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(54) A cable, a two-part connector therefor, a unit comprising a part of the two-part connector, and a fixed station for mobile telecommunications

(57) A communications cable is provided comprising a coaxial cable incorporating an optical fibre, and optionally at at least one end a connector part of a two-part connector.

A powered unit is provided for use in telecommunications station comprising a connector part of a two part connector and a main body, the connector part being mounted on the main body and including an inner conductor, an outer conductor coaxial with the inner conductor and an optical transmitter, receiver or transceiver operative to receive and/or launch light signals.

A two-part connector is provided for a communications cable comprising a coaxial cable incorporating an optical fibre, the connector comprising a male part and a female part for cooperative engagement, the male part comprising a plug in which an end of the optical fibre is held exposed, the plug comprising an inner conductor, the male part also comprising an outer conductor coaxial with the inner conductor, and the female part comprises a recess at the end of which an optical transmitter, receiver or transceiver is mounted so as to receive from and/or launch light signals into the optical fibre, the plug and recess being adapted for cooperative engagement.

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Description

Technical Field

[0001] The present invention relates to a communications cable comprising a coaxial cable. The present invention also relates to a powered unit for use in telecommunications station comprising a connector part of a two part connector. The present invention also relates to a fixed station for mobile telecommunications comprising a tower or mast, a base station, and a tower-or mast-mounted receiver. The present invention also relates to a two-part connector for a communications cable comprising a coaxial cable, the connector comprising a male part and a female part for co-operative engagement.

Background of the Invention

[0002] A known coaxial cable is shown in Figures 1 and 2, and consists of a plastic outer jacket 2, a metal outer conductor 4 and an inner conductor 6. The dielectric material between the inner conductor 6 and the outer conductor 4 is air or some other dielectric material. A known male coaxial cable connector is shown in Figure 3 in cross section, and consists of a solid extension 8 of the inner conductor 6, the outer conductor 4, and a locking nut 10. A known transceiver station for telecommunications with mobile terminals is shown in Figure 4. As shown in Figure 4, the known transceiver station consists of a receive tower mounted amplifier unit (TMA) 11 (incorporating a transmit bypass filter 9)connected to a base transceiver station (BTS)26 at the bottom of the tower(not shown). As shown in Figure 4, a receive signal 12 from an antenna 15 is separated from a transmit signal 14 by the receive input filter 16 within a receive section (18) of the receive tower mounted amplifier unit (TMA) 11. Within the receive section 18, a receive low noise amplifier 20, which is connected to the receive input filter 16, amplifies the receive signal. The receive signal is passed through a receive output filter 22 and is then recombined with the transmit signal onto a coaxial cable 24 so as to be sent down the tower to the Base Transceiver Station (BTS) 26. In the Base Transceiver Station (BTS) 26 the receive signal is again separated from the transmit signal by a receive filter 28. A second receive low noise amplifier 30 further amplifies the receive signal. It is then down-converted by down-converter 32 to a lower frequency, digitised by an Analog to Digital Converter (ADC) 34, and finally demodulated by a digital baseband processor 36. The transmit filter 38 provides a low-loss path for the transmit signal, from the transmitter 40 and power amplifier 42, but rejects the receive signal. Similarly, the receive filter 28 provides a low-loss path for the receive signal, but rejects the transmit signal.

[0003] As shown in Figure 4. the coaxial cable 24 connects the receive tower mounted amplifier (TMA) 11, at the top of the tower, to the base transceiver station (BTS) 26 at the base of the tower. The coaxial cable 24 carries direct current (DC) power for the receive tower mounted amplifier (TMA) 11, and also both the transmit signals up the cable 24 and receive signals down the cable 24.

[0004] In the known approach, DC current is supplied up the coaxial cable to the receive tower mounted amplifier TMA, and an alarm condition, i.e that the receive amplifier is not operating correctly, is registered when more than usual DC current is drawn. This is known as "current dumping". More advanced known approaches use a separate data cable (often RS-485 cable) for more detailed data communications, such as to transmit the Alarm condition data, and also other data such as so-called Inventory Data, for example serial number, an identifier of manufacturer, and calibration data. Alternatively, it is known to modulate such data directly onto the coaxial cable at an Intermediate Frequency (IF). Such techniques have limitations, in particular they are suitable for low-speed rather than high-speed data communications.

Summary of the Invention

[0005] The present invention provides a communications cable comprising a coaxial cable incorporating an optical fibre.

[0006] Preferably the optical fibre lies along the inside of a hollow inner conductor of the coaxial cable.The coaxial cable can incorporate multiple optical fibres. Some or all of the optical fibres can lie along the inside of a hollow inner conductor of the coaxial cable. The optical fibre (or some or all of the optical fibres) can lie in the space between an inner conductor and an outer conductor of the coaxial cable, for example in the air-gap of an air-spaced coaxial cable, or embedded in a solid dielectric.

[0007] Preferably the communications cable further comprises at at least one end. a connector part of a two-part connector. Preferably the or each connector part is male and includes a plug in which an end of the optical fibre is held exposed.

[0008] In the preferred embodiments, incorporating a fibre-optic cable into the coaxial cable is advantageous in being suitable for any application that requires transmission of DC, RF and fibre-optic (i.e light) signals, or just transmission of RF and fibre-optic signals, on a single cable.

[0009] In the preferred embodiments, RF, DC and fibre-optic signals can thus be combined onto a single cable with a single connector at each end.

[0010] Preferred embodiments thus include a connector for both RF and optical signals thus simplifying equipment installation. Installation time is reduced since only one cable is required, thus reducing operator costs for the same reason, whilst allowing a high data-rate for current and future applications.

[0011] The present invention also provides a powered

unit for use in telecommunications station comprising a connector part of a two part connector and a main body, the connector part being mounted on the main body and including an inner conductor, an outer conductor coaxial with the inner conductor and an optical transmitter, receiver or transceiver operative to, in use, receive and/or launch light signals.

[0012] Preferably the optical transmitter is a light emitting diode, the optical receiver is a p-i-n photodiode, and the optical transceiver comprises a light emitting diode, a p-i-n photodiode and an optical coupler .Preferably the connector part is female and includes a recess at the end of which the optical transmitter, receiver or transceiver is mounted.

[0013] In the preferred embodiments, an RF connector can thus incorporate an optical:electrical interface.

[0014] The present invention also provides the powered unit for use in telecommunications station to which the communications cable is connected.

[0015] The present invention also provides a fixed station for mobile telecommunications comprising a base station, and a raised receiver, the receiver and base station both being powered units, each being connected to the other by the communications cable both ends of which comprise a connector part of a two-part connector. Furthermore, preferably the fixed station further comprises a tower or mast, and the receiver is tower- or mast- mounted.

[0016] Furthermore preferably the coaxial cable transmits radio frequency signals and the optical fibre included in the coaxial cable transmits data as light signals. the optical fibre being operative to transmit data in both directions using a time division multiplex scheme or wave division multiplex scheme.

[0017] Preferred embodiments thus allow RF, DC and fibre-optic connection between a cellular radio base station and tower-mounted equipment, utilising a single cable and a single connector at either end of the cable. This simplifies the connection between tower mounted equipment (such as receive amplifiers and electrical antenna downtilt units) and base station equipment.

[0018] In preferred embodiments, by including an optical fibre into the coaxial cable and incorporating the optical interface into the RF (Radio Frequency) connector; it is only necessary to install a single cable with a single connector at either end of the cable, in order to pass RF, DC and fibre-optic signals up and down the tower. The requirement for a separate data cable is avoided, and much higher data rates are allowed than in the known Intermediate Frequency solution. For example, this solution could be used for Alarm information and Inventory information (as described earlier) down the optical fibre and Antenna Downtilt information (i.e for angle of elevation control) up the optical fibre.

[0019] Use of the coaxial cable incorporating the optical fibre allows both high data rates and more of the receiver equipment to be located up the tower, without the need for a separate data cable. Locating more of the receiver equipment up the tower has the advantage of increasing receive sensitivity, as attenuation of received signals between the antenna and receiver equipment is thereby reduced. Advantageously, the transmitter and power amplifier (PA) preferably remain in the base station at the bottom of the tower. This is advantageous as a network operator may still wish to replace a power amplifier with a higher-power or higher-efficiency unit, during the life of the base station.

[0020] The present invention also provides a two-part connector for a communications cable comprisng a coaxial cable incorporating an optical fibre, the connector comprising a male part and a female part for co-operative engagement, the male part comprising a plug in which an end of the optical fibre is held exposed, the plug comprising an inner conductor, the male part also comprising an outer conductor coaxial with the inner conductor. and the female part comprises a recess at the end of which an optical transmitter, receiver or transceiver is mounted so as to receive from and/or launch light signals into the optical fibre, the plug and recess being adapted for co-operative engagement.

Brief Description of the Drawings

[0021] Preferred embodiments of the present invention will now be described by way of example and with reference to the drawings, in which:

Figure 1 is a diagram illustrating a known coaxial cable in side view with layers cut away (prior art),
Figure 2 is a cross section along the line A-A shown in Figure 1 (prior art),
Figure 3 is a diagram illustrating an end-view of a known 7-16 DIN coaxial cable male connector(prior art),
Figure 4 is a diagram illustrating a known Base Transceiver Station (BTS) and Receive Tower Mounted Amplifier (TMA) (prior art),
Figure 5 is a diagram illustrating a coaxial cable (having air as the dielectric material between the conductors and with an integral optical fibre,
Figure 6 is a cross section along the line B-B shown in Figure 5,
Figure 7 is a diagram illustrating an end view of a 7-16 DIN coaxial cable male connector with integral optical fibre,
Figure 8 is a diagram illustrating a side view of a 7-16 DIN coaxial cable female connector with integral optical transceiver, and
Figure 9 is a diagram illustrating a Base Transceiver Station (BTS) with Tower Mounted Receiver.

Detailed Description

[0022] The cable itself is first described, then the cable with connectors and connectors for use with the cable are described. This is followed by a description of

application in a telecommunications base station.

Cable

[0023] As shown in Figures 5 and 6. the preferred cable 50 is a coaxial cable (also known as an RF (radio frequency) cable) contains an optical fibre 52. The cable 50 consists of a plastic outer jacket 54, a metal outer conductor 56 and an inner conductor 58. The dielectric material 60 between the inner conductor 58 and the outer conductor 56 is air. The inner conductor 58 is hollow and the optical fibre 52 runs along its inside.

[0024] In some other embodiments (not shown), a single optical fibre or multiple optical fibres may be run down the air-spacing inside the coaxial cable between the inner and outer conductors (high-power and low-loss RF coaxial cables often have such air spaces between inner and outer conductors). In some embodiments single or multiple optical fibres may be elsewhere in the coaxial cable, such as lying inside the inner conductor if hollow.

[0025] In the preferred embodiment, only a single optical fibre 52 is provided in the cable 50. In some other embodiments (not shown) for higher data-rate applications, multiple optical-fibres are provided.

[0026] In the preferred embodiment high-power/low-loss coaxial cable and modified high-power RF connectors similar to the 7/16 DIN connectors currently utilised on most cellular telecommunications base stations are used . In an alternative embodiment (not shown) smaller diameter cables with correspondingly sized RF connectors are used.

Cable with connectors

[0027] As regards connectors (sometimes referred to as RF connectors) for use with the cable 50, a single optical fibre is held in the centre of a "male" RF plug or "female" RF socket, such that the end of the optical fibre is exposed. A preferred male RF connector 62, incorporating an optical fibre 64 along the central axis of the RF plug 66 and terminating in the same plane is shown in Figure 7. The connector 62 consists of the RF plug 66 which is a largely solid metal extension of the inner conductor, and also the outer conductor 68, and a locking nut 70. The connector 62 and other preferred connectors described below are based on the known 7/16 DIN connector, where DIN indicates Deutsches Institut fur Normung e.v. and 7/16 indicates that the inner conductor 58 outer diameter is 7mm and the outer conductor 56 inner diameter is 16mm.

Connecting equipment using the cable

[0028] To connect the cable to fixed equipment, e.g a base transceiver station BTS such as a NodeB in Universal Mobile Telecommunications System UMTS terminology or tower top equipment such as a tower-mounted receiver, the male or female RF connector fixedly mounted on the fixed equipment (hence also known as a "bulkhead" connector) contains either a fibre-optic transmitter, receiver, or transmitter-receiver (transceiver), integral to the connector. This transmitter, receiver, or transceiver is located centrally (i.e along the central longitudinal axis) of the connector; in order to align with the optical-fibre located centrally along the coaxial cable.

[0029] A female connector 72 as mountable on such fixed equipment is shown in Figure 8. The female connector 72 includes an optical transceiver 74 integral to the socket of female connector, and operative to receive the optical signal from the optical fibre 64 terminating in the RF plug 66 of the male connector shown in Figure 7, or launch the optical signal into the optical fibre 64 of the male connector. The optical transceiver 74 is of the type known as a single fibre optical transceiver, and consists of, for reception, a p-i-n photodiode (not shown) connected to an amplifier (not shown) (namely a transimpedence amplifier). The optical transceiver 74 also includes, for transmission, a light emitting diode (LED, not shown). The p-i-n photodiode and light emitting diode (LED) are connected to respective ports of a 3-port optical coupler (also known as a combiner-splitter, not shown). The optical transceiver can thus be considered an electrical to optical and optical to electrical interface. A Time Division Duplex (TDD) transmission scheme is used for two-way communications along the optical fibre. In an alternative embodiment (not shown) with a single optical fibre, a Wave Division Duplex transmission scheme is used instead.

[0030] In use both RF and optical signals are sent along the cable 50 having a single connector 62,72 at each end.

[0031] This solution reduces installation time since it only requires one cable, reduces operator costs for the same reason, and allows a high data-rate for current and future applications.

[0032] In other embodiments (not shown) other locations for the optical fibre in the coaxial cable connector and bulkhead connector are possible. If the optical fibre is no longer located centrally, it will be necessary to modify the RF connectors (at both cable and bulkhead ends), to ensure alignment of the optical fibre with the transmitter / receiver / transceiver. This can require a locating/alignment mechanism, such as an alignment pin and corresponding groove, to be incorporated into the connectors.

[0033] Other possible types (not shown) of connectors involve multiple optical fibres and/or are based on different known RF coaxial cable connectors.

Base station application

[0034] A transceiver station for telecommunications with mobile terminals is shown in Figure 9. As shown in Figure 9, the transceiver station consists of a tower

mounted receiver 11' connected to a base transceiver station BTS,26' at the bottom of the tower(not shown). As shown in Figure 9, a receive signal 12' from an antenna 15' is separated from a transmit signal 14' by the receive filter 16' within the receive section 18' of the tower mounted receiver 11'. Within the receive section 18', a receive low noise amplifier 20', which is connected to the receive filter 16', amplifies the receive signal. The receive signal is then down-converted by a down-converter 76 to a lower frequency, digitised by an Analog to Digital Converter (ADC) 78, then converted to an optical signal by an optical transmitter 80. The received signal 82, which is now thus optical, travels down the tower via the optical-fibre in the coaxial cable 50 to the Base Transceiver Station (BTS) 26'.

[0035] At the Base Transceiver Station BTS 26', in the so-called receive chain 86, the optical signal 82 is converted back by an optical receiver 84 to an electrical signal for demodulation by a Digital Baseband Processor 36'. This avoids the need for RF filters (which would be expensive).

[0036] At the Base Transceiver Station BTS 26', in the so-called transmit chain 88, an optional transmit filter 38' provides additional filtering for the RF transmit signal, from the transmitter 40' and power amplifier 42' to the cable 50. In some other embodiments (not shown) the power amplifier 42' is directly connected to the cable 50.

[0037] As shown in Figure 9, the cable 50 with integral optical fibre, connects the Tower Mounted Receiver 11' at the top of the tower, to the base transceiver station BTS 26'at the base. The cable 50 routes both DC (direct current) power for the tower-mounted receiver TMR 11' and the transmit signals up the tower. The optical fibre 52 within the cable 50 routes digitised receive signals 82 in the opposite direction , i.e. down the tower.

[0038] It will be seen by comparison of Figures 4 and 9, that the preferred Base Transceiver Station BTS, (which could be a Node B to use Universal Mobile Telecommunications System UMTS terminology) shown in Figure 9 is simpler since most of the receive functionality (including down-conversion and analog to digital conversion) has moved to the top of the tower. Locating more of the receiver equipment up the tower in this way has the advantage of increasing receive sensitivity, as attenuation of received signals between the antenna and that receiver equipment is thereby reduced.

[0039] Assuming bi-directional data communication is required using the single optical-fibre 52 (i.e. both from the base transceiver station BTS 26' to the Tower mounted receiver 11' and vice versa), a WDM (Wave Division Multiplex) or TDM (Time Division Multiplex) transmission scheme is used.

[0040] In a modified embodiment (not shown) at the base transceiver station BTS, the coaxial cable incorporating the optical-fibre is connected to the base transceiver station BTS via a lightning protection unit. The lightning protection unit can incorporate the optical transmitter / receiver / transceiver.

[0041] In some other embodiments (not shown), two tower-mounted amplifiers or receivers are mounted up the tower in a single housing. Each of the two tower-mounted amplifiers or receivers is connected by a respective cable, consisting of a coaxial cable with integral optical fibre, to the base transceiver station. In such embodiments, one cable includes the optical fibre for transmission of light up the tower whilst the other cable includes the optical fibre for transmission of light down the tower. The cable having light going up has connectors at each end. For that cable, the connector at the bottom includes an optical transmitter, such as a light emitting diode (LED). The connector at the top includes an optical receiver such as a p-i-n photodiode connected to an amplifier, in particular a transimpedence amplifier. The cable for the light going down also has connectors at each end. For that cable, the connector at the bottom includes an optical receiver, such as a p-i-n photodiode connected to an amplifier, in particular a transimpedence amplifier. The connector at the top includes an optical transmitter, such as a light emitting diode (LED).

Claims

1. A communications cable comprising a coaxial cable incorporating an optical fibre.

2. A communications cable according to claim 1, in which the optical fibre lies along the inside of a hollow inner conductor of the coaxial cable.

3. A communications cable according to claim 1 or claim 2, further comprising at at least one end a connector part of a two-part connector.

4. A communications cable according to claim 3, in which the or each connector part is male and includes a plug in which an end of the optical fibre is held exposed.

5. A powered unit for use in telecommunications station comprising a connector part of a two part connector and a main body, the connector part being mounted on the main body and including an inner conductor, an outer conductor coaxial with the inner conductor and an optical transmitter, receiver or transceiver operative to, in use, receive and/or launch light signals.

6. A powered unit for use in telecommunications station according to claim 5, in which the optical transmitter is a light emitting diode, the optical receiver is a p-i-n photodiode, and the optical transceiver comprises a light emitting diode, a p-i-n photodiode and an optical coupler.

7. A powered unit for use in telecommunications station according to claim 5 or claim 6. in which the connector part is female and includes a recess at the end of which the optical transmitter, receiver or transceiver is mounted.

8. A powered unit for use in telecommunications station according to any of claims 5 to 7, to which a communications cable according to claim 3 or claim 4 is connected.

9. A fixed station for mobile telecommunications comprising a base station, and a raised receiver, the receiver and base station both being powered units according to any of claims 5 to 7, each being connected to the other by a communications cable according to claim 3 or claim 4 both ends of which comprise a connector part of a two-part connector.

10. A two-part connector for a communications cable comprisng a coaxial cable incorporating an optical fibre, the connector comprising a male part and a female part for co-operative engagement, the male part comprising a plug in which an end of the optical fibre is held exposed, the plug comprising an inner conductor, the male part also comprising an outer conductor coaxial with the inner conductor, and the female part comprises a recess at the end of which an optical transmitter, receiver or transceiver is mounted so as to receive from and/or launch light signals into the optical fibre, the plug and recess being adapted for co-operative engagement.

Fig. 1 Prior Art

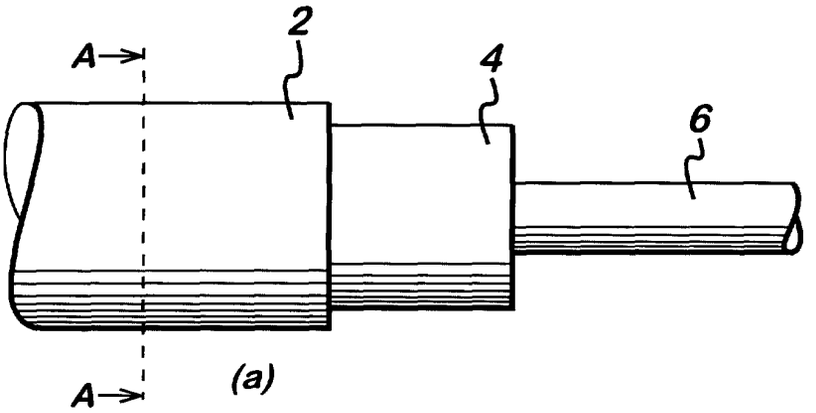


Fig. 2 Prior Art

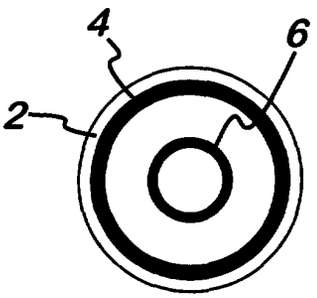
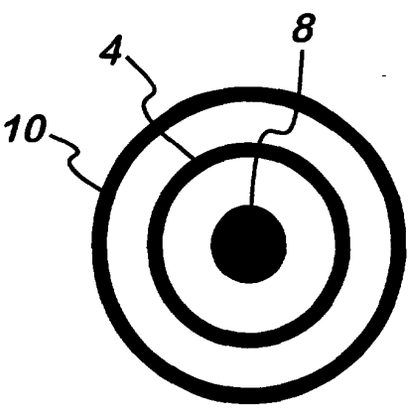


Fig. 3 Prior Art



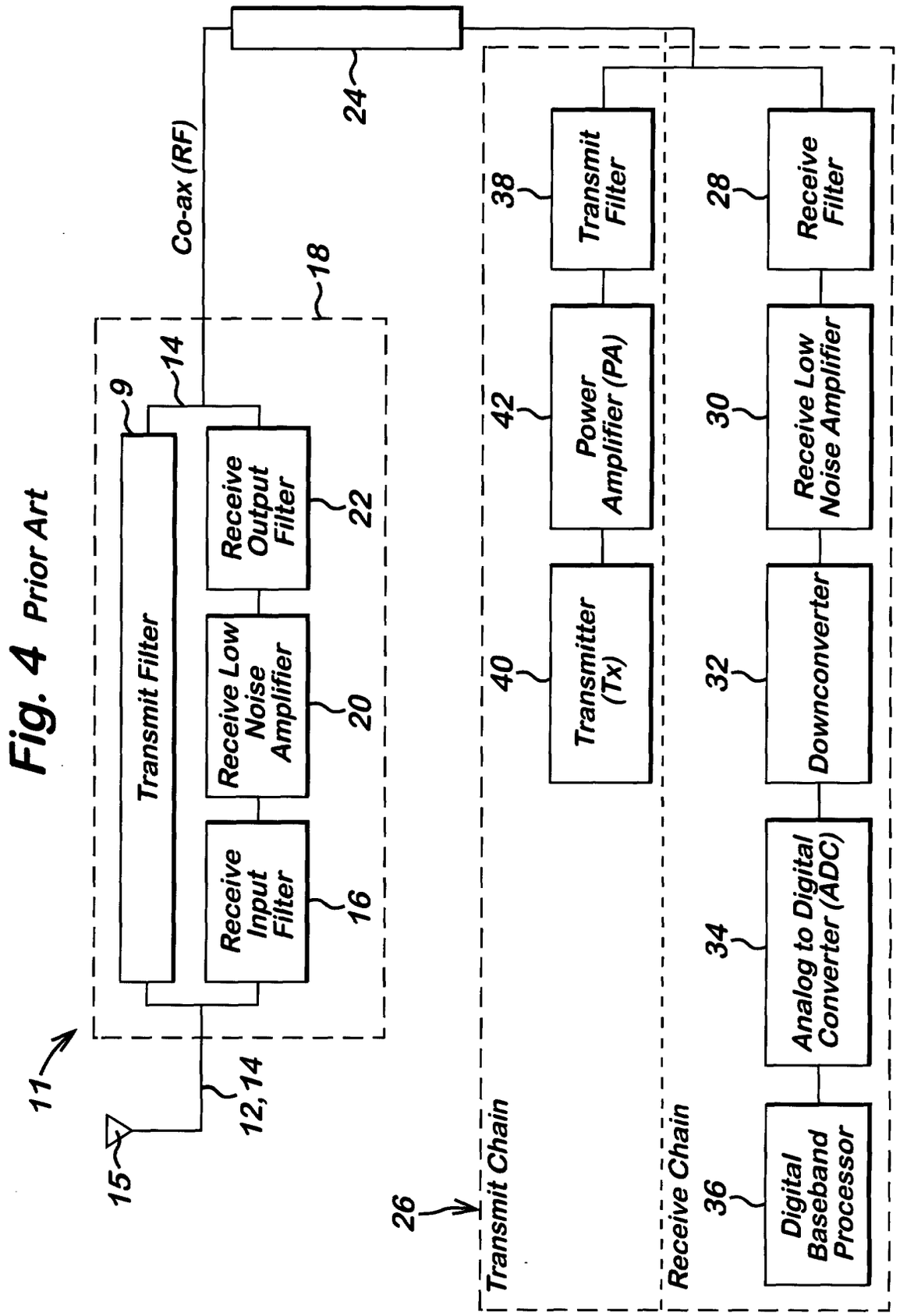


Fig. 4 Prior Art

Fig. 5

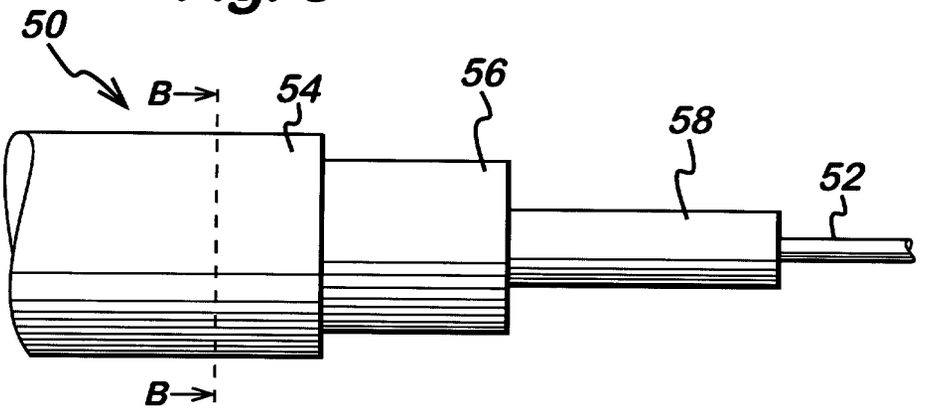


Fig. 6

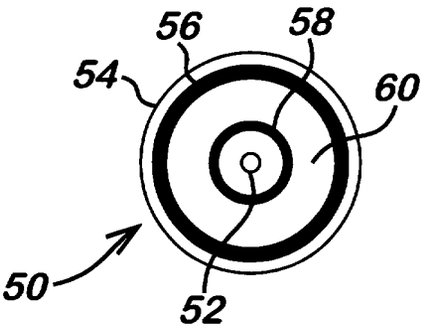


Fig. 7

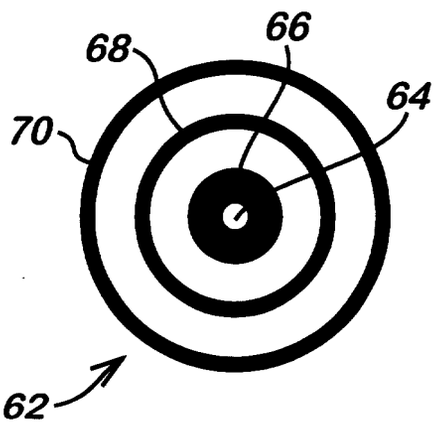


Fig. 8

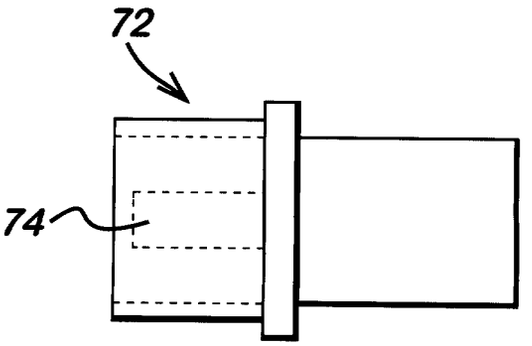
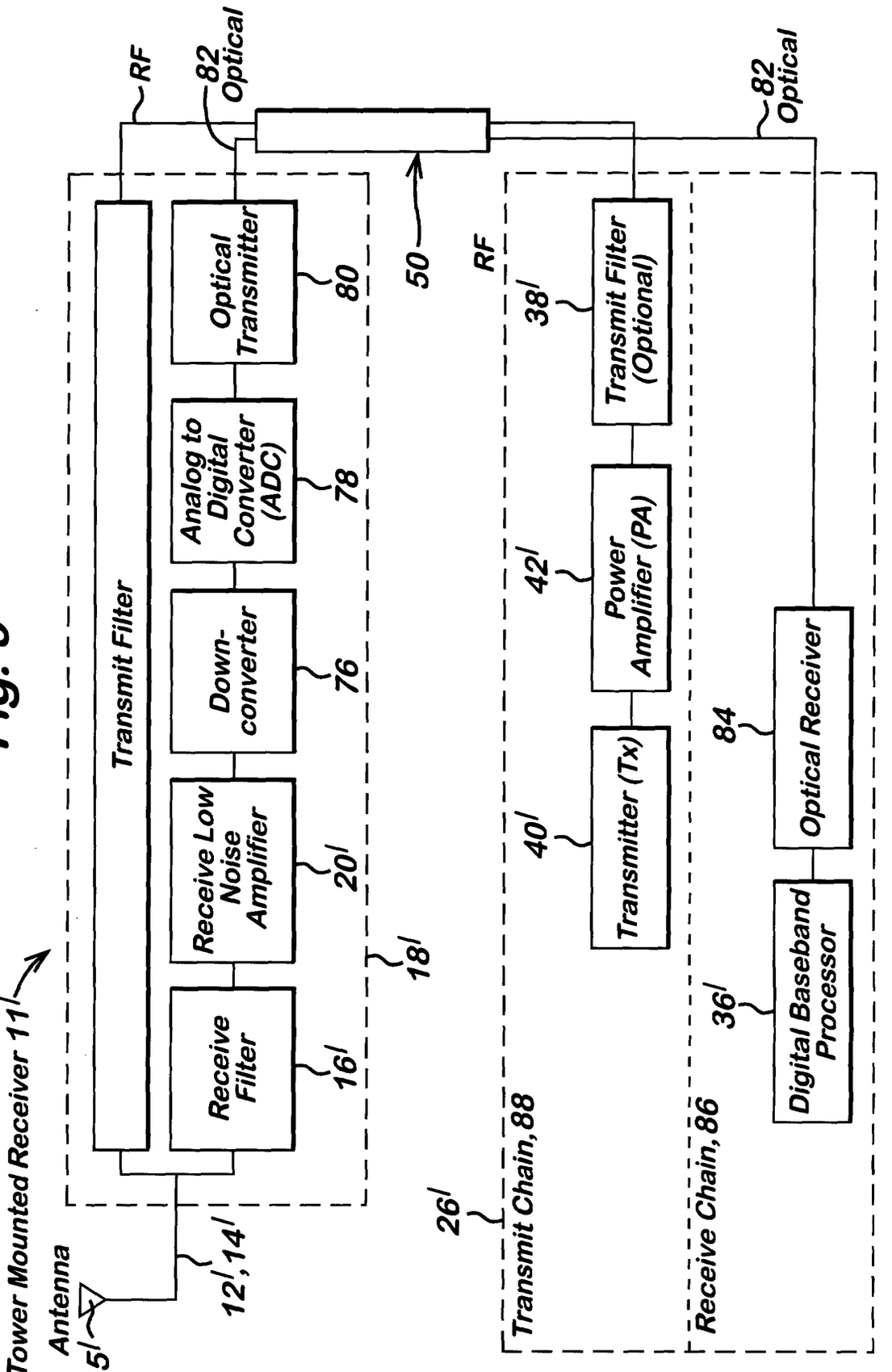


Fig. 9


Tower Mounted Receiver 11'
Antenna 15'
12', 14'
26'
Transmit Chain, 88
Receive Chain, 86
Transmit Filter
Receive Filter
16'
Receive Low Noise Amplifier
20'
18'
Down-converter
76
Analog to Digital Converter (ADC)
78
Optical Transmitter
80
RF
82 Optical
50
RF
82 Optical
Transmit Filter (Optional)
38'
Power Amplifier (PA)
42'
Transmitter (Tx)
40'
Optical Receiver
84
Digital Baseband Processor
36'

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 5821

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 896 939 A (O'BRIEN DONALD G) 30 January 1990 (1990-01-30) * column 3, line 48 - column 10, line 43; figures 1-4 * ---	1-4	H01B11/18
A	GB 2 252 422 A (BAROID TECHNOLOGY INC) 5 August 1992 (1992-08-05) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H01B

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 February 2003	DEMOLDER, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

Application Number

EP 02 25 5821

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-4

European Patent Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 02 25 5821

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-4

   A communications cable.

2. Claims: 5-10

   A powered unit for use in telecommunications station.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 02 25 5821

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-02-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4896939 A	30-01-1990	NONE	
GB 2252422 A	05-08-1992	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82