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(54) INTEGRATED CONNECTOR UNIT

(75) Inventors: **Robert A. Marshall**, Georgetown, TX (US); **Anthony L. Randall**, Austin, TX (US); **Frederick R. Schindler**, Sunnyvale, CA (US)

Correspondence Address:
BAKER BOTTS L.L.P.
2001 ROSS AVENUE
SUITE 600
DALLAS, TX 75201-2980 (US)

(73) Assignee: **Cisco Technology, Inc., a California corporation**

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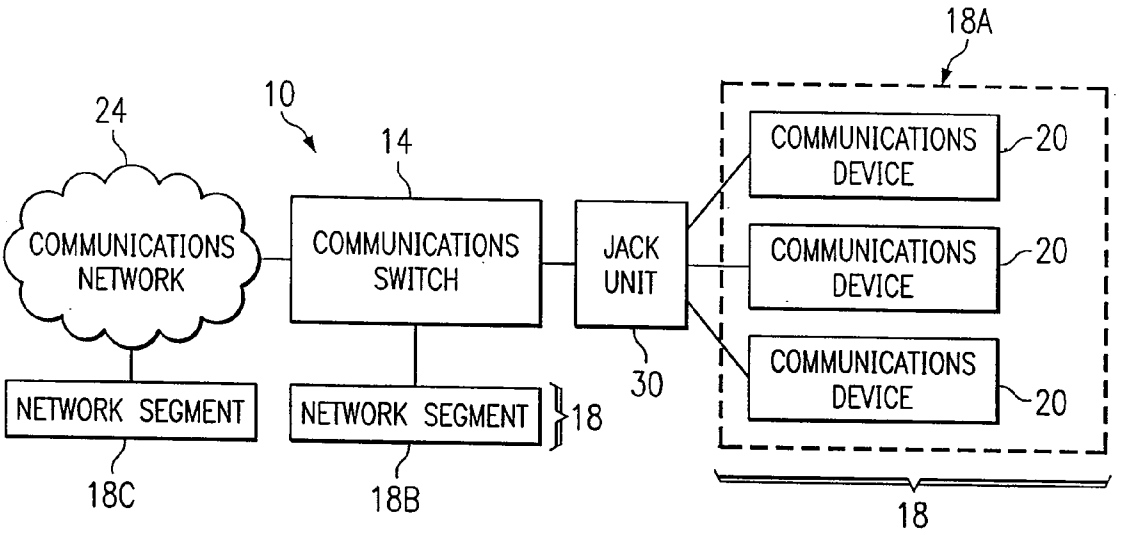
(57) **ABSTRACT**

According to one embodiment of the invention, an integrated jack unit is provided. The integrated jack unit includes a housing. The integrated jack unit also includes a jack positioned at least in part in the housing. The integrated jack unit also includes a power controller positioned in the housing and coupled to the jack by a line. The line is designated for coupling with a transformer. The integrated jack unit also includes a pin protruding outwardly from the housing. The pin is electrically coupled to the jack through the power controller and the line. The pin is positioned to receive power for the jack from a printed circuit board.



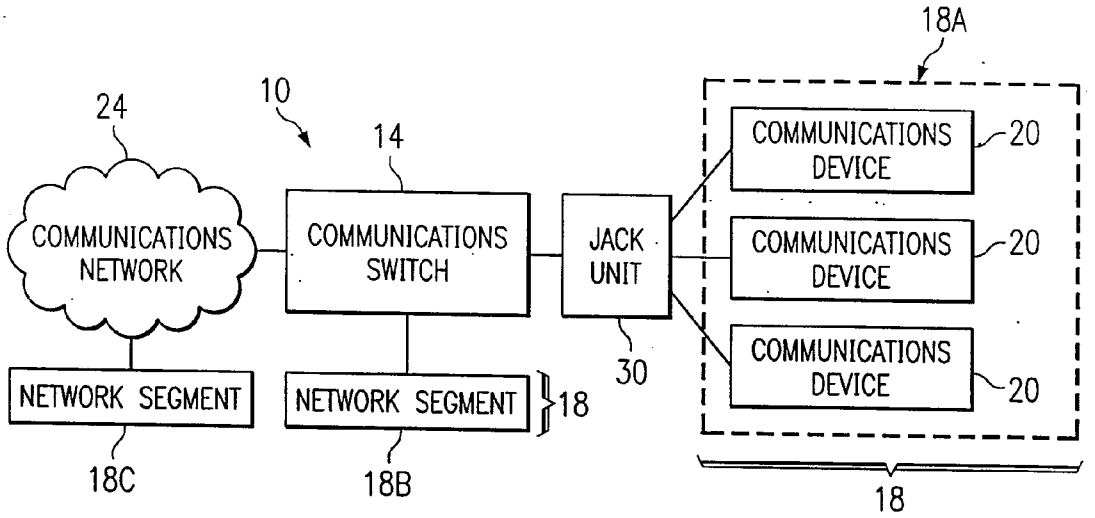

18A
10
24
14
COMMUNICATIONS NETWORK
COMMUNICATIONS SWITCH
JACK UNIT
COMMUNICATIONS DEVICE
20
COMMUNICATIONS DEVICE
20
COMMUNICATIONS DEVICE
20
30
NETWORK SEGMENT
NETWORK SEGMENT
18
18C
18B
18

FIG. 1

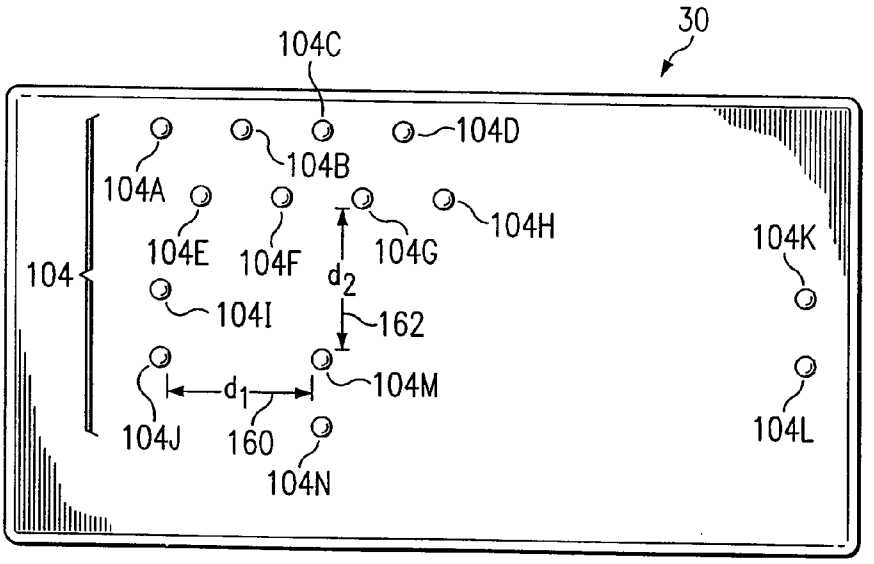

30
104C
104D
104B
104A
104H
104E
104F
104G
104K
104
d_2
104I
162
d_1
104M
104J
160
104N
104L

FIG. 3

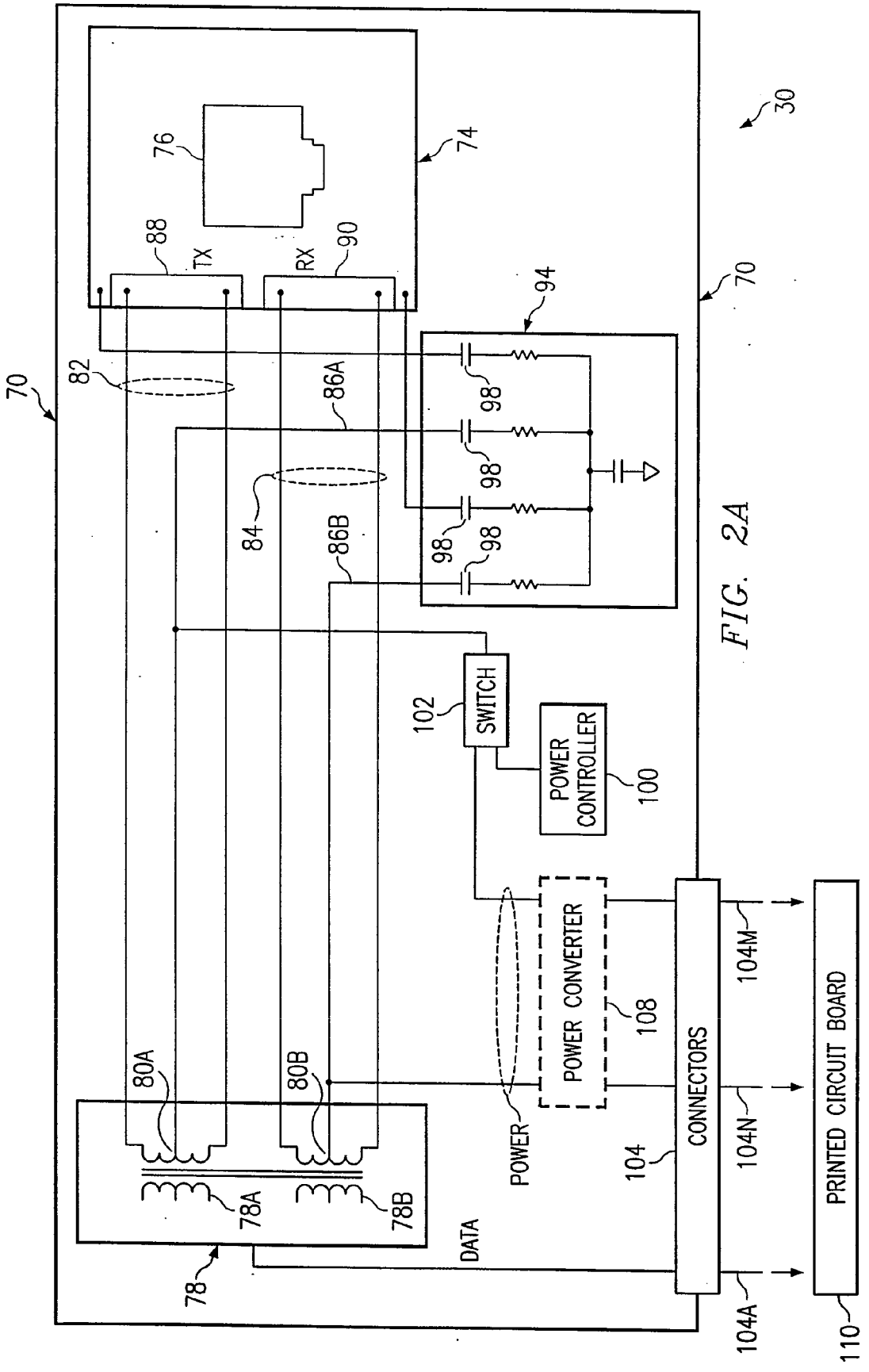

30
70
74
76
88
TX
90
RX
94
98
82
86A
84
86B
102
SWITCH
POWER CONTROLLER
100
POWER CONVERTER
108
POWER
80A
80B
78A
78B
78
DATA
104
CONNECTORS
104M
104N
104A
PRINTED CIRCUIT BOARD
110

FIG. 2A

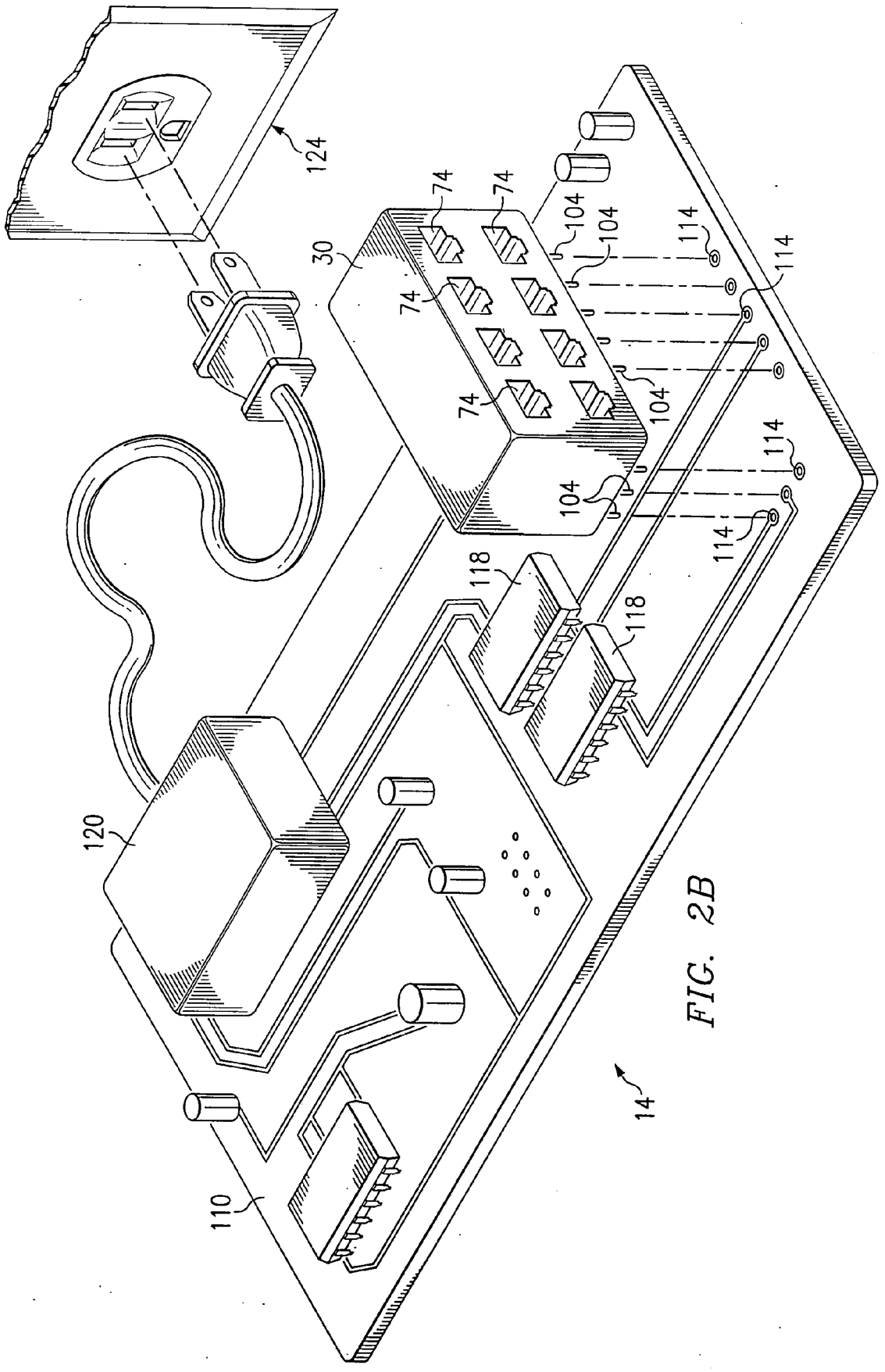
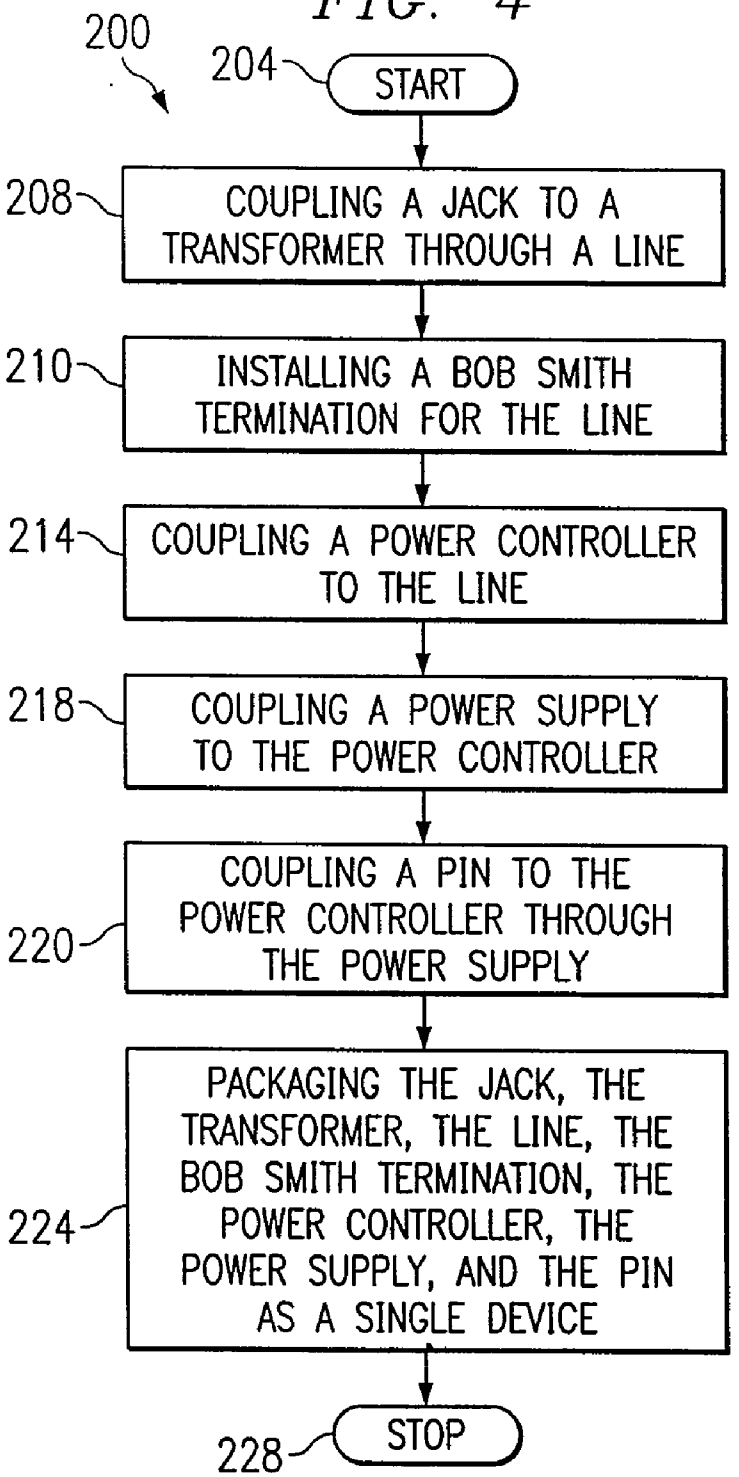

124
74
74
104
104
114
114
30
74
74
104
114
104
104
114
118
118
120
110
14

FIG. 2B

FIG. 4


200
204
START
208
COUPLING A JACK TO A TRANSFORMER THROUGH A LINE
210
INSTALLING A BOB SMITH TERMINATION FOR THE LINE
214
COUPLING A POWER CONTROLLER TO THE LINE
218
COUPLING A POWER SUPPLY TO THE POWER CONTROLLER
220
COUPLING A PIN TO THE POWER CONTROLLER THROUGH THE POWER SUPPLY
224
PACKAGING THE JACK, THE TRANSFORMER, THE LINE, THE BOB SMITH TERMINATION, THE POWER CONTROLLER, THE POWER SUPPLY, AND THE PIN AS A SINGLE DEVICE
228
STOP

INTEGRATED CONNECTOR UNIT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. application Ser. No. 10/326,236 filed Dec. 20, 2002 and entitled "Integrated Connector Unit", now U.S. Pat. No. 7,026,730.

TECHNICAL FIELD OF THE INVENTION

[0002] This invention relates generally to the field of communications and more particularly to an integrated connector unit.

BACKGROUND OF THE INVENTION

[0003] A communications switch, such as an ethernet switch, allows a plurality of communications devices to communicate with one another. To establish a conduit for data between the communications switch and the communications device, a connector may be coupled to the printed circuit board ("PCB") of the communications switch so that the communications device may plug into the connector. A connector is also referred to as a "jack." Where possible, the communication device may also receive power from the jack. Providing power through the jack eliminates the need for the communications device to have a separate power source, such as an AC/DC power source. Power provided through the jack is referred to as "inline power."

[0004] Jacks are sometimes manufactured as a jack unit that includes in its housing one or more jacks and some of the components for carrying data. For example, isolation transformers for the data lines may be included in the housing of a jack unit. The pins of a jack unit may be soldered onto the PCB to electrically couple the data components in the housing of jack unit to the appropriate components of the PCB. Including some of the components for carrying data in the housing saves board space on the PCB. However, positioning the isolation transformers in the housing of the jack unit may not allow inline power to be provided to the communications devices that plug into the jack unit. This is because the jack side of the isolation transformer, which must be accessible to provide inline power, is blocked by the housing of the jack unit. Thus, inline power may not be available where the isolation transformers are included in a jack unit.

SUMMARY OF THE INVENTION

[0005] According to one embodiment of the invention, an integrated jack unit is provided. The integrated jack unit includes a housing. The integrated jack unit also includes a jack positioned at least in part in the housing. The integrated jack unit also includes a power controller positioned in the housing and coupled to the jack by a line. The line is designated for coupling with a transformer. The integrated jack unit also includes a pin protruding outwardly from the housing. The pin is electrically coupled to the jack through the power controller and the line. The pin is positioned to receive power for the jack from a printed circuit board.

[0006] Some embodiments of the invention provide numerous technical advantages. Some embodiments may benefit from some, none, or all of these advantages. For example, according to one embodiment, inline power may be provided through integrated jack units. According to another embodiment, the design of a main printed circuit board is simplified without substantially complicating the design of the jack unit. According to another embodiment, the overall manufacturing process of networking equipment is simplified because jack units having integrated isolation transformers may be used for both Ethernet, non-Ethernet, standard Ethernet, and inline Ethernet applications. According to another embodiment, a same printed circuit board design may be used for both standard and inline powered systems because the inline power circuitry is in the jack unit.

[0007] Other technical advantages may be readily ascertained by one of skill in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Reference is now made to the following description taken in conjunction with the accompanying drawings, wherein like reference numbers represent like parts, in which:

[0009] **FIG. 1** is a schematic diagram illustrating one embodiment of a communications system that may benefit from the teachings of the present invention;

[0010] **FIG. 2A** is a schematic diagram illustrating one embodiment of an integrated jack unit of **FIG. 1**;

[0011] **FIG. 2B** is a perspective view of one embodiment of the integrated jack unit of **FIG. 2A**;

[0012] **FIG. 3** is a bottom view of one embodiment of the integrated jack unit of **FIG. 2B**; and

[0013] **FIG. 4** is a flow chart illustrating one embodiment of a method of providing inline power through one embodiment of the integrated jack unit of **FIG. 2A**.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

[0014] Embodiments of the invention are best understood by referring to **FIGS. 1 through 4** of the drawings, like numerals being used for like and corresponding parts of the various drawings.

[0015] **FIG. 1** is a schematic diagram illustrating one embodiment of a communications system **10** that may benefit from the teachings of the present invention. System **10** comprises network segments **18**A through **18**C that are coupled to each other over a communications network **24** and/or a communications switch **14**. Network segments **18**A through **18**C are jointly referred to as network segments **18**. As shown in **FIG. 1**, network segment **18**A is coupled to network segment **18**B over communications switch **14**. Network segment **18**C is coupled to network segments **18**A and **18**B over communications network **24** and communications switch **14**. More or less network segments **18** may be coupled to each other over communications network **24** and communications switch **14**.

[0016] Network segments **18**A through **18**C each comprises one or more communications devices **20**. A jack unit **30** is coupled to communications switch **14** to provide one or more ports (not explicitly shown) that may be used to physically connect communications devices **20**. For example, a cable having plugs may be used to plug in communications devices **20** to jack unit **30**. In some embodi-

ments, switch **14** and network segments **18** may be devices that are capable of operating according to the ethernet network standard.

[**0017**] Communications switch **14** may be operable to send and receive packets to and from communications devices **20** according to the addresses of the packets. Upon receiving one or more packets from device **20**, switch **14** sends the received packets to a particular communications device **20** that is identified by the included address. Switch **14** may send and receive the packets over network **24**, jack unit **30**, or any other suitable conduit or a combination of conduits that couples switch **14** to communications devices **20**. In some examples, a hub, a router, or any other suitable device may be used instead of switch **14**. Communications device **20** may be any communications device that is operable to communicate with other communications devices over a network architecture. Examples of communications device **20** include a Voice over Internet Protocol ("VoIP") phone and a computer.

[**0018**] Jack unit **30** may comprise one or more RJ-45 jacks; however, jack unit **30** may comprise other types of jacks. Where jack unit **30** comprises RJ-45 jacks, communications devices **20** may plug into jack unit **30** using cables having plugs that are adaptable to a RJ-45 jack. Jack unit **30** may also comprise one or more isolation transformers within its housing. A jack unit having isolation transformers within its housing is referred to as a "mag jack." Thus, jack unit **30** may also be referred to as mag jack **30**. An isolation transformer is a transformer that is operable to protect the components of switch **14**, such as integrated circuit chips, against excessive common mode voltages from communications devices **20** and/or cables attaching devices **20** to switch **14**. Mag jack **30** generally includes outwardly disposed pins that may be soldered onto the appropriate apertures of a printed circuit board of communications switch **14**, thereby electrically coupling the components of mag jack **30** to the components of communications switch **14**. The use of mag jack **30** saves space on the main printed circuit board ("PCB") of switch **14** because the isolation transformers are in mag jack **30** rather than on the PCB.

[**0019**] To send and receive packets from switch **14**, communications device **20** may establish a physical connection with switch **14**. To that end, communications device **20** may plug into mag jack **30**. Along with a physical connection to switch **14**, communications device **20** may also require access to power in order to send and receive packets to and from switch **14**. Power may be provided to communications device **20** in a variety of ways. For example, alternating current ("AC") power may be provided to communications device **20** by plugging communications device **20** into a wall socket. In another example, communications device **20** may receive direct current ("DC") power from a battery pack. Power may also be provided inline, which refers to transmitting power from switch **14** to communications device **20** over a jack unit and the physical cable that plugs into the jack unit. One advantage of providing inline power to communications device **20** is that it eliminates the need to provide a separate power source for device **20** at the physical location of device **20**. Providing inline power also simplifies the design and configuration of communications device **20**.

[**0020**] However, inline power is conventionally not provided for communications devices **20** plugged into a mag jack because the housing of the mag jack that integrates the isolation transformers to the jack unit also prevents a designer from injecting power into the side of the transformer that is electrically coupled to a jack of the mag jack. If inline power is not provided to the jack-side of the isolation transformer, then DC power is required to travel across the isolation transformer to reach the jack and thus is blocked by the isolation transformer. Also, AC line power may not pass readily across the isolation transformer. In some situations, it may be difficult for a designer to simply add a pin to a mag jack to access the jack side of the isolation transformer **30** for power injection because the proximity of the pins may cause an arcing of the power current. Thus, conventionally, the benefits of inline power are not available for a mag jack.

[**0021**] According to some embodiments of the present invention, an apparatus and method are provided that allow inline power to be provided for a mag jack by positioning a power controller within the mag jack. Additional details of example embodiments of the invention are described in greater detail below in conjunction with portions of **FIG. 1** and **FIGS. 2A through 4**.

[**0022**] Referring back to **FIG. 1**, in one embodiment of the invention, a power controller that controls inline power is positioned in mag jack **30** along with one or more isolation transformers. In another embodiment, a power converter that supplies the inline power is also positioned in mag jack **30**. Because the power controller is in the housing of mag jack **30**, inline power may be injected into the jack side of the isolation transformer to provide inline power for the jacks of mag jack **30**. A mag jack having a power controller in its housing is referred to as an "integrated inline power mag jack" or an "power mag jack." As such, mag jack **30** is referred to from hereinafter as power mag jack **30**.

[**0023**] **FIG. 2A** is a schematic diagram illustrating one embodiment of power mag jack **30** of **FIG. 1**, and **FIG. 2B** is a perspective view of one embodiment of power mag jack **30** of **FIG. 2A**. **FIGS. 2A and 2B** are described jointly. Power mag jack **30** comprises a housing **70** (shown on **FIG. 2B** as well). Housing **70** defines power mag jack **30** as a separate component separate from a PCB **110**. As shown in **FIG. 2B**, power mag jack **30** is a device that is separate from PCB **110** that may be added or removed from PCB **110** as a single component of PCB **110**. PCB **110** is also referred to as motherboard **110**. Referring back to **FIG. 2A**, a jack **74** defining a receiving cavity **76** is positioned at least in part in housing **70**. In one embodiment, an isolation transformer set **78** having at least two transformers **78**A and **78**B is positioned within housing **70** and coupled to jack **74** through lines **82** and **84**. Because lines **82** and **84** couple isolation transformer set **78** to jack **74**, lines **82** and **84** are also referred to as "jack side" lines **82** and **84**. In some embodiments, more than one jack **74** may be included in power mag jack **30**. In such embodiments, the number of components that support jack **74**, such as the number of transformers **78**A and **78**B in isolation transformer set **78**, may be increased to support the additional jacks **74**. However, regardless of the number of jacks **74** in power mag jack **30**, all of jacks **74** and their supporting components are packaged as a single component within housing **70**.

[**0024**] In one embodiment, lines **82** couple transformer **78**A to a data transmission portion **88** of jack **74**. Data

transmission portion **88** is used for outgoing packets. Lines **84** couple transformer **78**B to a data receive portion **90** of jack **74**. Data receive portion **90** is used for incoming packets. In one embodiment, lines **86**A and **86**B are coupled to respective center taps **80**A and **80**B of transformers **78**A and **78**B. Lines **86**A and **86**B are operable to carry inline power for jack **74** without going through transformer set **78** so that inline power may be available for communications devices **20**, which may be plugged into jack **74**. In one embodiment, lines **86**A and **86**B are terminated by a termination **94** prior to reaching jack **74**. A termination **94** is a load that is positioned within housing **70** and used to minimize common node noise. In one embodiment, termination **94** may comprise one or more DC blocking capacitors **98**. In one embodiment, three or fewer DC blocking capacitors **98** may be used. In some embodiments, a BOB SMITH termination may be used as termination **94**; however, any other suitable termination may be used as termination **94**.

[**0025**] According to the teachings of the invention, a power controller **100** is positioned in housing **70** of power mag jack **30** to provide inline power. In one embodiment, power controller **100** is coupled to center tap **80**A through a power switch **102** and line **86**A; however, in some embodiments, power controller **100** may be coupled to center tap **80**B through power switch **102** and line **86**B. Positioning power controller **100** in housing **70** of power mag jack **30** rather than on motherboard **110** of switch **14** (shown in **FIG. 1**) is advantageous in some embodiments of the invention for the following reason. Because power controller **100** is inside of housing **70**, power controller **100** is not physically prevented by housing **70** from physically coupling to one or more of jack side lines **86**A or **86**B. With physical access to jack side lines **86**A and **86**B, power controller **100** may provide inline power to jack **74**. Thus, manufacturing power controller **100** as a part of power mag jack **30** allows a designer to benefit from the advantages of integrating isolation transformers into a jack unit and the advantages of providing inline power to communications device **20**. In some embodiments, isolation transformer set **78** may not be included in housing **70**. Power controller **100** may be positioned within housing **70** that does not include isolation transformer set **78**. This is advantageous in some embodiments because, regardless of the type of jack unit, a printed circuit board receiving the jack unit may be manufactured using a same design because the circuitry for controlling inline power, if any, would be in the jack unit and not on the printed circuit board.

[**0026**] Power mag jack **30** may be coupled to PCB **110** by soldering connectors **104** to their corresponding apertures **114** (shown in **FIG. 2B**) of PCB **110**. Connectors **104** are also referred to herein as pins **104**. A "pin" refers to any type of connector, such as an edge connector or a mating connector. By coupling pins **104** to their corresponding apertures **114**, the various devices of power mag jack **30** are electrically coupled to the appropriate components of PCB **110**. For example, as shown in **FIG. 2B**, pin **104**A may be inserted into a particular aperture **114** that is connected to one or more physical devices **118**. Because pin **104**A is also coupled to isolation transformer set **78**, pin **104**A may be used as a data pin that carries data between physical devices **118** of PCB **110** and isolation transformer set **78**. In one embodiment, physical device **118** is an ethernet physical layer transceiver **118**. Physical device **118** may be operable to perform a variety of functions associated with communication depending on the network standard being used. For example, if physical device **118** were an ethernet physical device **118**, ethernet physical device **118** may perform some or all of the layer one functions, such as packeting TCP/IP packets received from communications device **20** over isolation transformer set **78** into ethernet packets. PCB **110** may also include a power converter **120** that may be coupled to a power source **124**. In one embodiment, pins **104**M and **104**N that are coupled to switch **102** and center tap **80**B, respectively, may be inserted into particular apertures **114** that are connected to power converter **120** of PCB **110**.

[**0027**] In one embodiment, a power converter **108** may also be positioned in power mag jack **30**. This is advantageous in some embodiments because of the resulting savings in board space on motherboard **110**. Although **FIG. 2A** shows power converter **108** positioned in housing **70**, power converter **108** may also be position outside of housing **70** and on motherboard **110** as a separate component. In such embodiments, DC power having 48 volts may be received from an outside power converter **108** through one or more of pins **104**, such as pins **104**M and **104**N. In one embodiment, when power mag jack **30** is coupled to motherboard **110**, pin **104**M may be used to receive power and carry that power to power switch **102** controlled by power controller **100** or directly to power controller **100**. In one embodiment, power switch **102** is a simple on/off switch; however, a variable resistance element may be used as power switch **102**. In one embodiment, power converter **108** is operable to receive AC power and provide DC power for power switch **102**. In one embodiment, power converter **108** is operable to provide DC power having a level of 48 volts. In one embodiment, some pins **104** may be used to couple different devices in power mag jack **30** to other appropriate portions of motherboard **110**. In one embodiment, power may be provided to ethernet unused pairs (not explicitly shown) . Such an embodiment does not require isolation transformers.

[**0028**] **FIG. 3** is a bottom view of portions of the power mag jack **30** illustrated in **FIGS. 2A and 2B**, showing the placement of pins **104**. As shown in **FIG. 3**, one embodiment of power mag jack **30** comprises pins **104**A through **104**N (jointly referred to as pins **104**) that are protruding outwardly from housing **70** of power mag jack **30**. In one embodiment, power mag jack **30** may comprise more pins **104** than conventional jack units because inline power is provided to power mag jack **30**. In some embodiments where an ethernet standard is used, pins **104** may serve the following functions: Pin **104**A carries an ethernet TX negative pulse. Pin **104**B carries an ethernet center tap TX bias. Pin **104**C carries an ethernet TX positive pulse. Pins **104**D and **104**E are no connect pins. In some embodiments, pins **104**D and **104**E may be omitted. Pin **104**F carries an ethernet RX center tap bias. Pin **104**G carries an ethernet RX negative pulse. Pin **104**H carries an ethernet RX positive pulse. The extra pins **104** for providing inline power are pins **104**I through **104**N, in one embodiment. Pin **104**I carries serial clock input signals. Pin **104**J carries serial data input signals. Pin **104**K carries serial clock output signals. Pin **104**L carries serial data output signals. Pin **104**M is for ethernet power main. Pin **104**N is for ethernet power return. Although a particular arrangement of pins **104** is shown in **FIG. 3**, other arrangements of pin **104** are possible in other embodiments. Further, more or less pins **104** may be used for power mag jack **30** depending on the design specifications. In one embodiment, distances d_1 and d_2 referred to by

reference numbers **160** and **162**, respectively, may be sufficiently wide to lower the probability of arcing between pins **104**A through **104**L and power pins **104**M through **104**N. In one embodiment, power converter **108** may comprise an isolation barrier (not explicitly shown) to reduce the distances referred to by reference numbers **160** and **162**. Examples of an isolation barrier include a transformer, a capacitor, and an optocoupler.

[**0029**] **FIG. 4** is a flow chart illustrating one embodiment of a method **200** for providing inline power through one embodiment of power mag jack **30**. Method **200** starts at step **204**. At step **208**, jack **74** is coupled to isolation transformer set **78** through a line, such as line **86**A or **86**A. At step **210**, a termination **94** is installed for the line. In some embodiments, step **210** may be omitted. In some embodiments, a BOB SMITH termination may be used as termination **94**; however, any other suitable termination may be used as termination **94**. At step **214**, power controller **100** is coupled to the line. Coupling power controller **100** to the line allows power to be injected into center taps **80** that are positioned on the jack-side of isolation transformer set **78**. At step **218**, power converter **108** is coupled to power controller **100**. In one embodiment, step **218** may be omitted. At step **220**, connector **104**, such as pins **104**, may be coupled to power controller **100**. In an embodiment where power converter **108** is included in power mag jack **30**, pin **104** is coupled to power controller **100** through power converter **108**. At step **224**, jack **74**, isolation transformer set **78**, the line, such as line **86**A or **86**B, BOB SMITH termination **94**, power controller **100**, power converter **108**, and pins **104** are packaged using housing **70** as a single component **30** that may be coupled to PCB **110**. In some embodiments, BOB SMITH termination **94** or power converter **108** may be omitted from being packaged in housing **70** at step **224**. Method **200** stops at step **228**.

[**0030**] Although some embodiments of the present invention have been described in detail, it should be understood that various changes, substitutions, and alterations can be made hereto without departing from the spirit and scope of the invention as defined by the appended claims.

1. (canceled)
2. (canceled)
3. (canceled)
4. (canceled)
5. (canceled)
6. (canceled)
7. (canceled)
8. (canceled)
9. (canceled)
10. (canceled)
11. (canceled)
12. (canceled)
13. (canceled)
14. (canceled)
15. (canceled)
16. (canceled)
17. (canceled)
18. (canceled)
19. (canceled)
20. (canceled)
21. (canceled)
22. (canceled)
23. (canceled)
24. (canceled)
25. (canceled)
26. (canceled)
27. (canceled)
28. (canceled)
29. (canceled)
30. (canceled)
31. An integrated jack unit, comprising:

a housing;

a jack positioned at least in part in the housing;

a power controller positioned in the housing and coupled to the jack by a line; and

a pin protruding outwardly from the housing, the pin electrically coupled to the jack through the power controller and the line.

32. The integrated jack unit of claim 31, and further comprising a termination having one or more direct current blocking capacitors, the termination positioned in the housing and coupled to the line.

33. The integrated jack unit of claim 31, and further comprising a power converter positioned in the housing, the power converter coupled to the pin and the power controller.

34. The integrated jack unit of claim 31, and further comprising a power converter positioned in the housing, the power converter coupled to the pin and the power controller, wherein the power converter is operable to receive power through the pin and in response provide electricity having a level of 48 volts to the power controller.

35. The integrated jack unit of claim 31, and further comprising a power converter positioned in the housing, the power converter coupled to the pin and the power controller, wherein the power converter is operable to receive alternating current through the pin and in response provide direct current.

36. The integrated jack unit of claim 31, and further comprising a power converter positioned in the housing, the power converter coupled to the pin and the power controller, wherein the power converter is operable to receive alternating current through the pin and in response provide direct current having a level of 48 volts.

37. The integrated jack unit of claim 31, wherein the jack is a RJ-45 jack.

38. An integrated RJ jack unit, comprising:

a housing means;

an isolation means;

means for receiving an RJ plug positioned at least in part in the housing means and coupled to the isolation means;

means for controlling power coupled to the line and located in the housing means; and

a conductive means for receiving power, the conductive means protruding outwardly from the housing means and electrically coupled to the means for receiving the RJ plug by the means for controlling power and the line.

39. The integrated RJ jack unit of claim 38, and further comprising means for supplying power coupled to the conductive means and the means for controlling power, the means for supplying power positioned in the housing means.

40. The integrated RJ jack unit of claim 38, wherein the predetermined level is 1.5 kilovolts.

41. A method for providing inline power using an integrated jack unit, comprising:

coupling a jack to at least one transformer;

coupling a power controller to the line;

coupling a pin to the power controller; and

packaging the jack, the transformer, the line, and the power controller in a housing.

42. The method of claim 41, and further comprising positioning a termination in the housing and coupling the termination to the line.

43. The method of claim 41, and further comprising:

providing a termination having one or more direct current blocking capacitors;

positioning the termination in the housing; and

coupling the termination to the line.

44. The method of claim 41, and further comprising positioning a power converter in the housing and coupling the power converter to the pin and the power controller.

45. The method of claim 41, and further comprising:

positioning a power converter in the housing;

coupling the power converter to the pin and the power controller;

using the power converter, receiving alternating current; and

using the power converter, converting the alternating current to direct current.

46. The method of claim 41, wherein the jack is a RJ-45 jack.

47. The method of claim 42, wherein the termination is a BOB SMITH termination.

48. The method of claim 44, and further comprising coupling a isolation barrier to the power converter.

49. The method of claim 41, and further comprising receiving, at the pin, a direct current from a printed circuit board.

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