

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN AND RELATING TO ELECTRICAL CONNECTORS

(71) We, COMPAGNIE FRANCAISE DES PETROLES, a French Corporate Body of 5 Rue Michel-Ange, 75781 Paris Cedex 16, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to improvements in electrical connectors particularly, but not exclusively, for use in a hostile environment such as deep sea water.

Prior electrical connectors for use in deep sea water or other hostile environment, such as outer space or nuclear irradiated atmosphere, have juxtaposed mating electrical contacts arranged in parallel planes with mating movement normal to the planes, see U.S. Patents 3,657,681; 3,784,959; 3,848,949.

In deep sea operations, such as offshore drilling and production operations, prior electrical control systems were somewhat restricted in the number of mating electrical contacts because the diameter of the pipe or casing imposed a space limitation thereon restricted by such diameter. The planar area in which the electrical contacts were arranged was usually relatively small. Also, many prior underwater connectors characterized by juxtaposed planar arrangements of contacts often utilized gravitational forces to mate the contacts and mechanical springs were used to compensate for or equalize such forces. Such typical electrical connectors included a cylindrical body having the electrical contact elements provided at one end of the body, such as across the end face thereof.

According to one aspect of the present invention there is provided an electrical connector comprising an elongate receptacle body having a longitudinal axis and a tapered axial chamber having an open end,

an elongate tapered member receivable through said open end in said chamber in coaxial relation therewith, a plurality of co-operable electrical contact means in said chamber on said body and on said member, said contact means being arranged angularly and longitudinally of said axis, means for longitudinally and angularly orienting said tapered member for juxtaposing said electrical contact means on said body with said electrical contact means on said member, and means for actuating said electrical contact means.

Preferably, said electrical contact means on said tapered member include piston and cylinder means actuatable by fluid under pressure, said tapered member is provided with a hollow elongate chamber connectable to a source of fluid under pressure for actuation of said piston and cylinder means to cause said electrical contact means on said tapered member to make electrical contact with said electrical contact means on said receptacle body.

According to another aspect of the present invention there is provided a self-purging electrical connector adapted for use in a hostile environment under varying pressures comprising an elongate hollow receptacle means open at one end and provided with a conical interior surface having a longitudinal axis of symmetry, electrical contact means at said interior surface, facing said axis, and having an elastomeric protective covering, an elongate, hollow, conical member for reception through said one end in said hollow receptacle means along said longitudinal axis, a plurality of electrical contact members carried by said conical member, facing away from said axis and toward contact means on said receptacle means, and each having an elastomeric protective covering, actuation means for causing said electrical contact members on said conical member to penetrate said pro-

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protective coverings and to make electrical contact with said electrical contact means on said receptacle means.

5 Preferably, the connector includes an external housing for said receptacle means, and at one end thereof fluid pressure equalizing means between said housing and said receptacle means.

10 Advantageously, said electrical contact members are provided in axially spaced zones, the number of electrical contact members in each axial zone being related to the diameter of said conical member and said receptacle body at said axial zone.

15 Advantageously, one or more groups of electrical contacts are provided arranged in transverse zones along the longitudinal axis, said electrical contacts being mated simultaneously by hydraulic fluid under pressure.

20 The invention will be more fully understood from the following description of an embodiment thereof, given by way of example only, with reference to the accompanying drawings, in which:

25 *Figure 1* is a sectional view of an embodiment of an electrical connector according to the invention, the section being taken in a plane longitudinally bisecting the connector, the connector being broken at its middle portion for purposes of clarity;

30 *Figure 2* is an enlarged fragmentary sectional view of the upper portion of the connector shown in *Figure 1*, the section being taken in a longitudinal plane bisecting both the receptacle body and the tapered member receivable therewithin;

35 *Figure 3* is a transverse sectional view on the line III-III of *Figure 1*;

40 *Figure 4* is a transverse sectional view on the line IV-IV of *Figure 1*, and

Figure 5 is an enlarged fragmentary sectional view taken on the line V-V of *Figure 1*.

45 The electrical connector 10 shown in *Figure 1* comprises an elongate receptacle means 11 have a longitudinal axis and an interior, elongate chamber means 12 which receives through one end a separable, elongate, tapered member 14. A plurality of co-operable, electrical contact means, generally indicated at 15, are provided on said receptacle means within said chamber and on said elongate, tapered member 14. The electrical contact means are arranged in axially spaced, transverse zones. Electrical connector 10 is self-purging and adapted for use in a hostile or harsh environment as in deep water offshore well installations. An example of such use is as part of a control means for a deep sea riser system, the control means being located at a manifold means located on the sea floor and serving a plurality of satellite subsea wells, such as described in U.S. Patent No. 4098333.

65 Receptacle means 11 comprises an elongate, hollow body 17 having a conical wall 18 with a conical interior surface 19. Conical surface 19 defines a tapered receptacle chamber 20. Receptacle body 17 is provided with an upper cylindrical end portion 21 provided with a radially extending flange 22. Adjacent flange 22 end portion 21 may be provided with an inwardly tapered surface 23 leading to a cylindrical passage 24 communicating with the tapered chamber 20 for reception therein of the conical, tapered member 14. Radial flange 22 and side cleats 22a provide suitable means for securing the receptacle means to a subsea manifold structure or to other structures for carrying such an electrical connector.

70 Passage 24 terminates in a downwardly and inwardly directed conical surface 25 which may serve as a landing surface for the member 14. The lower end of the receptacle body 17 has a bottom opening 26.

Receptacle means 11 also includes a cylindrical housing 28 of uniform diameter and having an upper end sleeved over a reduced portion of the cylindrical upper end 21 of body 17 and sealed therewith by suitable seal rings such as rings 29. The lower end of housing 28 has an intumed flange 30 for securement to lower, reduced, cylindrical end portion 31 of body 17, as by a plurality of screw bolts 32. The housing 28 defines, with the flange 30 and the receptacle body 17, an annular chamber 33, the lower part of which serves as a pressure compensating means. To this end an annular body 33a is slidably received in housing 28 and is slidable on the lower end portion 31 of receptacle body 17. Above the annular body, chamber 33 is filled with a dielectric fluid and below the annular body the chamber 33 is in communication with the external atmosphere through a passage in flange 30. The pressure of the external atmosphere is thus communicated to the dielectric fluid in chamber 33 by the body 33a which acts as a piston.

80 Elongate, tapered or conical member 14 is provided with a wall 35 (*Figure 2*) having an exterior conical surface 36 corresponding in taper to the conical or tapered surface 19 of the receptacle body. Wall 35 defines an elongate internal chamber 37 in the conical member 14, said chamber 37 being closed at its lower end by end 38. The upper end of member 14 is provided with an external conical surface 39 for landing on the corresponding conical surface 25 at the bottom of passage 24 to axially or longitudinally position member 14 within the receptacle chamber 20. The upper end of member 14 is provided with a threaded fitting 40 for closing and sealing the upper end of chamber 37. Fitting 40 is provided with a port 41 and a fitting 42 therefor adapted to provide a connection for conducting high pressure

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fluid into chamber 37. Fitting 40 also carries an electrical bulwark fitting 45 for passage therethrough, in pressure sealed relationship, of a plurality of electrical cables 46. The high pressure fluid may come from a hydraulic source within a control probe (not shown). The electric cables connected to fitting 45 pass into the control probe.

The upper end of member 14 may also include a radial flange 48 adapted to provide a connection with a control probe means or other means for landing the tapered member 14 in the receptacle body.

Means for rotationally or angularly orientating tapered means 14 with the fixed receptacle means 11 is provided by a lug or key 50 carried by the upper end of member 14, key 50 extending radially outwardly of the member 14 for engagement with a longitudinal slot 51 provided in the internal surface of the cylindrical portion 21 of the receptacle body.

The electrical contact means 15 are provided as previously mentioned both in the receptacle wall 18 and in the wall 35 of tapered member 14. A plurality of such co-operable, electrical contact means are shown, for brevity and clarity only one set of electrical contact means will be described.

In the receptacle body wall 18 and in a zone transverse to the longitudinal axis of the receptacle body may be provided a plurality of angularly spaced openings 55 within each of which is positioned an anvil or fixed contact disc 56 received within a cup-shaped, elastomeric cover 57. Cover 57 includes a wall 58 of selected thickness which projects inwardly from the conical surface 19. Side walls 59 of cover 57 provide a tight, sealed fit between the circumferential edges of the contact disc 56 and the edges of opening 55. The walls 59 of cover 55 may include an annular flange 60 to facilitate sealing of cover 57 by providing an integral seal gasket to prevent leakage of insulating oil in the annulus into the bore and to prevent displacement of cover 57 through opening 55.

Means for securing the electrical contact disc 56 and cover 57 in opening 55 includes a backup plate 62 seated in a circular recess 63 in wall 18 and having an inner surface in abutment with contact disc 56. Backup plate 62 may be suitably secured by a plurality of screw bolts 64 to wall 18 and contact disc 56 may be secured to the backup plate by a suitable screw bolt 65.

A terminal pin or bolt 66 is secured to contact disc 56 in electrically conductive relation and extending radially outwardly of backup plate 62 for a suitable clamped fitting 68 with an electrical wire 69 which leads to an electrical plug 70 suitably mounted in an opening 71 in the portion 21 of the receptacle body. The contact disc 56

is thus securely, immovably positioned in the opening 55 in the conical wall 18 of the receptacle body.

Electrical contact means 15 also includes an electrical contact penetrating element 75 mounted in an opening 76 provided in wall 35 of the tapered member 14. Penetrating element 75 is carried in a rigid body 77 of dielectric material, having a threaded mounting 78 in wall 35 and having an outwardly flared flange 79 provided with a sealing element 80 for sealing engagement with an exterior countersunk recess 81 in the outer surface 36 of wall 35.

The exterior conical surface 36 of wall 35 of member 14 may be ensleeved within a continuous boot or sleeve 83 of elastomeric material and having a selected thickness. At areas adjacent the penetrating element 75, the thickness of the elastomeric boot 83 may be increased to provide sufficient depth for the pointed, conical end 84 of penetrator element 75 and to provide an embossment 85 juxtaposed to elastomeric wall 58 covering the anvil contact disc 56. Thus, when the tapered member 14 is axially and rotationally oriented in the receptacle body, a penetrating contact element 75 will be juxtaposed to an anvil contact disc 56.

Penetrating element 75 carried within the rigid, dielectric plug 77 is provided at its inner end with suitable seal rings 87 so that said penetrating element 75 may act as a piston slidably movable in the cylindrical chamber 88 provided in plug 77. The back or interior end of penetrating element 75 provides a flat surface area for pressure fluid introduced into said cylindrical chamber 88 through a port 89 which leads to the interior of chamber 37. Also, an electrical line 90 is connected to element 75 and extends to and passes through sealed fitting 45 at the top end of the member 14.

Actuation of penetrating electrical contact elements 75 to drive said penetrating elements through the elastomeric material boot 83 and the cover 57 into electrical contact engagement with the anvil disc 56 is obtained by filling chamber 37 in conical member 14 with a dielectric pressure fluid, such as oil, through port 41. When the fluid in chamber 37 is placed under a selected pressure, penetrating elements 75 are simultaneously actuated and are driven through the elastomeric boot 83 and cover 57. The pressure area at the end of each penetrating element 75 is relatively large so that when the pressure fluid reaches a pressure of between 1000 and 1500 psi, each penetrating element 75 will forcibly make electrical contact with its mating contact disc. The pressure of the fluid in chamber 37 is maintained by means of a suitable accumulator and fluid pump connected with the pressure fluid system within the control

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probe means.

Electrical contact means 15 are disengaged by retraction of penetrating elements 75 caused by reduction in fluid pressure in chamber 37 and by the action of the resilient forces in the elastomeric material boot 83 on penetrating elements 75. Conical pointed end 84 of each element when actuated into electrical contact with disc 56 wedges the material 83 forwardly and radially outwardly with respect to the axis of each penetrating element. Thus, material 83 is under compressive forces which include an axially directed component. Thus, when there is a reduction in the fluid pressure, the elastomeric material 83 seeks to regain its former position and exerts an axially directed force upon the penetrating element 75 which moves element 75 axially away from its mating contact disc 56. In effect, the resiliency of the elastomeric material 83 acts as a spring force to bias the penetrating element into its retracted position.

In operation of the electrical connector described above, receptacle means 11 may be fixed and secured with its axis vertically disposed. Tapered member 14 is lowered and guided by suitable well-known means into the top opening of the receptacle means. As tapered member 14 is further lowered, its conical bottom end enters the cylindrical upper chamber 24 and then enters the tapered chamber 20 of the receptacle means. The angle of the taper on internal surface 19 of the receptacle means and the angle of the taper on the tapered member 14 is approximately the same and an example, of the angle of such taper is about 3°.

As the upper portion of tapered member 14 enters the cylindrical upper passage 24 of the receptacle means, the tapered member is more closely guided because of the tolerance 95, Figure 2, between the enlarged flange 96 of the upper end of the tapered member and the internal diameter of chamber 24. As flange 96 enters passage 24, the tapered member is rotated until guide lug 50 engages key slot 51 to thereby angularly orient the tapered member 14 with respect to the receptacle means. Such angular orientation is predetermined so that penetrating elements 75 carried by the tapered member 14 will be juxtaposed to respective electrical contact discs 56 carried by the receptacle means for making and breaking electrical contact therewith. As the tapered member 14 is further lowered into the receptacle means, the tapered member becomes longitudinally or axially oriented with respect to the receptacle means by the landing of the conical surface 39 of the conical landing surface 25 provided on the receptacle means.

During entry of the conical member 14

into the chamber 20 under subsea conditions, it will be understood that the chamber 20 may be filled with sea water. Sea water in chamber 20 is displaced through port 26 at the bottom of the receptacle means. It should also be noted that, as the conical member moves axially into its final position, each protruding annular embossments 85 slidably contact the outer surface of wall 58 of the covering for the respective contact disc 56. As best seen in Figure 5, the interface between the elastomeric material includes a flat face on wall 58 and a convex face on annular embossment 85. During movement into final axial position, the sliding engagement at the interface purges sea water from between the faces, particularly since in angular orientation the point on annular embossment 85 directly opposite the point of the penetrating element 75 is at the tangent of the circumferential surface of the embossment 85 to the planar flat face of the wall 58. Such tangential contact minimizes possible entrapment of sea water between the two faces. Such purging of sea water between the two faces is further improved when the penetrating elements are actuated in a radial direction and the point of the penetrating element exerts a radially outwardly directed force with respect to the axis of the penetrating element on the portions of the elastomeric material at the point of the penetrating element. Thus, when the penetrating element pierces the elastomeric embossment 85 and further pierces the wall 58, sea water will be pushed radially outwardly with respect to the axis of the penetrating element and purged and driven into the annular space between the connector elements.

It will also be apparent that, upon retraction of the penetrating elements, the elastomeric material will resiliently contract and close any opening made by the penetrating element 75.

As shown in Figures 3, 4 and 5, the number of electrical contact means provided in a transverse zone through the electrical connector 10 is dependent upon the diameter of the tapered member 14 and the tapered chamber 20 in which it is received. In the example shown, the lower end of the electrical connector includes four electrical connecting means 15 disposed at 90° to each other as shown in Figure 5. At an intermediate portion of the electrical connector means, the diameter thereof is sufficient to provide in each transverse zone groups of six electrical connector means as shown in Figure 4. At the uppermost end of the electrical connector means, adjacent transverse zones may include groups of eight electrical connector means as shown in Figure 3. The arrangement, of groups of electrical connector means 15 the number of

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which in each group increases along the length of the electrical connector 10, provides an effective arrangement of electrical connector means, the number of which is dependent upon the length of the connector means and the changing diameter of the taper of the tapered member 14 and tapered chamber 20. Thus, in subsea well operations, an electrical connector of the type described above may provide a multiple number of connector means dependent upon the length and diameter of the connector and all of the electrical connector means may be simultaneously actuated by the pressurized dielectric fluid in the hollow core chamber of the tapered member 14.

There is thus provided a self-purging hydraulically actuated electrical connector adapted for underwater operation and having a configuration characterized by providing electrical contacts along the length of the connector. The concept of providing electrical connectors along the length of a connector body is attractive for deep sea operations because in such operations the drilling or productions systems are characterized by length; that is, the systems extend for a few feet or for thousands of feet with minimal lateral size or dimension as contrasted with equipment adapted to be spread horizontally over a relatively unlimited area. The electrical connector utilizing elongated tapered geometry readily lends itself to offshore well operations. The electrical contacts are disposed in longitudinal and angular relation along the length of the connector means. The contacts are disposed on a tapered surface of the body whereby a mating electrical contact may be readily moved into juxtaposition by relative longitudinal movement of the electrical contacts to be connected.

The contacts are protected by elastomeric material configured to positively purge foreign matter or fluid between the juxtaposed contacts to be mated.

WHAT WE CLAIM IS:-

1. An electrical connector comprising an elongate receptacle body having a longitudinal axis and a tapered axial chamber having an open end, an elongate tapered member receivable through said open end in said chamber in coaxial relation therewith, a plurality of co-operable electrical contact means in said chamber on said body and on said member, said contact means being arranged angularly and longitudinally of said axis, means for longitudinally and angularly orienting said tapered member for juxtaposing said electrical contact means on said body with said electrical contact means on said member, and means for actuating said electrical contact means.

2. An electrical connector as claimed in claim 1, wherein said electrical contact

means on said tapered member include piston and cylinder means actuatable by fluid under pressure.

3. An electrical connector as claimed in claim 2, wherein said tapered member is provided with a hollow elongate chamber connectable to a source of fluid under pressure for actuation of said piston and cylinder means to cause said electrical contact means on said tapered member to make electrical contact with said electrical contact means on said receptacle body.

4. An electrical connector as claimed in any one of the preceding claims, wherein said orientation means includes engageable means on said tapered member and said receptacle body which are interengaged with said tapered member and receptacle body are in the required orientation.

5. An electrical connector as claimed in any one of the preceding claims, including a housing enclosing said receptacle body and defining an annular chamber therewith, said annular chamber being filled with a dielectric fluid.

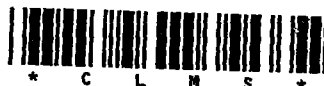
6. An electrical connector as claimed in claim 5, including pressure compensating means at one end of said annular chamber, said pressure compensating means having communication with ambient fluid pressure of the environment surrounding said connector.

7. A self-purging electrical connector for use in a hostile environment under varying pressures comprising an elongate hollow receptacle means open at one end and provided with a conical interior surface having a longitudinal axis of symmetry, electrical contact means at said interior surface, facing said axis, and each having an elastomeric protective covering, an elongate, hollow, conical member for reception through said one end in said hollow receptacle means along said longitudinal axis, a plurality of electrical contact members carried by said conical member, facing away from said axis and toward contact means on said receptacle means, and each having an elastomeric protective covering, and actuation means for causing said electrical contact members on said conical member to penetrate said protective coverings and to make electrical contact with said electrical contact means on said receptacle means.

8. A connector as claimed in claim 7, wherein said electrical contact members are moved by said actuation means in a radial outward direction with respect to said axis.

9. An electrical connector as claimed in either claim 7 or claim 8, wherein said hollow, conical member includes a chamber adapted to be filled with pressure fluid for actuating said electrical contact members simultaneously.

10. A connector as claimed in any one



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which in each group increases along the length of the electrical connector 10, provides an effective arrangement of electrical connector means, the number of which is dependent upon the length of the connector means and the changing diameter of the taper of the tapered member 14 and tapered chamber 20. Thus, in subsea well operations, an electrical connector of the type described above may provide a multiple number of connector means dependent upon the length and diameter of the connector and all of the electrical connector means may be simultaneously actuated by the pressurized dielectric fluid in the hollow core chamber of the tapered member 14.

There is thus provided a self-purging hydraulically actuated electrical connector adapted for underwater operation and having a configuration characterized by providing electrical contacts along the length of the connector. The concept of providing electrical connectors along the length of a connector body is attractive for deep sea operations because in such operations the drilling or productions systems are characterized by length; that is, the systems extend for a few feet or for thousands of feet with minimal lateral size or dimension as contrasted with equipment adapted to be spread horizontally over a relatively unlimited area. The electrical connector utilizing elongated tapered geometry readily lends itself to offshore well operations. The electrical contacts are disposed in longitudinal and angular relation along the length of the connector means. The contacts are disposed on a tapered surface of the body whereby a mating electrical contact may be readily moved into juxtaposition by relative longitudinal movement of the electrical contacts to be connected.

The contacts are protected by elastomeric material configured to positively purge foreign matter or fluid between the juxtaposed contacts to be mated.

WHAT WE CLAIM IS:-

1. An electrical connector comprising an elongate receptacle body having a longitudinal axis and a tapered axial chamber having an open end, an elongate tapered member receivable through said open end in said chamber in coaxial relation therewith, a plurality of co-operable electrical contact means in said chamber on said body and on said member, said contact means being arranged angularly and longitudinally of said axis, means for longitudinally and angularly orienting said tapered member for juxtaposing said electrical contact means on said body with said electrical contact means on said member, and means for actuating said electrical contact means.

2. An electrical connector as claimed in claim 1, wherein said electrical contact

means on said tapered member include piston and cylinder means actuatable by fluid under pressure.

3. An electrical connector as claimed in claim 2, wherein said tapered member is provided with a hollow elongate chamber connectable to a source of fluid under pressure for actuation of said piston and cylinder means to cause said electrical contact means on said tapered member to make electrical contact with said electrical contact means on said receptacle body.

4. An electrical connector as claimed in any one of the preceding claims, wherein said orientation means includes engageable means on said tapered member and said receptacle body which are interengaged with said tapered member and receptacle body are in the required orientation.

5. An electrical connector as claimed in any one of the preceding claims, including a housing enclosing said receptacle body and defining an annular chamber therewith, said annular chamber being filled with a dielectric fluid.

6. An electrical connector as claimed in claim 5, including pressure compensating means at one end of said annular chamber, said pressure compensating means having communication with ambient fluid pressure of the environment surrounding said connector.

7. A self-purging electrical connector for use in a hostile environment under varying pressures comprising an elongate hollow receptacle means open at one end and provided with a conical interior surface having a longitudinal axis of symmetry, electrical contact means at said interior surface, facing said axis, and each having an elastomeric protective covering, an elongate, hollow, conical member for reception through said one end in said hollow receptacle means along said longitudinal axis, a plurality of electrical contact members carried by said conical member, facing away from said axis and toward contact means on said receptacle means, and each having an elastomeric protective covering, and actuation means for causing said electrical contact members on said conical member to penetrate said protective coverings and to make electrical contact with said electrical contact means on said receptacle means.

8. A connector as claimed in claim 7, wherein said electrical contact members are moved by said actuation means in a radial outward direction with respect to said axis.

9. An electrical connector as claimed in either claim 7 or claim 8, wherein said hollow, conical member includes a chamber adapted to be filled with pressure fluid for actuating said electrical contact members simultaneously.

10. A connector as claimed in any one

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of claims 7 to 9, wherein said electrical contact means and members are arranged in axially spaced zones transverse to said axis.

5 11. A connector as claimed in any of claims 7 to 9, wherein said electrical contact members are provided in axially spaced zones, the number of electrical contact members in each axial zone being related to the diameter of said conical member and
10 said receptacle body at said axial zone.

12. A connector as claimed in any of claims 7 to 9, wherein said electrical contact means and members are arranged in groups
15 lying transversely to the axis of said conductor means, the groups of connectors progressively changing as the diameter of said conical configuration of said receptacle means and said conical member changes.

13. A connector as claimed in any one
20 of claims 7 to 12, including an external housing for said receptacle means, and at one end thereof fluid pressure equalizing means between said housing and said receptacle means.

14. A connector as claimed in any of claims 7 to 13, including means on said
25 receptacle means and means on said conical member for rotationally orienting said conical member in said receptacle means.

15. A connector as claimed in any of claims 7 to 13, including means for limiting
30 axial movement of said conical member within said receptacle means and for axially orienting said electrical contact means and members.

16. An electrical connector substantially
35 as herein described with reference to the accompanying drawings.

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