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Fernandez et al.

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(54) **CABLE CLAMPING SYSTEM FOR STRAIN RELIEF AND GROUNDING**

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H01R 13/6592 (2011.01)

(52) **U.S. Cl.**
CPC ***H01R 13/5804*** (2013.01); ***H01R 13/6592*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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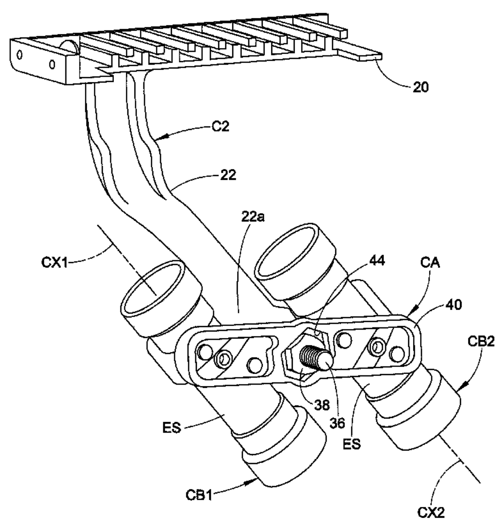
(57) **ABSTRACT**

An electronics module includes a cable clamp chassis projecting outward from a wall of the module. The cable clamp chassis includes first and second cable mounting locations adapted to receive respective first and second cables. The cable mounting locations each include an axially extending recess located adjacent a first reference plane. Each of the cable mounting locations includes an inner surface with an innermost point that lies tangent to a second reference plane that is parallel to and offset from the first reference plane such that the first and second cables are arranged in a zero stack configuration. A clamp is secured to the cable clamp chassis and adapted to secure the first and second associated cables in the first and second cable receiving locations.

19 Claims, 9 Drawing Sheets



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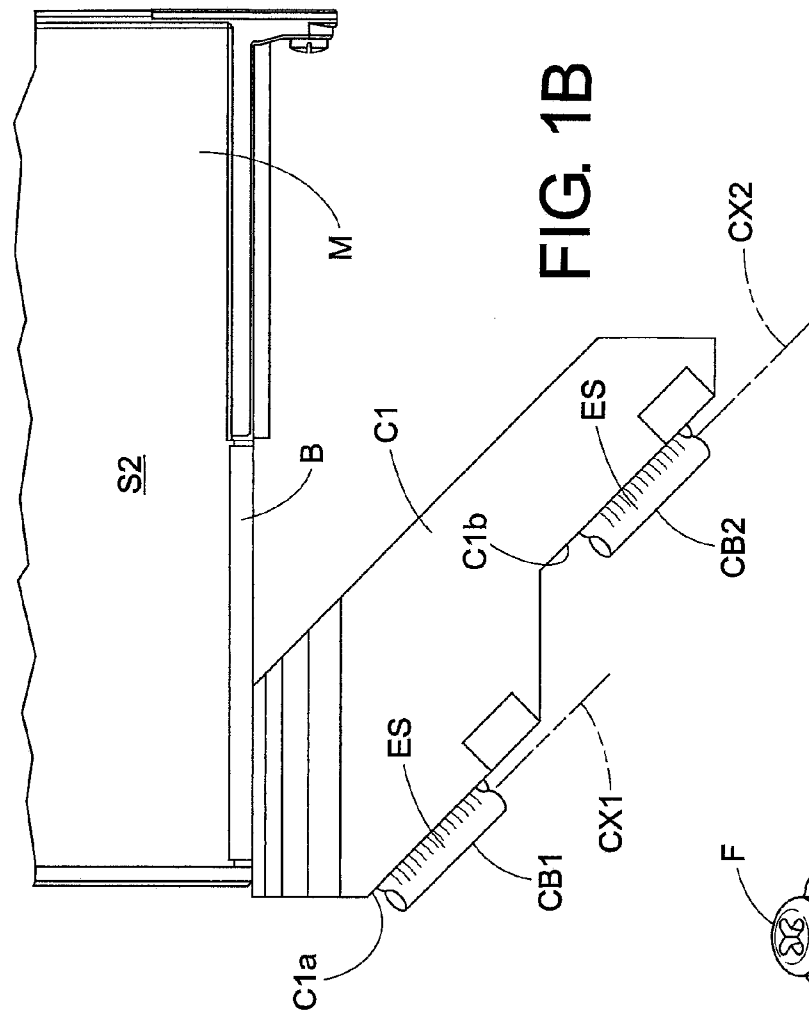

FIG. 1B

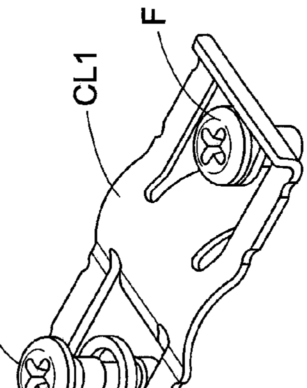

FIG. 1C

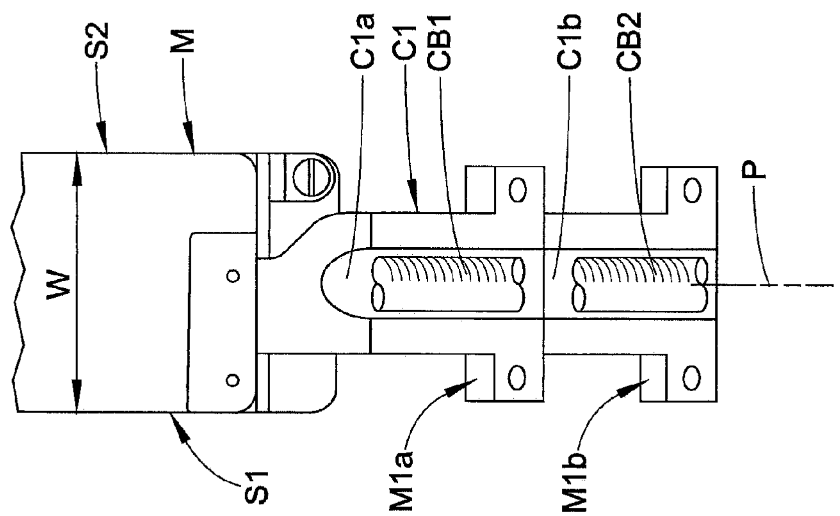

FIG. 1A

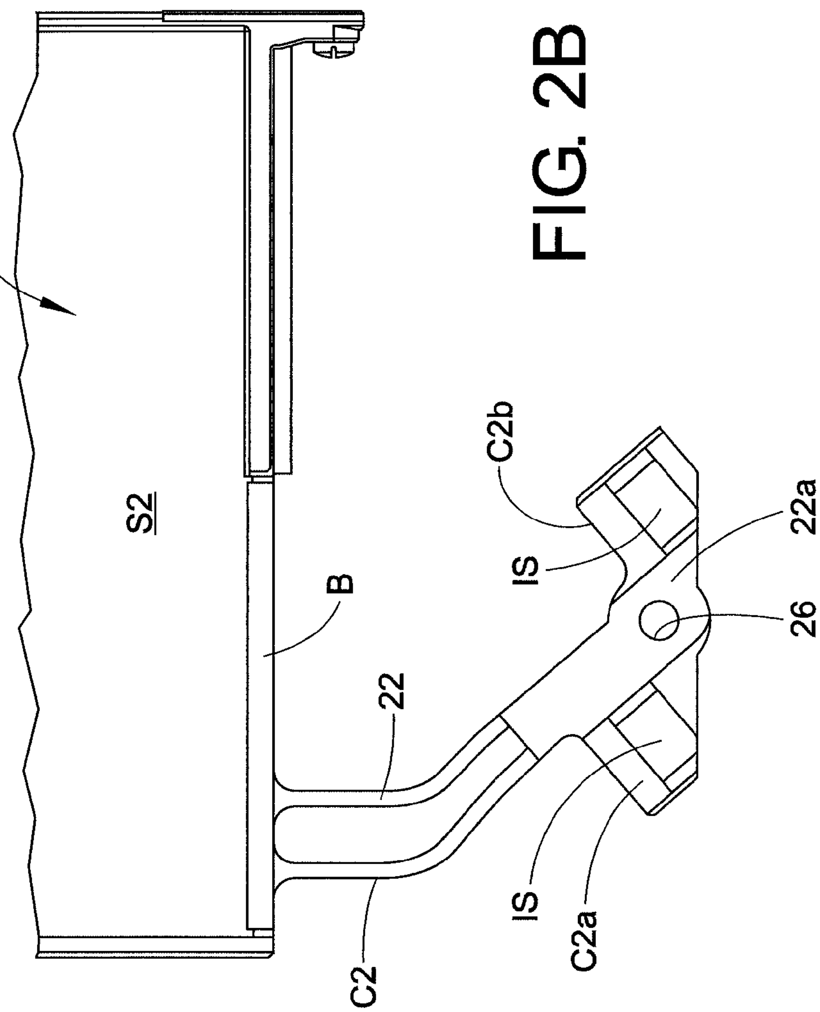

FIG. 2B

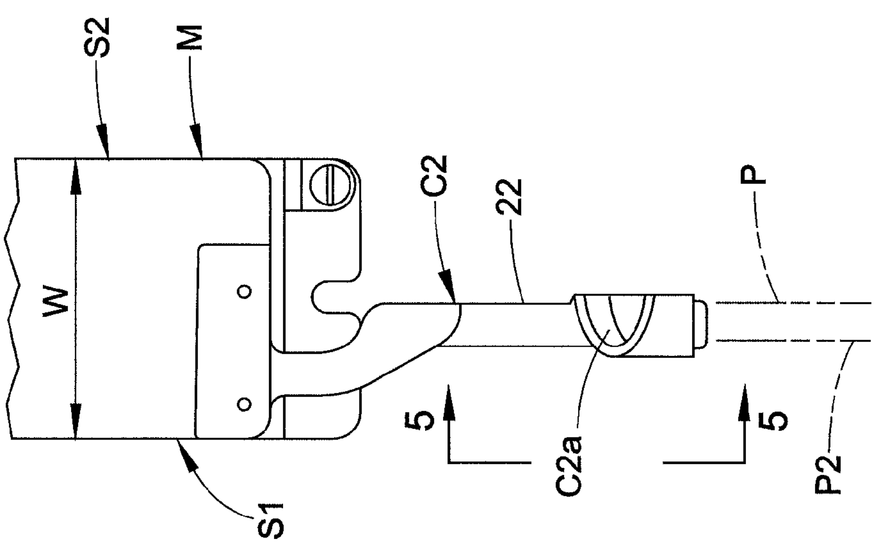

FIG. 2A

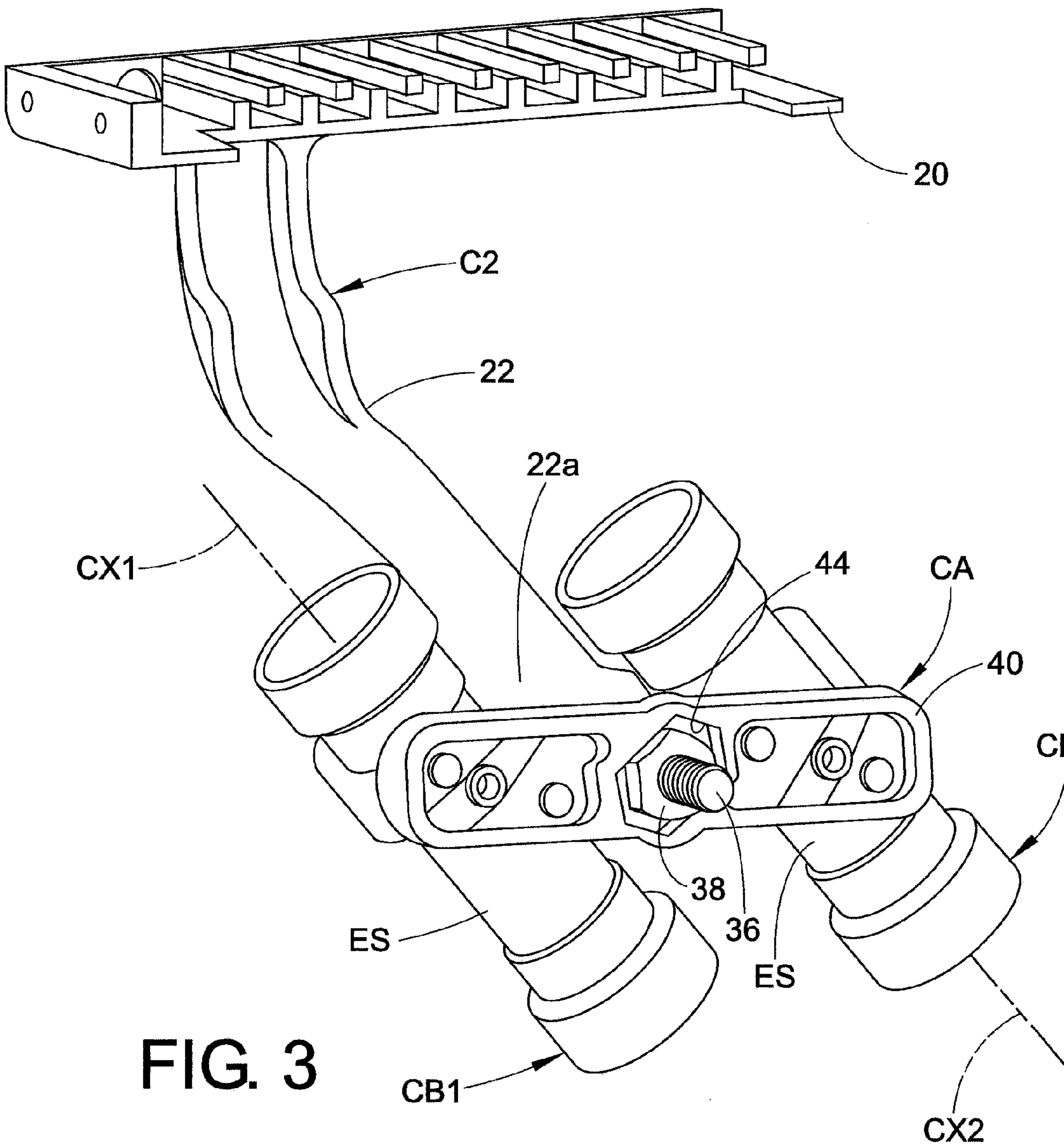

FIG. 3

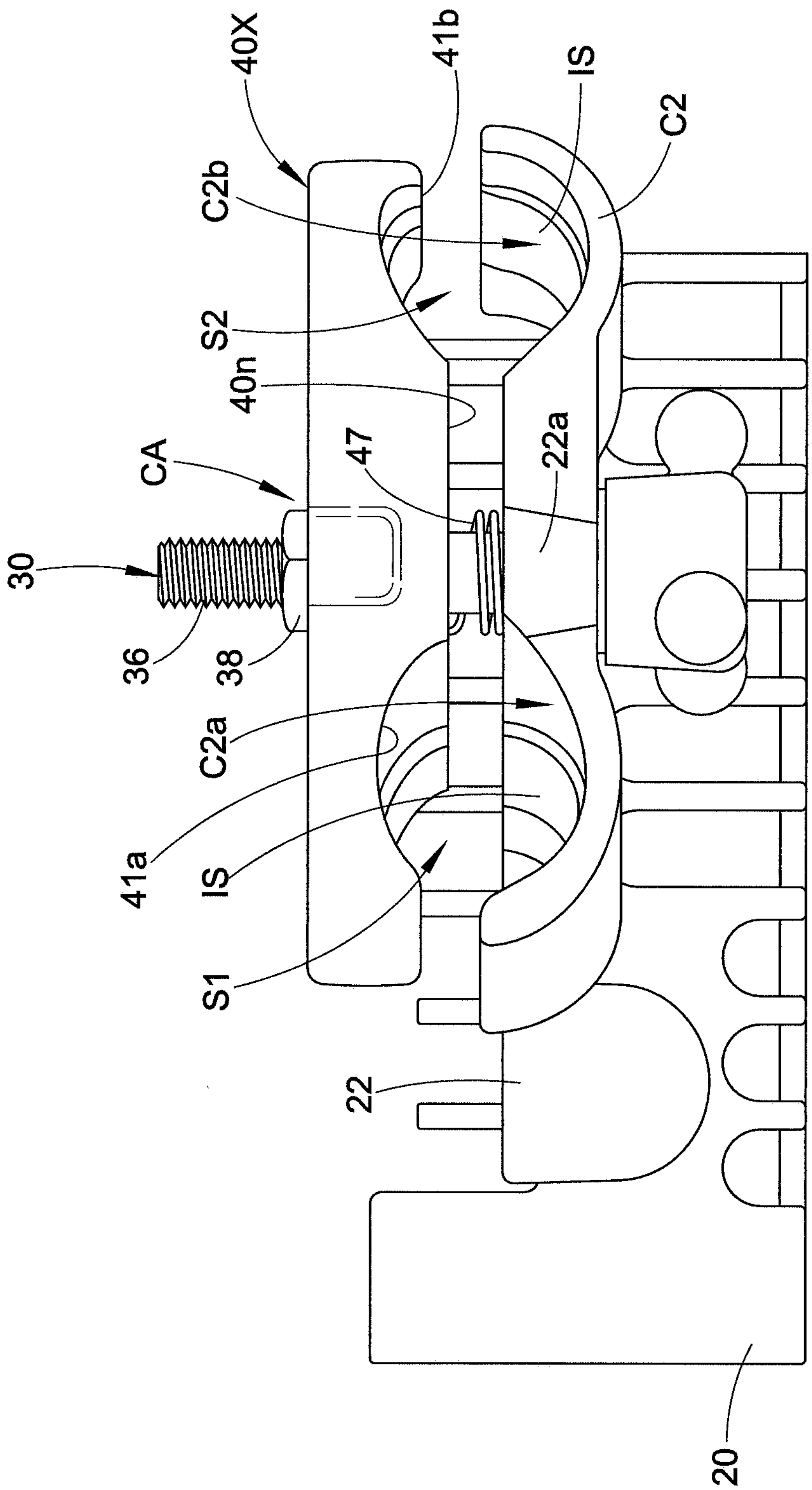

FIG. 4

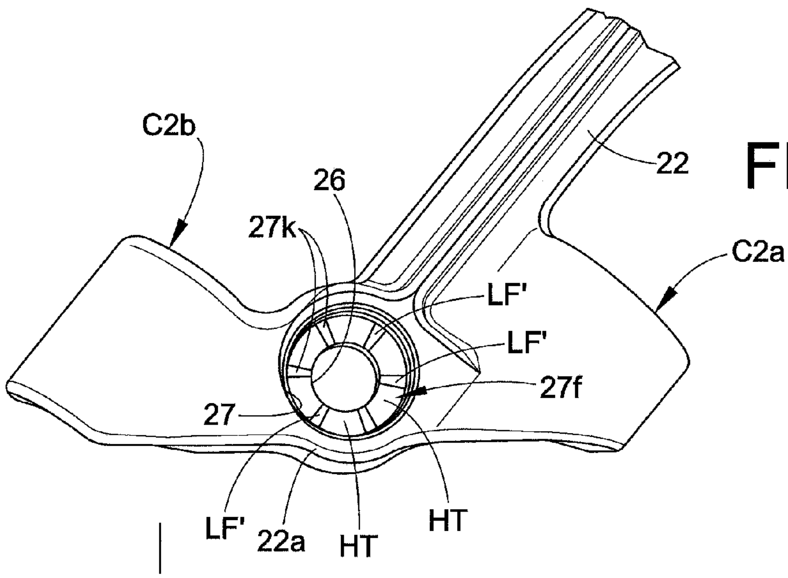

FIG. 5

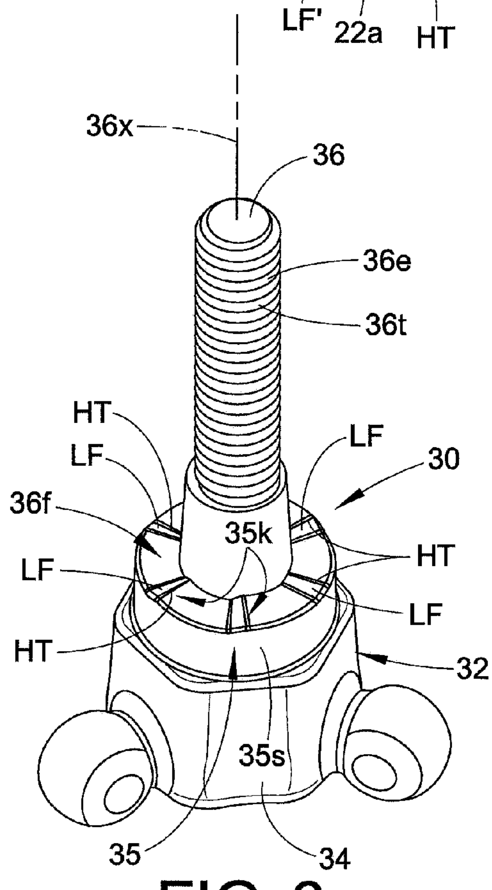

FIG. 6

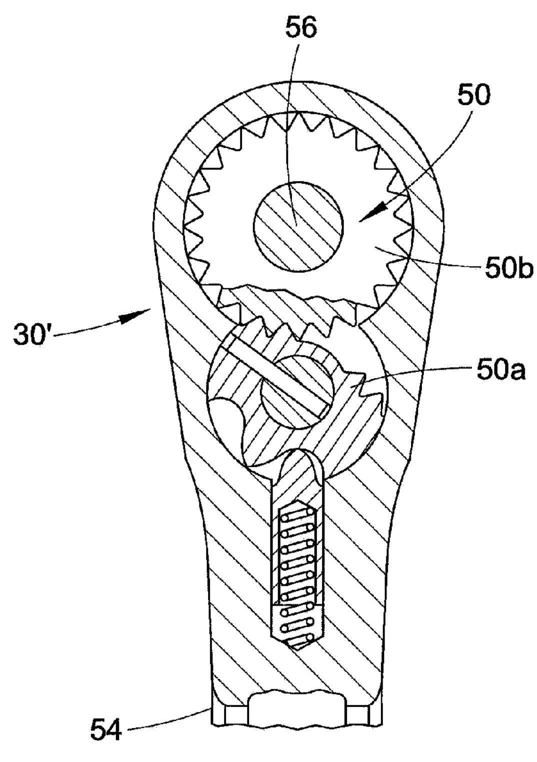

FIG. 7

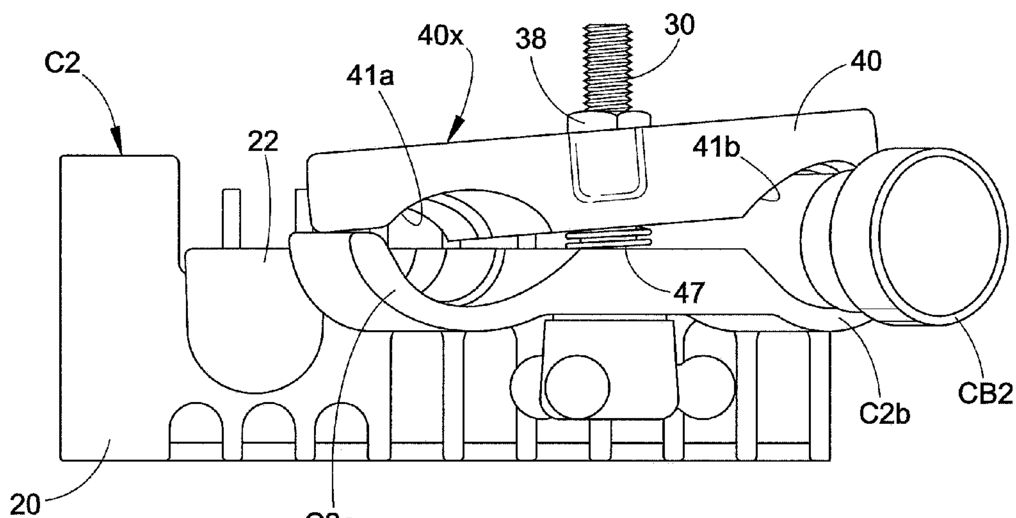

FIG. 8

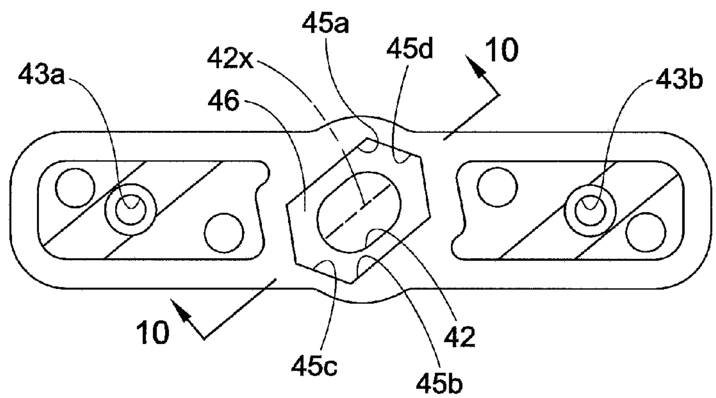

FIG. 9

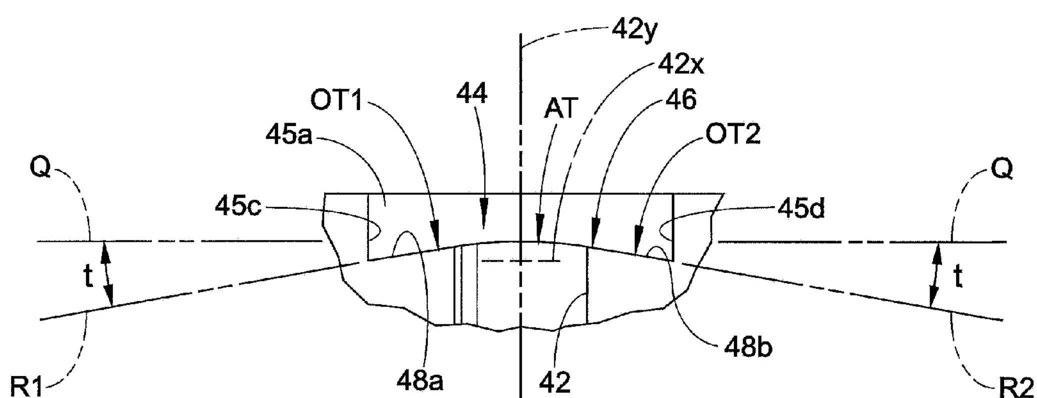

FIG. 10

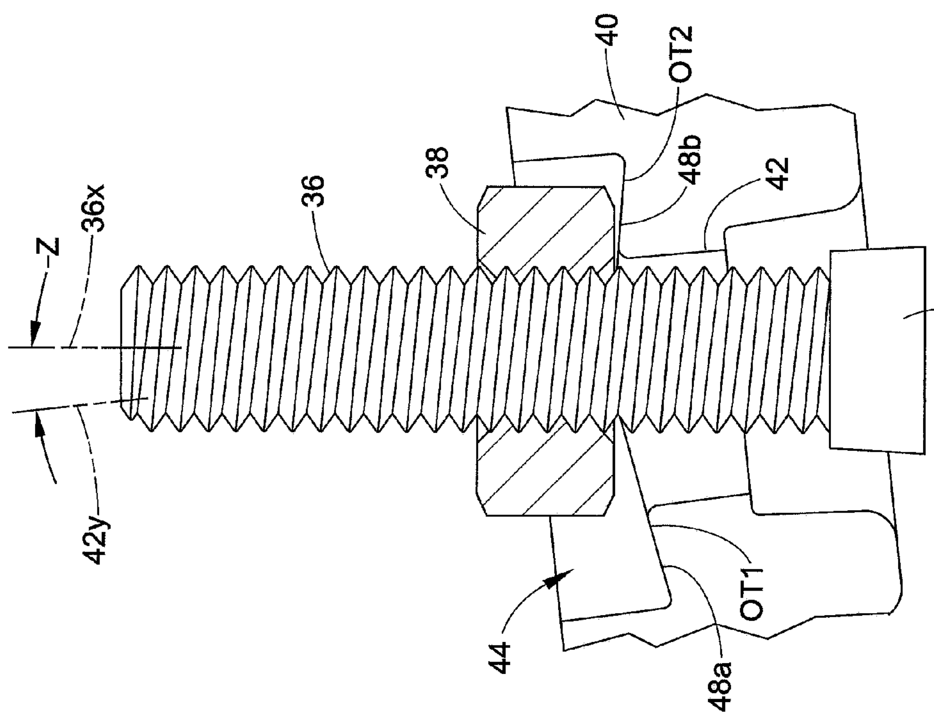

FIG. 11A

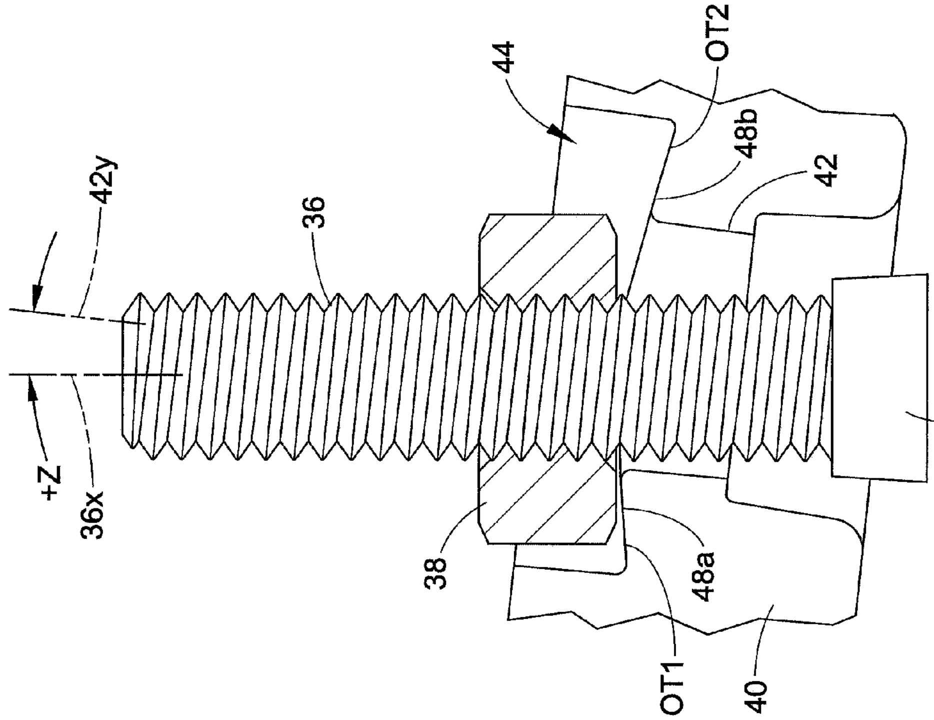

FIG. 11B

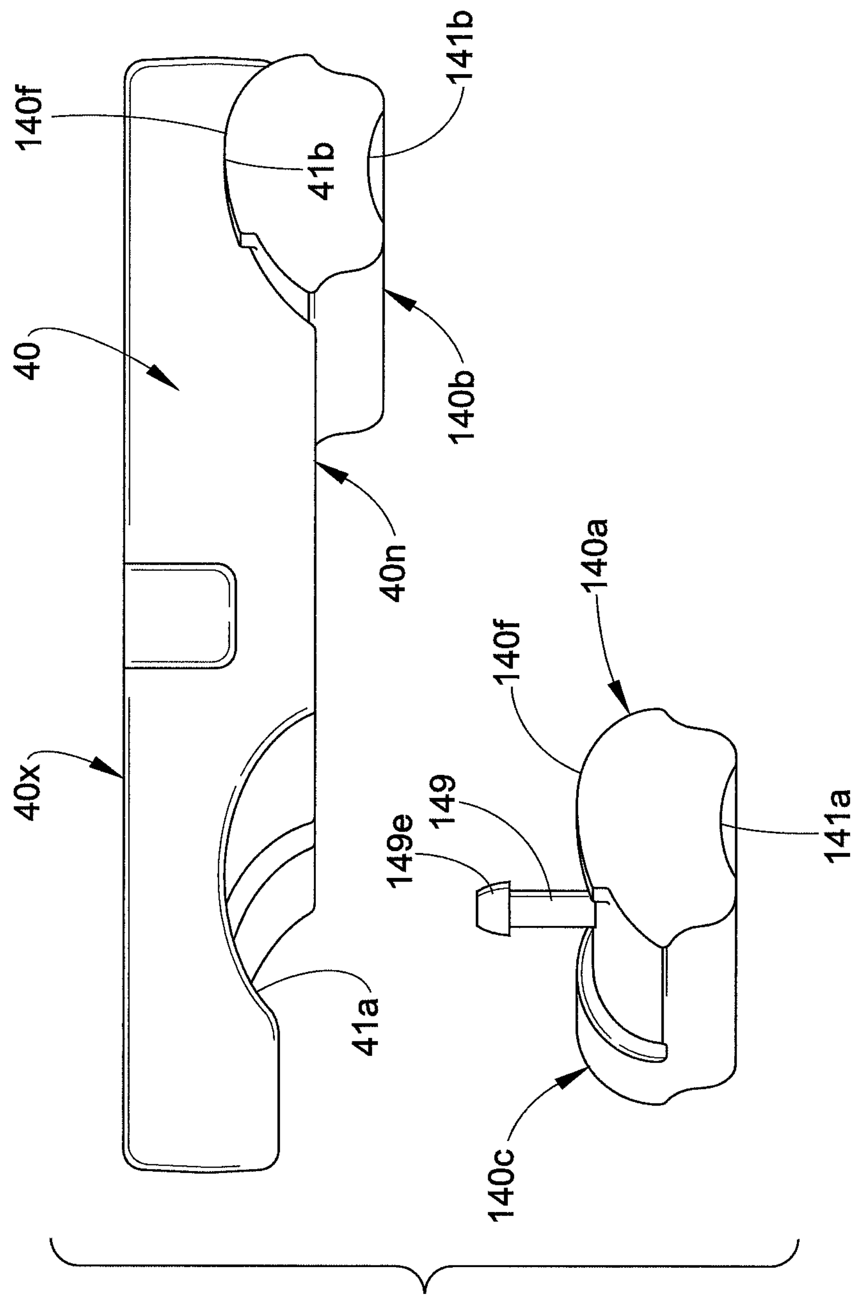

FIG. 12

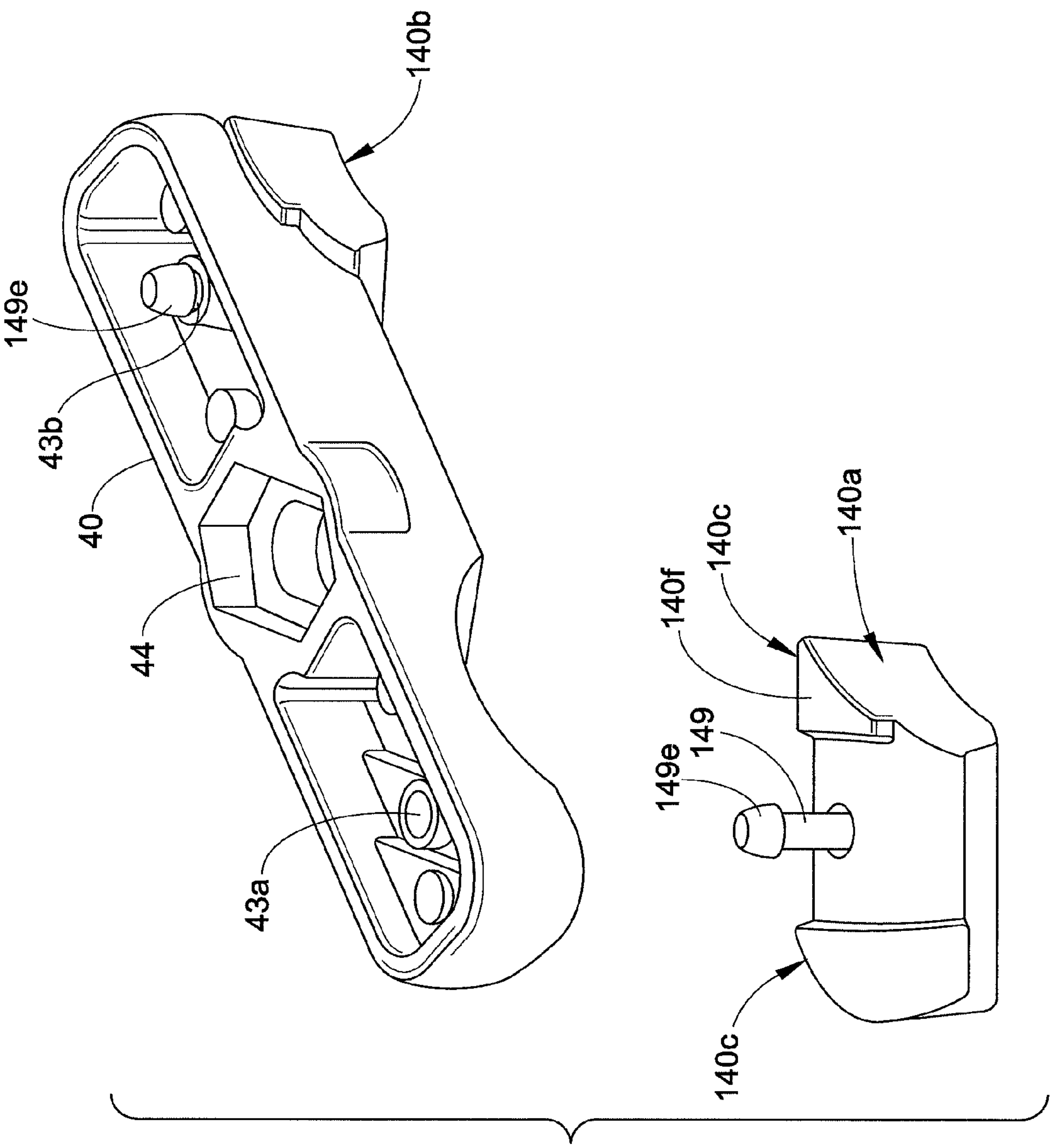

FIG. 13

CABLE CLAMPING SYSTEM FOR STRAIN RELIEF AND GROUNDING

BACKGROUND

Motor drives and other electronics modules require cable strain relief and cable EMI/RFI shield grounding for secure connection of the associated cable to the module and for establishing a low impedance ground path to a desired ground location. Many structures are known for providing the required strain relief and ground path.

Known systems have been found to be suboptimal with respect to the physical location of the cables in cases where more than one cable must be connected to the module, especially when used in connection with a narrow module, which can lead to the multiple cables being positioned undesirably outside of the width of the module where they can interfere with cables of adjacent modules, present an obstacle for mounting of an adjacent module, and generally detract from the proper mounting an installation of the module and its associated cables or adjacent modules and the associated cables thereof.

Another drawback of known cable strain relief and grounding arrangements is that the cable clamping structures for operatively securing the cable(s) to the chassis of the electronics module are sometimes difficult to use, require special tools, are subject to loss of parts, do not work well when cables of different sizes must be accommodated or when some cables are omitted, or have been found to be too complex and/or expensive.

In light of the foregoing issues and others associated with known cable strain relief and grounding systems for electronics modules, a need has been identified for a new and improved electronics module cable clamping system for strain relief and grounding.

SUMMARY

In accordance with one aspect of the present development, an electronics module includes left and right side walls and a bottom wall that extends between the left and right side walls. The module also includes an electrically conductive cable clamp chassis projecting outward from the bottom wall of the module. The cable clamp chassis comprises first and second cable mounting locations adapted to receive respective first and second associated cables. The first and second cable mounting locations are arranged in a zero stack configuration in which the first and second cable mounting locations are centered on a common reference plane P located between and parallel to the left and right side walls such that the respective longitudinal axes of the first and second associated cables are both located within said reference plane P. First and second cable clamps are secured to the cable clamp chassis respectively adjacent the first and second cable mounting locations and are respectively adapted to secure the first and second associated cables in the first and second cable mounting locations with an EMI shield of each associated cable electrically connected to the cable clamp chassis.

In accordance with another aspect of the present development, an electronics module includes a cable clamp chassis projecting outward from a wall of the module. The cable clamp chassis comprises first and second cable mounting locations adapted to receive respective first and second associated cables. The first and second cable mounting locations each include an axially extending recess located adjacent a first reference plane. Each of the first and second cable mounting locations includes an inner surface with an innermost point that lies tangent to a second reference plane that is parallel to and offset from the first reference plane such that the first and second cables are arranged in a zero stack configuration. A clamp is secured to the cable clamp chassis and adapted to secure the first and second associated cables in the first and second cable receiving locations.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. **1**A and **1**B are respective partial front and right side views of an electronics module including a first embodiment of a cable clamp chassis in accordance with the present development;

FIG. **1**C illustrates a known cable clamp to be used with the cable clamp chassis of FIGS. **1**A and **1**B;

FIGS. **2**A and **2**B are respective partial front and right side views of an electronics module including a second embodiment of a cable clamp chassis in accordance with the present development;

FIG. **3** is an isometric view of the chassis of FIGS. **2**A and **2**B, separated from the module M, and further including a clamp in accordance with the present development operatively secured thereto to provide a clamp assembly for in accordance with an embodiment of the present development (FIG. **3** also shows portions of first and second associated cables operatively secured by the clamp assembly to provide strain relief and grounding);

FIG. **4** is a bottom view of the clamp assembly of FIG. **3**, with the cable portions removed to better show the structure of the clamp assembly;

FIG. **5** is a partial left side view if the chassis of FIG. **2**A as taken at line **5**-**5** of FIG. **2**A showing the chassis fastener locking features in accordance with the present development;

FIG. **6** is a greatly enlarged isometric view of the fastener of the clamp assembly of FIGS. **3** and **4** showing the locking features of the fastener;

FIG. **7** is a section view that illustrates an alternative fastener including a ratchet mechanism to facilitate tightening and loosening of the fastener without requiring additional tools;

FIG. **8** is a bottom view similar to FIG. **4**, but showing a single associate cable operatively secured to the clamp assembly, and showing the clamp pivoted to an offset operative position;

FIG. **9** is a side view of the clamp of the clamp assembly of FIGS. **3** and **4**;

FIG. **10** is a partial section view of the clamp as taken at line **10**-**10** of FIG. **8**;

FIGS. **11**A and **11**B diagrammatically show the clamp in its first and second angularly offset positions relative to the fastener and nut of the clamp assembly, respectively;

FIGS. **12** and **13** provide respective bottom and isometric views of the clamp of FIG. **9**, further including a first cable size adapter operatively secured thereto and showing a second cable size adapter in an exploded condition relative to the clamp bar.

DETAILED DESCRIPTION

FIGS. **1**A and **1**B are respective partial front and right side views of an electronics module M including a first embodiment of a cable clamp chassis C**1** in accordance with the present development. The module M can be any type of enclosure or mounting structure defining an internal space or other location for mounting electronic components thereto.

As shown herein, the module M comprises a motor drive module, but is not intended to be limited to same.

The module M includes a cable clamp chassis C**1** according to a first embodiment and to which at least one cable CB**1**,CB**2** is secured when the cable is electrically connected to the circuitry contained in the module M. The clamp chassis C**1** is defined as a metallic structure such as a casting or other structure that is connected to and projects outwardly or downwardly from a bottom side or bottom wall B of the module M. The bottom wall B extends between left and right side walls S**1**,S**2** of the module M. In one embodiment, the clamp chassis comprises a one-piece zinc die-casting, but other materials and structures are contemplated. The clamp chassis C**1** is provided to secure the one or more cables to the module M for providing strain relief to prevent pulling forces on the cable from being transmitted to the electrical coupling of the cable to the module M, and to electrically connect with the electrical magnetic interference (EMI) and/or radio frequency interference (RFI) shield (the EMI and/or RFI shield is referred to generally herein as an "EMI shield") of the cables to provide a ground path to a desired location through the clamp chassis C**1** and module M.

The module M defines a lateral width W between its left and right side walls S**1**,S**2**, and the multiple modules M are often mounted in series with the right side wall S**2** of a first module abutted or adjacent the left side wall S**1** of a second module. Such an arrangement is complicated if the cables connected to each module are arranged in a row that extends laterally between the side walls S**1**,S**2**, as cables on the opposite ends of the row will often protrude beyond the side walls S**1**,S**2** and interfere with the adjacent module. According to one aspect of the present development, however, the clamp chassis C**1** restrains the cables CB**1**,CB**2** in a "zero stack" configuration. More particularly, the clamp chassis C**1** includes at least first and second (and optionally three or more) cable receiving or cable mounting locations C**1***a*,C**1***b* that are dimensioned and otherwise adapted to receive respective first and second cables CB**1**,CB**2**. As illustrated herein, each cable receiving location C**1***a*,C**1***b* comprises an axially extending recess with its surface preferably defined by a circular arc segment. The cable mounting locations C**1***a*,C**1***b* are centered on a common reference plane P that extends parallel to the left and right sidewalls S**1**,S**2** such that the cables CB**1**,CB**2** respectively located therein are likewise centered on the plane P, i.e., the respective origins of the circular arc segments defining each surface C**1***a*,C**1***b* are located in the plane P such that the longitudinal axis CX**1**,CX**2** of each cable CB**1**,CB**2** lies in the plane P and such that the reference plane P bisects the circular arc segment surfaces of the first and second cable mounting locations C**1***a*,C**1***b*. The plane P preferably lies roughly midway between the left and right sidewalls S**1**,S**2**. With the two or more cables CB**1**,CB**2** aligned in a single plane P, the cables CB**1**,CB**2** are located where they will not interfere with adjacent modules or the cables associated with same.

FIG. **1**C illustrates a known clamp CL**1** that is used to secure the cables CB**1**,CB**2** in their respective receiving locations C**1***a*,C**1***b*, with a first one of the clamps CL**1** secured via fasteners F to a first mounting location M**1***a* located adjacent the first cable receiving location C**1***a*, and with a second one of the clamps CL**1** secured via fasteners F to a second mounting location M**1***b* located adjacent the second cable receiving location C**1***b*. The structure and operation of the clamp CL**1** is described more fully in commonly owned U.S. Patent App. Pub. 2014/0014407 A1, the entire disclosure of which is hereby expressly incorporated by reference into the present specification. The outer electrical insulation of the cables CB**1**,CB**2** is removed in the region where the cables CB**1**,CB**2** are respectively seated in the cable receiving locations C**1***a*,C**1***b* to expose an electrically conductive sheath ES such that the sheath ES is electrically connected to the clamp chassis C**1** and the clamp CL**1** for conducting electrical interference in the sheath ES to a ground path of the module M through the clamp chassis C**1**.

FIGS. **2**A and **2**B are respective partial front and right side views of an electronics module M including a second embodiment of a cable clamp chassis C**2** in accordance with the present development and to which at least one cable CB**1**,CB**2** is secured when the cable is electrically connected to the circuitry contained in the module M. The clamp chassis C**2** also provides a zero stack cable mounting arrangement for strain relief and grounding as described above for the cable clamp chassis C**1**.

The clamp chassis C**2** is also defined as a metallic structure such as a casting or other structure that is connected to and projects outwardly or downwardly from a bottom side B of the module M. In one embodiment, the clamp chassis C**2** comprises a one-piece zinc die-casting, but other materials and structures are contemplated. The clamp chassis C**2** is provided to secure the one or more cables to the module M for providing strain relief to prevent pulling forces on the cable from being transmitted to the electrical coupling of the cable to the module M, and to electrically connect with the electrical magnetic interference/radio frequency interference (EMI/RFI) shield ES of the cable to provide a ground path to a desired location through the clamp chassis C**2**.

The clamp chassis C**2** includes at least first and second (and optionally three or more) cable receiving or cable mounting locations C**2***a*,C**2***b* that are dimensioned and otherwise adapted to receive respective first and second cables CB**1**,CB**2**. The first and second cables CB**1**,CB**2** (FIG. **3**) include respective longitudinal axes CX**1**,CX**2**. As illustrated herein, each cable receiving location C**2***a*,C**2***b* comprises an axially extending recess with its inner surface comprising a circular arc segment, although the recess can have a non-cylindrical surface such as an ovalized surface or a polygonal surface, or any combination of surfaces.

The cable mounting locations C**2***a*,C**2***b* are located adjacent a common first reference plane P that extends parallel to the left and right sidewalls S**1**,S**2** such that the cables CB**1**,CB**2** respectively located in the receiving locations C**2***a*,C**2***b* are centered on the plane P, i.e., the longitudinal axis of each cable CB**1**,CB**2** lies in the plane P. The first plane P preferably lies approximately midway between the left and right sidewalls S**1**,S**2**. With the two or more cables CB**1**,CB**2** aligned in a single first plane P, the cables CB**1**, CB**2** are located where they will not interfere with adjacent modules or the cables associated with same.

Each cable receiving location C**2***a*,C**2***b* includes an inner surface IS (see also FIG. **4**) that abuts a cable CB**1**,CB**2** located therein, and the innermost point on each inner surface IS, in terms of the depth of the cable receiving location C**2***a*,C**2***b*, is tangent to a common second reference plane P**2** that lies parallel to but is offset from the first reference plane P by a distance equal to half the maximum diameter of the cables CB**1**,CB**2** to be accommodated which locates the axis of each cable CB**1**,CB**2** in the reference plane P. As described more fully below and as shown in FIG. **3**, the outer electrical insulation of the cables CB**1**,CB**2** is removed in the region where the cables CB**1**,CB**2** are respectively seated in the cable receiving locations C**2***a*,C**2***b* to expose an electrically conductive sheath ES of the cable such that the cable sheath ES is electrically connected to the clamp chassis C2 for conducting electrical interference in the cable sheath ES to a ground path of the module M through the clamp chassis C2.

FIG. **3** is an isometric view of the clamp chassis C2 of FIGS. **2**A and **2**B, separated from the module M, and further including a clamp bar or clamp **40** operatively secured thereto to provide a clamp assembly CA in accordance with an embodiment of the present development. FIG. **4** is a bottom view of the clamp assembly of FIG. **3**, with the cables CB**1**,CB**2** removed to better show the structure of the clamp assembly CA. The clamp chassis C**2** includes a base **20** connected to or adapted to be connected to a wall of the module M, and includes an elongated arm **22** projecting outwardly from the base **20**. The first and second cable receiving locations C**2***a*,C**2***b* are connected to an outer end **22***a* of the arm, and are located on opposite sides of the arm **22** relative to each other. The clamp chassis C**2**, including the base **20**, arm **22** and first and second cable receiving locations C**2***a*,C**2***b* are preferably constructed as a one-piece metallic structure such as a cast structure, e.g., a zinc die casting.

The outer end **22***a* of the arm **22** includes an aperture **26** (see also FIGS. **2**B and **5**) defined there through and located between the first and second cable receiving locations C**2***a*, C**2***b*. The aperture **26** is adapted to receive a clamp fastener **30** which is rotatable in the aperture **26**. The fastener **30**, shown by itself in FIG. **6**, comprises a first end **32** including an enlarged driving head **34** adapted to be manually engaged by a user for rotation of the fastener. The head **34** can additionally or alternatively be adapted for engagement by a tool such as a wrench or screwdriver for user rotation of the fastener **30**. The fastener **30** comprises a shank **36** that projects outwardly from the head **34** and that includes threads **36***t*. The shank **36** is defined about and extends axially along a longitudinal axis **36***x*. Between the head **34** and the shank **36**, the fastener comprises a shoulder region **35** including a cylindrical outer surface **35***s* and a transverse lock face **35***f* including at least one and preferably a plurality of locking features or projections **35***k* that extend outwardly from the lock face **35***f*. In the illustrated embodiment, the locking features **35***k* comprise a plurality of helical teeth HT each comprising a ramped lock face LF that function as described in more detail below to inhibit unintended rotation of the fastener **30** in a direction that would retract or "loosen" the nut **38** due to shock and vibration.

The clamp fastener **30** is used to secure the clamp **40** in its operative position relative to the clamp chassis C**2**. In particular, the clamp **40** comprises an elongated bar structure or body including first and second cable receiving recesses **41***a*,**41***b* defined in an inner surface **40***n* that faces the clamp chassis C2 and configured to receive an associated cable CB**1**,CB**2** such that the clamp **40** engages each cable CB**1**, CB**2** in a saddle arrangement. In the illustrated embodiment, each cable receiving recess **41***a*,**41***b* includes an inner surface comprising a circular arc segment or another curved surface.

The clamp **40** is shown separately in FIGS. **9** and **10** and further includes an aperture **42** through which the fastener shank **36** extends located between the first and second cable receiving recesses **41***a*,**41***b*, and a nut **38** is threaded on the outer end of the shank to capture the clamp **40** on the shank **36** of the fastener **30**. The clamp **40** includes a recess **44** surrounding the aperture **42** in an outer surface **40***x* that is arranged opposite the inner surface **40***n* that faces the clamp chassis C**2**, and the aperture **42** opens through the recess **44**. The nut **38** is at least partially received in the recess **44** and

the nut **38** is non-rotatably engaged with the recess **44**. The recess **44** includes opposite first and second side walls **45***a*,**45***b* between which the nut **38** is closely received with some clearance, and the side walls **45***a*,**45***b* restrain/limit rotation of the nut **38** in the recess **44** due to engagement of respective flats of the nut **38** with the side walls **45***a*,**45***b* such that the nut is restrained against rotation with the fastener **30** when the fastener is rotated so that rotation of the fastener **30** in a first direction advances (tightens) the nut **38** on the threaded portion of the shank **36**, and rotation of the fastener in an opposite second direction retracts (loosens) the nut **38** on the threaded portion of the shank **36**. The recess also includes opposite first and second end walls **45***c*,**45***d* that connect the opposite ends of the side walls **45***a*,**45***b*. The clamp **40** is preferably defined from an electrically conductive material, such as a one-piece metallic casting or other structure, such as a one-piece zinc die casting or other one-piece or fabricated multi-piece metal structure.

In use, as shown in FIG. **3**, the clamp **40** is operatively secured to the clamp chassis C2 using the fastener **30** and mating nut **38**. When the clamp **40** is positioned in its operative position, the first and second cable receiving recesses **41***a*,**41***b* thereof are arranged in opposed spaced-apart facing relation with the first and second cable receiving locations C**2***a*,C**2***b* of the clamp chassis, respectively, such that respective first and second cable receiving spaces S1,S2 (FIG. **4**) are defined there between. The cable receiving spaces S1,S2 are respectively adapted to accommodate and retain the cables CB**1**,CB**2** when the fastener **30** is rotated sufficiently to advance the nut **38** on the threaded shank **36** to a location where the clamp **40** captures the cables CB**1**, CB**2** in the spaces S1,S2 defined between the cable receiving locations C**2***a*,C**2***b* of the clamp chassis and the cable receiving locations **41***a*,**41***b* of the clamp. When the cables CB**1**,CB**2** are operatively secured by the clamp assembly CA as just described, the exposed EMI sheath ES of the first cable CB**1** is in contact with and electrically connected to the first cable receiving locations C**2***a*,**41***a* of the chassis and clamp, and the exposed EMI sheath ES of the second cable CB**2** is in contact with and electrically connected to the second cable receiving locations C**2***b*,**41***b* of the chassis and clamp, such that the sheath ES of each cable CB**1**,CB**2** is electrically connected to a ground path of the module M, which includes the clamp chassis C**2**. The fastener **30** electrically connects the clamp **40** and clamp chassis C**2**.

In the illustrated embodiment, the clamp assembly CA comprises a spring **47** that biases the clamp **40** outwardly away from the clamp chassis C**2** to facilitate cable insertion and removal from the spaces S1,S2. In one embodiment as shown herein, the spring **47** comprises a coil spring coaxially positioned about the fastener shank **36** and located between the clamp chassis C**2** and the clamp **40**. Because the spring **47** biases the clamp **40** away from the clamp chassis C**2**, the nut **38** will be located in the recess **44**, even when no cables CB**1**,CB**2** are present, which facilitates one-handed operation of the fastener **30**, i.e., the fastener **30** can be rotated and the nut **38** will be restrained against rotation due to its presence in the recess **44**. When the fastener **30** is loosened to open the spaces S1,S2 sufficiently to receive the cables CB**1**,CB**2**, the cables can be easily inserted because the clamp **40** is maintained spaced-apart from the clamp chassis C**2** by the spring **47**. Of course, the biasing force of the spring **47** is overcome when the fastener **30** is rotated to advance the nut **38** and draw the clamp **40** toward the clamp chassis C**2** and capture the cables CB**1**,CB**2** in the spaces S1,S2, respectively. The fastener threads **36***t* can be deformed or obstructed at the outer end **36***e* of the shank to provide resistance to rotation of the nut **38** in such region, to provide a tactile indication to a user that the nut is located near the outer end **36***e* of the shank to reduce the likelihood that the fastener **30** is completely unthreaded from the nut.

In some cases, such as when the cables CB**1**,CB**2** are different diameters or when one of the cables CB**1**,CB**2** is absent as shown in FIG. **8**, the clamp **40** is designed to pivot to an offset operative position where the cable receiving spaces S**1**,S**2** are unequal sizes relative to each other due to pivoting movement of the clamp **40** about the longitudinal axis CX**1**,CX**2** of the larger diameter cable if two cables CB**1**,CB**2** are present, or about the longitudinal axis CX**1**, CX**2** of the single cable if only one cable CB**1** or CB**2** is being retained by the clamp assembly CA as shown in FIG. **8**. To enable the clamp **40** to pivot as shown in FIG. **8** (or to pivot in the opposite direction if the cable CB**1** is present and the cable CB**2** is absent), the aperture **42** of the clamp **40** is elongated or ovalized, along a major axis **42***x*, and the recess **44**, itself, is also elongated along the major axis **42***x*. The aperture **42** extends axially through the clamp **40** between the inner and outer surfaces thereof **40***n*,**40***x* along a longitudinal or central axis **42***y*. The major axis **42***x* intersects and is arranged perpendicular to the central axis **42***y* of the aperture **42**.

Referring now also to the section view of FIG. **10**, the recess **44** includes an inner wall or floor **46** arranged transverse to the side walls **45***a*,**45***b* and end walls **45***c*,**45***d*. The floor **46** is not planar but, instead comprises first and second offset, angled, or tapered floor surfaces or portions **48***a*,**48***b* located on opposite first and second sides of the aperture **42**, with the first offset floor portion **48***a* located between the first end wall **45***c* and the aperture **42**, and the second offset floor portion **48***b* located between the second end wall **45***d* and the aperture **42**. The first and second offset floor portions **48***a*,**48***b* are offset by an angle t relative to a reference plane Q that lies tangent to the floor **46** at the intersection of the floor **46** and the aperture **42**, with the angle t being measured between the reference plane Q and respective floor planes R**1**,R**2**. The floor planes R**1**,R**2** are either respectively coincident with the first and second offset floor portions **48***a*,**48***b* if the floor portions **48***a*,**48***b* are planar, or the floor planes R**1**,R**2** are respectively tangent with the first and second offset floor portions **48***a*,**48***b* if the floor portions **48***a*,**48***b* are curved. As such, the first and second offset floor surfaces **48***a*,**48***b* are spaced from the reference plane Q a greater distance when measured adjacent the respective first and second end walls **45***c*,**45***d* as compared to when measured adjacent the aperture **42**, with the distance equal to zero at the intersection of the aperture **42** with the floor **46**. Thus, a respective distance defined between the first and second offset floor surfaces **48***a*,**48***b* and the outer surface **40***x* of the clamp **40** increases as the first and second offset floor surfaces **48***a*,**48***b* extend away from said central axis **42***y* of said clamp aperture **42** along said major axis **42***x*. The region of the floor surrounding and adjacent the aperture **42** defines and provides a primary axial thrust surface AT, and the first and second offset floor portions **48***a*,**48***b* define and provide first and second offset thrust surfaces OT**1**,OT**2**.

FIGS. **11**A and **11**B diagrammatically show the clamp **40** in its first and second angularly offset positions relative to the fastener shank **36** and nut **38**, respectively. More particularly, FIG. **11**A corresponds to FIG. **8** and shows the clamp **40** pivoted about the longitudinal axis CX**2** of the cable CB**2** to a first angularly offset position. As such, a clamp offset angle −z is defined between the longitudinal axis **36***x* of the fastener shank **36** and the central axis **42***y* of the clamp aperture **42**, and the nut **38** is abutted with the second offset thrust surface OT**2**. FIG. **11**B illustrates an opposite arrangement relative to FIG. **11**A in which the clamp **40** is pivoted about the longitudinal axis CX**1** of the first cable CB**1** to a second angularly offset position when the second cable CB**2** is absent (the first and second cables are not shown in FIGS. **11**A and **11**B). In FIG. **11**B, a clamp offset angle +z is defined between the longitudinal axis **36***x* of the fastener shank **36** and the central axis **42***y* of the clamp aperture **42**, and the nut **38** is abutted with the first offset thrust surface OT**1**. Those of ordinary skill in the art will recognize that the elongated aperture **42** and elongated recess **44** allow the clamp **40** to move relative to the fastener shank **36** and nut **38** to the first and second angularly offset positions without bending stresses being exerted on the shank **36** and threads thereof, and the first and second offset thrust surfaces OT**1**,OT**2** are oriented such that the nut **38** exerts thrust forces on clamp **40** and opposite reaction forces on the shank **36** that are both coincident with the longitudinal axis **36***x* of the fastener shank **36**. This elimination bending stress on the fastener shank **36** increases the durability of the fastener **36** and allows the fastener **36** to be made less robust and using less expensive material such as zinc or another suitable low-cost material.

As noted above, the fastener **30** preferably comprises locking features **35***k* that engage and coact with the clamp chassis C**2** to inhibit unintended rotation of the fastener **30** in a direction (counter-clockwise in the present example) that would cause the nut **38** to retract or “loosen” on the shank **36**. In this regard, as shown in FIG. **5**, the aperture **26** of the clamp chassis C**2** includes a counter bore **27** comprising a transverse face **27***f* including a plurality of including at least one and preferably a plurality of locking features or projections **27***k* that extend outwardly from the lock face **27***f*. In the illustrated embodiment, the locking features **27***k* correspond to the fastener locking features **35***k* and thus comprise a plurality of helical teeth HT each comprising a ramped lock face LF', wherein the lock faces LF,LF' are oriented so that they will lie parallel to and abut each other when the shoulder region **35** of the fastener **30** is received in the counter bore **27** when the fastener **30** is operatively installed in the aperture **26** of the clamp chassis C**2**. The abutted lock faces **27**,**27'** will inhibit rotation of the fastener **30** in a direction that would cause the nut **38** to retract or “loosen” on the shank **36**. Alternative projecting locking features **27***k*,**35***k* are contemplated and the present development is not to be limited to the illustrated embodiment.

FIG. **7** is a section view of an alternative embodiment of the fastener **30'** which includes a ratchet mechanism **50**. The fastener **30'** comprises a handle **54** adapted to be grasped by a user to rotate the threaded shank **56** in a first direction or a second direction to advance (tighten) or retract (loosen) the nut **38**. The handle **54** is operatively connected to the shank **36** by the ratchet mechanism **50** including a pawl **50***a* and ratchet wheel **50***b*, wherein the ratchet wheel **50***b* is connected to the shank **56** such that the shank **56** rotates with the ratchet wheel **50***b*. The pawl **50***a* is manually moved between first and second operative positions where it engages the ratchet wheel **50***b* in first and second orientations to allow torque to be transmitted from the handle **54** to the ratchet wheel **50***b* in first and second directions, respectively, and allows freewheeling of the handle **54** relative to the ratchet wheel **50***b* in the opposite direction. Further details of the ratchet mechanism are described in U.S. Pat.

No. 1,957,462, the entire disclosure of which is hereby expressly incorporated by reference into the present specification

FIGS. **12** and **13** provide respective bottom and isometric views of the clamp **40**, and further illustrate the structure and function of first and second cable size adapters **140***a*,**140***b* that can be used together or individually as needed. The cable size adapters **140***a*,**140***b* are identical to each other and are adapted to be selectively received in the first and second cable receiving locations **41***a*,**41***b* of the clamp **40**, with their respective inner faces **140***f* abutted with the cable receiving locations **41***a*,**41***b*. The cable size adapters **140***a*,**140***b* include outer faces located opposite the inner face **140***f* comprising respective concave cable receiving locations **141***a*,**141***b* that are oriented outwardly away from and that are spaced outwardly from the cable receiving locations **41***a*,**41***b* when the adapters **140***a*,**140***b* are operatively installed on the clamp **40**. When operatively connected/installed on the clamp **40** (as shown for the cable size adapter **140***b*), the cable size adapters **140***a*,**140***b* partially fill and reduce the size of the cable receiving spaces S**1**,S**2** defined between the first and second cable receiving locations C**2***a*,C**2***b* of the clamp chassis C**2** and the clamp **40** to ensure that a smaller diameter cable is tightly engaged between the cable size adapters **140***a*,**140***b* of the clamp **40** and the clamp chassis C**2**. In particular, the sheath ES of a smaller diameter cable will be abutted with the inner surface IS of the cable receiving locations C**2***a*,C**2***b* of the clamp chassis **40** on one side and will be abutted with the cable receiving locations **141***a*,**141***b* of the adapters **140***a*,**140***b* on the opposite side. The presence of the adapters **140***a*,**140***b* ensures that the nut **38** can be advanced sufficiently on the fastener shank **36** to locate the clamp **40** where the cables will be tightly captured in the cable receiving spaces S**1**,S**2** before the clamp **40** abuts the clamp chassis C**2** or is otherwise prevented from moving closer to the clamp chassis C**2**.

The first and second cable size adapters **140***a*,**140***b* are selectively connected to and disconnected from the clamp **40** as needed, without requiring any tools. In the illustrated embodiment, the clamp **40** comprises first and second mounting holes **43***a*,**43***b* (see also FIG. **9**) that open into the first and second cable receiving locations **41***a*,**41***b*. Each adapter **140***a*,**140***b* includes a post **149** with an enlarged outer end **149***e* projecting outwardly from its inner face **140***f*. The post **149** is adapted to be inserted into one of the mounting holes **43***a*,**43***b* and the enlarged outer end **149***e* engages the clamp **40** with a snap-fit or otherwise such that the cable size adapter **140***a*,**140***b* is captured to the clamp **40** with the inner surface **140***f* abutted with the respective cable receiving location **41***a*,**41***b*. The inner surface **140***f* of each cable size adapter **140***a*,**140***b* is curved such that it defines a cam surface **140***c*. To separate the cable size adapter **140***a*, **140***b* from the clamp **40**, the cable size adapter is twisted relative to the clamp **40** such that the post **149** rotates in the hole **43***a*,**43***b*, which causes the cam surface **140***c* to engage the cable receiving location **41***a*,**41***b* of the clamp with a cam action that urges the cable size adapter **140***a*,**140***b* outwardly away from the clamp **40** and out of the cable receiving location sufficiently such that the enlarged end **149***e* of the post is disengaged from the clamp **40** and the adapter **140***a*,**140***b* can be manually separated from the clamp.

In the preceding specification, various embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

The invention claimed is:

1. An electronics module comprising:

left and right side walls and a bottom wall that extends between the left and right side walls;

an electrically conductive cable clamp chassis projecting outward from the bottom wall of the module, said cable clamp chassis defined as a one-piece metallic structure comprising first and second cable mounting locations adapted to receive respective first and second associated cables, said first and second cable mounting locations arranged in a zero stack configuration in which the first and second cable mounting locations are centered on a common reference plane (P) that lies between and parallel to the left and right side walls of the electronics module such that the respective longitudinal axes of the first and second associated cables are both located within said reference plane (P) between said left and right side walls of the module, wherein said first and second cable mounting locations each comprise an axially extending circular arc segment surface bisected by said reference plane (P);

first and second cable clamps secured to said cable clamp chassis respectively adjacent said first and second cable mounting locations and respectively adapted to secure the first and second associated cables in the first and second cable mounting locations with an EMI shield of each associated cable electrically connected to said cable clamp chassis.

2. The electronics module as set forth in claim **1**, wherein said reference plane (P) is situated midway between the left and right sidewalls of the electronics module.

3. An electronics module comprising:

a cable clamp chassis projecting outward from a wall of the module, said cable clamp chassis comprising a one-piece metallic structure including first and second cable mounting locations adapted to receive respective first and second associated cables, said first and second cable mounting locations each comprising an axially extending recess located adjacent a first reference plane (P) in which respective longitudinal axes of the first and second associated cables lie, and each of said first and second cable mounting locations comprising an inner surface including an innermost point that lies tangent to a second reference plane (P**2**) that is parallel to and offset from the first reference plane P such that the first and second cables are arranged in a zero stack configuration;

a clamp secured to said cable clamp chassis and adapted to secure the first and second associated cables in the first and second cable mounting locations.

4. The electronics module as set forth in claim **3**, wherein the second plane (P**2**) is offset from the first reference plane (P) by a distance equal to half a maximum diameter of the first and second associated cables such that the longitudinal axis of each of the first and second associated cables will be located in the first reference plane (P).

5. The electronics module as set forth in claim **3**, wherein said cable clamp chassis comprises:

a base connected to a wall of said electronics module;

an elongated arm projecting outwardly from the base, wherein the first and second cable mounting locations are connected to an outer end of the arm and are located on opposite sides of the arm, and wherein the outer end of the arm comprises an aperture defined therein and located between the first and second cable mounting locations.

6. The electronics module as set forth in claim 5, wherein:

the clamp comprises an elongated bar structure including first and second cable receiving recesses defined in an inner surface of the clamp and including an aperture located between the first and second cable receiving recesses; and

said electronics module further comprises:

a fastener that extends through said aperture defined in said arm of said clamp chassis and through said aperture defined in said clamp;

a nut engaged with the fastener such that said fastener and nut capture said clamp to said clamp chassis with said first and second cable receiving recesses of said clamp located in opposed facing relation with said first and second cable mounting locations, respectively, such that a first cable receiving space is defined between the first cable receiving recess of the clamp and the first cable mounting location of the clamp chassis and a second cable receiving space is defined between the second cable receiving recess of the clamp and the second cable mounting location of the clamp chassis, said first and second cable receiving spaces respectively adapted to accommodate and retain the first and second associated cables, with an EMI shield of each first and second associated cable electrically connected to said cable clamp chassis.

7. The electronics module as set forth in claim 6, wherein the fastener electrically connects the clamp to the clamp chassis.

8. The electronics module as set forth in claim 6, wherein said clamp comprises a recess located in an outer surface and into which said aperture of said clamp opens, and wherein said nut is located in said recess and restrained against rotation with said fastener.

9. The electronics module as set forth in claim 8, wherein:

said aperture of said clamp is defined about a central axis that intersects inner and outer surfaces of said clamp;

said aperture and said recess are both elongated along a major axis that intersects said central axis of said clamp aperture.

10. The electronics module as set forth in claim 9, wherein:

said recess comprises a floor including first and second tapered floor surfaces respectively located on opposite first and second sides of said clamp aperture;

a respective distance defined between said first and second floor surfaces and said outer surface of said clamp increases as said first and second floor surfaces extend away from said central axis of said clamp aperture along said major axis;

a region of the floor surrounding and adjacent the clamp aperture provides a primary axial thrust surface oriented perpendicular to the central axis of the clamp aperture, and the first and second offset floor surfaces respectively provide first and second offset thrust surfaces that are angled in respective first and second directions relative to the central axis of the clamp aperture.

11. The electronics module as set forth in claim 10, wherein:

the fastener comprises a shank that extends along a longitudinal axis, and wherein the clamp is movable to:

a first angularly offset position wherein a first clamp offset angle (−z) is defined between the longitudinal axis of the fastener shank and the central axis of the clamp aperture, and in which the nut is abutted with the second offset thrust surface;

a second angularly offset position wherein a second clamp offset angle (+z) is defined between the longitudinal axis of the fastener shank and the central axis of the clamp aperture, and in which the nut is abutted with the first offset thrust surface.

12. The electronics module as set forth in claim 6, wherein:

said aperture of said clamp chassis comprises a counterbore including a transverse face comprising a plurality of locking projections; and,

said fastener comprises a plurality of locking projections that engage said locking projections of said transverse face of said counterbore to inhibit rotation of said fastener relative to said clamp chassis.

13. The electronics module as set forth in claim 12, wherein said locking projections of said transverse face of said counterbore and said locking projections of said fastener each comprise a plurality of locking teeth each comprising a ramped lock face.

14. The electronics module as set forth in claim 6, wherein said fastener comprises a ratchet mechanism including a pawl and a ratchet wheel, wherein said ratchet wheel is connected to a threaded shank of said fastener and said pawl transmits torque to said ratchet wheel from a handle of said fastener, wherein said pawl is selectively movable between first and second operative positions for transmission of torque from said handle to said ratchet wheel in respective first and second directions.

15. The electronics module as set forth in claim 6, further comprising at least one cable size adapter connected to said clamp adjacent at least one of said first and second cable receiving recesses, said at least one cable size adapter comprising an inner face abutted with said clamp and an outer face defining a concave cable receiving location adapted to contact one of the first and second associated cables, wherein said at least one cable size adapter is selectively connected to and disconnected from the clamp.

16. The electronics module as set forth in claim 15, wherein said clamp comprises first and second mounting holes that open respectively into the first and second cable receiving locations of the clamp, and wherein the at least one cable size adapter comprises a post projecting outwardly therefrom that is releasably engaged with one of the first and second mounting holes of the clamp.

17. The electronics module as set forth in claim 16, wherein the at least one cable size adapter comprises an inner face that is abutted with said clamp and that defines a curved cam surface that urges said cable size adapter away from said clamp when said cable size adapter is twisted relative to said clamp.

18. The electronics module as set forth in claim 6, further comprising a spring coaxially positioned about said fastener and located between said clamp chassis and said clamp for biasing said clamp away from said clamp chassis.

19. An electronics module comprising:

a cable clamp chassis projecting outward from a wall of the module, said cable clamp chassis comprising first and second cable mounting locations adapted to receive respective first and second associated cables, said first and second cable mounting locations each comprising an axially extending recess located adjacent a first reference plane (P) in which respective longitudinal axes of the first and second associated cables lie, and each of said first and second cable mounting locations comprising an inner surface including an innermost point that lies tangent to a second reference plane (P**2**) that is parallel to and offset from the first reference plane P such that the first and second cables are arranged in a zero stack configuration, wherein the second plane (P**2**) is offset from the first reference plane (P) by a distance equal to half a maximum diameter of the first and second associated cables such that the longitudinal axis of each of the first and second associated cables will be located in the first reference plane (P), wherein said cable clamp chassis comprises:

a base connected to a wall of said electronics module;

an elongated arm projecting outwardly from the base, wherein the first and second cable mounting locations are connected to an outer end of the arm and are located on opposite sides of the arm, and wherein the outer end of the arm comprises an aperture defined therein and located between the first and second cable mounting locations;

a clamp secured to said cable clamp chassis and adapted to secure the first and second associated cables in the first and second cable mounting locations, wherein the clamp comprises an elongated bar structure including first and second cable receiving recesses defined in an inner surface of the clamp and including an aperture located between the first and second cable receiving recesses;

said electronics module further comprising:

a fastener that extends through said aperture defined in said arm of said clamp chassis and through said aperture defined in said clamp;

a nut engaged with the fastener such that said fastener and nut capture said clamp to said clamp chassis with said first and second cable receiving recesses of said clamp located in opposed facing relation with said first and second cable mounting locations, respectively, such that a first cable receiving space is defined between the first cable receiving recess of the clamp and the first cable mounting location of the clamp chassis and a second cable receiving space is defined between the second cable receiving recess of the clamp and the second cable mounting location of the clamp chassis, said first and second cable receiving spaces respectively adapted to accommodate and retain the first and second associated cables, with an EMI shield of each first and second associated cable electrically connected to said cable clamp chassis.

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