Oct. 1, 1940. W. O. HAMPTON 2,216,344

CONNECTOR

Filed April 9, 1937 3 Sheets-Sheet 1

Fig. 1

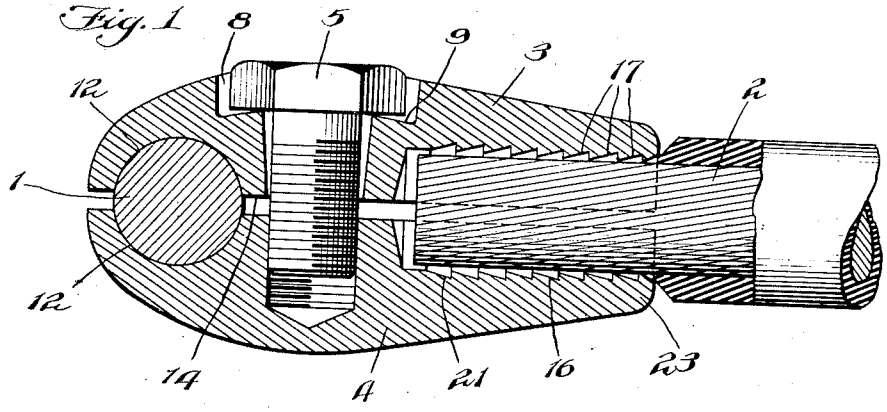



Fig. 2.

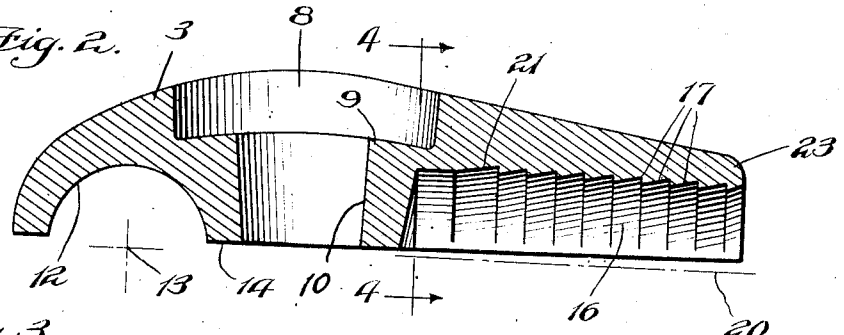



Fig. 3.

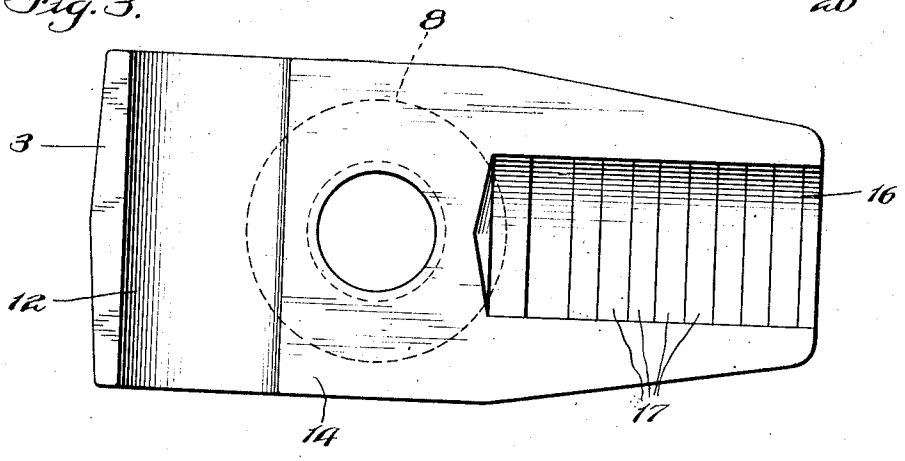



Fig. 4.

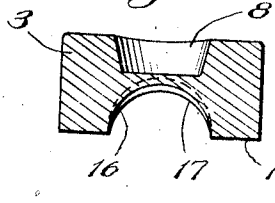
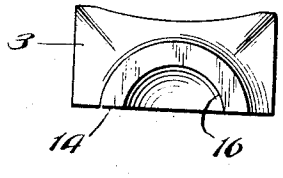



Fig. 5.




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Oct. 1, 1940. W. O. HAMPTON 2,216,344

CONNECTOR

Filed April 9, 1937 3 Sheets-Sheet 2

Fig. 6.

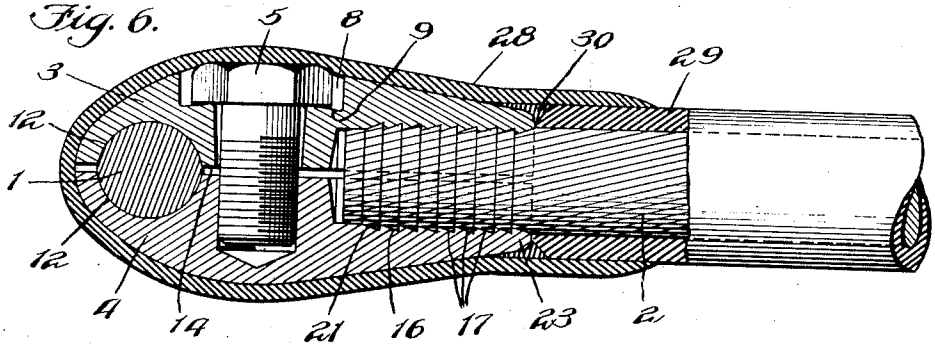



Fig. 7.

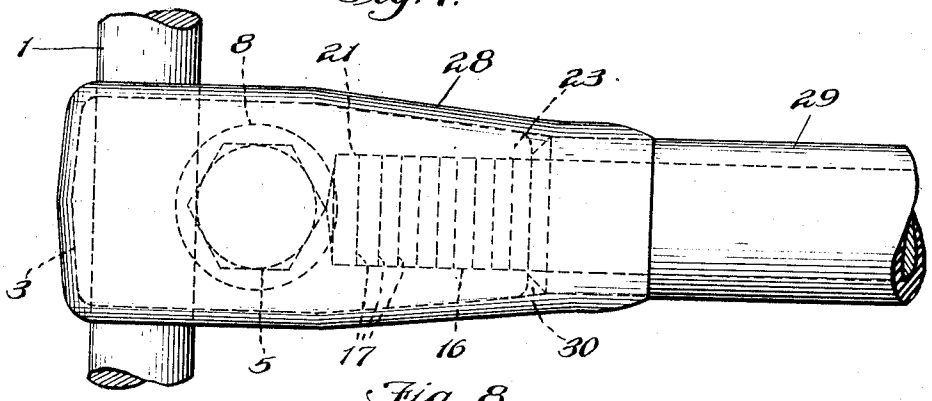



Fig. 8.

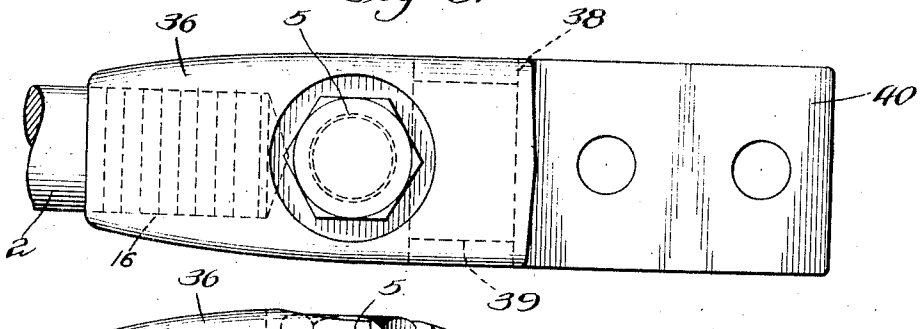
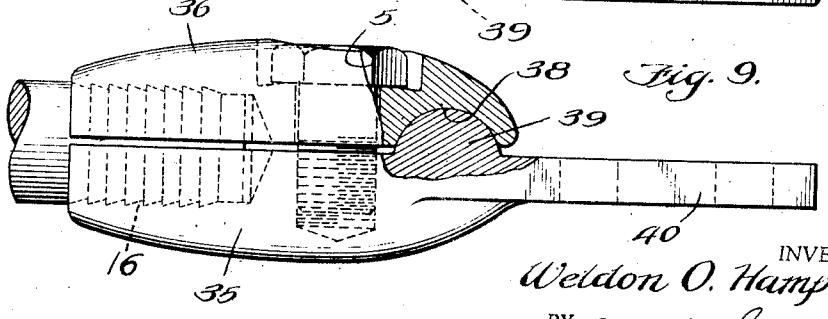



Fig. 9.




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Oct. 1, 1940. W. O. HAMPTON 2,216,344

CONNECTOR

Filed April 9, 1937 3 Sheets-Sheet 3

Fig. 10.

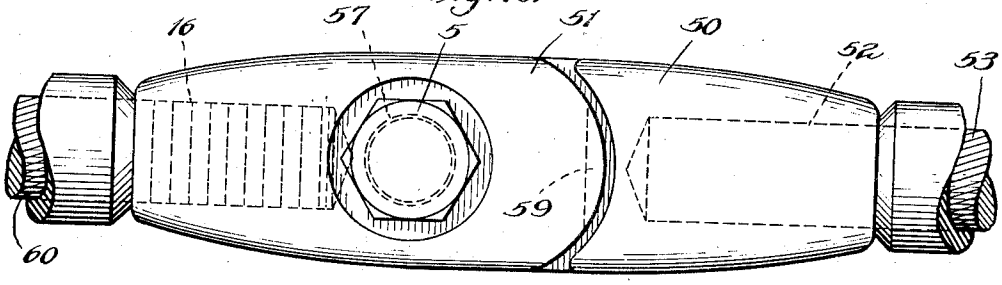



Fig. 11.

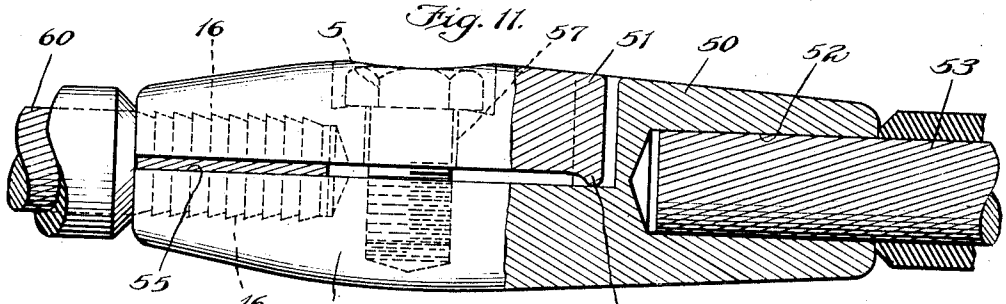



Fig. 12.

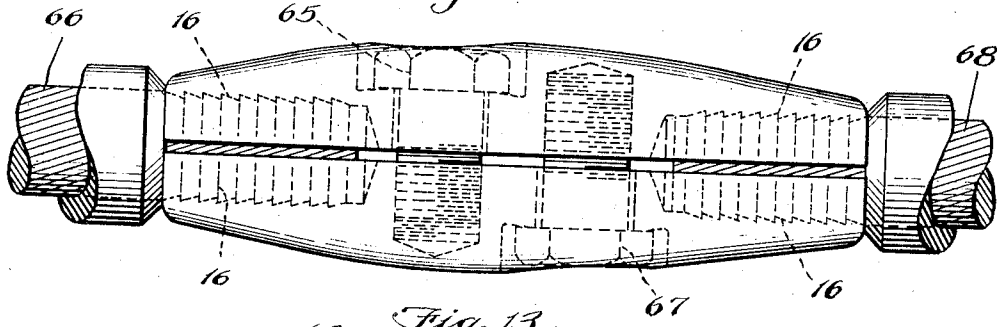
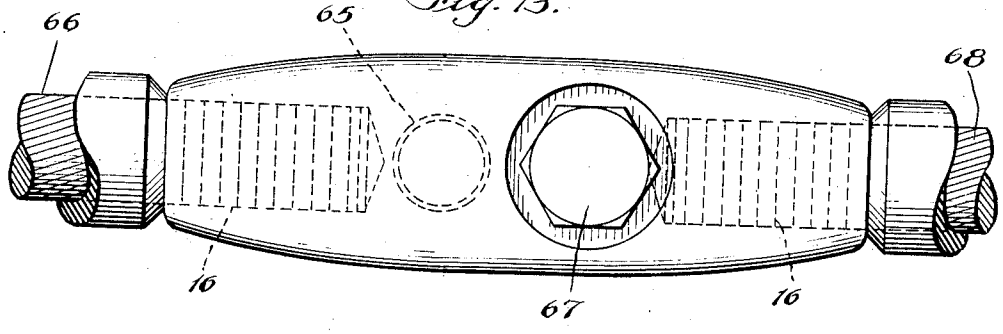



Fig. 13.




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Patented Oct. 1, 1940 2,216,344

# UNITED STATES PATENT OFFICE

2,216,344

## CONNECTOR

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Application April 9, 1937, Serial No. 135,963

3 Claims. (Cl. 173—269)

This invention relates to connectors in general and more particularly to such connectors as are used on high voltage or high current carrying electrical connections where space is limited. The invention is, however, not limited to such connectors, as in its broadest aspects it is capable of general application, it being applicable wherever a conductor, or pipe, or rod is to be joined to something else and wherein there is likely to be a pull exerted on the conductor tending to pull it out, and it is desired that the connector serve to grip the conductor firmly against such withdrawal.

In the making of electrical connections, where the current flow is of considerable magnitude, it is desirable that the parts being connected have an appreciable contacting area at high pressure, since up to certain limits the resistance, and therefore the amount of heat generated, varies as an inverse function of the pressure and area of contact. In those connectors where provision is made for an appreciable area of contact between engaging surfaces, it is a common experience to find that the parts engage one another at a few points, or along a few lines where practically all of the pressure appears to be concentrated, the remaining portion of the connector that is intended to bear against the conductor being practically useless for current carrying purposes. Thus the current flow is concentrated primarily at the points of high pressure, resulting in a large and concentrated heat generation. Also, in such arrangements the conductor is not held in the connection with sufficient effective grip to prevent the conductor from being pulled out of the connector. It is an object of the present invention to overcome the above difficulties. I accomplish this result by providing a connector which is so constructed and arranged that the pressure of engagement between the connector and the conductor is fairly evenly distributed along the entire length of the end of the conductor that is being gripped by the connector. This is accomplished by making the conductor receiving opening of the connector slightly tapered away from the conductor along its length of engagement with the conductor so that as the connector is clamped against the conductor the portion of the connection remote from the clamping means first engages the conductor and as the clamping means is progressively tightened the connector is flexed to bring it progressively into pressure engagement with more and more of the end of the conductor. The taper of the connector is such that upon flexing of the same the pressure of engagement between the connector and the conductor is fairly even throughout the engaged length of the conductor end. The connector is provided with a series of teeth that bite into the conductor, the pressure of the respective teeth being substantially uniform so that the current flow between the connector and the conductor will be substantially equally distributed at the respective teeth.

It is a further object of the present invention to provide a connector having a smooth exterior surface free of outward projections and free of sharp corners at points of electrical stress. By such construction I reduce the minimum distance that must be allowed between adjacent connectors on line conductors at different potentials. Also, by reason of the smooth exterior surface the connector may readily be taped over with cable insulation without the danger of leaving voids under the tape. Voids in taped insulation are highly objectionable since there may be such an increase in the electrical stress at the voids as to result in corona formation and consequent rapid deterioration of the tape.

It is another object of the present invention to provide a connector which will firmly grip the conductor to which the circuit is being extended and securely hold the conductor from being pulled out by any forces which might reasonably be encountered tending to pull the conductor out. This result is accomplished by constructing the connector in such a manner that it will firmly grip the conductor for an appreciable distance along the end of the conductor and providing a series of teeth in the connector which will bite into the conductor. I establish a plurality of rings of high pressure contact between the connector and the conductor, each ring comprising a tooth extending around the periphery of the conductor engaging portion of the connector, the connector being clamped to the conductor with sufficient pressure to cause the connector teeth or rings to penetrate the conductor.

It is a still further object of the present invention to so construct and locate the teeth on the connector that the respective teeth will exert substantially uniform pressure on the conductor. By this arrangement I obtain a connection having a minimum resistance and a maximum anchoring grip.

It is a still further object of the present invention to provide a connector of the character above set forth in which the parts may be drawn together by tightening a single bolt, so that only one hand need be used to manipulate the wrench

during tightening operations. By this arrangement the other hand is free so that the operator can amply support himself. This is of importance because frequently connections are in such a location that the operator must use one hand to maintain himself against falling.

The attainment of the above and further objects of the present invention will be apparent from the following specification taken in conjunction with the accompanying drawings forming a part thereof.

In the drawings:

Figure 1 is a longitudinal sectional view through the connection before tightening of the clamping bolt;

Figure 2 is an enlarged sectional view through one of the connector segments;

Figure 3 is a bottom view of a connector segment;

Figure 4 is a sectional view taken along the line 4—4 of Figure 2 and looking in the direction of the arrows;

Figure 5 is an end view of the connector segment of Figure 3;

Figure 6 is a longitudinal sectional view through the completed connection;

Figure 7 is a plan view of the connection of Figure 6;

Figure 8 is a plan view of a connector of a modified construction;

Figure 9 is a side view of the structure of Figure 8, a portion of the connector being shown in section for illustrative purposes;

Figure 10 is a plan view of another modification of a connector constructed in accordance with the teachings of the present invention;

Figure 11 is a side view in partial section of the structure of Figure 10;

Figure 12 is a side view of still another form of connector; and

Figure 13 is a plan view of the connector of Figure 12.

Reference may now be had more particularly to Figures 1 to 7 inclusive. Those figures illustrate an electrical connection between the line 1 and the conductor 2, and illustrate further the construction of the connector that effects the connection.

The line 1 may comprise a stranded, solid, or tubular conductor 2, or any other continuous conductor to which an electrical connection is to be made.

The connector includes two massive cast bronze connector segments 3 and 4 secured together by a single bolt 5 which passes freely through an oversized opening in the segment 3 and is threaded into the segment 4. The segment 3 is provided with a circular depression or cavity 8 at the top thereof for receiving all or a major portion of the head of the bolt 5, as may be seen from Figures 1, 6 and 7. The head of the bolt rests on a curved surface 9 of the connector segment 3, the surface being curved to permit a slight rolling of the head of the bolt with respect to the connector segment as the two segments are tightened by the bolt and flexed towards one another in a manner to be set forth more fully as this description proceeds. To facilitate this action the bolt hole 10 in the segment 3 for receiving the shank of the bolt 5 is made preferably slightly conical as is shown in somewhat exaggerated form for illustrative purposes.

Each connector segment is provided with an almost semi-cylindrical bore 12 at one end, adapted to fit over the conductor 1. The surface 12 is a portion of a cylindrical surface having its center at 13 (Fig. 2), which, in one construction, is approximately $\frac{1}{8}$'' from the plane of the edge surface 14 of the connector segment. Each connector segment is provided with a bore or cavity 16 at approximately right angles to the bore formed by the cylindrical surface 12.

The bore or cavity 16 has a plurality of teeth 17 for biting into the conductor 2. Each tooth extends around the periphery of the bore, and is preferably shaped on an arc of a circle, as may be seen from Figure 4, but the teeth are of varying depths from the edge surface 14 of the connector segment.

In Figure 2 I have shown a center line 20 which is the line for the centers of the grooves or teeth 17. This line is at a slight angle to the surface 14, so that at the inner end 21 of the connector the grooves extend further from the surface 14 than at the outer end 23, by a small amount. In one connector which I have made and used, this amount is approximately one thirty-second of an inch. When the two connector segments are placed around a conductor in the manner illustrated in Figure 1, the teeth at the end 23 of the two connectors first engage the conductor 2, while the teeth closer to the bolt, as at 21, do not engage the conductor. The bolt 5 is tightened to firmly clamp the segments against the conductors, the tightening being continued to cause deformation or flexing of the connector segments towards one another at the bolt 5 and thus bring the teeth progressively into high pressure engagement with the conductor 2 until the teeth at the end 21 firmly grip the conductor 2. Upon tightening of the bolt 5, the conductor 2 is being compressed but it cannot expand radially due to the fact that the width of the bore 16 at the surface 14 is approximately uniform throughout the length of the bore, as may be seen from Figure 3. Any yielding of the conductor upon clamping of the segments together results in a pushing of the metal of the conductor progressively to the left, as seen in Figures 1 and 6, namely, into the connector rather than outwardly thereof. As a result, all of the teeth 17 firmly grip the conductor 2 and positively lock it against withdrawal by an outward pull on that conductor. Also, due to the difference in the depth of the bore 16, gradually increasing from the end 23 of the bore towards the bolt 5, a tightening of the bolt and consequent deflection of the metal of the connector segment causes all of the teeth of the connector to grip the conductor substantially uniformly. In the absence of such a taper of the bore 16, a tightening of the bolt 5 would cause the teeth 17 adjacent the bolt 5 to grip the conductor tightly while the teeth at the end 23 of the conductor would bear against the conductor loosely, and would therefore be of only small, if any, effect both as to current conducting function and as to gripping the conductor against pull-out.

When the connector segments are clamped together to grip the conductor 2, they also firmly grip the conductor 1 and establish intimate contact with that conductor. During the tightening action by the bolt 5 and deflection of the connector 3, the head of the bolt 5 may roll slightly on the curved surface 9, thus avoiding any binding action on the bolt.

It is to be noted that the exterior surfaces of the connector segments are smooth and are free of any appreciable outward projections. This reduces the possibilities of streamer or corona formation and facilitates the application of insulat-

ing tape around the connector, thereby permitting the use of the connector in rather crowded spaces where the matter of obtaining adequate electrical clearance presents a problem. Also, by reason of the smooth exterior of the connector, it is easy to wind insulating tape around the same without trapping air or otherwise forming voids between layers of insulating tape. The presence of voids between layers of insulating tape is highly objectionable. The electrical stresses are increased at the voids, resulting frequently in the formation of corona and consequent rapid deterioration of the insulating tape.

In Figures 6 and 7, the wound tape is indicated at **28**, said tape being wound around the connector segments and over the cable insulation **29**. The winding of insulating tape or insulating cords **30**, suitably impregnated with insulating compound, fills the spaces that would otherwise be present between the end of the insulation **29** on the conductor **2** and the ends of the connector segments, this layer of insulation **30** forming a smooth, continuous connecting surface between the connector segments and the insulation **29** on the conductor.

The head of the bolt **5** lies practically entirely within the pocket **8** formed within the connector segment **3**. Since the head of the bolt is at exactly the same potential as that of the surrounding wall of the pocket **8**, this space is electrically dead and therefore the presence of an air pocket at this space is not objectionable. Since the head of the bolt does not project appreciably beyond the surface of the connector, if it projects therefrom at all, the bolt head does not interfere with the winding of the tape around the connector. The connector **5** is preferably made of bronze or other non-ferrous metal. Such a bolt holds its grip firmly and does not tend to become loosened.

Reference may now be had more particularly to Figures 8 and 9, wherein I show the principles of the present invention embodied in another connector structure. In this construction, the two cast bronze connector segments are indicated at **35** and **36**, the two segments being provided with a bore for receiving the conductor **2**, which bore is of a construction such as was previously described in connection with Figures 1 to 7 inclusive. The connector segment **36** is provided with a semi-cylindrical depression or transverse groove **38**, corresponding to the groove **12** of Figure 1, which fits over a corresponding semi-cylindrical projection **39** formed integral with the segment **35**. When the bolt **5** is tightened to draw the segments together, the segment **36** is flexed into firm gripping relationship to the conductor **2** in the same manner as do the connector segments **3** and **4**, previously described. The portions of the connector segments to the left of the bolt, as seen in Figure 9, are deflected, or distorted from their normal position, the amount of distortion being maximum at the bolt **5**, and minimum at the end remote from the bolt **5**, namely, at the outermost ends of the segments. During this action the segment **36** rocks about the projection **39**. Because of the taper of the conductor-receiving grooves, or portion **16**, previously described, the teeth on the segments **35—36** firmly grip the conductor **2** with a uniform pressure in the manner previously explained. The segment **35** is provided with a terminal lug **40**, of any desired construction, for receiving a terminal lug at the end of a conductor to which a connection is to be made, or whereby the connector may be bolted to a terminal of a switch or other structure to establish electrical and mechanical connections between the terminals. The connector segments **35—36** are of the smooth exterior as in the case of the connector shown in Figure 1, so that the segments may be taped with insulating tape, in the manner explained in connection with Figure 1.

In Figures 10 and 11 there is shown still another connector for establishing connections between two conductors. This connector includes two cast metal segments **50—51** of bronze or other suitable material. The connector segment **50** is provided with a bore **52**, into which the bared end of a conductor **53** is fitted, being soldered in place in the usual manner, to provide firm mechanical and electrical connections between the conductor **53** and the connector segment **50**. At its opposite end, the segment **50** has an extension **54** terminating in a top surface **55** in which a conductor-receiving toothed groove **16**, of a construction similar to that of the connector of Figure 1, is formed. The conductor segment **51**, has a similarly formed toothed groove **16**, the teeth of the grooves **16—16** being of a construction and varying depth, as in the connector segment, illustrated in Figures 1 to 7. The connector segment **51** is provided with a bolt-receiving bore **57** for receiving the bolt **5** which threads into a threaded portion in the connector segment **50** for securing the two connector segments together. The segment **51** is provided, at its lower surface, with a projecting nose **59**, which rests on the surface **55** of the projecting portion **54**. When the bolt **5** is tightened, the connector segment **51** and the projecting portion **54** of the segment **50** are flexed towards one another, the segment **51** rocking about the curved portion **59**. Here, as in the previous construction, the maximum deflection of the two segments is produced at the bolt, and the minimum deflection at the point furthest away from the bolt. Because of the varying depths of the teeth **17**, as previously described, each of the teeth from the left hand side of the connector bore **16**, to the right hand side thereof, is progressively brought into gripping relationship with the end of the conductor **60**. After a connection is established, the connector may be taped in the manner described in Figure 1.

While I have shown, in Figures 10 and 11, an arrangement wherein the connector segment **50** is provided with a bore **52** for receiving the conductor **53**, and while the connector of Figure 9 is shown with a lug for receiving electrical connections, it is to be understood that the connector of Figures 10 and 11 may be provided with a lug instead of the bore **52**, and conversely, the connector of Figure 9 may be provided with a bore such as the bore **52** instead of the lug **40**, or any other means may be provided for establishing connections with the connector segments at the right hand side of the connectors of Figures 8 and 9, or 10 and 11, as desired.

Reference may now be had more particularly to Figures 12 and 13. The connector shown in these figures employs two bolts instead of one. This connector is of the same shape in transverse section as the connector of Figures 1 to 7. It is provided, at each end, with toothed grooves **16—16** of a construction such as was described in connection with the groove **16** of the connector of Figure 1, of varying depths as previously described. The bolt **65** deflects the connector segments into firm gripping relationship to the end of the conductor **66**, and the bolt **67** produces a similar action with respect to the end of a conductor **68** at the other end of the connector, thus

establishing firm electrical and mechanical connections between the conductors **66** and **68**. It is to be noted that here, as in previous constructions, the connector segments are of a smooth exterior surface, free of any projections, and that the heads of the bolts lie in the pockets in the connector segments so that the space between the bolt heads and the adjacent connector surface at the bolt head receiving pocket is electrically dead. Because of the smooth exterior surfaces, it is a very simple matter to wind insulating tape around the connector segment after the segments have been bolted together into firm gripping relationship to a pair of conductors.

In each of the constructions above described the conductor is gripped firmly along the entire length of the end thereof that is within the connector. The pressure of the respective longitudinally spaced teeth against the conductor are substantially uniform. This results in a minimum electrical resistance loss at the connector, and in a firm gripping of the connector against withdrawal by an outward pull. While the connector segments are particularly adapted for anchoring the end of a conductor and establishing electrical connections thereto, it is to be understood that the connector is not limited to such use. It may be used, for instance, for merely anchoring the end of a conductor or the end of a pipe or for joining two pipes or rods, even though there is no question of establishing electrical connections between the pipes or rods that are joined. The connector of the present invention may be used wherever it is desired to firmly anchor the end of a pipe, rod or wire.

From the above description it is apparent that the connector of the present invention comprises essentially two massive cast metal segments which are, in effect, springs so that one or both of the segments may be distorted, or flexed, from its normal position by the application of a very great force thereto, but preferably within the elastic limit of the metal, and upon release of the applied force the segments resume their original shapes. The force applied to flex the segments is the force that exerts the clamping pressure between the segments and the connected conductor or conductors. Furthermore, it is to be noted that when the segments are in their fully clamped position, as illustrated in Figure 6, the adjacent surfaces **14—14** of the two segments are still spaced apart. By reason of this spacing the operator is assured that all the pressure exerted by the bolt is transmitted to the conductor or conductors between the segments. If the surfaces **14—14** were in abutment then the operator, upon tightening of the bolt **5** to the desired degree of tension, would not know whether the pressure exerted by the bolt is exerted on the conductors or on the faces **14—14**. Also, by reason of the curved surface **9**, the segment **3** can roll or rock with respect to the head of the bolt **5** as the two segments are being flexed with respect to one another. This arrangement precludes jamming of the bolt head with respect to the connector. It is known that the electrical resistance at a joint between two contacting metal members varies inversely as the pressure between the members, within predetermined limits. In the case of a point or line contact an increase in pressure results in a decrease in resistance until a predetermined pressure is reached, whereupon any further increase in pressure produces only a negligible, if any, change in resistance. For this reason it is important to have a number of teeth **17** on the connector segments, and to arrange the segment structure so that the pressure is distributed between all the teeth with more or less uniformity. Any concentration of pressure at one tooth with a corresponding diminution of pressure at one or more other teeth will reduce the total current carrying capacity of the connector, or increase the heating of the same, since the resistance is appreciably increased at those teeth where the pressure is reduced, and is not correspondingly decreased at that tooth where the pressure is increased. By reason of the original taper of the axes of the segments **3** and **4**, as illustrated by the inclination of the center line **20** of Figure 2, I assure a construction wherein the pressure exerted by the teeth on the conductor **2** will be substantially uniform. Also, as the connector segments are drawn together the metal of the stranded conductor **2** is forced progressively inwardly from the end of the connector towards the center thereof, rather than in the reverse direction. By this arrangement I assure a tight gripping of the conductor so that there is no reasonable danger that the conductor **2** may be pulled out of the connector by forces likely to be exerted upon the conductor **2**. The elastic bite of the connector segments against the conductor **2** assures a tight gripping of the conductor. Also, it is to be noted that the grooves formed by the teeth **17** are tapered in such a manner as to resist an outer pull on the conductor **2** when the segments are clamped tightly against the conductor. This is so by reason of the fact that the slots formed by the teeth **17** are wedge-shaped in cross section, with the right hand side of each slot, as seen in Figure 6, substantially vertical. This facilitates the anchoring of the conductor, or pipe, or tube, or rod, that may be held by the connector segments.

In Figures 8 to 13 I have omitted the conical shape or taper on the bolt receiving bore **10** or **57**. In these constructions the bore is slightly more oversized than in Figure 1, thus avoiding binding of the connector segments against the shank of the bolt as the segments are clamped together. Either the conical shape of the bolt receiving bore, or an oversize bore may be provided, as desired, in any of the embodiments here illustrated.

In compliance with the patent statutes I have here shown and described a few preferred embodiments of my invention. It is, however, to be understood that the invention is not limited to the precise constructions here shown, the same being merely illustrative of the principles of the invention. What I consider new and desire to secure by Letters Patent is:

1. A spring metal connector clamp comprising two segments having cooperating grooves for receiving a conductor, a conductor in said grooves, the axes of the cooperating grooves in the two segments diverging from one another from the ends of the segments towards the center of the segments, means for clamping the two segments together to exert a high pressure upon the conductor in the grooves of the segments, said segments being so proportioned in relation to the size of the conductor that the grooved part of at least one of the segments first contacts the conductor at the end of the segment remote from the clamping means the segments being sufficiently elastic to allow relative deflection thereof by the clamping means to bring the axes of the two grooves into parallelism, said clamping means

comprising a bolt extending into a countersunk hole in one of the segments so that the bolt head is substantially entirely within the countersunk hole, the seating surface for the head of the bolt in the countersunk hole being curved to permit rolling of the adjacent segment with respect to the bolt head as the segments are relatively deflected.

2. An electric connection comprising two massive metal segments having cooperating grooves between them for receiving a conductor, a conductor in said groove means projecting from and constituting an integral part of one of the segments for spacing the segments apart, a bolt extending through a countersunk hole in one of the segments and threaded into the other between said projecting means and said grooves for clamping the two segments together to grip the conductor in the cooperating grooves, the conductor-engaging surface of at least one of the segments being tapered to grip the conductor first at the end of the segment remote from the bolt and said last mentioned segment being flexed by the bolt to straighten the tapered surface whereby the tapered conductor-engaging surface is progressively brought into pressure-gripping engagement with more and more of the conductor length, the head of the bolt resting substantially entirely within the countersunk hole and the outer surfaces of the assembled segments being smooth and free of sharp corners and projections, to inhibit corona formation and facilitate the application of insulating tape thereto, and a wrapping of insulating tape enclosing said connection.

3. An electric connection including a connector comprising two separate connector segments adapted to be clamped together with adjacent faces separated by and pressing against a conductor, said adjacent faces having conductor-receiving grooves opposite one another to receive the end of a conductor between the segments so that a conductor may lie in the grooves of both segments, said grooves having teeth at the conductor engaging surfaces thereof, bolt means for drawing the two segments together to force the teeth into pressure egagement with the conductor in said grooves, said bolt means lying substantially entirely within the connector segments and including a non-circular part for facilitating turning of the bolt means, said connector having a socket within which said non-circular part lies in substantially its entirety, said non-circular part having a seating surface bearing against the inside of the socket as an opposite seating surface, said opposite seating surface being convex so that the peripherally outermost edge of the seating surface on the bolt means is out of high pressure engagement with the opposite seating surface when the bolt means is tightened to bring the segments into high pressure engagement with a conductor in the grooves.

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