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(54) **ELECTRICAL POWER DISTRIBUTION SYSTEMS WITH A BYPASS UNIT THAT COUPLES TO A LOAD AND ELECTRICALLY ENGAGES ONE OF TWO ALTERNATE UNITS FOR POWERING THE LOAD AND RELATED METHODS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 294 days.

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(60) Provisional application No. 62/867,980, filed on Jun. 28, 2019.

(51) **Int. Cl.**

H02B 1/48	(2006.01)
H02B 1/04	(2006.01)
H02B 1/20	(2006.01)
H02K 11/33	(2016.01)

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

CPC ***H02B 1/48*** (2013.01); ***H02B 1/04*** (2013.01); ***H02B 1/20*** (2013.01); *H02K 11/33* (2016.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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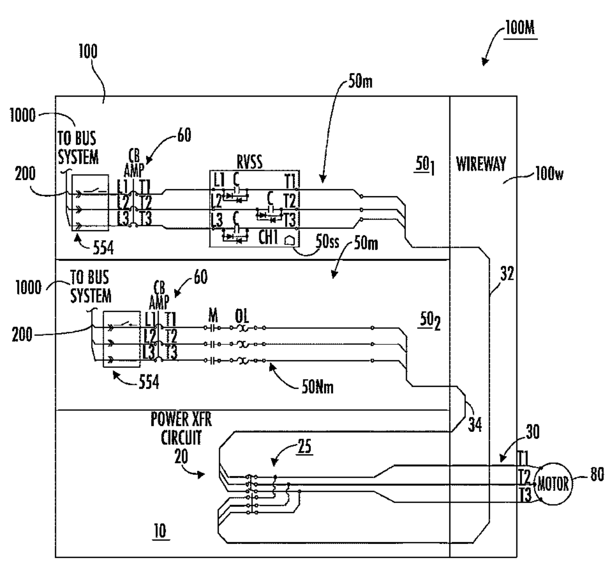
(74) *Attorney, Agent, or Firm* — Stanek Lemon Crouse & Meeks, PA

(57) **ABSTRACT**

Electrical power distribution devices with a bypass unit that electrically engages one of two alternate units for powering a load while electrically isolating the other using a six pole power transfer switch and mechanical and electrical interlocks to allow a technician to access one of the alternate units when de-energized and in position while the other of the alternate units is energized and powering the load.

16 Claims, 19 Drawing Sheets



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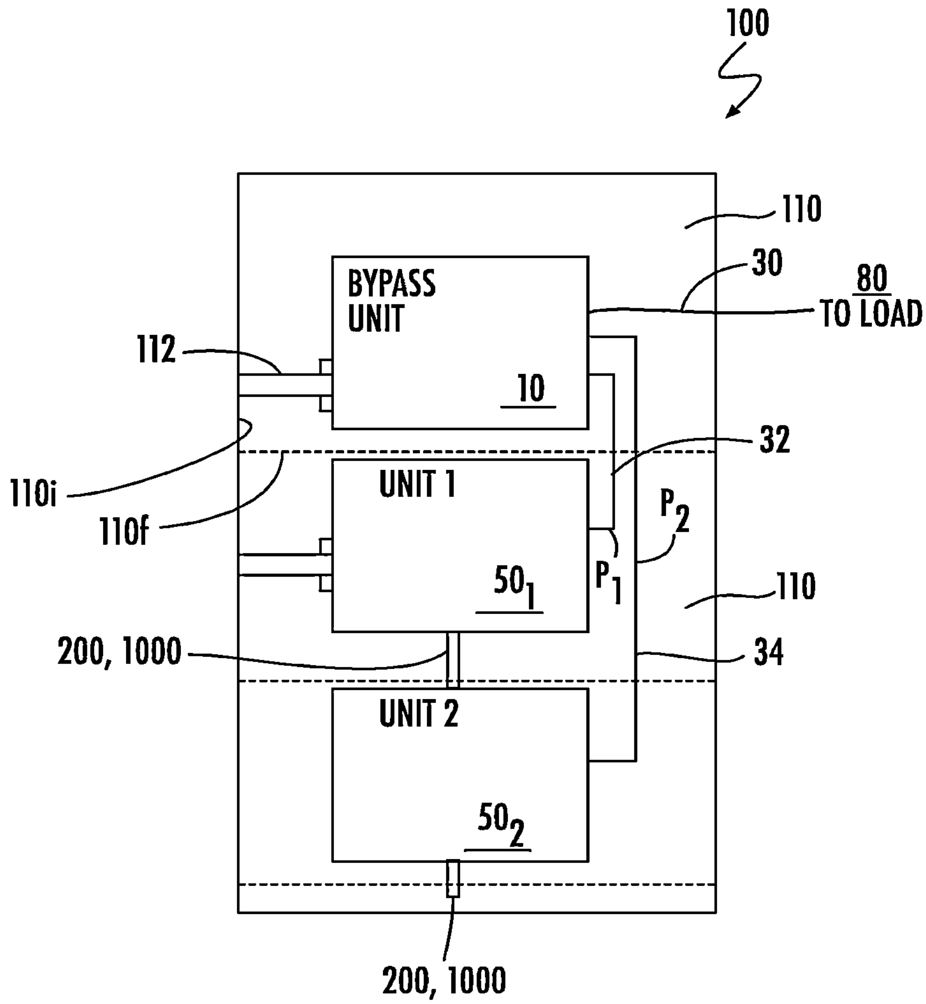

100
110
30
80
TO LOAD
BYPASS
UNIT
10
112
32
110i
110f
UNIT 1
P2
50
1
P1
110
200, 1000
34
UNIT 2
50
2
200, 1000

FIG. 1

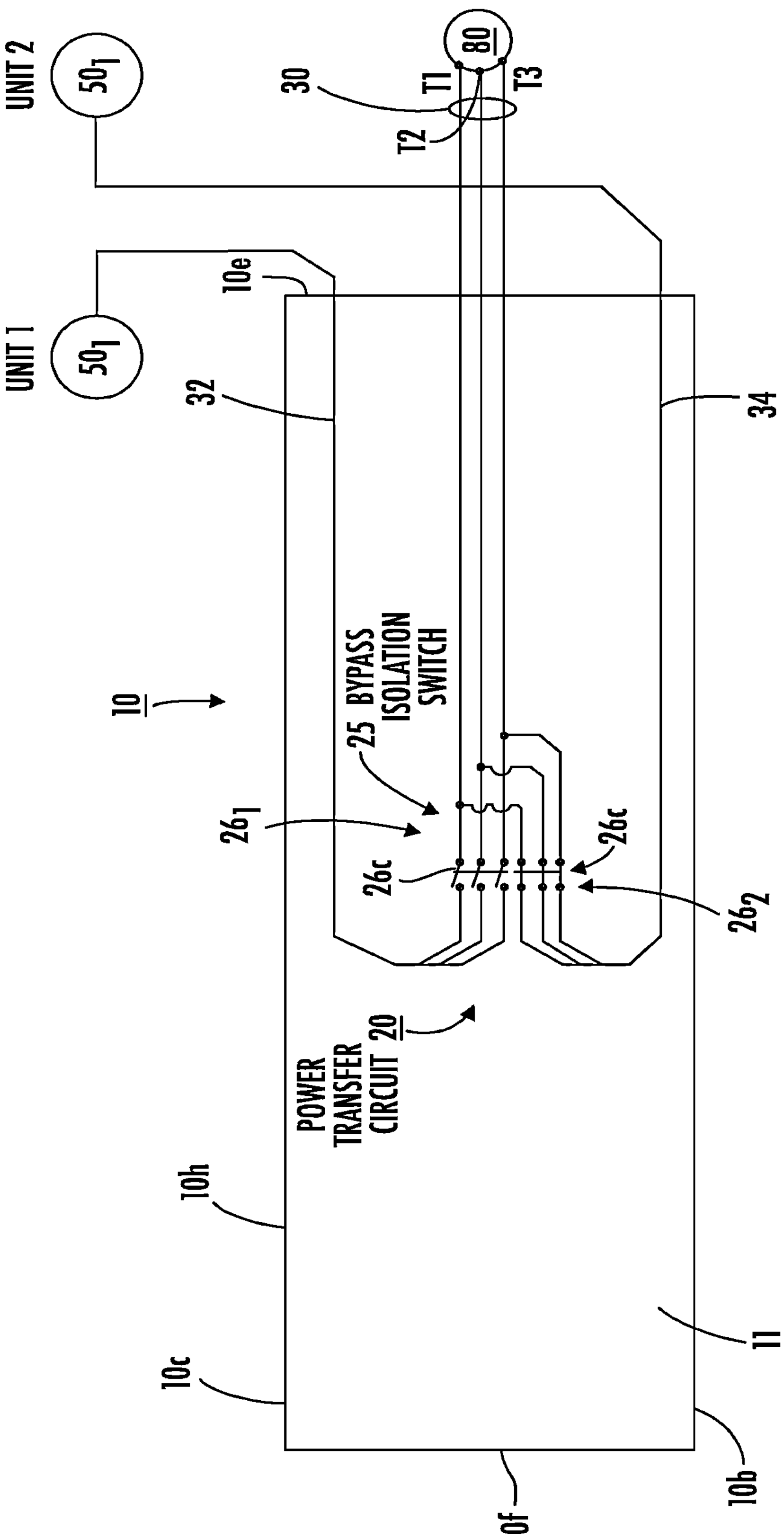

UNIT 2
50_1
UNIT 1
50_1
80
30
T1
T2
T3
10e
32
34
10
25 BYPASS ISOLATION SWITCH
26_1
26c
26c
26_2
POWER TRANSFER CIRCUIT 20
10h
11
10c
10f
10b

FIG. 2A

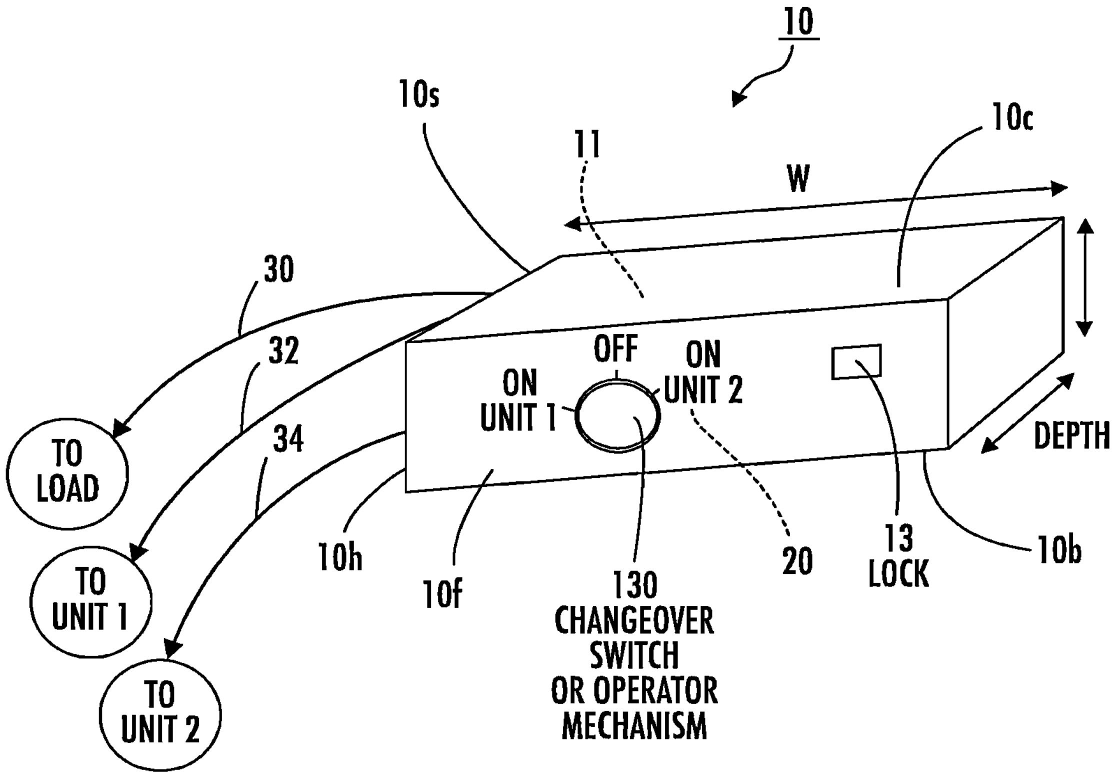

10
10s
11
W
10c
H
30
32
34
OFF
ON
UNIT 2
ON
UNIT 1
TO
LOAD
TO
UNIT 1
TO
UNIT 2
DEPTH
10h
10f
130
CHANGEOVER
SWITCH
OR OPERATOR
MECHANISM
20
13
LOCK
10b

FIG. 2B

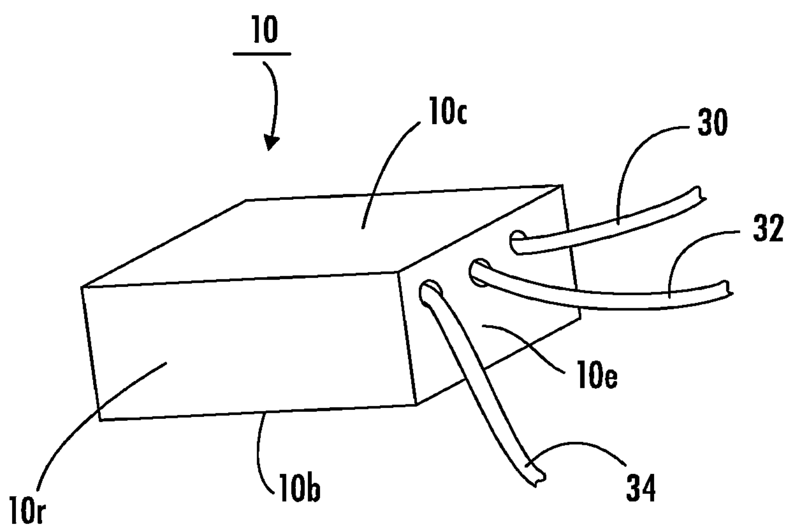

10
10c
30
32
10e
34
10r
10b

FIG. 2C

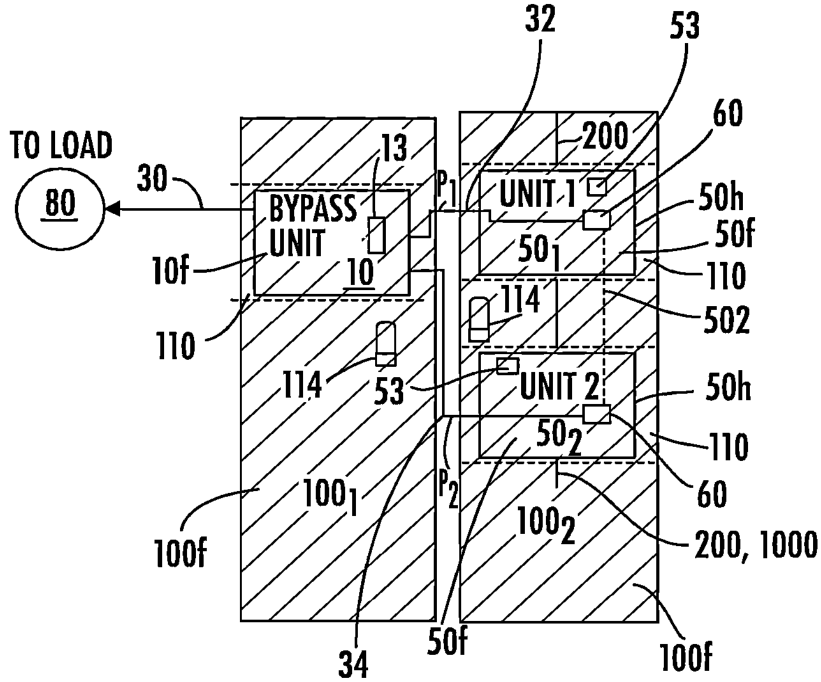

TO LOAD
80
30
BYPASS UNIT
10
13
10f
110
114
53
P1
P2
32
53
60
200
UNIT 1
501
UNIT 2
502
50h
50f
110
114
502
60
1001
1002
100f
200, 1000
34
50f
100f

FIG. 3A

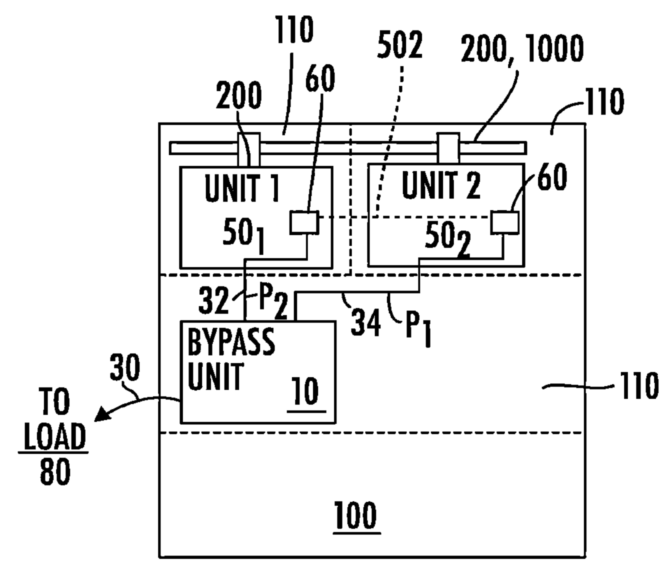

110
502
200, 1000
200
60
110
UNIT 1
501
UNIT 2
502
60
32
P2
34
P1
BYPASS UNIT
10
30
TO LOAD
80
110
100

FIG. 3B

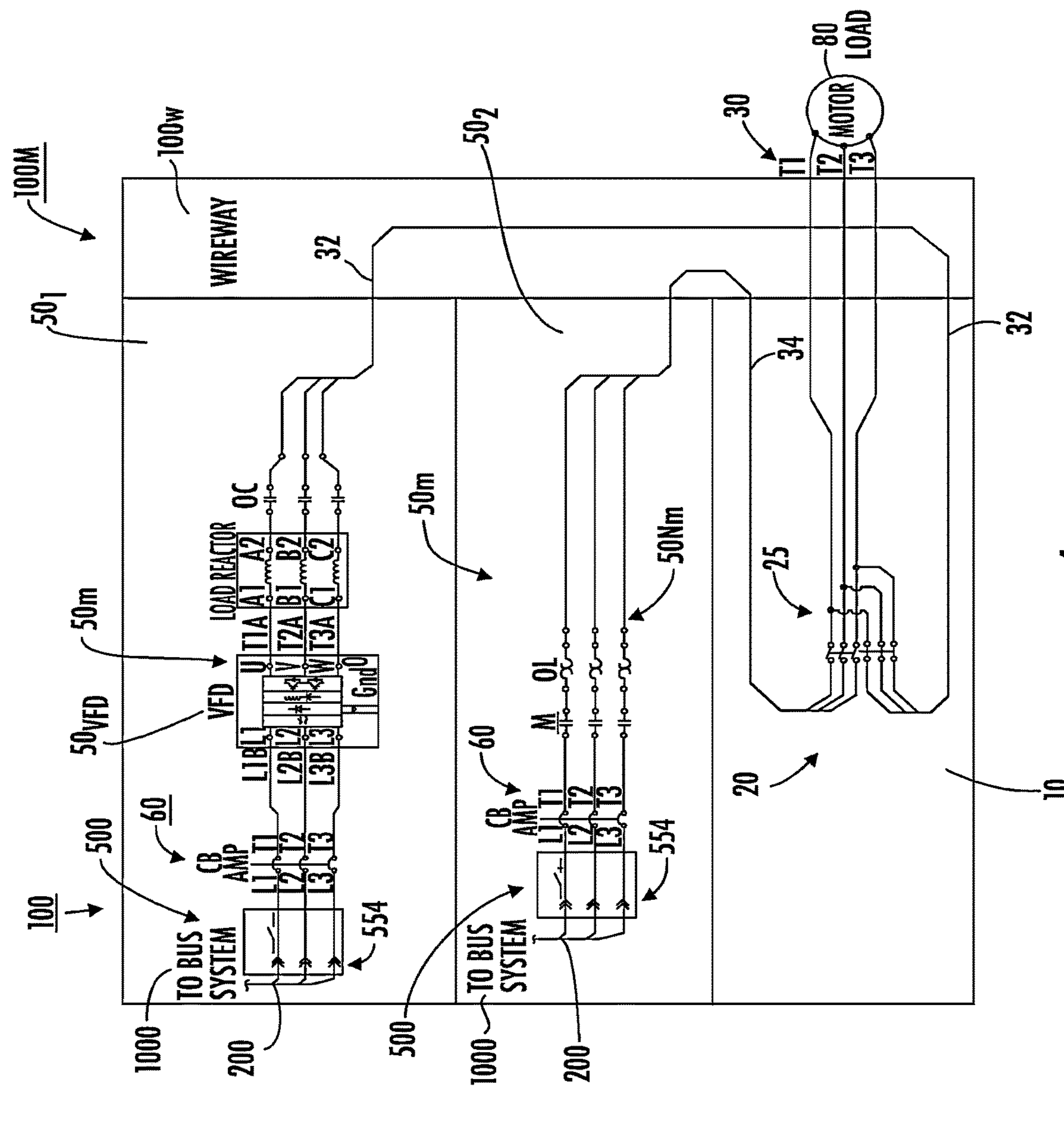

100M
100
100w
WIREWAY
50_1
50_2
50_{VFD}
50m
50Nm
VFD
LOAD REACTOR
OC
OL
M
CB
AMP
TO BUS SYSTEM
MOTOR
LOAD
1000
200
500
554
60
80
30
32
34
25
20
10

FIG. 4

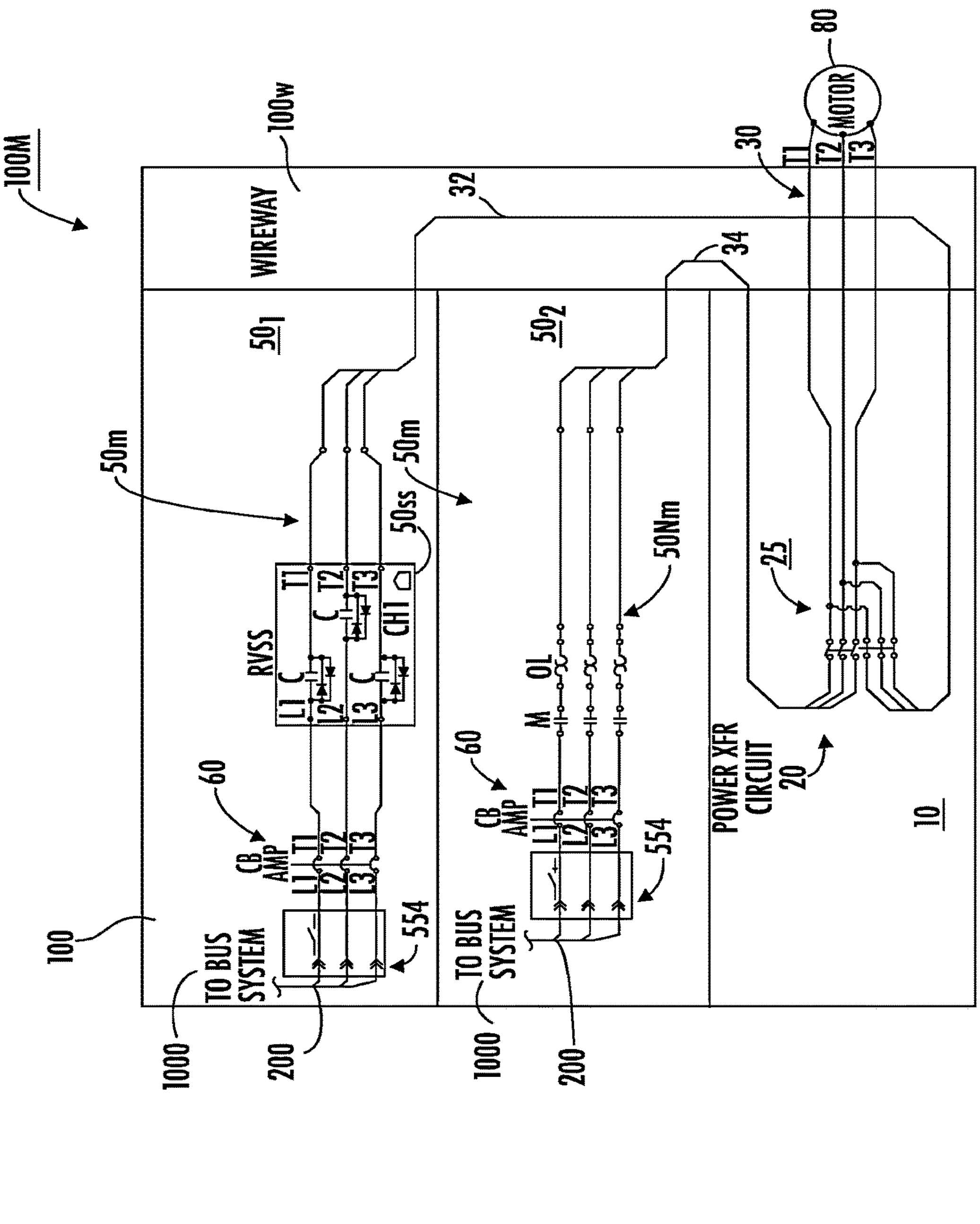

100M
100w
WIREWAY
32
34
30
80
MOTOR
T1
T2
T3
100
50_1
50_2
50m
50m
50ss
RVSS
L1
L2
L3
C
CH1
60
CB
AMP
554
TO BUS
SYSTEM
1000
200
50Nm
M
OL
25
POWER XFR
CIRCUIT
20
10

FIG. 5

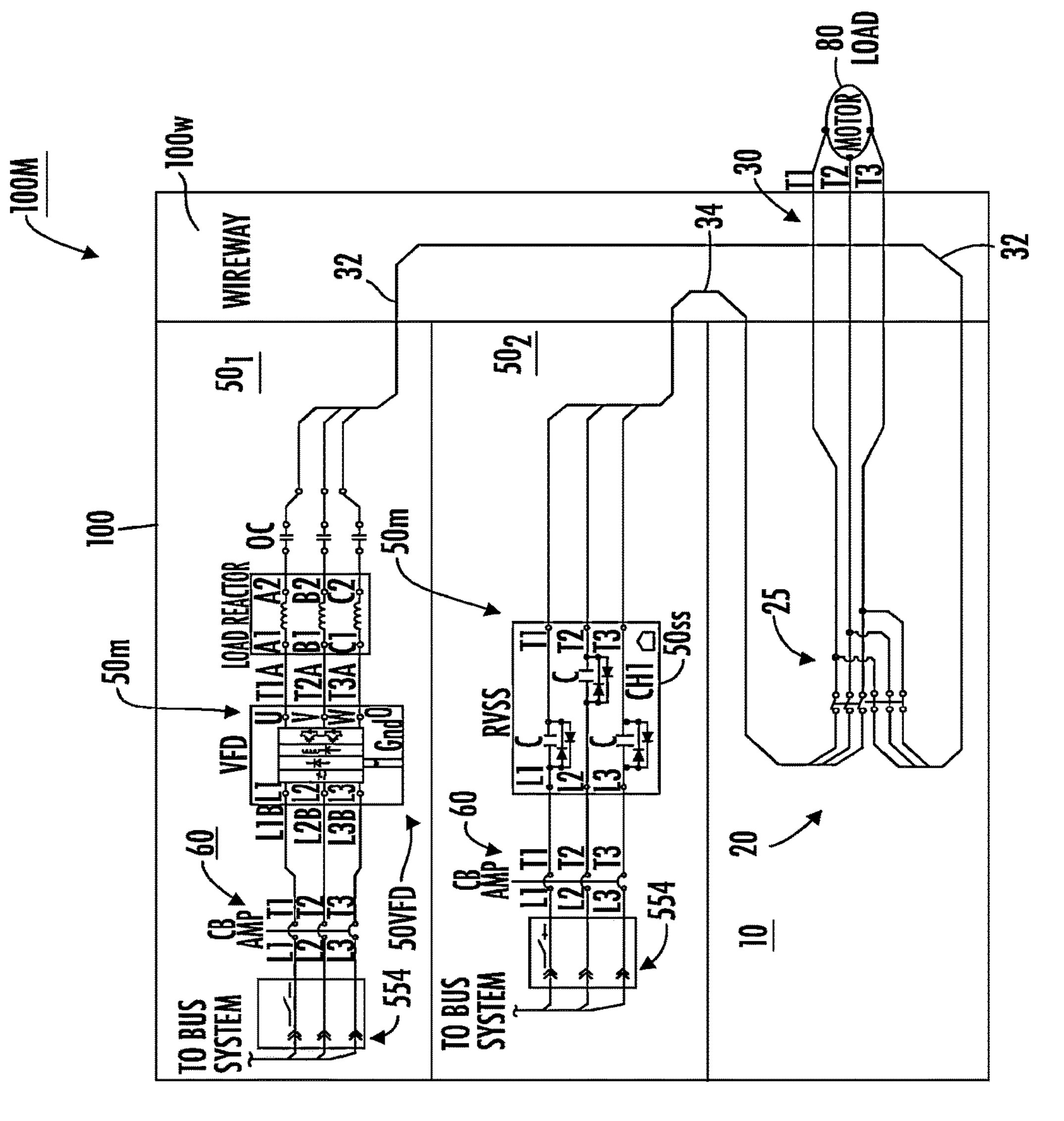

100M
100w
WIREWAY
100
32
34
30
32
80
LOAD
MOTOR
T1
T2
T3
50_1
50_2
50m
VFD
LOAD REACTOR
OC
60
CB
AMP
TO BUS
SYSTEM
554
50VFD
RVSS
50ss
CH1
25
20
10

FIG. 6

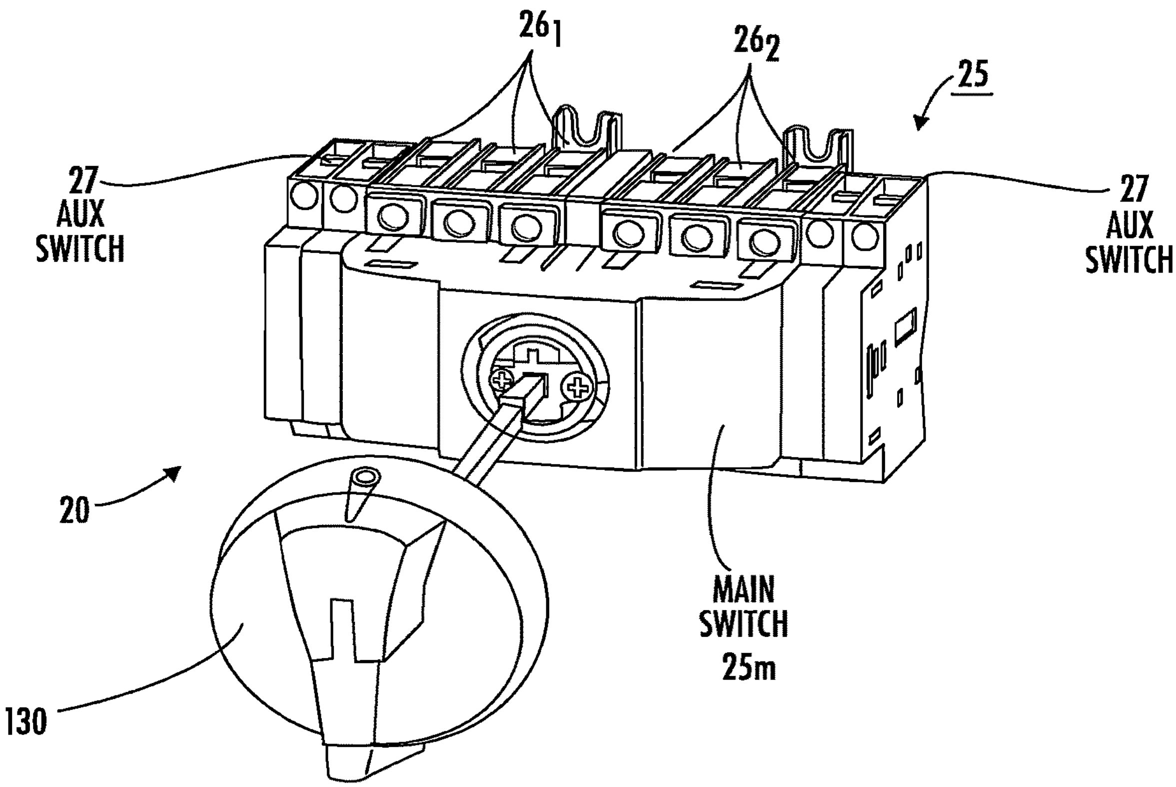


FIG. 7A

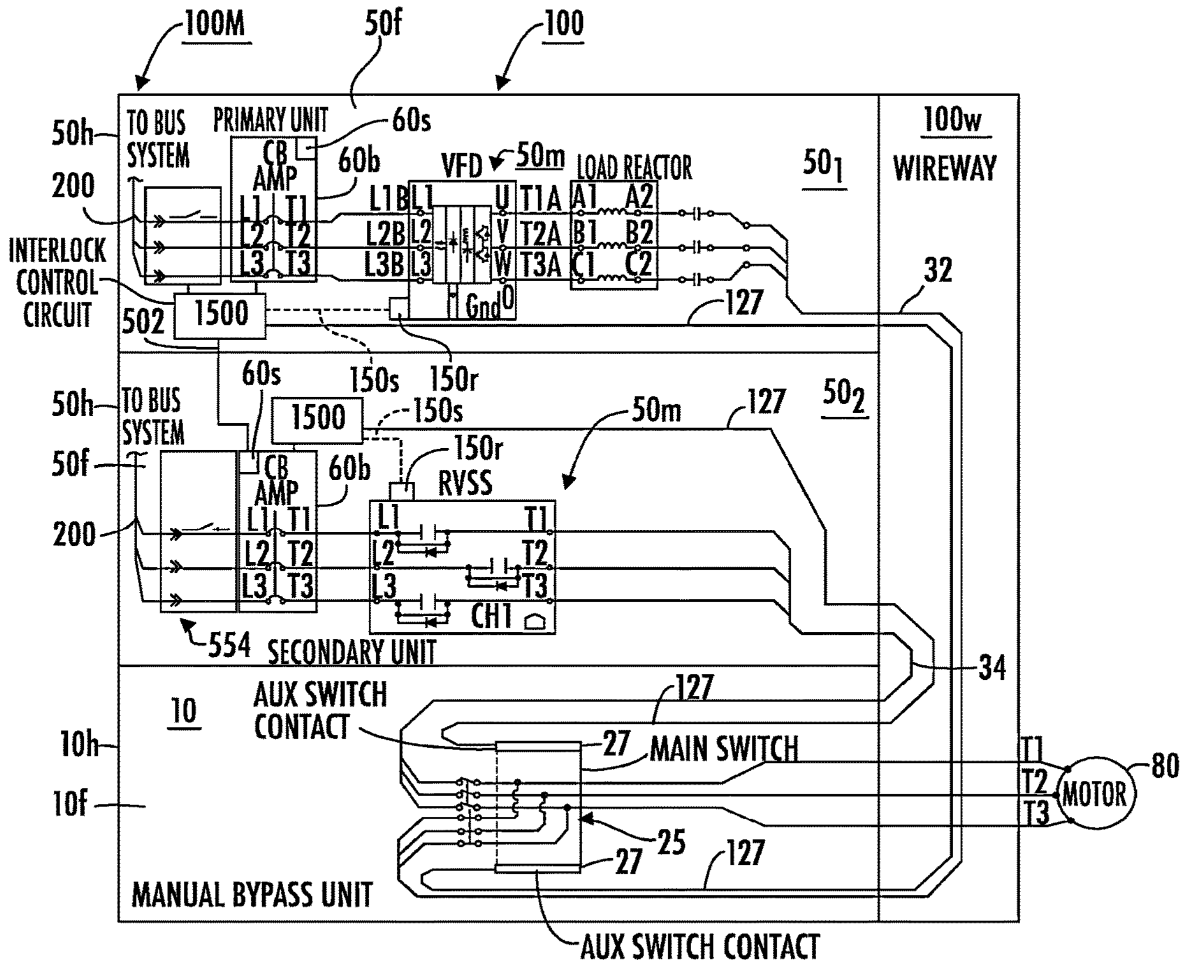

100M
50f
100
50h
TO BUS SYSTEM
PRIMARY UNIT
60s
CB AMP
60b
VFD
50m
LOAD REACTOR
50_1
100w
WIREWAY
200
L1 T1
L2 T2
L3 T3
L1B L1 U T1A A1 A2
L2B L2 V T2A B1 B2
L3B L3 W T3A C1 C2
Gnd
INTERLOCK CONTROL CIRCUIT
32
502
1500
127
150s
150r
60s
50_2
50h
TO BUS SYSTEM
1500
150s
127
50m
150r
RVSS
50f
60b
CB AMP
200
L1 T1
L2 T2
L3 T3
CH1
554
SECONDARY UNIT
34
10
AUX SWITCH CONTACT
127
10h
27
MAIN SWITCH
T1
T2
T3
MOTOR
80
10f
25
27
127
MANUAL BYPASS UNIT
AUX SWITCH CONTACT

FIG. 7B

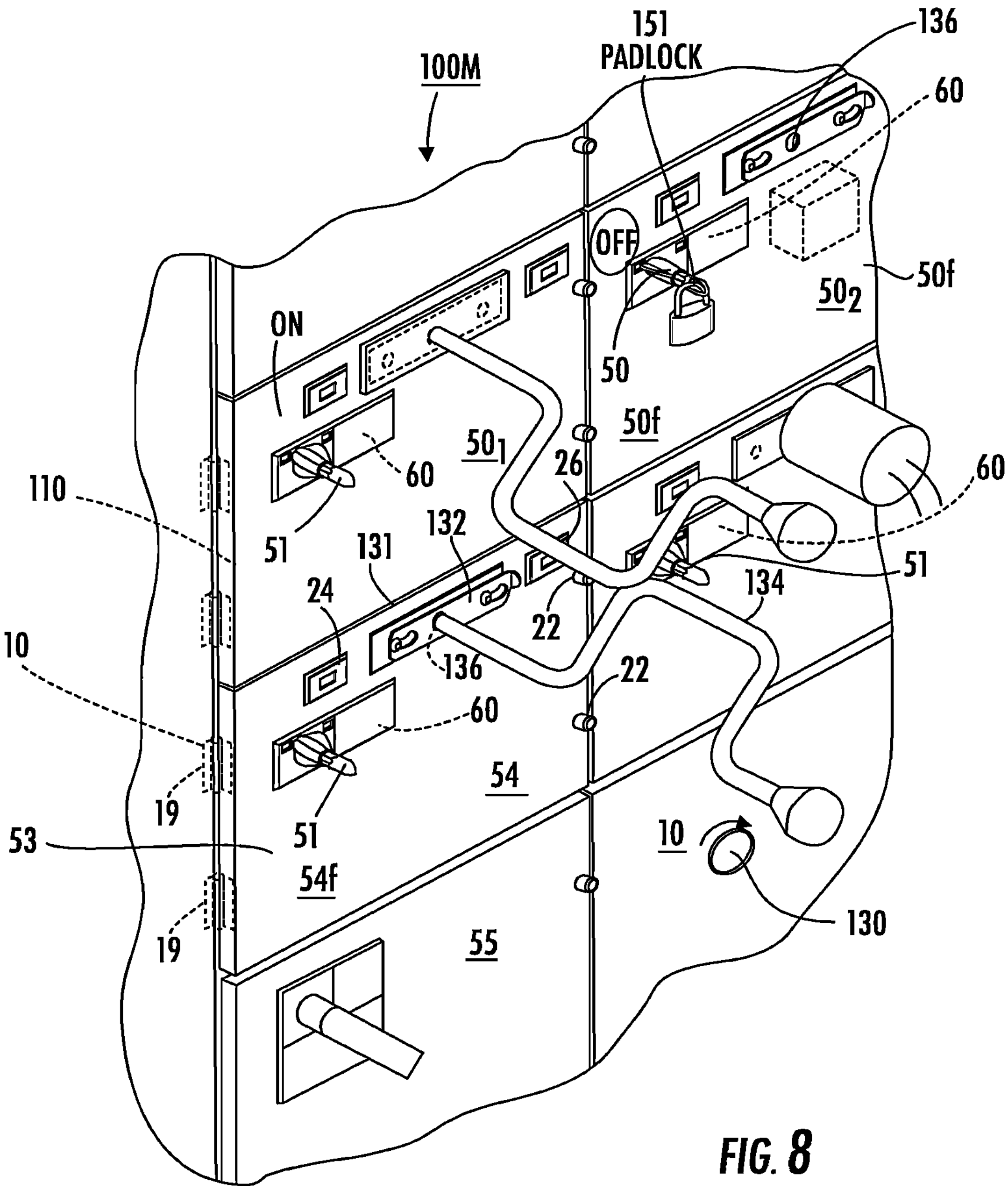

100M
151
PADLOCK
136
60
OFF
50f
50_2
50
ON
50f
50_1
60
26
60
110
51
132
131
51
134
24
22
22
136
110
60
54
19
51
53
54f
10
19
130
55

FIG. 8

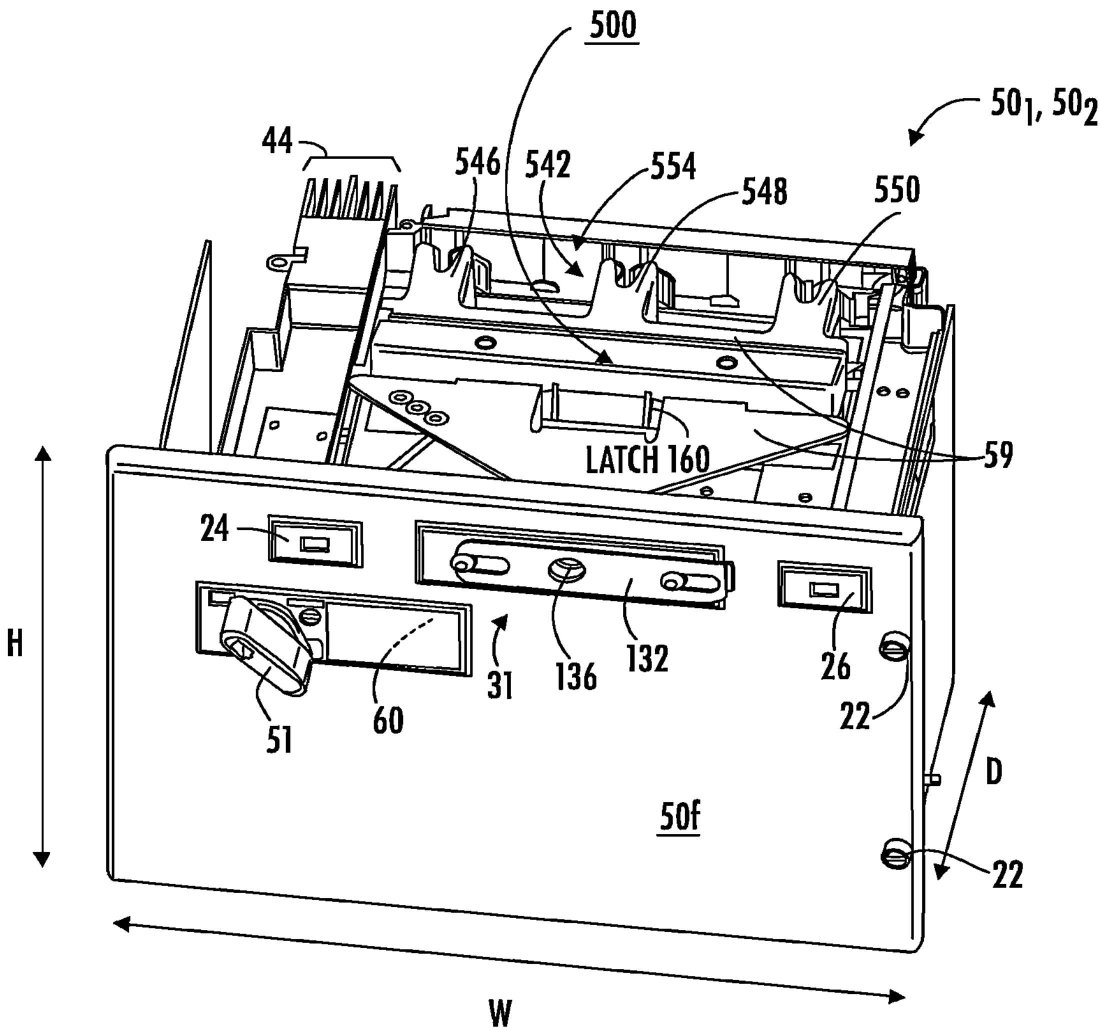
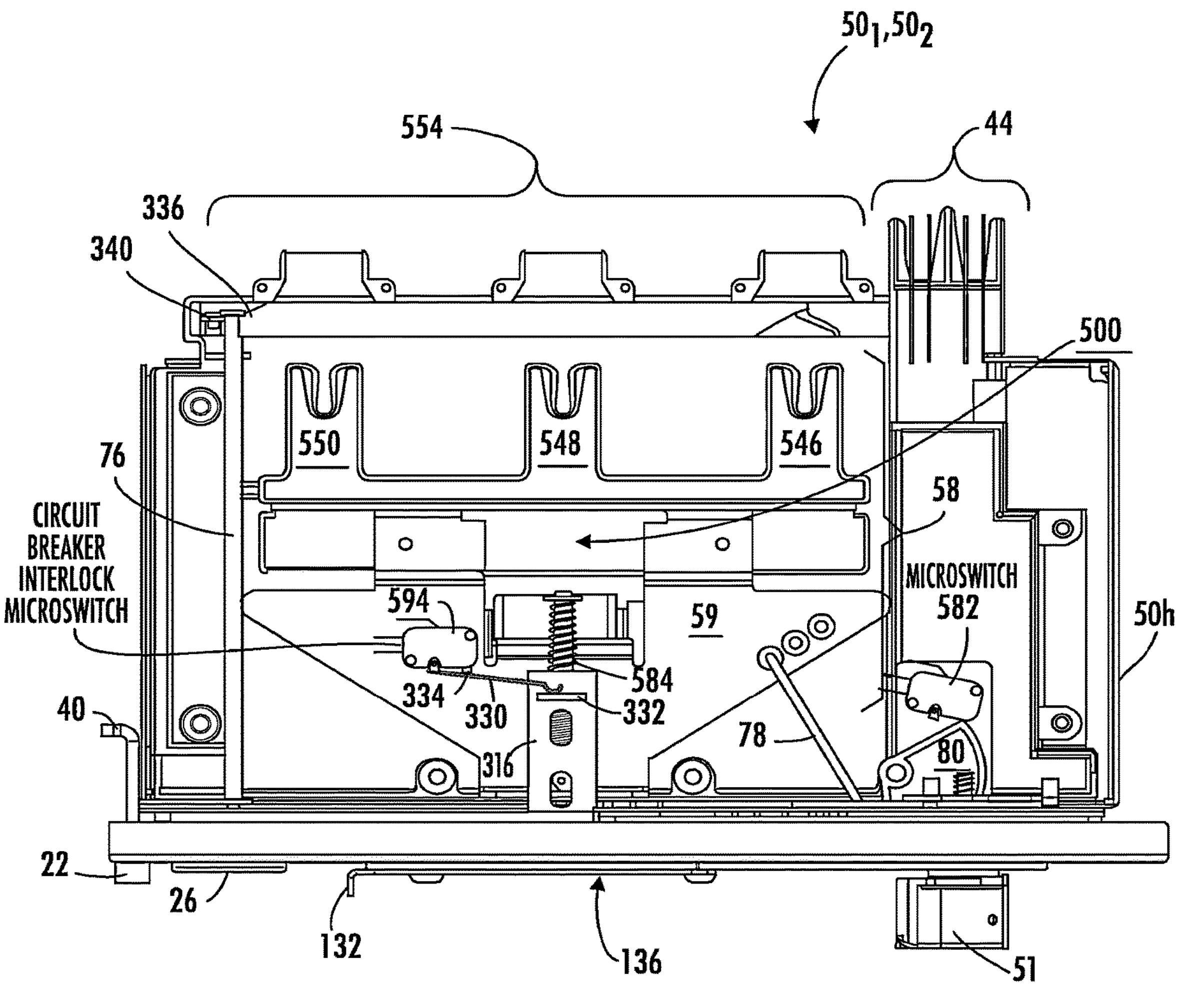

500
50$_1$, 50$_2$
44
546
542
554
548
550
LATCH 160
59
24
31
136
132
26
22
H
51
60
D
50f
22
W

FIG. 9



$50_1,50_2$
554
44
336
340
500
550
548
546
76
58
CIRCUIT BREAKER INTERLOCK MICROSWITCH
594
MICROSWITCH 582
59
50h
584
334
330
332
40
78
316
80
22
26
132
136
51

FIG. 10

ELECTRICAL INTERLOCKING SYSTEM

INTERLOCK	PRIMARY UNIT 50_1	SECONDARY UNIT 50_2	BYPASS UNIT 10
SECONDARY UNIT DISCONNECT (BREAKER)	ENERGIZED BREAKER AUXILIARY SWITCH AND/OR RELAY SENDS TRIP SIGNAL TO SECONDARY UNIT BREAKER	BREAKER SHUNT TRIP COIL TRIPS SECONDARY UNIT BREAKER	IN PRIMARY MODE
PRIMARY UNIT DISCONNECT (BREAKER)	BREAKER SHUNT TRIP COIL TRIPS PRIMARY UNIT BREAKER	ENERGIZED AUXILIARY SWITCH AND/OR MOTOR STARTER RELAY SENDS TRIP SIGNAL TO PRIMARY UNIT BREAKER	IN BYPASS MODE
MANUAL BYPASS **PRIMARY MODE**	ENERGIZED	BREAKER SHUNT TRIP COIL TRIPS BREAKER SECONDARY UNIT BREAKER	IN PRIMARY MODE AUXILIARY SWITCH SENDS TRIP SIGNAL TO SECONDARY UNIT BREAKER
MANUAL BYPASS **BYPASS MODE**	BREAKER SHUNT TRIP COIL TRIPS BREAKER PRIMARY UNIT BREAKER	ENERGIZED	IN BYPASS MODE AUXILIARY SWITCH SENDS TRIP SIGNAL TO PRIMARY UNIT BREAKER
SECONDARY UNIT DISCONNECT (POWER DISCONNECT ASSEMBLY)	ENERGIZED POWER DISCONNECT ASSEMBLY AUXILIARY SWITCH SENDS TRIP SIGNAL TO SECONDARY UNIT BREAKER	BREAKER SHUNT TRIP COIL TRIPS SECONDARY UNIT BREAKER	IN PRIMARY MODE
PRIMARY UNIT DISCONNECT (POWER DISCONNECT ASSEMBLY)	BREAKER SHUNT TRIP COIL TRIPS BREAKER OF PRIMARY UNIT BREAKER	ENERGIZED POWER DISCONNECT ASSEMBLY AUXILIARY SWITCH SENDS TRIP SIGNAL TO PRIMARY UNIT BREAKER	IN BYPASS MODE

FIG. 11

MECHANICAL INTERLOCKING SYSTEM

	PRIMARY UNIT 50_1	SECONDARY UNIT 50_2	BYPASS UNIT 10
PRIMARY UNIT DISCONNECT (POWER DISCONNECT ASSEMBLY)	DE-ENERGIZED POWER DISCONNECT ASSEMBLY PADLOCK OFF	ENERGIZED	IN BYPASS MODE
SECONDARY UNIT DISCONNECT (POWER DISCONNECT ASSEMBLY)	ENERGIZED	DE-ENERGIZED POWER DISCONNECT ASSEMBLY PADLOCK OFF	IN PRIMARY MODE
PRIMARY UNIT DISCONNECT (BYPASS)	ENERGIZED	DE-ENERGIZED	BYPASS UNIT OPERATING MECHANISM PADLOCKED IN PRIMARY MODE
SECONDARY UNIT DISCONNECT (BYPASS)	DE-ENERGIZED	ENERGIZED	BYPASS UNIT OPERATING MECHANISM PADLOCKED IN BYPASS MODE
SECONDARY UNIT KEY INTERLOCKING (BREAKER)	DE-ENERGIZED	SINGLE KEY ENABLES SECONDARY UNIT BREAKER TO BE OPERATED	
PRIMARY UNIT KEY INTERLOCKING (BREAKER)	SINGLE KEY ENABLES PRIMARY BREAKER TO BE OPERATED	DE-ENERGIZED	

FIG. 12

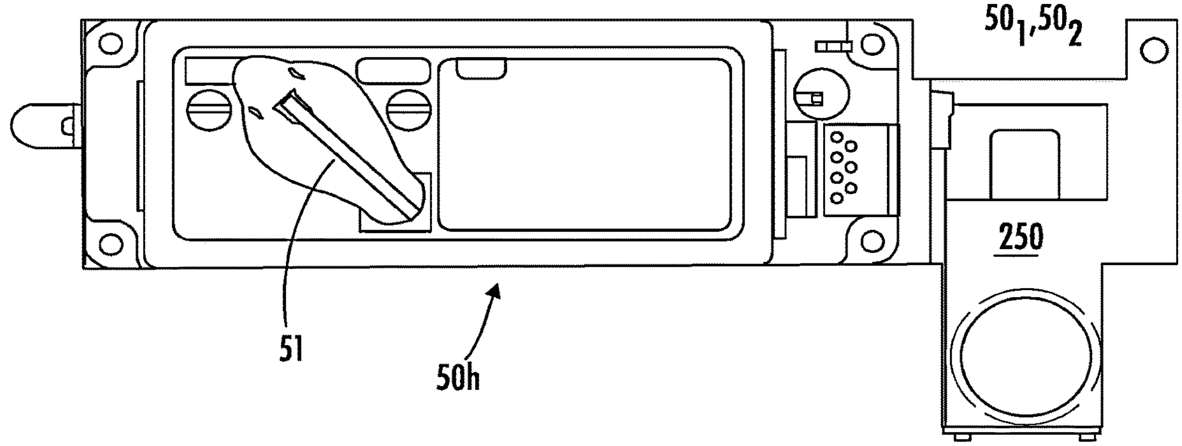


FIG. 13A

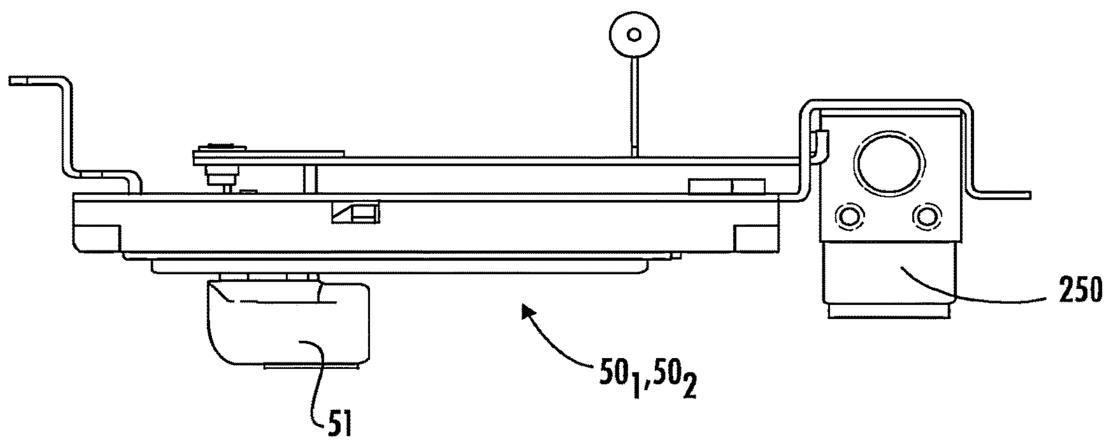


FIG. 13B

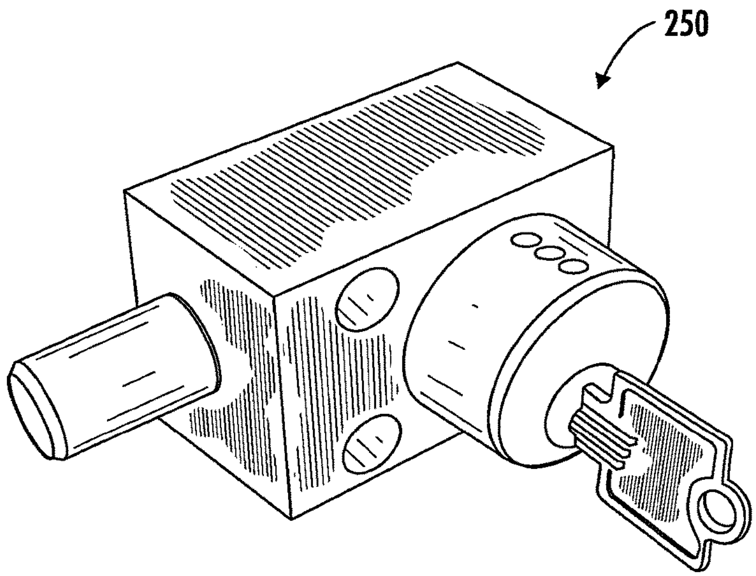


FIG. 14A

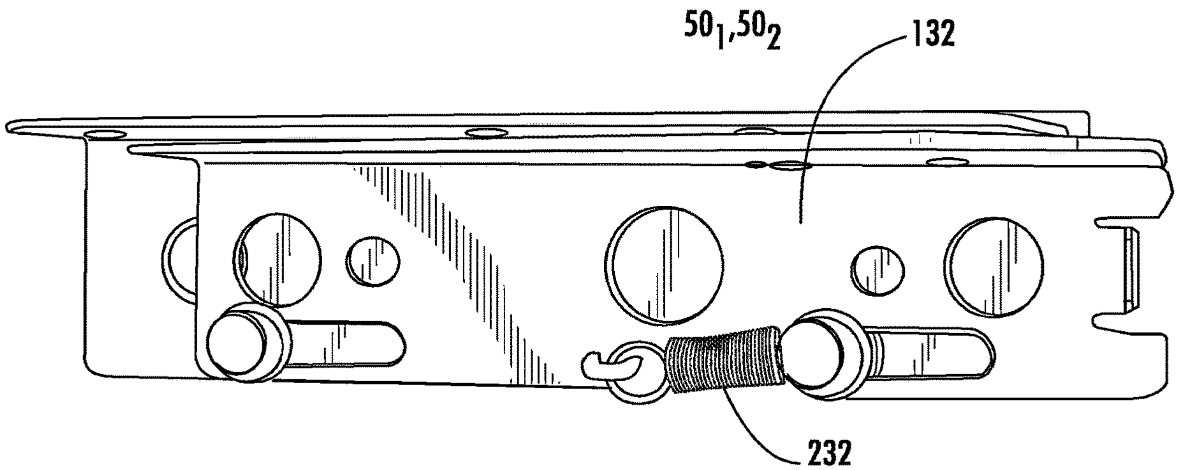


FIG. 14B

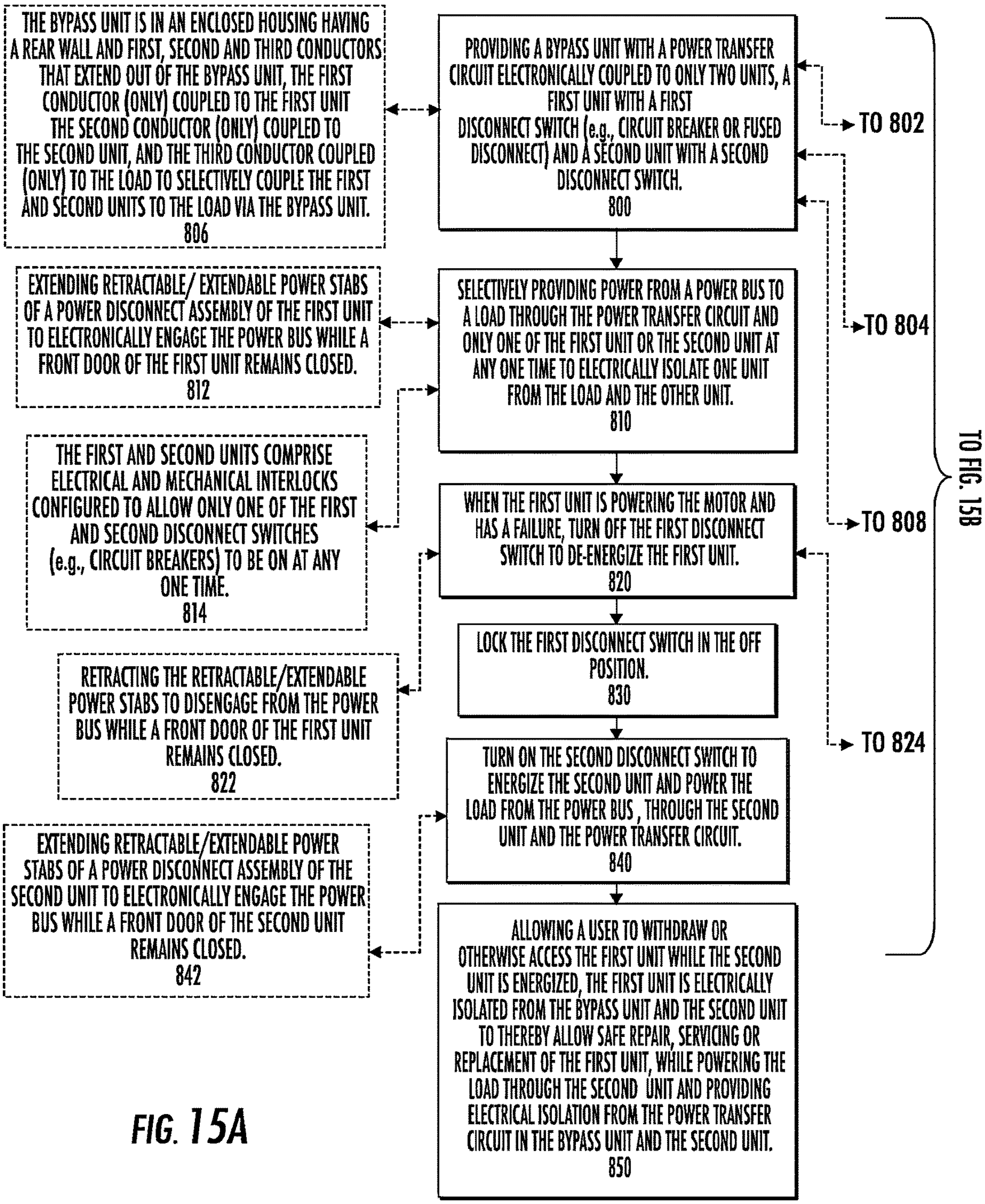

THE BYPASS UNIT IS IN AN ENCLOSED HOUSING HAVING A REAR WALL AND FIRST, SECOND AND THIRD CONDUCTORS THAT EXTEND OUT OF THE BYPASS UNIT, THE FIRST CONDUCTOR (ONLY) COUPLED TO THE FIRST UNIT THE SECOND CONDUCTOR (ONLY) COUPLED TO THE SECOND UNIT, AND THE THIRD CONDUCTOR COUPLED (ONLY) TO THE LOAD TO SELECTIVELY COUPLE THE FIRST AND SECOND UNITS TO THE LOAD VIA THE BYPASS UNIT.
806
PROVIDING A BYPASS UNIT WITH A POWER TRANSFER CIRCUIT ELECTRONICALLY COUPLED TO ONLY TWO UNITS, A FIRST UNIT WITH A FIRST DISCONNECT SWITCH (e.g., CIRCUIT BREAKER OR FUSED DISCONNECT) AND A SECOND UNIT WITH A SECOND DISCONNECT SWITCH.
800
TO 802
EXTENDING RETRACTABLE/ EXTENDABLE POWER STABS OF A POWER DISCONNECT ASSEMBLY OF THE FIRST UNIT TO ELECTRONICALLY ENGAGE THE POWER BUS WHILE A FRONT DOOR OF THE FIRST UNIT REMAINS CLOSED.
812
SELECTIVELY PROVIDING POWER FROM A POWER BUS TO A LOAD THROUGH THE POWER TRANSFER CIRCUIT AND ONLY ONE OF THE FIRST UNIT OR THE SECOND UNIT AT ANY ONE TIME TO ELECTRICALLY ISOLATE ONE UNIT FROM THE LOAD AND THE OTHER UNIT.
810
TO 804
THE FIRST AND SECOND UNITS COMPRISE ELECTRICAL AND MECHANICAL INTERLOCKS CONFIGURED TO ALLOW ONLY ONE OF THE FIRST AND SECOND DISCONNECT SWITCHES (e.g., CIRCUIT BREAKERS) TO BE ON AT ANY ONE TIME.
814
WHEN THE FIRST UNIT IS POWERING THE MOTOR AND HAS A FAILURE, TURN OFF THE FIRST DISCONNECT SWITCH TO DE-ENERGIZE THE FIRST UNIT.
820
TO 808
TO FIG. 15B
LOCK THE FIRST DISCONNECT SWITCH IN THE OFF POSITION.
830
RETRACTING THE RETRACTABLE/EXTENDABLE POWER STABS TO DISENGAGE FROM THE POWER BUS WHILE A FRONT DOOR OF THE FIRST UNIT REMAINS CLOSED.
822
TO 824
TURN ON THE SECOND DISCONNECT SWITCH TO ENERGIZE THE SECOND UNIT AND POWER THE LOAD FROM THE POWER BUS , THROUGH THE SECOND UNIT AND THE POWER TRANSFER CIRCUIT.
840
EXTENDING RETRACTABLE/EXTENDABLE POWER STABS OF A POWER DISCONNECT ASSEMBLY OF THE SECOND UNIT TO ELECTRONICALLY ENGAGE THE POWER BUS WHILE A FRONT DOOR OF THE SECOND UNIT REMAINS CLOSED.
842
ALLOWING A USER TO WITHDRAW OR OTHERWISE ACCESS THE FIRST UNIT WHILE THE SECOND UNIT IS ENERGIZED, THE FIRST UNIT IS ELECTRICALLY ISOLATED FROM THE BYPASS UNIT AND THE SECOND UNIT TO THEREBY ALLOW SAFE REPAIR, SERVICING OR REPLACEMENT OF THE FIRST UNIT, WHILE POWERING THE LOAD THROUGH THE SECOND UNIT AND PROVIDING ELECTRICAL ISOLATION FROM THE POWER TRANSFER CIRCUIT IN THE BYPASS UNIT AND THE SECOND UNIT.
850

FIG. 15A

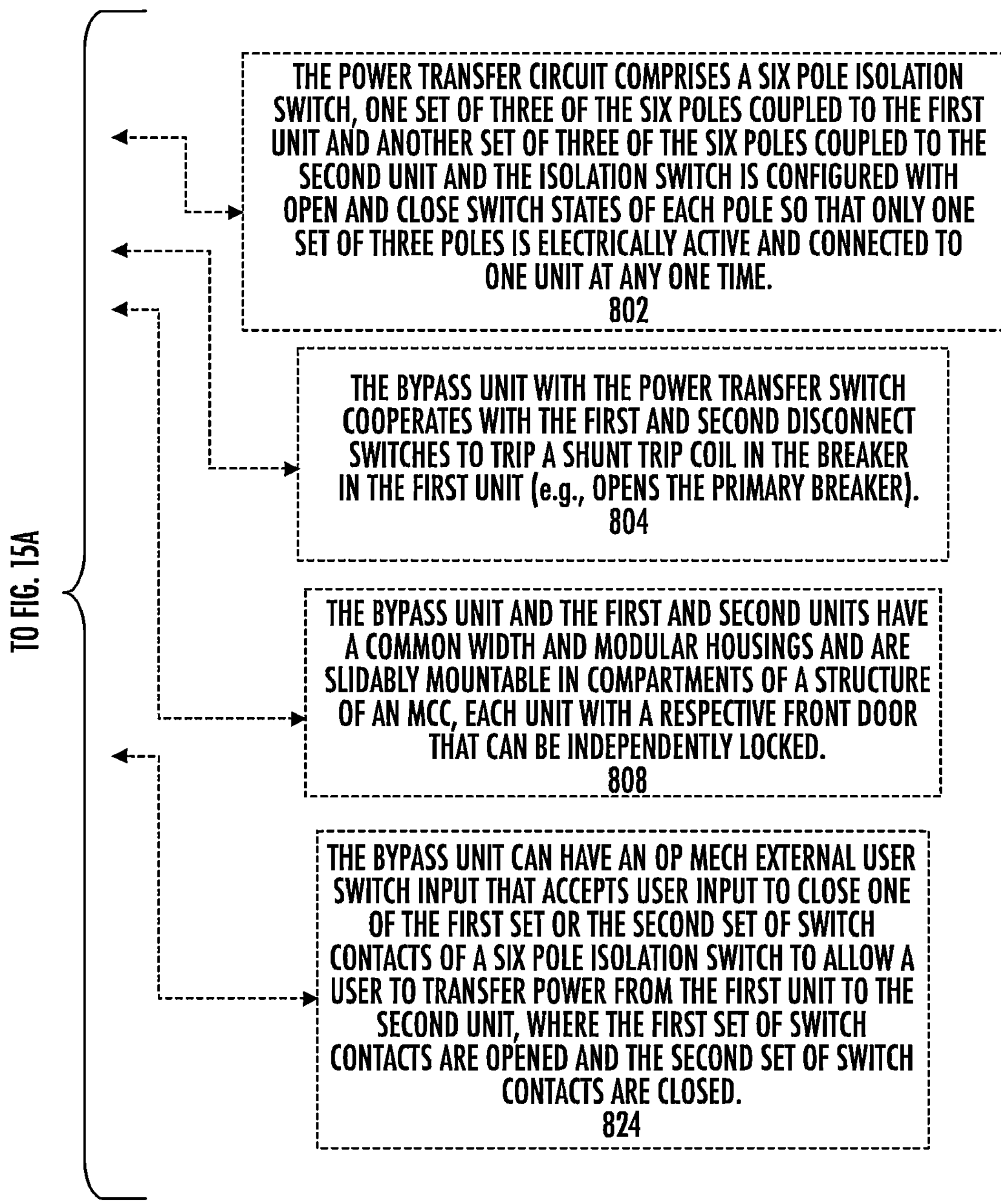

TO FIG. 15A
THE POWER TRANSFER CIRCUIT COMPRISES A SIX POLE ISOLATION SWITCH, ONE SET OF THREE OF THE SIX POLES COUPLED TO THE FIRST UNIT AND ANOTHER SET OF THREE OF THE SIX POLES COUPLED TO THE SECOND UNIT AND THE ISOLATION SWITCH IS CONFIGURED WITH OPEN AND CLOSE SWITCH STATES OF EACH POLE SO THAT ONLY ONE SET OF THREE POLES IS ELECTRICALLY ACTIVE AND CONNECTED TO ONE UNIT AT ANY ONE TIME.
802
THE BYPASS UNIT WITH THE POWER TRANSFER SWITCH COOPERATES WITH THE FIRST AND SECOND DISCONNECT SWITCHES TO TRIP A SHUNT TRIP COIL IN THE BREAKER IN THE FIRST UNIT (e.g., OPENS THE PRIMARY BREAKER).
804
THE BYPASS UNIT AND THE FIRST AND SECOND UNITS HAVE A COMMON WIDTH AND MODULAR HOUSINGS AND ARE SLIDABLY MOUNTABLE IN COMPARTMENTS OF A STRUCTURE OF AN MCC, EACH UNIT WITH A RESPECTIVE FRONT DOOR THAT CAN BE INDEPENDENTLY LOCKED.
808
THE BYPASS UNIT CAN HAVE AN OP MECH EXTERNAL USER SWITCH INPUT THAT ACCEPTS USER INPUT TO CLOSE ONE OF THE FIRST SET OR THE SECOND SET OF SWITCH CONTACTS OF A SIX POLE ISOLATION SWITCH TO ALLOW A USER TO TRANSFER POWER FROM THE FIRST UNIT TO THE SECOND UNIT, WHERE THE FIRST SET OF SWITCH CONTACTS ARE OPENED AND THE SECOND SET OF SWITCH CONTACTS ARE CLOSED.
824

FIG. 15B

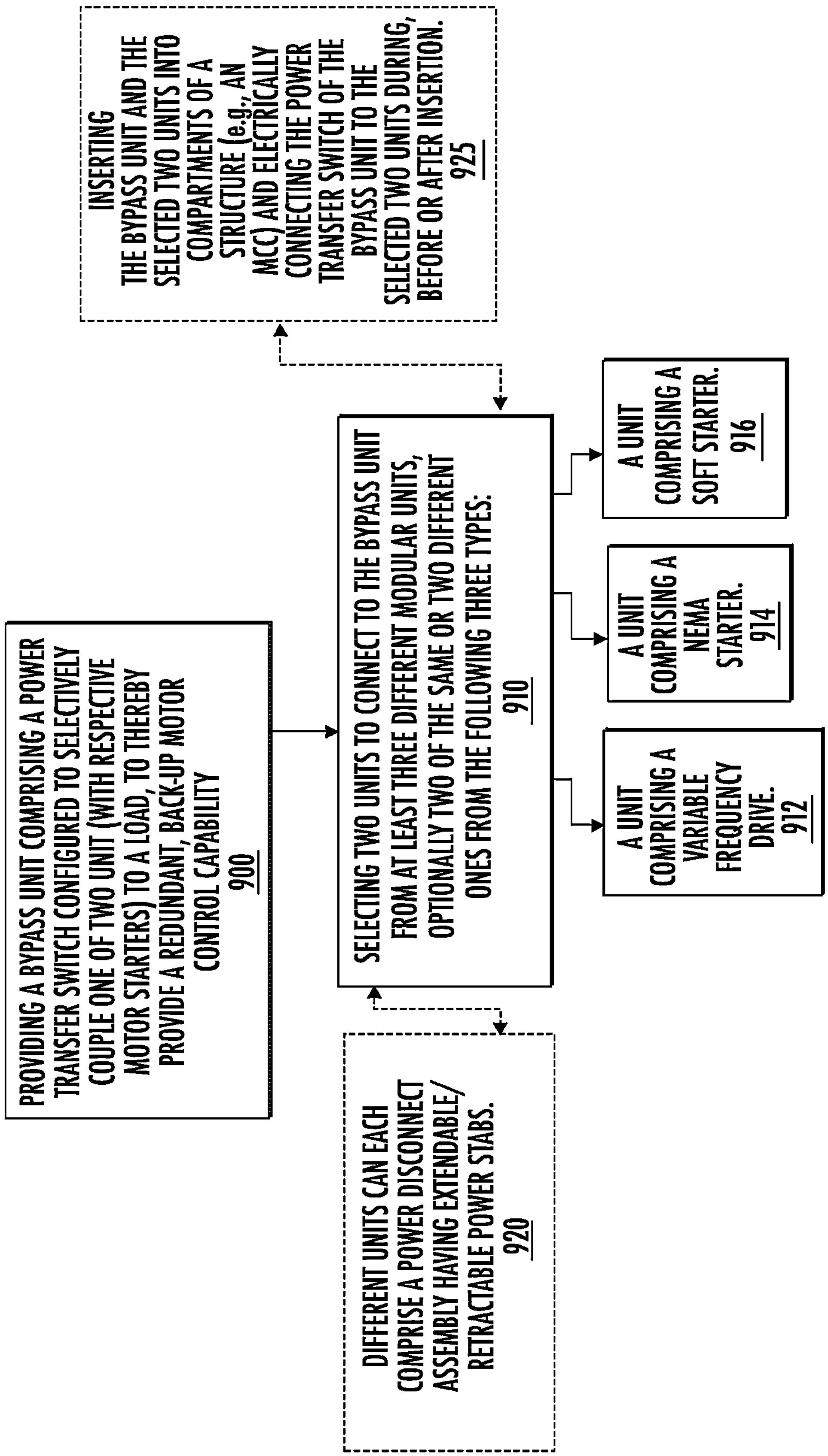

PROVIDING A BYPASS UNIT COMPRISING A POWER TRANSFER SWITCH CONFIGURED TO SELECTIVELY COUPLE ONE OF TWO UNIT (WITH RESPECTIVE MOTOR STARTERS) TO A LOAD, TO THEREBY PROVIDE A REDUNDANT, BACK-UP MOTOR CONTROL CAPABILITY
900
SELECTING TWO UNITS TO CONNECT TO THE BYPASS UNIT FROM AT LEAST THREE DIFFERENT MODULAR UNITS, OPTIONALLY TWO OF THE SAME OR TWO DIFFERENT ONES FROM THE FOLLOWING THREE TYPES:
910
A UNIT COMPRISING A VARIABLE FREQUENCY DRIVE.
912
A UNIT COMPRISING A NEMA STARTER.
914
A UNIT COMPRISING A SOFT STARTER.
916
DIFFERENT UNITS CAN EACH COMPRISE A POWER DISCONNECT ASSEMBLY HAVING EXTENDABLE/ RETRACTABLE POWER STABS.
920
INSERTING THE BYPASS UNIT AND THE SELECTED TWO UNITS INTO COMPARTMENTS OF A STRUCTURE (e.g., AN MCC) AND ELECTRICALLY CONNECTING THE POWER TRANSFER SWITCH OF THE BYPASS UNIT TO THE SELECTED TWO UNITS DURING, BEFORE OR AFTER INSERTION.
925

FIG. 16

ELECTRICAL POWER DISTRIBUTION SYSTEMS WITH A BYPASS UNIT THAT COUPLES TO A LOAD AND ELECTRICALLY ENGAGES ONE OF TWO ALTERNATE UNITS FOR POWERING THE LOAD AND RELATED METHODS

RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 16/911,557, filed Jun. 25, 2022, which claims the benefit of and priority to U.S. Provisional Application Ser. No. 62/867,980, filed Jun. 28, 2019, each of which is hereby incorporated by reference as if recited in full herein.

FIELD OF THE INVENTION

The present invention relates to electrical power distribution systems and is particularly suitable for motor control centers.

BACKGROUND OF THE INVENTION

In general, electrical power distribution systems distribute electrical power from power sources, such as private or public power grids, to different loads, such as motors. As a specific example, motor control centers (MCC) distribute electrical power to and control motors in a central location. MCCs can include structures, cabinets or enclosures containing a common power bus and multiple, typically modular, bucket assemblies or units, which generally contain a motor starter of various types, a circuit breaker or fuse(s) and a power disconnect. See, e.g., U.S. Pat. No. 4,024,441, the contents of which are hereby incorporated by reference as if recited in full herein. Eaton Corporation has recently introduced a MCC product line with compact bucket assemblies that conveniently plug into a slot, compartment or space in an MCC structure. The product is sold under the product name, Freedom 2100 MCC. See also, U.S. Pat. No. 8,934,218, the contents of which are hereby incorporated by reference as if recited in full herein.

SUMMARY OF EMBODIMENTS OF THE INVENTION

Embodiments of the invention are directed to enclosed bypass units that can connect to separate primary and secondary units with motor starters, allowing for one to power a load at any one time through the bypass unit while electrically isolating the other thereby providing redundant powering options which can electrically isolate the primary and secondary units from a load and/or line side bus and each other.

Embodiments of the invention are directed to electrical power distribution systems that include: a power bus; a bypass unit with a power transfer switch coupled to a load; a first unit with a first disconnect switch configured to selectively couple the power bus to the power transfer switch; and a second unit with a second disconnect switch configured to selectively couple the power bus to the power transfer switch. The power transfer switch of the bypass unit is configured to selectively couple the first unit to the load or the second unit to the load. When the power transfer switch couples the first unit to the load, the first disconnect switch is closed while the second disconnect switch is open to electrically isolate the second unit from the load and the first unit. When the power transfer switch couples the second unit to the load, the second disconnect switch is closed while the first disconnect switch is open to electrically isolate the first unit from the load and the second unit.

The first and second units can each further include a housing and a power disconnect assembly with extendable/retractable power stabs that independently move relative to the housing to connect to and disconnect from the power bus. The extendable/retractable power stabs of only one of the first unit or the second unit can be permitted to be connected to the power bus at any one time.

The bypass unit can include a housing with a front wall, side walls and a closed rear wall and can be devoid of power stabs. The bypass unit can be configured so that it does not directly connect to the power bus.

Each of the bypass unit, the first unit and the second unit can include a separate housing that is independently insertable and removable from a respective compartment in at least one structure of the electrical power distribution system.

The electrical power distribution system can also include at least one structure with defined spaced-apart internal compartments that hold the bypass unit, the first unit and the second unit in different ones of the defined spaced-apart internal compartments. The first unit can have a first front door with a first disconnect operator handle operably coupled to the first disconnect switch. The second unit can have a second front door with a second disconnect operator handle operably coupled to the second disconnect switch. The electrical power distribution system can further include interlocks that (a) prevent the first door from opening when either the first disconnect switch is closed or the first unit is coupled to the load and (b) prevent the second door from opening when either the second disconnect switch is closed or the second unit is coupled to the load.

The bypass unit and the first and second units can be configured to be insertable into and removable from spaced-apart compartments of a structure.

The first and second disconnect switches can be circuit breakers, and the first and second units can be operatively connected and configured to cause a first one of either the first disconnect switch or the second disconnect switch to trip to an open state when a second one of the first disconnect switch or the second disconnect switch is closed to allow conduction whereby only a single one of the first or second disconnect switch is in an on state at any one time.

The electrical power distribution system can be a motor control center (MCC).

The first disconnect switch and the second disconnect switch can each include or be a circuit breaker.

The first unit can have a first motor starter and the second unit can have a second motor starter.

The first unit and the second unit can have a motor starter and be configured as one of options A-L:

Option	first unit	second unit
A	VFD unit	VFD unit
B	Soft Starter (Reduced Voltage starter) unit	Soft Starter (Reduced Voltage starter) unit
C	NEMA Starter unit	NEMA Starter unit
D	IEC Starter unit	IEC Starter unit
E	VFD unit	Soft Starter (Reduced Voltage starter) unit
F	Soft Starter (Reduced Voltage starter) unit	NEMA Starter unit
G	NEMA Starter unit	IEC Starter unit
H	VFD unit	NEMA Starter unit

-continued

Option	first unit	second unit
I	Soft Starter (Reduced Voltage starter) unit	IEC Starter unit
J	VFD unit	IEC Starter unit
K	Feeder Breaker	Feeder Breaker
L	Feeder Fused Disconnect Switch	Feeder Fused Disconnect Switch

The power transfer switch can include a six-pole isolating switch. The six-pole isolating switch can have a first set of three switch contacts coupled to the first unit and a second set of three switch contacts coupled to the second unit to thereby allow the six-pole isolating switch to selectively couple the first unit or the second unit to the load.

The bypass unit can further include a first conductor coupled to the first set of switch contacts, a second conductor coupled to the second set of switch contacts, and a third conductor configured to couple to the load, the first conductor extending from the bypass unit a distance sufficient to couple to the first unit, the second conductor extending from the bypass unit a distance sufficient to couple to the second unit, and the third conductor having a length sufficient to couple to the load.

The first and second conductors can extend from the bypass unit through a wire way to connect to the respective first and second units.

The electrical power distribution system can be a motor control center (MCC). The first and second units can each further include a power disconnect assembly with extendable/retractable power stabs that move relative to a rear of the first and second units, respectively, to connect and disconnect from the power bus. Only a single one of the first and second units extend respective power stabs to connect to the power bus at any one time. The first unit and the second unit each comprise a lock that, when deployed, physically (a) locks the power disconnect assembly in at least one defined position associated with one or both (i) a retracted position associated with an electrically isolated state of the respective unit or (ii) an extended position associated with engagement with the power bus and an electrically active state, and/or (b) locks a laterally movable slide from allowing access to an aperture that allows a crank to change a position of the power stabs.

The electrical power distribution system can further include at least one interlock that is configured to allow a user to open or slidably remove one of the first unit or the second unit from the MCC only when a respective unit is in the electrically isolated state while allowing another one of the first or the second unit to be energized and power the load through the bypass unit.

Each of the first and second units can be slidably and releasably held in defined separate compartments of a structure of the electrical power distribution system and each is serially interchangeable with a different corresponding unit having a common size and shape housing thereby allowing modular repair and replacement. The bypass unit can be held in a housing with a closed front door and can have a height that is in a range of about 6-12 inches.

The bypass unit, the first unit and the second unit can be held in separate housings. The bypass unit, the first unit and the second unit can be configured to power a load with horsepower in a range of about ¼ horsepower to 200 horsepower. The bypass unit can have a closed front door with a front operating switch handle coupled to the isolation switch.

The power transfer switch of the bypass unit can include a six-pole isolation switch defining a main switch body and at least one auxiliary switch attached thereto. The at least one auxiliary switch can be configured to transmit and/or receive control signals to/from at least one of the first or second units.

The first disconnect switch can include a first circuit breaker and the second disconnect switch can include a second circuit breaker. The first and second circuit breakers can be electrically interlocked, such that only one of the first and second circuit breakers can be closed at any one time.

The units can be operatively connected and configured to cause a first one of either the first circuit breaker or the second circuit breaker to trip to an open state when a second one of the first circuit breaker or the second circuit breaker is closed to allow only a single one of the first or second circuit breaker to be in an on state at any one time.

The first disconnect switch can include a first circuit breaker and the second disconnect switch includes a second circuit breaker. The first and second circuit breakers and the power transfer switch can be electrically interlocked, such that, when the power transfer switch couples one of the first and second units to the load, only the associated first or second circuit breaker can be closed.

The power transfer switch can include at least one auxiliary switch coupled to the circuit breakers that is configured to transmit a trip signal to the circuit breaker of the first disconnect switch when the power transfer switch couples the second unit to the load.

Other embodiments are directed to a bypass unit for an electrical power distribution system, such as a motor control center, including a structure defining a plurality of compartments having first and second units installed therein. The bypass unit includes a housing configured to insertable into and removable from a compartment and a bypass circuit including a power transfer switch in the housing. The power transfer switch includes a six-pole isolation switch configured to selectively couple the first unit to a load and the second unit to the load. The six-pole isolation switch includes a first set of three switch contacts of the six-pole switch configured to couple to the first unit and a second set of three switch contacts configured to couple to the second unit.

The bypass unit can further include a first conductor electrically coupled to the first set of switch contacts and that extends out of the housing and is configured to electrically couple to the first unit and a second conductor that is electrically coupled to the second set of switch contacts and that extends out of the housing and is configured to electrically couple to the second unit. The first unit and/or the second unit can include a motor starter.

The housing can have a height in a range of about 6-12 inches. Optionally, the bypass unit further includes an operator handle coupled to the six-pole isolation switch and having a first ON position associated with the first set of three switch contacts and a second ON position associated with the second set of three switch contacts

The power transfer switch can be configured to power a load from a power bus to the load using a single one of the first unit or the second unit at any one time during normal operation and only when a disconnect switch of another one of the first unit or the second unit is in an off state associated with non-conduction.

The housing can be rectangular and configured to be slidably and releasably held in the compartment.

The bypass unit can further include at least one auxiliary switch attached to the six-pole isolation switch, wherein the at least one auxiliary switch is configured to transmit and/or receive control signals to/from at least one of the first or second units.

Embodiments of the invention are directed to electrical power distribution systems that include: a bypass unit with a power transfer switch configured to electrically couple to a load; a first unit that includes a first disconnect switch electrically coupled to the power transfer switch; and a second unit that includes a second disconnect switch electrically coupled to the power transfer switch. At any one point in time during normal operation, the power transfer switch of the bypass unit is configured to electrically connect a power bus to the load using only one of the first unit or the second unit. When the power transfer switch electrically connects the first unit to the load, the first disconnect switch is electrically on and allows conduction in an electrically active (energized) state while the second disconnect switch is electrically off and in an electrically inactive (non-energized) state with the second unit electrically isolated from the load and the first unit. When the power transfer switch electrically connects the second unit to the load, the second disconnect switch is electrically on and allows conduction in an electrically active (energized) state while the first disconnect switch is electrically off and in an electrically inactive (non-energized) state with the first unit electrically isolated from the load and the second unit.

The first and second units can each further include a power disconnect assembly with extendable/retractable power stabs that move relative to a rear of the first and second units, respectively, to connect and disconnect from the power bus, and only a single one of the first and second units have power stabs in an extended state to connect to the power bus at any one time.

The bypass unit can include an enclosure with a front wall, side walls and a closed rear wall and can be devoid of power stabs and does not directly connect to the power bus.

Each of the bypass unit, the first unit and the second unit can be held in separate housings and can be independently slidably removable from a respective compartment in at least one structure of the electrical power distribution system.

Other embodiments are directed to methods of assembling an electrical power distribution system. The methods include; providing a bypass unit in a housing comprising a power transfer switch configured to serially electrically couple to only two units defined by first and second separate units held in separate respective housings to a load, each of the two units to thereby provide a redundant, back-up drive capacity; and selecting only two units as the first and second units to connect to the bypass unit from one of options A-L:

Option	first unit	second unit
A	VFD unit	VFD unit
B	Soft Starter (Reduced Voltage starter) unit	Soft Starter (Reduced Voltage starter) unit
C	NEMA Starter unit	NEMA Starter unit
D	IEC Starter unit	IEC Starter unit
E	VFD unit	Soft Starter (Reduced Voltage starter) unit
F	Soft Starter (Reduced Voltage starter) unit	NEMA Starter unit
G	NEMA Starter unit	IEC Starter unit
H	VFD unit	NEMA Starter unit
I	Soft Starter (Reduced Voltage starter) unit	IEC Starter unit
J	VFD unit	IEC Starter unit
K	Feeder Breaker	Feeder Breaker
L	Feeder Fused Disconnect Switch	Feeder Fused Disconnect Switch

The first and second units can each comprise a power disconnect assembly having extendable/retractable power stabs.

The methods can further include: slidably inserting the bypass unit and the selected first and second units into compartments of a structure of the electrical power distribution system; and electrically connecting the power transfer switch of the bypass unit to the selected first and second units during, before or after the inserting.

The electrical power distribution system can be a motor control center.

The selected first and second units and the bypass unit can each have a dedicated, respective front door. The bypass unit can have a closed rear panel. A side wall of the bypass unit can have a plurality of conductors extending outward therefrom including a conductor that couples to a load, and first and second conductors that couple to the selected first and second units.

The power transfer switch of the bypass unit can include a six-pole isolation switch and at least one auxiliary switch attached thereto. The at least one auxiliary switch can be configured to transmit and/or receive control signals to/from at least one of the first or second units.

The power transfer switch can include a six-pole isolating switch configured to electrically couple to a load, and with a first set of three switch contacts coupled only to the first unit while a second set of three switch contacts that are different from the first set of three switch contacts and are coupled only to the second unit to thereby serially couple the load to the first unit and the second unit via the bypass unit.

The bypass unit can further include at least one auxiliary switch attached to the six-pole isolation switch. The at least one auxiliary switch can be configured to transmit and/or receive control signals to/from at least one of the first or second units.

Further features, advantages and details of the present invention will be appreciated by those of ordinary skill in the art from a reading of the figures and the detailed description that follow, such description being merely illustrative of the present invention.

It is noted that aspects of the invention described with respect to one embodiment, may be incorporated in a different embodiment although not specifically described relative thereto. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination. Applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to be able to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner. These and other objects and/or aspects of the present invention are explained in detail in the specification set forth below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a box diagram of an example electrical power distribution system according to embodiments of the present invention.

FIG. 2A is a schematic of an exemplary bypass unit according to embodiments of the present invention.

FIG. 2B is a front, side perspective view of the bypass unit shown in FIG. 2A according to embodiments of the present invention.

FIG. 2C is a rear, side perspective view of the bypass unit shown in FIG. 2A according to embodiments of the present invention.

FIGS. 3A and 3B are box diagrams of electrical power distribution systems according to embodiments of the present invention.

FIGS. 4-6 are schematic illustrations of electrical power distribution systems according to embodiments of the present invention.

FIG. 7A is an enlarged front view of a transfer switch and deadfront switch handle suitable for the bypass unit shown in FIGS. 1 and 2A according to embodiments of the present invention.

FIG. 7B is a schematic illustration of an electrical power distribution system according to embodiments of the present invention.

FIG. 8 is a partial front side perspective view of a motor control center (MCC) according to embodiments of the present invention.

FIG. 9 is a top, side perspective view of an example unit with power stabs according to embodiments of the present invention.

FIG. 10 is a bottom view of the example unit shown in FIG. 9 according to embodiments of the present invention.

FIG. 11 is a table of actions/conditions an electrical interlocking system for electrical power distribution systems according to embodiments of the present invention.

FIG. 12 is a table of actions/conditions for a mechanical interlocking system according to embodiments of the present invention.

FIG. 13A is a partial front view of a front panel segment of an example unit with a keyed interlock according to embodiments of the present invention.

FIG. 13B is a top view of the device shown in FIG. 13A.

FIG. 14A is an enlarged view of the keyed interlock shown in FIG. 13A.

FIG. 14B is an enlarged view of a mechanically locked slide of a unit of the MCC shown in FIG. 8.

FIGS. 15A and 15B is a flow chart of actions that can be carried out to power a load according to embodiments of the present invention.

FIG. 16 is a flow chart of an example build process allowing for end user builds from a defined set of modular unit options according to embodiments of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. Like numbers refer to like elements and different embodiments of like elements can be designated using a different number of superscript indicator apostrophes (e.g., 10, 10', 10", 10"').

In the drawings, the relative sizes of regions or features may be exaggerated for clarity. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

Spatially relative terms, such as "beneath", "below", "lower", "above", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device or system in use or operation in addition to the orientation depicted in the figures. For example, if the device or system in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device or system may be otherwise oriented (rotated 90° or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The term "about", when used with a number, refers to numbers in a range of +/−20% of the noted value(s).

As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms "includes," "comprises," "including" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

The terms "operating mechanism" and "operator mechanism" are used interchangeably and refer to an assembly that is a primary disconnect for a unit and typically has a manually operative lever for opening and closing separable contacts in a circuit breaker and/or for turning power ON and OFF using a disconnect switch associated with a fuse (e.g., a fused disconnect). When a disconnect switch of the operating mechanism (e.g., circuit breaker) is ON (with contacts closed) and connected to a power bus, the unit is energized.

The terms "bucket assembly", "bucket", "control unit," and "unit" are used interchangeably and refer to a housing (typically a protective metal shell) that contains a disconnect switch, such as an isolation switch (for a bypass unit), a fused disconnect switch, or a circuit breaker (which can be manually operated by an operator mechanism) for controlling energization/de-energization of the power circuit in the unit. A unit can also include other components such as a power transformer, PLCs (programmable logic controllers), position sensors and the like.

The unit can be a motor starter unit, a feeder unit, a unit with a transfer switch or any other unit type. The term "motor starter" is used herein to refer to any starter type. The motor starter can be, for example, a variable frequency drive (VFD) (also known as a variable speed drive), a soft starter (reduced voltage starter), a NEMA starter (NEMA contactor and overload relay, or an IEC starter (IEC contactor and overload relay). The unit can comprise a feeder such as a feeder with a circuit breaker ("feeder breaker") or a feeder with a disconnect switch with a fuse ("feeder with fused disconnect switch"), a lighting contactor, a resistive contactor or an ATS (automatic transfer switch), by way of further example.

The term "disconnect switch" when used with respect to a unit refers to a switch in or on the unit for controlling energization or de-energization of the unit, including a circuit breaker or a switch for opening and closing separable contacts in, e.g., a circuit breaker and/or for turning power ON and OFF using a switch associated with a fuse (e.g., a fused disconnect). A disconnect switch can also include an isolation switch for the bypass unit. The disconnect switch can include an operator mechanism to permit manual operation of the circuit breaker or fused disconnect.

The terms "load" and "load device" are used interchangeably and are intended to mean devices that consume electrical power and that are connected to and controlled by the electrical power distribution system (e.g., a motor control center). Load devices are typically motors, but may also be pumps or other machinery that may comprise motors or pumps or other miscellaneous critical loads such as hospitals, dam emergency pumps, data centers, back-up generator systems and the like.

Referring to FIG. **1**, one embodiment of an electrical power distribution system **100** (e.g., a MCC) is shown. The electrical power distribution system **100** includes a structure with compartments **110**, a wire way **100***w* (FIG. **4**, for example), a common power bus **200**, units $\mathbf{50}_1$, $\mathbf{50}_2$ and a bypass unit **10** for providing power from the power bus **200** of a power bus bar system **1000** (FIG. **4**, for example) to an external load **80**. The electrical power distribution system **100** can include more than two units $\mathbf{50}_1$, $\mathbf{50}_2$ and the bypass unit **10** as shown in FIG. **8**, for example.

Embodiments of the invention can allow for electrical isolation of one of the units $\mathbf{50}_1$, $\mathbf{50}_2$, from the other of the units $\mathbf{50}_1$, $\mathbf{50}_2$, while the other unit is operational, online, and providing power to the load **80**, thereby providing a continuous operational system while also providing increased safety for a technician. For example, since the primary or first unit $\mathbf{50}_1$ is electrically isolated from the secondary or second unit $\mathbf{50}_2$, a technician can access the first unit $\mathbf{50}_1$ which is offline and electrically isolated from the second unit $\mathbf{50}_2$, the power bus **200** (FIGS. **1**, **4**) and the load **80**, while the second unit $\mathbf{50}_2$ is operational, online, and providing power to the load **80**, thereby providing a continuous operational system while also providing increased safety for a technician.

Embodiments of the invention can also provide for physical separation/isolation of the first and second units $\mathbf{50}_1$, $\mathbf{50}_2$ and the bypass unit **10** from each other in compartments **110** of the structure **100** using barriers such as partitions, walls, ceilings and floors, for example.

Referring to FIGS. **1** and **2**A, the bypass unit **10** includes a housing **10***h* that encloses a power transfer circuit **20** with a bypass isolation switch **25**. The power transfer circuit **20** is coupled to a load **80**, e.g., a load side device such as a motor **80***m* (FIG. **2**A), via a conductor **30**, shown as a three pole/three phase lead with three electrical contact connections. The term "conductor" refers to one or more cables, each of which can include one or more wires, leads or other elements that conduct electricity, or one or more wires, leads, traces, lines or other elements that conduct electricity.

The power transfer circuit **20** is also electrically coupled to a first unit $\mathbf{50}_1$ and a second unit $\mathbf{50}_2$ (FIGS. **1**, **3**A, **3**B, **4-6**) via conductors **32**, **34**, respectively, and is configured to only electrically connect the load **80** to a single one unit of the first unit $\mathbf{50}_1$ or the second unit $\mathbf{50}_2$ at any one time during normal operation. The conductors **30**, **32**, **34** can be of the same or different lengths. The conductors **32**, **34** can extend from the bypass unit **10** to the first and second units $\mathbf{50}_1$, $\mathbf{50}_2$, inside a wire way **100***w* of a structure **100**, such as an MCC **100**M (FIGS. **4-6**).

As shown in FIGS. **2**A and **2**B, the bypass unit **10** has a front panel **10***f*, sidewalls **10***s*, a ceiling **10***c*, a floor **10***b* and a back wall **10***r* that defines an enclosed compartment **11** and does not require, and typically does not have, power stabs (for engaging a power bus) that extend out from the back wall **10***r*. A plurality of conductors **30**, **32**, **34** extend out of the housing **10***h*, typically one of the side walls **10***s*, shown as the right side wall **10***e* (FIG. **2**B). The term "right side" refers to the orientation when held in a structure for normal operation with the front **10***f* facing forward. The incoming conductors (e.g., nine wires, three associated with each conductor **30**, **32**, **34**) can be fed into the bypass unit **10** through one side of the unit and into a wire way **100***w* (FIG. **4**) and the rear **10***r* of the housing **10***h* can be a closed panel. The bypass unit **10** can electrically isolate each of the first unit $\mathbf{50}_1$ and the second unit $\mathbf{50}_2$ from the load **80** and/or from each other while respective front panels **50***f* (FIGS. **1**, **3**A, **3**B) remain closed and typically locked in the closed position.

In some embodiments, the housing **10***h* of the bypass unit **10** can define an enclosure with a solid back wall **10***r* with the conductors **30**, **32**, **34** extending from a common portion or different portions of the housing **10***h* via a ceiling, floor, sidewall or back wall. The housing **10***h* can be a 1× size housing (about 6 inches tall) of a 2× size housing (about 12 inches tall) in some embodiments.

It is contemplated that embodiments of the invention can comply with the recommendation of IEEE P1814 with respect to a reduced hazard requirement, which recommends a drive unit, such as a VFD unit, be isolated. Embodiments of the invention can provide a bypass unit that couples to both primary and secondary (redundant) units, which can comprise respective motor starters of the same or different motor starter types. Embodiments of the invention provide modular build options without requiring expensive, complex and larger cumbersome customizations for providing different build configurations while providing the bypass power transfer function.

In some embodiments, the technician can interchangeably replace a malfunctioning primary/first unit from the structure **100** of an electrical power distribution system (FIGS. **1**, **3**A, **3**B) with a modular replacement unit of the same type (e.g., the same housing and build configuration with the same internal components) while the other (secondary/second) unit is operational.

As shown in FIG. 2B, the bypass unit **10** can include a user interface member **130** (which is typically a lever or handle of an operating mechanism) extending from the front panel **10***f* and connected to the power transfer circuit **20**, typically directly coupled to the bypass isolation switch **25**. The user interface member **130** can include, e.g., a rotary switch, that allows a user to select a first position that couples the first unit 50_1 to the load **80**, a second position that couples the second unit 50_2 to the load **80**, and an optional third position that concurrently disconnects the first unit 50_1, the second unit 50_2 and, optionally, also disconnects the bypass unit **10** from the load **80**. Thus, there can be first and second "ON" positions and an optional "OFF" position, and, where used, the OFF position can be between the first and second ON positions as shown in FIG. 2B.

The user interface member **130** can be a switch handle that is manually operated and configured to receive a lock so as to be able to be physically locked (e.g., padlocked) in an OFF or ON position. Referring to FIGS. 2A and 2B, the user interface member **130** can have two ON positions, a first ON position to close a first set 26_1 of (three) switch contacts **26***c* that couple to the first unit 50_1 and the second ON position to close the other set 26_2 of (three) switch contacts **26***c* that couple to the second unit 50_2 to electrically selectively couple only a single one of the units 50_1, 50_2. The ON position is associated with the corresponding unit being energized providing an electrical path from the power bus **1000** (FIG. **4**) through the selectively closed switch contacts **26***c* of the bypass unit **10** to a load **80** at any one time.

Still referring to FIG. 2B, the bypass unit **10** can also optionally include a lock **13** that locks the front panel **10***f* (which can be a front door that pivots open from a side) closed so that a technician cannot open the front panel or door **10***f* when the lock is deployed. The lock **13** can be a physical/mechanical or electromechanical interlock that locks the front panel or door **10***f* closed.

One or all of the units **10**, 50_1, 50_2 (FIGS. **1**, **3**A, **3**B) can be configured as a modular unit to allow the internal components to be assembled as a unit **10**, 50_1, 50_2 that can be easily, typically slidably and replaceably, installed into a compartment **110** of a structure **100** (FIGS. **1**, **3**A, **3**B) such as an enclosure, a cabinet, and/or a motor control center (MCC) **100**M (FIGS. **4**-**6**). Embodiments of the invention provide modular (plug and play) configurations which can provide economic advantages to known conventional custom bypass designs that are cumbersome and may not provide the additional electrical isolation allowed by embodiments of the present invention. To be clear, the term "modular" refers to units that have defined standardized dimensions so that one unit of one type is replaceably interchangeable with another unit of that type.

Referring again to FIG. **2**A, the bypass unit **10** can be provided in package or frame sizes of about 6 inches to about 72 inches (tall) in a height dimension "H" with substantially common depth and width dimensions, known as 1× (6 inches) to 12× (72 inches) sizes. The sizes can be in single X increments, from 1×, 2×, 3×, 4×, 5×, 6×, 7×, 8×, 9×, 10×, 11× and 12×. Thus, a 5× unit **10** can be about 30 inches tall. In some embodiments, the bypass unit **10** can be a 1× unit with a height "H" of about 6 inches or a 2× unit with a height H of about 12 inches. The frame sizes can be provided for target operational amperages, including a plurality of: 125 A, 150 A, 225 A, 250 A, 400 A, 600 A, 1200 A and 2000 A, for example.

FIGS. **1**, **3**A and **3**B illustrate that the bypass unit **10** can be placed in a compartment **110** of a structure **100** and concurrently attached via cables **32**, **34** but selectively electrically coupled to the first unit 50_1 and the second unit 50_2. The first and second units 50_1, 50_2 can each be configured as a motor starter unit comprising a motor starter **50***m* (FIGS. **4**-**6**) and a disconnect switch **60** for controlling energization and de-energization of the motor starter **50***m*. Each unit 50_1, 50_2 can include a front panel or door **50***f*.

The front door **50***f* of each unit 50_1, 50_2 may be configured to engage at least one lock **53** that, when deployed, can lock the door **50***f* in the closed position. The lock **53** can be a physical mechanical interlock.

In some embodiments, each disconnect switch **60** of the first and second units 50_1, 50_2 includes a circuit breakers **60***b* with a shunt trip **60***s* as shown schematically in FIG. **7**B. The terms "shunt trip" and "shunt trip coil" are used interchangeably herein and are well known components of circuit breakers.

The isolation switch **25** of the bypass unit **10** can be configured with open and closed switch states of each switch contact **26***c* (FIG. **2**A) so that only one set 26_1, 26_2 of three switch contacts/poles **26***c* is electrically active and connected to one of the first and second units 50_1, 50_2 at any one time to provide either a first electrical path P_1 between a power bus **200**, the first unit 50_1, the bypass unit **10**, and the load **80** or a second electrical path P_2 between the power bus **200**, the second unit 50_2, the bypass unit **10**, and the load **80**.

Referring to FIGS. **1**, **2**A, **2**B, **3**A, **3**B, a conductor 50_2 can be coupled to the first and second units 50_1, 50_2 to permit signal communication therebetween, to thereby provide electrical interlocking functionality. For example, when a user selects the first unit 50_1 to power the load by switching the user interface member **130** (e.g., operator handle of an operator mechanism) to an ON position and switching the isolation bypass switch **25** to Unit 1-ON position, the first unit 50_1 (either or both the auxiliary switch of the circuit breaker **60***b* or the auxiliary relay **150***r* of the motor starter **50***m*) can transmit a trip signal to the circuit breaker **60***b* of the second unit 50_2, typically via the shunt trip **60***s* (FIG. **7**B). Likewise, the second unit 50_2 can transmit a trip signal to the circuit breaker **60***b* of the first unit 50_1, typically the shunt trip **60***s* (FIG. **7**B), when the second unit 50_2 is selected by the power transfer circuit **20** via the isolation bypass switch **25** to create the electrical path to power the load **80** via the bypass unit **10**. This can provide an extra degree of safety via an electrical interlock system.

Referring to FIGS. **3**A, **3**B and **7**B, the disconnect switch **60** of the first unit 50_1 can electrically couple to the disconnect switch **60** of the second unit 50_2. In some embodiments, the disconnect switch **60** of each of the units 50_1, 50_2 comprises or is a circuit breaker **60***b*. In certain defined conditions, the first unit 50_1 can send a trip signal to the circuit breaker **60** of the second unit 50_2 to cause the breaker shunt trip coil **60***s* to trip the breaker in the second unit 50_2. In certain defined conditions, the second unit 50_2 can send a trip signal to the circuit breaker **60***b* of the first unit 50_1 to cause the breaker shunt trip coil **60***s* to trip the breaker in the first unit 50_1.

The first unit 50_1, for ease of discussion can be referred to as a "primary unit", and a second unit 50_2, for ease of discussion can be referred to as a "secondary unit" that can be coupled to the bypass unit **10** for selectively powering a load **80** through the power transfer circuit of the bypass unit **10**.

In some embodiments, an electrical power distribution system **100** (e.g., MCC) can include a plurality of different electrical interlocks to ensure that only one unit of units 50_1, 50_2 is energized and capable of providing power to the load **80** through the bypass unit **10** at any one time. FIG. **11** lists exemplary electrical interlocks. These defined conditions and associated actions can provide an electrical interlock system. FIG. **11** lists example actions of the first (primary) unit 50_1, the second (redundant) unit 50_2, and the bypass unit **10** providing an electrical interlocking system based on defined operative conditions or states of the first and second units 50_1, 50_2.

Example interlocks associated with a primary mode (when the first unit 50_1 is powering the load **80** through the bypass unit **10**) or a bypass mode (when the second unit 50_2 is powering the load **80** through the bypass unit **10**) are listed. The defined conditions can include positions of power stabs **554** optionally provided as retractable/extendable power stabs **546**, **548**, **550** of a power disconnect assembly **500** (FIGS. **9** and **10**) whether the power stabs **546** are fully extended and connected to a power bus **1000** or retracted (FIGS. **4-6**) based on position sensors **582**, **594** such as one or more microswitches (FIG. **10**) in the respective units 50_1, 50_2. Other conditions can be based on an energized status of a respective primary or secondary unit based on an auxiliary switch and/or auxiliary relay in each of the first and second units which can send a trip signal to the other unit. The bypass unit **10** can also send a trip signal to the primary 50_1 or secondary unit 50_2 depending on whether the bypass unit **10** is in the primary mode (trip signal to the secondary unit) or the bypass mode (trip signal to the primary unit).

However, while the power disconnect assembly **500** is believed to be desired for certain end applications/uses, it is not required in all motor starter units. For further description of position sensors using auxiliary switches such as microswitches in a unit with a power disconnect assembly **500**, see U.S. 2008/0022673 (labeled as features **82** and/or **94** in FIG. **17** of this document), the contents of which are hereby incorporated by reference as if recited in full herein. For further descriptions of example power disconnect assemblies and interlocks, see also, U.S. patent application Ser. No. 15/848,103, the contents of which are hereby incorporated by reference as if recited in full herein.

Table 1 below provides a list of example configurations of the first unit/primary unit 50_1 and the second unit/secondary unit 50_2.

TABLE 1

UNIT COMBINATION OPTIONS

Option	Primary Unit	Secondary unit
A	VFD unit	VFD unit
B	Soft Starter (Reduced Voltage starter) unit	Soft Starter (Reduced Voltage starter) unit
C	NEMA Starter unit	NEMA Starter unit
D	IEC Starter unit	IEC Starter unit
E	VFD unit	Soft Starter (Reduced Voltage starter) unit
F	Soft Starter (Reduced Voltage starter) unit	NEMA Starter unit
G	NEMA Starter unit	IEC Starter unit
H	VFD unit	NEMA Starter unit
I	Soft Starter (Reduced Voltage starter) unit	IEC Starter unit
J	VFD unit	IEC Starter unit
K	Feeder Breaker	Feeder Breaker
L	Feeder with Fused Disconnect Switch	Feeder with Fused Disconnect Switch

Referring to FIG. **7**B, the trip signal for the electrical interlock system can be generated/transmitted via at least one interlock circuit **1500** that can include (a) one or more inputs for receiving a signal from an auxiliary switch **27** (FIG. **7**A) of the bypass unit **10** via conductor **127** and (b) one or more input(s) for receiving a signal from the first and second units 50_1, 50_2 such as from an auxiliary switch or contact associated with the circuit breaker **60***b* of the disconnect switch **60** and/or an auxiliary relay **150***r* coupled to or in the motor starter **50***m*. As discussed above, the first and second units 50_1, 50_2 can be coupled via a conductor 50_2, for example. One or more of the outputs/signals from the auxiliary switch **27** and/or the interlock circuit **1500** can provide a voltage signal as a trip signal to a shunt trip **60***s* in a circuit breaker **60***b* of one of the first and second units 50_1, 50_2 when the other unit of the first and second units 50_1, 50_2 has a circuit breaker **60***b* that is energized.

Still referring to FIG. **7**B, each motor starter **50***m* can be coupled to an auxiliary relay **150***r* that can transmit a trip signal **150***s* to the interlock circuit **1500**. For example, when a motor starter **50***m* of one of the first and second units first and second units 50_1, 50_2 is on and/or operating, an auxiliary relay **150***r* can transmit a voltage trip signal **150***s* to the circuit breaker **60***b* of the other unit to make sure that the other unit is off, contacts open, as a safety interlock feature.

In some embodiments, the auxiliary relay **150***r* of the motor starter (e.g., soft starter) **50***m*, the auxiliary switch **27** of the bypass unit **10** and an auxiliary switch **60***s* in the breaker **60***b* of first unit 50_1 can be synchronized and/or transmit in parallel, trip signals to the second unit 50_2 when the first unit 50_1 is energized. The auxiliary relay **150***r* of the motor starter (e.g., soft starter) **50***m*, the auxiliary switch **27** of the bypass unit **10** and the auxiliary switch **60***s* in the breaker **60***b* of the second unit 50_2 can be synchronized and/or transmit in parallel trip signals to the first unit 50_1 when the second unit 50_2 is energized.

The term "auxiliary switch" for the primary unit and the secondary unit in FIG. **11** that can send the trip signal(s) to the appropriate breaker can include one or more auxiliary switches including, for example, an auxiliary switch **582**, **594** (FIG. **10**) identifying a position of the retractable/extendable power stabs, an auxiliary switch of a circuit breaker **60***b* (FIG. **7**B) associated with a contacts closed condition, or an auxiliary relay **150***r* (FIG. **7**B) of a motor starter **50***m* indicating an motor on condition.

The structure **100** can be designed to slidably receive multiple units **10**, 50_1, 50_2 in various defined sizes. For example, the first and second units 50_1, 50_2 can each have housings **50***h* of the same or different modular heights (i.e., 1×-12× frame sizes as discussed above). Each housing **10***h*, **50***h* can include a front door **10***f*, **50***f* that can remain closed when a respective unit is energized. Only one of the two units 50_1, 50_2 can be energized when connected to the power bus bars **200** and connected to the load **80** via the bypass unit **10** at any one time. When de-energized, one of the front doors **50***f* of the two units 50_1, 50_2 can be opened to allow a technician access to replace or repair that unit while the other of those two units 50_1, 50_2 is energized but electrically isolated from the de-energized unit and the bypass unit **10**.

FIG. 3A illustrates that the bypass unit **10** can be placed in a first structure **1001** while the first unit 50_1 and the second unit 50_2 are in a separate, but typically adjacent, structure **1002**. Each structure **100** can optionally have a front door **100***f* (shown by the shading over the respective units) that closes and releasably locks via at least one mechanical lock **114** in the closed position over one or more of the units 50_1, 50_2 and **10**, respectively.

FIGS. **1** and 3B illustrate that the bypass unit **10** and the first and second units 50_1, 50_2 are held in the same structure **100**. FIG. 3B illustrates that the units 50_1, 50_2 can be held in side by side, laterally adjacent compartments **110**. FIG. **1** illustrates that the bypass unit and the first and second units 50_1, 50_2 can be held in a vertically stacked arrangement of compartment **110**.

Referring again to FIG. **1**, each compartment **110** can have a closed floor **110***f* and/or ceiling and/or rails **112** coupled to internal sidewalls **1101** that slidably receive and support the units **10**, 50_1, 50_2.

Referring to FIGS. **4-6**, the first and second units 50_1, 50_2 can have power stabs **554** extending rearward from the back **50***r* that connect to one or more (typically vertically oriented) power bus bars **200** that are part of a power bus system **1000** that carries power (current) to the compartments of a vertical section in the structure such as the MCC **100**M. These power stabs **554** may optionally be provided by a power disconnect assembly **500** as discussed above. As is well known, the bus bars **200** can be connected to larger (typically horizontal bus bars) that bring power to the vertical sections. The larger (typically horizontal) bus bars are usually in the top, but some structures may have them in the center or bottom. The structures of MCCs **100**M usually have at least one wireway **100***w* for conductors **30**, **32**, **34** (i.e., wires) to the load(s) and control cables and/or wires.

FIG. **4** illustrates an MCC **100**M with the bypass unit **10** and a first unit 50_1 that can comprise a VFD 50_{VFD} as the motor starter **50***m* and can also comprise power stabs **554**, shown as provided by a power disconnect assembly **500**. FIG. **4** also illustrates that the second unit 50_2 can comprise a NEMA starter 50_{Nm} as the motor starter **50***m* and can also comprise power stabs **554**, shown as provided by a power disconnect assembly **500**. The microswitches **582** and/or **594** (FIG. **10**) can identify when the stabs **554** are fully engaged to the (vertical) power bus **200** and when the stabs **554** are fully withdrawn and isolated from the (vertical) bus **200**.

FIG. **5** illustrates an MCC **100**M with the bypass unit **10** and a first unit 50_1 that can comprise a soft starter **50***ss* as the motor starter **50***m* and can also comprise power stabs **554**, shown as provided by a power disconnect assembly **500**. FIG. **5** also illustrates that the second unit 50_2 can comprise a NEMA starter 50_{Nm} as the motor starter **50***m* and can also comprise power stabs **554**, shown as provided by a power disconnect assembly **500**. The position sensors **582** and/or **594** (FIG. **10**) can identify when the stabs **554** are fully engaged to the (vertical) power bus **200** and when the stabs **554** are fully withdrawn and isolated from the (vertical) power bus **200**.

FIG. **6** illustrates an MCC **100**M with the bypass unit **10** and a first unit 50_1 that can comprise a VFD 50_{VFD} as the motor starter **50***m* and can also comprise power stabs **554**, shown as provided by a power disconnect assembly **500**. FIG. **6** illustrates that the second unit 50_2 can comprise a soft starter **50***ss* as the motor starter **50***m* and can also comprise power stabs **554**, shown as provided by a power disconnect assembly **500**. The position sensors (e.g., microswitches) **582** and/or **594** (FIG. **10**) can identify when the stabs **554** are fully engaged to the (vertical) power bus **200** and when the stabs **554** are fully withdrawn and isolated from the (vertical) bus **200**.

Thus, as shown by the examples of FIGS. **4-6**, modular units 50_1, 50_2 of different motor starter configurations can allow a number of different MCC build selections and/or configurations without requiring unique more expensive custom units.

Referring to FIG. **7**A, the bypass isolation switch **25** of the bypass unit **10** can comprise a six pole isolation switch with a first set of three poles 26_1 coupled to the first unit 50_1 and a second set of three poles 26_2 electrically coupled to the second unit 50_2. The switch **25** can include a main switch body **25***m* with the six poles and one or more auxiliary switches **27**, typically at least one auxiliary switch on each opposing end or side of the main switch body **25***m*.

The auxiliary switches **27** can be configured to receive and/or transmit signals from and/or to the first unit 50_1 and the second unit 50_2. For example, one or more of the auxiliary switches **27** can transmit a trip signal to the circuit breaker **60***b* of the disconnect switch **60** of one of the first unit 50_1 or the second unit 50_2 either or both (a) when the other of the first unit 50_1 or the second unit 50_2 is energized with the stabs **554** contacting the power bus **200** or (b) when the bypass switch **25** connects the first or second set of switch contacts **26***c* to be in the bypass mode whereby the aux switch **27** sends a trip signal to the primary unit 50_1 or the primary mode whereby the aux switch **27** sends a trip signal to the secondary unit 50_2. A respective auxiliary switch **27** can be coupled to one or both units 50_1, 50_2 via a conductive cable **127** (e.g., wire(s)) (FIG. **7**B).

As also shown in FIG. **7**B, the first and second units 50_1, 50_2 can be electrically coupled via one or more conductors 50_2 so that the first unit 50_1 can send a trip signal to the second unit 50_2 when the first unit 50_1 is connected to the power bus bars **200**. Similarly, the second unit 50_2 can send a trip signal to the first unit 50_1 when the second unit 50_2 is connected to the power bus bar **200**. In some embodiments, the trip signal can be generated by an auxiliary switch **60***s* (FIG. **7**B) in a respective unit 50_1, 50_2 and/or a microswitch assembly associated with a position sensor **594** and/or **582** (FIG. **10**) associated with one of the units with a power disconnect assembly **500** when the stabs of one of the units 50_1, 50_2 are fully extended and the stabs of the other unit are not extended (i.e., are retracted).

By way of example only and without limitation, an example isolation switch **25** is an R5 series six pole isolation switch (UL **508**) non-fusible 16 A-80 A rotary disconnect that comprises a (rotary) user interface handle as the user interface member **130**.

FIG. **7**B illustrates that the structure **100**, optionally an MCC **100**M, can comprise the bypass unit **10** coupled to the first unit 50_1 and the second unit 50_2. Each unit **10**, 50_1, 50_2, can be in separate housings **10***h*, **50***h* and placed in separate compartments of the structure **100**. Each housing **10***h*, **50***h* can have a closed front panel or door **10***f*, **50***f*.

FIG. **8** illustrates an example MCC **100**M with the first and second units 50_1, 50_2 and the bypass unit **10**. The first and second units 50_1, 50_2 include operator handles **51** that are coupled to internal disconnect switches **60**, such as circuit breakers, as is well known to those of skill in the art. The bypass unit **10** includes a user interface member **130** (deadfront switch operable through a closed door) which can be a rotary handle that is coupled to the power transfer circuit **20** (FIG. **1**) to allow an operator to select to connect power from a load **80** to a single one of the first unit 50_1 or the second unit 50_2 and power bus **200**.

The user interface member **130** can be configured to have three defined positions for defined ON and OFF states, a primary ON position, a primary OFF position and a bypass ON position. The user interface member **130** can be locked, such as padlocked, in one or both of the bypass ON and primary ON position, and can be interlocked to the door in one or both of the primary and bypass ON positions, and a door of the unit **10** can be locked closed when in an ON position.

Still referring to FIG. **8**, a typical MCC structure **100**M is an enclosure with a number of small doors arranged in rows and columns along the front and flat, mostly featureless, back and sides. The units **10**, **50** can be provided in varying sizes. For starter units $\mathbf{50}_1$, $\mathbf{50}_2$, the size can be based on the size of the load **80**, e.g., motor **80***m* (FIG. **2**A) they are controlling. The units **10**, $\mathbf{50}_1$, $\mathbf{50}_2$ can be configured to be relatively easily removable for repair, service or replacement. MCCs **100**M can have different sets of units, for example, regular starters, reversing starters, soft start, and variable frequency drives. MCCs **100**M can be configured so that sections can be added for expansion if needed.

MCCs **100**M can be configured in many ways. Each compartment **110** can have a different height to accept different frame sizes of respective bucket assemblies or units **10**, typically in about 6-inch increments. The vertical bus can be omitted or not run through the full height of the section to accommodate deeper buckets for larger items like variable frequency drives. The MCC can be a modular cabinet system for powering and controlling motors and/or feeder circuits. Several may be powered from main switchgear which, in turn, gets its power from a transformer attached to the incoming line from a public or private grid, e.g., a power company.

Referring to FIG. **8**, a partial perspective view of a motor control center structure **100**M is shown. Units **10**, **54**, $\mathbf{50}_1$, $\mathbf{50}_2$ are shown fully installed into a motor control center compartment **110** such that its respective front panel **10***f*, **54***f*, **50***f* is seated securely against the periphery of the compartment enclosure and flush with the front panel **54***f* of unit **54** and with the front panel **50***f* of units $\mathbf{50}_1$, $\mathbf{50}_2$.

In some embodiments, some or all units, e.g., units **54**, **55**, $\mathbf{50}_1$, $\mathbf{50}_2$ can include a number of latching mechanisms **22** on front panels thereof so that an operator may lock a unit into place once installed. In some embodiments, the front panel **50***f*, **54***f* may be a deadfront door having a set of hinges **19** in order to permit access to motor control components within a unit while the unit is installed in a compartment **111** of the MCC **100**M. However, even when closed or sealed, front panel or door **50***f* still permits access to the disconnect switch **60** which can comprise a circuit breaker, stab indicator **24**, shutter indicator **26**, and line contact actuator **31**. Line contact actuator **31** is a mechanism of the power disconnect assembly **500** (FIG. **9**) for selectively engaging a power bus **200** to engage power stabs **554** defining line contacts (FIG. **4**) with line power from the MCC **100**M. Thus, even when a unit **10**, **50** is fully installed in a compartment **110** and latches **22** have been secured, an operator may still use respective switch handles **51**, **130**.

As shown in FIG. **8**, the first unit has the handle **51** in an ON position associated with conduction and an energized state while the second unit $\mathbf{50}_2$ has the handle **51** in an OFF position associated with non-conduction and a de-energized state and the handle **51** can engage a lock **151** such as a padlock to lock the unit $\mathbf{50}_2$ in this state.

For units with the power disconnect assembly **500**, a user can also open slide **132** to insert crank **134** to move one or more line contacts (not shown) of the unit. When slide **132** is moved laterally aside to permit access to actuating mechanism **131**, door **50***f* is prevented from opening, thereby closing off access to components inside the unit $\mathbf{50}_1$, $\mathbf{50}_2$. Additionally, a user may desire to padlock **232** the slide **132** in the closed position (FIG. **14**B), to further regulate who may operate actuating mechanism **131** and when.

When slide **132** is moved aside, an aperture **136** (FIG. **9**) is exposed. Opening **36** accepts a crank **134**. Additionally, when slide **132** is moved aside as shown, slide **132** may optionally extend over a portion of front panel **50***f*. Thus, in embodiments in which front panel **50***f* is a hinged door, moving slide **132** to expose aperture **136** will inhibit a user from opening front panel **50***f*. Accordingly, so long as an operator has a crank **134** inserted into aperture **136** aligned with the internal actuator **131**, the operator cannot open the door of the unit $\mathbf{50}_1$, $\mathbf{50}_2$.

FIGS. **9** and **10** show an example unit $\mathbf{50}_1$, $\mathbf{50}_2$ with an operator handle **51** coupled to the disconnect switch **60** and a power disconnect assembly **500** with retractable/extendable power stabs **554**. During the extension of the power disconnect assembly **500** with the stabs **554** an automatic latch **60** can be triggered to engage the compartment **110** into which unit $\mathbf{50}_1$, $\mathbf{50}_2$ has been installed. Also due to the extension of the power disconnect assembly **500**, a rod **78** is pulled by a stab bracket **59** such that a cam **80** is rotated away from a microswitch **582**. Microswitch **582** is thus actuated to permit control voltage from a control power contact **44** to a motor control component, such as a contactor or overload relay (not shown). It is appreciated, however, that the position sensor assembly using the microswitch **582**, cam **80** and rod **78** can be provided in other manners.

Also shown in FIG. **10** a second microswitch **594** can be connected to activate and deactivate a disconnect switch **60** such as a circuit breaker. When stabs **546**, **548**, **550** reach the fully engaged position with bus bars **200**, stab bracket **59** actuates microswitch **594**. When actuated, microswitch **594** permits closure of the disconnect switch **60**, completing the circuit between bus bars **200** and the line side of motor control components (not shown) in unit $\mathbf{50}_1$, $\mathbf{50}_2$. Otherwise, microswitch **594** can prevent closure of its disconnect switch **60**, e.g., circuit breaker. The microswitch **594** of the first unit **51** can send a trip signal to the disconnect switch **60** of the second unit $\mathbf{50}_2$ when the microswitch **594** permits closure of its disconnect switch to trip the disconnect switch **60** in the second unit $\mathbf{50}_2$ (and vice versa). This can be the signal transmitted via conductor $\mathbf{50}_2$ (FIGS. **3**A, **3**B, **3**C, **7**B).

Control power stab **44** can be un-shielded and connected to a control power once a respective unit $\mathbf{50}_1$, $\mathbf{50}_2$ is installed into a motor control center. However, microswitch **582** is in an activated state, due to the pressure thereon by cam **80**. When microswitch **582** is in the activated state, as shown, microswitch **582** is interrupting control power from contact **44**. Thus, the motor control components (not shown) housed in the unit housing **50***h* cannot initially be operated. Cam **80** will be moved by rod **78** via advancement of stab bracket **59**, deactivating microswitch **582** and thereby permitting the flow of control power to motor control components (not shown) of the unit. Cam **80** also acts to display a location status of the stabs **546**, **548**, **550** to an operator. Cam **80** can have a number of colors thereon which can be displayed through front door **50***f* of the unit via stab indicator **24** (FIG. **8**).

In the embodiment shown in FIG. **10**, a disconnect switch (e.g., circuit breaker) interlock **316** includes microswitch **594**, which gates the operation of the disconnect switch **60**. FIG. **10** shows microswitch **594** in a deactivated state, in which button **334** thereof is not depressed. Arm **330** of microswitch **594** is positioned to abut a ledge **332** of interlock **316**. Thus, when disconnect switch interlock **316** moves, due to the motion of stab assembly **58**, the arm **330** of microswitch **594** will pivot, depressing button **334**. When button **334** is depressed, microswitch **594** will be activated and will electrically allow operation of the disconnect switch (FIGS. **4**-**6**).

FIG. **9** also has height "H", width "W" and depth "D" dimensions which may be provided in modular frame sizes of 1×-12× as discussed above with respect to the bypass unit **10**. In some embodiments, the bypass unit **10** has a height that is less than the height of the units $\mathbf{50}_1$, $\mathbf{50}_2$. The bypass unit **10** and the units $\mathbf{50}_1$, $\mathbf{50}_2$ can have common depth and width dimensions. In other embodiments, the units $\mathbf{50}_1$, $\mathbf{50}_2$ can have common depth and width dimensions and the bypass unit **10** can have a different depth and/or width dimension.

Also shown in FIG. **10** is a shutter arm **336**, having a sloped end **338**. As stab **546** is advanced, stab **546** will engage the sloped end **338** and slide past shutter arm **336**, thereby shifting shutter arm **336** to the left, as depicted in FIG. **10**. When shutter arm **336** is shifted, it will strike a tab **340** of a rod **76** extending in a front to back direction of the unit. When tab **340** is struck, rod **76** will rotate, changing the color showing on shutter indicator **26** through door **50*f*** of a respective unit $\mathbf{50}_1$, $\mathbf{50}_2$.

The electrical power distribution systems **100** (e.g., MCCs) contemplated by embodiments of the invention can optionally include one or more mechanical interlocks. FIG. **12** lists example mechanical locks that can optionally be used to provide a mechanical interlocking system to ensure that only one unit of units $\mathbf{50}_1$, $\mathbf{50}_2$, is energized and capable of providing power to the load through the bypass unit **10** at any one time.

The user interface member **130** of the bypass unit **10** providing a lever of a unit operating mechanism can be padlocked or otherwise locked into a primary mode when powering the load through the first unit $\mathbf{50}_1$ or the bypass mode when powering the load through the second unit $\mathbf{50}_2$.

For embodiments where units $\mathbf{50}_1$, $\mathbf{50}_2$ comprise the optional power disconnect assembly **500** (FIGS. **4**-**6**, **9**, **10**), when one unit is energized, the other unit can be padlocked via padlock **132** (FIG. **14**B) or a padlock that locks the operator mechanism **130** to lock the unit that is not being used to power the load to lock the power disconnect assembly **500** with its stabs in a retracted state with the slide **32** (FIGS. **8**, **9**) misaligned from portal **36** and can also padlock the operator mechanism **130** in the off/open contacts position.

A third interlock may be used where a trapped-key interlock device **250** of a unit $\mathbf{50}_1$, $\mathbf{50}_2$ that allows a disconnect switch **51** (e.g., breaker) to be operated only when the key is turned to allow the handle **51** to be turned to the ON position (FIGS. **13**A, **13**B, **14**A). As is known to those of skill in the art, a trapped-key interlock typically has a lock cylinder which operates a sliding bolt through a cam. The sliding bolt, when extended, mechanically prevents operation of a switch, valve, gate, or other device. Many variations exist, with different shapes of interlock bolt and multiple lock cylinders on an interlock. The key is held or trapped in one position of the lock; releasing the key indicates that the interlocked device has been made safe; the interlocked device cannot be re-energized until the key has been returned and operated to retract the bolt. An example of a trapped-key interlock device **250** is a Kirk® key safety interlock from Kirk Key Interlock Company, North Canton, OH.

A first standard unit $\mathbf{50}_1$ with a first motor starter (e.g., a VFD, Soft starter, NEMA starter, IEC starter or the like) can be referred to as unit "A" and a second standard unit $\mathbf{50}_2$ as a redundant unit with a motor starter of the same or different type (e.g., a VFD, Soft starter, NEMA starter or IEC starter of the like) can be referred to as unit "B" and can be placed in an adjacent location next to unit A. A third (compact) unit "C" provided as the bypass unit **10** comprises the power transfer circuit **20** with a transfer switch **25** which controls the connection to the load **80**, and which switches motor control from the unit "A" to unit "B". Both unit A and unit B can comprise power disconnect assemblies **500** allowing for (FlashGard™ isolator features providing arc flash safety, e.g., a stab racking mechanism with bus isolation and stab position indicators) power bus isolated unit configurations. The disconnect switches **60** in the two units can be configured as main circuit breakers that can be mechanically interlocked with a mechanical lock such as a Kirk® Key interlock and can also be electrically interlocked with shunts trip accessories controlled by position sensors such as microswitches and auxiliary switches in those units $\mathbf{50}_1$, $\mathbf{50}_2$ associated with, for example, FlashGard™ isolators and interlocks. As each unit $\mathbf{50}_1$, $\mathbf{50}_2$ has a separate unit door **50*f***, each of these units can be electrically isolated and completely disconnected from the power bus **200**, i.e., a 480V/600V system, providing a safe working environment.

The unit **10**, $\mathbf{50}_1$, $\mathbf{50}_2$ can be configured for DC (direct current) and/or AC (alternating current) operation.

In some embodiments, the disconnect switch **60** of the unit **50** can comprise a molded case circuit breaker. Molded case circuit breakers are well known to those of skill in the art, as exemplified by U.S. Pat. Nos. 4,503,408 and 5,910,760, the contents of which are incorporated herein by reference as if recited in full herein. In other embodiments, the disconnect switch **60** can comprise a fused disconnect switch to turn power on and off. Either rotary or up/down operator mechanism switch handles can be used.

Exemplary fuses are FUSETRON™ 600V Class RK5 fuses (BU-SB13729) available from Cooper Bussmann Company, St. Louis, MO However, the design is flexible and can accommodate other fuses including those in different classes.

FIGS. **15**A and **15**B illustrate example actions that can be carried out according to embodiments of the present invention.

A bypass unit with a power transfer circuit is the power transfer circuit is provided. The power transfer circuit is electrically coupled to only two units and is configured to serially electrically couple one of the two units to a load, each of the two units having a motor starter and respective disconnect switch (block **800**).

Power from a power bus is selectively provided to a load through the power transfer circuit and only one of the first unit or the second unit at any one time to thereby allow power transfer from a first unit to a second while electrically isolating the first unit from the load and the second unit (block **810**).

When the first unit is powering the motor and has a failure, the first disconnect switch is turned off to prevent electrical conduction in the first unit (block **820**).

The first disconnect switch is locked in the off position (block **830**).

The second disconnect switch is turned on to allow electrical conduction in the second unit. Power from the power bus, through the second unit and the power transfer circuit is provided to the load (block **840**).

A user is allowed to slidably withdraw or otherwise access the first unit while the second unit is operative (electrically active), with the first unit electrically isolated from the bypass unit and the second unit to thereby allow safe repair, servicing or replacement of the first unit while powering the load through the second unit and providing electrical isolation from the power transfer circuit in the bypass unit and the second unit (block **850**).

The power transfer circuit can include a six pole isolation switch, with one set of three of the six poles (switch contacts) coupled to the first unit and another set of three of the six poles (switch contacts) coupled to the second unit. The isolation switch is configured with open and close switch states of each pole (switch contact) so that only one set of three poles is electrically active and connected to one unit at any one time to serially provide a first electrical path between the power bus, the bypass unit, and the load and a second electrical path between the power bus, the bypass unit, and the load (block **802**).

The bypass unit with the power transfer switch cooperates with the first and second disconnect switches to force a shunt trip coil to trip the first disconnect switch (primary breaker) in the first unit to off (e.g., opens the primary breaker) (block **804**).

The bypass unit and the first and second units have a common width and modular housings and are slidably mountable in compartments of a structure of an MCC, each unit with respective front doors that can be independently locked (block **808**).

The bypass unit is in an enclosed housing having a rear wall and first, second and third conductors that extend out of the bypass unit, the first conductor (only) coupled to the first unit and the second conductor (only) coupled to the second unit to electrically couple the first and second units to the load via the bypass unit (block **806**).

Extending retractable/extendable power stabs of a power disconnect assembly of the first unit to electrically engage the power bus while a front door of the first unit remains closed (block **812**).

The first and second units comprise electrical and mechanical interlocks configured to allow only one of the first and second disconnect switches (e.g., circuit breakers) to be ON at any one time (block **814**).

Retracting the retractable/extendable power stabs to disengage from the power bus while a front door of the first unit remains closed (block **822**).

The bypass unit can have an external user switch input that accepts user input to close one of the first set or the second set of switch contacts of a six pole isolation switch. When transferring power from the first unit to the second unit, the first set of switch contacts are opened and the second set of switch contacts are closed (block **824**).

The method can include extending retractable/extendable power stabs of a power disconnect assembly of the second unit to electrically engage the power bus while a front door of the second unit remains closed (block **842**).

FIG. **16** is a flow chart of an example modular assembly method, allowing for standardized builds from defined sets of different units avoiding unique single build customization according to embodiments of the present invention.

A bypass unit is provided. The bypass unit comprising a power transfer switch configured to electrically couple to two units with respective motor starters to serially power a load and thereby provide a redundant, back-up drive capacity (block **900**). Two units are selected to connect to the bypass unit from at least three different modular units, optionally two of the same or two different ones from the following at least three types (block **910**).

A first unit can comprise a variable frequency drive (block **912**). A second unit can comprise a NEMA starter (block **914**), and a third unit can comprise a soft starter (block **916**).

The first, second and third units can each comprise a power disconnect assembly having extendable/retractable power stabs (block **920**).

The bypass unit and the selected two units can be slidably inserted into compartments of a structure, such as a structure of an MCC and the power transfer switch of the bypass unit is electrically coupled to the selected two units during, before or after the inserting (block **925**).

It is contemplated that both "new" builds and field-retrofit structures of electrical power distribution systems **100**, such as MCCs **100M**, can benefit from the new bypass unit **10** and primary and secondary units $\mathbf{50}_1$, $\mathbf{50}_2$ discussed above.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the invention.

That which is claimed is:

1. A bypass unit for a motor control center including a structure defining a plurality of compartments having first and second units installed therein, the bypass unit comprising:

a housing configured to be insertable into and removable from a compartment of the plurality of compartments; and

a bypass circuit including a power transfer switch in or on the housing, wherein the power transfer switch comprises a six-pole isolation switch configured to selectively couple the first unit to a load or the second unit to the load, wherein the six-pole isolation switch includes a first set of three switch contacts of the six-pole isolation switch configured to couple to the first unit and a second set of three switch contacts configured to couple to the second unit.

2. The bypass unit of claim **1**, further comprising a first conductor electrically coupled to the first set of three switch contacts and that extends out of the housing and is configured to electrically couple to the first unit and a second conductor that is electrically coupled to the second set of switch contacts and that extends out of the housing and is configured to electrically couple to the second unit, and wherein the first unit and/or the second unit comprises a motor starter.

3. The bypass unit of claim **1**, wherein the housing has a height in a range of about 6 to 12 inches, optionally wherein the bypass unit further comprises an operator handle coupled to the six-pole isolation switch and having a first ON position associated with the first set of three switch contacts and a second ON position associated with the second set of three switch contacts.

4. The bypass unit of claim **1**, wherein the power transfer switch is configured to power the load from a power bus to the load using a single one of the first unit or the second unit at any one time during normal operation and only when a disconnect switch of another one of the first unit or the second unit is in an off state associated with non-conduction.

5. The bypass unit of claim **1**, wherein the housing is rectangular and configured to be slidably and releasably held in the compartment.

6. The bypass unit of claim **1**, further comprising at least one auxiliary switch attached to the six-pole isolation switch, wherein the at least one auxiliary switch is configured to transmit and/or receive control signals to/from at least one of the first or second units.

7. The bypass unit of claim **1**, wherein the housing is configured as a modular component adapted for slidable engagement within the compartment of the motor control center, the housing being suitable for interchangeable installation in a plurality of motor control center configurations.

8. The bypass unit of claim **1**, wherein the six-pole isolation switch is operable to electrically isolate the first unit from the load when the second unit is coupled to the load, and to electrically isolate the second unit from the load when the first unit is coupled to the load, thereby providing selective isolation of each unit relative to the load.

9. The bypass unit of claim **1**, further comprising interlock mechanisms operably associated with the first and second units, wherein each interlock mechanism is configured to prevent removal of a respective unit from the motor control center when the respective unit is in an electrically active state.

10. The bypass unit of claim **1**, wherein the power transfer switch further comprises at least one auxiliary switch configured to transmit or receive control signals to and from at least one of the first unit or the second unit, the auxiliary switch being operably positioned relative to the six-pole isolation switch to facilitate automated control and monitoring of a coupling state of the load.

11. The bypass unit of claim **1**, wherein each of the first and second units further comprises a power disconnect assembly with extendable and retractable power stabs, the extendable and retractable power stabs being configured to selectively engage or disengage with a power bus within the motor control center, thereby enabling selective connection and disconnection of each unit from the power bus.

12. The bypass unit of claim **1**, wherein the housing comprises a front-operating switch handle coupled to the six-pole isolation switch, the front-operating switch handle being configured to position the six-pole isolation switch to selectively couple the load to either the first unit or the second unit, wherein the front-operating switch handle is further configured to be lockable in at least one predefined position.

13. The bypass unit of claim **1**, wherein the housing further comprises conductor interfaces configured to extend from the housing to electrically couple the six-pole isolation switch to the first unit, the second unit, and the load, each conductor interface comprising three conductors configured for three-phase load transfer.

14. The bypass unit of claim **1**, wherein the motor control center includes mechanical and/or electrical interlock systems configured to ensure that only one of the first or second units is coupled to the load at any given time, the mechanical and/or electrical interlock systems comprising an auxiliary switch configured to detect a state of the power transfer switch and communicate with respective units to maintain exclusivity of a coupling to the load.

15. The bypass unit of claim **11**, wherein each of the first and second units further comprises a disconnect switch configured to trip to an open state in response to a control signal from the six-pole isolation switch, the disconnect switch being operable to maintain only one active conductive path between the power bus and the load at any given time.

16. The bypass unit of claim **11**, wherein the housing further comprises an enclosure with a rear wall, the enclosure having a defined front face with a user-accessible control panel operatively connected to the power transfer switch, the user-accessible control panel being configured to enable manual operation of a load-coupling state while maintaining electrical isolation from the power bus.

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