Sept. 8, 1953 M. D. BERGAN 2,651,767

BOLTED BUS CONNECTOR

Filed March 11, 1946 2 Sheets-Sheet 1

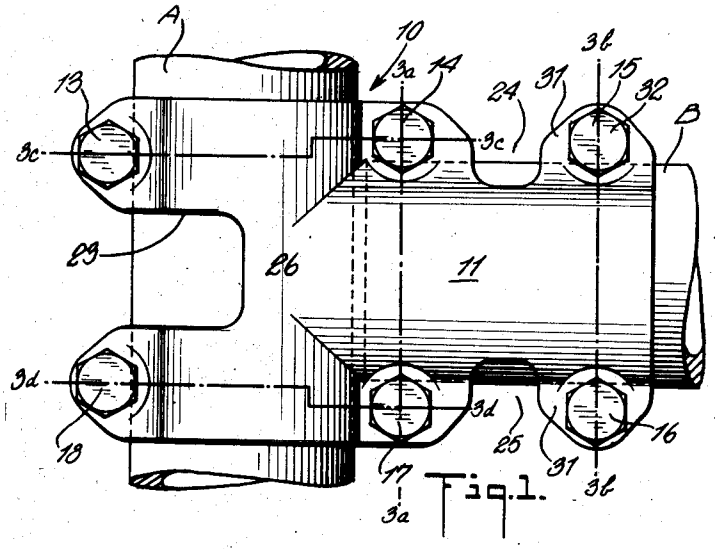


Fig. 1.

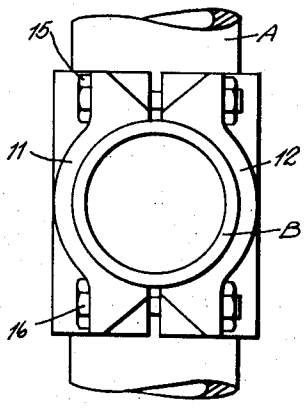


Fig. 4.

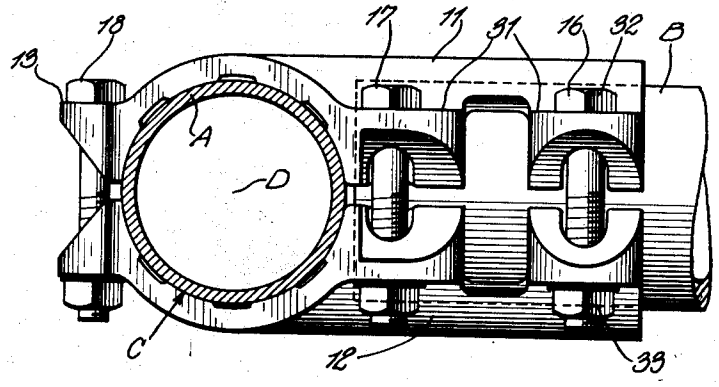


Fig. 2.

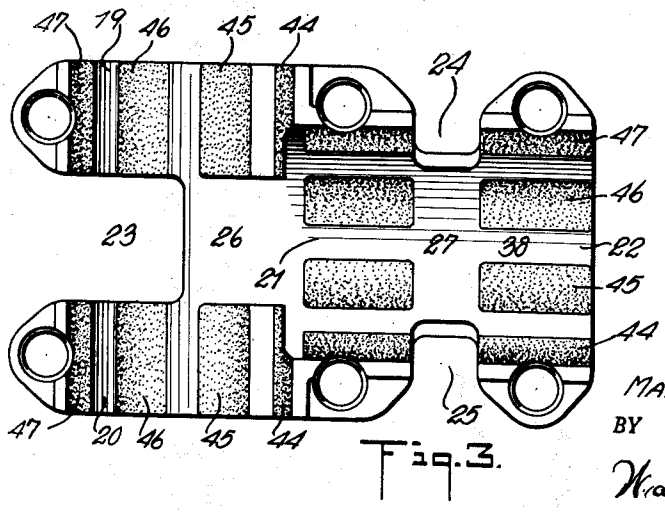


Fig. 3.

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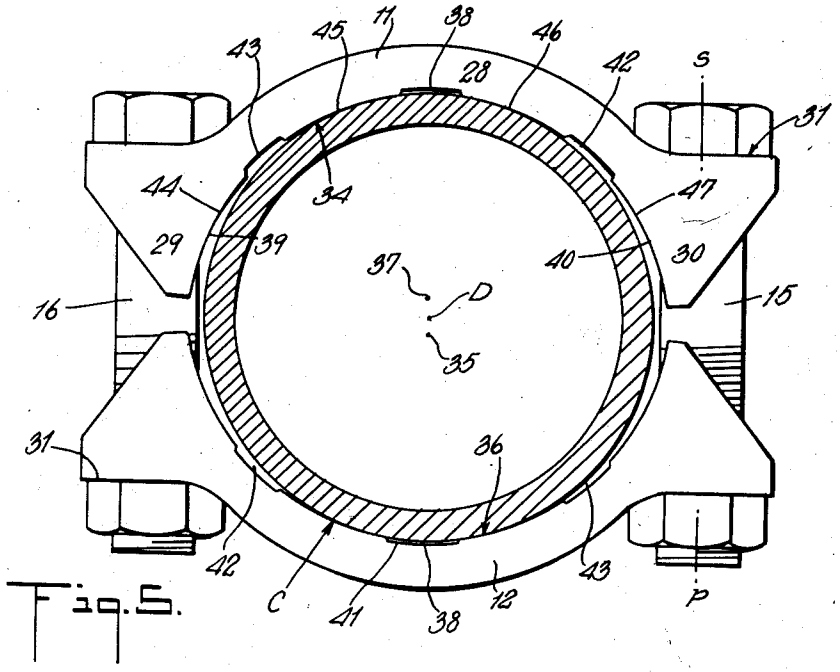


Fig. 5.

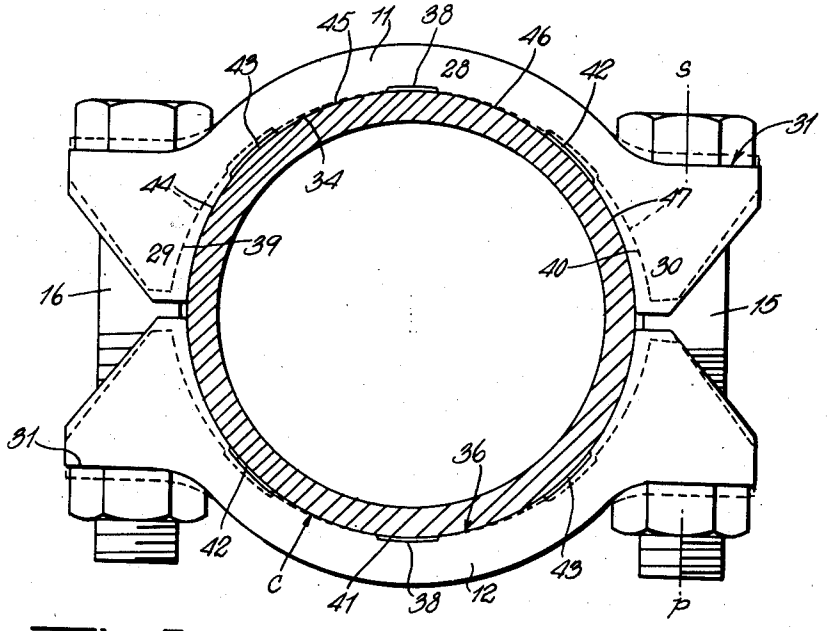


Fig. 6.

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BOLTED BUS CONNECTOR

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Application March 11, 1946, Serial No. 653,631

4 Claims. (Cl. 339—265)

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The invention relates to a metallic clamp for mechanically and electrically connecting two cylindrical connectors or bus bars. Known forms of such connectors have not proven satisfactory in practice due to many reasons. For instance, they often fail solely because of fatigue in the metal of which they are formed, especially after they have been in use for a time. This fatigue of the metal is due, as is now found, to an improper distribution of the stress strains imposed thereon as they are installed in position and this in turn is due, first to an improper design of the connector considered as a whole.

In general, the primary object of the invention is to provide a form of bus connector which will function efficiently over a long period of time and which will tend to avoid fatigue of its metal even when exposed to the vibration to which such devices are subjected when in use.

This objective is obtained by a peculiar design of the clamping jaws of the connector featuring semi-flexibility in those parts of their clamping faces which are in direct engagement with the surfaces of the conductors engaged thereby and otherwise contoured so that strains applied between the lines of clamping bolts will provide for the necessary degree of cold-flowing of the jaws forming the clamping frame to cause them to conform to the external configuration of the conductor or conductors, and with the parts thereof co-related so that when tightening one line of bolts there is a minimum of interference to the cold-flowing of the fitting in conforming itself to the detailed portions of conductors engaged thereby.

The desired degree of flexibility in what is generally regarded as a rigid form of clamping jaws is provided by forming the clamping surfaces with one or more shallow grooves extending lengthwise of the conductors and designed to provide lines of weakened cross section of material, and which lines form in effect hinge lines which permit the jaws of the clamp to wrap down about the conductors clamped thereby.

While the disclosure features a limited degree of flexibility in the parts designed to be distorted into a fit with the particular conductors clamped thereby, on the other hand the design of the connector features the maximum degree of rigidity in those strain transmitting parts, like the bolt flanges, where any flexibility would be a disadvantage. In general, the invention features a design of connector which can be formed of a limited mass of conducting material but in which the metal is distributed in such a way as

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to obtain the maximum efficiency in current transmission between the same and the conductors engaged thereby.

It is generally known that greater current capacity can be carried from one conductice face to another through small areas of high pressure than through large areas of low pressure. The present disclosure features a form of connector in which the contacting faces are of reduced area and arranged to be applied to the associated conductors under heavy load. However, as a practical matter, electric connections of the type herein discussed must be made in situ and with no more force available than can be supplied manually by the linesman making the connection.

Accordingly, an object of the invention is to provide a jaw clamp form of connector, the clamping faces of which will be of less area than would be provided normally by the jaws if their contacting areas were not so reduced, and in this way utilize to its best advantage, the available manually imposed squeeze pressure acting through the bolts over relatively small contact areas, and thus to obtain the best possible electric engagement between the conductors and the connector.

Forming the clutching surfaces of the jaws of the clamp with one or more shallow grooves particularly when arranged in parallel relation to the axes of bend of the connector provides contact areas of reduced dimensions, hereinafter referred to as pressure pads, disposed to utilize the manually imposed load thereon to give the desired high pressure per unit of surface engaged.

The present disclosure thus features a progressive utilization of the available manual effort of the operator distributed so that the force applied at each succeeding turn of the bolts is available to bend successive, and in each case a limited and restricted area of metal, and as the clamping effect progresses, its long clamping pads tend to readjust themselves automatically, and structure is designed so that an increased leverage effect is available to press the pads nearest the bolts into bearing engagement with the conductors with the full powerful squeeze effect of the bolts. Forming the clutch surfaces as separated pressure pads as herein featured has the advantage of providing better heat dissipation than is provided by the known types of connectors having clutch faces with smooth continuity of clutching surfaces.

The present disclosure also features the providing of the pressure pads with their originally

cast metal and thus not machined, surfaces with minute projections which penetrate through the oxide skin formation found in such cases, and thus provide sharp or roughened surfaces which will penetrate the oxide film forming minute depressions therein to permit the contacting surfaces of conductor and connector to be brought into an intimate metal-to-metal-contact.

Fig. 1 is a plan view of a T-form of connector engaging and electrically connecting a pair of tubular conductors and constituting a preferred embodiment of the invention;

Fig. 2 is a side view of the connector of Fig. 1, showing one of the conductors in cross section and the other in side elevation;

Fig. 3 is a plan view looking down into the lower jaw of the connector shown in the preceding figures;

Fig. 4 is a view in elevation of the device looking at the same from the right side of Fig. 1;

Figs. 5 and 6 are enlarged explanatory views showing the engagement of the connector in end elevation corresponding to Fig. 4, with one of the conductors and which insofar as the clutching surfaces are concerned can be regarded as a showing in cross section on any of the lines 3*a*—3*a*, 3*b*—3*b*, 3*c*—3*c* or 3*d*—3*d* of Fig. 1;

Fig. 5 shows the position of the jaws each in its normal, non-distorted form and in position lightly engaging a tubular conductor at its crown at the beginning of the bolt tightening operation, and

Fig. 6 shows in full lines the position of the jaws at the end of the bolt tightening operation, and in dotted lines shows the normal position of the jaws corresponding to their initial position, as shown in Fig. 5.

In the drawings and referring first to Figs. 1 and 2, there is disclosed an end of a copper tubular conductor A forming a T with another similar conductor B. These conductors in the illustrated case are each rugged one and seven-eighths inch copper tubes, not intended to be distorted under the squeeze pressures hereinafter referred to, and on the contrary are intended to act as rigid mandrels about which the castings forming the connector herein featured may be sprung out to fit the particular conductors used. The conductors are shown to be tubes whose outer surfaces are as close to being true cylinders as is usual with such tubular conductors as are now available on the market and which cylinders will sometimes hereinafter be referred to as a cylinder of reference, marked C in Figs. 5 and 6 and whose axis is at the axis D respectively of the cylinders A or B.

The two conductors are clamped to each other through the connector or clamping frame **10**, particularly forming the subject matter of this disclosure. This connector comprises primarily two identical clutch jaws or half frames identified for convenience of reference in some of the figures as an upper jaw **11** and a lower jaw **12**. The jaws are secured together in position snugly clamped about the two conductors by six bolts numbered clockwise in Fig. 1 as **13**, **14**, **15**, **16**, **17** and **18**. These bolts are arranged in transverse pairs, with bolts **14** and **17** located in the two corners formed between the conductors A and B; with an outer or right-hand pair of bolts **15** and **16**, disposed on opposite sides of the conductor B and with bolts **13** and **18** coacting respectively with bolts **14** and **17** to clamp conductor A. It is a feature of this disclosure that the bolts are located as close to the sides of the conductors as

it is possible to locate them without actually touching the perimeters of the conductors.

As the two jaws are identical the detailed description of one will equally fit the other. Each jaw is a heavy casting and in the instant case is formed of a copper alloy of a lower conductivity rating than is the pure copper used in competitive makes now known. Also the device illustrated contains less weight of material than comparable fittings, and thus features a superior form of connector which can be manufactured at less cost of material than those on the market designed to connect the same size of conductors.

The connector considered as a whole is designed to provide two sets of relatively narrow clutching bands integrally connected, each set formed of a pair of parallel bands, one set in spaced apart relation for encircling each conductor in such a way that the clutching of one conductor will have little, if any, effect on the clutching of the other conductor. The lower halves of the four bands are best shown in Fig. 3 and are designated **19** and **20** for conductor A, and **21** and **22** for conductor B. The clutch forms in effect two cylindrical clutching jaws, one for the conductor A and the other for the conductor B, and with the conductor receiving space of one opening at right angles into the other. Differently expressed the arch which overlaps (and underlaps) one conductor merges into the arch which overlaps (and underlaps) the other conductor at the central portion which is common to the portions which lap both conductors.

The jaws are each recessed in the portion forming the bands **19** and **20** encircling the conductor A by a deep cut-back or recess **23** which spaces apart at least half of each of the bands **19** and **20**. The jaws are recessed in the portion forming the bands **21** and **22** encircling the conductor B by a pair of opposing waist forming recesses **24** and **25** of less depth than the recess **23**. The bands **19** and **20** are integrally connected by web **26**. The bands **21** and **22** are connected by a web **27** (see Fig. 3) so that the part of the jaw formed by this web is of materially reduced cross section of material as viewed in Fig. 3. The webs **26** and **27** form in effect a solid T-shaped portion not intended to have any noticeable degree of flexibility. Assuming that the interior band **21** is held rigid by being clamped firmly to the end of conductor B, then band **22** may be twisted or otherwise deformed relative thereto if such twisting or deforming be necessary to cause band **22** to conform to the portion of the conductor B clamped thereby. Differently defined, each jaw has a solid central portion in the area between the pairs of center bolts **14**—**17** forming with its corresponding portion a main clamping means for simultaneously engaging both conductors. It is noted that where the webs **26** and **27** join to form a T, that is where conductor B comes closest to conductor A is the region of least distortion. The areas engaged by the bolts **15** and **16** form a supplemental clamping means for clutching the conductor B. The bolts **13** and **14** form one of a pair of parallel supplemental clamping means for clutching the conductor A and the bolts **17** and **18** form the other supplemental clamping means for clamping the conductor A.

Considering the cross section of the material which forms the upper or lower half of any one of these bands reference is made to Figs. 5 and 6. It is noted that the mid portions form rugged arches **28** almost semi-cylindrical, relatively flexible and having outwardly extending feet **29** and

30 which are particularly rugged and not intended to have any flexible characteristics under the operative conditions here presented. The arch forming portions are substantially of equal thickness of material and of sufficient mass to resist normal distorting loads. The feet 29 and 30 are relatively deep in the direction of squeeze pressure indicated by the lines *s*—*p* and constitute bolt flanges outstanding on all sides from the portions of the arches which form the bands. The outer faces of these flanges are flat and provide pressure faces 31 for receiving either the head 32 or the nut 33 of the associated bolt.

These bolts are rather short compared to their diameters, thus providing a particularly rugged form of bolt. These bolts are each preferably provided with lock washers located under the nuts to defeat possibility of the parts becoming loose in practice.

The inner face of each jaw in its arch-forming portion is concave at opposite ends thereof to form a pair of clutching surfaces one for each conductor each a little less than a complete semicircle. Considering any one of the semi-cylindrical recesses it is noted by reference to Fig. 5 that the surface 34 defining either recess of the upper jaw 11 has its axis at 35 below the axis D. Similarly the surface 36 of the lower jaw 12 has its axis at 37 above the cylinder axis D. Each clutch surface then has a radius slightly greater than the radius of the circle of reference C defined by the cylindrical outer surface of the associated conductor.

This has the effect of providing on opposite sides of the crown 38 of each arch, two clearances, as best shown in Fig. 5, a left clearance 39 and a right clearance 40, both gradually increasing in width from the crown 38 towards the lowermost inner edge of each of the feet 29 and 30. It is understood however that the showing of the clearances 39 and 40 has been very much exaggerated in Figs. 5 and 6.

Each clutching surface is provided in the portion thereof within the flexible band forming arches with three grooves parallel to the axis of the associated conductor and circumferentially spaced apart and each relatively wide and shallow. One of the grooves 41 is located at the crown 38 and the other two grooves 42 and 43 are located respectively left and right as viewed in Fig. 5 about half way between the central groove 41 and the outer end of the clutch surface. These grooves form therebetween four long pressure pads designated clockwise in Figs. 3, 5, and 6 as 44, 45, 46 and 47 as best shown in Fig. 3.

The two end pressure pads 44 and 47 extend beyond what may be regarded as the flexible part of the arch and define the curved inner faces of the two rugged feet 29 and 30 and are not intended to have any noticeable degree of deformation within their own dimensions.

In those cases where two conductors are to be secured in end-to-end relation the left half of the connector to be used therewith is a duplicate of the right half shown in Figs. 1–3 each half receiving an end of the conductor as shown for conductor B with its four bolts 14, 15, 16 and 17 duplicated. In other words such a conductor would have eight bolts, four on a side in alignment.

In operation and referring first to Fig. 1, it will be assumed that the conductors A and B are pre-disposed in the T arrangement shown. Then one-half of the fitting, that is the upper jaw 11, is located on top of the adjacent portions of the conductors and the other half of the fitting, that is the lower jaw 12 is located beneath the adjacent portions of the conductors; the six bolts are passed downwardly through the associated bolt flanges and their nuts are threaded on to the lower end of the bolts and tightened up, first by finger action until it becomes difficult to further advance the bolts simply by manual effort. At this time the parts are in the position shown in Fig. 5, with the inner pads 45 and 46 on opposite sides of the groove 41 in light bearing engagement with the associated conductor, A or B as the case may be.

From this point on a novel sequence of bolt tightening is practiced. The central bolts 14 and 17 (see Fig. 1) defining the initial clamping plane or main neutral axis 3^a—3^a at the inner end of the conductor B are first tightened; first one of the pair 14 or 17 is advanced for a partial turn and then the other and then back to the first and so on until these first two bolts can be turned no further even with the long wrench usually used in tightening such bolts. In this way there is developed a tightening of the connector along an interior plane spaced from both of its ends which carry the other bolts 13—18 and 15—16.

It is understood that the jaws are to all appearances rugged and not deformable except by powerful distorting forces. However, under the powerful turning torque of the long wrenches used in such situations, there is a straining or deforming or cold flowing of the heavy jaws. The showing of what happens is best described by reference to Figs. 5 and 6. As the squeeze pressure is gradually increased along the lines *s*—*p* of the associated bolts, such as bolts 15 and 16 in Fig. 5, the crown portion 38 of each jaw will form in effect a hinge line substantially fixed relative to the high or low point of the associated conductor. The portion of the arch on both sides of each of these hinge lines will swing or cold flow downwardly in the case of the upper jaw 11 and upwardly in the case of the lower jaw 12 and in both cases inwardly wrapping themselves about the conductor as a rigid cylindrical form of mandrel. At this time the crown portion 38 tends to move radially outward, that is, the portion of the arc which is outwardly of the central groove 41 is strained outwardly at least to a slight almost imperceptible degree.

This initial distortion of each jaw will have the effect of first causing the inner pads 45 and 46 to swing inwardly into bearing engagement with the outer surface of the conductor and thus to conform exactly to the circle of reference C. With the two inner pads 45 and 46 thus held from any further inward movement two new hinge lines begin to form outwardly of the initial hinge line and in the two areas of reduced cross section of material formed by the grooves 42 and 43. With a continued forcible turning of the bolts the outer or end pressure pads 44 and 47 are caused to creep or swing or cold flow inwardly towards each other in a substantially horizontal direction as viewed in Figs. 5 and 6 and this movement is continued until these side pads are likewise stopped by their pressing engagement against the surface of the cylindrical conductor. This action of course gradually closes both of the clearances 39 and 40. In Fig. 6 an attempt has been made in an exaggerated way to show the movement of the opposite sides of the jaws from the initial dotted line position strained into the full line finally clamped position. In the final showing all of the pads 44, 45, 46 and 47 have been pressed inwardly, conform exactly to the circle of reference C and are

firmly restrained and held restrained bolted in such position. It is understood of course that the distortion in the case of any of the bands is well within the elastic limits of the material of which the clamping jaws are formed so that the jaws are held by the bolts in their strained and distorted positions, and that when released from their held position the jaws tend to spring back by virtue of their elasticity into their initial unstrained position.

Then (reverting to Fig. 1) the two bolts 15 and 16 which define the secondary transverse clamping plane 3^b—3^b at the out end of the portion clamping the conductor B are tightened, first one until partly tight then the other, and the operation is continued back and forth until these two bolts 15 and 16 can no longer be turned. This means that the four bolts 14, 15, 16 and 17 have clamped both of the bands 21 and 22 tight onto the conductor B; that the bands 21 and 22 have by this time adjusted themselves, if necessary, and that any relative canting of these bands have in no way been influenced by the presence of the then loosely held conductor A.

Then going to the other or left end of the connector to secure the conductor A thereto, the bolts 13 and 18 are similarly tightened, alternately first one and then the other, until this set of bolts can not be further turned. In this case bolts 13 and 14 form a longitudinal secondary neutral axis of bent 3^c—3^c, and similarly bolts 17 and 18 form another longitudinal secondary neutral axis of bend 3^d—3^d in the jaws as they are bent or wrapped about the conductor A as a mandrel as previously described for the initial clamping operation on the conductor B.

During the time while the bolts 13 and 18 were being tightened bands 19 and 20 were each conforming to the contour of the parts of the conductor A encircled thereby. As these bands are capable under the distorting forces used to have some degree of relative flexibility enhanced by the cut-away portion 23, the conforming of one band to the associated cylinder of reference will not seriously affect the conforming of the other band relative to its associated band or to the previously clamped bands 21 and 22. This means that all four bands 19, 20, 21 and 22 are free to become distorted relative each to the other despite the fact that the half band forming parts of each jaw are integrally connected in a one-piece rugged casting.

Another action takes place as the clutching surfaces finally reach their clamping engagement with the conductors in that a slight abrasive action occurs between the contacting surfaces. The more or less roughened face of the several pads provide minute projections which break through the surface oxidation present on both the pads and the conductors. These minute projections which form on the pads incidental to the formation of their cast surfaces obtained in the sand casting or molding operation, move with the pads not only inwardly as above described, but also partake of a slight rotary shearing action along the surfaces of the conductors, and thus there is provided a scraping of one surface on the other to effect an intimate metal-to-metal contact between the connector and each of the conductors. If the sand finished surface is not sufficient the surfaces of the pads may be serated or otherwise machined to provide the desired high contacting spots. Preferably the surfaces which are to be brought into contact are acid cleaned just before the connector is applied so as to minimize the presence of any foreign matter which might otherwise deleteriously affect the desired electrical conductivity between the contacting parts in the final assembly.

I claim:

1. In a device of the class described, the combination of two cylindrical rigid conductors with an end of one in juxtaposition to the other, clamping means for mechanically and electrically connecting said end with the other conductor, said means including a pair of half fittings having such rigidity as will cause them to maintain their configuration until subjected to the distorting actions of bolts disposed in spaced apart relation on opposite sides of the conductors and squeezing the conductors therebetween and each provided with a pair of substantially semi-cylindrical recesses, one for partially encircling each conductor, the portion engaging each conductor including a pair of half bands disposed in spaced-apart tandem relation with a web integrally connecting the associated half bands and with one web merging integrally into the other, each half band provided at its opposite ends with an outstanding bolting flange with a greater cross section of material and thus more resistance to distortions than the balance of the associated half band therebetween, bolts connecting each flange of one half fitting with the corresponding flange of the other half fitting and each half band capable when its associated bolts are drawn tight to become distorted as a whole to conform to the configuration of the particular part of the conductor encircled thereby and each half band having capacity to become distorted relative to every other half band.

2. In a device of the class described, the combination of a rigid cylinder of conductive metal, a bolted connector including a pair of jaws of similar configuration in spaced-apart relation for engaging opposite sides of the cylinder, each jaw constituting a casting of conductive metal having the rigidity characterizing such castings, each jaw including an arch in cross section with outstanding bolting flanges at the feet of the arch, the inner face of the arch being of substantially semi-cylindrical form and normally of slightly greater diameter than the cylinder, the surface forming such inner face provided adjacent the crown of the arch with a wide shallow groove extending axially of the arch and forming axially extending pressure pads on opposite sides of the groove and parallel thereto, said pads on their cylinder-engaging surfaces having a roughness approximating that of their original cast metal finish, rugged bolts connecting the related flanges of the jaws and operating therethrough with a squeeze force to distort the jaws from their original configuration initially to cause the portions of the pads nearest the groove to move radially outward to a slight extent as the pads as a whole are swung inwardly to bring them into firm bearing engagement with the rigid cylinder and progressively as the bolt pressure increases to wrap one side of each arch clockwise and the other side counter-clockwise with a cold flowing of the metal to cause each pad as it moves both radially inward and at least slightly circularly in engaging the cylinder to scrape on the cylinder surface and thus cause the rough-faced pads to break through the oxides which form on the interengaging surfaces to scrape the insulating layers away from the surfaces and to bring the

connector and cylinder into a freshly formed metal-to-metal contact.

3. A bolted connector including a pair of jaws of similar configuration for clamping therebetween a rigid cylinder of conductive metal, each jaw constituting a casting of conductive metal having the rigidity characterizing such castings, each jaw including an arch in cross section with outstanding bolting flanges at the feet of the arch, the inner face of the arch being of substantially semi-cylindrical form, the surface forming such inner face provided adjacent the crown of the arch with a wide shallow groove extending axially of the arch and forming axially extending pressure pads on opposite sides of the groove and parallel thereto, said pads on their cylinder-engaging surfaces having a roughness approximating that of their original cast metal finish, rugged bolts connecting the related flanges of the jaws and operating therethrough with a squeeze force to distort the jaws from their original configuration to engage the cylinder initially to cause the portions of the pads nearest the groove to move raidally outward to a slight extent as the pads as a whole are swung inwardly to bring them into firm bearing engagement with the rigid cylinder and progressively as the bolt pressure increases to wrap one side of each arch clockwise and the other side counter-clockwise with a cold flowing of the metal to cause each pad as it moves both radially inward and at least slightly circularly in engaging the cylinder to scrape on its cylinder surface and thus cause the rough-faced pads to break through the oxides which form on the interengaging surfaces to scrape the insulating layers away from the surfaces and to bring the connector and cylinder into a freshly formed metal-to-metal contact.

4. A metallic clamp for mechanically and electrically connecting two cylindrical conductors, said clamp including a pair of similar clutch jaws each rectangular in plan arranged in opposing relation, each jaw provided on its inner or conductor-engaging side with two straight grooves extending at right angles to each other in a T relation, one of said grooves constituting a head groove and the other a stem groove, one end portion of each jaw containing all of the head groove and the adjacent inner end of the stem groove, said jaw end portion provided with four bolting flanges outstanding from the associated grooves and arranged substantially at the four corners of a rectangle and comprising two outer flanges and two inner flanges, said end portion provided with a recess extending from an edge thereof inwardly substantially to the crown of the head groove and separating the two outer flanges, the outer flanges and the inner flanges

being disposed in pairs on opposite sides of the head groove and in transverse relation thereto and the two inner flanges being located on opposite sides of the inner end of the stem groove and in the portion of the jaw which forms the corners between the head and stem grooves, and the other end portion of the jaw which contains the outer end of the stem groove provided with a pair of bolting flanges disposed on opposite sides of the stem groove at the outer end thereof, said other end portion provided with a pair of waist forming recesses projecting inwardly from opposite sides thereof into the stem groove to form a web therebetween at the crown of the stem groove, bolts connecting each flange of one jaw with the corresponding flange of the other jaw and each jaw capable when the bolts are drawn tight about the conductors clamped thereby to become distorted as a whole to conform to the configuration of the particular part of the conductor engaged thereby and the bolts engaging the associated inner flanges operative simultaneously to draw the adjacent parts of the jaws containing both grooves into engagement with both conductors.

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