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(56) Documents cited

GB 1587531 A

US 4896939 A

US 4568145 A

(58) Field of search

UK CL (Edition K) G5R JGEA

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(54) Optical and electrical connectors

(57) A rotary optical and electrical connector for connecting together two down-hole measurement sondes in a borehole surveying system comprises male and female connector parts 21 and 22 connected together by a screwthreaded connection. The male connector part 21 has a coaxial socket 26, and the female connector part 22 has a coaxial plug 27, the socket and plug being able to relatively rotate during connection and each of which has three coaxial electrical contacts 26A, 27A and a central fibre optic connector 36, 37. The fibre optic connectors 36 and 37 connect together two optical fibre parts 38 and 39 which are in turn connected to respective transmitter/receiver modules 34, 35 by tree couplers 32, 33. Such a system enables rapid two-way communication between measurement sondes.

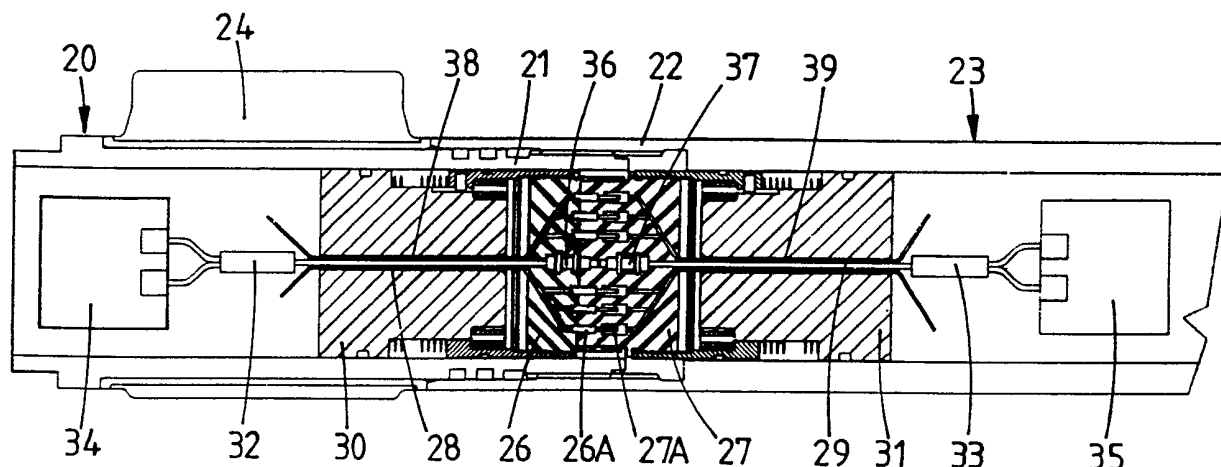


FIG.3.

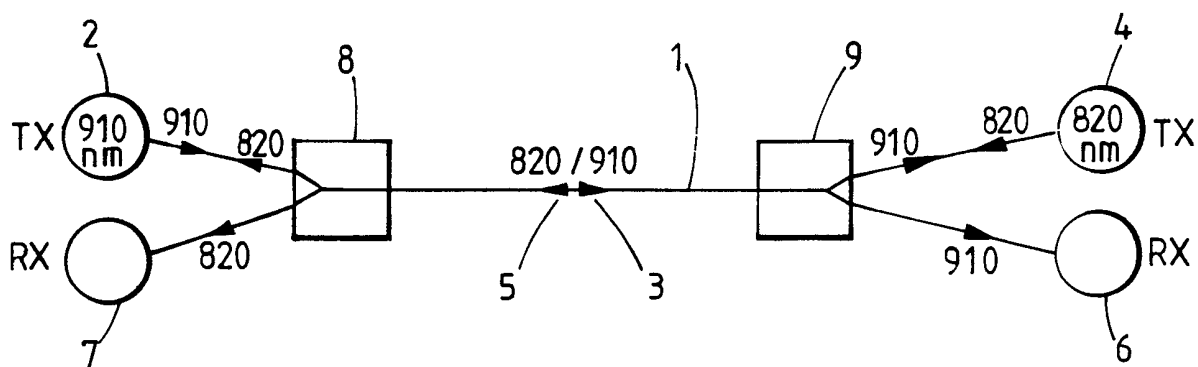


FIG. 1.

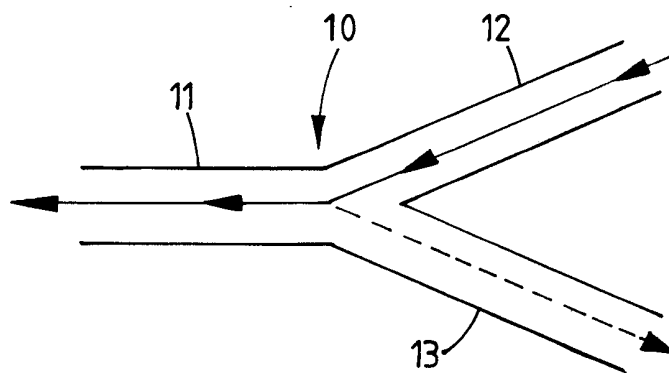


FIG. 2.

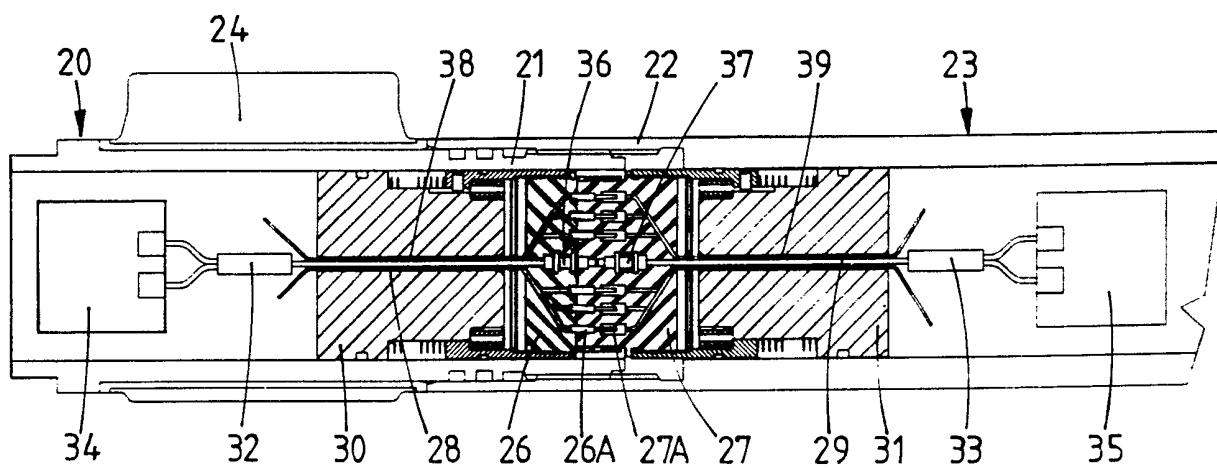


FIG. 3.

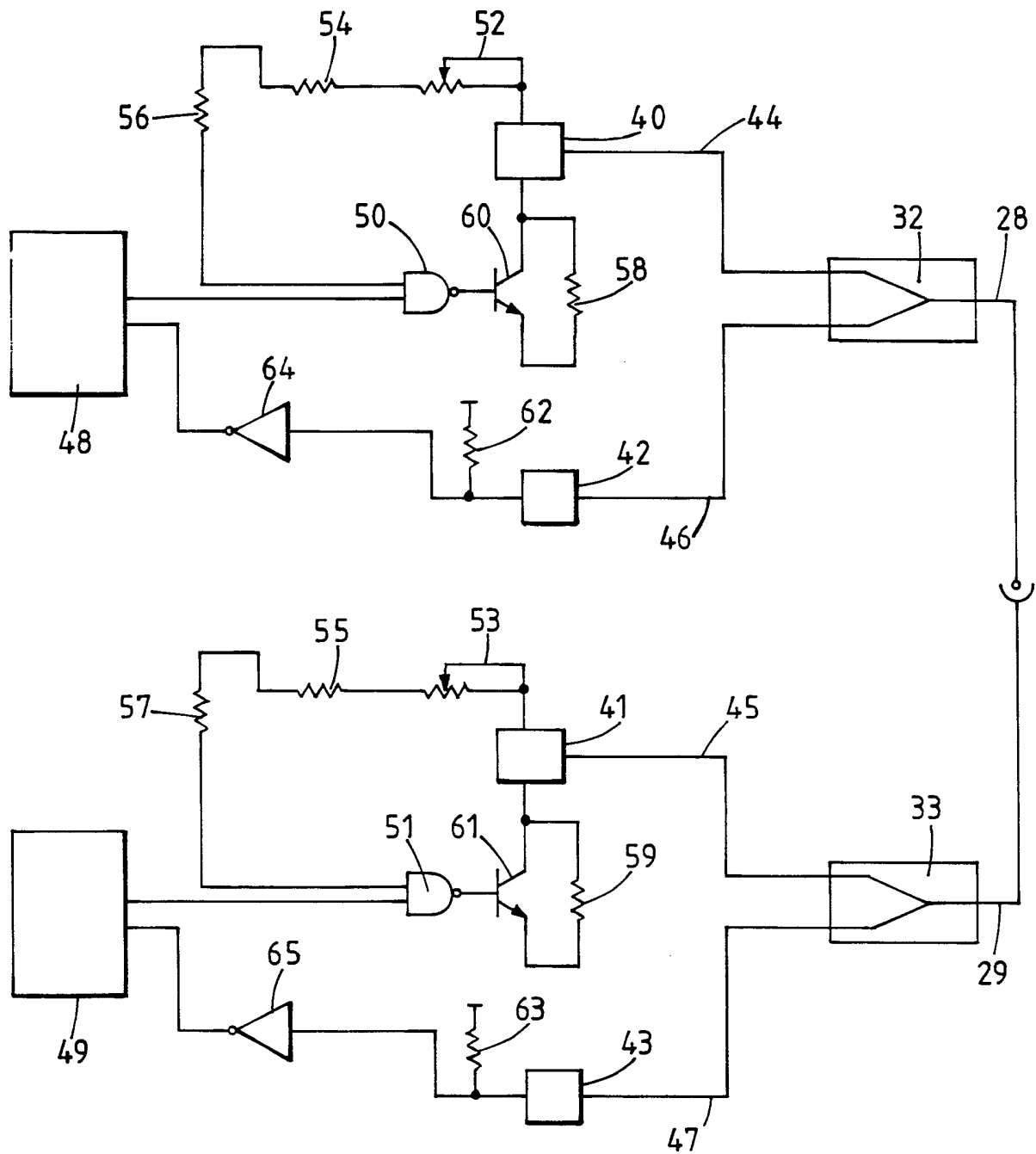


FIG. 4.

-1-

"Electrical Connectors"

This invention relates to electrical connectors and is concerned more particularly, but not exclusively, with electrical connectors for connecting together two measurement sondes of a down-hole borehole surveying system.

In the field of borehole surveying it is often necessary to establish an electrical connection permitting two-way communication between two measurement sondes located downhole within a drill string in the vicinity of the drill bit for taking survey measurements. The electrical connection must be particularly rugged as it is subjected to extreme vibration down-hole, and this generally dictates that the male and female connector parts are held together by a screwthreaded mechanical connection which can be tightened to maintain the two sets of electrical contacts in electrical connection with one another at all times. Conventional electrical connectors of this type are either insufficiently rugged or are unable to meet the particular requirements to be met in connection of two measurement sondes, such as the requirement for high speed two-way communication between the sondes.

It is an object of the invention to provide an improved electrical connector which is particularly suitable for use in connecting together two measurement sondes in the described application.

According to the present invention there is provided a rotary electrical connector part for connection to a complementary rotary electrical connector part by means of interengaging screwthreads on the two connector parts, comprising axially extending optical fibre means contactable with complementary optical fibre means of the other connector part to establish optical coupling therebetween, and coaxial electrical contact means surrounding the optical fibre means and contactable with complementary electrical contact means of the other connector part to establish electrical connection therebetween, the two connector parts being connectable together by relative rotation to engage the screwthreads and to simultaneously establish optical coupling and electrical connection therebetween.

The provision of axially extending optical fibre means and of coaxial electrical contact means in such a connector part enables the required optical and electrical connections to be established between the connector parts during tightening of the screwthreaded mechanical connection between the parts, as well as allowing high speed two-way communication along the optical fibre means.

The invention also provides an electrical connector part for connection to a complementary electrical connector part, comprising a first optical fibre part contactable at one end with an adjacent end of a second optical fibre part of the complementary connector

part to establish optical coupling therebetween, and a tree coupler coupled to the other end of the first optical fibre part and having a first branch for coupling to a first light transmitter for transmitting light along the first optical fibre part in one direction for receipt by a first light receiver optically coupled to the other end of the second optical fibre part, and a second branch for coupling to a second light receiver for receiving light transmitted along the first optical fibre part by a second light transmitter coupled to said other end of the second optical fibre part, whereby the light transmitted by the second light transmitter is transmitted in the opposite direction to, and simultaneously with, the light transmitted by the first light transmitter.

The tree couplers used for coupling the transmitters and receivers to the ends of the optical fibre parts in such a system are much less costly to use than the multiplexer/demultiplexer units which are conventionally used in two-way optical communication systems. The system makes use of the fact that the proportion of light transmitted along one branch of a tree coupler which is transmitted back up the other branch of the tree coupler due to internal backscatter and reflections is very small, generally less than $1/10000$. This level of reflection would not be sufficient say for the second light receiver to be triggered by means of light transmitted by the first light transmitter and reflected back along the other branch of the tree coupler

(assuming the second light receiver to be responsive to the wavelengths of the light in question). This therefore also enables the different wavelengths of light used to be fairly close in wavelength, so that relatively inexpensive light transmitters can be used for transmitting light of both wavelengths. Also, since tree couplers are not wavelength selective, the system is immune to wavelength shifts due to the effects of temperature on the transmitters.

10 In order that the invention may be more fully understood, a preferred embodiment of the connector in accordance with invention will now be described, by way of example, with reference to the accompanying drawings, in which:

15 Figures 1 and 2 are explanatory diagrams illustrating the principle of operation of the two-way fibre optic communication system used in the connector;

 Figure 3 is an axial section through the connector; and

20 Figure 4 is a circuit diagram of the two-way fibre optic communication system.

 The illustrated connector comprises two detachable connector parts for connecting together two down-hole measurement sondes in a borehole surveying system and incorporating a fibre optic communication system for two-way communication between the measurement sondes. The principle of operation of the fibre optic communication system will first be described with

reference to Figures 1 and 2.

Figure 1 shows an optical fibre 1 having a first light transmitter 2 at one end for transmitting light of 910 nm wavelength along the fibre in the direction of the arrow 3, a second light transmitter 4 at the other end for transmitting light of 820 nm wavelength along the fibre in the direction of the arrow 5, a first light receiver 6 at the same end as the transmitter 4 for receiving light of 910 nm wavelength transmitted along the fibre by the transmitter 2, and a second light receiver 7 at the same end as the transmitter 2 for receiving light of 820 nm wavelength transmitted along the fibre by the transmitter 4. The transmitter 2 and the receiver 7 are coupled to the one end of the fibre by a first tree coupler 8, and the transmitter 4 and the receiver 6 are connected to the other end of the fibre by a second tree coupler 9.

The principle of operation of the two tree couplers will now be described with reference to Figure 2 which shows a tree coupler 10 having a trunk 11 and two branches 12 and 13. In operation with the trunk 11 connected to the optical fibre, substantially all the light transmitted along the branch 12, for example by the transmitter 2 above, will pass along the trunk 11 to the fibre. The only light transmitted along the branch 13 due to the light transmitted along the branch 12 will be caused by internal backscatter and reflections and will be less than 1/10000 of the light transmitted along the

branch 12.

Thus, if such operation of the tree couplers 8 and 9 in Figure 1 is considered, it will be appreciated that negligible light is received by the receiver 7 from the transmitter 2, and negligible light is received by the receiver 6 from the transmitter 4, with the result that false triggering will be avoided even if the two transmitted wavelengths are close together. Also, of the light of 910 nm wavelength transmitted by the transmitter 2, some will pass to the receiver 6 and some will pass to the transmitter 4. Similarly, of the light of 820 nm wavelength transmitted by the transmitter 4, some will pass to the receiver 7 and some will pass to the transmitter 2. However, in each case, the transmission of some light to the transmitter at the opposite end of the fibre will have no adverse effect, and the associated light attenuation will not prevent reliable triggering of the associated receiver.

Furthermore, since the two wavelengths of transmitted light are close together, and since there is no requirement for the receivers to have high wavelength selectivity, a unit of a common type may be used for both of the receivers 6 and 7. This simplifies assembly of the system, since two types of transmitter must be used, namely a 910 nm transmitter and an 820 nm transmitter, but only one type of receiver.

The overall arrangement of the connector will now be described with reference to Figure 3 which shows

part of a measurement sonde 20 having a male connector part 21 at one end for connection to a female connector part 22 at one end of another measurement sonde 23. The sonde 20 includes radial blades 24 for performing a centralising function, and the two connector parts 21 and 22 are connected together by a screwthreaded connection 25.

Furthermore the male connector part 21 has a coaxial socket portion 26, and the female connector part 22 has a coaxial plug portion 27 so positioned that, when the male connector part 21 is screwed into the female connector part 22, the socket portion 26 and the plug portion 27 are brought into engagement so as to establish electrical contact between three coaxial electrical contacts 26A of the connector part 21 and three coaxial electrical contacts 27A of the connector part 22, whilst permitting relative rotation between the socket portion 26 and the plug portion 27 during screwing together of the two connector parts. The electrical contacts 26A and 27A serve to connect together respective conductor portions 38 and 39 extending through axial bores in support members 30 and 31 of the sondes 20 and 23.

Furthermore the connector part 21 incorporates a central expanded beam fibre optic connector 36 for establishing an optical connection with a central expanded beam fibre optic connector 37 of the connector part 22. When the connector parts 21 and 22 are screwed together, the two fibre optic connectors 36 and 37 provide light

coupling between respective optical fibre portions 28 and 29 extending through axial bores in the support members 30 and 31 of the sondes 20 and 23. Each fibre optic connector 36 or 37 is of a type comprising a sprung
5 contact member having a plane contact face for contacting the corresponding contact face of the other fibre optic connector. The use of such a fibre optic connector minimises the risk of dirt becoming trapped in the vicinity of the contact faces, whilst ensuring that the
10 contact faces are maintained in intimate contact by spring pressure.

Each optical fibre portion 28 or 29 is connected to a respective tree coupler 32 or 33 and hence to a transmitter/receiver module 34 or 35. Since only a single
15 optical fibre comprising the portions 28 and 29 is provided for two-way communication between the sondes 20 and 23, and since the optical fibre extends along the central axis of the sondes 20 and 23, it will be appreciated that the required optical connection may be
20 established between the sondes 20 and 23 at the same time as the described electrical connection during screwing together of the two connector parts.

Figure 4 shows the circuit diagram of the two transmitter/receiver modules interconnected by the
25 optical fibre portions 28 and 29. In each case the optical fibre portion 28 or 29 is connected by way of the tree coupler 32 or 33 to both a light transmitter 40 or 41 by way of an optical fibre link 44 or 45 and a light

receiver 42 or 43 by way of an optical fibre link 46 or 47. The transmitter 40 and receiver 42 are coupled to the output and the input of a parallel processing device 48, and the transmitter 41 and receiver 43 are coupled to the
5 output and the input of a parallel processing device 49.

The light-emitting diode of the transmitter 40 or 42 is driven by a combination of an open collector transistor 60 or 61 and a NAND gate 50 or 51, the drive current being adjustable by a potentiometer 52 or 53 and
10 the maximum drive current being set by a resistor 54 or 55. A pull-up resistor 56 or 57 is provided on one input of the NAND gate 50 or 51, and a trickle current resistor 58 or 59 is connected across the transistor 60 or 61 to ensure fast turn on of the transistor 60 or 61 when a
15 signal is supplied to the other input of the NAND gate 50 or 51 by the parallel processing devices 48 or 49. The output of the receiver 42 or 43 is connected to a pull-up resistor 62 or 63, and the output signal is supplied to the parallel processing devices 48 or 49 by way of a
20 conditioning circuit 64 or 65 which speeds up the rise times of the leading edges of the signal.

Thus two-way asynchronous communication is provided between the parallel processing devices 48 and 49 by way of the optical fibre portions 28 and 29, and rapid
25 and reliable transfer of data between the measurement modules is possible using the optical fibre link. A number of different measurement modules can be connected end to end in this manner, the top measurement module

being connected to a pulser module for transmitting data to the surface in the form of mud pulses. Furthermore the linking together of a number of parallel processing units of measurement modules by means of optical fibre links can
5 be used to provide a particularly powerful downhole computing capability in which the parallel processing units form a combined parallel computing system.

In a non-illustrated modification of the above described connector, the coaxial electrical contacts are
10 replaced by pin and socket contacts. In this case, since the provision of such contacts prevents relative rotation of the connector parts as a whole, one of the connector parts is provided with a rotary collar having an internal screwthread for engagement with an external screwthread
15 on the other connector part.

CLAIMS

1. A rotary electrical connector part for connection to a complementary rotary electrical connector part by means of interengaging screwthreads on the two
5 connector parts, comprising axially extending optical fibre means contactable with complementary optical fibre means of the other connector part to establish optical coupling therebetween, and coaxial electrical contact means surrounding the optical fibre means and contactable
10 with complementary electrical contact means of the other connector part to establish electrical connection therebetween, the two connector parts being connectable together by relative rotation to engage the screwthreads and to simultaneously establish optical coupling and
15 electrical connection therebetween.

2. An electrical connector part according to Claim 1, wherein the optical fibre means incorporates an expanded beam fibre optic connector for cooperating with a further expanded beam fibre optic connector forming part
20 of the complementary optical fibre means.

3. An electrical connector part according to Claim 1 or 2, wherein the optical fibre means incorporates a fibre optic connector having a plane contact face for contacting under spring pressure a plane contact face of a
25 further fibre optic connector forming part of the complementary optical fibre means.

4. An electrical connector part according to Claim 1, 2 or 3, wherein the optical fibre means incorporates an

optical fibre part extending along a central axial bore in the connector part.

5. An electrical connector part according to any preceding claim, wherein a tree coupler is coupled to the optical fibre means and has a first branch for coupling to a light transmitter for transmitting light along the optical fibre means in one direction, and a second branch for coupling to a light receiver for receiving light transmitted along the optical fibre means in the opposite direction.

6. An electrical connector part for connection to a complementary electrical connector part, comprising a first optical fibre part contactable at one end with an adjacent end of a second optical fibre part of the complementary connector part to establish optical coupling therebetween, and a tree coupler coupled to the other end of the first optical fibre part and having a first branch for coupling to a first light transmitter for transmitting light along the first optical fibre part in one direction for receipt by a first light receiver optically coupled to the other end of the second optical fibre part, and a second branch for coupling to a second light receiver for receiving light transmitted along the first optical fibre part by a second light transmitter coupled to said other end of the second optical fibre part, whereby the light transmitted by the second light transmitter is transmitted in the opposite direction to, and simultaneously with, the light transmitted by the first light transmitter.

7. An electrical connector part according to Claim 5 or 6, further comprising a light transmitter coupled to the first branch of the tree coupler, and a light receiver coupled to the second branch of the tree coupler.

5 8. An electrical connector part according to Claim 7, further comprising a processing device having an output connected to the light transmitter and an input connected to the light receiver for two-way communication with a further processing device forming part of the
10 complementary electrical connector part.

9. A measurement sonde for a down-hole borehole surveying system, the sonde having at at least one end an electrical connector part according to any preceding claim for connection to a complementary electrical connector
15 part of another measurement sonde.

10. An electrical connector part substantially as hereinbefore described with reference to the accompanying drawings.

11. A measurement sonde for a down-hole borehole
20 surveying system, the sonde being substantially as hereinbefore described with reference to the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition K) G2J - JGEA

(ii) Int Cl (Edition 5) G02B

Search Examiner

M K B REYNOLDS

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

6 APRIL 1992

Documents considered relevant following a search in respect of claims 1-5, 7-11

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1587531 (FERRANTI) - Figures 1-3, page 1 line 87 - page 2 line 59	1-2, 4
X	US 4896939 (O'BRIEN) - Figures, column 5 lines 60-68 and column 6 line 35, 54	1-4
X	US 4568145 (CABLES DE LYON) - Figures and and column 2 and EP 73023 A	1-4

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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