization circuit 110. Turning them OFF, disables the battery cell equalization circuit 110. The switches Q2, Q4, Q6 are turned ON simultaneously by applying a nominal 12V control voltage signal between the terminals marked "Control +", "Control -". They are simultaneously turned OFF by applying a nominal zero volt control signal. In this implementation, the control voltage needed to be greater than or equal

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to the nominal voltage of the battery whose cells are being equalized. The nominal 12 V control voltage level was chosen due to its availability within, for example, a hand-held jump starter unit, as it is readily obtained via the external charge port or from the Li-ion battery 112 itself.

Placement of the voltage divider resistor R3 (or R13, R23) on the drain (terminal 3) side of MOSFET switches Q2 (Q4 or Q6), instead of on the source (terminal 2) side, is critical to the proper operation of the enable/disable circuit 116. If it is desired to keep Q2 (Q4, Q6) turned ON, it is essential to maintain its gate-source voltage at a level higher than its gate-source threshold voltage. When Q2 (Q4, Q6) gets turned on, the voltage drop across R3 (R13, R23) causes its source terminal to be pulled below its corresponding positive cell terminal potential, enabling a gate to source voltage at a level higher than its chosen gate-source threshold voltage. To allow a larger voltage drop across R3 (R13, R23), its value is kept much larger than R4 (R14, R24), such that it would allow a standard valued, readily available voltage reference DZ_1 (DZ_2, DZ_3) to be chosen.

The gate-source threshold voltage of MOSFETs Q2, Q4, Q6 has been chosen to be a minimum of 1.1 V, as opposed to a few tenths of a volt, in order to prevent their spurious turning ON due to stray voltages present between their gate-source terminals. This in turn imposes a higher voltage requirement across the gate-source voltage of Q2, Q4, Q6 in order to turn them ON and keep them in that state. It can be seen that if R3 were kept on the source (terminal 2) side of Q2, then the source terminal of Q2 would be pulled to the nominal 12 V battery potential as soon as Q2 were turned ON with a 12 V control signal. However, this would result in a zero voltage applied between the gate-source of Q2, immediately turning it back OFF.

The values of R10, R30, R32 have been chosen to allow an equitable distribution of the applied voltages between the gate-source terminals of Q2, Q4, Q6 when the 12 V control voltage is present. R10, R32 are kept much smaller than R32 to allow similar amounts of current to reach the gates of Q2, Q4, Q6. Large valued resistors R9, R19 act as another layer of safety by further introducing electrical resistance between the individual battery cells 112 as well as between the battery and the control voltage source by limiting fault current in case of short circuits across multiple components of the circuit. Value R32 needs to be kept large enough so that most of the control voltage drops across it, in case the control voltage source has significant resistance in series with it.

EXAMPLE #1

The battery cell equalization circuit 110 can be applied or installed into the battery jump start boost device disclosed in U.S. Pat. No. 9,007,015, which is incorporated herein by reference.

The invention having been thus described, it will be apparent to those skilled in the art that the same may be varied in many ways without departing from the spirit or scope of the invention. Any and all such variations are intended to be encompassed within the scope of the following claims.

The invention claimed is:

1. A portable or hand held jump starting apparatus, comprising:
 - a battery comprising a plurality of individual battery cells connected in series;
 - a battery cell equalization circuit connected to the battery, the battery cell equalization circuit comprising:

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a plurality of individual battery cell equalization circuits each provided for each respective battery cell; and

a plurality of load resistors each provided for each respective battery cell,

wherein the individual battery cell equalization circuits are configured to discharge an individual battery cell by its particular load resistor upon the individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the individual battery cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the individual battery cell charging process is terminated.

2. The apparatus according to claim 1, wherein the battery cell equalization circuits are configured to discharge or slow a charging rate upon the particular cell reaching the cell voltage exceeding the pre-determined upper voltage threshold while charging the lower voltage cells at a higher rate, allowing the lower voltage cells to catch up to the particular cell having a highest voltage.

3. The apparatus according to claim 1, wherein the battery cell equalization circuit is configured to be enabled or disabled using a single control signal.

4. The apparatus according to claim 3, wherein disabling the battery cell equalization circuit during active battery cell discharge stops the discharge of the battery cells.

5. The apparatus according to claim 3, wherein the battery cell equalization circuit comprises MOSFET switches and voltage divider resistors, and wherein enabling the battery cell equalization circuit involves turning on the MOSFET switches electrically connecting the voltage divider resistors that scale down individual cell voltage of the battery cells and feed them to non-inverting inputs of respective comparators, allowing them to sense the individual cell voltages.

6. The apparatus according to claim 5, wherein disabling the battery cell equalization circuit turns off the MOSFET switches disconnecting the resistors and preventing cell voltages reaching the comparators' non-inverting signals and presenting zero voltage to the comparator's non-inverting inputs, causing their output voltages to be zero, which prevents the load resistors from being connected across the cells.

7. The apparatus according to claim 1, wherein the battery is a Li-ion battery.

8. The apparatus according to claim 7, wherein the battery is a Li-ion battery pack comprising a plurality of Li-ion battery cells.

9. The apparatus according to claim 1, further comprising an output port having positive and negative polarity outputs; a vehicle battery isolation sensor connected in circuit with the positive and negative polarity outputs, configured to detect presence of a vehicle battery connected between the positive and negative polarity outputs; a reverse polarity sensor connected in circuit with the positive and negative polarity outputs, configured to detect polarity of a vehicle battery connected between the positive and negative polarity outputs and to provide an output signal indicating whether positive and negative terminals of the vehicle battery are properly connected with the positive and negative polarity outputs of the output port; a power switch connected between the internal power supply and the output port; and a microcontroller configured to receive input signals from the vehicle isolation sensor and the reverse polarity sensor, and to provide an output signal to the power switch, such that the power switch is turned on to cause the internal power supply to be connected to the output port in response

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to signals from the sensors indicating the presence of a vehicle battery at the output port and proper polarity connection of positive and negative terminals of the vehicle battery with the positive and negative polarity outputs, and is not turned on when signals from the sensors indicate either the absence of a vehicle battery at the output port or improper polarity connection of positive and negative terminals of the vehicle battery with the positive and negative polarity outputs,

wherein the battery equalization circuit is a separate isolated circuit relative to the circuit with the positive and negative polarity outputs, and

wherein the microcontroller is connected to and controls the battery equalization circuit.

10. The apparatus according to claim 9, wherein the power switch comprises a plurality of FETs connected in parallel.

11. The apparatus of claim 9, wherein the vehicle isolation sensor and reverse polarity sensor comprise optically coupled isolator phototransistors.

12. The apparatus of claim 9, further comprising a plurality of power diodes coupled between the output port and the internal power supply to prevent back-charging of the internal power supply from an electrical system connected to the output port.

13. The apparatus of claim 9, further comprising a temperature sensor configured to detect temperature of the internal power supply and to provide a temperature signal to the microcontroller.

14. The apparatus of claim 9, further comprising a voltage measurement circuit configured to measure output voltage of the internal power supply and to provide a voltage measurement signal to the microcontroller.

15. The apparatus of claim 9, further comprising a voltage regulator configured to convert output voltage of the internal power supply to a voltage level appropriate to provide operating power to internal components of the apparatus.

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16. A portable or hand held jump starting apparatus, comprising:

a battery comprising a plurality of individual battery cells connected in series;

a battery cell equalization circuit connected to the battery, the battery cell equalization circuit comprising a plurality of individual battery cell equalization circuits each provided for each respective battery cell, the individual battery cell equalization circuits each comprising:

a first MOSFET switch configured to electrically connect voltage divider resistors that scale down an individual battery cell voltage and feed the individual battery cell voltage to a non-inverting input of a respective comparator allowing the respective comparator to sense the individual battery cell voltage;

a second MOSFET switch configured to limit the amount of current through the individual battery cell to a safe value, in case an output of the comparator gets clamped to its cell voltage and gate-source terminals of the second MOSFET switch get short-circuited; and

a load resistor connected across the individual battery cell,

wherein the individual battery cell equalization circuits are configured to discharge each individual battery cell by its particular load resistor upon the individual battery cell reaching a cell voltage exceeding a pre-determined upper voltage threshold until the individual battery cell reaches a pre-determined lower voltage level below the upper voltage threshold or until the particular individual battery cell charging process is terminated.

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EXHIBIT C



US011447023B2

(12) **United States Patent**
Nook et al.

(10) **Patent No.:** **US 11,447,023 B2**
(45) **Date of Patent:** **Sep. 20, 2022**

(54) **PORTABLE VEHICLE BATTERY JUMP START APPARATUS WITH SAFETY PROTECTION AND JUMPER CABLE DEVICE THEREOF**

(58) **Field of Classification Search**

CPC B60L 53/14; H02J 7/342; H02J 7/0047;
H02J 7/0034; H02J 7/0029; H02J 1/122;
H02J 7/00; H02J 7/0048; H02J 2310/46
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(71) Applicant: **THE NOCO COMPANY**, Glenwillow, OH (US)

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Primary Examiner — M Baye Diao

(74) Attorney, Agent, or Firm — Vorys, Sater, Seymour & Pease LLP; William Klima

(72) Inventors: **Jonathan Lewis Nook**, Gates Mills, OH (US); **William Knight Nook**, Shaker Heights, OH (US); **James Richard Stanfield**, Peoria, AZ (US); **Derek Michael Underhill**, Tempe, AZ (US)

(73) Assignee: **THE NOCO COMPANY**, Glenwillow, OH (US)

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(Continued)

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B60L 53/14 (2019.01)
H02J 7/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **B60L 53/14** (2019.02); **H02J 7/0029** (2013.01); **H02J 7/0034** (2013.01);
(Continued)

(57) **ABSTRACT**

A handheld device for jump starting a vehicle engine includes a rechargeable lithium ion battery pack and a microcontroller. The lithium ion battery is coupled to a power output port of the device through a FET smart switch actuated by the microcontroller. A vehicle battery isolation sensor connected in circuit with positive and negative polarity outputs detects the presence of a vehicle battery connected between the positive and negative polarity outputs. A reverse polarity sensor connected in circuit with the positive and negative polarity outputs detects the polarity of a vehicle battery connected between the positive and negative polarity outputs, such that the microcontroller will enable power to be delivered from the lithium ion power pack to the output
(Continued)

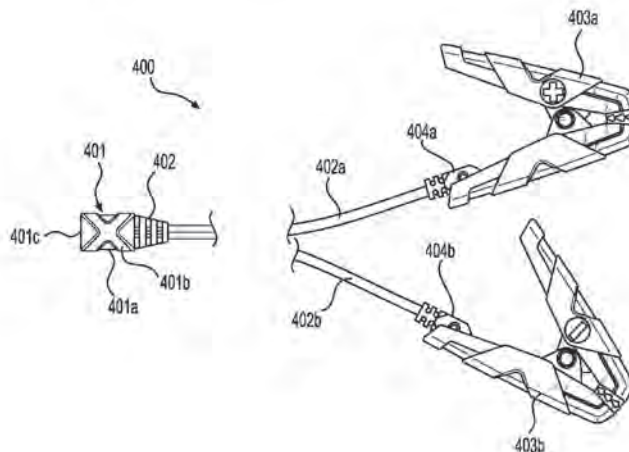


Exhibit C

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port only when a good battery is connected to the output port and only when the battery is connected with proper polarity of positive and negative terminals.

54 Claims, 13 Drawing Sheets

Related U.S. Application Data

continuation of application No. 15/691,884, filed on Aug. 31, 2017, now Pat. No. 10,604,024, which is a continuation of application No. 14/619,655, filed on Feb. 11, 2015, now Pat. No. 9,770,992, which is a division of application No. 14/325,938, filed on Jul. 8, 2014, now Pat. No. 9,007,015, which is a continuation of application No. PCT/US2014/045434, filed on Jul. 3, 2014.

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- (52) **U.S. Cl.**
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- (58) **Field of Classification Search**
 USPC 320/105
 See application file for complete search history.

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Exhibit C

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Exhibit C

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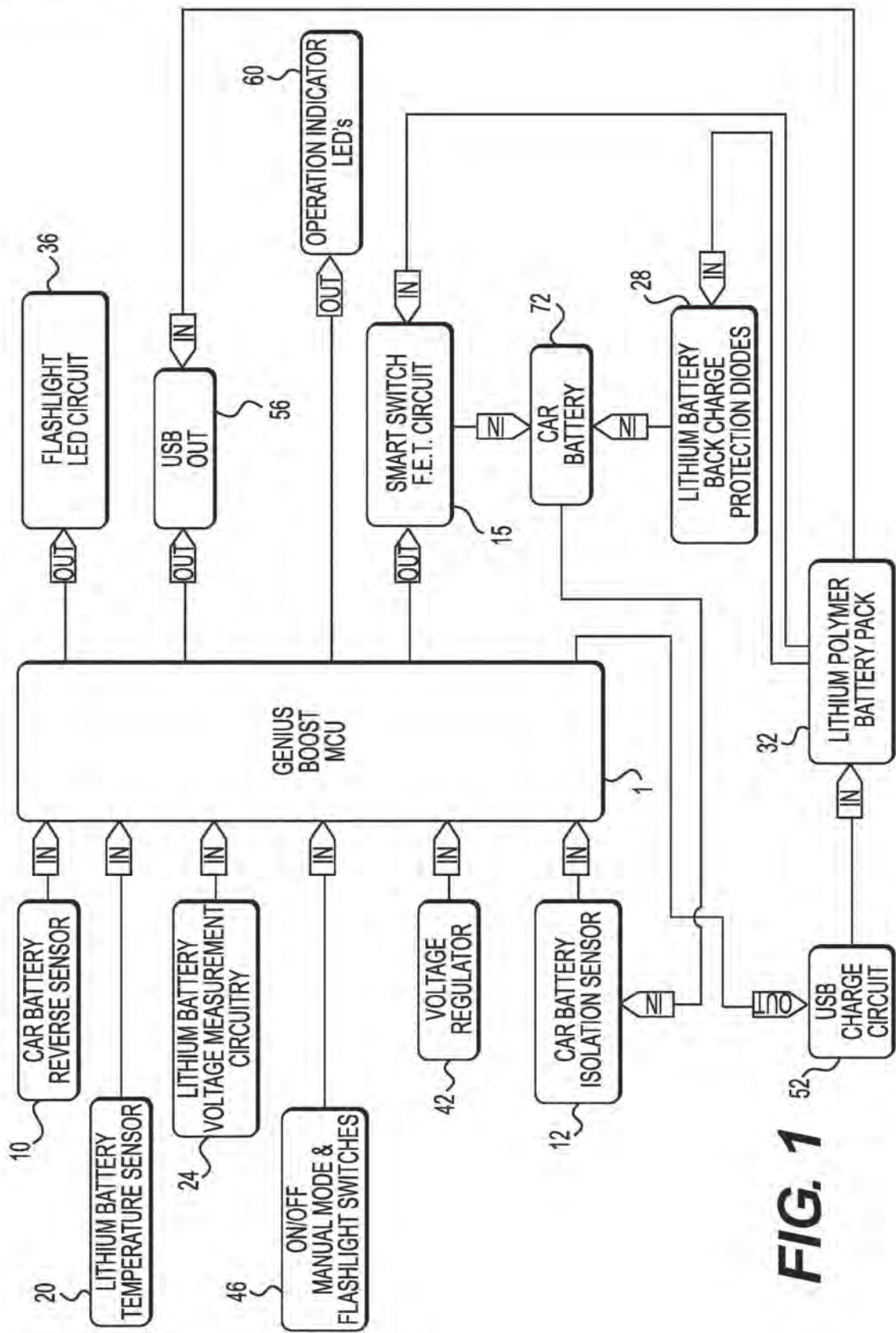


FIG. 1

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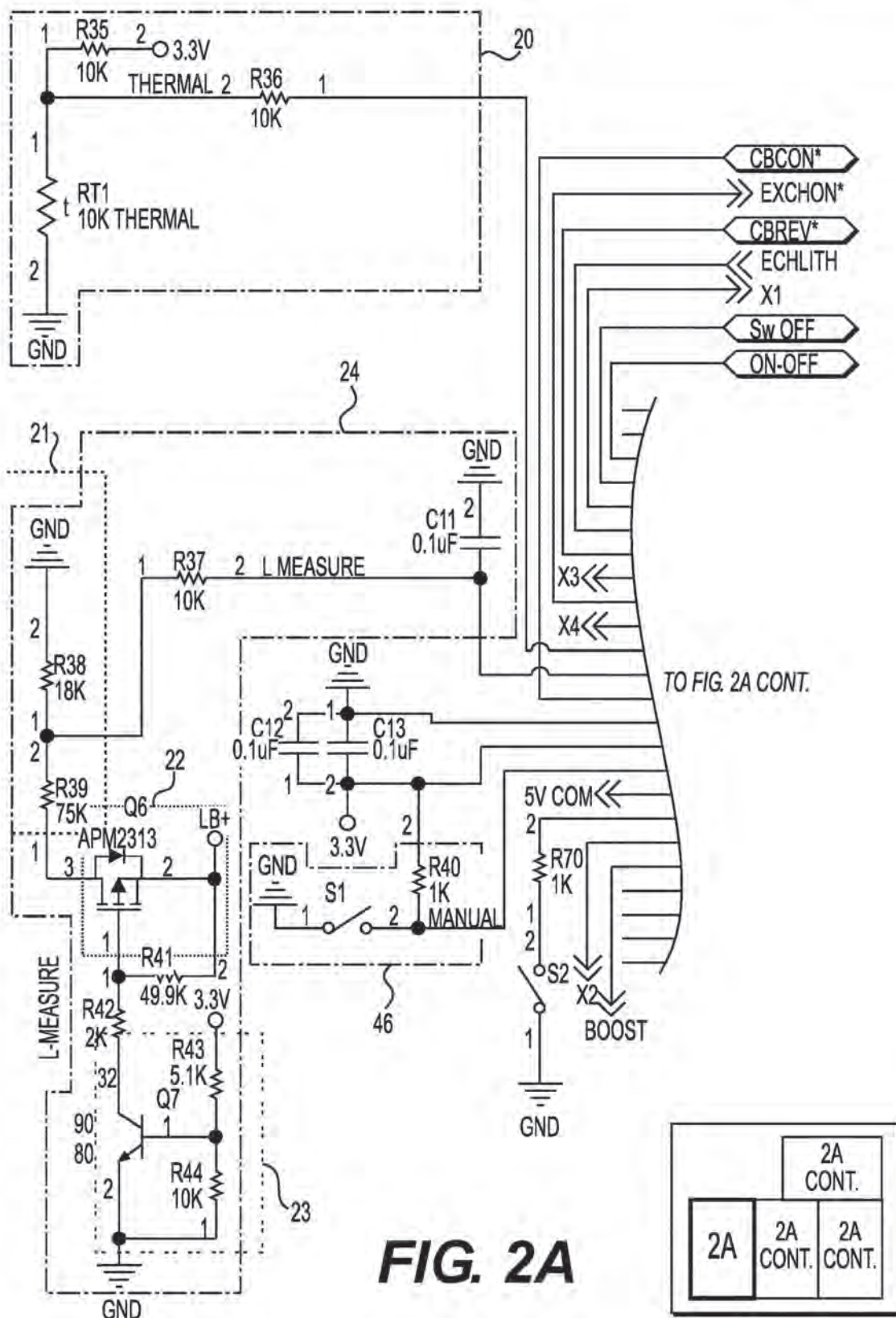
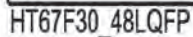


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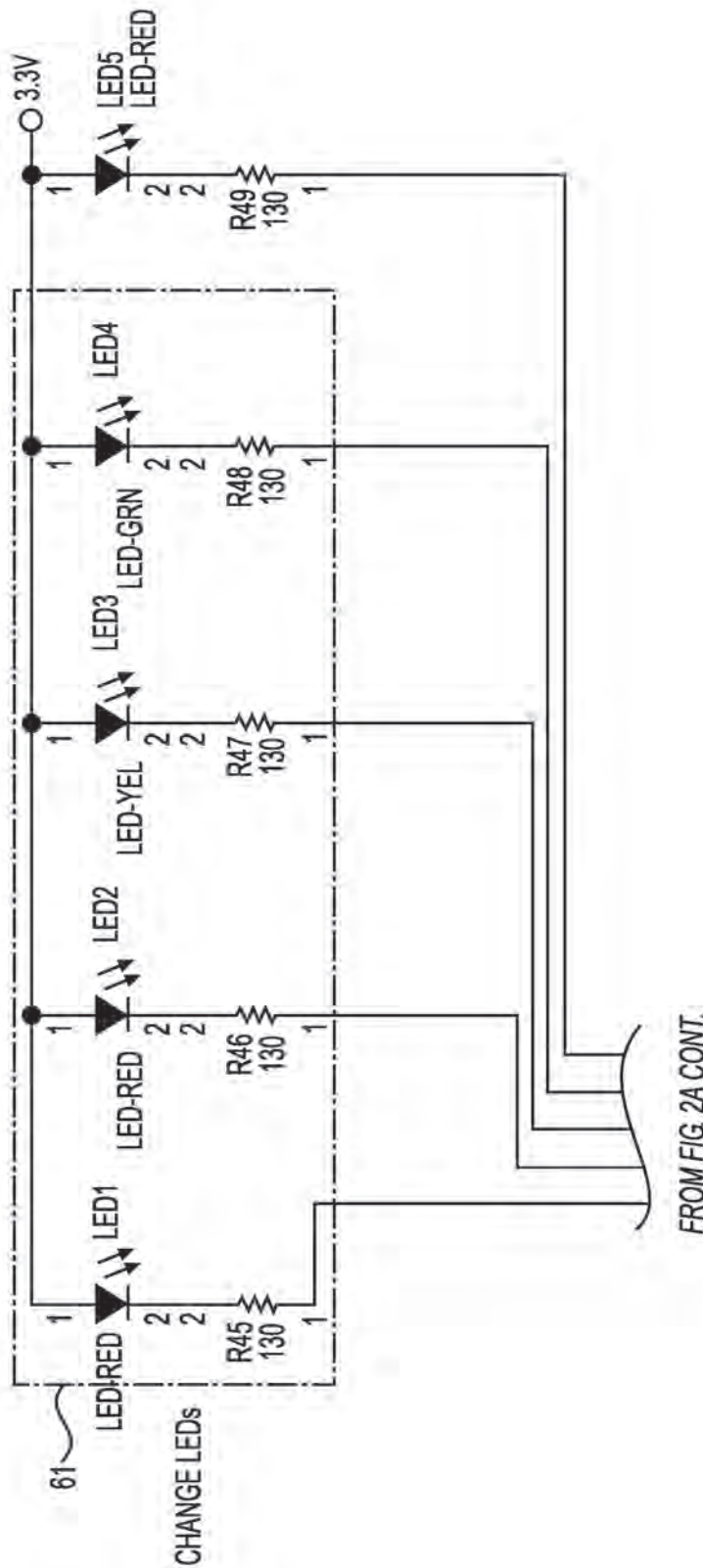
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2A	2A	2A
CONT.	CONT.	CONT.

FIG. 2A CONT.

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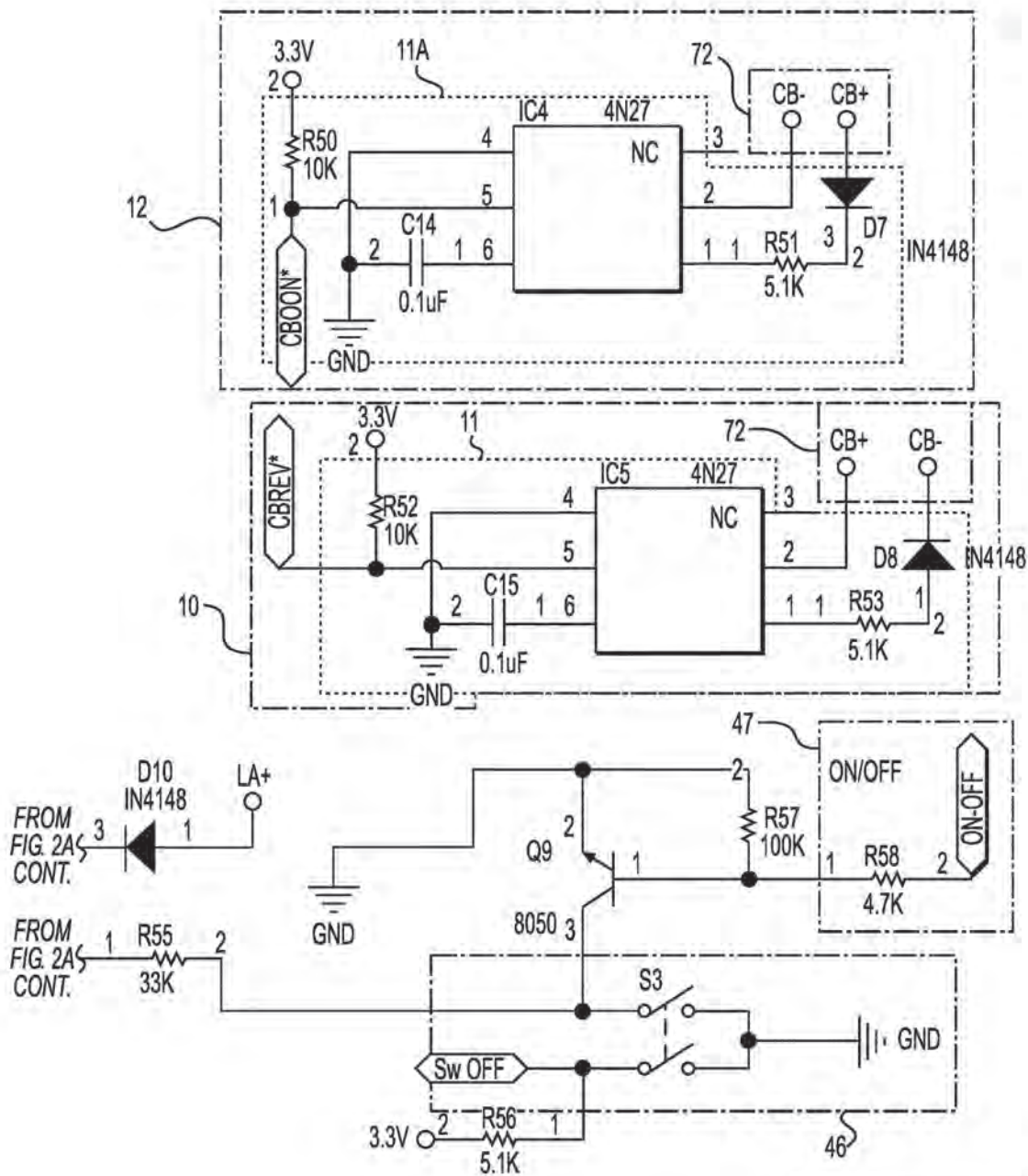
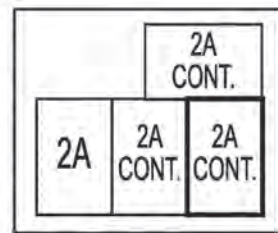


FIG. 2A CONT.



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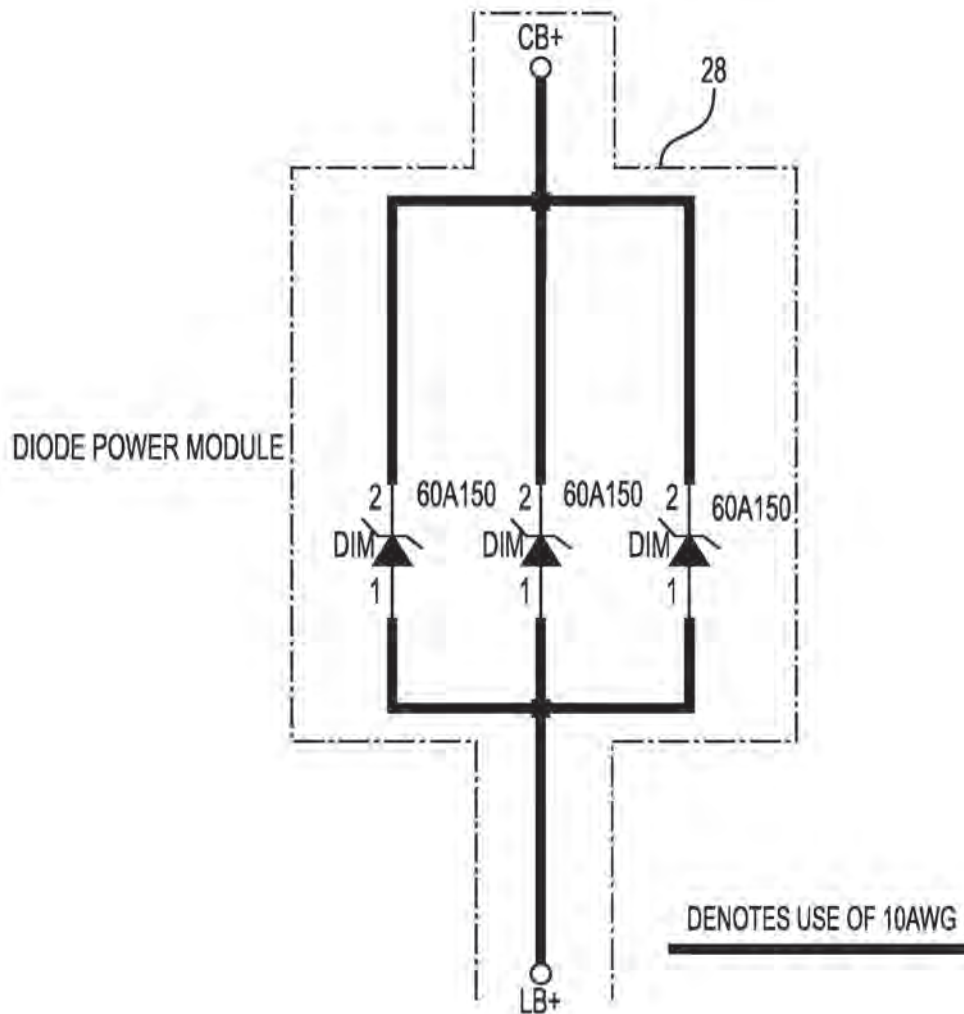


FIG. 2B

	2B CONT.	2B CONT.
2B	2B CONT.	

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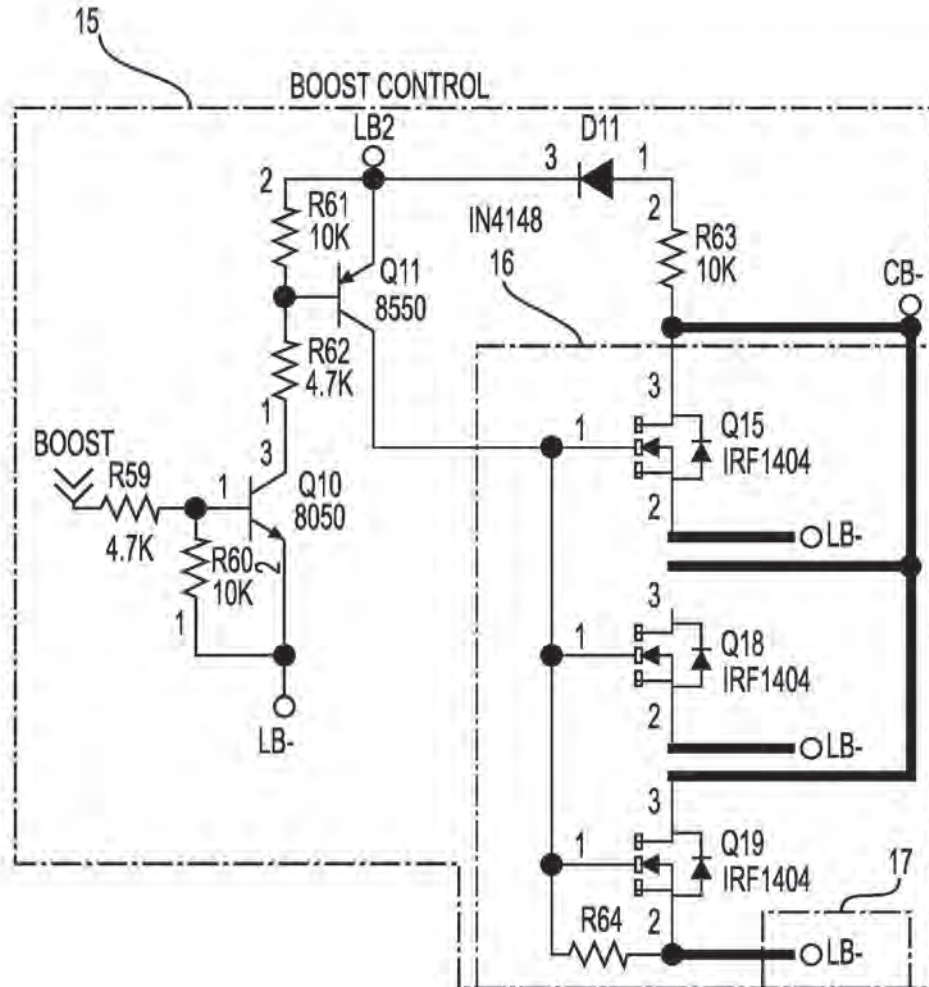
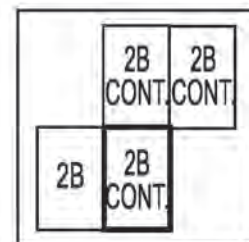


FIG. 2B CONT.



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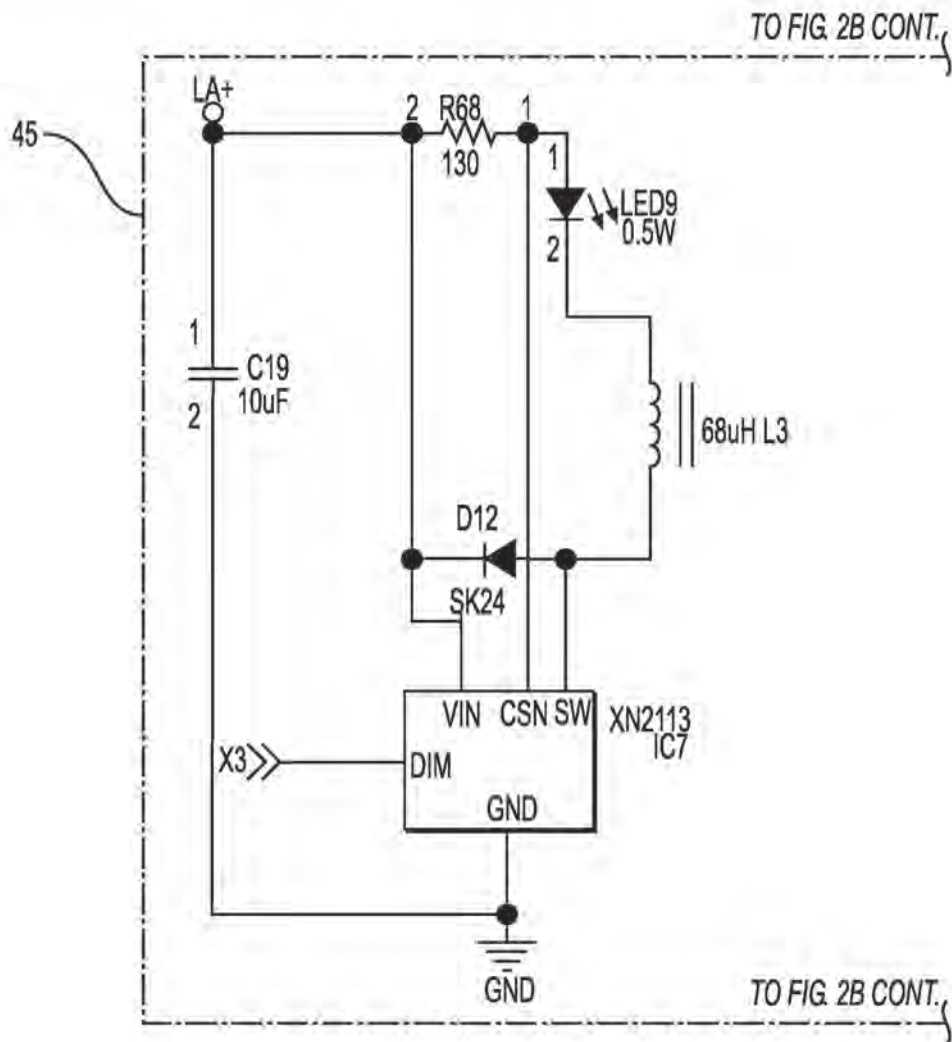
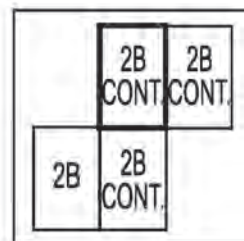


FIG. 2B CONT.



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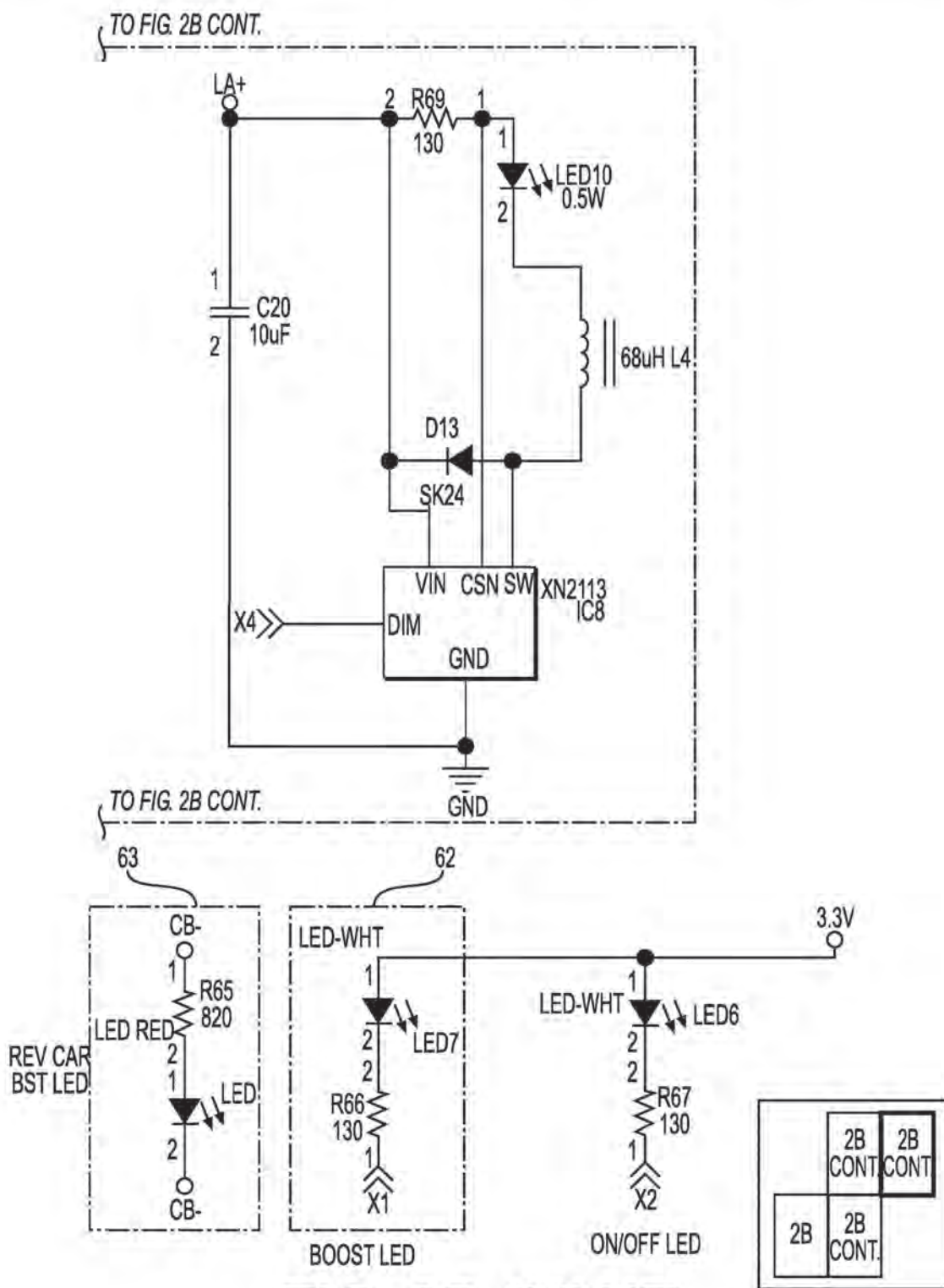


FIG. 2B CONT.



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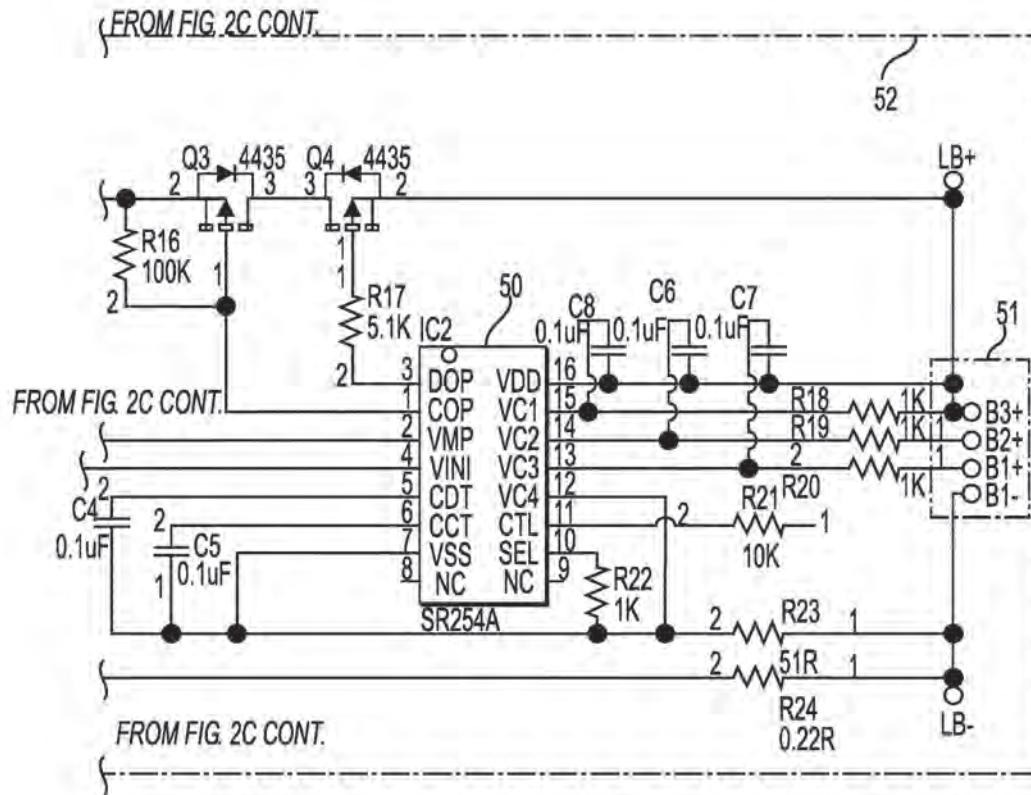
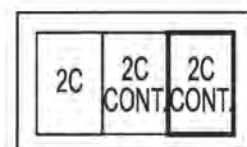


FIG. 2C CONT.



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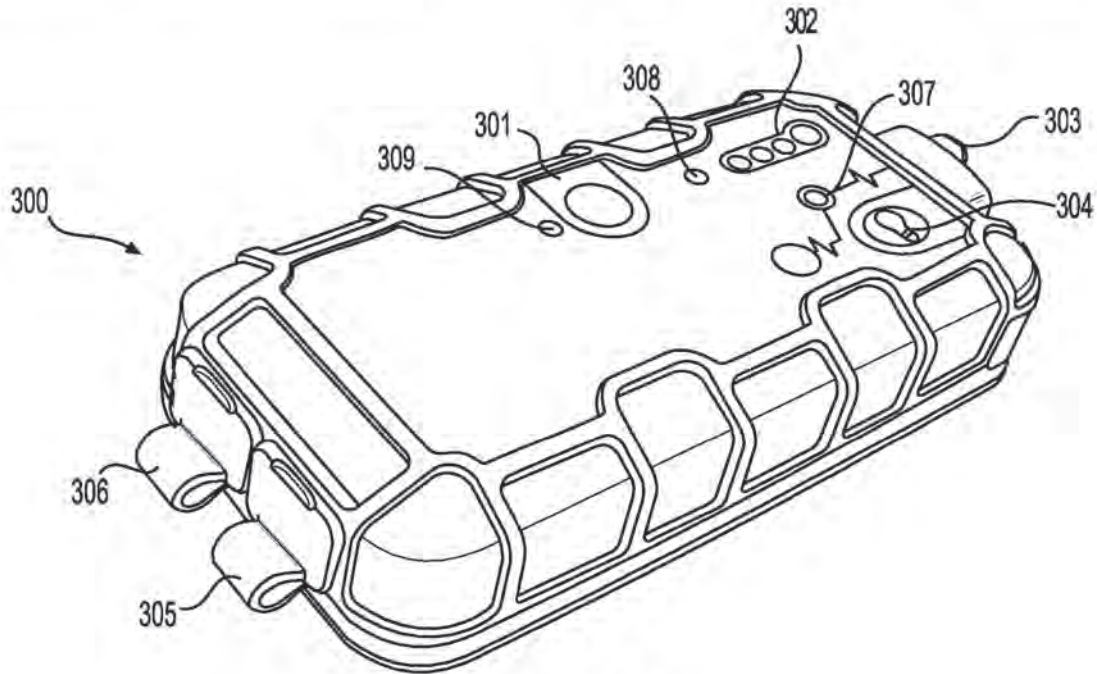


FIG. 3

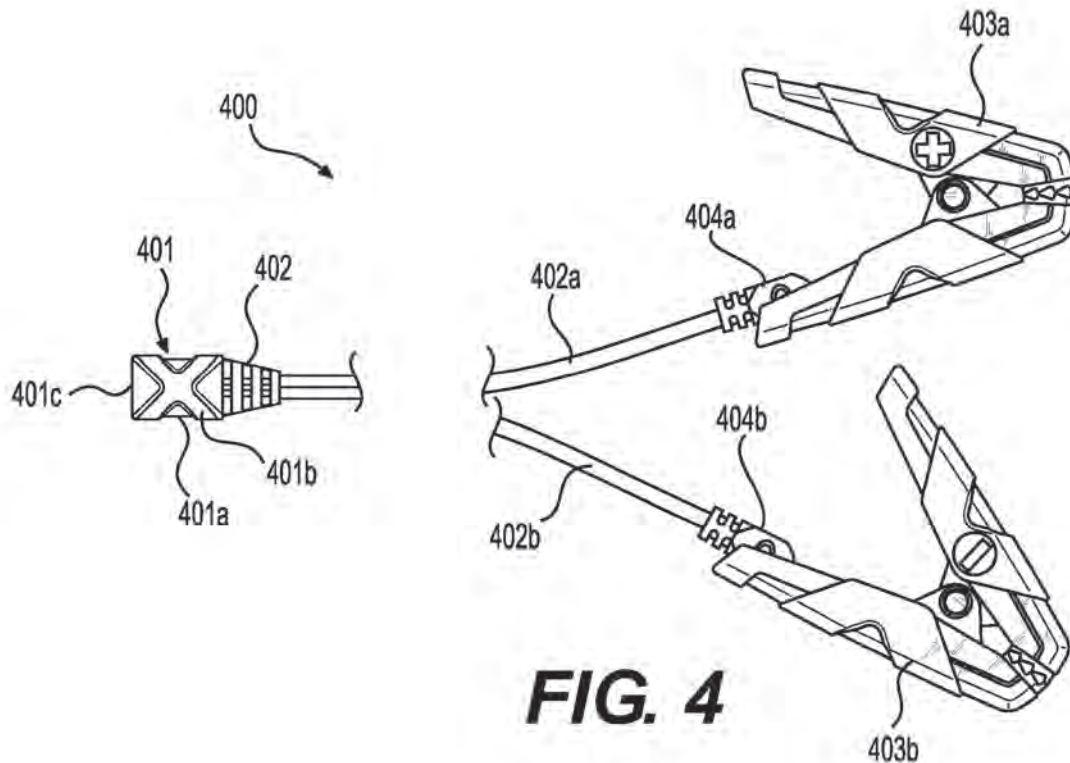


FIG. 4

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**PORTABLE VEHICLE BATTERY JUMP
START APPARATUS WITH SAFETY
PROTECTION AND JUMPER CABLE
DEVICE THEREOF**

BACKGROUND OF THE INVENTION

The present invention relates generally to apparatus for jump-starting a vehicle having a depleted or discharged battery. Prior art devices are known, which provide either a pair of electrical connector cables that connect a fully-charged battery of another vehicle to the engine start circuit of the dead battery vehicle, or portable booster devices which include a fully-charged battery which can be connected in circuit with the vehicle's engine starter through a pair of cables.

Problems with the prior art arose when either the jumper terminals or clamps of the cables were inadvertently brought into contact with each other while the other ends were connected to a charged battery, or when the positive and negative terminals were connected to the opposite polarity terminals in the vehicle to be jumped, thereby causing a short circuit resulting in sparking and potential damage to batteries and/or bodily injury.

Various attempts to eliminate these problems have been made in the prior art. U.S. Pat. No. 6,212,054 issued Apr. 3, 2001, discloses a battery booster pack that is polarity sensitive and can detect proper and improper connections before providing a path for electric current flow. The device uses a set of LEDs connected to optical couplers oriented by a control circuit. The control circuit controls a solenoid assembly controlling the path of power current. The control circuit causes power current to flow through the solenoid assembly only if the points of contact of booster cable clamp connections have been properly made.

U.S. Pat. No. 6,632,103 issued Oct. 14, 2003, discloses an adaptive booster cable connected with two pairs of clips, wherein the two pairs of clips are respectively attached to two batteries to transmit power from one battery to the other battery. The adaptive booster cable includes a polarity detecting unit connected to each clip, a switching unit and a current detecting unit both provided between the two pairs of clips. After the polarity of each clip is sensed by the polarity detecting unit, the switching unit generates a proper connection between the two batteries. Therefore, the positive and negative terminals of the two batteries are correctly connected based on the detected result of the polarity detecting unit.

U.S. Pat. No. 8,493,021 issued Jul. 23, 2013, discloses apparatus that monitors the voltage of the battery of a vehicle to be jump started and the current delivered by the jump starter batteries to determine if a proper connection has been established and to provide fault monitoring. Only if the proper polarity is detected can the system operate. The voltage is monitored to determine open circuit, disconnected conductive clamps, shunt cable fault, and solenoid fault conditions. The current through the shunt cable is monitored to determine if there is a battery explosion risk, and for excessive current conditions presenting an overheating condition, which may result in fire. The system includes an internal battery to provide the power to the battery of the vehicle to be jump started. Once the vehicle is started, the unit automatically electrically disconnects from the vehicle's battery.

U.S. Pat. No. 5,189,359 issued Feb. 23, 1993, discloses a jumper cable device having two bridge rectifiers for developing a reference voltage, a four-input decoder for deter-

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mining which terminals are to be connected based on a comparison of the voltage at each of the four terminals to the reference voltage, and a pair of relays for effecting the correct connection depending on the determination of the decoder. No connection will be made unless only one terminal of each battery has a higher voltage than the reference voltage, indicating "positive" terminals, and one has a lower voltage than the reference voltage, indicating "negative" terminals, and that, therefore, the two high voltage terminals may be connected and the two lower voltage terminals may be connected. Current flows once the appropriate relay device is closed. The relay device is preferably a MOSFET combined with a series array of photodiodes that develop MOSFET gate-closing potential when the decoder output causes an LED to light.

U.S. Pat. No. 5,795,182 issued Aug. 18, 1998, discloses a polarity independent set of battery jumper cables for jumping a first battery to a second battery. The apparatus includes a relative polarity detector for detecting whether two batteries are configured cross or parallel. A three-position high current capacity crossbar pivot switch is responsive to the relative polarity detector for automatically connecting the plus terminals of the two batteries together and the minus terminals of the two batteries together regardless of whether the configuration detected is cross or parallel, and an under-current detector and a delay circuit for returning the device to its ready and unconnected state after the device has been disconnected from one of the batteries. The crossbar pivot switch includes two pairs of contacts, and a pivot arm that pivots about two separate points to ensure full electrical contact between the pairs of contacts. The invention can also be used to produce a battery charger that may be connected to a battery without regard to the polarity of the battery.

U.S. Pat. No. 6,262,492 issued Jul. 17, 2001, discloses a car battery jumper cable for accurately coupling an effective power source to a failed or not charged battery, which includes a relay switching circuit connected to the power source and the battery by two current conductor pairs. First and second voltage polarity recognition circuits are respectively connected to the power source and the battery by a respective voltage conductor pair to recognize the polarity of the power source and the battery. A logic recognition circuit produces a control signal subject to the polarity of the power source and the battery, and a driving circuit controlled by the control signal from the logic recognition circuit drives the relay switching circuit, enabling the two poles of the power source to be accurately coupled to the two poles of the battery.

U.S. Pat. No. 5,635,817 issued Jun. 3, 1997, discloses a vehicle battery charging device that includes a control housing having cables including a current limiting device to prevent exceeding of a predetermined maximum charging current of about 40 to 60 amps. The control housing includes a polarity detecting device to verify the correct polarity of the connection of the terminals of the two batteries and to electrically disconnect the two batteries if there is an incorrect polarity.

U.S. Pat. No. 8,199,024 issued Jun. 12, 2012, discloses a safety circuit in a low-voltage connecting system that leaves the two low-voltage systems disconnected until it determines that it is safe to make a connection. When the safety circuit determines that no unsafe conditions exist and that it is safe to connect the two low-voltage systems, the safety circuit may connect the two systems by way of a "soft start" that provides a connection between the two systems over a period of time that reduces or prevents inductive voltage spikes on one or more of the low-voltage systems. When one

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of the low-voltage systems has a completely-discharged battery incorporated into it, a method is used for detection of proper polarity of the connections between the low-voltage systems. The polarity of the discharged battery is determined by passing one or more test currents through it and determining whether a corresponding voltage rise is observed.

U.S. Pat. No. 5,793,185 issued Aug. 11, 1998, discloses a hand-held jump starter having control components and circuits to prevent overcharging and incorrect connection to batteries.

While the prior art attempted solutions to the abovementioned problems as discussed above, each of the prior art solutions suffers from other shortcomings, either in complexity, cost or potential for malfunction. Accordingly, there exists a need in the art for further improvements to vehicle jump start devices.

SUMMARY OF THE INVENTION

In accordance with an aspect of the invention, apparatus is provided for jump starting a vehicle engine, including: an internal power supply; an output port having positive and negative polarity outputs; a vehicle battery isolation sensor connected in circuit with said positive and negative polarity outputs, configured to detect presence of a vehicle battery connected between said positive and negative polarity outputs; a reverse polarity sensor connected in circuit with said positive and negative polarity outputs, configured to detect polarity of a vehicle battery connected between said positive and negative polarity outputs; a power FET switch connected between said internal power supply and said output port; and a microcontroller configured to receive input signals from said vehicle isolation sensor and said reverse polarity sensor, and to provide an output signal to said power FET switch, such that said power FET switch is turned on to connect said internal power supply to said output port in response to signals from said sensors indicating the presence of a vehicle battery at said output port and proper polarity connection of positive and negative terminals of said vehicle battery with said positive and negative polarity outputs.

In accordance with another aspect of the invention, the internal power supply is a rechargeable lithium ion battery pack.

In accordance with yet another aspect of the invention, a jumper cable device is provided, having a plug configured to plug into an output port of a handheld battery charger booster device having an internal power supply; a pair of cables integrated with the plug at one respective end thereof; said pair of cables being configured to be separately connected to terminals of a battery at another respective end thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of a handheld vehicle battery boost apparatus in accordance with one aspect of the present invention;

FIGS. 2A-2C are schematic circuit diagrams of an example embodiment of a handheld vehicle battery boost apparatus in accordance with an aspect of the invention;

FIG. 3 is a perspective view of a handheld jump starter booster device in accordance with one example embodiment of the invention; and

FIG. 4 is a plan view of a jumper cable usable with the handheld jump starter booster device in accordance with another aspect of the invention.

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DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a functional block diagram of a handheld battery booster according to one aspect of the invention. At the heart of the handheld battery booster is a lithium polymer battery pack 32, which stores sufficient energy to jump start a vehicle engine served by a conventional 12 volt lead-acid or valve regulated lead-acid battery. In one example embodiment, a high-surge lithium polymer battery pack includes three 3.7V, 2666 mAh lithium polymer batteries in a 3S1P configuration. The resulting battery pack provides 11.1V, 2666 Ah (8000 Ah at 3.7V, 29.6 Wh). Continuous discharge current is 25C (or 200 amps), and burst discharge current is 50C (or 400 amps). The maximum charging current of the battery pack is 8000 mA (8 amps).

A programmable microcontroller unit (MCU) 1 receives various inputs and produces informational as well as control outputs. The programmable MCU 1 further provides flexibility to the system by allowing updates in functionality and system parameters, without requiring any change in hardware. According to one example embodiment, an 8 bit microcontroller with 2Kx15 bits of flash memory is used to control the system. One such microcontroller is the HT67F30, which is commercially available from Holtek Semiconductor Inc.

A car battery reverse sensor 10 monitors the polarity of the vehicle battery 72 when the handheld battery booster device is connected to the vehicle's electric system. As explained below, the booster device prevents the lithium battery pack from being connected to the vehicle battery 72 when the terminals of the battery 72 are connected to the wrong terminals of the booster device. A battery presence sensor (e.g. car battery isolation sensor 12) detects whether or not a vehicle battery 72 is present and connected to the booster device, and prevents the lithium battery pack from being connected to the output terminals of the booster device unless there is a good (e.g. chargeable) battery present and connected to the output terminals.

A smart switch FET circuit 15 electrically switches the handheld battery booster lithium battery to the vehicle's electric system only when the vehicle battery is determined by the MCU 1 to be present (in response to a detection signal provided by isolation sensor 12) and connected with the correct polarity (in response to a detection signal provided by reverse sensor 10). A lithium battery temperature sensor 20 monitors the temperature of the lithium battery pack 32 to detect overheating due to high ambient temperature conditions and overextended current draw during jump starting. A lithium battery voltage measurement circuit 24 monitors the voltage of the lithium battery pack 32 to prevent the voltage potential from rising too high during a charging operation and from dropping too low during a discharge operation.

Lithium battery back-charge protection diodes 28 prevent any charge current being delivered to the vehicle battery 72 from flowing back to the lithium battery pack 32 from the vehicle's electrical system. Flashlight LED circuit 36 is provided to furnish a flashlight function for enhancing light under a vehicle's hood in dark conditions, as well as providing SOS and strobe lighting functions for safety purposes when a vehicle may be disabled in a potentially dangerous location. Voltage regulator 42 provides regulation of internal operating voltage for the microcontroller and sensors. On/Off manual mode and flashlight switches 46 allow the user to control power-on for the handheld battery booster device, to control manual override operation if the

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vehicle has no battery, and to control the flashlight function. The manual button functions only when the booster device is powered on. This button allows the user to jump-start vehicles that have either a missing battery, or the battery voltage is so low that automatic detection by the MCU is not possible. When the user presses and holds the manual override button for a predetermined period time (such as three seconds) to prevent inadvertent actuation of the manual mode, the internal lithium ion battery power is switched to the vehicle battery connect port. The only exception to the manual override is if the car battery is connected in reverse. If the car battery is connected in reverse, the internal lithium battery power shall never be switched to the vehicle battery connect port.

USB charge circuit 52 converts power from any USB charger power source, charge voltage and current for charging the lithium battery pack 32. USB output 56 provides a USB portable charger for charging smartphones, tablets, and other rechargeable electronic devices. Operation indicator LEDs 60 provide visual indication of lithium battery capacity status as well as an indication of smart switch activation status (indicating that power is being provided to the vehicle's electrical system).

Detailed operation of the handheld booster device will now be described with reference to the schematic diagrams of FIGS. 2A-2C. As shown in FIG. 2A, the microcontroller unit 1 is the center of all inputs and outputs. The reverse battery sensor 10 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D8 in the lead conductor of pin 1 (associated with the negative terminal CB-), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11 will not conduct current, and is therefore turned off, providing a "1" or high output signal to the MCU 1. The car battery isolation sensor 12 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D7 in the lead conductor of pin 1 (associated with the positive terminal CB+), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11A will conduct current, and is therefore turned on, providing a "0" or low output signal to the MCU, indicating the presence of a battery across the jumper output terminals of the handheld booster device.

If the car battery 72 is connected to the handheld booster device with reverse polarity, the optocoupler LED 11 of the reverse sensor 10 will conduct current, providing a "0" or low signal to microcontroller unit 1. Further, if no battery is connected to the handheld booster device, the optocoupler LED 11A of the isolation sensor 12 will not conduct current, and is therefore turned off, providing a "1" or high output signal to the MCU, indicating the absence of any battery connected to the handheld booster device. Using these specific inputs, the microcontroller software of MCU 1 can determine when it is safe to turn on the smart switch FET 15, thereby connecting the lithium battery pack to the jumper terminals of the booster device. Consequently, if the car battery 72 either is not connected to the booster device at all, or is connected with reverse polarity, the MCU 1 can keep the smart switch FET 15 from being turned on, thus prevent sparking/short circuiting of the lithium battery pack.

As shown in FIG. 2B, the FET smart switch 15 is driven by an output of the microcontroller 1. The FET smart switch 15 includes three FETs (Q15, Q18, and Q19) in parallel, which spreads the distribution of power from the lithium

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battery pack over the FETs. When that microcontroller output is driven to a logic low, FETs 16 are all in a high resistance state, therefore not allowing current to flow from the internal lithium battery negative contact 17 to the car battery 72 negative contact. When the micro controller output is driven to a logic high, the FETs 16 (Q15, Q18, and Q19) are in a low resistant state, allowing current to flow freely from the internal lithium battery pack negative contact 17 (LB-) to the car battery 72 negative contact (CB-). In this way, the microcontroller software controls the connection of the internal lithium battery pack 32 to the vehicle battery 72 for jumpstarting the car engine.

Referring back to FIG. 2A, the internal lithium battery pack voltage can be accurately measured using circuit 24 and one of the analog-to-digital inputs of the microcontroller 1. Circuit 24 is designed to sense when the main 3.3V regulator 42 voltage is on, and to turn on transistor 23 when the voltage of regulator 42 is on. When transistor 23 is conducting, it turns on FET 22, thereby providing positive contact (LB+) of the internal lithium battery a conductive path to voltage divider 21 allowing a lower voltage range to be brought to the microcontroller to be read. Using this input, the microcontroller software can determine if the lithium battery voltage is too low during discharge operation or too high during charge operation, and take appropriate action to prevent damage to electronic components.

Still referring to FIG. 2A, the temperature of the internal lithium battery pack 32 can be accurately measured by two negative temperature coefficient (NTC) devices 20. These are devices that reduce their resistance when their temperature rises. The circuit is a voltage divider that brings the result to two analog-to-digital (ND) inputs on the microcontroller 1. The microcontroller software can then determine when the internal lithium battery is too hot to allow jumpstarting, adding safety to the design.

The main voltage regulator circuit 42 is designed to convert internal lithium battery voltage to a regulated 3.3 volts that is utilized by the microcontroller 1 as well as by other components of the booster device for internal operating power. Three lithium battery back charge protection diodes 28 (see FIG. 2B) are in place to allow current to flow only from the internal lithium battery pack 32 to the car battery 72, and not from the car battery to the internal lithium battery. In this way, if the car electrical system is charging from its alternator, it cannot back-charge (and thereby damage) the internal lithium battery, providing another level of safety. The main power on switch 46 (FIG. 2A) is a combination that allows for double pole, double throw operation so that with one push, the product can be turned on if it is in the off state, or turned off if it is in the on state. This circuit also uses a microcontroller output 47 to "keep alive" the power when it is activated by the on switch. When the switch is pressed the microcontroller turns this output to a high logic level to keep power on when the switch is released. In this way, the microcontroller maintains control of when the power is turned off when the on/off switch is activated again or when the lithium battery voltage is getting too low. The microcontroller software also includes a timer that turns the power off after a predefined period of time, (such as, e.g. 8 hours) if not used.

The flashlight LED circuit 45 shown in FIG. 2B controls the operation of flashlight LEDs. Two outputs from the microcontroller 1 are dedicated to two separate LEDs. Thus, the LEDs can be independently software-controlled for strobe and SOS patterns, providing yet another safety feature to the booster device. LED indicators provide the feedback the operator needs to understand what is happening

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with the product. Four separate LEDs 61 (FIG. 2A) are controlled by corresponding individual outputs of microcontroller 1 to provide indication of the remaining capacity of the internal lithium battery. These LEDs are controlled in a "fuel gauge" type format with 25%, 50% 75% and 100% (red, red, yellow, green) capacity indications. An LED indicator 63 (FIG. 2B) provides a visual warning to the user when the vehicle battery 72 has been connected in reverse polarity. "Boost" and on/off LEDs 62 provide visual indications when the booster device is provide jump-start power, and when the booster device is turned on, respectively.

A USB output 56 circuit (FIG. 2C) is included to provide a USB output for charging portable electronic devices such as smartphones from the internal lithium battery pack 32. Control circuit 57 from the microcontroller 1 allows the USB Out 56 to be turned on and off by software control to prevent the internal lithium battery getting too low in capacity. The USB output is brought to the outside of the device on a standard USB connector 58, which includes the standard voltage divider required for enabling charge to certain smartphones that require it. The USB charge circuit 52 allows the internal lithium battery pack 32 to be charged using a standard USB charger. This charge input uses a standard micro-USB connector 48 allowing standard cables to be used. The 5V potential provided from standard USB chargers is up-converted to the 12.4 VDC voltage required for charging the internal lithium battery pack using a DC-DC converter 49. The DC-DC converter 49 can be turned on and off via circuit 53 by an output from the microcontroller 1.

In this way, the microcontroller software can turn the charge off if the battery voltage is measured to be too high by the ND input 22. Additional safety is provided for helping to eliminate overcharge to the internal lithium battery using a lithium battery charge controller 50 that provides charge balance to the internal lithium battery cells 51. This controller also provides safety redundancy for eliminating over discharge of the internal lithium battery.

FIG. 3 is a perspective view of a handheld device 300 in accordance with an exemplary embodiment of the invention. 301 is a power on switch, 302 shows the LED "fuel gauge" indicators 61. 303 shows a 12 volt output port connectable to a cable device 400, described further below, 304 shows a flashlight control switch for activating flashlight LEDs 45. 305 is a USB input port for charging the internal lithium battery, and 306 is a USB output port for providing charge from the lithium battery to other portable devices such as smartphones, tablets, music players, etc. 307 is a "boost on" indicator showing that power is being provided to the 12V output port. 308 is a "reverse" indicator showing that the vehicle battery is improperly connected with respect to polarity. 309 is a "power on" indicator showing that the device is powered up for operation.

FIG. 4 shows a jumper cable device 400 specifically designed for use with the handheld device 300. Device 400 has a plug 401 configured to plug into 12 volt output port 303 of the handheld device 300. A pair of cables 402a and 402b are integrated with the plug 401, and are respectively connected to the positive and negative polarity battery terminal connectors (e.g. battery terminal clamps 403a and 403b) via ring terminals 404a and 404b. The output port 303 and plug 401 may be dimensioned so that the plug 401 will only fit into the output port 303 in a specific orientation, thus ensuring that clamp 403a will correspond to positive polarity and clamp 403b will correspond to negative polarity, as indicated thereon. Additionally, the ring terminals 404a and 404b may be disconnected from the clamps and connected directly to the terminals of a vehicle battery. This feature

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may be useful, for example, to permanently attach the cables 302a-302b to the battery of a vehicle. In the event that the battery voltage of the vehicle battery becomes depleted, the handheld booster device 300 can be properly connected to the battery very simply by plugging the plug 401 into the output port 303 of the handheld booster device 300 and connecting the battery clamps 403a and 403b to the battery. The plug 401 provides both positive polarity and negative polarity electrical connections between the output port 303 of the handheld battery charger booster device 300 and the plug 401 of the jumper cable device 400. The plug 401 does not have any exposed prongs, as shown in FIG. 5. Further, the individual cables of the pair of cables at one end are connected together (left side in FIG. 5) and integrated with the plug, and the individual cables at the opposite ends are separated apart (right side in FIG. 5). The plug 401 (FIG. 4) comprises a plug body 401a having a uniform or substantially uniform width W along the length of the plug body 401a, as shown in FIG. 4. The plug body 401a of the plug 401 is provided with a surface protrusion 401b (e.g. X-shaped surface protrusion) extending above the outer surface of the plug body 401a of the plug 401. The plug body 401a is a continuous plug body along the length and width of the plug body, and rectangular-shaped. A downwardly tapering transition 402 is provided between the plug body 401a and the pair of cables 402a and 402b. The downwardly tapering transition 402 is provided with transverse ridges. The plug 401 is a single plug having a single connection end or single prong (left end in FIG. 4) provided with a flat end 401c, as shown, and configured to fit into the output port 303 of the handheld booster device 300.

The invention having been thus described, it will be apparent to those skilled in the art that the same may be varied in many ways without departing from the spirit or scope of the invention. Any and all such variations are intended to be encompassed within the scope of the following claims.

What is claimed is:

1. A jump starting apparatus configured for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starting apparatus comprising:
 - a power supply;
 - a positive polarity battery terminal connector configured for connecting the jump starting apparatus to the positive polarity battery terminal of the depleted or discharged battery;
 - a negative polarity battery terminal connector configured for connecting the jump starting apparatus to the negative polarity battery terminal of the depleted or discharged battery;
 - a power switch or circuit configured to turn on power from the power supply to the positive and negative polarity battery terminal connectors;
 - a control system or circuit connected to and controlling the power switch, the control system or circuit configured to detect whether the positive and negative polarity battery terminal connectors have a correct polarity connection with the positive and negative polarity battery terminals of the depleted or discharged battery prior to turning on the power switch or circuit;
 - a USB input circuit connected to the power supply, the USB input circuit comprising a DC/DC converter, the USB input circuit configured for converting power from a USB power source to increase power voltage to the power supply; and

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a USB input connector connected to the USB input circuit, the USB input connector configured for connecting to the USB power source and providing power input from the USB power source through the USB input connector and the USB input circuit to the power supply.

2. The apparatus of claim 1, wherein the power supply comprises a lithium ion battery.

3. The apparatus of claim 2, wherein the lithium ion battery comprises a battery pack of multiple lithium ion batteries.

4. The apparatus of claim 1, wherein the power switch comprises one or more FETs.

5. The apparatus of claim 1, wherein the control system or circuit is configured to detect a presence of the depleted or discharged battery connected between the positive and negative polarity battery terminal connectors and to detect the correct polarity connection of the positive and negative polarity battery terminal connectors of the jump starting device with the positive and negative battery terminals of the depleted or discharged battery.

6. The apparatus of claim 1, further comprising a plurality of power diodes coupled between the positive and negative battery terminal connectors and the power supply to prevent back-charging of the power supply from an electrical system connected to the positive and negative battery terminal connectors.

7. The apparatus of claim 1, further comprising a temperature sensor configured to detect temperature of the power supply and to provide a temperature signal to a microcontroller.

8. The apparatus of claim 1, further comprising a voltage measurement circuit configured to measure output voltage of the power supply and to provide a voltage measurement signal to a microcontroller.

9. The apparatus of claim 1, further comprising a voltage regulator configured to convert output voltage of the power supply to a voltage level appropriate to provide operating power to internal components of the jump starting apparatus.

10. The apparatus of claim 1, further comprising a USB output port configured to provide charging power from the power supply to a USB-chargable device.

11. The apparatus of claim 1, further comprising a flash-light circuit configured to provide a source of light to a user.

12. The apparatus of claim 11, wherein the source of light is at least one LED.

13. The apparatus of claim 12, wherein the control system or circuit is configured to control the at least one LED to provide a visual alarm indicating an emergency situation.

14. The apparatus of claim 1, further comprising a plurality of visual indicators configured to display remaining capacity status of the power supply.

15. The apparatus of claim 14, wherein the plurality of visual indicators comprises a plurality of LEDs providing output light of different colors.

16. The apparatus of claim 1, further comprising a visual indicator configured to warn a user when the depleted or discharged battery is connected to the jump starting apparatus with reverse polarity.

17. The apparatus of claim 1, further comprising separate visual indicators configured to display a power on status of the jump starting apparatus, and a jump start boost power status of power supplied to an output device.

18. The apparatus of claim 1, further comprising a manual override switch configured to activate a manual override mode to enable a user to connect jump start power to the

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depleted or discharged vehicle battery when a vehicle battery isolation sensor is unable to detect presence of the vehicle battery.

19. The apparatus of claim 18, wherein the control system or circuit is configured to detect actuation of the manual override switch for at least a predetermined period of time before activation of the manual override mode.

20. The apparatus of claim 1, further comprising a jumper cable device, the jumper cable device comprising a plug configured to plug into an output port of the jump starting apparatus, a pair of battery cables integrated with the plug at one end of the pair of cables, and the positive and negative battery terminal connectors connected to an opposite end of the pair of battery cables.

21. The apparatus of claim 20, wherein the jumper cable device further comprises a pair of ring terminals configured to respectively connect the pair of cables at the opposite end to the respective positive and negative battery terminals of the depleted or discharged battery, or connect to respective positive and negative battery clamps.

22. The apparatus of claim 20, wherein the output port and the plug are dimensioned so that the plug will fit into the output port only in one specific orientation.

23. The apparatus according to claim 1, further comprising a USB output circuit connecting the power supply to a USB output connector for charging portable electronic devices from the power supply.

24. The apparatus according to claim 23, wherein the USB output circuit is connected to a microcontroller, the USB output circuit is configured to allow the USB output circuit to be turned on and off by software control to prevent the power supply from getting too low in capacity.

25. The apparatus according to claim 23, wherein the USB output circuit includes a voltage divider to enable charging of certain electronic devices.

26. The apparatus according to claim 1, including an operation indicator LED to provide visual indication of the power supply capacity status.

27. The apparatus according to claim 1, including an operation indicator LED to provide visual indication of the switch activation status indicating power is being provided to the depleted or discharged battery.

28. The apparatus according to claim 1, wherein the correct polarity connection with the positive and negative polarity battery terminal connectors of the depleted or discharged battery prior to turning on the power switch or circuit can, alternatively, be an incorrect polarity connection.

29. The apparatus according to claim 1, wherein the control system or circuit comprises one or more sensors connected to a microprocessor for determining whether the depleted or discharged battery is present and connected between the positive and negative polarity battery terminal connectors.

30. The apparatus according to claim 1, wherein the control system or circuit comprises one or more sensors connected to a microprocessor for determining whether the depleted or discharged battery is properly or improperly connected to the positive and negative polarity battery terminal connectors.

31. The apparatus according to claim 1, wherein the control system or circuit comprises one or more sensors connected to a microprocessor for determining whether the depleted or discharged battery is present and connected between the positive and negative polarity battery terminal connectors and determining whether the depleted or dis-

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charged battery has a correct or incorrect polarity connection with the positive and negative polarity battery terminal connectors.

32. The apparatus according to claim 1, wherein the DC-DC converter can be turned on and off by a microprocessor.

33. The apparatus according to claim 1, wherein the jump starting apparatus is configured to prevent an incorrect polarity connection of the positive and negative battery terminal connectors of the jump starting apparatus with the positive and negative polarity battery terminals of the depleted or discharged battery.

34. The apparatus according to claim 1, wherein the jump starting apparatus is configured to prevent an incorrect polarity connection of the positive and negative battery terminal connectors of the jump starting apparatus with the positive and negative polarity battery terminals of the depleted or discharged battery prior to turning on the power switch or circuit.

35. The apparatus according to claim 1, wherein the jump starting apparatus is configured to prevent an incorrect polarity connection of the positive and negative battery terminal connectors of the jump starting apparatus with the positive and negative polarity battery terminals of the depleted or discharged battery when turning on the power switch or circuit.

36. The apparatus according to claim 1, wherein the jump starting apparatus is configured to prevent an incorrect polarity connection of the positive and negative battery terminal connectors of the jump starting apparatus with the positive and negative polarity battery terminals of the depleted or discharged battery by turning on the power switch only when the depleted or discharged battery is connected with correct polarity to the jump starting apparatus.

37. The apparatus according to claim 1, wherein the jump starting apparatus is configured to prevent an incorrect polarity connection of the positive and negative battery terminal connectors of the jump starting apparatus with the positive and negative polarity battery terminals of the depleted or discharged battery by the jump starting device supplying power to the depleted or discharged battery only when or while connected with correct polarity to the jump starting apparatus.

38. A jump starting apparatus for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starting apparatus comprising:

- a power supply;
- a positive polarity battery terminal connector configured for connecting the jump starting apparatus to the positive polarity terminal of the depleted or discharged battery;
- a negative polarity battery terminal connector configured for connecting the jump starting apparatus to the negative polarity terminal of the depleted or discharged battery;
- a battery presence sensor or circuit connected in circuit with the positive polarity battery terminal connector and the negative polarity battery terminal connector;
- a reverse polarity sensor or circuit connected in circuit with the positive polarity battery terminal connector and the negative polarity terminal connector;
- a power switch or circuit connected or connectable in circuit with the power supply and the positive and negative polarity battery terminal connectors;

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a microcontroller configured to receive input signals provided by the battery presence sensor or circuit and the reverse polarity sensor or circuit, the microcontroller configured to provide an output signal to control the power switch,

a USB input circuit connected to the power supply, the USB input circuit configured for converting power from a USB power source to increase power voltage to the power supply; and

a USB input connector connected to the USB input circuit, the USB input connector configured for connecting to the USB power source and providing power input from the USB power source through the USB input connector and the USB input circuit to the power supply.

39. A jump starting device for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starter device comprising:

a power supply;

a positive battery terminal connector for connecting the jump starter device to the positive battery terminal of the depleted or discharged battery;

a negative battery terminal connector for connecting the jump starter device to the negative battery terminal of the depleted or discharged battery;

a power switch or circuit connected in circuit with the power supply and the positive and negative battery terminal connectors, the power switch configured to turn power on from the power supply to the depleted or discharged battery when the positive and negative battery terminal connectors are properly connected to the positive and negative battery connectors;

a power switch control system or circuit connected to and controlling the power switch, the power switch control system or circuit configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery terminal connectors and to detect polarity of the depleted or discharged battery when connected between the positive and negative battery terminal connectors;

a USB input circuit connected to the power supply, the USB input circuit configured for converting power from a USB power source to increase power voltage to the power supply; and

a USB input connector configured for connecting to the USB power source and providing power input from the USB power source through the USB input connector and the USB input circuit to the power supply.

40. The device according to claim 39, wherein the power switch control system or circuit does not switch on the power supply to connect the power supply to the depleted or discharged battery when the power switch control system or circuit detects either that (i) the depleted or discharged battery is absent or not connected between the positive and negative battery connectors, and (ii) the depleted or discharged battery is not connected with a correct polarity connection between the positive and negative battery terminal connectors.

41. The device according to claim 39, wherein the power switch control system or circuit is configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery connectors and to detect polarity of the depleted or discharged battery when connected between the positive and negative battery connectors prior to turning power on from the power supply to the depleted or discharged battery.

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42. The device according to claim 39, wherein the power switch control system or circuit comprises a microcontroller configured for providing an output controlling the power switch.

43. The device according to claim 42, wherein the microcontroller receives input from one or more sensors configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery connectors and to detect polarity of the depleted or discharged battery when connected between the positive and negative battery connectors.

44. The device according to claim 43, wherein the one or more sensors includes one sensor configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery terminal connectors, and another sensor configured to detect polarity of the depleted or discharged battery when connected between the positive and negative battery terminal connectors.

45. The device according to claim 44, wherein the one or more sensors comprises one or more sensing circuits.

46. The device according to claim 42, wherein the microcontroller is configured to turn on the power switch to provide power from the power supply to the depleted or discharged battery only when the depleted or discharged battery is determined by the microcontroller to be present and properly or improperly connected to the jump starting apparatus.

47. A jump starting device for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starter device comprising:

- a power supply;
- a positive battery terminal connector for connecting the jump starter device to the positive battery terminal of the depleted or discharged battery;
- a negative battery terminal connector for connecting the jump starter device to the negative battery terminal of the depleted or discharged battery;
- a power switch or circuit connected in circuit with the power supply and the positive and negative battery terminal connectors, the power switch configured to turn power on from the power supply to the depleted or discharged battery when connected to the positive and negative battery terminal connectors;
- a power switch control system or circuit connected to and controlling the power switch, the power switch control system or circuit configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery terminal connectors and to detect correct or incorrect polarity of the depleted or discharged battery when connected between the positive and negative battery terminal connectors;
- a USB input circuit connected to the power supply, the USB input circuit configured for converting power from a USB power source to increase power voltage to the power supply; and
- a USB input connector connected to the USB input circuit, the USB input connector configured for connecting to the USB power source and providing power input from the USB power source through the USB input connector and the USB input circuit to the power supply.

48. The apparatus according to claim 47, wherein the USB input circuit comprises a DC-DC converter.

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49. The apparatus according to claim 48, wherein the DC-DC converter is configured for up-converting the input voltage received by the USB input connector.

50. The apparatus according to claim 49, wherein the input voltage is about 5V that is up-converted to at least 11.1 VDC for powering the power supply.

51. The apparatus according to claim 48, wherein the USB input charge circuit is configured to turn on and off the DC-DC converter by an output of the control system or circuit comprising a microcontroller.

52. A jump starting apparatus configured for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starting apparatus comprising:

- a power supply;
- a positive polarity battery terminal connector configured for connecting the jump starting apparatus to the positive polarity battery terminal of the depleted or discharged battery;
- a negative polarity battery terminal connector configured for connecting the jump starting apparatus to the negative polarity battery terminal of the depleted or discharged battery;
- a power switch or circuit configured to turn on power from the power supply to the positive and negative polarity battery terminal connectors;
- a control system or circuit connected to and controlling the power switch, the control system or circuit comprising a microcontroller, the control system or circuit configured to detect whether the positive and negative polarity battery terminal connectors have a correct or incorrect polarity connection with the positive and negative polarity battery terminals of the depleted or discharged battery prior to turning on the power switch;
- a USB input connector configured for removably connecting to a USB power source and providing power input from the USB power source to the USB input connector; and
- a USB input circuit connecting the USB input connector to the power supply, the USB input circuit comprising a DC/DC converter, the USB input circuit configured for converting power from the USB power source to increase power voltage to the power supply, wherein the DC-DC converter can be turned on and off by an output from the microcontroller.

53. The apparatus according to claim 52, wherein the DC-DC converter can be turned on and off via the control system or circuit by the output from the microcontroller.

54. A jump starting apparatus configured for boosting or charging a depleted or discharged battery having a positive polarity battery terminal and a negative polarity battery terminal, the jump starting apparatus comprising:

- a power supply;
- a positive polarity battery terminal connector configured for connecting the jump starting apparatus to the positive polarity battery terminal of the depleted or discharged battery;
- a negative polarity battery terminal connector configured for connecting the jump starting apparatus to the negative polarity battery terminal of the depleted or discharged battery;
- a power switch or circuit configured to turn on power from the power supply to the positive and negative polarity battery terminal connectors;
- a control system or circuit connected to and controlling the power switch, the control system or circuit configured to detect whether the positive and negative polar-

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ity battery terminal connectors have a correct polarity connection with the positive and negative polarity battery terminals of the depleted or discharged battery and prevent an incorrect polarity connection with the positive and negative polarity battery terminals of the depleted or discharged battery prior to turning on the power switch or circuit;

a USB input connector; and

a USB input circuit connecting the USB input connector to the power supply, the USB input circuit comprising a DC/DC converter for up-converting the voltage from the USB input connector to the power supply.

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EXHIBIT D



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(12) **United States Patent**
Nook et al.

(10) **Patent No.:** **US 11,584,243 B2**
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(54) **JUMP STARTING DEVICE WITH USB**

(71) Applicant: **THE NOCO COMPANY**, Glenwillow, OH (US)

(72) Inventors: **Jonathan Lewis Nook**, Gates Mills, OH (US); **William Knight Nook**, Shaker Heights, OH (US); **James Richard Stanfield**, Glendale, AZ (US); **Derek Michael Underhill**, Tempe, AZ (US)

(73) Assignee: **The NOCO Company**, Glenwillow, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 41 days.

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(52) **U.S. Cl.**

CPC **B60L 53/14** (2019.02); **H02J 1/122** (2020.01); **H02J 7/0029** (2013.01);
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(58) **Field of Classification Search**

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(Continued)

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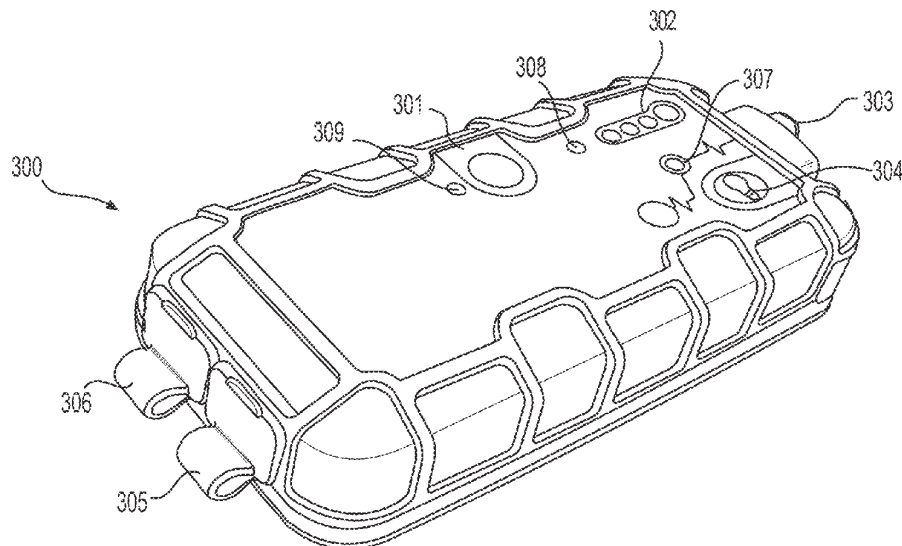
Primary Examiner — M Baye Diao

(74) *Attorney, Agent, or Firm* — Jones Day

(57) **ABSTRACT**

A jump starting device having USB. For example, a handheld jump starting device having USB for boosting or charging a depleted or discharged battery. The handheld jump starting device, for example, can include a rechargeable lithium ion battery pack and a microcontroller. The lithium ion battery can be coupled to a power output port of the device through a power switch circuit actuated by the microcontroller.

57 Claims, 13 Drawing Sheets



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Related U.S. Application Data

continuation of application No. 14/619,655, filed on Feb. 11, 2015, now Pat. No. 9,770,992, which is a division of application No. 14/325,938, filed on Jul. 8, 2014, now Pat. No. 9,007,015, which is a continuation of application No. PCT/US2014/045434, filed on Jul. 3, 2014.

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 See application file for complete search history.

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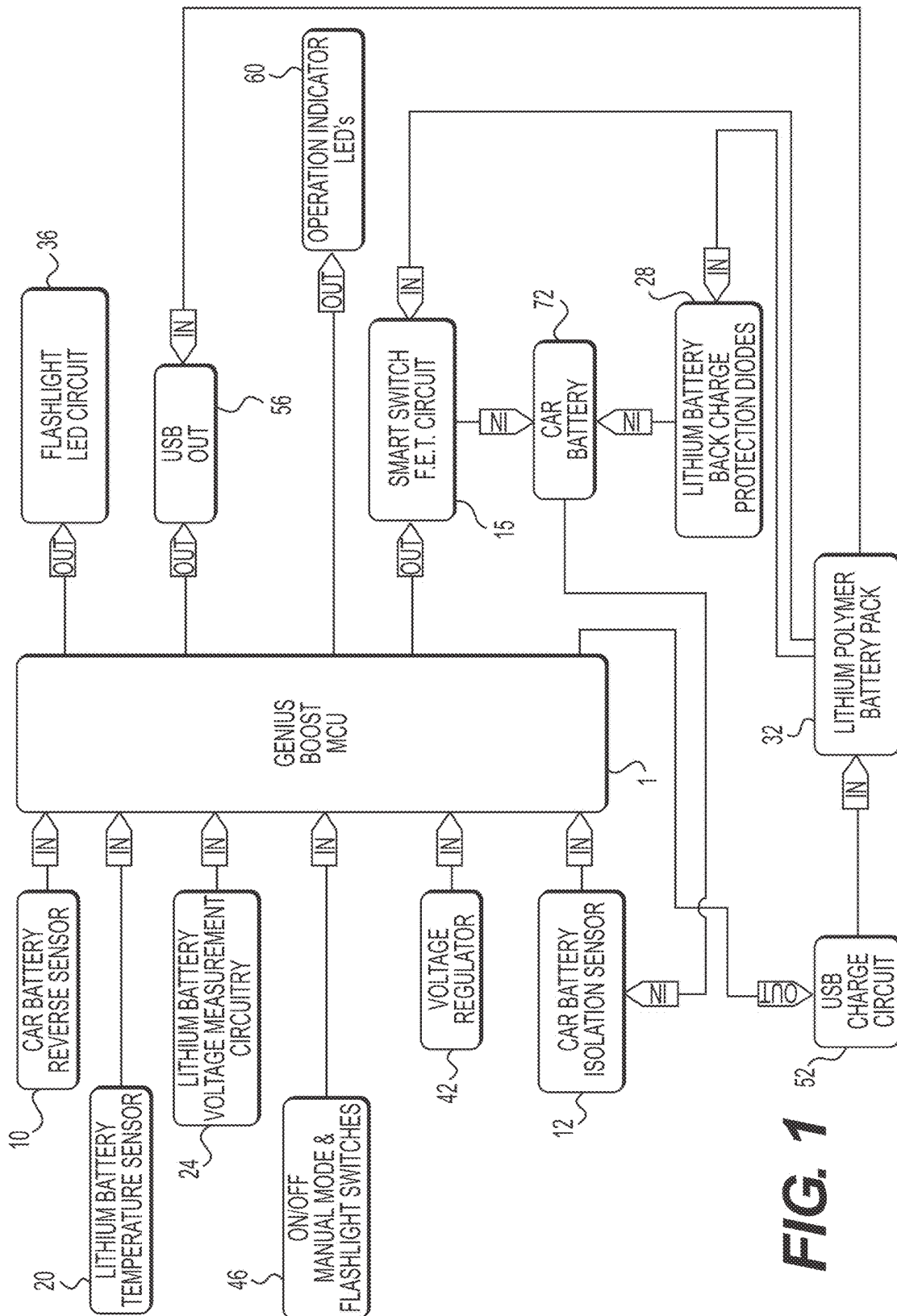


FIG. 1

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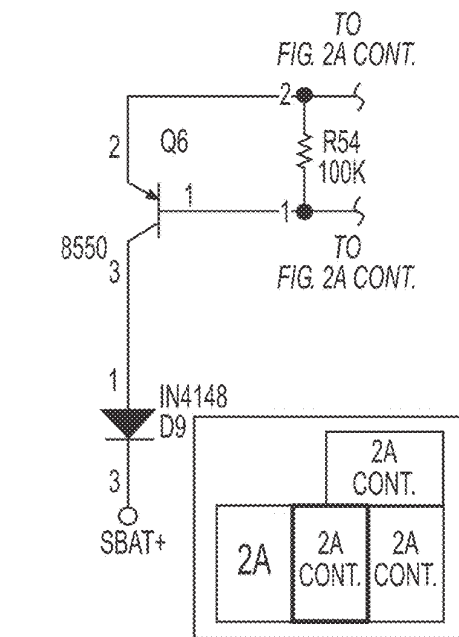
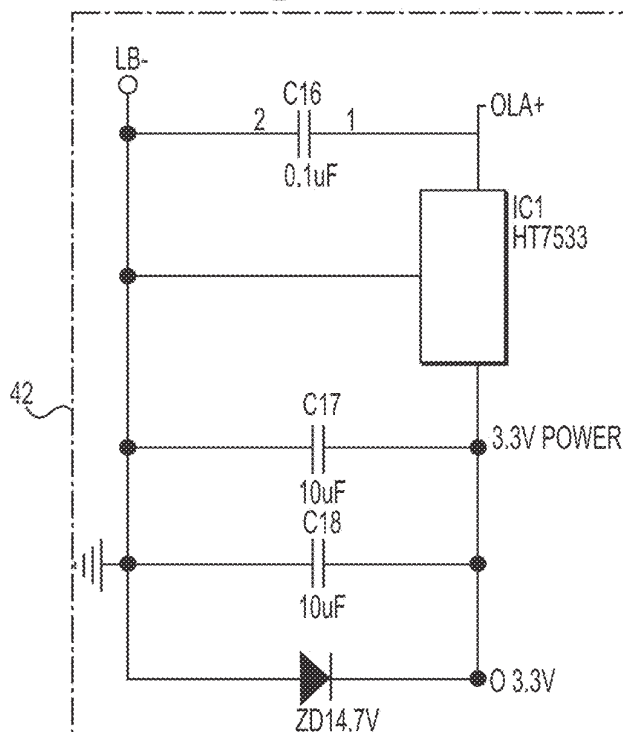
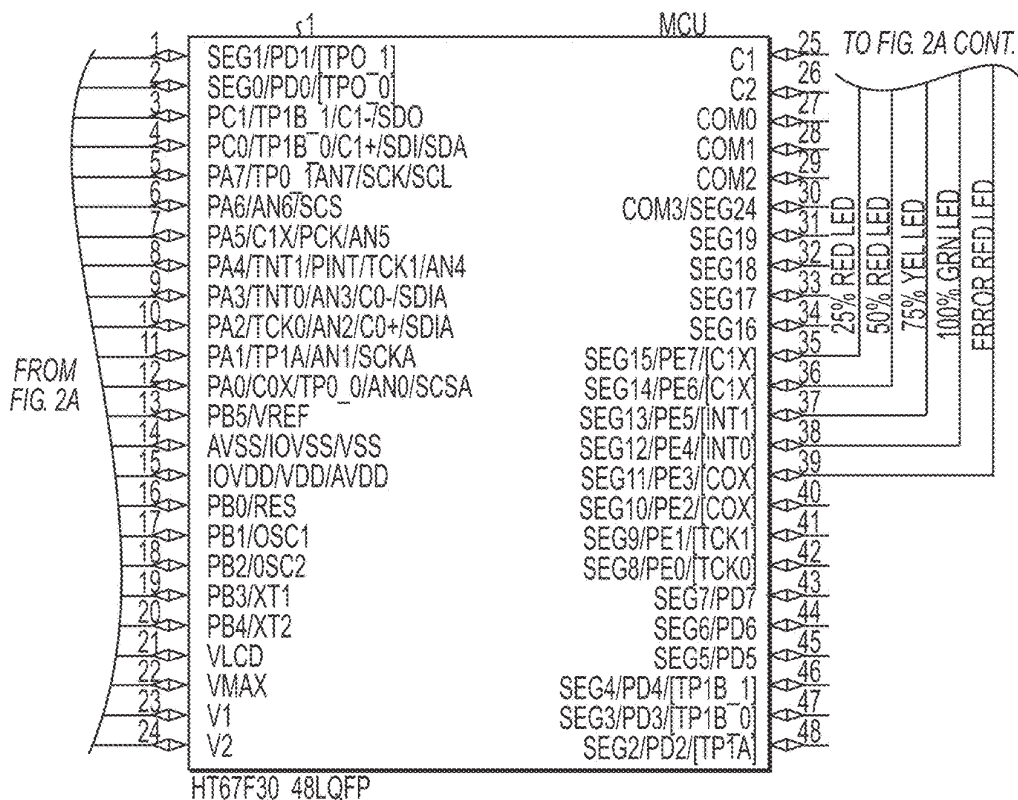


FIG. 2A CONT.

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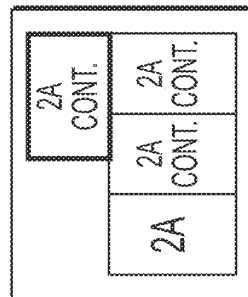
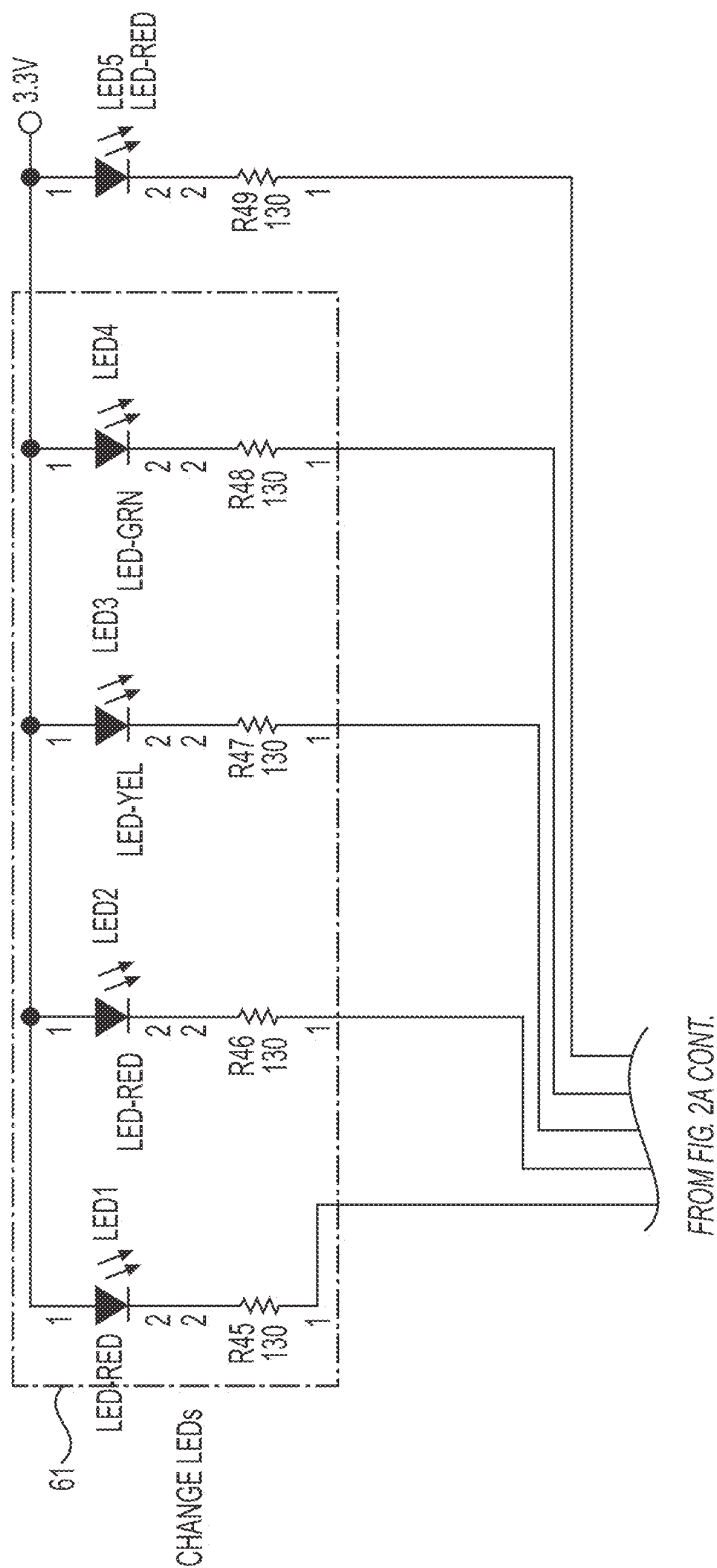


FIG. 2A CONT.

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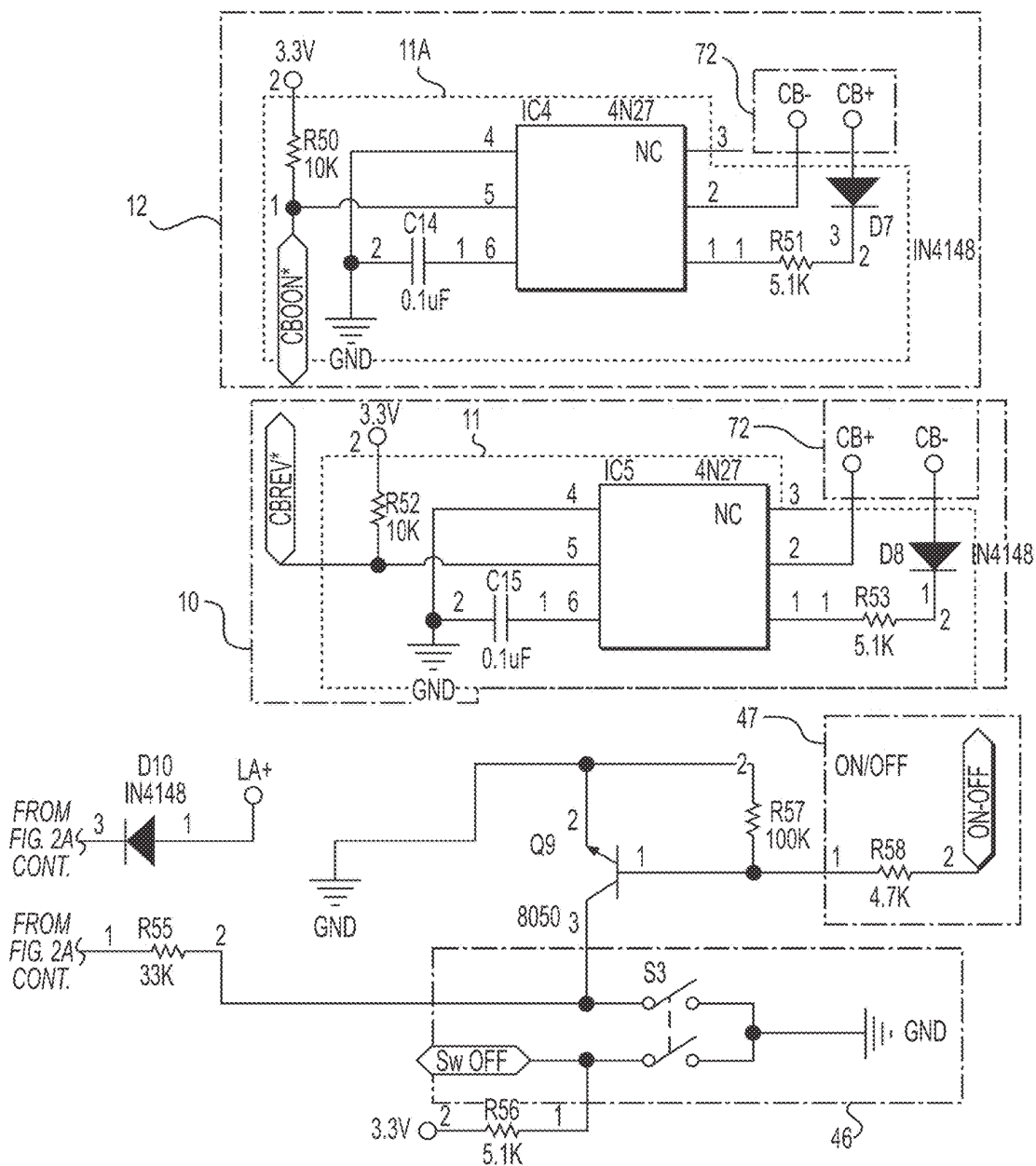
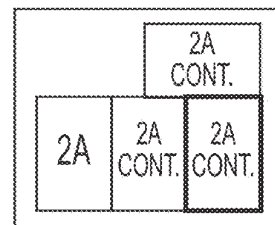


FIG. 2A CONT.



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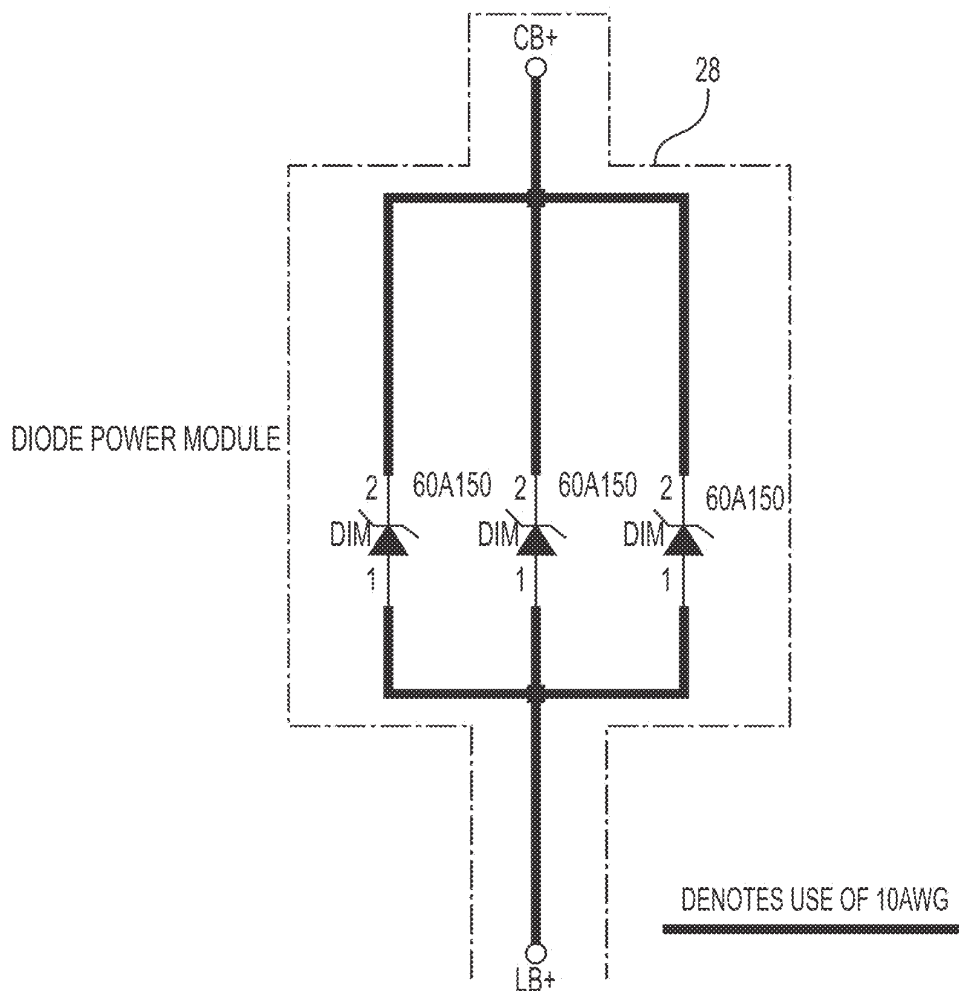
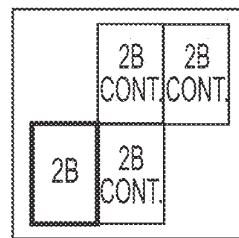


FIG. 2B



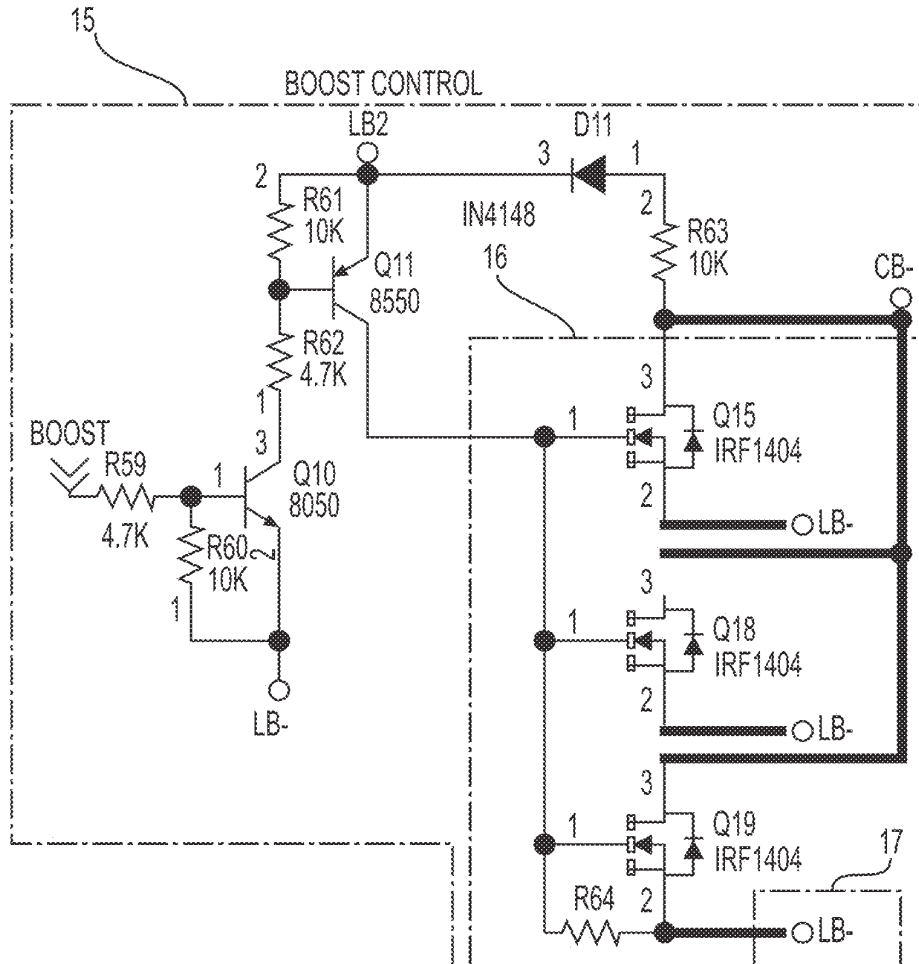
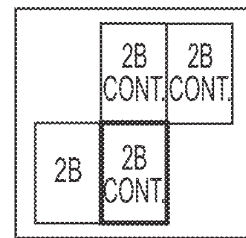


FIG. 2B CONT.



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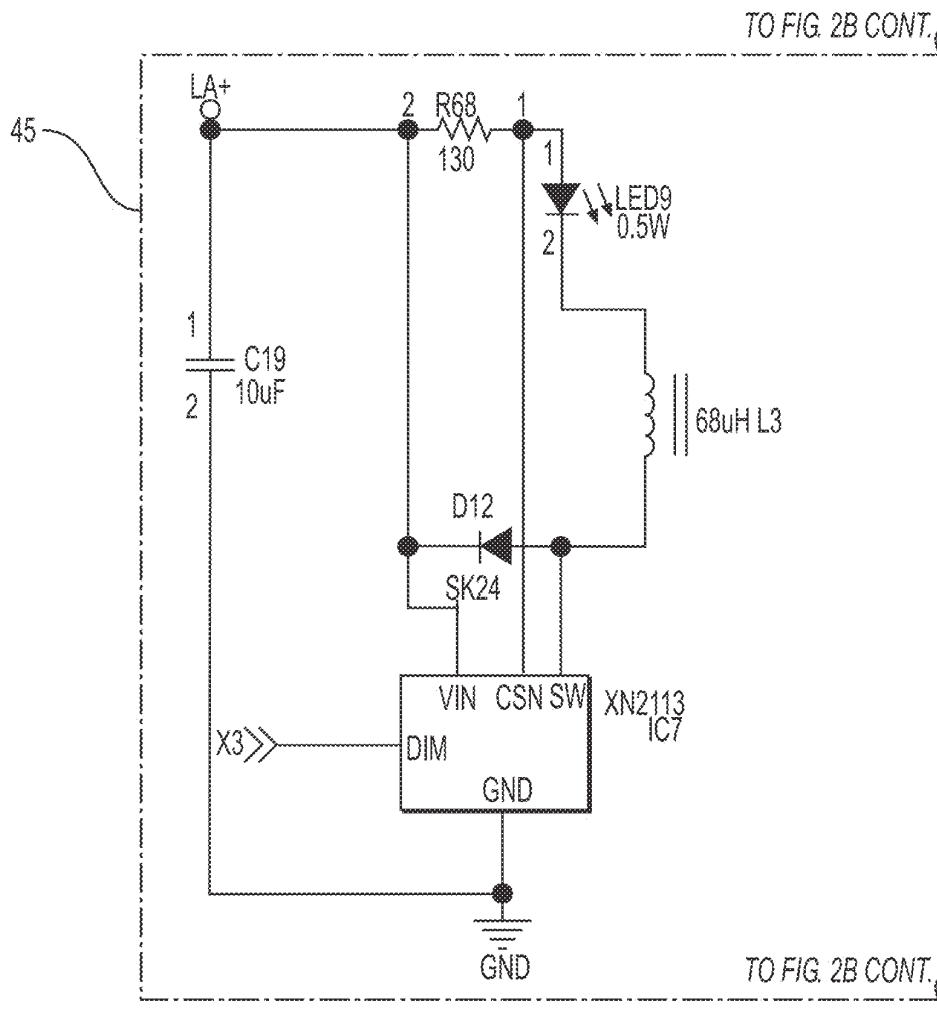
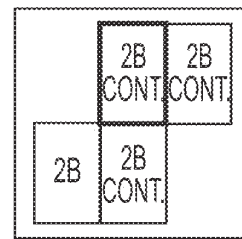


FIG. 2B CONT.

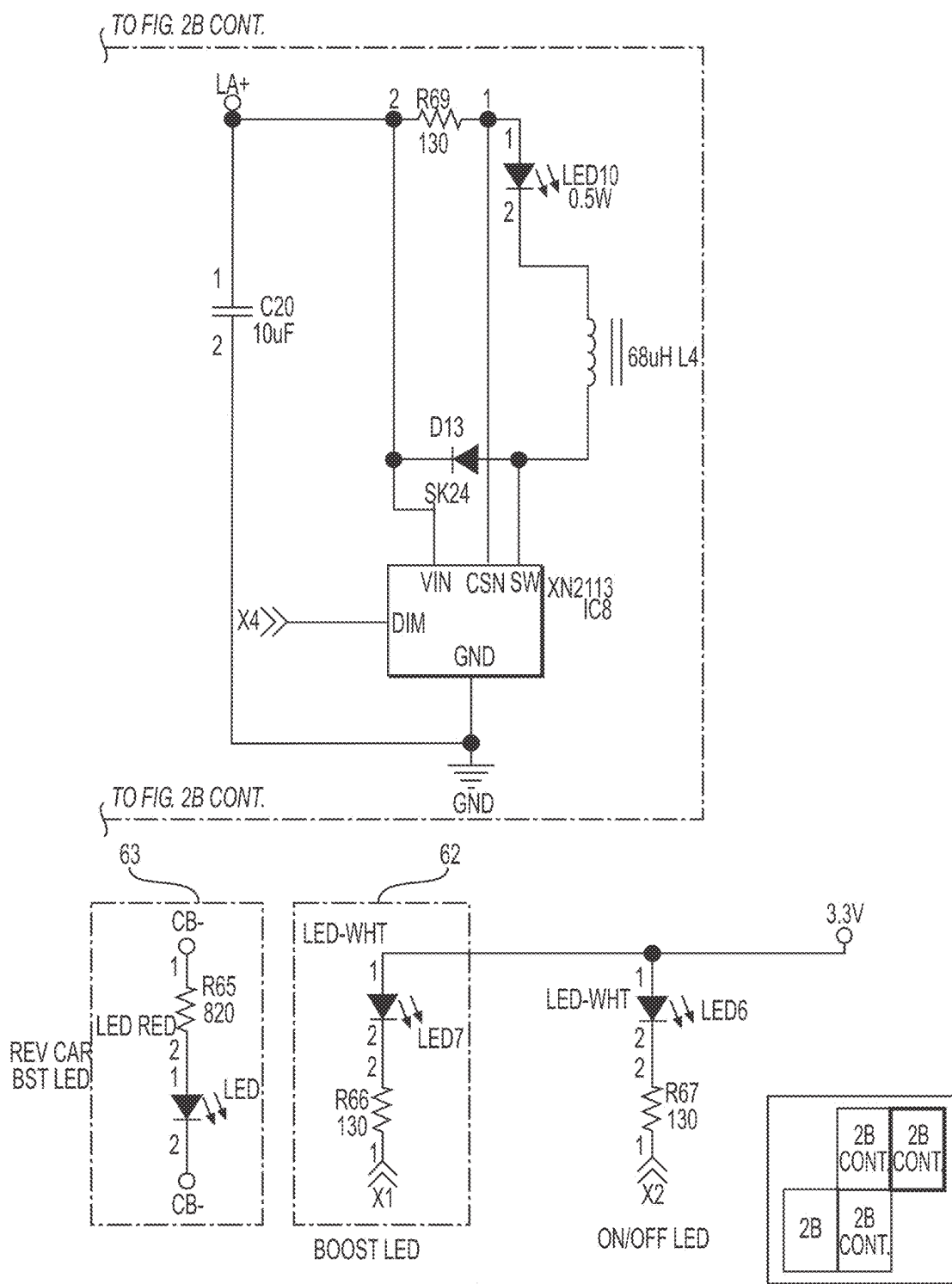


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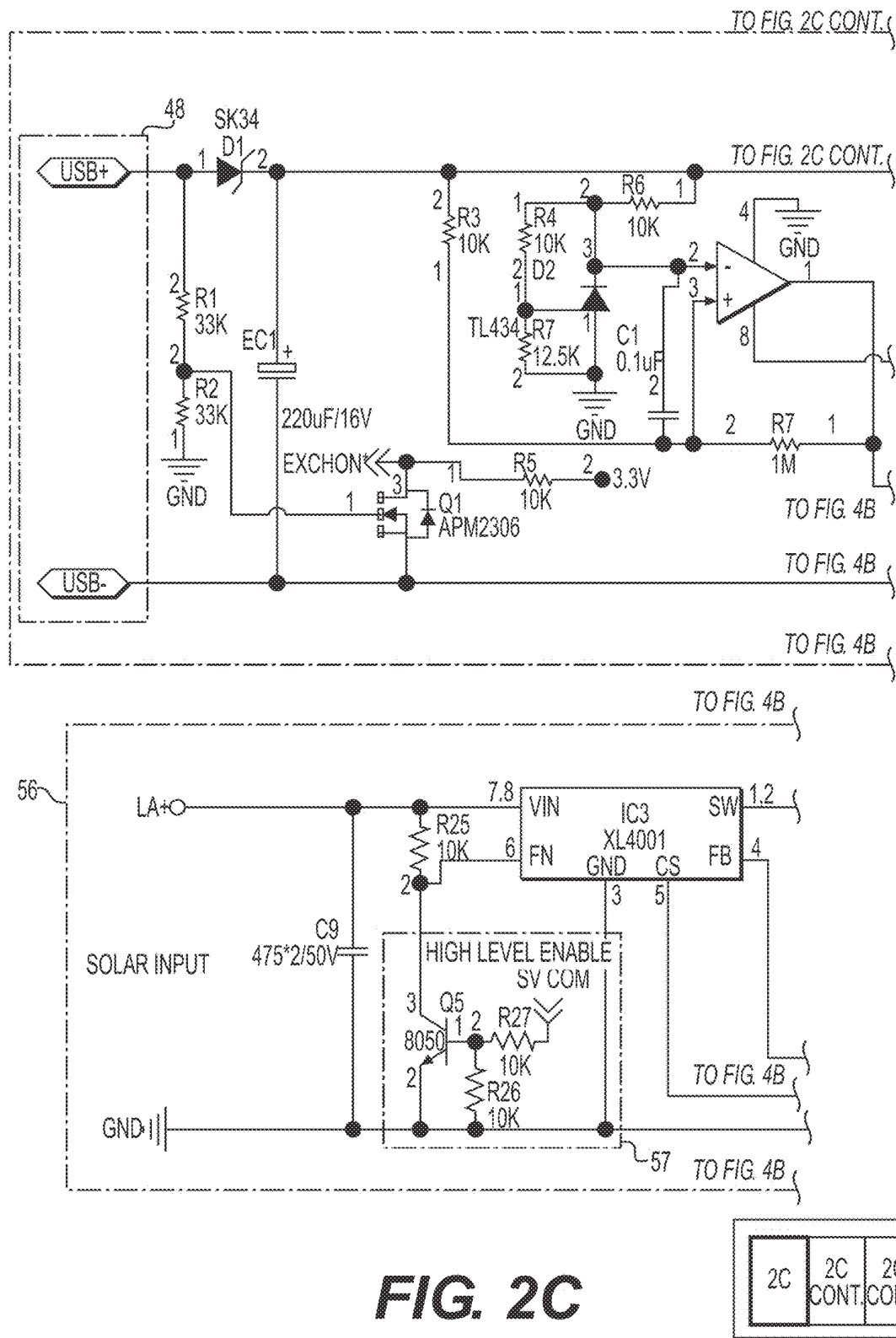


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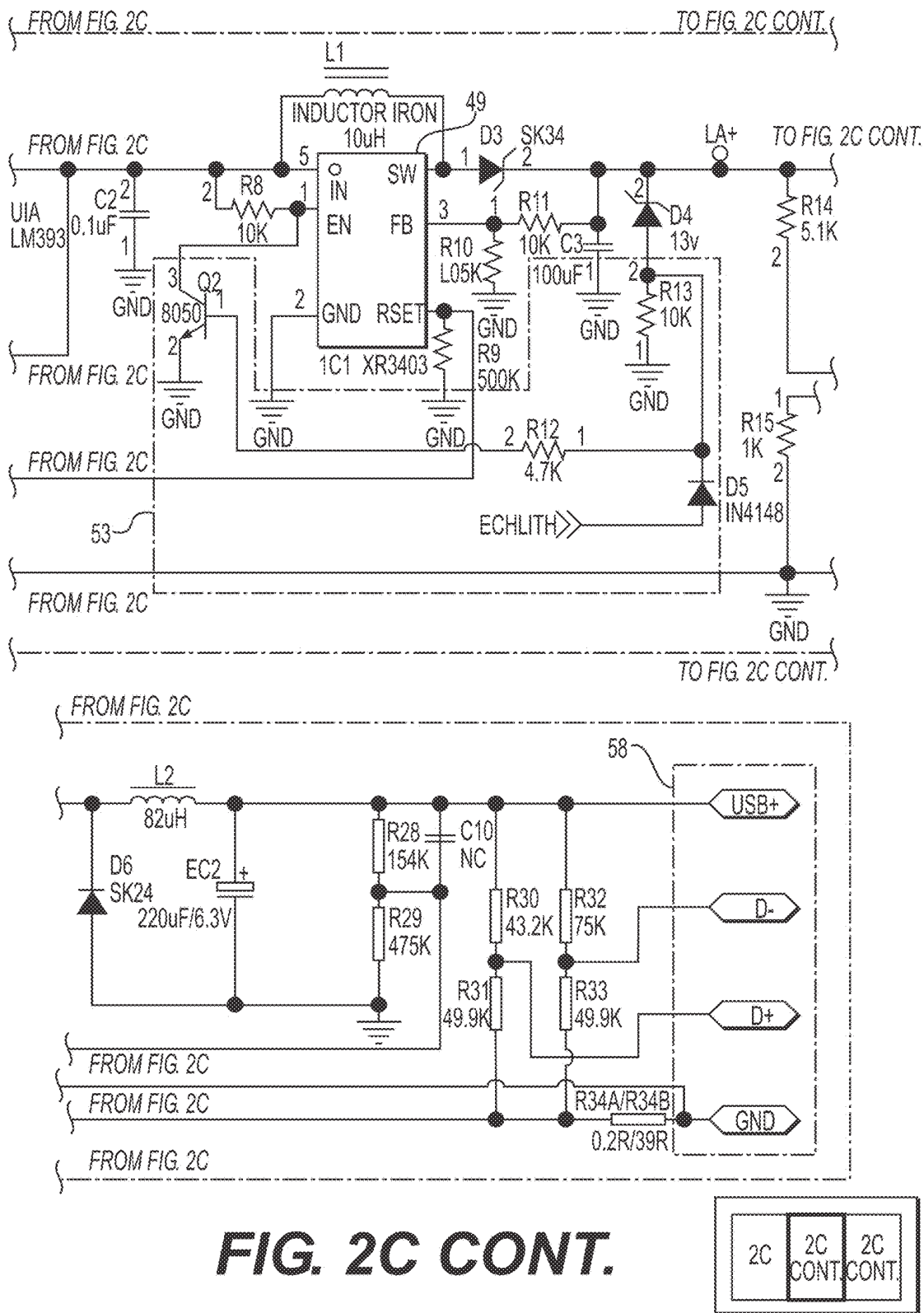


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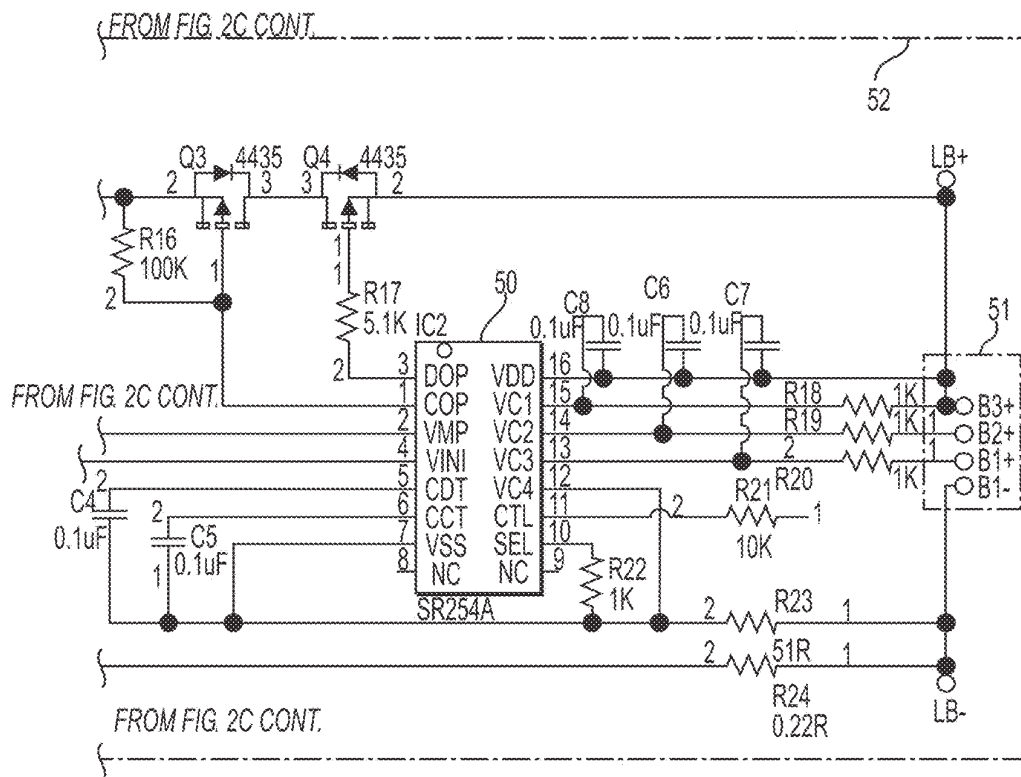
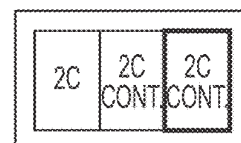


FIG. 2C CONT.



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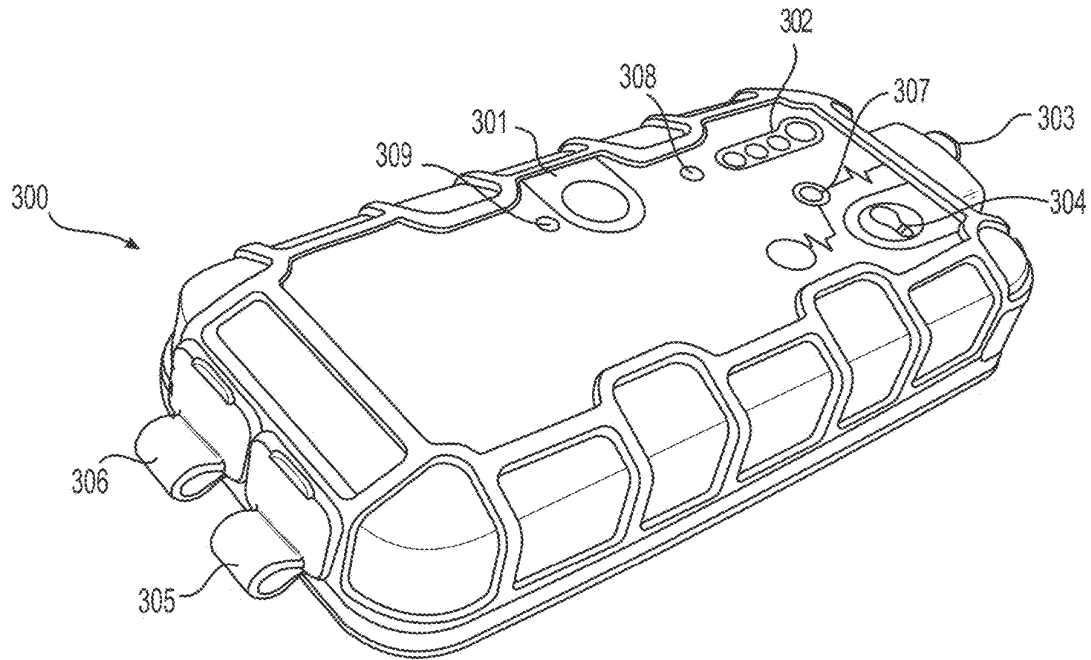


FIG. 3

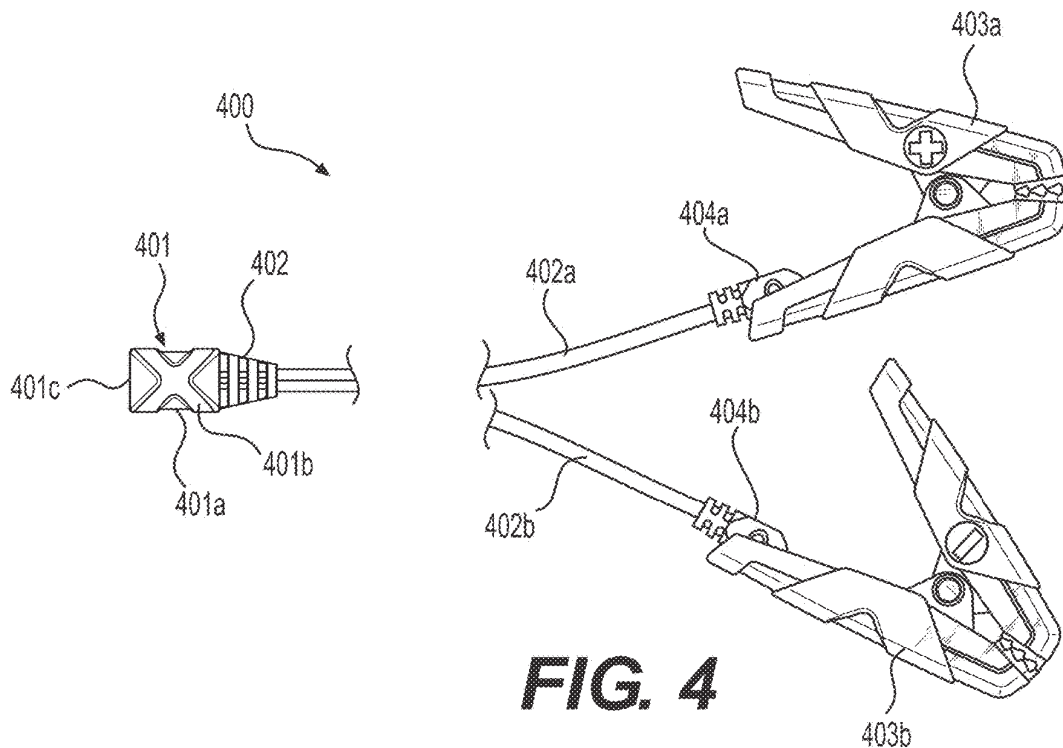


FIG. 4

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JUMP STARTING DEVICE WITH USB

FIELD OF THE INVENTION

The present invention relates generally to apparatus for jump-starting a vehicle having a depleted or discharged battery.

BACKGROUND TO THE INVENTION

Prior art devices are known for jump-starting a vehicle, which provide either a pair of electrical connector cables that connect a fully-charged battery of another vehicle to the engine start circuit of the dead battery vehicle, or portable booster devices which include a fully-charged battery which can be connected in circuit with the vehicle's engine starter through a pair of cables.

Problems with the prior art arose when either the jumper terminals or clamps of the cables were inadvertently brought into contact with each other while the other ends were connected to a charged battery, or when the positive and negative terminals were connected to the opposite polarity terminals in the vehicle to be jumped, thereby causing a short circuit resulting in sparking and potential damage to batteries and/or bodily injury.

Various attempts to eliminate these problems have been made in the prior art. U.S. Pat. No. 6,212,054 issued Apr. 3, 2001, discloses a battery booster pack that is polarity sensitive and can detect proper and improper connections before providing a path for electric current flow. The device uses a set of LEDs connected to optical couplers oriented by a control circuit. The control circuit controls a solenoid assembly controlling the path of power current. The control circuit causes power current to flow through the solenoid assembly only if the points of contact of booster cable clamp connections have been properly made.

U.S. Pat. No. 6,632,103 issued Oct. 14, 2003, discloses an adaptive booster cable connected with two pairs of clips, wherein the two pairs of clips are respectively attached to two batteries to transmit power from one battery to the other battery. The adaptive booster cable includes a polarity detecting unit connected to each clip, a switching unit and a current detecting unit both provided between the two pairs of clips. After the polarity of each clip is sensed by the polarity detecting unit, the switching unit generates a proper connection between the two batteries. Therefore, the positive and negative terminals of the two batteries are correctly connected based on the detected result of the polarity detecting unit.

U.S. Pat. No. 8,493,021 issued Jul. 23, 2013, discloses apparatus that monitors the voltage of the battery of a vehicle to be jump started and the current delivered by the jump starter batteries to determine if a proper connection has been established and to provide fault monitoring. Only if the proper polarity is detected can the system operate. The voltage is monitored to determine open circuit, disconnected conductive clamps, shunt cable fault, and solenoid fault conditions. The current through the shunt cable is monitored to determine if there is a battery explosion risk, and for excessive current conditions presenting an overheating condition, which may result in fire. The system includes an internal battery to provide the power to the battery of the vehicle to be jump started. Once the vehicle is started, the unit automatically electrically disconnects from the vehicle's battery.

U.S. Pat. No. 5,189,359 issued Feb. 23, 1993, discloses a jumper cable device having two bridge rectifiers for devel-

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oping a reference voltage, a four-input decoder for determining which terminals are to be connected based on a comparison of the voltage at each of the four terminals to the reference voltage, and a pair of relays for effecting the correct connection depending on the determination of the decoder. No connection will be made unless only one terminal of each battery has a higher voltage than the reference voltage, indicating "positive" terminals, and one has a lower voltage than the reference voltage, indicating "negative" terminals, and that, therefore, the two high voltage terminals may be connected and the two lower voltage terminals may be connected. Current flows once the appropriate relay device is closed. The relay device is preferably a MOSFET combined with a series array of photodiodes that develop MOSFET gate-closing potential when the decoder output causes an LED to light.

U.S. Pat. No. 5,795,182 issued Aug. 18, 1998, discloses a polarity independent set of battery jumper cables for jumping a first battery to a second battery. The apparatus includes a relative polarity detector for detecting whether two batteries are configured cross or parallel. A three-position high current capacity crossbar pivot switch is responsive to the relative polarity detector for automatically connecting the plus terminals of the two batteries together and the minus terminals of the two batteries together regardless of whether the configuration detected is cross or parallel, and an under-current detector and a delay circuit for returning the device to its ready and unconnected state after the device has been disconnected from one of the batteries. The crossbar pivot switch includes two pairs of contacts, and a pivot arm that pivots about two separate points to ensure full electrical contact between the pairs of contacts. The invention can also be used to produce a battery charger that may be connected to a battery without regard to the polarity of the battery.

U.S. Pat. No. 6,262,492 issued Jul. 17, 2001, discloses a car battery jumper cable for accurately coupling an effective power source to a failed or not charged battery, which includes a relay switching circuit connected to the power source and the battery by two current conductor pairs. First and second voltage polarity recognition circuits are respectively connected to the power source and the battery by a respective voltage conductor pair to recognize the polarity of the power source and the battery. A logic recognition circuit produces a control signal subject to the polarity of the power source and the battery, and a driving circuit controlled by the control signal from the logic recognition circuit drives the relay switching circuit, enabling the two poles of the power source to be accurately coupled to the two poles of the battery.

U.S. Pat. No. 5,635,817 issued Jun. 3, 1997, discloses a vehicle battery charging device that includes a control housing having cables including a current limiting device to prevent exceeding of a predetermined maximum charging current of about 40 to 60 amps. The control housing includes a polarity detecting device to verify the correct polarity of the connection of the terminals of the two batteries and to electrically disconnect the two batteries if there is an incorrect polarity.

U.S. Pat. No. 8,199,024 issued Jun. 12, 2012, discloses a safety circuit in a low-voltage connecting system that leaves the two low-voltage systems disconnected until it determines that it is safe to make a connection. When the safety circuit determines that no unsafe conditions exist and that it is safe to connect the two low-voltage systems, the safety circuit may connect the two systems by way of a "soft start" that provides a connection between the two systems over a period of time that reduces or prevents inductive voltage

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spikes on one or more of the low-voltage systems. When one of the low-voltage systems has a completely-discharged battery incorporated into it, a method is used for detection of proper polarity of the connections between the low-voltage systems. The polarity of the discharged battery is determined by passing one or more test currents through it and determining whether a corresponding voltage rise is observed.

U.S. Pat. No. 5,793,185 issued Aug. 11, 1998, discloses a handheld jump starter having control components and circuits to prevent overcharging and incorrect connection to batteries.

While the prior art attempted solutions to the abovementioned problems as discussed above, each of the prior art solutions suffers from other shortcomings, either in complexity, cost or potential for malfunction. Accordingly, there exists a need in the art for further improvements to vehicle jump start devices.

SUMMARY OF THE INVENTION

In accordance with an aspect of the invention, an apparatus is provided for jump starting a vehicle engine, comprising: an internal power supply; an output port having positive and negative polarity outputs; a vehicle battery isolation sensor connected in circuit with said positive and negative polarity outputs, configured to detect presence of a vehicle battery connected between said positive and negative polarity outputs; a reverse polarity sensor connected in circuit with said positive and negative polarity outputs, configured to detect polarity of a vehicle battery connected between said positive and negative polarity outputs and to provide an output signal indicating whether positive and negative terminals of said vehicle battery are properly connected with said positive and negative polarity outputs of said output port; a power switch connected between said internal power supply and said output port; and a microcontroller configured to receive input signals from said vehicle isolation sensor and said reverse polarity sensor, and to provide an output signal to said power switch, such that said power switch is turned on to cause said internal power supply to be connected to said output port in response to signals from said sensors indicating the presence of a vehicle battery at said output port and proper polarity connection of positive and negative terminals of said vehicle battery with said positive and negative polarity outputs, and is not turned on when signals from said sensors indicate either the absence of a vehicle battery at said output port or improper polarity connection of positive and negative terminals of said vehicle battery with said positive and negative polarity outputs.

In accordance with an embodiment of the invention, the internal power supply is a rechargeable lithium ion battery pack.

A jumper cable device may also be provided, having a plug configured to plug into said output port; a pair of cables integrated with the plug at one respective end thereof; said pair of cables being configured to be separately connected to terminals of a battery at another respective end thereof.

Comprises/comprising and grammatical variations thereof when used in this specification are to be taken to specify the presence of stated features, integers, steps or components or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a functional block diagram of a handheld vehicle battery boost apparatus in accordance with one aspect of the present invention;

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FIGS. 2A-2C are schematic circuit diagrams of an example embodiment of a handheld vehicle battery boost apparatus in accordance with an aspect of the invention;

FIG. 3 is a perspective view of a handheld jump starter booster device in accordance with one example embodiment of the invention; and

FIG. 4 is a plan view of a jumper cable usable with the handheld jump starter booster device in accordance with another aspect of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a functional block diagram of a handheld battery booster according to one aspect of the invention. At the heart of the handheld battery booster is a lithium polymer battery pack 32, which stores sufficient energy to jump start a vehicle engine served by a conventional 12 volt lead-acid or valve regulated lead-acid battery. In one example embodiment, a high-surge lithium polymer battery pack includes three 3.7V, 2666 mAh lithium polymer batteries in a 3S1P configuration. The resulting battery pack provides 11.1V, 2666 Ah (8000 Ah at 3.7V, 29.6 Wh). Continuous discharge current is 25C (or 200 amps), and burst discharge current is 50C (or 400 amps). The maximum charging current of the battery pack is 8000 mA (8 amps).

A programmable microcontroller unit (MCU) 1 receives various inputs and produces informational as well as control outputs. The programmable MCU 1 further provides flexibility to the system by allowing updates in functionality and system parameters, without requiring any change in hardware. According to one example embodiment, an 8 bit microcontroller with 2K×15 bits of flash memory is used to control the system. One such microcontroller is the HT67F30, which is commercially available from Holtek Semiconductor Inc.

A car battery reverse sensor 10 monitors the polarity of the vehicle battery 72 when the handheld battery booster device is connected to the vehicle's electric system. As explained below, the booster device prevents the lithium battery pack from being connected to the vehicle battery 72 when the terminals of the battery 72 are connected to the wrong terminals of the booster device. A car battery isolation sensor 12 detects whether or not a vehicle battery 72 is connected to the booster device, and prevents the lithium battery pack from being connected to the output terminals of the booster device unless there is a good (e.g. chargeable) battery connected to the output terminals.

A smart switch FET circuit 15 electrically switches the handheld battery booster lithium battery to the vehicle's electric system only when the vehicle battery is determined by the MCU 1 to be present (in response to a detection signal provided by isolation sensor 12) and connected with the correct polarity (in response to a detection signal provided by reverse sensor 10). A lithium battery temperature sensor 20 monitors the temperature of the lithium battery pack 32 to detect overheating due to high ambient temperature conditions and overextended current draw during jump starting. A lithium battery voltage measurement circuit 24 monitors the voltage of the lithium battery pack 32 to prevent the voltage potential from rising too high during a charging operation and from dropping too low during a discharge operation.

Lithium battery back-charge protection diodes 28 prevent any charge current being delivered to the vehicle battery 72 from flowing back to the lithium battery pack 32 from the vehicle's electrical system. Flashlight LED circuit 36 is

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provided to furnish a flashlight function for enhancing light under a vehicle's hood in dark conditions, as well as providing SOS and strobe lighting functions for safety purposes when a vehicle may be disabled in a potentially dangerous location. Voltage regulator 42 provides regulation of internal operating voltage for the microcontroller and sensors. On/Off manual mode and flashlight switches 46 allow the user to control power-on for the handheld battery booster device, to control manual override operation if the vehicle has no battery, and to control the flashlight function. The manual button functions only when the booster device is powered on. This button allows the user to jump-start vehicles that have either a missing battery, or the battery voltage is so low that automatic detection by the MCU is not possible. When the user presses and holds the manual override button for a predetermined period time (such as three seconds) to prevent inadvertent actuation of the manual mode, the internal lithium ion battery power is switched to the vehicle battery connect port. The only exception to the manual override is if the car battery is connected in reverse. If the car battery is connected in reverse, the internal lithium battery power shall never be switched to the vehicle battery connect port.

USB charge circuit 52 converts power from any USB charger power source, to charge voltage and current for charging the lithium battery pack 32. USB output 56 provides a USB portable charger for charging smartphones, tablets, and other rechargeable electronic devices. Operation indicator LEDs 60 provide visual indication of lithium battery capacity status as well as an indication of smart switch activation status (indicating that power is being provided to the vehicle's electrical system).

Detailed operation of the handheld booster device will now be described with reference to the schematic diagrams of FIGS. 2A-2C. As shown in FIG. 2A, the microcontroller unit 1 is the center of all inputs and outputs. The reverse battery sensor 10 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D8 in the lead conductor of pin 1 (associated with the negative terminal CB-), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11 will not conduct current, and is therefore turned off, providing a "1" or high output signal to the MCU 1. The car battery isolation sensor 12 comprises an optically coupled isolator phototransistor (4N27) connected to the terminals of vehicle battery 72 at input pins 1 and 2 with a diode D7 in the lead conductor of pin 1 (associated with the positive terminal CB+), such that if the battery 72 is connected to the terminals of the booster device with the correct polarity, the optocoupler LED 11A will conduct current, and is therefore turned on, providing a "0" or low output signal to the MCU, indicating the presence of a battery across the jumper output terminals of the handheld booster device.

If the car battery 72 is connected to the handheld booster device with reverse polarity, the optocoupler LED 11 of the reverse sensor 10 will conduct current, providing a "0" or low signal to microcontroller unit 1. Further, if no battery is connected to the handheld booster device, the optocoupler LED 11A of the isolation sensor 12 will not conduct current, and is therefore turned off, providing a "1" or high output signal to the MCU, indicating the absence of any battery connected to the handheld booster device. Using these specific inputs, the microcontroller software of MCU 1 can determine when it is safe to turn on the smart switch FET 15, thereby connecting the lithium battery pack to the jumper

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terminals of the booster device. Consequently, if the car battery 72 either is not connected to the booster device at all, or is connected with reverse polarity, the MCU 1 can keep the smart switch FET 15 from being turned on, thus prevent sparking/short circuiting of the lithium battery pack.

As shown in FIG. 2B, the FET smart switch 15 is driven by an output of the microcontroller 1. The FET smart switch 15 includes three FETs (Q15, Q18, and Q19) in parallel, which spreads the distribution of power from the lithium battery pack over the FETs. When that microcontroller output is driven to a logic low, FETs 16 are all in a high resistance state, therefore not allowing current to flow from the internal lithium battery negative contact 17 to the car battery 72 negative contact. When the microcontroller output is driven to a logic high, the FETs 16 (Q15, Q18, and Q19) are in a low resistant state, allowing current to flow freely from the internal lithium battery pack negative contact 17 (LB-) to the car battery 72 negative contact (CB-). In this way, the microcontroller software controls the connection of the internal lithium battery pack 32 to the vehicle battery 72 for jumpstarting the car engine.

Referring back to FIG. 2A, the internal lithium battery pack voltage can be accurately measured using circuit 24 and one of the analog-to-digital inputs of the microcontroller 1. Circuit 24 is designed to sense when the main 3.3V regulator 42 voltage is on, and to turn on transistor 23 when the voltage of regulator 42 is on. When transistor 23 is conducting, it turns on FET 22, thereby providing positive contact (LB+) of the internal lithium battery a conductive path to voltage divider 21 allowing a lower voltage range to be brought to the microcontroller to be read. Using this input, the microcontroller software can determine if the lithium battery voltage is too low during discharge operation or too high during charge operation, and take appropriate action to prevent damage to electronic components.

Still referring to FIG. 2A, the temperature of the internal lithium battery pack 32 can be accurately measured by two negative temperature coefficient (NTC) devices 20. These are devices that reduce their resistance when their temperature rises. The circuit is a voltage divider that brings the result to two analog-to-digital (A/D) inputs on the microcontroller 1. The microcontroller software can then determine when the internal lithium battery is too hot to allow jumpstarting, adding safety to the design.

The main voltage regulator circuit 42 is designed to convert internal lithium battery voltage to a regulated 3.3 volts that is utilized by the microcontroller 1 as well as by other components of the booster device for internal operating power. Three lithium battery back charge protection diodes 28 (see FIG. 2B) are in place to allow current to flow only from the internal lithium battery pack 32 to the car battery 72, and not from the car battery to the internal lithium battery. In this way, if the car electrical system is charging from its alternator, it cannot back-charge (and thereby damage) the internal lithium battery, providing another level of safety.

The main power on switch 46 (FIG. 2A) is a combination that allows for double pole, double throw operation so that with one push, the product can be turned on if it is in the off state, or turned off if it is in the on state. This circuit also uses a microcontroller output 47 to "keep alive" the power when it is activated by the on switch. When the switch is pressed the microcontroller turns this output to a high logic level to keep power on when the switch is released. In this way, the microcontroller maintains control of when the power is turned off when the on/off switch is activated again or when the lithium battery voltage is getting too low. The micro-

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controller software also includes a timer that turns the power off after a predefined period of time, (such as, e.g. 8 hours) if not used.

The flashlight LED circuit **45** shown in FIG. 2B controls the operation of flashlight LEDs. Two outputs from the microcontroller **1** are dedicated to two separate LEDs. Thus, the LEDs can be independently software-controlled for strobe and SOS patterns, providing yet another safety feature to the booster device. LED indicators provide the feedback the operator needs to understand what is happening with the product. Four separate LEDs **61** (FIG. 2A) are controlled by corresponding individual outputs of microcontroller **1** to provide indication of the remaining capacity of the internal lithium battery. These LEDs are controlled in a “fuel gauge” type format with 25%, 50%, 75% and 100% (red, red, yellow, green) capacity indications. An LED indicator **63** (FIG. 2B) provides a visual warning to the user when the vehicle battery **72** has been connected in reverse polarity. “Boost” and on/off LEDs **62** provide visual indications when the booster device is provide jump-start power, and when the booster device is turned on, respectively.

A USB output **56** circuit (FIG. 2C) is included to provide a USB output for charging portable electronic devices such as smartphones from the internal lithium battery pack **32**. Control circuit **57** from the microcontroller **1** allows the USB Out **56** to be turned on and off by software control to prevent the internal lithium battery getting too low in capacity. The USB output is brought to the outside of the device on a standard USB connector **58**, which includes the standard voltage divider required for enabling charge to certain smartphones that require it.

The USB charge circuit **52** allows the internal lithium battery pack **32** to be charged using a standard USB charger. This charge input uses a standard micro-USB connector **48** allowing standard cables to be used. The 5V potential provided from standard USB chargers is up-converted to the 12.4 VDC voltage required for charging the internal lithium battery pack using a DC-DC converter **49**. The DC-DC converter **49** can be turned on and off via circuit **53** by an output from the microcontroller **1**.

In this way, the microcontroller software can turn the charge off if the battery voltage is measured to be too high by the A/D input **22**. Additional safety is provided for helping to eliminate overcharge to the internal lithium battery using a lithium battery charge controller **50** that provides charge balance to the internal lithium battery cells **51**. This controller also provides safety redundancy for eliminating over discharge of the internal lithium battery.

FIG. 3 is a perspective view of a handheld device **300** in accordance with an exemplary embodiment of the invention. **301** is a power on switch. **302** shows the LED “fuel gauge” indicators **61**. **303** shows a 12 volt output port connectable to a cable device **400**, described further below. **304** shows a flashlight control switch for activating flashlight LEDs **45**. **305** is a USB input port for charging the internal lithium battery, and **306** is a USB output port for providing charge from the lithium battery to other portable devices such as smartphones, tablets, music players, etc. **307** is a “boost on” indicator showing that power is being provided to the 12V output port. **308** is a “reverse” indicator showing that the vehicle battery is improperly connected with respect to polarity. **309** is a “power on” indicator showing that the device is powered up for operation.

FIG. 4 shows a jumper cable device **400** specifically designed for use with the handheld device **300**. Device **400** has a plug **401** configured to plug into 12 volt output port **303** of the handheld device **300**. A pair of cables **402a** and

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402b are integrated with the plug **401**, and are respectively connected to battery terminal clamps **403a** and **403b** via ring terminals **404a** and **404b**. The port **303** and plug **401** may be dimensioned so that the plug **401** will only fit into the port **303** in a specific orientation, thus ensuring that clamp **403a** will correspond to positive polarity, and clamp **403b** will correspond to negative polarity, as indicated thereon. Additionally, the ring terminals **404a** and **404b** may be disconnected from the clamps and connected directly to the terminals of a vehicle battery. This feature may be useful, for example, to permanently attach the cables **302a-302b** to the battery of a vehicle. In the event that the battery voltage becomes depleted, the handheld booster device **300** could be properly connected to the battery very simply by plugging in the plug **401** to the port **303**.

The invention having been thus described, it will be apparent to those skilled in the art that the same may be varied in many ways without departing from the spirit or scope of the invention. Any and all such variations are intended to be encompassed within the scope of the following claims.

The invention claimed is:

1. A jump starting device for boosting or charging a depleted or discharged battery having a positive battery terminal and a negative battery terminal, the jump starting device comprising:

- a power supply;
- a positive battery connector for electrically connecting the jump starting device to the positive battery terminal of the depleted or discharged battery;
- a negative battery connector for electrically connecting the jump starting device to the negative battery terminal of the depleted or discharged battery;
- a power switch or switch circuit connected in circuit with the power supply and the positive and negative battery connectors, the power switch or switch circuit configured to switch power on from the power supply to boost or charge the depleted or discharged battery when connected between the positive and negative battery connectors;
- a USB input connector; and
- a USB charge circuit electrically connecting the USB input connector to the power supply, the USB charge circuit comprising a DC-DC converter configured to upconvert voltage from the USB input connector to the power supply.

2. The device according to claim 1, wherein the power switch or switch circuit is controlled to turn on power to the depleted or discharged battery only when the jump starting device is connected with correct polarity to the depleted or discharged battery.

3. The device according to claim 1, wherein the power supply is an internal power supply.

4. The device according to claim 1, wherein the USB charging circuit and power supply are located within the jump starting device.

5. The device according to claim 4, wherein the DC-DC converter is one or more DC-DC converters.

6. The device according to claim 1, wherein the DC-DC converter is configured to convert about 5 VDC from the USB input connector to at least 11.1 VDC for the power supply when an active USB power source is connected to the USB input connector.

7. The device according to claim 6, wherein the USB charger power source is a USB charger, and the USB charging circuit is configured to convert power from the

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USB charger to charge voltage and current for supplying power or charging the power supply.

8. The device according to claim 6, wherein the USB charging source is a USB charger.

9. The device according to claim 8, wherein the USB charger is a standard USB charger.

10. The device according to claim 1, wherein the DC-DC converter is configured to be turned on and off via a circuit by an output from a microcontroller.

11. The device according to claim 10, wherein the power supply is a rechargeable battery, and wherein the microcontroller software can turn charge off if the rechargeable battery voltage is measured to be too high by an A/D input.

12. The device according to claim 11, wherein the rechargeable battery is a rechargeable lithium battery, and further comprising a rechargeable lithium battery charge controller configured to provide charge balance to internal lithium battery cells of the rechargeable lithium battery.

13. The device according to claim 12, wherein the rechargeable lithium battery charge controller is also configured to provide safety redundancy for eliminating over discharge of the rechargeable lithium battery.

14. The device according to claim 1, wherein the USB input connector is a micro-USB connector.

15. The device according to claim 1, further comprising a USB output connector for providing a power output from the power supply to a USB-chargeable device.

16. The device according to claim 15, wherein the USB output connector at least partially defines a USB output port.

17. The device according to claim 15, wherein the USB output connector is electrically connected to a USB output circuit, the USB output circuit connecting the power supply to the USB output connector.

18. The device according to claim 17, further comprising a microcontroller with a control circuit, the control circuit for the microcontroller allows the USB output circuit to be turned on and off by software control to prevent the power supply getting too low in capacity.

19. The device according to claim 17, wherein the USB output connector and the USB output circuit define a USB output port.

20. The device according to claim 19, wherein the USB output port is configured to provide a portable charger for charging smartphones, tablets, music players, and other rechargeable electronic devices.

21. The device according to claim 19, wherein the USB output port is accessible from outside of the jump charge device using the USB output connector.

22. The device according to claim 21, wherein the USB connector includes a voltage divider configured to enable charge to certain smartphones that require the voltage divider.

23. The device according to claim 1, wherein the power supply is a rechargeable battery disposed within the jump starting device.

24. The device according to claim 1, wherein the power switch or switch circuit comprises at least one power switch or switch circuit configured to turn power on from the power supply to the depleted or discharged battery when connected to the positive and negative battery connectors.

25. The device according to claim 24, wherein the power switch or switch circuit comprises one or more sensors configured to detect whether the positive and negative battery connectors are properly connected to the depleted or discharged battery prior to switching on the power switch or switch circuit.

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26. The device according to claim 25, wherein the power switch or switch circuit is configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery connectors.

27. The device according to claim 25, wherein the power switch or switch circuit is configured to detect polarity of the depleted or discharged battery when connected between the positive and negative battery connectors.

28. The device according to claim 25, wherein the power switch or switch circuit is configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery connectors, and configured to detect polarity of the depleted or discharged battery when connected between the positive and negative battery connectors,

wherein the power switch or switch circuit switches on the power supply to connect the power supply to the depleted or discharged battery only when the depleted or discharged battery is present when connected between the positive and negative battery connectors and the depleted or discharged battery is connected with correct polarity between the positive and negative battery terminals.

29. The device according to claim 24, wherein the power switch or switch circuit comprises a microcontroller configured for providing an output controlling the power switch or switch circuit.

30. The device according to claim 29, wherein the microcontroller receives input from one or more sensors configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery connectors, and to detect polarity of the depleted or discharged battery when connected between the positive and negative battery connectors.

31. The device according to claim 30, wherein the one or more sensors includes one sensor configured to detect presence of the depleted or discharged battery when connected between the positive and negative battery connectors, and another sensor configured to detect polarity of the depleted or discharged battery when connected between the positive and negative battery connectors.

32. The device according to claim 31, wherein the one or more sensors is one or more sensing circuits.

33. The device according to claim 30, wherein the one or more sensors is a presence sensor configured for detecting presence of the depleted or discharged battery when connected between the positive and negative battery connectors, and a reverse polarity sensor configured to detect polarity of a connection of the positive and negative battery connectors of the jump starting device with the depleted or discharge battery.

34. The device according to claim 33, wherein the presence sensor and the reverse polarity sensor comprise optically coupled isolator phototransistors.

35. The device according to claim 33, further comprising a manual override switch configured to activate a manual override mode to enable a user to connect jump start power to the positive and negative battery connectors when the one sensor configured for detecting presence of the depleted or discharged battery is unable to detect presence of the depleted or discharged battery.

36. The device according to claim 35, wherein the microcontroller is configured to detect actuation of the manual override switch for at least a predetermined period of time before activation of the manual override mode.

37. The device according to claim 29, wherein the microcontroller switches the power switch or switch circuit on to

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provide power from the power supply to the depleted or discharged battery only when the depleted or discharged battery is determined by the microcontroller to be present and connected with correct polarity to the positive and negative battery connectors.

38. The device according to claim 29, wherein the microcontroller is a programmable microcontroller configured to allow updates in functionality and system parameters.

39. The device according to claim 38, wherein the programmable microcontroller comprises a memory.

40. The device according to claim 29, further comprising a temperature sensor configured to detect temperature of the power supply and to provide a temperature signal to the microcontroller.

41. The device according to claim 29, further comprising a voltage measurement circuit configured to measure output voltage of the power supply and to provide a voltage measurement signal to the microcontroller.

42. The device according to claim 1, wherein the positive battery connector comprises a positive battery cable, and the negative battery connector comprises a negative battery cable.

43. The device according to claim 42, wherein the positive battery cable comprises a positive battery clamp and the negative battery cable comprises a negative battery clamp.

44. The device according to claim 1, wherein said power switch or switch circuit comprises a plurality of FETs in parallel.

45. The device according to claim 1, further comprising a plurality of power diodes coupled between the positive and negative battery connectors and the power supply to prevent back-charging of the power supply from an electrical system connected to the depleted or discharged battery.

46. The device according to claim 1, further comprising an output port providing positive and negative polarity outputs to the positive and negative battery connectors.

47. The device according to claim 1, further comprising a voltage regulator configured to convert output voltage of the power supply to a voltage level appropriate to provide operating power to internal components of the device.

48. The device according to claim 1, wherein the positive and negative battery connectors are defined by a jumper cable device including a plug configured to plug into an output port of the jump starting device, a pair of cables integrated with the plug at one respective end of the pair of cables and being configured to be connected to positive and negative battery terminals of the depleted or discharged battery at an opposite end of the pair of cables.

49. The device according to claim 48, wherein the output port and the plug are dimensioned so that the plug will fit into the output port only in one specific orientation.

50. The device according to claim 1, wherein the power switch or switch circuit is configured to switch power on

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only when the jump starting device is properly connected to the depleted or discharged battery.

51. The device according to claim 1, wherein the power supply is a rechargeable lithium battery pack.

52. The device according to claim 18, wherein the rechargeable lithium battery pack is an internal power supply.

53. The device according to claim 18, wherein the USB charge circuit is configured to convert power from a USB charger power source, to charge voltage and current suitable for charging the rechargeable lithium battery pack.

54. The device according to claim 51, further comprising a rechargeable lithium battery pack voltage measurement circuit configured to monitor the rechargeable lithium battery pack to prevent voltage potential from rising too high during a charging operation and from dropping too low during a discharge operation.

55. The device according to claim 51, further comprising a fuel gauge LEDS for indicating a charge level of the rechargeable lithium battery pack.

56. The device according to claim 1, wherein the power switch or switch circuit is a smart switch, or comprises a smart switch.

57. A jump starting device for boosting or charging a depleted or discharged battery having a positive battery terminal and a negative battery terminal, the jump starting device comprising:

- a power supply;
- a positive battery connector for electrically connecting the jump starting starter device to the positive battery terminal of the depleted or discharged battery;
- a negative battery connector for electrically connecting the jump starting starter device to the negative battery terminal of the depleted or discharged battery;
- a power switch or switch circuit in circuit with the power supply and the positive and negative battery connectors, the power switch or switch circuit configured to switch power on from the power supply to boost or charge the depleted or discharged battery when connected between the positive and negative battery connectors;
- a USB input connector;
- a USB charge circuit electrically connecting the USB input connector to the power supply, the USB charge circuit configured to up-convert voltage from a USB charger power source connected to the USB input connector to the power supply using a DC-DC converter;
- a USB output connector; and
- a USB output circuit electrically connecting the power supply to the USB output connector.

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