

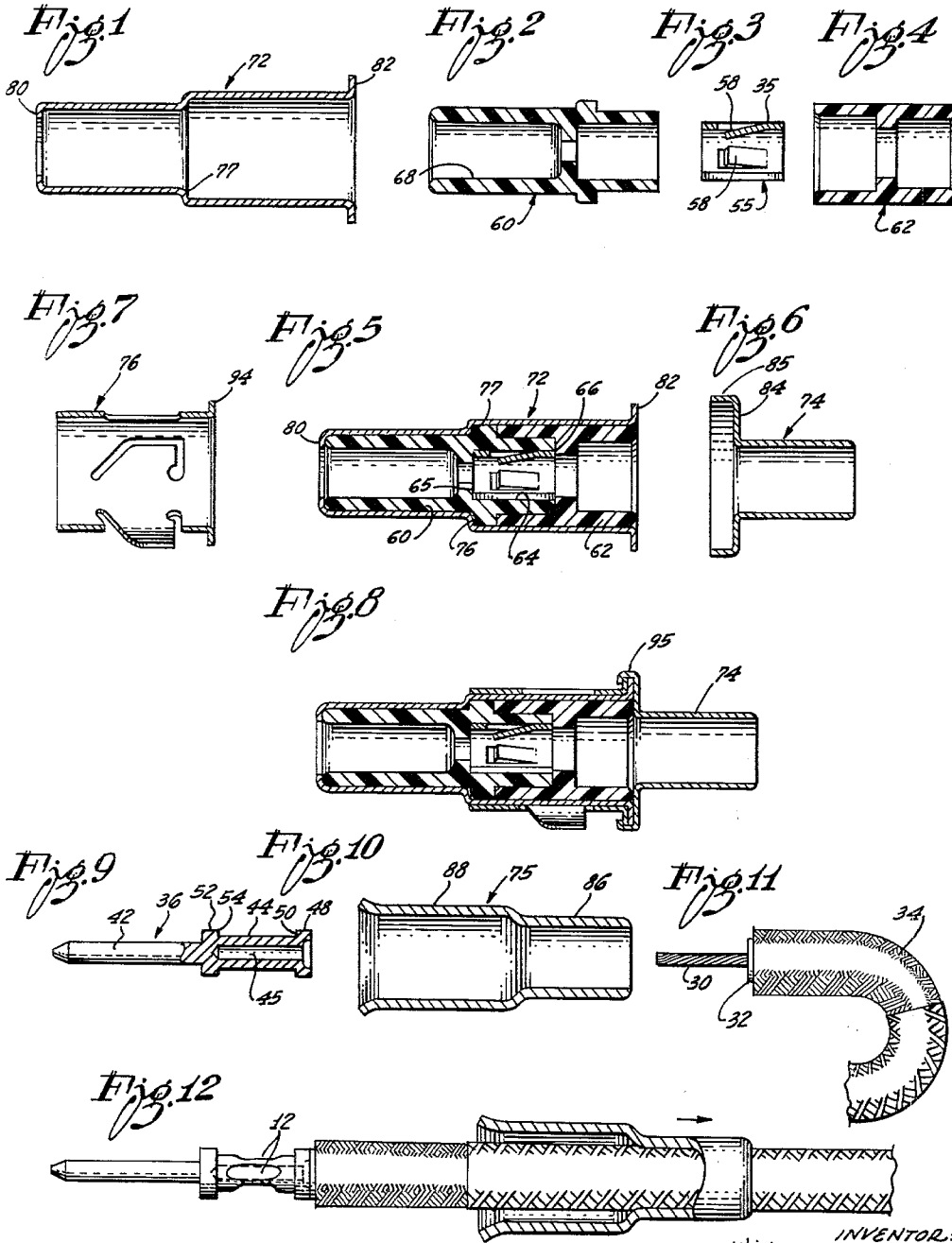
Jan. 4, 1966

W. A. BENTLEY
ELECTRICAL CONNECTOR

3,227,993

Filed Oct. 24, 1960

4 Sheets-Sheet 1



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Fig. 13

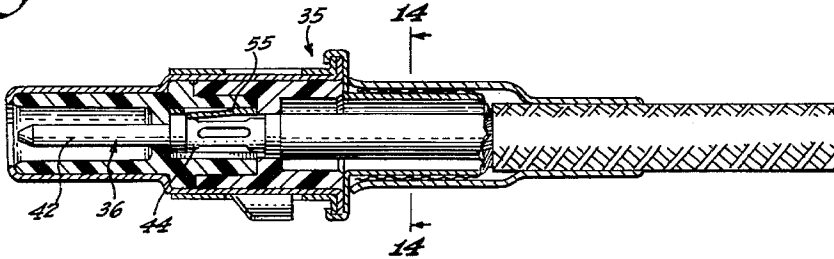


Fig. 15

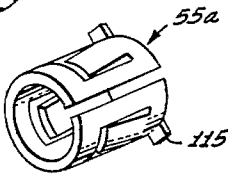


Fig. 14

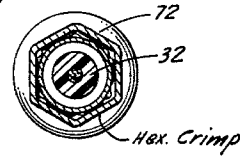


Fig. 16

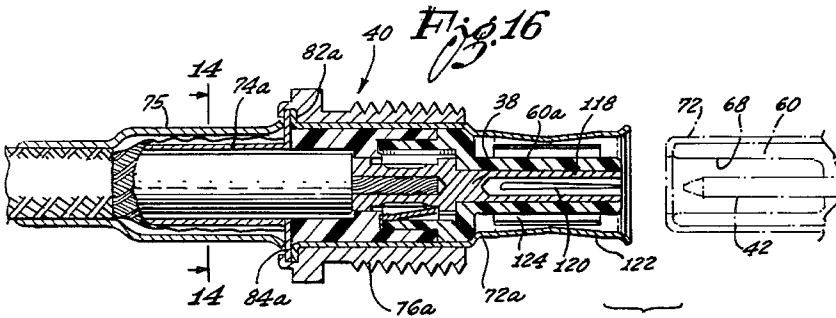


Fig. 17

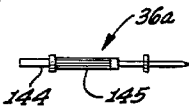


Fig. 18

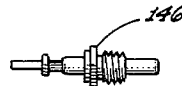


Fig. 17a

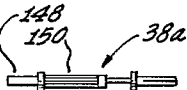
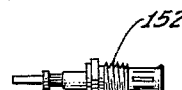


Fig. 18a



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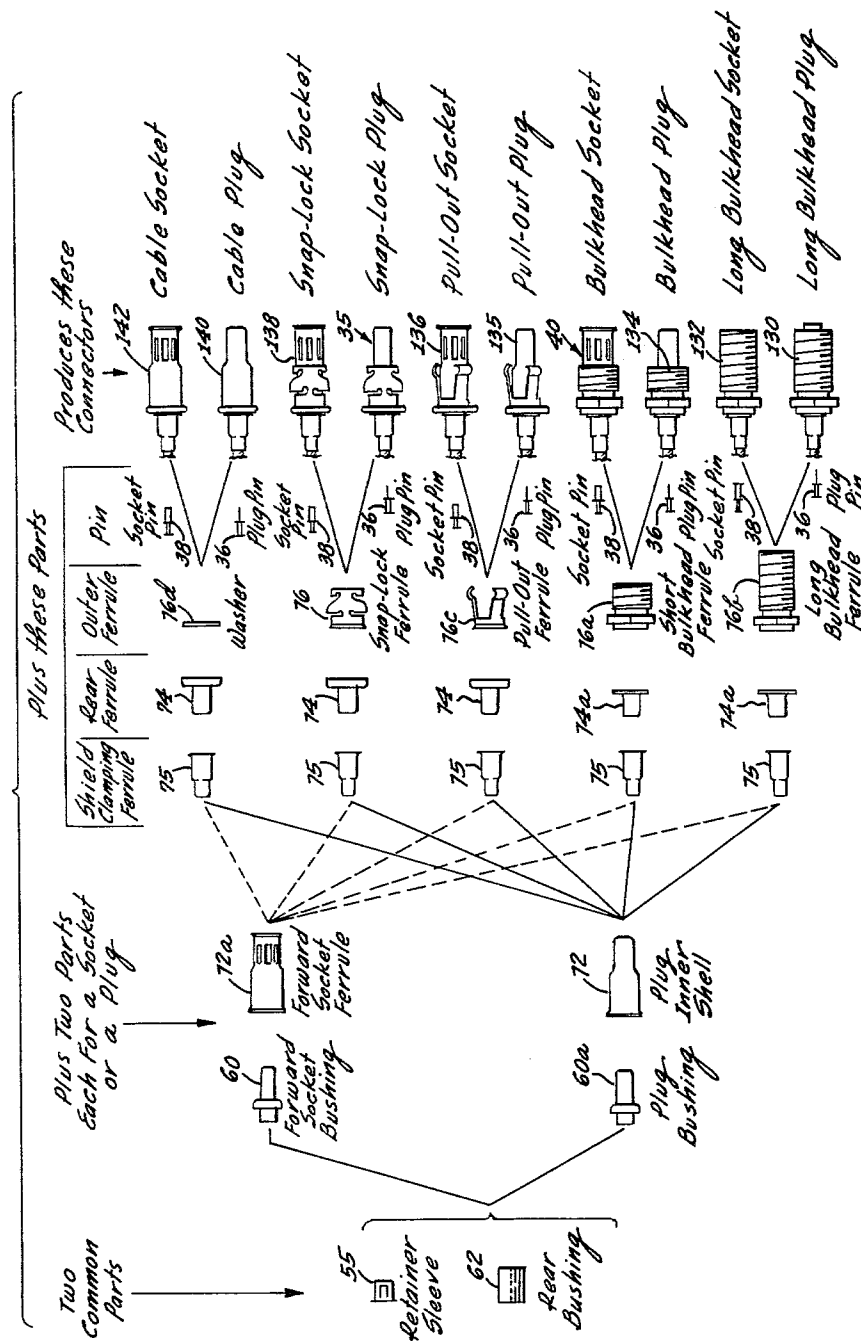
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ELECTRICAL CONNECTOR

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Fig. 20

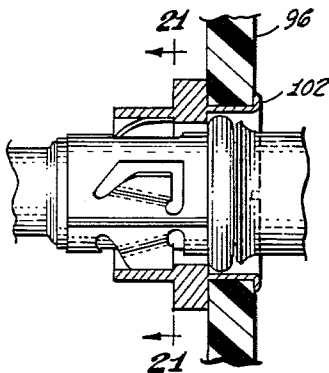


Fig. 21

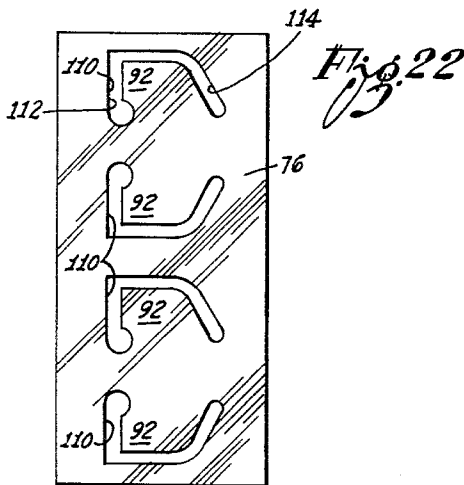
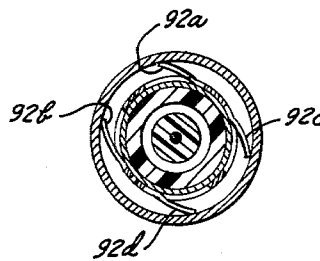
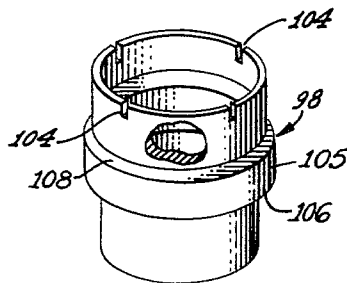


Fig. 23



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3,227,993

ELECTRICAL CONNECTOR

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Filed Oct. 24, 1960, Ser. No. 64,606
14 Claims. (Cl. 339-177)

This invention relates to electrical connectors of the plug-and-socket type and, more particularly, refers to such electrical connectors of miniature size for use with coaxial cables. A conventional coaxial cable comprises an inner conductor in the form of a wire, an insulating jacket enclosing the wire, and an outer shield or outer conductor in the form of a woven wire sheath.

The essential parts of such a plug-and-socket connector for a coaxial cable include an axial contact element or pin for permanent attachment to the wire of the cable insulation material surrounding the pin, and an outer shell structure adapted for connection with the cable shield. In most instances the outer shell structure is additionally adapted for engagement with a support structure such as a panel or bulkhead.

The pin is either a plug pin or a socket pin adapted for mating with a complementary pin and further adapted for permanent attachment to the inner conductor or wire of the coaxial cable. The insulation surrounding the pin is usually made of dielectric plastic material. The outer shell structure functions either as a plug or socket to mate with a complementary shell structure of a complementary connector and is further constructed for permanent connection with the shield or outer conductor of the coaxial cable to serve as a conducting extension thereof. Where mounting of the connector in fixed support structure is required, the outer shell structure of the connector may be provided either with resilient elements for frictional or snap engagement with the support structure or with a screw thread for screw engagement with the support structure.

The invention is directed to certain needs for improvement in the construction of such electrical connectors and in the procedures for fabricating, assembling and installing such connectors.

One of these needs is to make such electrical connectors more compact to reduce the space required for installation. A second need is to reduce the factory cost of the connectors. A third need is to reduce the cost of assembly and installation by the purchaser. Finally, a further need is to increase the efficiency of the electrical connectors for their purpose.

With respect to compactness, reduction in diameter is made possible by using for insulation an assembly of plastic bushings of high dielectric strength. Ordinarily, reduction in diameter of such a dielectric bushing assembly would result in corresponding reduction in length of the current leakage paths at the junctures of the bushings. The invention avoids this penalty, however, by employing a dielectric bushing assembly in which the bushings interlock with overlap and thus provide relatively long current leakage paths at the bushing junctures.

In a conventional electrical connector of this general type the pin is connected to the wire of the coaxial cable in one longitudinal zone of the connector and the pin is interlocked with the surrounding dielectric assembly in a different longitudinal zone of the connector so that the two zones are additive with respect to determining the overall length of the connector. Different longitudinal

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zones are necessary because the pin itself is constructed for both functions and is designed for crimp engagement with the wire. The same portion of the length of the pin cannot both be crimped radially inward for anchorage to the wire and expanded radially outward for interlocking engagement with the surrounding dielectric assembly.

The invention makes it possible to use the same longitudinal zone of the connector for both of these purposes by constructing the pin for crimp engagement with the wire and in the same longitudinal zone providing the dielectric assembly with means for interlocking engagement with the pin. The means incorporated in the dielectric assembly for interlocking the pin with the dielectric assembly has resilient tongues for snap engagement with the pin. The feature of the invention is the concept of providing the dielectric assembly with such engagement tongues instead of providing the pin with the engagement tongues. With these two provisions in the same longitudinal zone of the connector, the length of the connector is reduced by approximately one-third.

With reference to reduction of factory cost, the invention is characterized by the concept of an outer shell structure in the form of a ferrule assembly comprising two inner mating ferrules and at least one outer surrounding ferrule. The two inner ferrules which cooperate to enclose and unify dielectric bushing assembly comprise a forward ferrule for telescopically mating with a complimentary ferrule of a complementary connector and a rearward ferrule that makes electrical connection with the outer conductor or shield of the coaxial cable.

An outer ferrule which may be the only outer ferrule surrounds the rearward inner ferrule and cooperates therewith for clamp engagement with the shield or outer conductor of the coaxial cable. If the electrical connector is constructed for mounting in a support structure such as a panel or a bulkhead, a second outer ferrule surrounds the forward inner ferrule and is adapted for engagement with the support structure. This second outer ferrule may be formed with peripheral resilient tongues for engagement with the support structure or may be formed with a screw thread for threaded engagement with the support structure.

One advantage in cost of using such a ferrule assembly for the shell of the connector is that the individual ferrules may be of simple construction and may be simple sheet metal stampings instead of more expensive parts produced by screw machines. Sheet metal ferrules cost approximately one-third as much as equivalent parts made by automatic screw machines. Another advantage in cost is that the different ferrules may be made of different materials. If one portion of the shell structure must be plated with silver or gold, it is not necessary to plate the whole shell structure with silver or gold. If one portion of the shell structure must be made of resilient metal for engagement with support structure, it is not necessary to make the whole shell structure of resilient metal. At least one of the ferrules of the ferrule assembly may be made of relatively inexpensive material such as brass.

A further feature of the invention with respect to economy is the concept of so constructing and arranging the ferrules of the ferrule assembly that with the ferrules in their correct relative positions merely swaging one ferrule into engagement with another ferrule unifies the whole assembly. The swaging operation not only unites the parts of the whole ferrule assembly but,

also, serves to unify the dielectric bushing assembly that is enclosed by the ferrule assembly.

The concept of employing the described ferrule assembly to enclose and unify a dielectric bushing assembly makes it possible to achieve further economy by using interchangeable ferrules and interchangeable dielectric bushings that may be assembled selectively in different ways to make a number of different connectors for different specific purposes. In practice, eighteen separate parts may be assembled selectively to make as many as thirty different connectors.

The need for reducing the cost of assembly and installation by the purchaser of the connectors is achieved in large part by unifying the combined ferrule assembly and dielectric assembly at the factory to leave the purchaser with only the relatively simple task of crimping the connector pin into engagement with the wire of the coaxial cable and crimping an outer ferrule into clamping engagement with the outer conductor or shield of the coaxial cable.

The described construction of the connector also makes it possible to produce a connector that is highly efficient for its purpose. The provision of relatively long leakage paths in a connector of relatively small diameter has already been mentioned. The fabrication of the outer shell of the connector in the form of an assembly of ferrules make it possible to plate the individual ferrules in advance to provide plating of higher than usual quality. The fabrication of the outer shell in the form of a ferrule assembly also makes it possible to avoid galvanic action by properly selecting contiguous metals with consideration for their relative positions in the electromotive series.

One practice of the invention is further characterized by an outer ferrule of unique construction for snap engagement with the support structure in which the connector is to be mounted. As will be made clear, the resilient mounting ferrule permits liberal dimension tolerances, permits lateral shift of the connector relative to the support structure, permits angular misalignment of the connector relative to the support structure, resists loosening of the connector from the support structure by vibration, and avoids any tendency for the connector to be disengaged from the support structure if the connector is manually rotated on its axis.

The various features and advantages of the invention may be understood by reference to the following detailed description and the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a longitudinal sectional view of a forward inner ferrule employed in a selected embodiment of the invention;

FIG. 2 is a forward dielectric bushing of the dielectric assembly of the selected embodiment;

FIG. 3 is a longitudinal sectional view of a spring metal retainer that is enclosed by the dielectric assembly;

FIG. 4 is a longitudinal sectional view of a rearward dielectric bushing of the dielectric assembly;

FIG. 5 is a longitudinal sectional view indicating how the members shown in FIGS. 1 to 4 are assembled together;

FIG. 6 is a longitudinal sectional view of the inner rearward ferrule of the ferrule assembly;

FIG. 7 is a longitudinal sectional view of an outer mounting ferrule for mounting the connector with snap action in a supporting structure such as a panel;

FIG. 8 is a longitudinal sectional view indicating how the ferrules shown in FIGS. 6 and 7 may be permanently joined to the assembly shown in FIG. 5 to complete the factory assembly of the connector;

FIG. 9 is a view partly in side elevation and partly in section of a plug pin fitting that is adapted for crimp engagement with the axial wire of a coaxial cable;

FIG. 10 is a longitudinal sectional view of an outer ferrule for cooperation with the rearward inner ferrule of FIG. 6 for clamping engagement with the outer conductor or shield of the coaxial cable;

FIG. 11 is a side elevational view of the end of a coaxial cable prepared for attachment to the connector;

FIG. 12 indicates an initial step by the purchaser in the installation of the connector, the view showing the plug pin of FIG. 9 crimped to the wire of the coaxial cable with the outer ferrule of FIG. 10 embracing the coaxial cable in a retracted position;

FIG. 13 is a longitudinal sectional view of the selected connector completely installed on the end of a coaxial cable;

FIG. 14 is a cross section taken as indicated by the line 14—14 of FIG. 13 to show how the outer ferrule of FIGS. 10 and 12 may be crimped to hexagonal cross-sectional configuration for clamping the shield of the coaxial cable against the periphery of the rearward inner ferrule of FIGS. 6 and 8;

FIG. 15 is a perspective view of a modified form of retainer that may be used in the construction of the connector;

FIG. 16 is a longitudinal sectional view similar to FIG. 13 showing a second embodiment of the invention in the form of a bulkhead socket connector;

FIG. 17 is a side elevation of a turret-type plug pin for use in a turret connector;

FIG. 17a is a side elevation of a turret-type socket pin for use in a turret plug connector;

FIG. 18 is a side elevation of a turret plug connector incorporating the turret pin shown in FIG. 17;

FIG. 18a is a side elevation of a turret socket connector incorporating the turret pin of FIG. 17a;

FIG. 19 is a chart showing connector parts in side elevation, including interchangeable parts, and indicating how the parts may be assembled selectively to make different connectors for different specific purposes;

FIG. 20 is a fragmentary side elevational view of the first described embodiment of the invention showing how the connector mounts with snap action in a panel, the panel and its associated structure being shown in section;

FIG. 21 is a transverse section, taken as indicated by the line 21—21 of FIG. 20, to show how the outer resilient tongues of the connector center the connector in the bushing in the panel;

FIG. 22 shows the planar development of the mounting ferrule, i.e., the unrolled configuration of the mounting ferrule in FIG. 20, which is the mounting ferrule shown in FIG. 7; and

FIG. 23 is a perspective view of the panel bushing shown in FIG. 20 prior to the installation of the bushing, a portion of the bushing being broken away.

The various forms of the connector are constructed for use with a coaxial cable of the character shown in FIG. 11. The inner or axial conductor of the cable is a multiple-strand wire 30 which is covered by a jacket in the form of tubular insulation 32. An outer conductor in the form of a woven wire shield 34 encases the tubular insulation 32. In preparation for mounting a connector on the end of such a coaxial cable, the tubular insulation 32 and the woven wire shield 34 are cut back as shown in FIG. 11 to expose an end portion of the wire 30 and then the end portion of the shield is retracted temporarily as shown.

The first embodiment of the invention, which may be termed a snap-lock plug connector, is indicated by reference numeral 35 in FIG. 19 where it is shown in side elevation on a small scale. The same connector 35 is shown in section on a larger scale in FIG. 13.

The principal parts of the snap-lock plug connector 35 in FIG. 13 comprise a pin, a retainer for assembly engagement therewith, a dielectric bushing assembly enclosing the retainer and pin and, finally, an encasing ferrule assembly. The pin mates with a complementary pin

of a complementary connector to effect a plug-and-socket connection. In this instance, the pin is a plug pin 36 which is best shown in FIG. 9 and which is intended to mate with a socket pin of a complementary connector, for example, the socket pin 38 of the connector 40 that is shown in section in FIG. 16 and is shown in a smaller scale in side elevation in FIG. 19.

The plug pin 36 shown in FIG. 9 has a pin portion 42 that serves as a plug and has a base portion 44 which is suitably adapted for attachment to the wire end 30. In this particular embodiment of the invention, the base portion 44 forms an axial socket 45 into which the wire end 30 is inserted, and the inserted wire end is positively engaged by crimping the base portion 44 as indicated at 46 in FIG. 12. The base portion 44 of the socket pin 36 has a rearward circumferential flange 48 which forms a forwardly directed shoulder 50 and has a second forward circumferential flange 52 which forms a rearwardly directed shoulder 54.

The retainer which engages the socket pin 36, and which is indicated by numeral 55 in FIG. 13, may comprise a sleeve of spring metal of the construction shown in FIG. 3. The retainer in FIG. 3 is longitudinally split as indicated at 56, and is lanced to form three longitudinal tongues 58. Each of the tongues 58 is bent radially inward as indicated to serve as resilient means for engaging the rearwardly directed shoulder 54 of the plug pin 36 with a snap action. The manner in which the retainer engages the socket pin may be seen in FIG. 13.

The dielectric bushing assembly that encloses the retainer 55 together with the plug pin 36 may comprise a forward bushing 60 that is shown in FIG. 2 and a rearward bushing 62 that is shown in FIG. 4. These two bushings mate to form a chamber 64 to confine the retainer 55 in the manner shown in FIG. 5. As may be seen in FIG. 5, the chamber 64 provides a forward shoulder 65 to abut the shoulder formed by the forward end of the retainer 55 and further provides a rear shoulder 66 to abut the shoulder formed by the other end of the retainer. It may further be seen in FIG. 5 that the rearward bushing 62 telescopes over the rearward portion of the forward bushing 60 to form a joint that provides a relatively long current leakage path, the path being a tortuous path with a relatively extensive dimension longitudinally of the bushing assembly. The forward bushing 60 forms a forward axial socket 68 to surround the pin portion 42 of the plug pin 36 with radial spacing as shown in FIG. 13. The rearward bushing 62 forms a rearward axial socket 70 to receive the jacket or tubular insulation 32 of the coaxial cable.

The ferrule assembly of the snap-lock plug connector 35 of FIG. 13 has multiple purposes. It encloses the described dielectric bushing assembly to hold the bushing assembly together and to protect the bushing assembly together and to protect the bushing assembly against mechanical damage; it serves as means to anchor the woven wire shield 34 to the connector and serves as an outer conductor extension of the shield; it mates with the ferrule assembly of a complementary conductor; and, finally, in this instance it serves as means for mounting the connector in support structure.

In the first embodiment of the invention illustrated by FIG. 13, the ferrule assembly comprises a forward inner ferrule 72 that is shown in FIG. 1, a rearward inner ferrule 74 that is shown in FIG. 6; an outer rearward ferrule 75 that is shown in FIG. 10, which may be aptly termed a shield-clamping ferrule; and, finally, an outer forward mounting ferrule 76 that is shown in FIG. 7.

The forward inner ferrule 72 encloses the bushing assembly and conforms with the configuration of the bushing assembly. Thus the ferrule 72 is formed with an inner circumferential shoulder 77 (FIG. 1) to abut an outer circumferential shoulder 78 (FIG. 5) of the bushing assembly, and is further formed with an inwardly directed end flange 80 (FIG. 1) to overhang the forward

end of the bushing assembly as shown in FIG. 5. At its rear end the ferrule 72 is formed with a radially outward flange 82.

The rearward inner ferrule 74 is formed with a forward radial flange 84 for abutment against the flange 82 of the ferrule 72. The radial flange 84 is further formed with a peripheral cylindrical flange 85 that is dimensioned to telescope over the flange 82 of the ferrule 72.

The outer shield-clamping ferrule 75 is dimensioned with a rearward portion 86 (FIG. 10) of reduced diameter to fit snugly around the coaxial cable and is further formed with a forward portion 88 of larger diameter which clamps the woven wire shield 34 against the periphery of the ferrule 74 as indicated in FIG. 13. Preferably, the ferrule 75 is formed with a flared forward lip 90 to facilitate the telescoping of the ferrule over the woven wire shield. It is contemplated that the shield-clamping ferrule 75 will be permanently anchored at its assembled position by crimping. Preferably, a suitable tool is employed to crimp the forward portion 88 of the ferrule to the hexagonal configuration shown in FIG. 14.

The outer ferrule 76 is shown in FIG. 7 is employed for mounting the connector on support structure at an installation. For this purpose, the ferrule 76 is formed with a circumferential series of flexible tongues 92 for engaging the support structure with snap action, in a manner to be described later. The ferrule 76 is formed with a radially outward circumferential flange 94 at its rearward end (FIG. 7) to abut the flange 82 of ferrule 72.

The ferrule assembly is united by inserting the two abutting radial flanges 82 and 94 into the cylindrical flange 85 of the ferrule 74 against the radial flange 85 of the ferrule and then swaging the cylindrical flange 85 radially inward into clamping engagement with the two abutting flanges 82 and 94 as shown in FIG. 8. By virtue of this construction, the united ferrule assembly is formed with an outer circumferential rib 95 (FIG. 8) which is relatively strong since it is made of multiple layers of sheet metal.

It may be noted in FIG. 8 that the bushing assembly comprising the two bushings 60 and 62 is clamped together between the inwardly directed end flange 80 of the ferrule 72 and the radially outward flange 84 of the ferrule 74, and is also held together between the inner circumferential shoulder 77 of the ferrule 72 and the radial flange 84 of ferrule 74.

The outer mounting ferrule 76 having the flexible tongues 92 mounts the connector in support structure in the manner shown in FIG. 20. FIG. 20 shows a panel 96 that is formed with a circumferential opening to receive a mounting bushing 98 that is shown in perspective in FIG. 23. The mounting bushing 98 has an outer circumferential rib to abut one face of the panel 96 and has a cylindrical end portion 102 that may be swaged radially outward into engagement with the other face of the panel 96. As may be seen in FIG. 23, the cylindrical end portion 102 may be formed with circumferentially spaced notches or end slots 104 to facilitate the swaging operation. The mounting bushing 98 forms a socket provided with an inner circumferential rib 105. This inner rib 105 forms a forwardly directed inner circumferential shoulder 106 for engagement by the flexible tongues 92, and also forms a rearwardly directed inner circumferential shoulder 108 for abutment with the previously mentioned outer circumferential rib 95 of the connector.

FIG. 22, which is the unrolled configuration of the ferrule 76, shows how the thin spring metal of the ferrule is provided with four angular slots 110 to form the four flexible tongues 92. It will be noted that the tongues 92 extend in circumferential directions and that each of the tongues is formed with a straight side edge 112 for engagement with the mounting bushing 98, the four side of the connector. A feature of the invention is that each of the tongues 92 has a second opposite side

edge 114 which is inclined relative to the plane of the side edges 112. These inclined side edges 114 of the flexible tongues 92 may be aptly termed cam edges since they cooperate with the mounting bushing for camming of the flexible tongues radially inward when the connector is initially inserted into the mounting bushing.

As may be seen in FIG. 21, this construction provides the ferrule 96 with a pair of opposed tongues 92a and 92b on one diametrical half of the ferrule 76, and a second pair of opposed tongues 92c and 92d on the other diametrical half. Since these two pair of tongues press radially outward in opposite directions, they serve to center the ferrule 76 inside the mounting bushing 98 in a yielding manner. It is important to note also that two diametrically opposite tongues 92a and 92d are turned in the same circumferential direction, i.e., in the counter-clockwise direction, and a second pair of diametrically opposite tongues 92b and 92c are turned in the opposite, or clockwise, direction.

It has been found that when an installed connector of this type is manually rotated in a given circumferential direction in a mounting socket such as the socket provided by the mounting bushing 98, the rotation tends to cause collapse of the tongues that are turned opposite to the direction of the rotation. Thus, if the ferrule 76 is manually rotated in a clockwise direction as viewed in FIG. 21, the two counter-clockwise tongues 92a and 92d tend to collapse and become ineffective for retaining the ferrule in engagement with the mounting bushing. In the described construction, however, the clockwise rotation actually tends to keep the other two tongues 92b and 92c radially extended because the leading longitudinal edges of the tongues tend to resist the relative rotation by digging into the material of the surrounding mounting bushing. It is apparent that if the ferrule 76 is rotated in either circumferential direction, a pair of the flexible tongues 92 will be effective to keep the ferrule in positive engagement with the forwardly directed inner circumferential shoulder 106 of the mounting bushing 98.

The manner in which the connector 35 shown in FIGS. 13 and 19 may be assembled, and the manner in which the connector serves its purpose, may be readily understood from the foregoing description.

The procedure for assembling the connector parts at the factory comprises the following steps: First, the retainer 55 is inserted into the rear end of the forward dielectric bushing 60 and then the dielectric bushings 60 and 62 are telescoped together to enclose the retainer. The dielectric bushing assembly comprising the two telescoped bushings 60 and 62 is then inserted into the ferrule 72 in the manner shown in FIG. 5. The mounting ferrule 76 is then telescoped over the ferrule 72 to place the flange 94 of the ferrule 76 in abutment against the flange 82 of the ferrule 72, and the ferrule 74 is positioned against the inner end of the ferrule 72. The cylindrical flange 85 of the ferrule 74 is then swaged radially inward as shown in FIG. 8 to complete the factory assembly of the connector assembly with the dielectric bushing assembly enclosed by the ferrule assembly and with the retainer 55 enclosed by the dielectric bushing assembly.

The purchaser receives the connector assembly shown in FIG. 8 along with the plug pin 36 shown in FIG. 9 and the shield-clamping ferrule 75 shown in FIG. 10. To install the connector on a coaxial cable, the purchaser prepares the end of the coaxial cable in the manner shown in FIG. 11, and then inserts the wire end 30 of the cable into the axial socket 45 (FIG. 9) of the plug pin 36. A suitable hand tool is then employed to crimp the base portion 44 of the plug pin into permanent engagement with the wire end 30 with the base portion 44 of the plug pin backed against the end of the jacket or tubular insulation 32 of the coaxial cable as shown in FIG. 12. The shield-clamping ferrule 75 is then

backed onto the coaxial cable in the manner shown in FIG. 12.

With the plug pin 36 secured on the end of the coaxial cable in the manner shown in FIG. 12, the coaxial cable is manipulated to insert the plug pin into the factory assembly that is shown in FIG. 8. When the plug pin is completely inserted into the factory assembly, the flexible tongues 58 of the retainer 55 snap into engagement with the rearwardly directed circumferential shoulder 54 (FIG. 9) of the plug pin 36 for effective anchorage of the factory assembly to the coaxial cable as shown in FIG. 13. The mounting of the connector on the end of the coaxial cable is completed by advancing the retracted end portion of the woven wire shield 34 over the periphery of ferrule 74, then sliding the shield-engaging ferrule 75 forward to its assembled position shown in FIG. 13 and, finally, crimping the ferrule 75 to the hexagonal configuration shown in FIG. 15.

The assembled connector may then be mounted on the panel 96 as shown in FIG. 20 by simply thrusting the connector into the mounting bushing 98. When the inclined cam edges 114 of the tongues 92 encounter the inner circumferential rib 105 of the mounting bushing, the rib cams the flexible tongues radially inwardly to permit the tongues to pass through the rib. With the continued axial movement of the connector through the mounting bushing, the depressed flexible tongues 92 snap radially outward into engagement with the forwardly directed inner circumferential shoulder 106 of the mounting bushing and at the same time the outer circumferential rib 100 of the connector reaches abutment with the inner circumferential rib 105 of the mounting bushing. Thus the installed connector is anchored against axial movement relative to the mounting bushing by the cooperation of the flexible tongues 92 and the outer circumferential rib 100 in their engagement with the opposite shoulders of the inner circumferential rib 105 of the mounting bushing.

It may be readily appreciated that the described connector is of economical construction since the ferrule assembly and the retainer 55 consist of sheet metal stampings that may be mass produced, and the bushing assembly consists of molded parts which may also be mass produced. As heretofore stated, the ferrules of the ferrule assembly may be made of different metals and may be separately plated. The insulating bushings of the bushing assembly may be made of various nonconducting materials, in various practices of the invention, including "Teflon" and silicone plastics, for high temperature installations.

The described construction for the connector is especially compact in longitudinal dimension because the construction permits the plug pin 36 to be crimped in engagement with the wire end 30 in the same longitudinal zone of the connector where the plug pin is anchored to the dielectric bushing assembly. The feature of the present invention in this regard is the provision of the retainer 55 to function in effect as a part of the dielectric bushing assembly instead of functioning as an integral part of the plug pin. This arrangement permits the retainer to telescope over the same portion of the plug pin that is crimped into engagement with the wire end, the resulting reduction in the necessary length of the plug pin being as much as one-third.

The construction of the mounting bushing 76 is especially advantageous because it permits liberal tolerances in the dimensioning of the mounting ferrule and in the dimensioning of the cooperating mounting bushing 98. The difference in diameter between the outer circumference of the cylindrical body of the mounting ferrule 75 and the inner circumference of the inner circumferential rib 100 of the mounting bushing 98 may be as great as .025 inch, in contrast with the usual requirement of tolerance in the range of .005 inch to .010 inch.

An important feature of the mounting ferrule 76 which makes the liberal dimensional tolerances possible is that a single set of flexible tongues is employed for two purposes, namely, the purpose of yieldingly centering the mounting ferrule in the mounting bushing and, secondly, the purpose of positively interlocking the mounting ferrule and the mounting bushing. If two different sets of tongues were employed for these two different purposes in a well-known manner, the tongues of the two sets would necessarily be smaller and weaker than the tongues of the single set.

The single set of tongues, being relatively large, provides liberal freedom for both radial displacement of the connector relative to the mounting bushing and angular displacement of the connector relative to the mounting bushing. This freedom for movement of the connector relative to the mounting bushing is especially advantageous for rack and panel installations where one connector of a pair of cooperating connectors is mounted in a retractable structure, with the other connector mounted in fixed structure. The two cooperating connectors when disconnected and unrestrained may be out of axial alignment with each other by as much as $\frac{1}{32}$ inch without causing malfunctioning.

FIG. 14 shows a retainer 55a which may be substituted for the previously described retainer 55. The retainer 55a is of the same construction as is the first retainer, as indicated by the use of corresponding numerals to indicate corresponding parts. The only difference is that the retainer 55a is formed with a plurality of radial tongues 115 (FIGURE 15) at its inner end for insertion between confronting surfaces of the two insulating bushings 60 and 62 at the juncture of the assembled bushings. Thus, the bushing assembly clamps the radial tongues to provide increased resistance to withdrawal of the plug pin 36 from the connector.

The previously mentioned bulkhead socket connector 40, which is shown on a small scale in FIG. 19 and is shown on a larger scale in FIG. 16, is of the same general construction as the previously described connector 35 shown in FIG. 13. The previously mentioned socket pin 38 of the bulkhead socket connector 40 is of the same construction as the plug pin 36 but, instead of being formed with a pin portion, the socket pin 38 is formed with a leading socket portion 118 which is formed with longitudinal slots 120 to enable the socket pin to receive a plug pin with resilient gripping action. FIG. 16 shows the pin portion 42 of a plug pin 36 poised to telescope into the socket 118.

The dielectric bushing assembly of the bulkhead socket 40 comprises a forward insulating bushing 60a which is substituted for the previously mentioned forward bushing 60 of FIG. 2 and which mates in the same manner with the previously described rearward bushing 62 of FIG. 4. As indicated in FIG. 16, this forward insulating bushing 60a is dimensioned to telescope into the forward axial socket 68 of a complementary insulating bushing 60 of a complementary connector such as the first described plug connector 35 shown in FIG. 13.

The ferrule assembly employed in the bulkhead socket connector 40 comprises a forward inner ferrule 72a which is substituted for the previously mentioned ferrule 72, a rearward inner ferrule 74a which is substituted for the previously mentioned ferrule 74, the previously mentioned shield-clamping ferrule 75 and, finally, a bulkhead mounting ferrule 76a which is substituted for the previously described ferrule 76. The ferrule 72a forms a forwardly extending flexible socket 122 to telescope over and yieldingly grip the ferrule 72 of a complementary socket connector. FIG. 16 shows in phantom a ferrule 72 of a complementary connector poised for insertion into the flexible socket 122. The flexible socket 122 is formed with longitudinal slots 124 for increased flexibility. The ferrule 72a is formed with a radial flange 82a at its rear end

which is identical with the previously mentioned radial flange 82 of ferrule 72.

The ferrule 74a differs from the previously described ferrule 74 in having a plain radial flange 84a which abuts the flange 82a and is of the same outside dimensions.

The ferrule 76a is formed with a screw thread 125 for threaded engagement with a bulkhead and is further formed with an outer circumferential hexagonal flange 126 to facilitate the use of tools for installing the connector. The mounting ferrule 76a is further formed with a cylindrical flange 128 at its inner end and, as shown in FIG. 16, this cylindrical flange 128 is swaged radially inward over the two abutting ferrule flanges 82a and 84a to unify the ferrule assembly.

It is apparent that in the connector shown in FIG. 16, as in the previously described connector shown in FIG. 13, two of the ferrules of the ferrule assembly have abutting flanges and a third ferrule of the assembly is formed with a cylindrical flange that is swaged into clamping engagement with the two abutting flanges. The two abutting flanges are on different ferrules in the two assemblies, and the swaged flange is also on different ferrules in the two assemblies, but both assemblies embody the same concept of structural cooperation on the part of three ferrules.

FIG. 19 shows other forms of mounting ferrules that may be used in ferrule assemblies of connectors instead of the previously described mounting ferrules 76 and 76a. One additional mounting ferrule is a long, screw-threaded mounting ferrule 76b for bulkheads that may be substituted for the mounting ferrule 76a. Another is a simple friction-type ferrule 76c having two flexible outwardly biased legs, which ferrule may be substituted for the previously described ferrule 76 where frictional mounting engagement without snap locking action is desired. In addition, FIG. 19 shows a washer 76d which may be considered as a ferrule since, in effect, it serves as one of the two abutting ferrule flanges that are clamped by a third ferrule flange in the fabrication of an electrical connector that is not intended to be mounted in supporting structure.

FIG. 19 indicates how the various connector components mentioned to this point may be assembled in various ways to make 10 different connectors, including the snap-lock plug connector 35 and the bulkhead socket-connector 40 that have been described in detail. The other 8 connectors are: a long bulkhead plug connector 130; a long bulkhead socket connector 132; a bulkhead plug connector 134; a pull-out plug connector 135; a pull-out socket connector 136; a snap-lock socket connector 138; a cable plug connector 140; and a cable socket connector 142.

FIG. 17 shows a turret plug pin 36a which is similar to the previously described plug pin 36 but is provided on its base end with an axial extension or turret 144, the turret being provided with an insulating sleeve 145. The turret plug pin 36a may be used wherever a connector is to be mounted in supporting structure to provide a terminal post for electrical connections. Thus FIG. 18 shows how the turret plug pin 36a may be substituted for the turret pin 36 in the bulkhead plug connector 134 of FIG. 19 to make a turret connector 145.

In like manner, FIG. 17a shows how a turret socket pin 38a may be constructed to replace the previously described socket pin 38 where a turret-type connector is desired. Here, again, the turret socket pin 38a is similar to the previously described socket pin 38 but has an axial extension to form a turret 148, the turret having an insulating sleeve 150. FIG. 18a shows a turret connector 152 incorporating the turret socket pin 38a. Except for the substitution of the turret socket pin 38a for the socket pin 38, the connector 152 is identical with the bulkhead socket connector 40 in FIG. 19.

My description in specific detail of the various embodiments of the invention will suggest various changes, substitutions and other departures from my disclosure, within the spirit and scope of the appended claims.

I claim:

1. An electrical connector for mating with a complementary connector having a complementary pin and a complementary ferrule and for mounting on the end of a wire that is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation, said electrical connector having: a pin for mating with the complementary pin of said complementary connector for effecting a plug-and-socket connection, said pin having a base portion crimped to the end of said wire, said base portion having a rearwardly directed shoulder; a retainer in the form of a sleeve of spring metal, the sleeve being disposed on the base portion of said pin, said sleeve being lanced to form a plurality of flexible tongues extending in one longitudinal direction and flexed radially inward for snap engagement with said shoulder of the pin, said sleeve having a radially outward flange; a dielectric bushing assembly including a pair of mated bushings jointly forming a chamber to confine said retainer with one bushing of the assembly forming an axial socket to receive the end of said tubular insulation of the wire and with another bushing of the assembly forming a socket to surround the leading end of said contact element, said bushings telescoping together to form at least one joint providing a relatively long, tortuous current leakage path, said bushings cooperating for clamp engagement with said flange of the retainer to anchor the retainer; and a ferrule assembly enclosing said dielectric bushing assembly and holding the bushing assembly together, said ferrule assembly being electrically connected with said flexible metal shield and having a forward tubular portion to mate with the complementary ferrule assembly of said complementary connector.

2. An electrical connector for mating with a complementary connector having a complementary pin and a complementary ferrule and for mounting on the end of a wire that is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation, said connector having:

a pin for mating with the complementary pin of said complementary connector and having a base portion for connecting to the end of said wire;

means including a dielectric bushing assembly enclosing and immobilizing said base portion of the pin, said dielectric bushing assembly means including a rearward bushing having a rearwardly directed outer shoulder and forming an axial socket to receive the end of said tubular insulation of the wire, said assembly including a forward bushing having a forwardly directed outer shoulder; and

a ferrule assembly enclosing said dielectric bushing assembly, said ferrule assembly including a forward ferrule with an inner rearwardly directed shoulder to engage said forwardly directed shoulder of the forward bushing, said ferrule assembly including a rearward ferrule having an inner forwardly directed shoulder to engage said rearwardly directed shoulder of the rearward bushing, one of said forward and rearward ferrules having an outer circumferential flange at its inner end, and said ferrule assembly including another ferrule enclosing and engaging said flange to hold the bushing assembly together, said ferrule assembly being electrically connected with said flexible metal shield and having a forward tubular portion to mate with the complementary ferrule assembly of said complementary connector, one of said forward and rearward ferrules having a first outer circumferential flange at its inner end and the other of said forward and rearward ferrules having a second outer circumferential flange at its inner end, one of said two flanges enclosing and engaging the other of the two flanges to hold the ferrule assembly together.

3. An electrical connector for mounting in surrounding support structure for mating with a complementary

connector having a complementary pin and for mounting on the end of a wire that is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation, said electrical connector having: a pin for mating with the complementary pin of said complementary connector and having a base portion for connecting to the end of said wire; means including a dielectric bushing assembly enclosing and immobilizing said base portion of the pin, said bushing assembly means including a rearward bushing having a rearwardly directed outer shoulder and also forming an axial socket to receive the end of said tubular insulation of the wire, said bushing assembly including a forward bushing having a forwardly directed outer shoulder; and a ferrule assembly enclosing said bushing assembly, said ferrule assembly including a forward ferrule with an inner rearwardly directed shoulder to engage said forwardly directed shoulder of the forward bushing, said ferrule assembly including a rearward ferrule having an inner forwardly directed shoulder to engage said rearwardly directed shoulder of the rearward bushing, said ferrule assembly including an outer ferrule for engagement with said surrounding support structure to support the electrical connector, said outer ferrule embracing one of said forward and rearward ferrules with its inner end adjacent the outer end of the embraced ferrule member, two of said three ferrules having two respective abutting radial flanges, the third of said three ferrules lying against one side of the two abutting flanges and both enclosing the abutting flanges and confining the abutting flanges against axial separation to hold the ferrule assembly together.

4. A combination as set forth in claim 3 in which said forward and rearward ferrules respectively have the two abutting flanges and said outer ferrule encloses and confines the two abutting flanges.

5. A combination as set forth in claim 3 in which said outer ferrule and one of said forward and rearward ferrules respectively have the two abutting flanges, and the other of said forward and rearward ferrules encloses and confines the two abutting flanges.

6. An electrical connector for mounting in surrounding support structure for mating with a complementary connector having a complementary pin and for mounting on the end of a wire that is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation said connector having: a pin for mating with the complementary pin of said complementary connector for effecting a plug-and-socket electrical connection, said pin having a crimpable base portion with an axial socket to receive the end of said wire for crimp engagement therewith, said base portion having a rearwardly directed shoulder; a retainer for said pin and having a forwardly directed spring portion for snap engagement with said rearwardly directed shoulder; a dielectric bushing assembly including a forward bushing with a forwardly directed shoulder and a rearward bushing with a rearwardly directed shoulder, said bushings forming a chamber to confine said retainer; and a ferrule assembly enclosing said bushings, said ferrule assembly including a forward ferrule with an inner rearwardly directed shoulder to engage said forwardly directed shoulder of the forward bushing, said ferrule assembly including a rearward ferrule having an inner forwardly directed shoulder to engage said rearwardly directed shoulder of the rearward bushing, said ferrule assembly including an outer ferrule for engagement with said surrounding support structure to support the connector, said outer ferrule embracing one of said forward and rearward ferrules with its inner end adjacent the outer end of the embraced ferrule member, two of said three ferrules having respective abutting radial flanges at their inner ends, the third of said three ferrules lying against one side of the abutting flanges and both enclosing the abutting flanges and confining the abutting flanges against axial separation to hold the ferrule assembly together.

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7. A combination as set forth in claim 6 in which said outer ferrule embraces said forward ferrule; and in which a second outer ferrule embraces said rearward ferrule to clamp said flexible metal shield against the outer circumference of the rearward ferrule.

8. An electrical connector for mounting in surrounding support structure for mating with a complementary connector having a complementary pin and for mounting on the end of a wire that is covered by tubular insulation, said electrical connector having: a pin for mating with the complementary pin of said complementary connector and having a base portion for attachment to the end of said wire; means including a dielectric bushing assembly enclosing and immobilizing said base portion of the pin, said bushing assembly means including a rearward bushing having a rearwardly directed outer shoulder and forming an axial socket to receive the end of said tubular insulation of the wire, said assembly including a forward bushing having a forwardly directed outer shoulder; and a ferrule assembly enclosing said bushing assembly, said ferrule assembly including a forward ferrule with an inner rearwardly directed shoulder to engage said forwardly directed shoulder of the forward bushing, said ferrule assembly including a rearward ferrule having an inner forwardly directed shoulder to engage said rearwardly directed shoulder of the rearward bushing, said ferrule assembly including an outer ferrule for engagement with said surrounding support structure to support the connector, said outer ferrule embracing one of said forward and rearward ferrules with its inner end adjacent the inner end of the embraced ferrule, said outer ferrule having a plurality of resilient outer tongues to press radially outward against the surrounding support structure, said tongues having side edges for snap engagement with the surrounding support structure, some of said tongues being directed in one circumferential direction and others of the tongues being directed in the opposite circumferential direction, two of said three ferrules having respective abutting radial flanges at their inner ends, the third of said three ferrules lying against one side of the two abutting flanges and both enclosing the abutting flanges and confining the abutting flanges against axial separation to hold the ferrule assembly together.

9. A connector of the character described, having mounting means for snap engagement with an inner circumferential shoulder of a circular socket of supporting structure, said mounting means comprising a ferrule of spring metal having a plurality of resilient outer tongues to press radially outward against the inner surface of the socket, said tongues having side edges for snap engagement with said inner circumferential shoulder, some of said tongues being directed in one circumferential direction having a first tangential component and others of the tongues being directed in the opposite circumferential direction having a second tangential component opposite to the first tangential component, said tongues comprising two pairs of tongues on two diametrical halves, respectively, of the ferrule, the two tongues of each pair being directed in opposite circumferential directions.

10. An electrical connector for mating with a complementary connector having a complementary pin and a complementary ferrule and for mounting on the end of a wire that is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation, said connector having: a pin for mounting with the complementary pin of the complementary connector and having a base portion for connection to the end of the wire; means including a dielectric bushing enclosing the base portion of the pin; and a ferrule assembly enclosing said dielectric bushing assembly, said ferrule assembly including a forward ferrule engaging one end of the bushing and having a first flange, said ferrule assembly further including a second ferrule engaging the opposite end of the bushing and having a second flange, and said ferrule assembly

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further including a third ferrule disposed on a particular one of the first and second ferrules and having a third flange, the flange on a particular one of the first, second and third ferrules enclosing and engaging the flanges on the other two ferrules to retain the bushing assembly, said ferrule assembly being electrically connected with the flexible metal shield and having a forward tubular portion to mate with the complementary ferrule of the complementary connector.

11. An electrical connector for mounting in a surrounding support structure and for mating with a complementary connector having a complementary pin and for mounting on the end of a wire that is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation, said electrical connector having: a pin for mating with the complementary pin of the complementary connector and having a base portion for connecting to the end of the wire; dielectric bushing means enclosing the base portion of the pin; and a ferrule assembly enclosing the bushing assembly, said ferrule assembly including a forward ferrule engaging the forward end of the bushing means and further including a rearward ferrule engaging the rearward end of the bushing means, said ferrule assembly also including an outer ferrule for engagement with the surrounding support structure to support the electrical connector, the outer ferrule embracing a particular one of the forward and rearward ferrules, two of the forward, rearward and outer ferrules having two respective abutting flanges, the third of the forward, rearward and outer ferrules having a flange disposed against the abutting flanges of the other two ferrules and engaging and confining the abutting flanges of the other two ferrules against axial separation to hold together the ferrule assembly.

12. The combination set forth in claim 4 in which the forward and rearward ferrules respectively have the two abutting flanges and in which the outer ferrule has a flange which engages and confines the abutting flanges of the forward and rearward ferrules.

13. A combination as set forth in claim 4 in which the outer ferrule and one of the forward and rearward ferrules respectively have the two abutting flanges and the other one of the forward and rearward ferrules has a flange which encloses and confines the two abutting flanges.

14. An electrical connector for mounting in a surrounding support structure and for mating with a complementary pin and for mounting on the end of a wire which is covered by tubular insulation with a flexible metal shield enclosing the tubular insulation, said connector having a pin for mating with the complementary pin of the complementary connector to provide a plug-and-socket electrical connection, said pin having a crimpable base portion with an axial socket to receive the end of the wire for crimp engagement with the wire, the base portion on the pin having a rearwardly directed shoulder; a retainer for the pin and having a forwardly directed spring portion for disposition on the pin and for snap engagement with the rearwardly directed shoulder on the pin; dielectric bushing means disposed on the retainer; and a ferrule assembly enclosing the bushing means, the ferrule assembly including a forward ferrule engaging the forward end of the bushing means, the ferrule assembly also including a rearward ferrule engaging the rearward end of the bushing means, the ferrule assembly further including an outer ferrule for engagement with the surrounding support structure to support the connector, the outer ferrule being disposed on a particular one of the forward and rearward ferrules, two of the forward, rearward and outer ferrules having abutting flanges and the third one of the forward, rearward and outer ferrules having a portion lying against the abutting flanges of the other two ferrules and enclosing and confining the abutting flanges against axial separation to hold together the ferrule assembly.

(References on following page)

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References Cited by the Examiner

UNITED STATES PATENTS

2,125,843	8/1938	Hall	339—128
2,411,861	12/1946	Antony et al.	339—89 X
2,419,018	4/1947	Gudie	339—217
2,593,479	4/1952	Nieter	339—258 X
2,736,872	2/1956	Heath et al.	339—142
2,888,662	5/1959	Hammell	339—217
2,943,293	6/1960	Bucher et al.	339—276 X

16

3,009,130	11/1961	Redslob et al.	339—217 X
3,054,981	9/1962	Malek et al.	339—89

FOREIGN PATENTS

1,166,637	6/1958	France.
755,159	8/1956	Great Britain.

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