

March 7, 1967

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3,308,316

SUBMERSIBLE MOTOR WITH A SEALED CONNECTOR PLUG

Filed Feb. 5, 1964

2 Sheets-Sheet 1

FIG. 1.

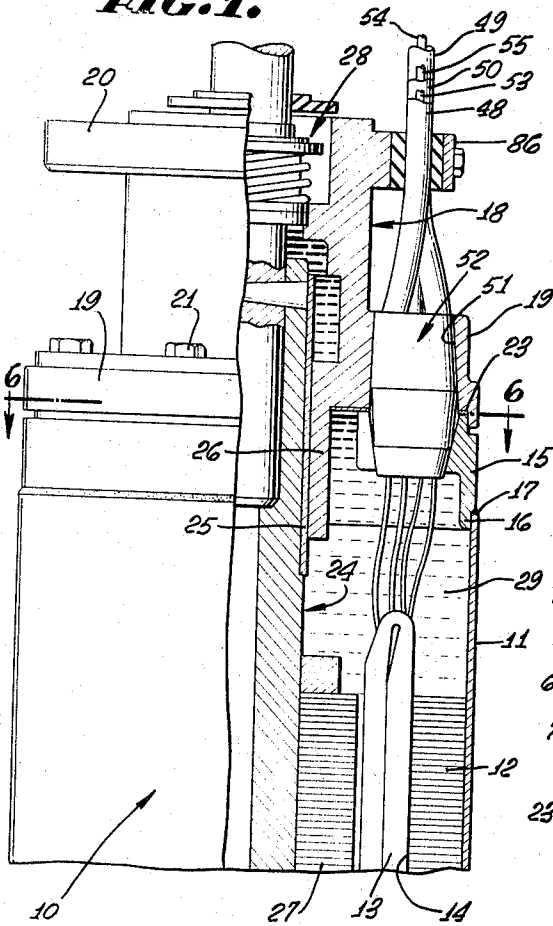


FIG. 2.

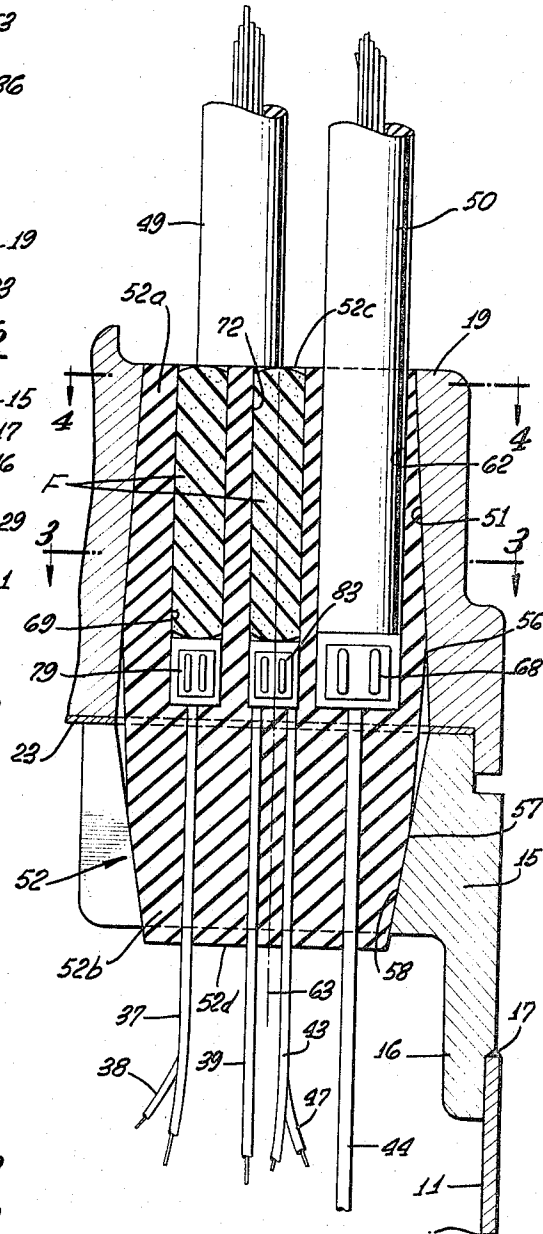
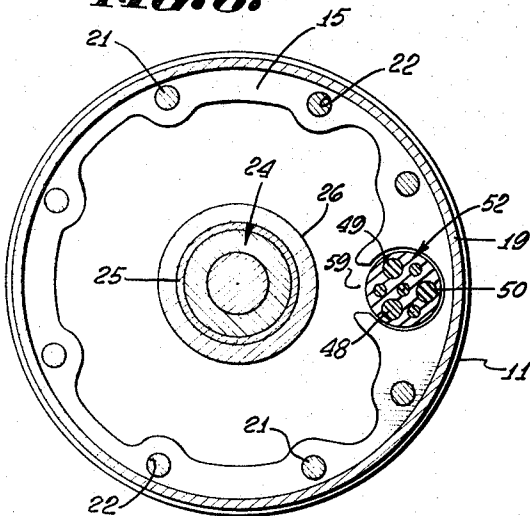


FIG. 6.



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FIG. 4.

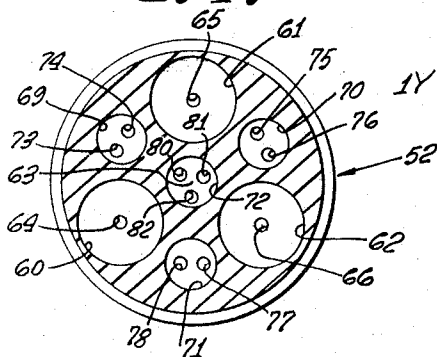


FIG. 7.

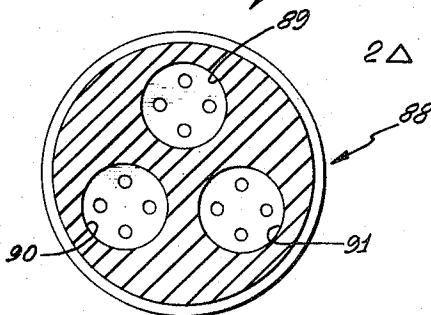


FIG. 8.

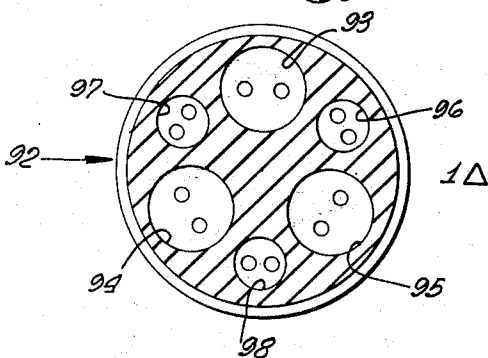


FIG. 9.

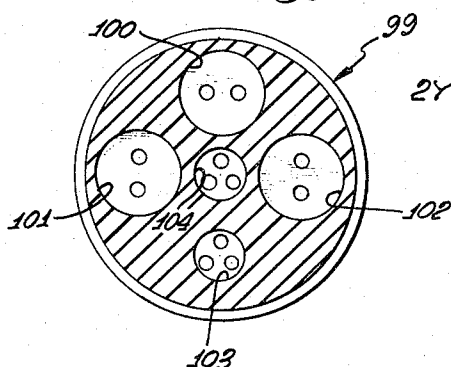


FIG. 5.

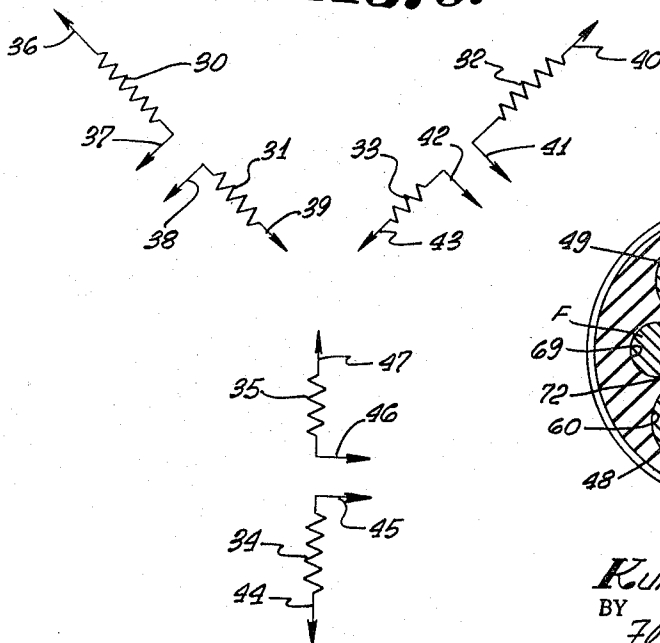
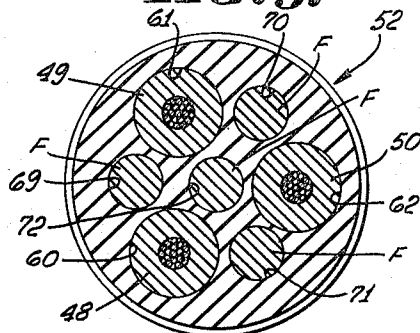


FIG. 3.



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SUBMERSIBLE MOTOR WITH A SEALED CONNECTOR PLUG

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20 Claims. (Cl. 310—87)

This invention relates to submersible motors, and particularly to a seal structure for the electrical leads supplying energy to the motor windings.

Various methods have heretofore been used for accomplishing a sealed connection to the leads of submersible motors. Rather complicated sealed detachable connector structures have been used in some instances. In other instances, a number of individual splicing devices have been used. One of the primary objects of this invention is to provide a simple unitary connector plug that insulates and seals all of the splices, and also simultaneously seals the access opening of the motor housing through which the leads extend.

Still another object of this invention is to provide a series of interchangeable connector plugs of this character whereby connections to the stator winding sections may readily be changed. Thus, for example, without rewinding the motor the leads can be changed to match different voltage sources.

Another object of this invention is to provide a connector structure of this character that provides a relatively long electrical leakage path to ground.

Another object of this invention is to provide a connector structure of this character that can be made inexpensively by simple molding processes.

Another object of this invention is to provide a connector structure of this character that can be readily installed with conventional hand tools.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification, and which drawings, unless described as diagrammatic, or unless as otherwise indicated, are true scale. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a fragmentary view, partly in longitudinal section, of an electric submersible motor incorporating the present invention;

FIG. 2 is an enlarged fragmentary sectional view showing the plug and adjacent structures;

FIGS. 3 and 4 are transverse sectional views taken along planes corresponding to lines 3—3 and 4—4, respectively, of FIG. 2, but with the jacketed leads and fillers removed in FIG. 4;

FIG. 5 is a schematic diagram illustrating the stator winding sections of the motor;

FIG. 6 is a sectional view taken along the plane indicated by line 6—6 of FIG. 1; and

FIG. 7, 8 and 9 are transverse sectional views similar to FIG. 4, but illustrating modified connector plugs for facilitating alternate connections of the stator winding sections.

In FIG. 1 the upper portion of a submersible motor 10 is illustrated. The motor 10 has an outer shell 11, which may be made of sheet metal or the like, in which a stack of stator laminations 12 is accommodated. Windings 13 extend through slots 14 of the stator stack 12. An adapt-

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er or end ring 15 is secured to the upper end of the shell 11. For this purpose, the ring has a reduced annular projection 16 fitting into the end of the shell. The adapter ring 15 and shell 11 are welded together, as at 17.

A bracket 18 closes the upper end of the motor 10 and furthermore serves as a means whereby the motor 10 may be suspended, as for example from a pump structure (not shown). The bracket 18 has a lower flange 19 secured to the adapter ring 15 and an upper flange 20 which may be secured to the companion apparatus. The lower bracket flange 19 abuts the adapter ring 15 and is secured by the aid of a plurality of cap screws 21 that engage suitable threaded apertures 22 shown in FIG. 6. Interposed between the flange 19 and the adapter ring 15 is a sealing gasket 23.

A shaft structure 24 extends upwardly through the bracket 18 such as for cooperation with a pump structure. A bearing sleeve 25 for the shaft is carried by a central annular wall 26 formed in the bracket structure 18.

The shaft structure 24 carries a rotor 27. The lower end of the shaft may be supported by an appropriate thrust bearing structure (not shown). The lower end of the motor may be sealed in an appropriate manner. A liquid seal 27 accommodated in the bracket 18 is provided for maintaining a suitable liquid filling 29 in the motor structure and against leakage along the shaft structure.

The stator windings 13, as indicated diagrammatically in FIG. 5, include six winding groups 30, 31, 32, 33, 34 and 35, two groups for each phase. Thus the winding groups 30 and 31 may be connected together in series or parallel to form one section of a three-phase winding. Similarly, the winding groups 32—33 and 34—35 may be connected together either in series or parallel. Furthermore, the winding groups 30—31, 32—33 and 34—35 can be connected together either in Y or delta. Accordingly, in a well-understood manner the winding groups 30 to 35 can be connected together in accordance with the specifications of the alternating current source.

Twelve terminal wires 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, and 47 are provided, two for each winding section. These wires 36—47 must be connected to jacketed power leads 48, 49 and 50 located exteriorly of the motor 10. For this purpose, an access opening 51 is provided in an upwardly extending boss formed in the bracket flange 19. The access opening 51 is sealed by a plug 52, the plug also serving as an insulation support for the splices between the wires 36 to 47 and the conductors 53, 54 and 55 of the insulated leads 48, 49 and 50.

The plug 52 is made as a casting of neoprene or other suitable flexible resilient material. The exterior surface of the plug tapers conically in opposite directions from spaced circular edges 56 and 57. The degree of taper of the upper end of the plug is about half that of the lower end.

The access aperture 51 has a conical configuration with a degree of taper corresponding to that of the upper end 52a of the plug 52. The plug is received through the lower end of the access aperture 51 and capable of achieving a wedging fit therewith.

The lower end 52b of the plug is accommodated in a seat 58 formed in the adapter ring 15, which has a tapered configuration corresponding to that of the lower end 52b of the plug. As shown in FIG. 6, a slot 59 provides radial access to the seat 58. The seat thus encompasses less than the full circumference of the plug.

By urging the bracket 18 toward the adapter ring 15, a wedging fit is established between the upper and lower ends of the plug with the access aperture 51 and the seat 58. The outside area of the plug 52 between the circular

edges 56 and 57 is relieved so as to provide a space for expansion of the plug without interfering with the fitted relationship of the parts 15 and 19 which otherwise might tend to cause tilting between the parts and consequent misalignment of the bearing sleeve 25.

The outer end of the plug 52, as shown clearly in FIG. 4, in this instance has seven recesses extending inwardly from the outer end surface 52c. These recesses facilitate the connection of the stator winding groups 30 to 35 in a single Y configuration. In this configuration the winding groups 30 and 31 are connected in series by connection of the wires 37 and 38. Similarly, the winding groups 32 and 33 are connected in series by connection of the wires 41 and 42. And the winding groups 34 and 35 are connected in series by connection of the wires 45 and 46. The wires 39, 43 and 47 are connected together to form the point of the Y or star and the wires 36, 40 and 44 are respectively connected to the conductors 53, 54 and 55 of the jacketed cables 48, 49 and 50.

Three of the recesses 60, 61 and 62 are normally just slightly larger than the leads 48, 49 and 50 for reception thereof. These recesses are equiangularly arranged about the axis 63 of the plug. Opening into the bottom of the recesses 60, 61 and 62 are restricted apertures 64, 65 and 66 that extend from the inner end surface 52d of the plug 52.

The wires 36, 40 and 44, which may have thin insulation sheaths, are respectively passed upwardly through the restricted apertures 64, 65 and 66 and into the bottom of the recesses 60, 61 and 62. The apertures 64, 65 and 66 may normally be just slightly smaller than the sheathed wires 36, 40 and 44, requiring a slight flexure to accomplish assembly. The wire 44 is connected to the conductor 55 of the power lead 50 by the aid of a splicing clasp 68. The splicing clasp peripherally encompasses the bared conductor 55 as well as the bared wire 44 and is constricted in order to establish a firm electrical and mechanical connection. In a similar manner the wires 36 and 40 are electrically and mechanically coupled to the conductors 53 and 54 of the other power leads.

The four remaining recesses 69, 70, 71 and 72 of the plug are adapted to cooperate with the wires 37-38, 41-42, 45-46 and 39-43-47. The recesses 69-72 are smaller in diameter than the recesses 60, 61 and 62 since they need not accommodate power leads. Three of the recesses are located equiangularly about the axis 63 and in interspaced relationship with the recesses 60, 61 and 62. The fourth recess 72 is located at the axis of the plug. The recesses 69, 70 and 71 each have two restricted apertures 73-74, 75-76 and 77-78 that extend to the inner end surface 52d. The wires 37 and 38 extend upwardly through the apertures 73 and 74 and into the recess 69 where their bared ends are joined by a small splicing clasp 79. The wires 41 and 42 similarly extend upwardly through the apertures 75 and 76 for juncture, and the leads 45 and 46 extend upwardly through the apertures 77 and 78. The central recess 72 has three apertures 80, 81 and 82 into which the star point wires 39, 43 and 47 extend where they are joined by a splicing clasp 83. Accordingly, a single Y connection for the motor winding groups 30 to 35 is established.

In order to assemble the various wires and leads with the plug 52, the bracket 18 is of course removed. The wires 36 to 47 are pushed through the appropriate plug apertures with the plug out of the seat 58 and located radially inwardly of the adapter ring 15. The wires are extended beyond the apertures and past the upper end 52c of the plug. After suitably stripping the wires, the splicing clasps 68, 79 and 83, etc. are affixed. The connected wires with the jacketed leads are then pulled back into the plug until the splicing clasps firmly seat at the bottom of the recesses. If desired, an adhesive may be placed about the insulated power leads. A suitable filler material F is then packed in the smaller recesses. The

fillers F can be in the form of inserts, or they may be formed by placement of epoxy or similar compound on the recesses. The plug is then moved laterally into the seat 58. The bracket 18 is then attached. Since the wires 36-47 need not be threaded through the seat 58, there is no danger of their breaking due to sharp bending.

As the bracket 18 is clamped in place by the screws 21, opposite ends of the plug are constricted respectively at the seat 58 and the access aperture 51. Since the taper at the upper end 52a of the plug is less than at the lower end 52b, most of the wedging takes place at the upper end 52a. When the bracket 18 has been firmly affixed, the upper end of the plug firmly constricts about the jacketed power leads to establish the requisite seal. The access aperture 51 is likewise sealed. The slight wedging action that takes place at the seat 58 assists the seal already established between the lower end 52b of the plug and the sheathed wires 36 to 47.

A strain release clamp 86 for the leads 48, 49 and 50 is provided at an upper flange 20 of the bracket 18.

If desired, an adhesive may be used between the exterior of the plug and the aperture 51 to contain the plug against excessive cold flowing.

In the form of the invention illustrated in FIG. 7, a plug 88 is provided that has an external contour similar to the plug 52. However, the outer end surface of the plug is provided with three recesses 89, 90 and 91 for fitting the power leads 48, 49 and 50. At the bottom of each recess are four through apertures whereby a double delta connection of the winding groups 30, 31, 32, 33, 34 and 35 may be effective. The wires 36, 38, 40 and 42, for example, are inserted through the apertures leading through one of the recesses and spliced together and to the conductor of one of the power leads in a manner described in connection with the previous form. At the second recess the leads 37, 39, 44 and 46 are connected together and to the power lead. And at the third recess the leads 45, 47, 41 and 43 are connected. Accordingly, a double delta connection results.

In the form illustrated in FIG. 8, a plug 92 is provided that facilitates a connection of the winding sections in single delta. The plug 92 has an external contour similar to that of the plug 52, and its end surface is provided with three large recesses 93, 94 and 95 for the jacketed cable leads 48, 49 and 50, and three smaller recesses 96, 97 and 98 arrayed substantially as shown. Each of the recesses is provided with two apertures for passage of the stator wires. At one of the smaller apertures 96, the leads 37 and 38 are connected together in order to establish a serial relationship of the winding sections 30 and 31. Similarly, at the aperture 97 the leads 41 and 42 are connected together. And at the aperture 98 the leads 45 and 46 are connected.

The six remaining wires 36, 39, 40, 43, 44 and 47 are connected together in pairs respectively at the three larger apertures 93, 94 and 95. Thus, for example, at the recess 93 the wires 36 and 40 are connected together and to one of the power leads. At the second recess 94 the wires 44 and 39 are connected together and to another power lead. And at the third recess 95 the wires 43 and 47 are connected together and to the third power lead.

In the form illustrated in FIG. 9, plug 99 facilitates a double Y connection. The plug has five recesses, three larger recesses 100, 101 and 102, and two smaller recesses 103 and 104. One of the smaller recesses 104 is located at the center of the plug. Two through apertures communicate with the larger recesses 100, 101 and 102, and three apertures communicate with the bottom of the smaller recesses 103 and 104. At the central recess 104 the wires 39, 43 and 47 are connected together. At the other small recess 103 the wires 37, 41 and 45 are connected together. At one of the larger apertures, as for example 100, the wires 36 and 38 are connected together

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and to one of the power leads. The other wires are similarly connected.

Except for the orientation and number of recesses, the plugs, 88, 92 and 99 are identical to the plug 52. The small recesses 96, 97, 98, 103 and 102 are filled in the same manner as the recesses 69, 70 and 71 of the form shown in FIGS. 1-4.

In order to change the motor connection, it is merely necessary to remove the existing plug, detach it by cutting or otherwise, and reconnect the leads to a suitable plug having the appropriate recesses for the desired connection.

I claim:

1. In a submersible motor structure: means forming an interiorly sealed space; a stator structure in said space; a plurality of phase windings for the stator structure having separate insulated terminal wires for conducting current to the windings; means forming an access opening to said space, said access opening having peripheral tapered walls; a connector plug made of flexible electrical insulation material and having one end in the access opening; said connector plug having a series of through apertures, each of said apertures having enlarged outer ends accessible exteriorly of said space and having restricted inner ends accessible in said space; said terminal wires extending into the restricted ends of said apertures and into the enlarged outer ends thereof; leads having electrical insulation jackets extending into and fitting into the enlarged ends of at least some of said apertures, said leads being electrically and mechanically spliced to said terminal wires at the corresponding apertures; there being more terminal wires than jacketed leads; and clamping means for wedging the plug into the access opening for sealing engagement with said access opening, said peripheral tapered walls tapering inwardly of said clamping means, said clamping means constricting said plug tightly about said jacketed leads to establish a seal; said phase windings being connected together in a selected configuration by connection of said terminal wires to said leads and to each other at said connector plug.

2. The combination as set forth in claim 1 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three terminal wires at three of said plug apertures, there being three other plug apertures each having two restricted substantially parallel branches forming said restricted ends for connection of two wires of each pair of phase windings for serial connection, there being still another plug aperture having three restricted substantially parallel branches forming said restricted ends for connection of the three terminal wires together at a star point for a single Y connection of said phase windings

3. The combination as set forth in claim 1 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three plug apertures, each of the plug apertures having four restricted substantially parallel branches forming said restricted ends for connection of four wires to each other and to the lead for double delta connection of the phase windings.

4. The combination as set forth in claim 1 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three plug apertures, each of the plug apertures having two restricted substantially parallel branches forming said restricted ends for connection of wires of two of the phases; there being three other plug apertures each having two restricted substantially parallel branches forming said restricted ends for connection of two wires of each pair of phase windings for serial connection for single delta connection of the phase windings.

5. The combination as set forth in claim 1 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three plug apertures, each of the plug apertures having two restricted substantially parallel branches forming

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said restricted ends for connection of wires of two of the phases; there being two other plug apertures each having three restricted substantially parallel branches forming said restricted ends for connection of wires from the respective phase windings to form star points for a double Y connection of said phase windings.

6. The combination as set forth in claim 1 in which leads are fitted in some but not all of said apertures, the wires at the other apertures being electrically and mechanically spliced together; and filler means in the outer ends of said other plug apertures.

7. In a submersible motor structure: a housing; a stator in the housing; windings for the stator having insulated wires for conducting current to the windings; said housing having an adapter ring at one end, said adapter ring having a seat; a plug made of flexible electrical insulation material and accommodated in the seat; one end of the plug being exposed and accessible within the housing through the seat, the other end of the plug being tapered toward said other end and extending beyond the seat; jacketed power cable leads; said plug having a series of through apertures, the outer ends of at least some of said apertures fitting said jacketed power cable leads; the number of insulated wires being greater than the number of jacketed power cable leads fitted to said plug; the inner ends of the apertures being adapted to fit said insulated terminal wires; splicing means electrically and mechanically joining the terminal wires to each other and the jacketed leads and located intermediate the length of said apertures; a closure bracket attached to the ring and having an inwardly tapered aperture in which the plug is wedged; said plug being so sized as to be constricted in said tapered aperture of said bracket to seal the aperture as well as the jacketed leads, the insulated terminal wires and said splicing means.

8. The combination as set forth in claim 7 in which said windings are provided for a number of phases, each of the phase windings having separate insulated terminal wires; said phase windings being connected together in a selected configuration by connection of said terminal wires to said leads and to each other at said plug whereby additional splicing of the phase windings is obviated.

9. The combination as set forth in claim 7 in which said seat is provided with a slot opening laterally thereof whereby said plug can be installed with minimum slack in said terminal wires.

10. The combination as set forth in claim 7 in which said tapered aperture has a relieved area for free expansion of said plug.

11. In a submersible motor structure: a housing; a stator in the housing; windings for the stator having insulated wires for conducting current to the windings; said housing having an adapter ring at one end, said adapter ring having an open ended tapered seat; a plug made of flexible electrical insulation material having tapered ends, one end being accommodated in said seat and the other end projecting beyond the seat; said one end of said plug being exposed and accessible within the housing through the seat; jacketed power cable leads; said plug having a series of apertures, the other ends of at least some of said apertures fitting said jacketed power cable leads; the number of insulated wires being greater than the number of jacketed power cable leads fitted to said plug; the inner ends of the apertures being adapted to fit said insulated terminal wires; splicing means electrically and mechanically joining the terminal wires to each other and the jacketed leads and located intermediate the length of said apertures; a closure bracket overlying and attached to the ring and having a tapered aperture receiving said other end of said plug; said plug being so sized as to be constricted in said tapered aperture of said bracket to seal said tapered aperture as well as the jacketed leads, the terminal wires and said splicing means; the taper of said other end of said plug being substantially less than that of

said one end to ensure substantial constriction of said plug at said tapered aperture of said bracket.

12. In combination: a plug connector made of flexible electrical insulation material and having spaced cylindrical recesses extending inwardly of the plug from one end thereof; said plug having a plurality of apertures extending inwardly from the other ends of said plug and opening at the bottom of the recesses; some of said recesses communicating with a plurality of apertures; insulated terminal wires extending through the apertures and into the recesses; jacketed electrical leads extending into and fitting some of the recesses; there being more terminal wires than jacketed leads; splicing means electrically and mechanically attaching the jacketed leads to the corresponding terminal wires and attaching the terminal wires together at the other of the recesses; filler means for the other of the recesses; a wall having an opening at which said plug is accommodated; and clamping means constricting said plug to seal the jacketed leads.

13. In a submersible motor: a stator structure of magnetic material; a three-phase winding for the stator, each phase winding comprising a pair of winding sections whereby the sections may be connected together in Y or delta with the sections either in parallel or series; a pair of insulated conductors for each winding section; means forming a sealed space for enclosing the stator, and having an access opening; a plug in said access opening and having a series of apertures extending from the inner end of said plug and accommodating said insulated conductors; said plug having enlarged recesses at its outer end each communicating with a number of apertures; the number of insulated conductors being greater than the number of apertures; at least some of said recesses having a configuration for fitting insulated power leads; splicing means in the bottom of the recesses for electrically and mechanically joining the wires to each other and to the insulated power leads; and clamping means constricting the plug for sealing against the insulated power leads.

14. In a submersible motor structure: means forming an interior space; a stator structure in said space; means forming an access opening to said space; a connector plug made of flexible electrical insulation material and located at the access opening; said connector plug having a series of through apertures, the outer and inner ends of said apertures being respectively accessible exteriorly and interiorly of said space; insulated power leads fitted in said outer ends of said apertures; stator windings having insulated terminal wires located in the space and fitted in said inner ends of said apertures; the number of terminal wires being greater than the number of insulated power leads; splicing means electrically joining said power leads and said terminal wires; and means for constricting said apertures for sealing the connected leads and wires therein whereby other separate splices for the stator windings are obviated.

15. In a submersible motor structure: a stator structure; phase windings for the stator structure and having insulated terminal wires; a connector plug made of flexible electrical insulation material having a series of through apertures; insulated power leads for conducting current to said phase windings; said insulated terminal wires and said insulated power leads being fitted in opposite ends of said through apertures, and mechanically and electrically spliced together; the number of terminal wires being greater than the number of power leads; and means

for constricting said apertures for sealing the connected leads and wires therein whereby other separate splices for the phase windings are obviated.

16. The combination as set forth in claim 15 in which phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three terminal wires at three of said plug apertures, there being three other plug apertures each having two restricted substantially parallel branches forming said restricted ends for connection of two wires of each pair of phase windings for serial connection, there being still another plug aperture having three restricted substantially parallel branches forming said restricted ends for connection of the three terminal wires together at a star point for a single Y connection of said phase windings.

17. The combination as set forth in claim 15 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three plug apertures, each of the plug apertures having four restricted substantially parallel branches forming said restricted ends for connection of four wires to each other and to the lead for double delta connection of the phase windings.

18. The combination as set forth in claim 15 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three plug apertures, each of the plug apertures having two restricted substantially parallel branches forming said restricted ends for connection of wires of two of the phases; there being three other plug apertures each having two restricted substantially parallel branches forming said restricted ends for connection of two wires of each pair of phase windings for serial connection for single delta connection of the phase windings.

19. The combination as set forth in claim 15 in which the phase windings are six in number, two for each of three phases, there being three leads cooperable respectively with three plug apertures, each of the plug apertures having two restricted substantially parallel branches forming said restricted ends for connection of wires of two of the phases; there being two other plug apertures each having three restricted substantially parallel branches forming said restricted ends for connection of wires from the respective phase windings to form star points for a double Y connection of said phase windings.

20. The combination as set forth in claim 15 in which leads are fitted in some but not all of said apertures, the wires at the other apertures being electrically and mechanically spliced together; and filler means in the outer ends of said other plug apertures.

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