US009271431B2

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

(10) **Patent No.: US 9,271,431 B2**
(45) **Date of Patent: Feb. 23, 2016**

(54) **ELECTRONIC DEVICE HAVING CONNECTOR WITH INTEGRATED SHIELDING**

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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 202 days.

(21) Appl. No.: **13/899,971**

(22) Filed: **May 22, 2013**

(65) **Prior Publication Data**

US 2014/0268598 A1 Sep. 18, 2014

Related U.S. Application Data

(60) Provisional application No. 61/794,844, filed on Mar. 15, 2013.

(51) **Int. Cl.**

H01R 12/00	(2006.01)
H05K 9/00	(2006.01)
H01R 13/6594	(2011.01)
H01R 24/50	(2011.01)
H01R 12/72	(2011.01)

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

CPC ***H05K 9/0024*** (2013.01); ***H01R 13/6594*** (2013.01); ***H01R 24/50*** (2013.01); *H01R 12/724* (2013.01)

(58) **Field of Classification Search**

USPC 439/581, 583, 63, 607.13, 810

IPC H01R 2103/00,24/50, 9/0515, 23/7073, H01R 23/6873, 13/65802

See application file for complete search history.

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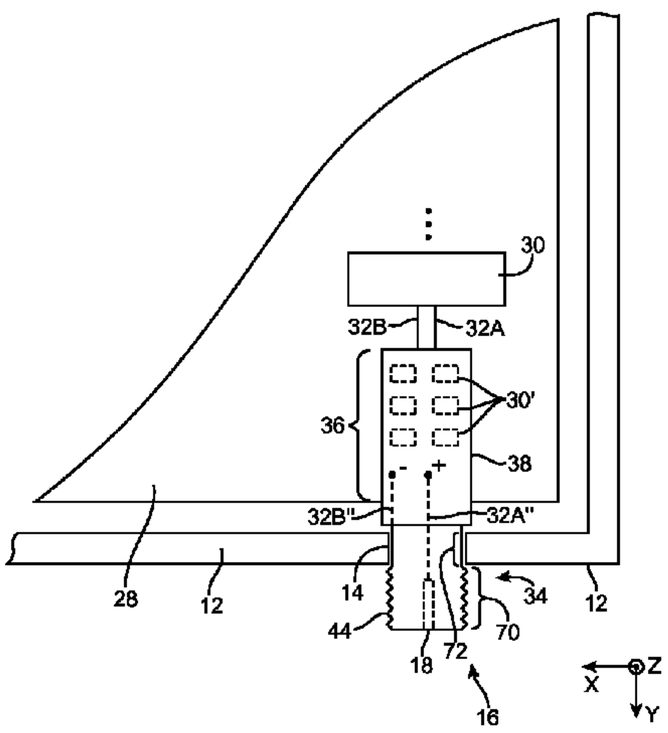
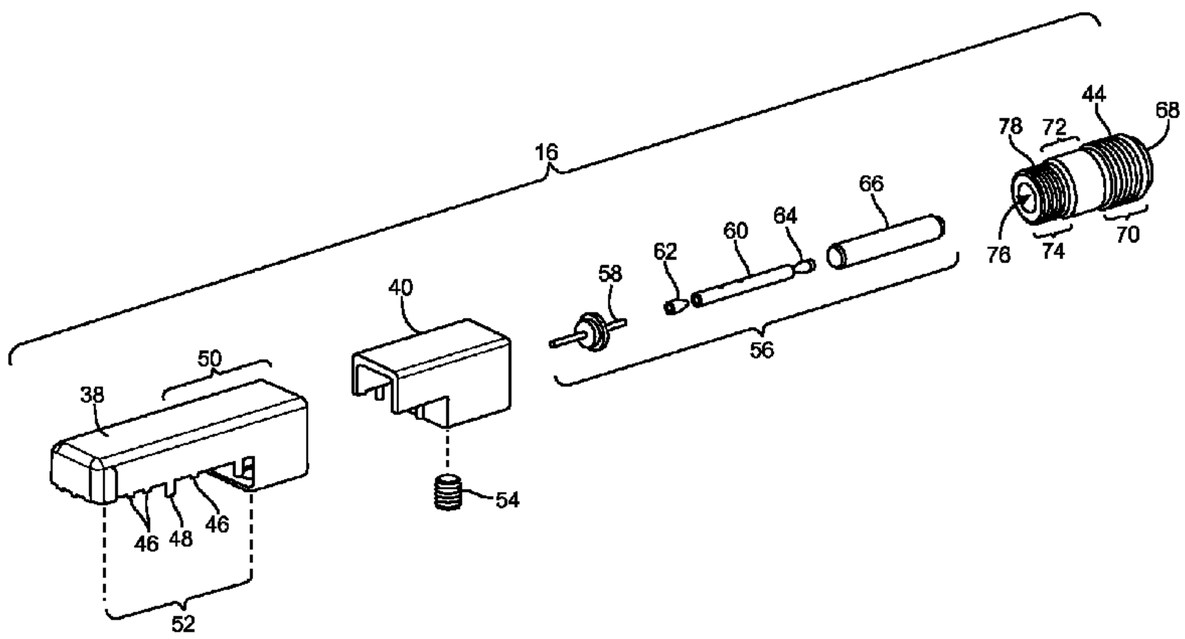
(57) **ABSTRACT**

An electronic device may have a housing in which electrical components on a printed circuit board are mounted. A connector may be mounted to the edge of the printed circuit board using solder. The connector may have a threaded portion that protrudes through the housing. A threadless portion of the connector may be aligned with the housing. The connector may have a metal body member covered with a metal shell. The metal shell may have a portion that covers the electrical components and serves as an electromagnetic interference shield for the electrical components. The connector may have a threaded barrel. The threaded barrel may have a threaded outer portion with a diameter that is larger than a threaded inner portion. The threadless portion of the connector may lie between the threaded outer and inner portions.

16 Claims, 11 Drawing Sheets





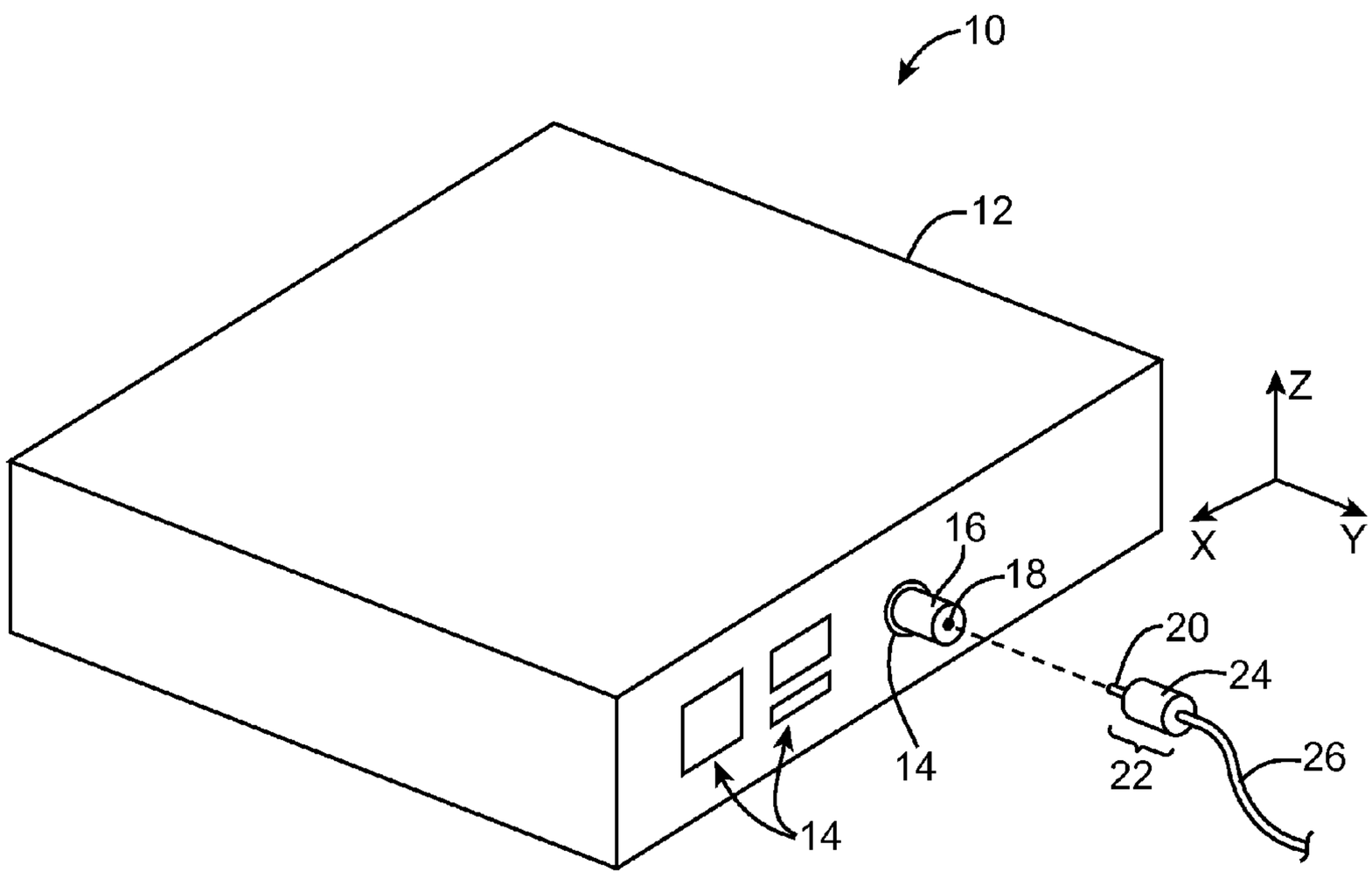


FIG. 1

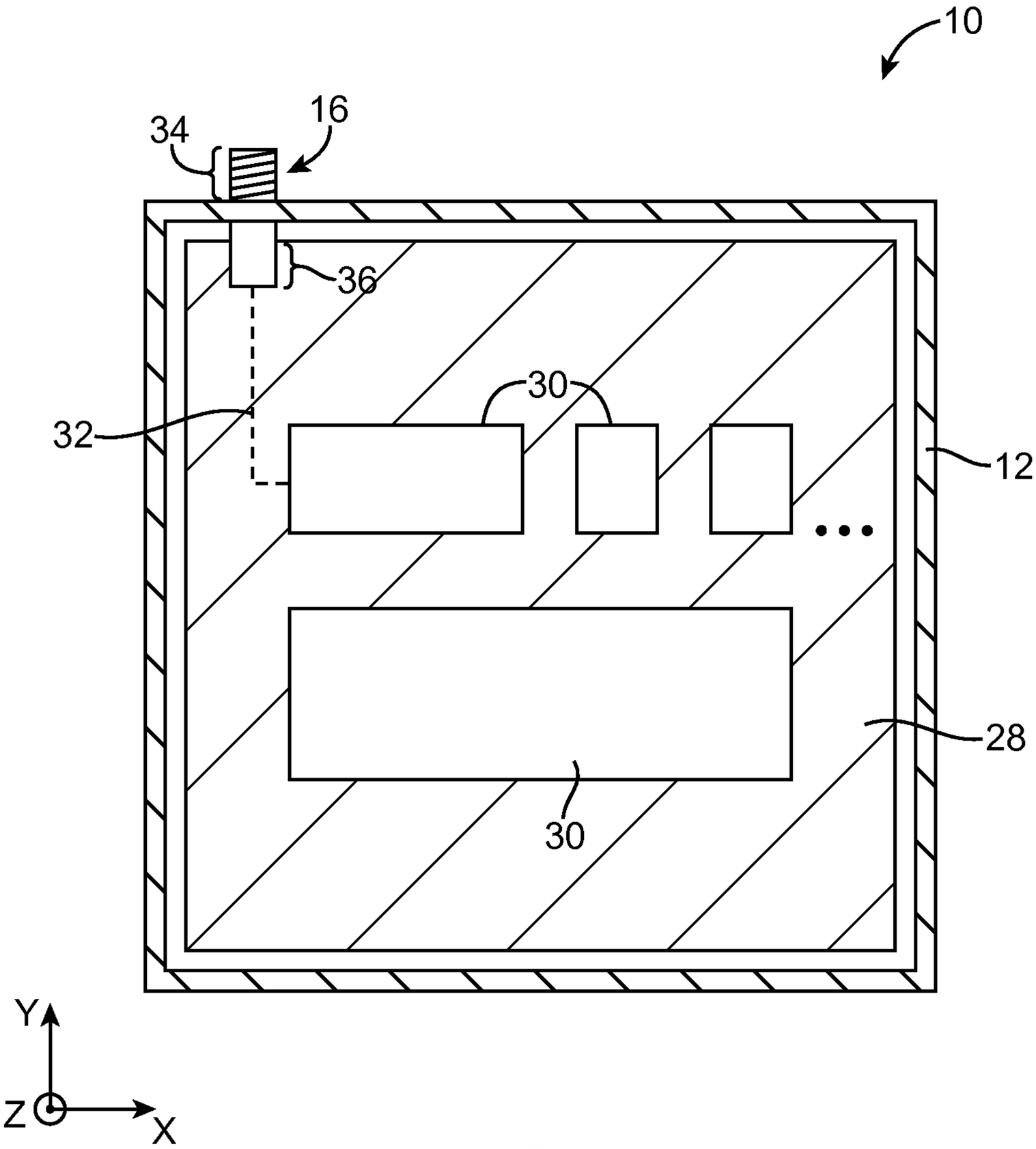


FIG. 2

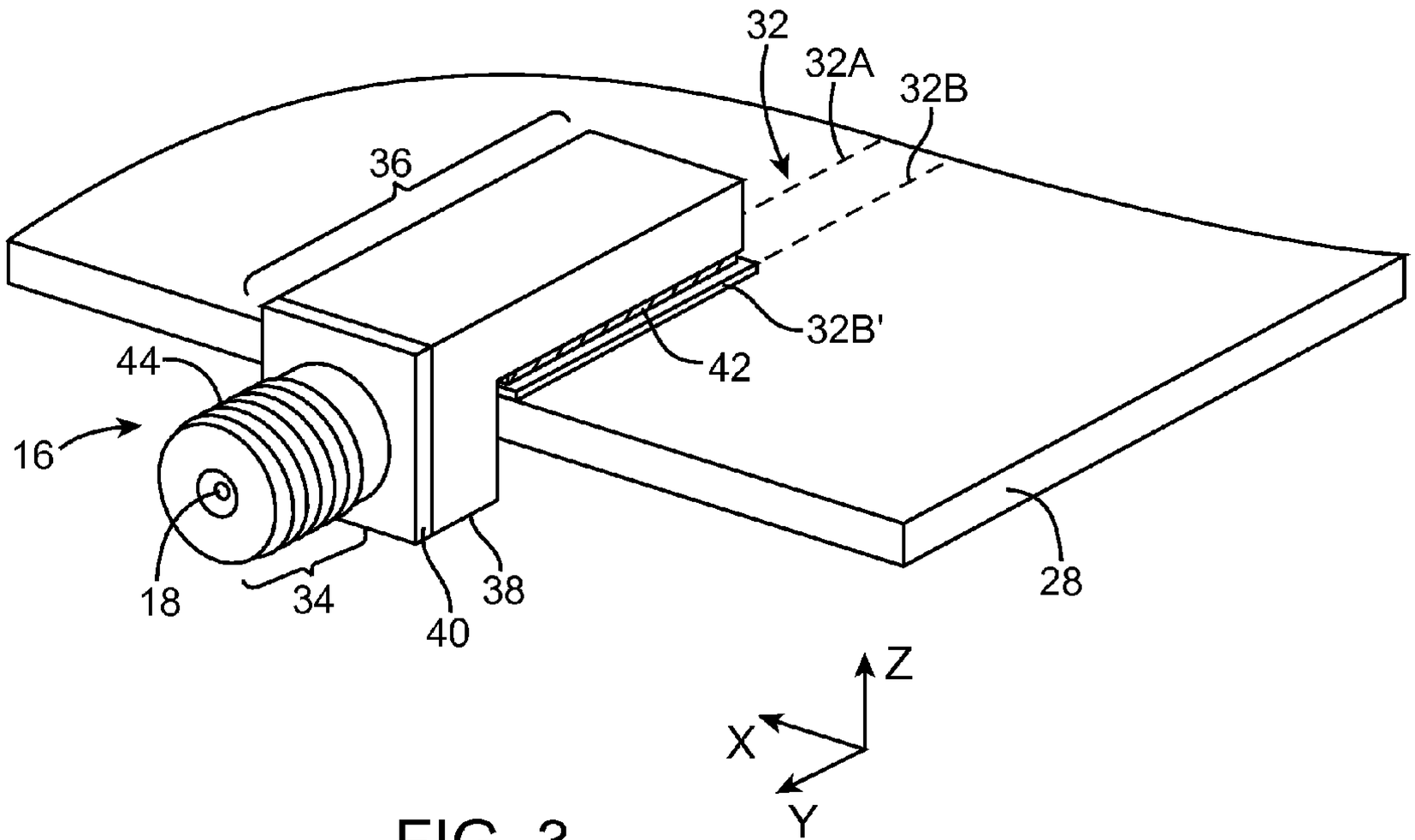


FIG. 3

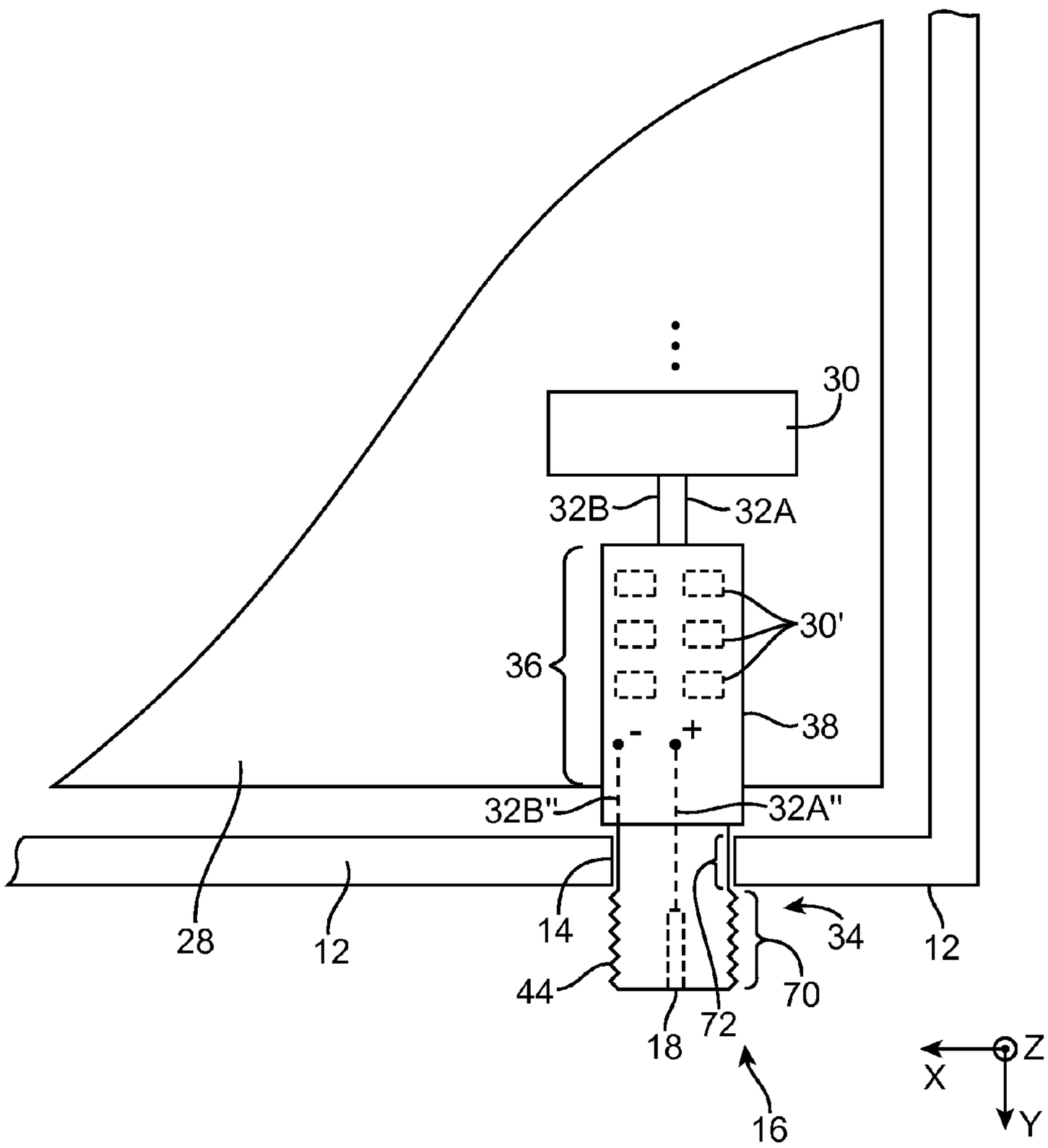


FIG. 4

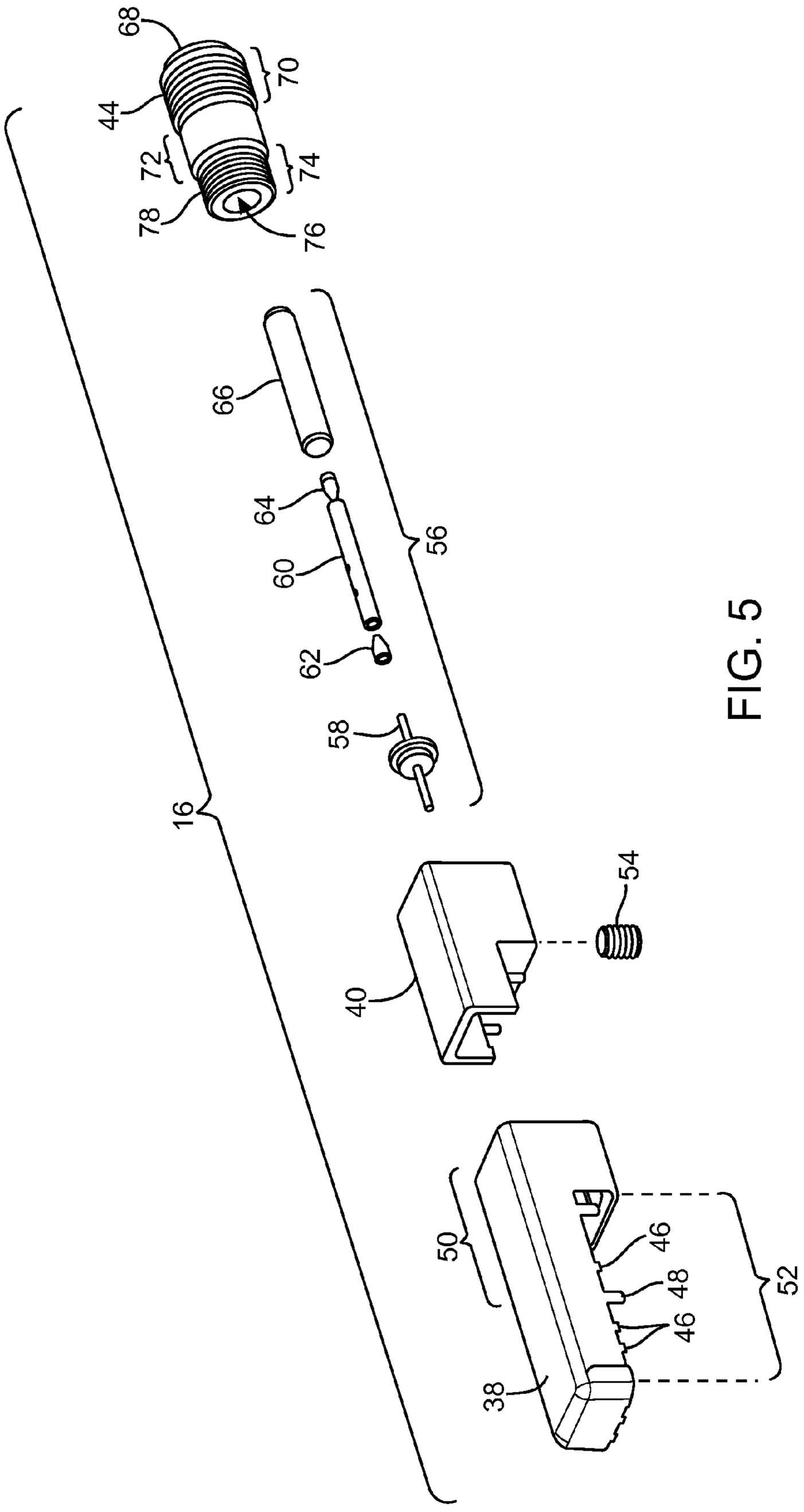


FIG. 5

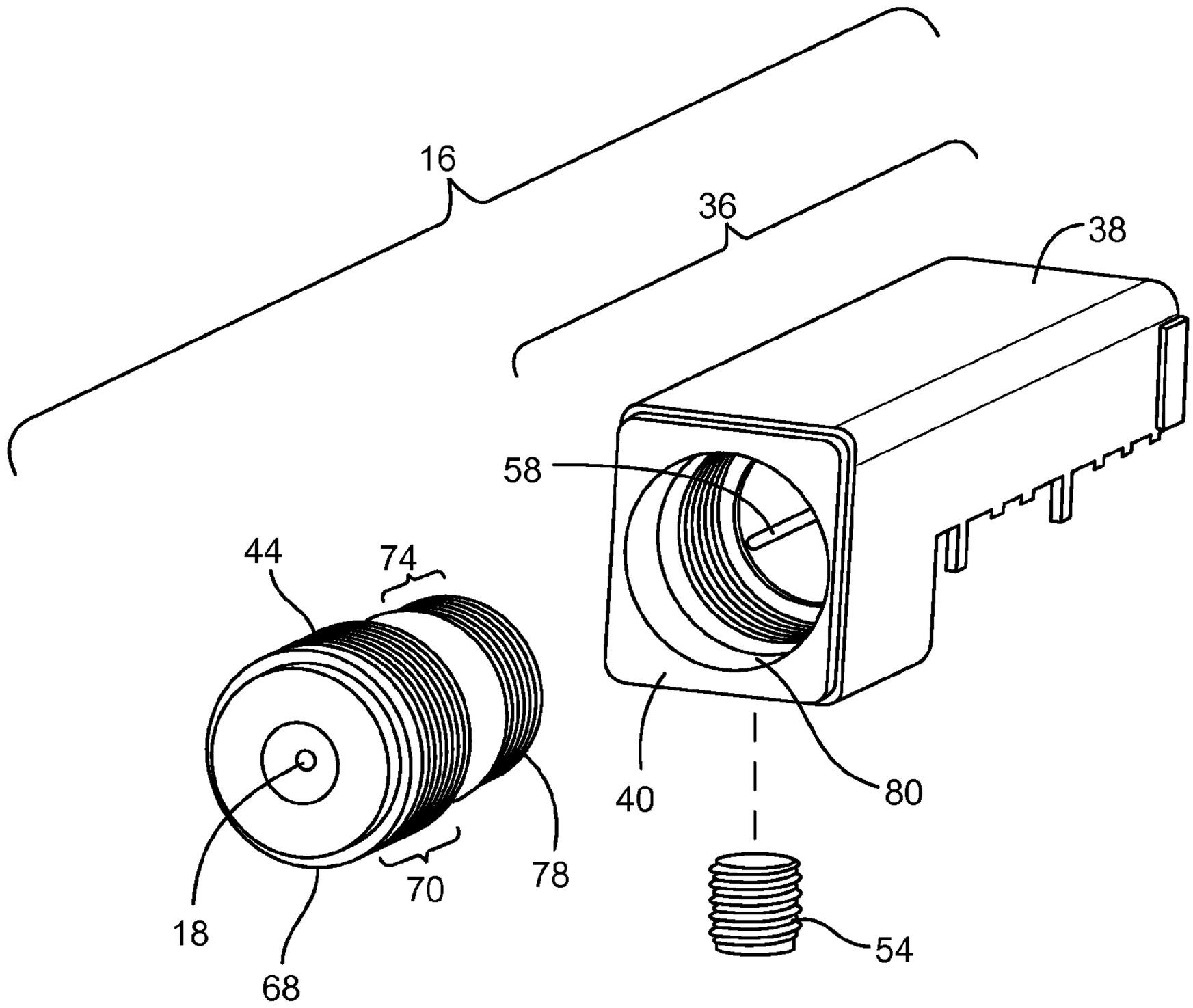


FIG. 6

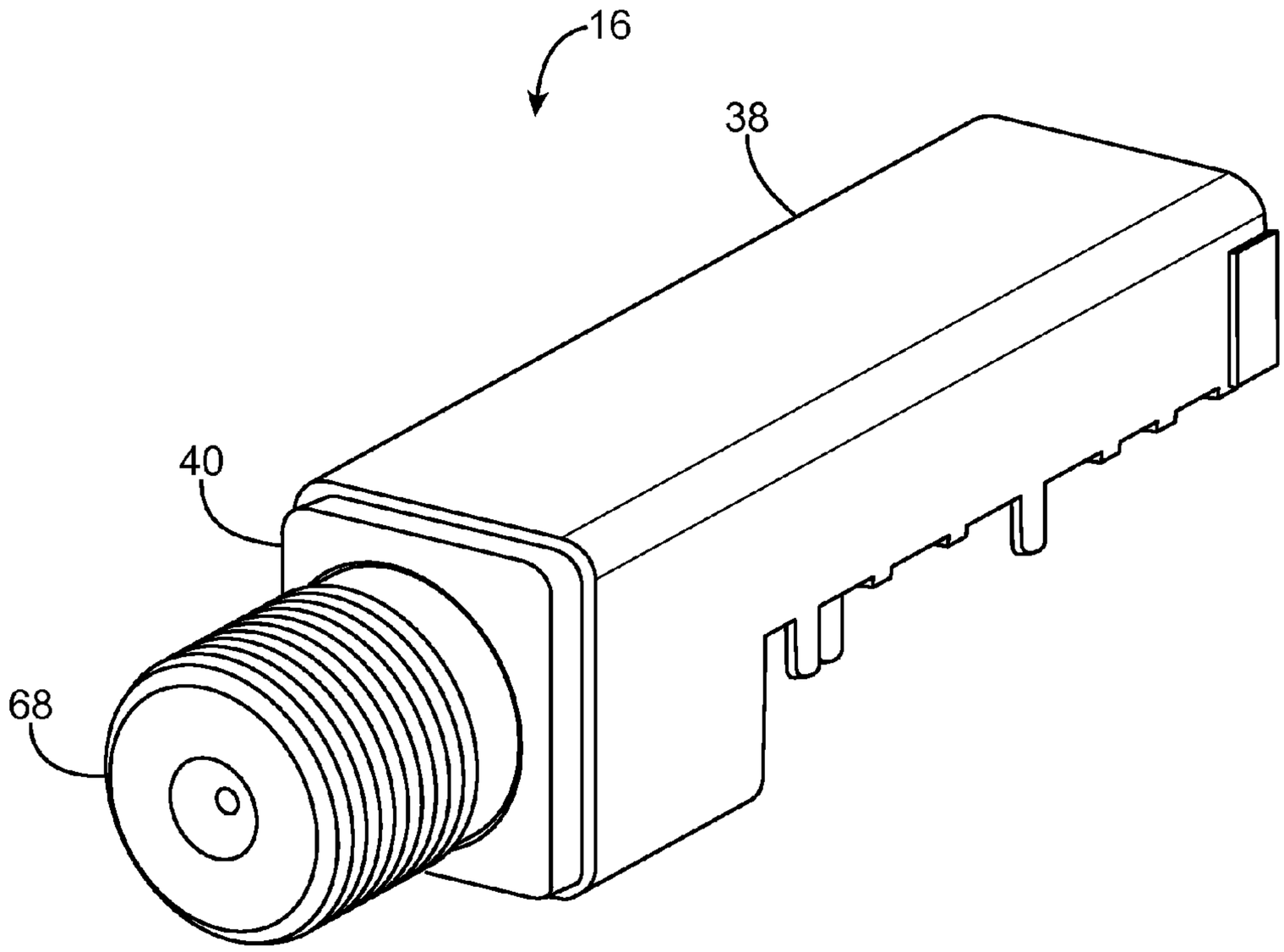


FIG. 7

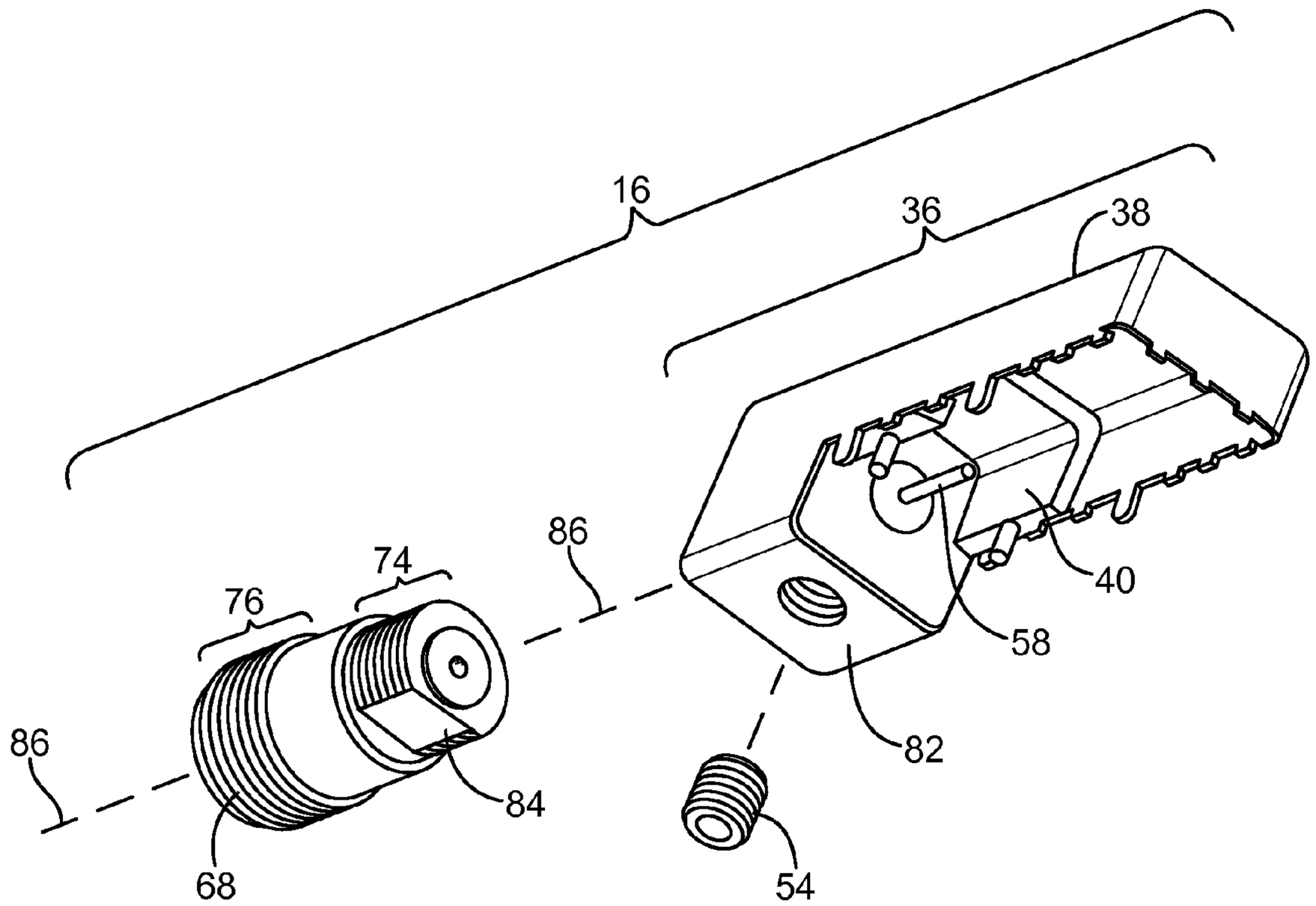


FIG. 8

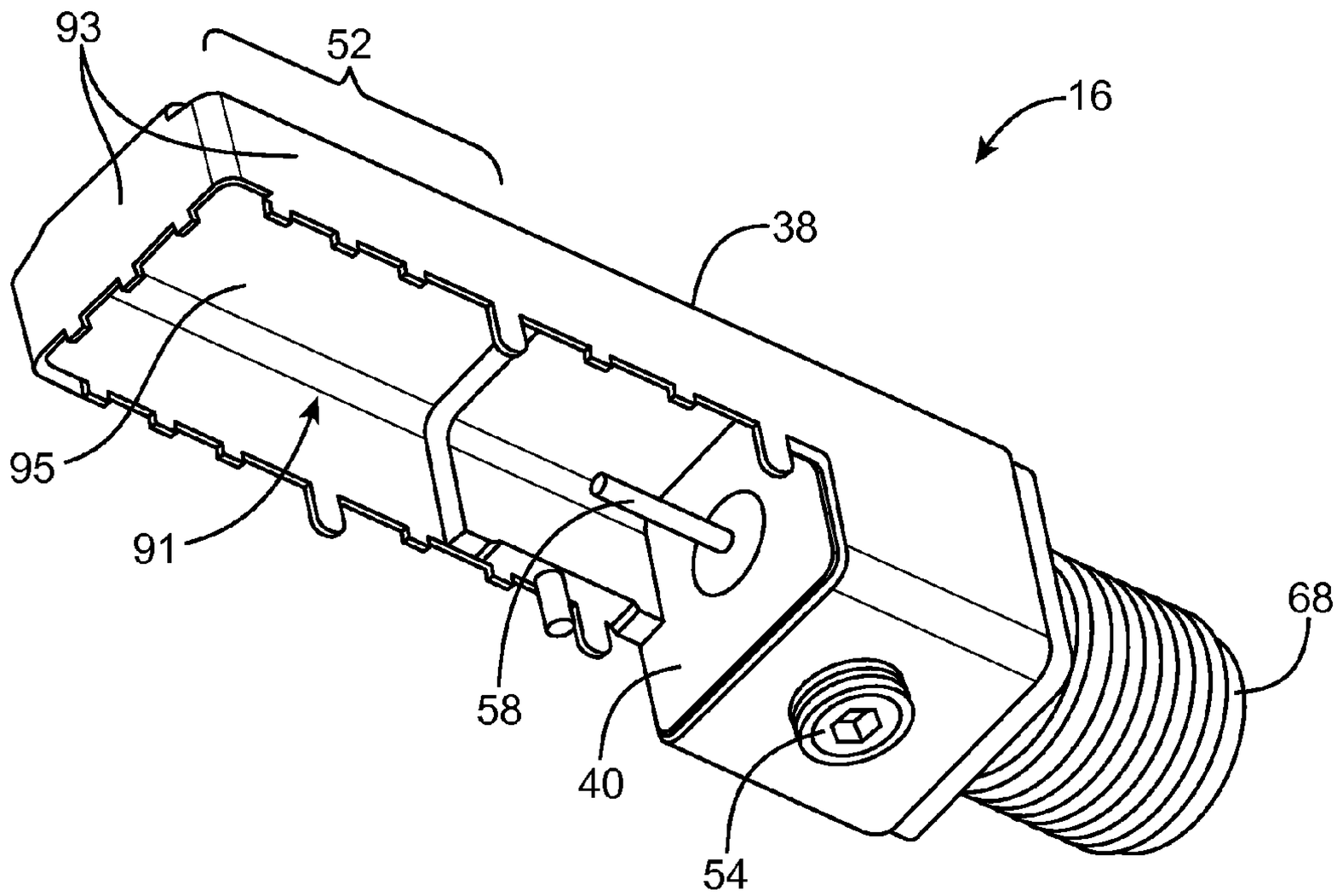


FIG. 9

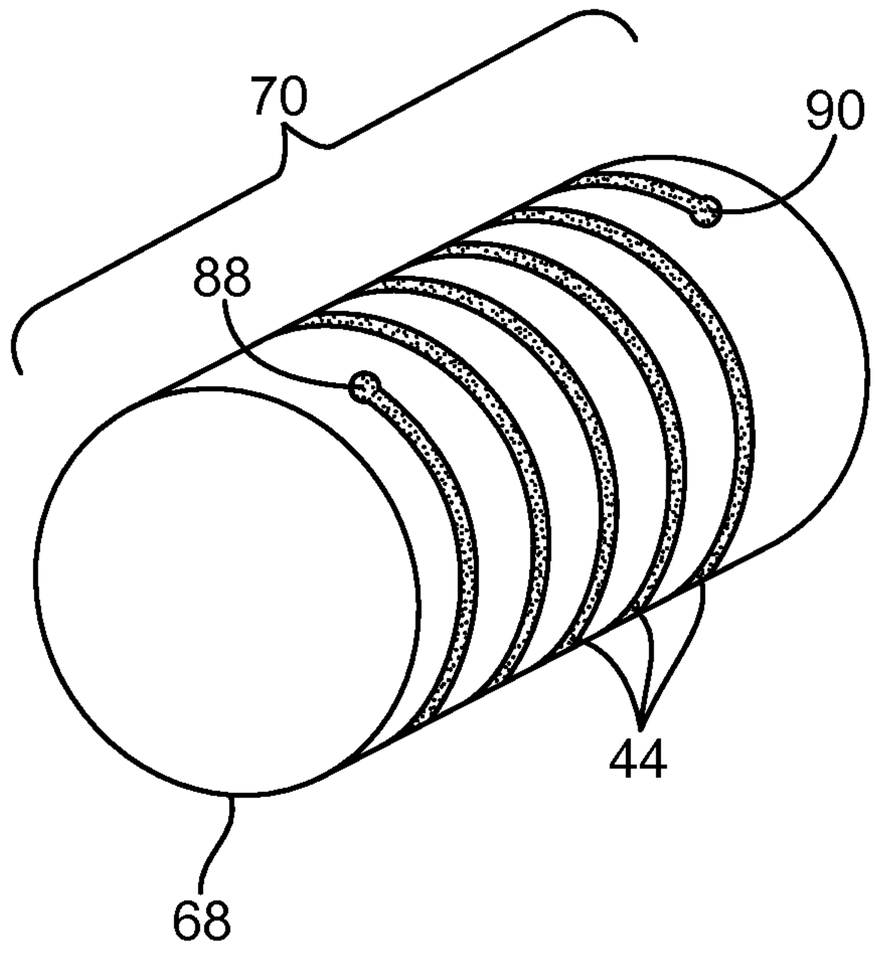


FIG. 10

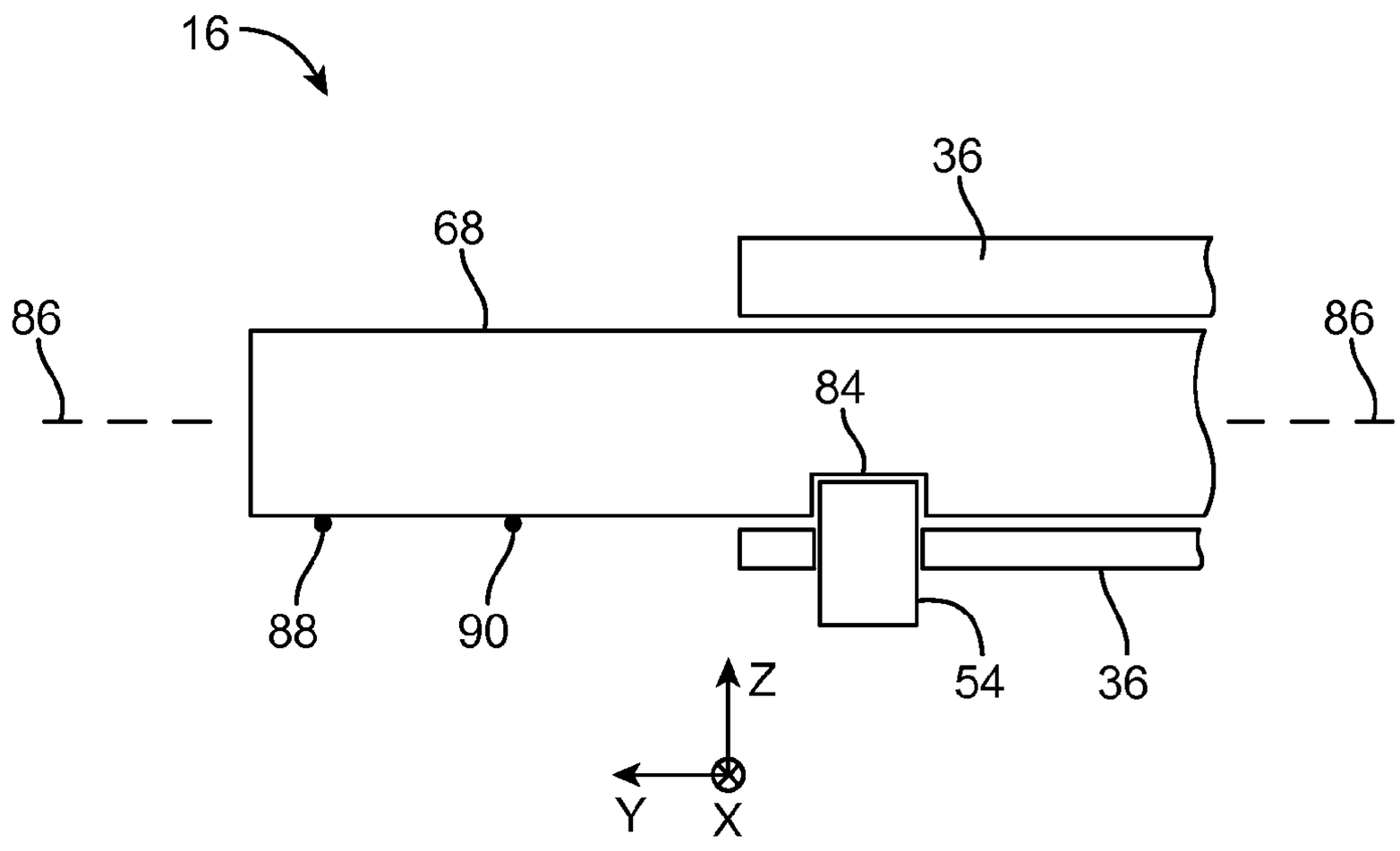


FIG. 11

ELECTRONIC DEVICE HAVING CONNECTOR WITH INTEGRATED SHIELDING

This application claims priority to U.S. provisional patent application No. 61/794,844 filed Mar. 15, 2013, which is hereby incorporated by reference herein in its entirety.

BACKGROUND

This relates generally to electronic devices and, more particularly, to connectors such as radio-frequency connectors for use in electronic devices.

Electronic devices often contain connectors. For example, electronic equipment may contain coaxial cable connectors that mate with coaxial cables. Coaxial cables are often used to convey radio-frequency signals such as video signals.

Components in electronic devices such as radio-frequency circuits may use electromagnetic interference (EMI) shielding structures. Electromagnetic interference shielding structures may help prevent radio-frequency signals that are generated by one component from disrupting the operation of another component that is sensitive to radio-frequency interference. Electromagnetic shielding structures may be formed from metal shielding cans soldered to printed circuit boards.

It can be challenging to mount connectors in electronic devices. Connectors that are not mounted to printed circuit boards are often cumbersome, because they may need to be secured to device housings using fasteners such as nuts and may require that solder connections be formed following attachment of the connector to the housing. Space is often at a premium in electronic devices, so mounting arrangements in which shielding structures and connectors compete for space on a printed circuit or in which connectors are bulky may not be acceptable.

It would therefore be desirable to be able to provide improved connectors for use in electronic devices.

SUMMARY

An electronic device may have electrical components mounted on a printed circuit board. The printed circuit board may be mounted within a housing. A connector may be mounted to an edge of the printed circuit board using solder, so that a portion of the connector protrudes through an opening in the housing.

The protruding portion of the connector may be formed from a threaded barrel mounted in a connector body member. The threaded barrel may have a first threaded portion that is configured to mate with a coaxial cable connector. The threaded barrel may also have a second threaded portion that screws into a threaded opening in the connector body. A threadless portion of the threaded barrel between the first and second threaded portions may be aligned with the housing.

The connector body member may be covered with the metal shell. A portion of the metal shell may form an electromagnetic interference shielding cavity in which the electrical components are housed. By covering the electrical components with the electromagnetic interference shielding cavity formed from the metal shell, the metal shell may serve both as a portion of the connector and as an electromagnetic interference shielding structure for the electrical components.

The metal shell and the connector body may have aligned openings configured to receive a threaded set screw. The threaded barrel may have a flat area aligned with thread initiation and termination points. When the set screw bears against the flat area, the threaded barrel may be rotationally aligned so that the thread initiation and termination points are located out of view on the lower side of the threaded barrel.

Further features, their nature and various advantages will be more apparent from the accompanying drawings and the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an illustrative electronic device of the type that may be provided with a connector in accordance with an embodiment.

FIG. **2** is a top interior view of an illustrative electronic device with a connector having one end that extends through a housing wall and an opposing end that has been mounted to a printed circuit board in accordance with an embodiment.

FIG. **3** is a perspective view of an edge portion of a printed circuit board to which a connector has been mounted using solder in accordance with an embodiment.

FIG. **4** is a top view of the interior of a corner portion of an electronic device having a connector mounted to a printed circuit board with an extended portion that serves as an electromagnetic interference shield for shielding electrical components on the printed circuit board in accordance with an embodiment.

FIG. **5** is an exploded perspective view of an illustrative connector in accordance with an embodiment.

FIG. **6** is a top exploded perspective view of a partially assembled version of the illustrative connector of FIG. **5** showing how the connector may include a connector body assembly, a threaded barrel that is received within a threaded opening in the body assembly, and a set screw in accordance with an embodiment.

FIG. **7** is a perspective view of the illustrative connector of FIGS. **5** and **6** following installation of the threaded barrel and set screw into the connector body assembly in accordance with an embodiment.

FIG. **8** is a bottom exploded perspective view of the illustrative connector of FIG. **5** showing how the connector may include a connector body assembly that has a threaded opening for receiving a set screw that secures the threaded barrel in accordance with an embodiment.

FIG. **9** is a bottom perspective view of the illustrative connector of FIG. **8** following assembly in accordance with an embodiment.

FIG. **10** is a perspective view of a portion of the threaded barrel of an illustrative connector showing the locations of thread initiation and thread termination locations on the barrel in accordance with an embodiment.

FIG. **11** is a cross-sectional side view of a portion of a connector showing how thread initiation and thread termination locations on a threaded barrel in the connector may be configured to face downwards out of view of a user of an electronic device in accordance with an embodiment.

DETAILED DESCRIPTION

An electronic device may be provided with electronic components such as integrated circuits. These components may be mounted on a printed circuit board. Connectors may also be mounted on the printed circuit board. For example, a coaxial cable connector or other connector for mating with an external cable may be mounted on an edge of a printed circuit board. The connector may include integral electromagnetic interference shielding structures for shielding some of the electronic components on the printed circuit board. As an example, an amplifier integrated circuit that is used in amplifying signals passing through the connector may be shielded

using the integral electromagnetic interference shielding structures. The connector may also have features to minimize size and improve device aesthetics.

An illustrative electronic device of the type that may be provided with a printed circuit board connector is shown in FIG. **1**. Electronic device **10** of FIG. **1** has openings **14** in housing **12**. Openings **14** form connector ports for connectors such as Ethernet plugs, Universal Serial Bus connectors, power connectors, audio jacks, connectors for coaxial cables for television signals and other signals, and other connectors. Housing **12**, which may sometimes be referred to as an enclosure or case, may be formed of plastic, glass, ceramics, fiber composites, metal (e.g., stainless steel, aluminum, etc.), other suitable materials, or a combination of any two or more of these materials. Housing **12** may be formed using a unibody configuration in which some or all of housing **12** is machined or molded as a single structure or can be formed using multiple structures (e.g., an internal frame structure, one or more structures that form exterior housing surfaces, etc.).

Electronic device **10** of FIG. **1** may be a set-top box, a wireless access point, a router, a storage device, a device for providing still and moving images to an attached display such as a television or computer monitor, a cellular telephone, a handheld portable device such as a media player, a somewhat smaller portable device such as a wrist-watch device, a pendant device, other wearable or miniature device, gaming equipment, tablet computer, notebook computer, desktop computers, television, computer monitor, a computer integrated into a computer display, a hybrid device that includes the functionality of two or more devices such as these, or other electronic equipment. The use of a set-top box form factor of the type shown in the example of FIG. **1** in implementing device **10** is merely illustrative.

Device **10** may include internal structures such as printed circuits. Electrical components may be mounted on the printed circuits and may be electrically connected through conductive paths in the printed circuits and in external cables. Printed circuits in device **10** may include rigid printed circuit boards (e.g., printed circuits formed from fiberglass-filled epoxy or other rigid substrate material) and/or flexible printed circuits (e.g., printed circuit substrates formed from flexible polymer layers such as sheets of polyimide).

Components that may be mounted on the printed circuits include power supply components, inductors, capacitors, resistors, integrated circuits such as amplifiers and other integrated circuits, switches, connectors, sensors, wireless circuits, and other electrical components. Some of these components and the printed circuits on which the components are mounted may be mounted within the interior of a shielding enclosure that is formed as part of a connector. The connector may be, for example, be a printed circuit board connector that is mounted on the edge of one of the printed circuit boards in device **10**. With one suitable configuration, which is sometimes described herein as an example, the connector may be a coaxial cable connector such as connector **16** of FIG. **1**

Coaxial cable connector **16** may be a female coaxial cable F connector or other connector suitable for coupling to external cables such as coaxial cable **26**. Cable **26** may be terminated in a male coaxial cable F connector **22** or other suitable male cable connector. Connector **22** may have a threaded grounded body **24** that surrounds central positive signal pin **20**. Signal pin **20** in male connector **22** may be a protruding center conductor associated with coaxial cable **26**. Threaded male connector body **24** may screw onto mating threads in a threaded barrel in connector **16** (see, e.g., the protruding cylindrical portion of connector **16** that protrudes through the circular opening **14** in housing **12** in the FIG. **1** example). When male connector **22** is installed on female connector **16** of device **10** in this way, male connector pin **20** will be received within center conductor **18** of female connector **16**.

A top view of an interior portion of electronic device **10** is shown in FIG. **2**. As shown in FIG. **2**, printed circuit board **28** may be mounted in the cavity formed in the interior of housing **12**. Electrical components **30** may be mounted on printed circuit board **28**. Electrical components **30** may include integrated circuits, discrete components such as resistors, capacitors, and inductors, switches, application-specific integrated circuits, processor circuits, storage, video processing circuitry, wireless transceiver circuitry, and other circuitry. Components **30** may be interconnected with each other and connectors such as connector **16** using wires, metal traces in printed circuit board **28**, flexible printed circuit cables, coaxial cables, and other signal path structures. For example, a microstrip transmission line or other transmission line formed from metal traces on printed circuit board **28** such as transmission line path **32** may be used to route signals between the circuitry of components **30** and connector **16**.

Connector **16** may have a portion such as portion **34** that protrudes from housing **12**. Portion **34** may include the tip of a threaded barrel. Connector **16** may also have a portion such as portion **36** (sometimes referred to as a connector body assembly) that is mounted on printed circuit **28** and that is housed within the interior of housing **12**.

FIG. **3** is a perspective view of an edge portion of printed circuit board **28** showing how connector **16** may be mounted to printed circuit board **28**. Printed circuit board **28** may be formed from a rigid printed circuit board substrate material such as fiberglass-filled epoxy. Metal traces in printed circuit board **28** such as metal traces **32**A and **32**B may be used to form transmission lines and other signal paths. In transmission line path **32**, for example, metal trace **32**A may form a positive transmission line conductor and metal trace **32**B may form a ground transmission line conductor (as an example). Metal trace **32**A and other positive signal conductors associated with connector **16** may be coupled to positive connector center contact **18**. Metal trace **32**B and other ground signal conductors associated with connector **16** may be coupled to metal threads **44** in portion **34** of connector **16**.

Body assembly (body structures) **36** of connector **16** may include a body member such as body **40** (e.g., a cast or machined member formed from stainless steel, brass, or other metal) covered with a stamped metal shell such as stainless steel shell **38** or a metal shell formed from other metals. Metal trace **32**B may be shorted to metal shell **38** in connector body assembly **36** using solder pad portion **32**B' of metal trace **32**B and solder **42**. The solder joint formed from solder **42** may attach connector **36** to printed circuit board **28**. Attachment mechanisms such as screws or other fasteners, welds, mounting brackets, adhesive, and other mounting structures may be used, if desired. By attaching connector **16** to board **28** prior to insertion of printed circuit board **28** into housing **12**, potentially cumbersome operations associated with wiring a separate connector to traces **32**A and **32**B after board installation can be avoided.

FIG. **4** is a top interior view of a corner portion of electronic device **10** showing how portion **34** of connector **16** may extend through opening **14** in the wall of housing **12** to expose threads **44**. Threads **44** may lie within protruding threaded portion **70**. Threadless portion **72** of connector **16** may be aligned with opening **14** in housing **12** (i.e., threadless portion **72** overlaps the wall in housing **12**). Conductive paths such as ground conductive path **32**B" may couple threads **44** of connector **16** to metal shell **38** and other grounded elements.

Conductive paths such as positive signal path **32**A" may be coupled to center conductor terminal **18** (i.e., the positive terminal of connector **16**).

The signals on positive line **32**A" and ground line **32**B" may be routed to respective positive signal path **32**A and ground path **32**B via one or more electrical components **30'**. Electrical components **30'** may be mounted on printed circuit board **28** under a portion of metal shell **38**. Electrical components **30'** may include amplifier circuitry, filter circuitry, and other circuitry for enhancing signal strength and quality. Electrical components **30'** may, for example, include one or more integrated circuits (e.g., amplifier integrated circuits) and discrete components such as capacitors, inductors, and resistors.

The circuitry formed from electrical components **30'** may produce electromagnetic interference signals that have the potential to interfere with other components **30** in device **10** such as other components **30** on printed circuit board **28**. There is also a potential for electromagnetic signal interference that is generated by components **30** to interfere with the operation of electrical components **30'**. By mounting components **30'** under metal connector shell **38**, metal connector shell **38** may serve as an electromagnetic interference shielding structure that helps shield components **30'** from interference from components **30** and that helps shield components **30** from interference from components **30'**.

FIG. **5** is an exploded perspective view of connector **16**. As shown in FIG. **5**, connector **16** may include threaded barrel **68**. Barrel **68** may be formed from metals such as brass or stainless steel (as examples). Barrel **68** may be provided with threads such as threads **44** to mate with threaded connector member **24** in cable connector **22** (FIG. **1**). For example, threads **44** may be configured to form a female coaxial cable F connector that mates with a corresponding male coaxial cable F connector. Barrel **68** may also be provided with threads **78** that mate with a threaded cylindrical opening in connector body **40**. Threaded barrel **68** may have portions with different outer diameters. Threaded portion **70** may, for example, have a larger diameter than threaded portion **78**.

A portion such as threadless portion **72** may be formed between threaded portions **70** and **74**, if desired. When mounted in device **10**, portion **72** may be aligned with the wall of housing **12**. By ensuring that portion **72** is bare of threads, tight tolerances (small gaps) may be established between barrel **68** and the opening (opening **14**) in housing **12** through which barrel **68** passes.

Threaded barrel **68** may have an opening such as opening **76** into which center contact components **56** are mounted. Components **56** may include metal center contact pin **58**, hollow metal rod **60**, springs **62** and **64**, and hollow dielectric cylinder (sheath) **66**. When assembled, springs **62** and **64** may be inserted into opposing ends of hollow metal rod **60**. Spring **62** receives one end of metal pin **58**. The opposing end of metal pin **58** may form positive signal path **32**A" of FIG. **4**. When connector **22** is screwed onto threads **44** of connector **16**, center conductor **20** of connector **22** will be received within spring **64**. Dielectric cylinder **66** shields the center conductor contact of connector **16** from the ground contact formed from barrel **68**.

When assembled to form a completed connector, components **56** and threaded barrel **68** are mounted in connector body **40**. Body **40** may be formed from a brass member, a stainless steel member, or other metal structure (as examples). Threaded barrel **68** may be held in place within body **40** using set screw **54**.

Metal shell **38** may have a portion such as portion **50** that is configured to receive metal body **40**. Metal shell **38** may also have portion **52** that serves as an electromagnetic interference shield that overlaps and shields electrical components **30'** on printed circuit board **28**. In region **52**, the lower edge of shell **38** may have a straight surface to facilitate formation of solder joints such as solder joint **42** of FIG. **3**. In the illustrative example of FIG. **5**, shell **38** has optional prong **48**. Prong **48** may be received within a mating hole in printed circuit board **28**. In configurations in which prongs such as prong **48** are provided on shell **38**, the prongs may help secure connector **16** to printed circuit board **28**. If desired, the lower edge of shell **38** in region **52** may be provided with protrusions **46** (e.g., castellation features) as shown in the example of FIG. **5** to help reduce solder wicking.

FIG. **6** is a partially exploded top perspective view of connector **16**. As shown in FIG. **6**, threads **78** of reduced diameter portion **74** of threaded barrel **68** may be received by corresponding threaded cylindrical opening **80** in body **40** of connector body assembly **36**. Set screw **54** may be used to secure threaded barrel **68** after threaded barrel **68** has been screwed into opening **80**. Because the diameter of internal threaded portion **74** of connector **16** is smaller than the diameter of external threaded portion **70** of connector **16**, the volume of body member **40** that is required to form threaded cylindrical opening **80** in body **40** can be reduced, thereby helping to ensure that connector **16** is not overly bulky. The diameter of external threaded portion **70** may be configured to mate with ground connector portion **24** of connector **22**. For example, if connector **22** is a male cable F connector, threaded portion **70** may be sized to form a mating female F connector.

FIG. **7** is a top perspective view of connector **16** of FIG. **6** following assembly of connector **16** by screwing threaded barrel **68** into opening **80** in the front face of body **40** and after screwing set screw **54** into a corresponding threaded opening in the lower surface of body **40**.

FIG. **8** is a partially exploded bottom perspective view of connector **16** showing how opening **82** of connector body assembly **36** may be formed by aligned circular openings in shell **38** and connector body **40**. Set screw **54** may have threads that are received by corresponding threads within body assembly opening **82** (i.e., threads formed on the inner walls of the cylindrical opening in body **40**). Threaded barrel **68** may have a flattened portion such as flat area **84** in reduced-diameter threaded region **74**. Set screw **54** may bear against flat portion **84** of threaded barrel **68** when barrel **68** is screwed into connector body assembly **36**. This helps ensure that barrel **68** is assembled with a desired rotational orientation with respect to rotational axis **86** of barrel **68**.

FIG. **9** is a bottom perspective view of connector **16** of FIG. **8** following assembly of connector **16**. In the configuration of FIG. **9**, threaded barrel **68** has been screwed into threaded opening **80** in connector body assembly **36** (FIG. **6**) and set screw **54** has been screwed into set screw opening **82** in connector body assembly **36** (FIG. **8**). As shown in FIG. **9**, stamped metal shell **38** contains portions such as shielding portion **52** with sidewalls **93** and upper wall **95** that define an internal electromagnetic interference shielding cavity (cavity **91**) for receiving and shielding components **30'** on printed circuit board **28**. Cavity **91** may have a rectangular box shape (e.g., in arrangements of the type shown in FIG. **9** in which shell **38** forms an upside-down open box) or may have other shapes (e.g., shapes with curved edges, shapes with more than one cavity height above printed circuit board **28**, etc.). The configuration of FIG. **9** is merely illustrative.

As shown in FIG. **10**, external threaded portion **70** of threaded barrel **68** may have threads **44**. Threads **44** may start and end at locations such as locations **88** and **90**. Locations **88** and **90** may sometimes be referred to as thread initiation and

termination discontinuities, thread discontinuities, thread endpoints, or thread initiation and termination points. For example, location **88** may be referred to as a thread initiation discontinuity (i.e., a point at which threads **44** start along the length of barrel **69** parallel to rotational axis) and location **90** may be referred to as a thread termination discontinuity (i.e., a point at which threads **44** finish).

The presence of thread initiation and termination points in threads **44** may be unsightly to a user of device **10**. As shown in FIG. **11**, thread initiation and termination points **88** and **90** may be hidden from view by locating thread initiation and termination points **88** and **90** on the underside of threaded barrel **68** in alignment with flat area **84**. When set screw **54** bears against flat area **84**, the rotational orientation of threaded barrel **68** about rotational axis will be established so that thread initiation and termination points **88** and **90** will be located on the underside of barrel **68** and connector **16**, hidden from view.

The foregoing is merely illustrative and various modifications can be made by those skilled in the art without departing from the scope and spirit of the described embodiments. The foregoing embodiments may be implemented individually or in any combination.

What is claimed is:

1. A connector, comprising:

a threaded barrel having a first threaded portion with a first diameter that is configured to mate with a coaxial cable connector and a second threaded portion with a second diameter that is smaller than the first diameter;

a metal body member having sidewalls that extend around a threaded opening that receives the second threaded portion of the threaded barrel; and

a metal shell in which the metal body member is mounted, wherein the metal shell comprises sidewalls that completely surround the sidewalls of the metal body member and that form a first portion of the metal shell, and wherein the metal shell comprises a second portion that extends outwardly from the first portion to form an electromagnetic shielding cavity that is configured to cover electrical components mounted therein.

2. The connector defined in claim **1** wherein the metal shell and the body member have aligned openings.

3. A connector, comprising:

a threaded barrel having a first threaded portion with a first diameter that is configured to mate with a coaxial cable connector and a second threaded portion with a second diameter that is smaller than the first diameter;

body structures having a threaded opening that receives the second threaded portion of the threaded barrel, wherein the body structures include a metal shell that is configured to form an electromagnetic interference shielding cavity and a body member mounted in the metal shell, and wherein the metal shell and the body member have aligned openings; and

a set screw in the aligned openings.

4. The connector defined in claim **3** wherein the second threaded portion has a flat area and wherein the set screw bears against the flat area.

5. The connector defined in claim **4** wherein the first threaded portion has threads with a thread initiation point and a thread termination point and wherein the thread initiation point and the thread termination point are located out of view on a lower portion of the first threaded portion when the set screw bears against the flat area.

6. Apparatus, comprising:

a printed circuit board;

electrical components mounted on the printed circuit board; and

a connector having comprising:

a metal shell that forms an electromagnetic interference shielding cavity covering at least some of the electrical components, the metal shell having an opening;

a conductive pin mounted within the metal shell, the conductive pin extending into the opening and having a first end and a second end opposite the first end that is electrically coupled to the electrical components by a conductive path on the printed circuit board; and

a removable connector component in the opening of the shell that is detachably coupled to the first end of the conductive pin, wherein the removable connector component transmits signals to the electrical components through the conductive pin, and wherein the removable connector component is configured to connect with a mating connector.

7. The apparatus defined in claim **6** wherein the electrical components include at least one integrated circuit.

8. The apparatus defined in claim **7** wherein the removable connector component comprises a threaded barrel configured to mate with a coaxial cable connector and wherein the integrated circuit comprises an amplifier.

9. The apparatus defined in claim **6** further comprising:

a metal body in the opening of the metal shell, wherein the removable connector component comprises a threaded metal barrel that is configured to mate with a coaxial cable connector.

10. The apparatus defined in claim **9** wherein the threaded metal barrel has a first threaded portion with a first diameter and a second threaded portion with a second diameter that is smaller than the first diameter.

11. The apparatus defined in claim **10** wherein the metal body has a threaded opening that receives the second threaded portion.

12. An electronic device, comprising:

a printed circuit;

electrical components on the printed circuit;

a housing with an opening; and

a connector that is mounted on the printed circuit, wherein the connector comprises:

a connector body having a threaded opening;

a pin mounted in the connector body, wherein the pin has an end that extends into the threaded opening; and

a threaded barrel with a first threaded portion, a second threaded portion, and a threadless portion between the first and second threaded portions, wherein the connector protrudes through the opening in the housing so that the threadless portion is aligned with the housing, wherein the threaded opening in the connector body receives the second threaded portion of the threaded barrel, and wherein the end of the pin is received in an opening in the threaded barrel when the second threaded portion is received in the threaded opening.

13. The electronic device defined in claim **12** wherein the first threaded portion has a diameter that is larger than the second threaded portion.

14. The electronic device defined in claim **13** wherein the connector has a metal shell that forms an electromagnetic interference shielding cavity covering the electrical components.

15. The electronic device defined in claim **14** wherein the electrical components include an amplifier.

16. The electronic device defined in claim **15** wherein the first threaded portion is configured to mate with a coaxial

cable F connector, the electronic device further comprising solder that attaches the metal shell to an edge of the printed circuit.

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