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Linn et al.

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[45] **May 8, 1973**

[54] **CONNECTOR FOR HIGH AMPERAGE APPLICATIONS**

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[52] **U.S. Cl.** .....**339/198 N,** 339/242, 339/272 R

[51] **Int. Cl.** **H01r 9/00**

[58] **Field of Search**.....339/198 R, 198 E, 339/198 C, 198 G, 198 GA, 198 H, 198 J, 198 K, 198 S, 198 P, 198 M, 198 N, 14 R, 272 R, 272 B, 272 U, 272 A, 263 R, 263 B, 263 E, 263 L, 263 S, 19, 242; 174/71, 90

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[57] **ABSTRACT**

A unitary connector particularly suitable for high amperage applications is disclosed. It provides a high density of smaller conductor connections per length of connector. In spite of the high density, the connection of any one conductor can be adjusted without disturbing the connection of any other conductor. The connector greatly facilitates visual inspection of all connections for confirmation of the completeness and security of each connection. The connector body can be made from metal extrudate, and current passing through the integral connector does so without passing across butting interfaces between elements within the connector assembly.

9 Claims, 6 Drawing Figures

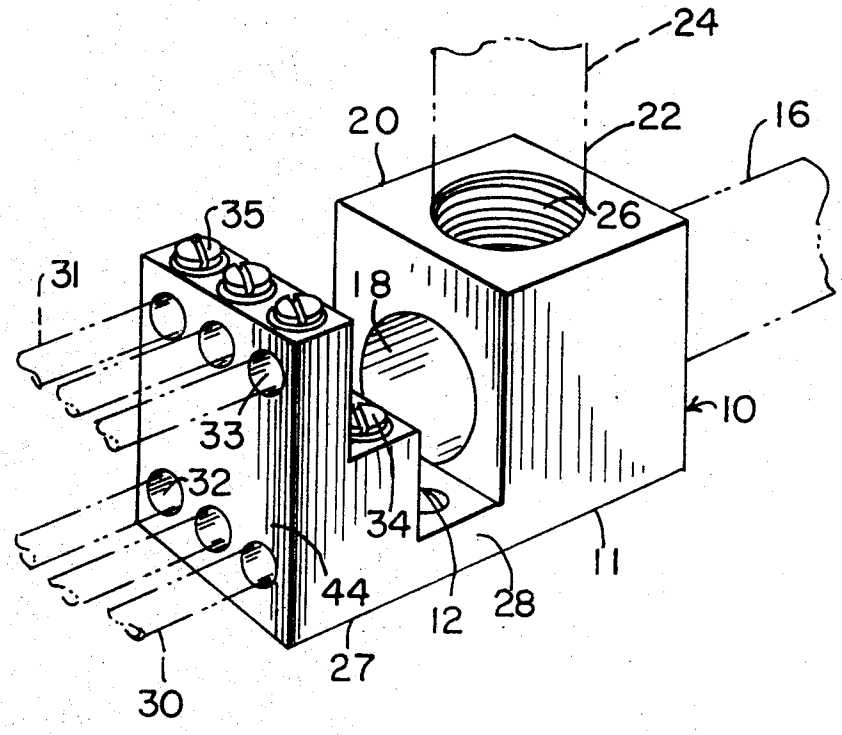


Fig. 1

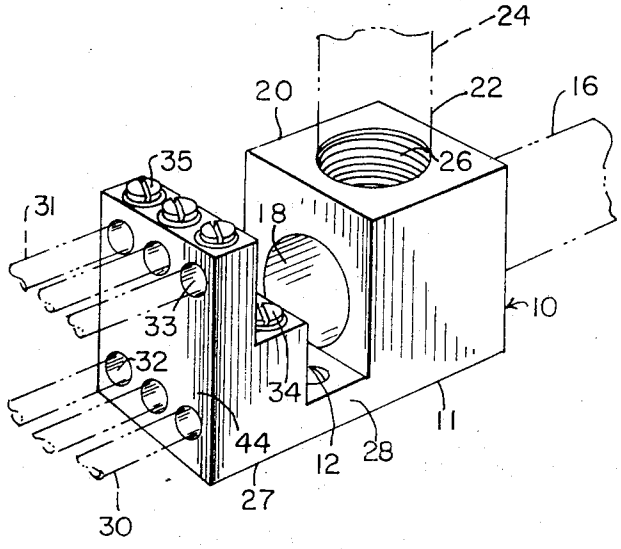
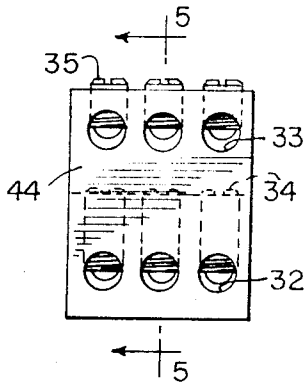


Fig. 2



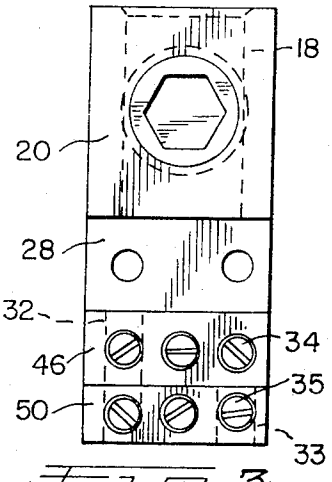


Fig. 3

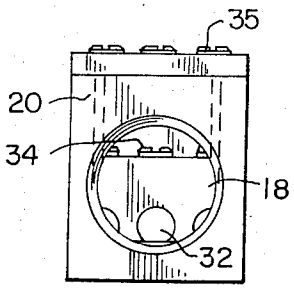
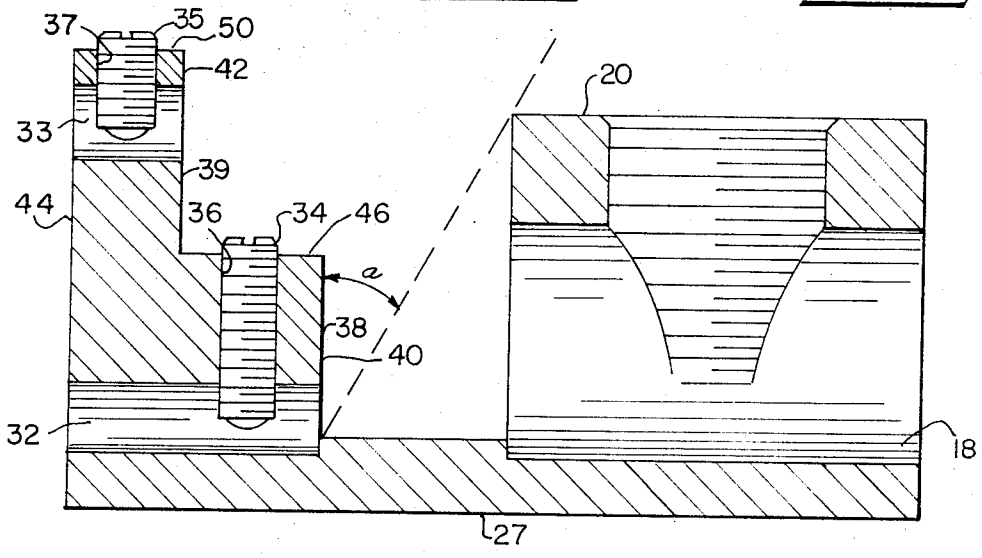


Fig. 4

Fig. 5



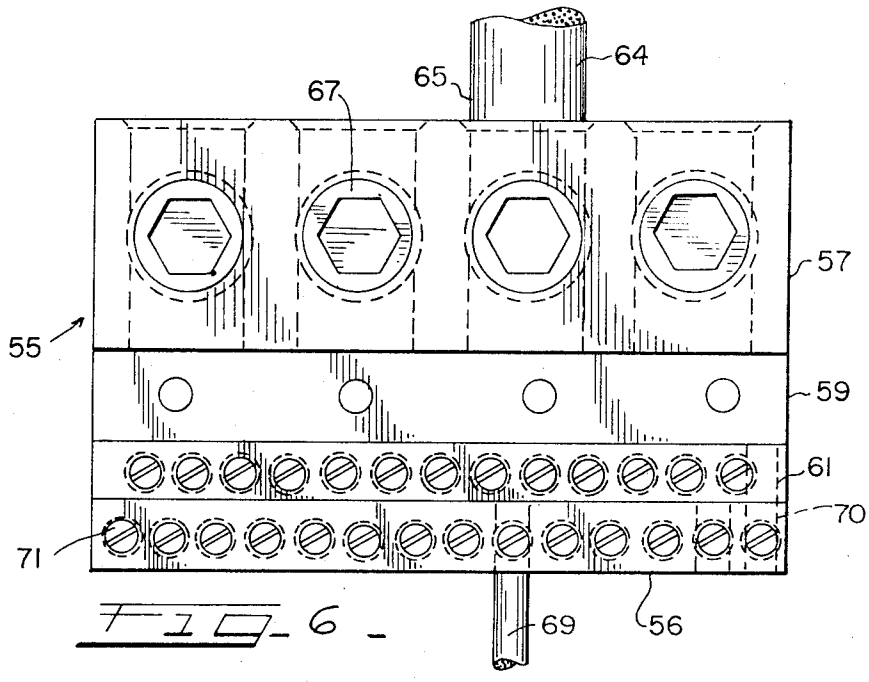


FIG. 6

CONNECTOR FOR HIGH AMPERAGE APPLICATIONS

This invention relates to distribution of electrical power to a plurality of branch circuits and particularly pertains to a unitary connector for electrically connecting a plurality of conductors to a common potential. The connectors of the present invention are suitable for use as feeder bars, neutral junction connections, and the like, and power distribution systems involving relatively high amperage, such as for example, 100 amps and higher.

This invention is an improvement over the invention disclosed in copending application Ser. No. 221,975 filed Jan. 31, 1972 by Richard L. Linn for Connector For High Amperage Applications, both applications being owned by a common assignee.

It is an object of the present invention to provide a unitary electrical connector which is relatively inexpensive to manufacture, which is suitable for use in high amperage applications, and which does not involve the use of butting interfaces within a connector assembly across which the current would pass.

It is another object of the present invention to provide such a unitary connector which cannot only accommodate relatively large ground or supply conductors, but moreover can accommodate a relatively high density of smaller conductors per length of connector face for feeding a plurality of individual loads.

Another object of the present invention is to provide a connector which greatly facilitates visual inspection of the unit after all electrical connections are made, for confirmation that each of the electrical connections is complete and secure.

It is a further object of the present invention to provide a connector which not only can accommodate a high density of smaller connections per length of connector face, but also permits adjustment of the securing means for any individual conductor without disturbing the securing means for connecting any other conductor connected thereto.

These and other objects are all achieved in accordance with the present invention which is described herein and with the aid of the accompanying drawings in which:

FIG. **1** is a perspective view of a preferred embodiment of the present invention;

FIG. **2** is an end view taken toward the end of the connector which is shown at the left of FIG. **1**;

FIG. **3** is a top view of the connector shown in FIG. **1**;

FIG. **4** is an end view of the end opposite that shown in FIG. **2**;

FIG. **5** is a cross sectional view taken approximately along the lines **5—5** of FIG. **2**; and

FIG. **6** is a top view of an alternative embodiment of the present invention.

In FIG. **1** a unitary metal connector in accordance with the present invention is generally indicated by the numeral **10**. Connector **10** comprises a unitary integral segment **11** of metal extrudate, securing means for electrically connecting a plurality of conductors thereto, and other important structural features. Connector **10** is secured by securing means, such as threaded fasteners **12**, to an insulating support (not shown), and conventionally is installed within a suitable box or cabinet (not shown because conventional).

In the illustrated embodiment a large conductor **16** is secured within a substantially circular opening **18** which passes through a first enlarged portion **20** of connector **10**. Conductor **16** is secured therein by compression by means of a set screw **22** (indicated by broken lines **24** in FIG. **1**), which can be threaded within opening **26** which, in turn, communicates with opening **18**.

First enlarged portion **20** of connector block **11** is connected to a second enlarged portion through a relatively narrow central bridging portion **28**. The space or gap between enlarged portions **20** and **27** is sufficiently great to provide a line of sight over the top of portion **20** to the junction between bridge **28** and portion **27**. This line of sight forms an angle of at least 10°, and more preferably at least 20° with the adjacent part of portion **27**. (See angle *a*, FIG. **5**).

A number of smaller conductors **30, 31**, such as for example, feeder wires, are receivable in respective openings **32, 33** which pass through second enlarged portion **27**. As used herein, the numeral **30** is intended to indicate any of the conductors which are secured within one of the lower openings **32** (as viewed in FIG. **1**) and **31** is intended to include any of the conductors affixed in any of the upper openings **33**.

The conductors **30** of the lower tier are secured by compression in the respective openings **32** by adjustment of respective set screws **34**. Conductors **31** are secured by compression in their respective openings **33** by adjustment of respective set screws **35**. Thus, when secured, all conductors are pressed directly against the integral metal body **11** of the connector **10**. Set screws **34, 35** are threaded through respective tapped openings **36, 37** which are positioned to direct the respective set screws across the respective conductor-receiving openings **32, 33**.

It is noted that openings **32, 33** pass entirely through section **27**. Although it is not essential that pass-through openings be employed, and "blind" openings of sufficient depth can be employed, it is preferred that all conductor-receiving openings pass entirely through section **27**. In such an embodiment in which pass-through openings **32, 33** are employed, the completed connector system can be visually inspected for confirmation that the conductors in each of the respective openings have been inserted a sufficient distance to provide a complete and secure electrical connection. When pass-through conductor-receiving openings are employed, and when conductors are inserted sufficiently to cause the ends thereof to extend at least to the inner sides **38, 39** of enlarged portion **27**, the completed assembled unit can be visually inspected by glancing down along sides **38, 39**, to visually confirm the proper insertion of each of the conductors. When "blind" conductor-receiving holes are employed, it is not uncommon for inadequate or incomplete insertion of the conductor to be encountered. In the high amperage applications to which the present invention primarily directs itself, the use of multiple strand cable is conventional. When such cable is inserted in the conductor-receiving openings, there is a tendency for some of the strands to jam against burrs, threads, etc., and give the impression that the conductor is completely inserted past the set screw. Tightening of the set screw under such circumstances may provide a very insecure

electrical connection. On the other hand, in accordance with the preferred embodiment of the present invention in which pass-through openings are utilized and sufficient spacing is provided between the enlarged lateral portions **20**, **27** to permit visual inspection, it will be immediately apparent whether the individual cables are completely and properly inserted for secure electrical connection. This visual inspection is particularly facilitated as a consequence of the novel structural relationships between the elements of the present invention, and these relationships are now discussed in further detail.

The second enlarged portion **27** has a cross section (as seen in FIG. **5**) resembling stairs, and comprises steps **40**, and **42**. It is noted that, as shown in FIG. **5**, the steps **40**, **42** are so positioned that successive steps descend as the first enlarged portion **20** is approached along a line drawn through steps **40**, **42** toward the enlarged portion **20** such as for example, along a line proceeding in a direction from the left of FIG. **3** through second enlarged portion **27** toward first enlarged portion **20**.

Openings **32**, **33** pass through side face **44** and thence through walls **38**, **39**, respectively. Thus first step **40** includes a side face **38** through which openings **32** pass, and a top surface **46** through which openings **36** pass. The second higher step **42** includes a side face **39** through which openings **33** pass and a top surface **50** through which openings **37** pass. Additional steps can be provided if desired. Thus openings **32** pass through the entire width of surfaces **50** and **46**, whereas openings **33** pass through portion **27**, the width of surface **50**.

Thus in the embodiment illustrated in FIGS. **1**, **2** and **3**, a single large conductor **16** approaches connector **10** along a line from a first direction, and smaller conductors **30**, **31** enter conductor **10** along parallel lines from the opposite direction, and current can pass directly through the connector segment **11** without passing through butting interfaces such as those which would be encountered in a non-unitary connector comprising a number of assembled elements.

As a consequence of the positioning of enlarged portions **20**, **27** on opposite sides of narrow central bridging portion **28**, and providing openings along the sides **44**, **51** of the connector **10** to accomodate and secure the conductors and by arranging the connections for the smaller conductors along the steps **40**, **42**, relatively high density smaller connector input is achieved along the length of enlarged portion **27**. Moreover as a result of this configuration, all the set screws **22**, **34**, **35** and threaded fasteners **12** are accessible from the same direction (i.e., from the top as viewed in FIG. **5**) and this provides considerable convenience and facilitates safety during the course of installation or servicing of the connector connections or the distribution system. Moreover, as a consequence of these spacings between enlarged portions **20** and **27** and as a consequence of the arrangement of the present invention in which steps **40**, **42** ascend in the direction away from the enlarged portion **20**, and in combination with the pass-through openings **32**, **33**, two major advantages are achieved. First of all, visual inspection by glancing along surfaces **38**, **39** readily confirms whether or not conductors **30**, **31** are completely and securely secured. The staggering of the steps in the direction away from enlarged portion **20** provides very large line of sight angles with surface **39**, and the surfaces of any additional steps, thus affording an even better view of the secured conductor. Secondly, because of the particular configuration of the steps, the particular set screws **34**, **35** which secure any particular conductors **30**, **31** can be adjusted without disturbing the set screws which secure any other conductors **30**, **31**. This greatly increases the convenience of making changes, and facilitates safety during the course of installation, or servicing.

In the preferred illustrated embodiments, all conductors enter the connector **10** through parallel lines into two opposite sides of the connector **10**. However, the connecting means for the large conductors **16** could be arranged to accept conductors approaching from different directions, e.g., from the bottom, but this would involve changing the direction of approach of tools for adjustment of conductor-securing means.

In the embodiment illustrated in FIG. **1** six smaller conductors **30**, **31** are accomodated along a length of extrudate which is not quite twice the diameter of the large conductor **16**. As indicated above, more steps (not shown) which are substantially identical to steps **40**, **42** can be provided adjacent step **42**, in which case still more smaller conductors could be accomodated by a connector having the same length.

In the embodiment illustrated in FIG. **6**, a greater length of metal extrudate **56** is employed to provide a connector **55** which is suitable for higher amperage applications even through it has a cross section which is substantially identical to that shown in FIG. **5**. Connector **55** comprises a first enlarged portion **57**, a central narrow bridging portion **59** and a second enlarged portion **61**. These and other elements are similar to the corresponding elements in the first described embodiment. For example, openings **63** are provided in the central bridging portion **59** to accommodate fasteners, for example, threaded fasteners **12** or rivets (not shown), to secure connector **55** to an insulating support (not shown because conventional). Large conductors **64** are admitted through openings **65**, which are equivalent to openings **18** in the first described embodiment, and are secured therein by compression by set screws **67**. Smaller conductors **69** are received in pass-through openings **70** corresponding to openings **32**, **33** and are secured therein by set screws **71**.

The embodiment illustrated in FIG. **6** is particularly useful for very high amperage applications. For example, for very high applications, instead of utilizing extremely large diameter conductors, which are difficult to pull, bend and install, it is more convenient to use a number of relatively smaller large cables which are easier to pull, bend and install, and yet which provide in aggregation the same current carrying capacity as the one extremely large diameter conductor. One of the individual smaller large cables is indicated in FIG. **6** by the numeral **64**.

In the embodiment shown in FIG. **6** the conductor **55** can accommodate four such large conductors **64** and 27 smaller conductors **69**.

The unitary metal piece **11** from which conductor **10** is manufactured is a length of metal extrudate having a cross section shown in FIG. **3**. The depth of the bridge

portion **28**, **59** is chosen to amply accommodate anticipated current even though one or more passages **52**, **63** are provided in bridge portion **28**, **59**, respectively, to accommodate fasteners. In the preferred embodiments a metal extrudate is utilized, and the structural elements corresponding to first enlarged portions **20**, **57**, bridging portions **28**, **59** and second enlarged portions **27**, **61** are automatically produced during the extrusion. The extrudate metal segment after appropriate hardening treatment, if desired, is cut into appropriate lengths and holes are drilled and tapped as desired. Alternately, the holes can be drilled and tapped before the larger segments of extrudate are cut into operating segments **11**, and segments **56** from which connector **55** is made.

Although any conducting solid metal can be used to make the conductor of the present invention, preferred metals are those metals having a tensile strength greater than about 35,000 psi and a yield strength greater than about 25,000 psi. It is unnecessary to use an expensive material such as highly conductive silver in accordance with the present invention. Copper or aluminum can be employed, and other solid conducting metals can be used. A most preferred metal, however, is an aluminum alloy identified as AA 6061. This is a heat-hardenable extrudable aluminum alloy having approximately the following constituents in addition to aluminum.

silicon	0.4–0.8% (nominally 0.6%)
iron	less than 1%
copper	0.15–0.4% (nominally 0.25%)
manganese	0.15% max.
magnesium	0.08–1.2% (nominally 1.0%)
chromium	0.15–0.35% (nominally 0.25%)
nickel	none
zinc	0.25% max.
titanium	0.15% max.
others	0.05% max.

Physical characteristics of these and other alloys are described in Metals Handbook, Eighth Edition, Volume I, Properties and Selection, published by the American Society for Metals (See page 917 for description of Aluminum 6061). The preferred Aluminum 6061 is that metal which has been heat treated to provide a hardness identified as T-6. This metal has a yield strength of 37,000 psi and a tensile strength of 42,000 psi. Consequently, even though the electrical volume conductivity of this metal is only 40 percent IACS, the physical characteristics of this alloy, particularly the high strength and low cold flow, are believed to be factors contributing to its outstanding success when used in the connector of the present invention.

In illustrated embodiments of the present invention the enlarged side portions **20**, **27** and **57**, **61** are connected by relatively thin bridging portions **28** and **59** respectively, near the base thereof. These bridging portions **28**, **59** can be eliminated, and the connector **10** secured to an insulating support by means of threaded fasteners, etc., extending through the insulating support into the bottom of connector **10**. However, it is much more preferable to provide the narrow bridging portion since several additional advantages accrue as a result. For example, the presence of the gap above the bridging portion **28** or **59** between enlarged portions **20** and **27**, or between enlarged portions **57**, and **61**, respectively, combined with the use of pass-through openings **18**, **32**, **33**, **64**, **70**, assists the installer in visually confirming complete insertion of the conductors **16**, **30**, **31** within their respective securing openings **18**, **32**, **33**. Thus, upon insertion of conductors **16**, **30**, **31** into their respective securing openings, until the respective conductor is visible at walls **38**, or **78** above bridge portion **28** or **59**, respectively, provides confirmation of the positioning of the respective smaller conductor that the necessary secure and complete electrical connection is made. Visual inspection of the completeness and security of the connection of the larger wires is also facilitated in the same way.

In general, the structural relationships and spacings of the preferred connector of the present invention are such that the line of sight over the top inner edge of first enlarged portion **20**, **27** receiving the large conductor forms an angle of at least 10° and preferably more than 20° with the bottom of the nearest wall of the second enlarged portion (angle *a*, FIG. **3**).

It will be appreciated that all of the laterally extending planes formed by the body **11**, **56** such as for example, inner sides **38**, **78** and sides **44**, **48**, which form vertical planes, and also horizontally extending surfaces such as, for example, top surfaces **46**, **50**, and all the other laterally extending surfaces of the body, extend the entire width of the body, encountering no other transverse structural elements of body **11**, **56**. Thus the topography or external surfaces of the general cross section of the body **11**, **56**, is substantially constant from end to end, except of course for the conductor-receiving and set screw-receiving openings.

We claim:

1. A unitary connector comprising: an integral body portion consisting of a single piece of solid metal having two ends and being shaped such that the topography of the general cross section of the body is the same from end to end, and in which said general cross section comprises first and second laterally positioned enlarged portions, said first and second enlarged portions being joined near the bases thereof by an integral relatively thin bridging portion, whereby adjacent opposing sides of said first and second enlarged portions are spaced apart from each other, said cross section having a shape such that steps are provided in said second enlarged portion, said steps being ascending in the direction away from said first enlarged portion; said first enlarged portion comprising first recess means for axially receiving a large conductor through one side of said body, and first securing means for compressing said large conductor transversely against said body within said recess means; said second enlarged portion including a plurality of second recess means for axially receiving respective smaller conductors perpendicularly through another side of said body, and second securing means for compressing said respective smaller conductors transversely against said body within said second recess means, said second recess means comprising sets of recesses passing through respective parallel faces of said steps, and said second securing means passing transversely to said conductors through respective tops of said steps.

2. The connector of claim **1** in which said first and second recess means are parallel and enter said body from opposite sides of said body, and wherein said recess means comprise channels passing through said

respective enlarged portions into the space above said bridge and between said enlarged portions, and wherein said first and second enlarged portions are spaced apart a sufficient distance such that a line of sight over the top edge of said first enlarged portion and extending to the juncture of the thin bridging portion and the adjacent opposing side of the second enlarged portion forms an angle of at least 10° with opposing side.

3. The unitary connector of claim 2 in which said line of sight passing over the top of the first enlarged portion forms an angle greater than 20° with said opposing side of said second enlarged portion.

4. A connector of claim 1 in which said first enlarged portion includes a plurality of first recess means and first securing means for receiving and securing a plurality of respective large conductors.

5. A unitary connector particularly suitable for high amperage applications comprising: an integral body consisting of a single piece of solid metal having two ends and a cross section with uniform external shape the entire width of said body between said ends, said body comprising first and second enlarged lateral portions connected by a relatively narrow integral bridging portion disposed between the bases of the lateral portions whereby opposing sides of said first and second lateral portions are spaced apart; first recess means for receiving a large conductor, and first securing means for compressing said large conductor in said first recess means, said recess means and securing means being positioned in said first enlarged lateral portion of said body; said second enlarged portion being shaped to include at least a portion thereof which has a cross section in the form of steps wherein said steps are ascending in the direction away from said first enlarged portion, and wherein a first surface of the steps is parallel with said opposing side of said first enlarged portion, and a second surface of the steps is in a plane which is transverse to the step's first surface; said second recess means comprising a plurality of pass-through recesses passing completely through said second enlarged portion, said pass-through recess being sized for receiving smaller conductors, said pass-through recesses opening in the first surfaces of said steps, and said second securing means passing transversely to said first respective recesses through said second surface of said steps; and wherein a line of sight drawn over the top of the first enlarged portion to the juncture of the bridging portion and the first surface of the adjacent step forms an angle of at least 10° with said first surface of said adjacent step.

6. The connector of claim 5, wherein all the recess means are parallel and pass through their respective enlarged portions and open into the space between the enlarged portions.

7. The connector of claim 5 wherein the first enlarged portion comprises a plurality of said recess means and said securing means for receiving and securing a plurality of respective larger conductors.

8. The connector of claim 5 wherein at least one opening passes through said bridging portion, said opening being sized to receive a fastener for securing said body to an insulating support.

9. The connector of claim 5 in which said securing means comprises set screws, and in which said set screws enter said body from the same direction which is transverse to the base of the connector.

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