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Murtland

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[54] **ELECTRICAL CONDUCTING FLUID TIGHT TUBULAR ASSEMBLY**

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[51] **Int. Cl.** **H01r 7/02**

[58] **Field of Search** ..... 339/94 R, 94 M, 15, 116 R, 339/48, 49 B, 66 R, 137, 201, 204–5, 213 R, 213 T, 216 R, 218 R, 113 R

[56] **References Cited**

UNITED STATES PATENTS

2,740,098	3/1956	Phillips	339/94 R
3,162,806	12/1964	Voetter	339/15 X
3,217,282	11/1965	Chevalier et al.	339/15
3,285,629	11/1966	Cullen et al.	339/16 R X

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[57] **ABSTRACT**

An electrical conducting, fluid tight, tubular assembly comprising a number of elongate, interchangeable, reusable tubular sections that may be removably connected end to end and extended downwardly in an oil well bore hole adjacent a tubing string situated therein to supply electrical power to a down hole electrical pump or other electrically operated device that mav be situated in the bore hole. The assembly is concurrently made up as the tubing string is lowered into the bore hole, with the sections being clamped to the tubing string and supported therefrom. The sections of the tubing string are longitudinally movable relative to one another within predetermined limits and as a result the assembly may elongate and contract in conformity with changes in the longitudinal length of the tubing string due to temperature changes in the bore hole. When the tubing string is pulled from the oil well bore hole the sections of the tubular assembly are sequentially unclamped therefrom and disengaged from one another. The disengaging of the sections one from the other is extremely simple, as the sections are in slidable engagement and the uppermost sections on an assembly simply has to be lifted upwardly to effect such disengagement. The tubular sections when assembled provides protection for a number of longitudinally extending laterally spaced electrical conductors or cables therein, both from mechanical damage, as well as damage that may result from excessive temperatures or gas pressure in the bore hole.

9 Claims, 8 Drawing Figures

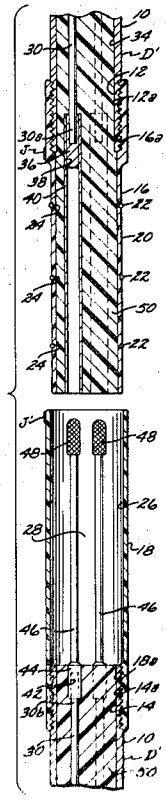
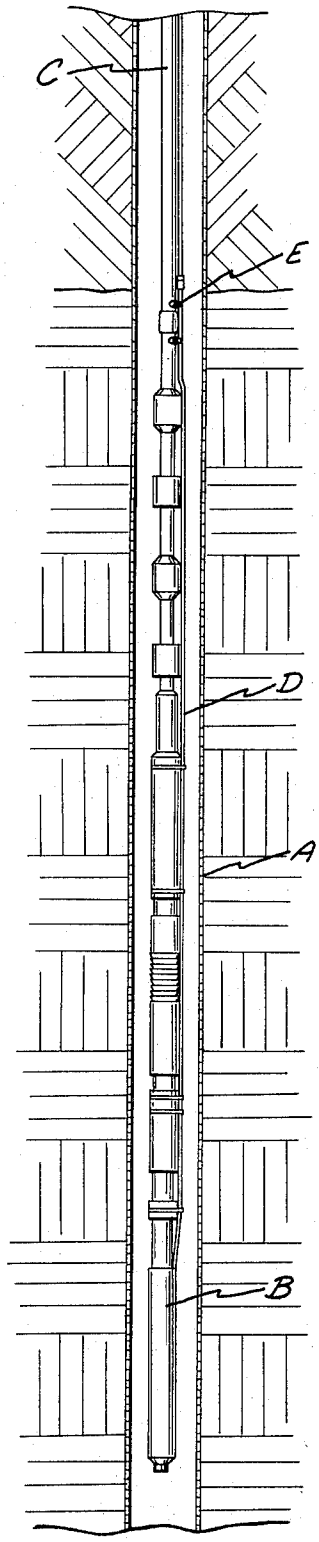


FIG. 1



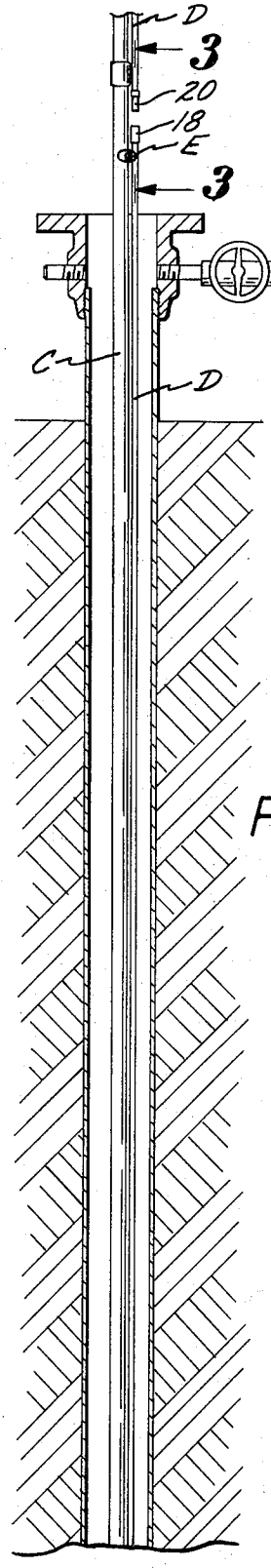
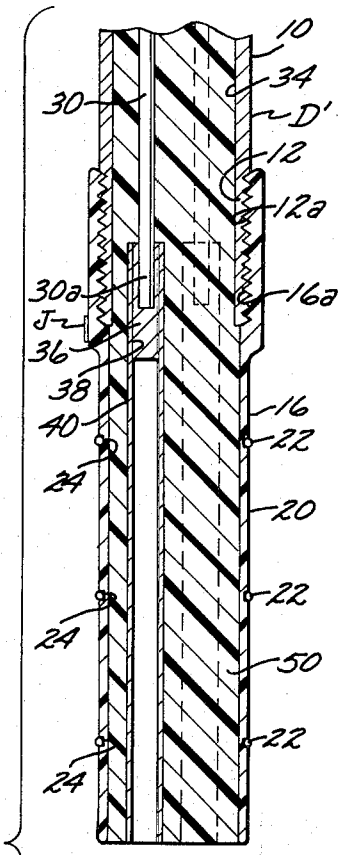


FIG. 2

FIG. 3



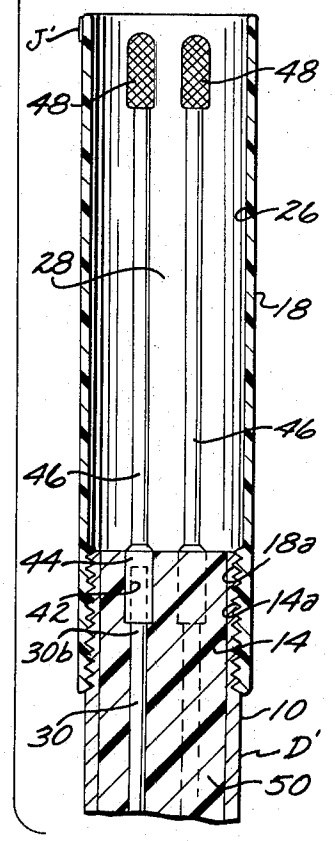
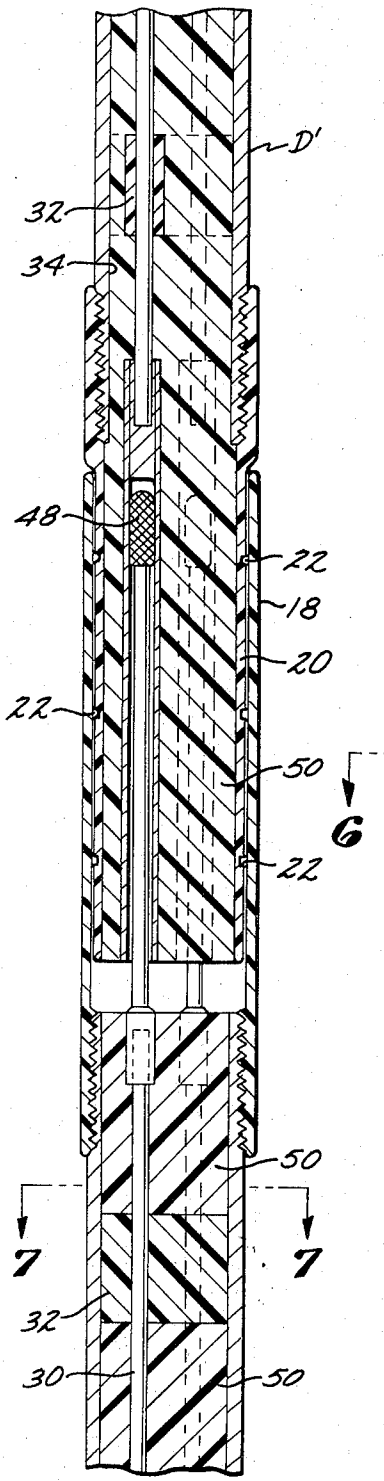


FIG. 4



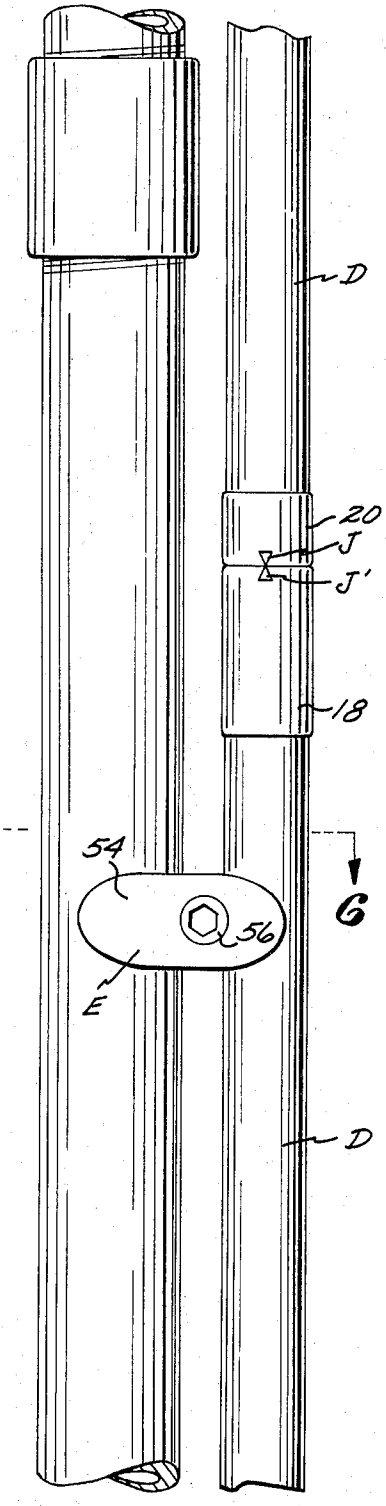


FIG. 5

FIG. 6

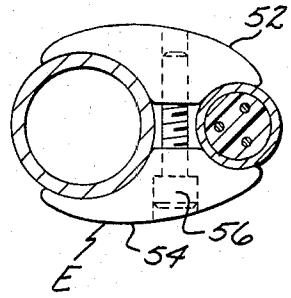


FIG. 7

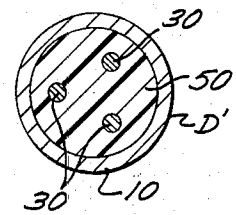
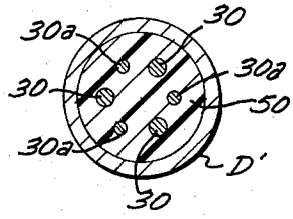


FIG. 8



ELECTRICAL CONDUCTING FLUID TIGHT TUBULAR ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

Electrical conducting fluid tight tubular assembly.

2. Description of the Prior Art

For many years it has been common practice in oil field production to utilize an electrically operated pump situated at a desired depth at an oil well bore, and the pump now being attached to the lower end of downwardly extending string of oil well tubing. Electric power in the past has been supplied to a down hole pump of the type previously mentioned by an insulated electric cable that is connected to the pump and extends upwardly therefrom and is secured to the oil well tubing string.

When the tubing string is being made up and when it is being pulled from the oil well bore hole, such cable is susceptible to being damaged mechanically, and as a result a short may develop therein. Also, in some oil well bore holes, especially those that are of substantial depth, the cable may be exposed to high temperatures that is detrimental to the insulating material of the cable, and as a result the cable will deteroriate and require the oil well tubing to be pulled for replacement of the damaged cable.

Another problem encountered in using the prior art cable to supply electrical power to a down hole pump in a well that has substantial gas pressure in the bore hole thereof, is that minute holes may form in the insulating material of the cable, and high pressure gas penetrate therethrough into the interior of the cable.

When a tubing string is being pulled from a well this operation is carried out as rapidly as possible, and the cable is concurrently removed from the oil well bore hole at the same rate. Under such conditions the high pressure gas cannot escape readily from the interior of the insulating material partially defining the cable. When the cable with the entrapped high pressure gas is exposed to the ambient pressure, the high pressure gas expands, and in so doing may balloon out the insulating material of the cable to the extent it cracks and the cable must be scrapped.

The primary purpose in devising the present invention is to supply an electrical conducting tubular assembly comprising a number of elongate tubular sections that may be removably connected end to end and supported from a tubing string in an oil well bore, with the assembly capable of supplying electrical energy to a downhole pump in an oil well bore or other electrically operated devices that may be disposed therein, and the assembly when so positioned being substantially unaffected by high temperature conditions in the well, high gas pressure, and to substantial mechanical stresses to which an assembly would normally be subjected.

Another object of the invention is to supply an electrical conducting tubular assembly that includes a number of elongate interchangeable tubular sections of a type that may be quickly and easily connected end to end to one another, as well as easily separate from one another, and the sections capable of being reused over and over in supplying electrical energy to a device situated a substantial depth in an oil well bore hole.

SUMMARY OF THE INVENTION

A fluid tight elongate tubular assembly that includes a number of elongate sections that may be removably connected end to end and supported sequentially from a string of oil well tubing in an oil well bore hole. Each of the sections of the assembly include an elongate tubular member formed from a rigid material that has first and second ends, and with first and second tubular sleeves projecting outwardly from these ends.

A number of longitudinally extending, laterally spaced electrical cables are situated in the tubular member and are in electrical communication with a number of electrical conducting tubes situated in the first sleeve and a number of electrically conducting prongs disposed in the second sleeve. A solidified non-electrical material is situated in the tubular member and first sleeve to hold the cables and tubes in desired lateral spacing, and the material gripping the portions of the prongs most adjacent the tubular members to hold the prongs in desired lateral spacing. A number of longitudinally shaped circumferentially extending resilient sealing rings are mounted on the external surface of the first sleeve. The assembly is made up by sequentially sliding a first sealing ring bearing sleeve into a second sleeve of an adjoining section, and in so doing placing the tubes of the first sleeve in electrical communication with the prongs in a second sleeve of an adjoining section.

The lowermost one of the sections of the assembly when it is made up as above described, is in communication with a number of prongs that extend upwardly from the electric motor of the down hole pump, and by other electrical connections that may be affected between terminals of the electric motor of the down hole pump and the electrical cables situated in the lowermost one of the sections of the assembly, when the assembly is in an oil well bore hole. Electric power to the assembly is supplied by conventional means that are in communication with the prongs that extend upwardly from the uppermost one of the sections of the assembly disposed in the oil well bore hole.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical cross sectional view of an oil well bore hole, an oil well tubing string that supports a down hole electrically operated pump and the lower portion of the tubular assembly disposed in electrical communication with the pump, with the assembly being clamped to the oil well string;

FIG. 2 is a vertical cross sectional view of the upper portion of an oil well bore hole, and illustrating the manner in which sections of the tubular assembly are sequentially connected to one another as the tubing string is lowered into an oil well bore hole;

FIG. 3 is a vertical cross sectional view of two tubular sections of the tubular assembly prior to the sections being slid longitudinally into both mechanical and electrical engagement with one another;

FIG. 4 is a vertical cross sectional view of two of the sections after the same have been made up and disposed in electrical communication with one another;

FIG. 5 is a fragmentary side elevational view of a section of a tubing string and portions of two sections of the tubular assembly adjacently disposed thereto, removably supported from the tubular string by clamping means;

FIG. 6 is a transverse cross sectional view of the tubing string and section of the assembly taken on the line 6—6 of FIG. 5;

FIG. 7 is a transverse view of one of the sections of the assembly taken on the line 7—7 of FIG. 4; and

FIG. 8 is a transverse cross sectional view of an alternate form of the invention that may be used in the tubular assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 an oil well bore hole A is shown that has an electrically operated pump B disposed at a sustantial depth therein, and the pump being connected to the lower end of an upwardly extending tubing string C. Electric power to the pump is supplied by the tubular assembly D that is removably secured to the tubing string C by clamps E shown in detail in FIG. 6 or by other suitable fastening means.

The assembly D is defined by a number of elongate electrically operated pump B disposed at a substantial movably and slidably connected in end to end relationship, and as a result the assembly D may expand and contract longitudinally in conformity with the overall length of the oil well string due to variations in the temperature of the environment in the bore hole A to which it is exposed.

The detailed structure of the sections D' is shown in FIGS. 3 and 4. Each section D' includes a rigid tubular member 10 that may be formed from galvanized steel or the like with each member having first and second end portions 12 and 14 that have external threads 12*a* and 14*a* formed thereon.

First and second tubular sleeves 16 and 18 are provided that have internally threaded end portions 16*a* and 18*a* that engage first and second threads 12*a* and 14*a* as shown in FIG. 4. First sleeve 16 has an external cylindrical surface 20 on which a number of longitudinally spaced, circumferentially extending resilient sealing rings 22 are mounted in grooves 24 formed therein. Each second sleeve 18 has an interior cylindrical surface 26 that defines a recess 28 within the confines thereof. The recess 28 and surface 26 are of such dimensions that when a first sleeve 16 of an adjacently disposed section D' with supported resilient rings 22 is slidably inserted therein, the rings 22 are compressed and a fluid tight connection is established between the two tubular sections D'.

Each tubular section D' as shown in FIGS. 3 and 4 has a number of cables 30 or other elongate electrical conducting members disposed therein, in a desired lateral spacing. The cables 30 are initially held in this desired lateral spacing in a tubular member D' by a number of longitudinally spaced plugs 32 formed from a non-electrical conducting material, with the plugs gripping the cables 30 and the interior surface 34 of tubular member 10. Cables 30 have first end portions 30*a* and second end portions 30*b*.

Each first end portion 30*a* is preferably situated within the confines of tubular member 10 and is mechanically connected to a cylindrical electrical conducting lug 36, which lug in turn is bonded to a first interior end portion 38 of an elongate electrical conducting tube 40. The bonding of member 30 to lugs 36, and lugs 36 to tubes 40 may be by soldering or the like (not shown).

Second end portions 30*b* of cables 30 are preferably situated within the confines of a tubular member 10 as shown in FIG. 3. The second end portions 30*b* engage longitudinal recesses 42 formed in first end portions 44 of prongs 46 that are formed from an electrical conducting material. The prongs 46 are laterally spaced from one another in the same lateral spacing pattern as tubes 40. The prongs 46 are preferably of such length as to not extend outwardly from the recess 28 in which they are disposed. Prongs 46 on their outer ends develop into enlarged generally cylindrical heads 48 that are snugly and slidably insertable into tubes 40 of an adjacently disposed tubular section D'. The prongs 46, heads 48 and engaged tubes 40 then cooperate to establish electrical communication between two adjacently disposed sections D'.

The plugs 32 not only serve to hold the cables 30 in a desired lateral spacing, but also act as barriers to permit a liquid electrical non-conducting material 50 such as an epoxy or the like that solidifies upon standing to be poured into the interior of tubular member 10 and interior of first sleeve 16 as shown in FIG. 3. The material 50 when it solidifies grips the first end portions 44 of prongs 46 as shown in FIG. 3, and holds the prongs in the desired lateral spacing.

When the assembly D is disposed as shown in FIG. 1, the tubes 40 of the lowermost tubular section D' are in electrical conducting engagement with prongs 46 (not shown) that are connected to the terminals of the electric motor that forms a part of the pump B.

The tubular assembly D is removably secured in parallel spaced relationship to the tubing string C by the clamps E illustrated in FIG. 6. Each clamp E engages first and second jaws 52 and 54 that engage both the tubing string C and assembly D. Jaws 52 and 54 may be moved towards or away from one another by a threaded bolt 56 that forms a part of the clamp.

The tubular assembly D is assembled section by section as the tubing string C is made up and lowered into the bore hole A, with this concept being illustrated in FIG. 2. When a tubing string C is being pulled from the bore hole A the operation is reversed. The prongs 46 in the uppermost section D' in a bore hole have electric power supplied thereto from a source (not shown) by conventional means.

In FIG. 7 it will be seen that the section D' illustrated has three cables 30 therein for supplying electric power to the electric motor driven pump B. However, the tubular assembly is not limited to this structure, as additional cables 30*a* may be included as a part thereof that are connected to prongs 46 and tubes 40 (not shown) may be used to supply electric power to a thermistor, pressure sensor or other instrument located in the bore hole A.

In fabricating the sections D' it has been found that the material 50 may be a vulcanized compound, epoxy or other polymerized resin that is not adversely affected by elevated temperatures and high gas pressures frequently encountered in oil well bore holes. The sealing rings 22 which may be O-rings are formed from "Viton" or like material that is adapted to effect a high pressure seal.

The use and operation of the tubular assembly D that is adapted to supply electric energy to a downhole location in an oil well bore hole without being damaged by high temperature and high pressure has been explained previously in detail and need not be repeated. The up-

permost one of the sections D' will have prongs **46** extending upwardly therefrom that may be engaged by a plug or body (not shown) of an electrical insulating material that supports a number of tubes **40** that may slidably and removably engage the prongs. The tubes **40** in the plug or body are connected by suitable conventional electrical conducting means to the source of power (not shown). The material defining the tubular members **10** and first and second sleeves **18** is so selected as to have sufficient mechanical strength as to protect the cables **30**, tubes **40** and prongs **46** from damage during the time the assembly D is in the bore hole A or being made up to put therein or disassembled to be removed therefrom. The sealing rings **22** prevent solvents and liquids in bore hole A, as well as high pressure gas therein, reaching the material **50** in the tubular sections D' to do damage thereto. From the previous description it will be apparent that the tubular sections D' may be used repeatedly to provide tubular assemblies D for use in various bore holes A.

The material used in forming the cables **30**, tubes **40** and prongs **46** is one that has a low electrical resistance, such as copper or an alloy thereof, to minimize heating of said cables, tubes and prongs as well as loss of electric power as an electric current flows through the cables, tubes and prongs to the electrically operated pump or other electrically operated device. The first and second sleeves **16** and **18** preferably have insignias J and J' on the exterior surfaces thereof, as shown in FIGS. **3** and **5**, which insignias are so disposed that when they are longitudinally aligned the tubes **40** and prongs **46** most adjacent thereto are longitudinally aligned as so positioned as to slidably engage one another. The insignias are a distinct convenience when sections D' are being made up to provide an assembly D shown in FIG. **1**. The non-electrical conducting material envelops the cables **30**, the tubes **40** and portions of the prongs **46** and effects a fluid tight seal therewith as well as the interior surfaces of tubular member **10** and first sleeve **16**, and as a result, high pressure gas or liquid under high pressure cannot flow longitudinally through the interior of one tubular section D' to reach the interior of an adjacent section D'.

I claim:

1. A fluid tight tubular assembly that includes a plurality of engaging sections that are longitudinally movable relative to one another and are disposed in coaxial alignment end to end in an oil well bore hole to supply electric power to a device situated in said bore hole, said assembly being removably secured to a string of oil well tubing situated in said bore hole and extending longitudinally therein, said tubular assembly including:

a. a plurality of said sections, with each of said sections comprising:

1. an elongate tubular member that has first and second ends;
2. first and second tubular sleeves that are longitudinally aligned with said tubular members and extend outwardly from said first and second ends thereof, with the exterior diameter of said first sleeve being slightly less than the interior diameter of said second sleeve;
3. a plurality of longitudinally extending laterally spaced electrical conducting cables in said tubular member;
4. a plurality of electrical conducting tubes in said first sleeve that are laterally spaced from one another and in electrical communication with said cables;
5. a plurality of rigid elongate electrical conducting prongs in said second sleeve that are in the same lateral spacing as said tubes, with said prongs being of such transverse cross section as to be slidably insertable in one of said tubes of an adjacently disposed one of said sections, and each of said prongs when so inserted establishing electrical communication between said prong and said tube in which it is inserted;
6. a solidifed non-electrical conducting material in said tubular member and first sleeve that holds said cables and tubes in said lateral spacing, and said material gripping the portions of said prongs most adjacent said tubular member to maintain said prongs in said lateral spacing in said second sleeve; and
7. a plurality of longitudinally spaced, circumferentially extending resilient sealing rings mounted on the exterior surface of said first sleeve that effect a fluid tight seal between said first sleeve and a second sleeve of an adjacent one of said sections when said first sleeve is longitudinally inserted in the latter;

b. first means for electrically connecting said tubes in said first sleeve of the lowermost one of said sections in said bore hole to the terminals of said device;

c. second means for electrically connecting said prongs in said second sleeve of the uppermost one of said sections to a source of electric power, with said assembly between said lowermost and uppermost sections comprising a plurality of said sections that are axially aligned with said first and second sleeves of the adjacent end portions of said plurality of sections in slidable sealing engagement and said tubes and prongs thereof also in slidable electrical communication with one another; and

d. third means for removably securing each of said sections to said tubing string to maintain said tubular assembly in fixed lateral spacing relative thereto, with said tubular assembly elongating and contracting as said tubing string changes in length due to variations in temperature in said bore hole by said first and second sections and tubes and prongs therein of adjacently disposed of said sections moving longitudinally relative to one another.

2. A tubular assembly as defined in claim **1** in which said non-electrical conducting material is initially a liquid polymerizable material, and each of said sections in addition including:

e. a plurality of longitudinally spaced plugs of sufficient rigidity to hold said cables in said desired lateral spacing prior to said liquid polymerizable material solidifying, and said plugs also serving as barriers to prevent said liquid polymerizable material escaping from the interior of said tubular member of said section prior to said polymerizable material solidifying.

3. A tubular assembly as defined in claim **2** in which said first and second sleeves have internally threaded end portions and said tubular sleeve has externally threaded end portions that are engaged thereby, with said first sleeve permanently secured to said tubular member due to said non-electrical conducting material substantially filling the interiors of said tubular member

and first sleeve and being in bonding contact with the interior surfaces thereof.

4. A tubular assembly as defined in claim **2** in which the material that defines said cables, tubes and prongs has low electrical resistance to minimize heating of said cables, tubes and prongs and electrical power loss as electric current flows downwardly through said cables, tubes and prongs to said electrically operated device.

5. A tubular assembly as defined in claim **1** in which each of said sections in addition includes:

d. insignia means on said first and second sleeves thereof which when in predetermined relationship with insignia means on adjacently disposed sections of said assembly visually indicate that said tubes and prongs are longitudinally aligned and said first and second sleeves of said section may slidably engage second and first sleeves of adjacently disposed sections that are axially aligned with said section.

6. An electrical conducting tubular section capable of being longitudinally connected to additional axially aligned tubular sections of the same structure, said section when so connected to said additional sections providing a fluid tight, temperature resistant assembly that can be subjected to substantial physical shock without damage to said section, said section comprising:

a. an elongate tubular member;

b. first and second tubular sleeves rigidly connected to opposite ends of said tubular member, said tubular member and first and second sleeves formed from a rigid material and of such thickness as to be capable of withstanding substantial physical shock without appreciable damage thereto;

c. a plurality of parallel, laterally spaced electrical conducting tubes disposed in said first sleeve;

d. a plurality of parallel, laterally spaced electrical conducting prongs in said second sleeve, with at least a portion of each of said prongs of such transverse cross section as to snuggly and slidably engage the interior surface of one of said tubes in an adjacently disposed one of said sections;

e. a plurality of laterally spaced elongate electrical conductors disposed in said tubular member that are in electrical communication with said tubes and prongs;

f. a body of said non-electrical conducting material in said tubular member and first sleeve that envelops said electrical conductors and tubes and holds them in said lateral spacing therein, said material being impervious to the highest fluid pressure to which said section will be subjected when forming a part of said assembly, and said material not being adversely affected by the highest temperature to which said section will be subjected; and

g. a plurality of longitudinally spaced, circumferentially extending resilient sealing rings mounted on the exterior of said first sleeve, with the external diameters of said first sleeve and rings being such that they may concurrently be slid into a second sleeve of an adjoining one of said sections to effect a fluid tight seal with the interior surface of said second sleeve, and said section capable of moving longitudinally relative to said next adjacent section within predetermined limits without adversely affecting said fluid tight seal.

7. A tubular section as defined in claim **6** in which said solid body of non-electrical conducting material was initially a polymerizable liquid resin that was polymerized in place in said tubular member and first sleeve.

8. A tubular section as defined in claim **7** in which said solid body engages portions of said prongs adjacent said tubular member to hold said prongs in said lateral spacing in said second sleeve.

9. A tubular section as defined in claim **7** in which said sections adjacent thereto have insignia thereon which when in a predetermined relationship visually indicate that said tubes and prongs of said section are longitudinally aligned with prongs and tubes of adjacently disposed of said sections and that said sections may be longitudinally slid together to provide said assembly.

* * * * *