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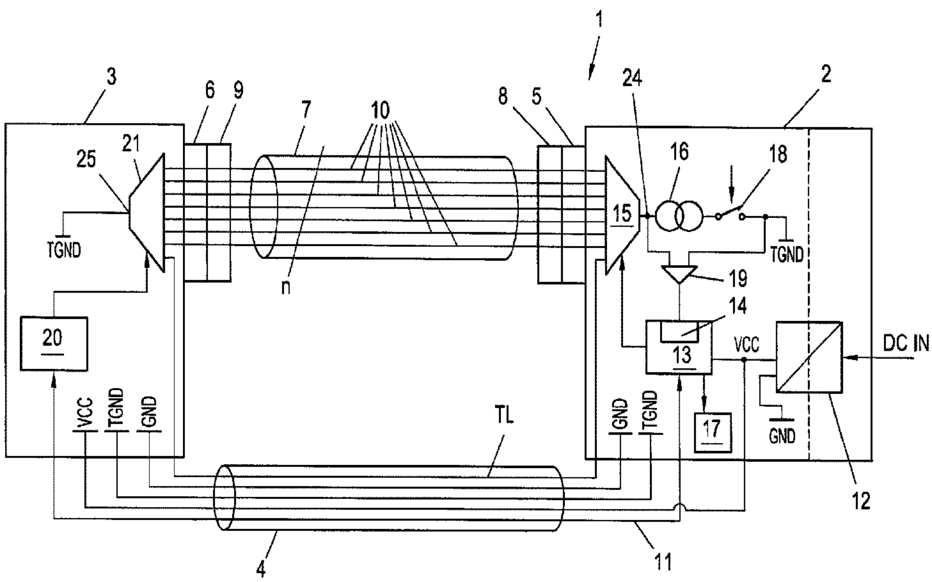
(54) Titre : TESTEUR DE CABLES ET PROCEDE DE TEST D'UN CABLE A N POLES
(54) Title: CABLE TESTER AND METHOD FOR TESTING AN N-POLE CABLE



(57) Abrégé/Abstract:
To allow a cable (7) of almost any length to be tested even during normal cable (7) operation, it is suggested that an individual conductor (10) of said cable (7) is connected to a separate test ground (TGND) that differs from the electrical ground (GND) of the cable tester (1), and an electrical variable (U_{ADC}, I_T) relating to said test ground (TGND) is measured in a first tester unit (2) or a second tester unit (3) and evaluated in order for testing to be carried out.

Abstract

To allow a cable (7) of almost any length to be tested even during normal cable (7) operation, it is suggested that an individual conductor (10) of the cable (7) is connected to a separate test ground (TGND) that differs from the electrical ground (GND) of the cable tester (1), and an electrical variable (U_{ADC}, I_T) relating to the test ground (TGND) is measured in a first tester unit (2) or a second tester unit (3) and assessed to perform the test.

Cable tester and method for testing an n-pole cable

The subject invention relates to a cable tester having a first tester unit with a first control unit and a second tester unit with a second control unit, wherein, in the first tester unit, a first selection circuit controlled by the first control unit is provided, which is connected to a first connector at the first tester unit, and, in the second tester unit, a second selection circuit controlled by the second control unit is provided, which is connected to a second connector at the second tester unit. Moreover, the invention relates to a method for performing a functional test on an n-pole cable having a number of individual conductors using a cable tester having a first tester unit with a first control unit and a second tester unit with a second control unit, wherein a first selection circuit in the first tester unit is controlled by the first control unit and a second selection circuit in the second tester unit is controlled by the second control unit, wherein a cable to be tested is connected with one end to a first connector of the first tester unit connected to the first selection circuit and with the other end to a second connector of the second tester unit connected to the second selection circuit, and, to perform the test, an individual conductor of the cable is connected through by the first selection circuit and the second selection circuit.

So far, to test an n-pole cable, the cable has been disconnected at both ends and the individual conductors of the n-pole cable have been tested individually using a multimeter, for example, by measuring resistance. Understandably, this procedure is time-consuming and prone to error, especially when it comes to multipole cables with very many individual conductors. An improvement may be achieved with cable testers where both ends of the cable are inserted into connectors provided at the cable tester. The cable tester then tests the individual conductors in an automated manner. However, in both cases, the cable must be disconnected and the system in which the cable is used in normal operation must be interrupted for this purpose. Moreover, this is only possible for small cable lengths.

CN 102520308 A describes a cable tester having a master and a slave portion to which the ends of the cable to be tested are respectively connected. Controlled by the master, the individual conductors are individually tested through a relay circuit in the master and slave in an automated manner. By separating the cable tester into a master and a slave, long cables can also be tested. Here too, however, the cable must be disconnected to be able to perform the test.

One object of the subject invention now is to provide a cable tester and a method for testing a cable which enables testing cables of almost any length even during normal cable operation.

This object is achieved for the apparatus by the first tester unit and the second tester unit being interconnected by at least one tester cable, wherein the tester cable comprises at least one line for a separate test ground that differs from the ground of the cable tester, and a measuring unit is provided in at least one of the first tester unit or the second tester unit, measuring an electrical variable relating to the test ground, in particular an electric voltage or an electric current, which the cable tester assesses to perform a test. Similarly, the method according to the invention is characterized by the individual conductor to be tested being connected to a separate test ground that differs from the ground of the cable tester, and an electrical variable relating to the test ground, in particular an electric voltage or an electric current, being measured in the first tester unit or the second tester unit and assessed to perform the test. By using a separate test ground that differs from the ground of the cable tester, it is possible to carry out a measurement of an electrical variable on the individual conductor independently of any other system voltage or system current applied to the individual conductor. At the same time, this procedure does in no way influence the cable in normal operation and thus an electrical connection of system components through the cable. Therefore, it is not only possible to test the cable when not in operation, but also during normal cable operation. This also ensures a very flexible field of application for the cable tester. Due to the separation of the cable tester into a first tester unit and a second tester unit and the connection thereof by a dedicated tester cable, the possible length of the cable to be tested essentially only depends on the length of the tester cable, thereby also allowing even very long cables to be tested.

If the tester cable comprises a communication link, or a wireless communication link is provided between the first control unit and second control unit through which the first control unit and the second control unit communicate, a master/slave operation of the cable tester may be implemented in a very advantageous manner. This means that a tester unit (the master unit) controls the other tester unit (the slave unit) through the communication link. Similarly, this can also be used to implement a master/master operation, wherein both tester units exchange data over the communication link.

Using a tester cable with a test line connected to both the first selection circuit and the second selection circuit, a functional test of the cable tester can be readily implemented. Similarly, the resistance of the line can also be easily estimated for the test ground in the tester cable to render the measurement of the electrical variable relating to the test ground and/or the subsequent assessment thereof more accurate and/or reliable.

If an electrical power source is provided in at least one of the first tester unit or the second tester unit which is connected to the output of the associated first or second selection circuit and is connected to the test ground, a second test case can be implemented in the form of a current measurement.

Here, it is particularly advantageous if the electrical power source is executed as a current source and the measuring unit measures a voltage relating to the test ground, since a single measuring unit will then be sufficient for measuring a voltage.

In a first test case, to perform a voltage measurement on the individual conductor connected through, the voltage relating to the test ground is measured and compared to a threshold value, and a fault in the individual conductor is detected if the measured value is greater or less than the threshold value.

In a second test case, to perform a current measurement, the individual conductor connected through is switched to an electrical power source relating to the test ground, and the electrical variable produced thereby relating to the test ground is measured. Here, the electrical power source may either be executed as a current source or as a voltage source.

In a very particularly advantageous embodiment of the invention, a first end of the cable to be tested is simultaneously connected to a first system unit and a first tester unit and the other end of the cable to be tested is simultaneously connected to a second system unit and a second tester. Thereby, a test of the cable in normal cable operation is implemented without disrupting normal operation.

The subject invention will now be explained in greater detail with reference to figures 1 through 6, schematically showing advantageous embodiments of the invention in an exemplary and non-limiting manner. Thereof,

Fig. 1 shows the configuration of a cable tester according to the invention,
Fig. 2 shows the configuration of a cable tester according to the invention with a cable in normal operation,
Fig. 3 shows the performance of a voltage measurement using the cable tester,
Fig. 4 shows the performance of a voltage measurement with a fault in the cable,
Fig. 5 shows the performance of a current measurement using the cable tester, and
Fig. 6 shows the performance of a current measurement with a fault in the cable.

Cable tester 1 of the invention, as exemplified in fig. 1, consists of a first first tester unit 2 and a second measuring unit 3 and a tester cable 4 connecting the two measuring units 2, 3. The first measuring unit 2 and the second tester unit 3 each have a connector 5, 6 to which the cable 7 to be tested having a number n ≥ 1 of individual conductors 10 (n-pole cables 7) may be connected using connectors 8, 9 thereof.

Tester cable 4 comprises a communication link 11, a line for supply voltage VCC and a line of the ground GND of cable tester 1. In addition, tester cable 4 also comprises an additional line for a separate test ground TGND, the function of which will be described in detail below. The ground GND and test ground TGND are not directly interconnected in cable tester 1. Tester cable 4 may also comprise a test line TL which will also be described in detail below. It is understood that tester cable 4 may also consist of several individual cables and does not have to be configured as one cable. Similarly, communication link 11 may also be implemented wirelessly, for example, as a Bluetooth or WLAN connection.

With this separation of cable tester 1 into a first measuring unit 2 and a second measuring unit 3 connected thereto by a tester cable 4, almost any length of cable 7 may be tested. The length of cable 7 is essentially only limited by the possible length of tester cable 4 and/or an acceptable distance in the case of a wireless connection.

The first tester unit 2 comprises a voltage supply 12 providing supply voltage VCC of cable tester 1. Voltage supply 12 may also be implemented as a galvanically isolated voltage supply, as indicated by the dashed line in the first tester unit 2. The galvanic isolation may increase the safety of cable tester 1. Preferably, the ground of the voltage supply coincides with ground GND of cable tester 1.

Moreover, a first control unit 13 is provided in the first tester unit 2, e.g. in the form of a microcontroller or a programmable memory device. The first control unit 13 may have an analog-to-digital converter (ADC) 14 to digitize a measuring variable for further processing in the first control unit 13. It is understood, that the first tester unit 2 could also be implemented completely analogously.

Connector 5 of the first tester unit 2, and thus also the individual conductors 10 of n-pole cable 7, is connected to a first selection circuit 15, e.g. in the form of a multiplexer or a relay circuit, connecting exactly one individual conductor 10 of cable 7 to be tested through to an output 24 of the first selection circuit 15. The first selection circuit 15 and/or output 24 thereof is also connected to an electrical power source 16 also supplied by the voltage supply, which may be activated or deactivated via a switch 18. However, the electrical power source 16 is connected to test ground TGND rather than to ground GND of voltage supply 12. Thus, in a test case, as explained in greater detail below, the electrical power source 16 is incorporated into a closed circuit with test ground TGND as the ground. The first selection circuit 15 and switch 18 are controlled by the first control unit 13, as indicated in fig. 1. The electrical power source 16 may be configured as a current source, as shown in the figures, or as a voltage source.

A measuring unit 19 measures an electrical variable, current I_T or voltage U_{ADC}, depending on the configuration of the electrical power source 16, between output 24 of the first selection circuit 15, at which an individual conductor 10 is connected through, and test ground TGND. A current source and a voltage measurement are shown throughout the figures. As an equivalent, however, cable tester 1 of the invention may also be configured with a voltage source and a current measurement as the measuring unit 19. What is essential for the invention is that the electrical variable, current or voltage, is measured against test ground TGND and that test ground TGND differs from ground GND of cable tester 1. This measured electrical variable, here voltage U_{ADC}, is transmitted to ADC 14 and thus to the first control unit 13 as a measuring variable and can be assessed to perform a test on a cable 7, as will be explained in greater detail below.

The first tester unit 2 may further comprise an input/output unit 17 to control the sequence of a test of cable 7 and/or display the result of the test. The first tester unit 2 may, of course, also have an interface with a data network, e.g. a LAN, WAN, WLAN or the like, to control the first tester unit 2 from a remote computing unit.

In the second tester unit 3, a second control unit 20 is provided, e.g. in the form of a microcontroller or a programmable memory device, which is connected to the first control unit 13 via communication link 11 of tester cable 4, e.g. a serial interface or data bus. The second control unit 20 and the first control unit 13 may exchange data and commands via communication link 11. In particular, the second control unit 20 may be controlled by the first control unit 13 via communication link 11.

Moreover, in the second tester unit 3, a second selection circuit 21 is provided, e.g. in the form of a multiplexer or a relay circuit, which is controlled by the second control unit 20. The second selection circuit 21 is connected to connector 6 of the second tester unit 3 and thus to the individual conductors 10 of cable 7, on the one hand, and by output 25 thereof to test ground TGND, on the other hand.

The first tester unit 2 and the second tester unit 3 may also have an identical hardware setup and be configured correspondingly for use as a master or slave. However, a configuration as master and master is also conceivable.

To perform a test on cable 7, an individual conductor 10 of cable 7 is connected through via the first selection circuit 15 by the first control unit 13. Via communication link 11, the second tester unit 3 is caused by the second control unit 20 and the second selection circuit 21 to connect through the same individual conductor 10 of cable 7. In this way, a respective one of the individual conductors 10 is selected for the test and connected to test ground TGND. The individual conductors 10 may therefore be tested individually and successively in an automated manner. Testing cable 7 will now be described in detail with reference to figures 2 through 6 taking an n-pole cable 7 in normal operation as an example.

In normal operation, n-pole cable 7 connects a first system unit 30 to a second system unit 31. System voltages $U_S(t)$ that are different or vary over time from a system ground GND_S may be applied to the individual conductors 10 of cable 7, as exemplified in fig. 2 by the first individual conductor 10. System ground GND_S differs from test ground TGND. At the same time, cable 7 is connected to cable tester 1 as described above. For this purpose, the cable ends of cable 7 may each be provided with a Y-adapter 22, 23 (indicated in fig. 2), which makes it possible to connect cable 7 to both the first and second system units 30, 31 and the first and second tester units 2, 3. Of course, instead of an advantageous Y-adapter 22, 23, other connection options may also be provided, such as alligator clips, pins, etc. Therefore, cable tester 1 may also be connected to cable 7 only if needed, without disrupting normal operation. Thus, for the cable test, cable 7 does not need to be disconnected from the first and second system units 30, 31. However, it is understood, that is also possible to test a cable 7 not in operation by connecting it, as in fig. 1, by connectors 8, 9 thereof to cable tester 1.

Fig. 3 shows a voltage measurement as a first test case, only including the parts of cable tester 1 which are relevant for this test. As described above, an individual conductor 10 of n-pole cable 7 to be tested is connected through for the test. Electrical power source 16 is switched off. Measuring unit 19 measures the voltage U_{ADC} dropping between the first selection circuit 15 and/or output 24 thereof and the second selection circuit 21 and/or output 25 thereof connected to test ground TGND, i.e. a voltage potential relative to test ground TGND. Substantially disregarding any other line resistance, the voltage drop is thereby measured at individual conductor 10 of cable 7 to be tested. Due to the measurement against test ground TGND, this voltage drop is completely independent of the system voltages U_S and a system current I_S across individual conductor 10. This voltage drop U_{ADC} will be very small with a faultless individual conductor 10, usually in the range of $>0V$ to $<1V$. Once the electrical properties of cable 7, such as line resistance, are known or can at least be estimated, the expected voltage drop U_{ADCset} may also be estimated in advance and compared to the measured voltage drop U_{ADC} as a setpoint value. The comparison of the measured voltage drop U_{ADC} with a threshold value U_{TS}, e.g. in the form of the expected voltage drop U_{ADCset} or a predetermined voltage value, allows to determine whether individual conductor 10 is damaged, in particular broken, or not. This fault case is shown in fig. 4. Due to a fault F in individual conductor 10, here a break, system voltage U_S is essentially measured, i.e. $U_{ADC} \sim U_S$, which is usually much higher than the normal voltage drop across an undamaged individual conductor 10. The result of the test may be displayed on input-/output unit 17.

Fig. 5 shows a current measurement as a second test case, only including the parts of cable tester 1 which are relevant for this test. As described above, an individual conductor 10 of cable 7 to be tested is connected through for the test. Electrical power source 16 is switched on (and/or switch 18 closed) for the current measurement such that a test current I_T flows. Depending on the system, test current I_T may be in the kA range for high-voltage operation or in the mA range for small control lines.

When using a current source as the electrical power source 16, measuring unit 19 measures the voltage U_{ADC} dropping between the first selection circuit 15 and the second selection circuit 21 which is connected to test ground TGND, i.e. again a voltage potential relative to test ground TGND. In the event a voltage source is used as the electrical power source 16, measuring unit 19 would measure the test current I_T flowing in the circuit formed by test ground TGND and individual conductor 10. However, use of a current source is preferred, since measuring unit 19 then measures a voltage for both test cases.

Test current I_T flows via the first tester unit 2 to the individual conductor 10 to be tested and connected through cable 7 to be tested. There, system current I_S, flowing across cable 7 during normal operation, and test current I_T overlap. At the opposite end of cable 7, test current I_T flows to the second tester unit 3 and from there via test ground TGND back to the first tester unit 2. Since system ground GND_S and test ground TGND are electrically isolated, system current I_S and test current I_T can be clearly separated and test current I_T does in no way influence the first or second system unit 30, 31. In the illustrated exemplary embodiment, voltage measuring unit 19 again measures voltage U_{ADC} (and/or test current I_T when using a voltage source) dropping between the first selection circuit 15 and the second selection circuit 21 which is connected to test ground TGND, i.e. a voltage potential relative to test ground TGND. Due to the measurement against test ground TGND, this voltage drop is completely independent of system voltages U_S and a system current I_S across individual conductor 10. The measured voltage U_{ADC} essentially results from the resistance R_W of individual conductor 10, the resistance R_K of the return line of test ground TGND in tester cable 4 and the test current I_T with $U_{ADC} = (R_W + R_K) * I_T$. The same applies analogously if a voltage source having a nominal voltage U_{ADC} is used as the electrical power source 16. Once the electrical properties of cable 7 and tester cable 4, such as line resistance, are known or can at least be estimated, the expected voltage drop U_{ADCset} (and/or expected test current I_{Tset}) may also be estimated in advance and compared to the measured voltage drop U_{ADC} (and/or test current I_T) as a setpoint value. The comparison of the measured value with a threshold value U_{TS} (and/or I_{TS}), e.g. in the form of the expected voltage drop U_{ADCset} or a predetermined voltage value, allows to determine whether individual conductor 10 is damaged, in particular broken, or not. This fault case is shown in fig. 6.

Due to a fault F in individual conductor 10, here a break, test current I_T can no longer flow across individual conductor 10 but flows via system ground GND_S and the second system unit 31 to the second tester unit 3, as shown in fig. 6. Therefore, the voltage drop U_{ADC} measured in the first tester unit 2 is considerably higher since additional voltage is lost to internal resistance R of the second system unit 31 and R_S of the first system unit 30. When measuring current, the measured test current I_T would be smaller in the event of a fault. Accordingly, in the event of a fault, the measured voltage drop U_{ADC} is $U_{ADC} = (R_W + R_K + R + R_{S)} * I_T$. The same applies analogously if a voltage source having a nominal voltage U_{ADC} is used as the electrical power source 16. Thus, a fault is clearly detectable when performing a comparison with a threshold value U_{TS} and/or I_{TS}. The result of the test may again be displayed on input-/output unit 17. The threshold values U_{TS} and/or I_{TS} of both test cases will usually not have the same values.

Test line TL of communication link 11 may also be used to estimate the resistance of the return line of test ground TGND in communication link 11. To this end, like individual conductor 10, test line TL in the first tester unit 2 and second tester unit 3 is connected to the first selection circuit 15 and second selection circuit 21. Thus, test line TL can be connected through and a test current I_T can be applied thereto and the resistance R_K of test line TL, approximately corresponding to the resistance of the return line of test ground TGND, can be inferred by measuring the resulting voltage drop U_{ADC} and applying Ohm's law.

However, test line TL may also be used for a simple functional check of cable tester 1. If test line TL is connected through and a test current I_T or voltage U_{ADC} is applied, a voltage drop U_{ADC} or test current I_T should be measured in the first tester unit 2. If this is not the case, there must be a fault, for example, in the communication between the first tester unit 2 and second tester unit 3.

For testing an n-pole cable 7, either the voltage measurement or current measurement described above or both can be used as a test case. In case of a voltage measurement, system voltage U_S may be zero at the time of testing an individual conductor 10 (e.g. with a logical 0 in a binary line). This means that, during a voltage measurement on cable 7 in normal operation, an intact cable 7 or intact individual conductor 10 cannot be safely assumed when measuring a small voltage U_{ADC}. Since this low voltage U_{ADC} may also result from individual conductor 10 having a fault F, and system voltage would then be measured as $U_S \sim 0$. In this case, the voltage measurement should be supplemented with a current measurement test case, since a fault F can then be identified with certainty.

In the above exemplary embodiments, the measurement of electrical variables for the test is always carried out in the first tester unit 2. However, it is understood, that it is also contemplated to perform this measurement in the second tester unit 3. The above explanations then apply analogously. For this purpose, as with the first tester unit 2, a measuring unit 19 and an ADC 14 may be provided in the second tester unit 3. The measurement will again be carried out relative to test ground TGND. The measured value may also be transmitted from the second tester unit 3 via communication link 11 to the first tester unit 2 and/or to the first control unit 13 and be assessed therein. However, the assessment may also be performed in the second tester unit 3 and/or the second control unit 20. The results of a test may also be displayed at the second tester unit 3 and/or at both tester units 2, 3.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A cable tester having a first tester unit with a first control unit and a second tester unit with a second control unit, wherein, in the first tester unit, a first selection circuit controlled by the first control unit is provided, which is connected to a first connector at the first tester unit, and, in the second tester unit, a second selection circuit controlled by the second control unit is provided, which is connected to a second connector at the second tester unit, wherein the first tester unit and the second tester unit are interconnected by at least one tester cable, wherein the tester cable comprises at least one line for a separate electrical test ground that differs from the electrical ground of the cable tester, and wherein a measuring unit is provided in at least one of the first tester unit or the second tester unit which measures an electrical variable relating to the test ground which is assessed by the cable tester to perform a test.

2. The cable tester as claimed in claim 1, wherein the tester cable comprises a communication link via which the first control unit and the second control unit communicate.

3. The cable tester as claimed in claim 1, wherein a wireless communication link is provided between the first control unit and the second control unit.

4. The cable tester as claimed in claim 1, wherein the tester cable comprises a test line which is connected to both the first selection circuit and the second selection circuit.

5. The cable tester as claimed in any one of claims 1 to 4, wherein at least in one of the first tester unit or the second tester unit, an electrical power source is provided which is connected to an output of the associated first or second selection circuit and is connected to the test ground.

6. The cable tester as claimed in claim 5, wherein a current source is provided as the electrical power source and the measuring unit measures a voltage relating to the test ground.

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7. The cable tester as claimed in claim 5, wherein a voltage source is provided as the electrical power source and the measuring unit measures a current relating to the test ground.

8. A method for preforming a functional test on an n-pole cable having a number of individual conductors using a cable tester having a first tester unit with a first control unit and a second tester unit with a second control unit, wherein a first selection circuit in the first tester unit is controlled by the first control unit and a second selection circuit in the second tester unit is controlled by the second control unit, wherein the cable to be tested is connected with a first end to a first connector of the first tester unit connected to the first selection circuit and with the other end to a second connector of the second tester unit connected to the second selection circuit, and, to perform the test, an individual conductor of the cable is connected through by the first selection circuit and the second selection circuit, wherein the individual conductor is connected to a separate test ground that differs from the electrical ground of the cable tester, and wherein an electrical variable relating to the test ground is measured in the first tester unit or the second tester unit and assessed to perform the test.

9. The method as claimed in claim 8, wherein, to perform a voltage measurement on the individual conductor connected through, a voltage relating to the test ground is measured and compared to a threshold value, and a fault in the individual conductor is detected if the threshold value is exceeded.

10. The method as claimed in claim 8, wherein, to perform a current measurement, the individual conductor connected through is switched to an electrical power source relating to the test ground, and a resulting electrical variable relating to the test ground is measured.

11. The method as claimed in claim 10, wherein the individual conductor connected through is switched to a current source as the electrical power source, and a test current is applied to the individual conductor, and the voltage relating to the test ground is measured and compared with a threshold value, and a fault in the individual conductor is detected if the threshold value is exceeded.

12. The method as claimed in claim 10, wherein the individual conductor connected through is switched to a voltage source as the electrical power source, and a voltage is ap-

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plied to the individual conductor, and the test current relating to the test ground is measured and compared with a threshold value, and a fault in the individual conductor is detected if the threshold value is undercut.

13. The method as claimed in any one of claims 8 to 12, wherein the first end of the cable to be tested is simultaneously connected to a first system unit and the first tester unit and the other end of the cable to be tested is simultaneously connected to a second system unit and the second tester unit.

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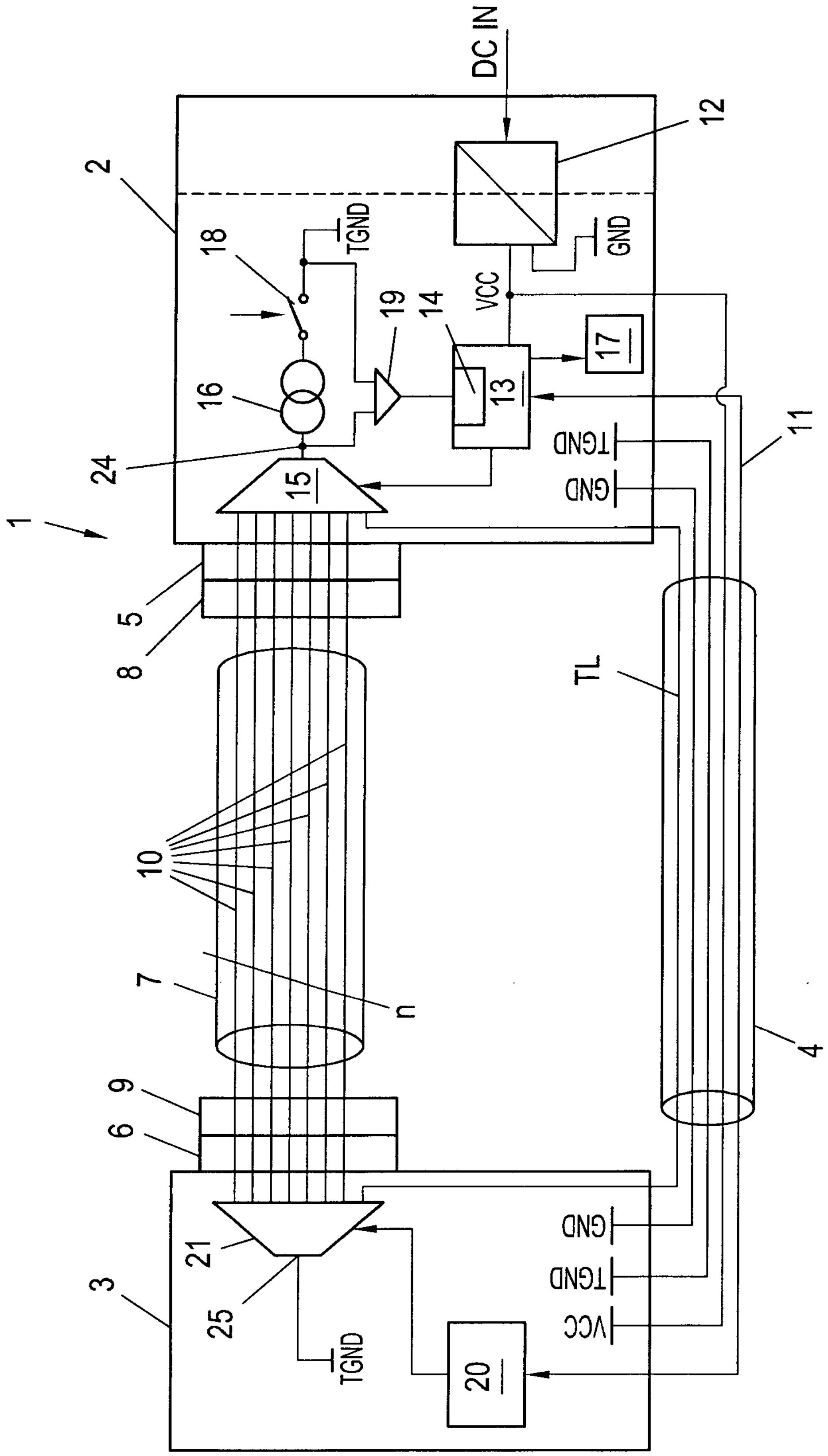
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Fig. 1

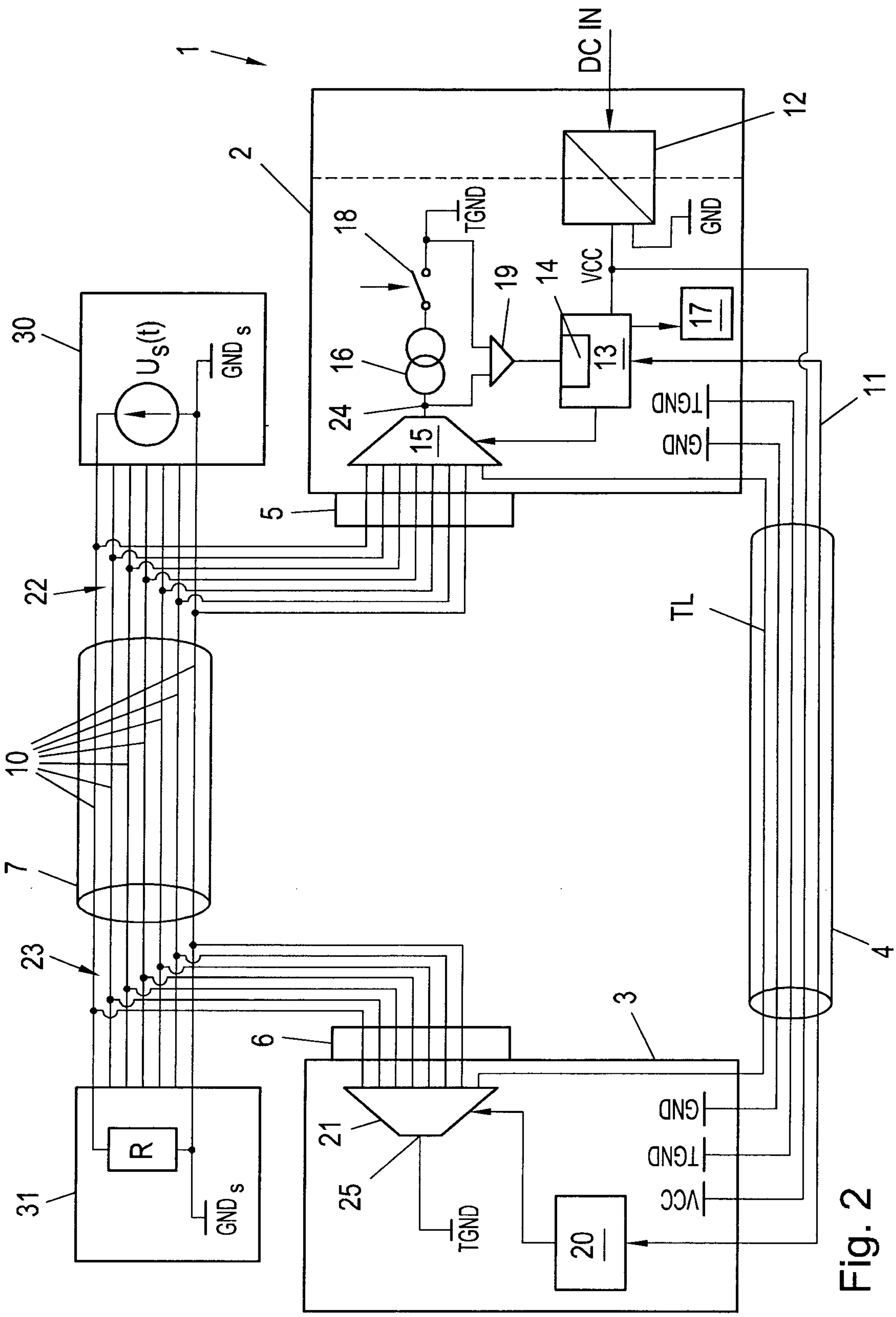
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Fig. 2

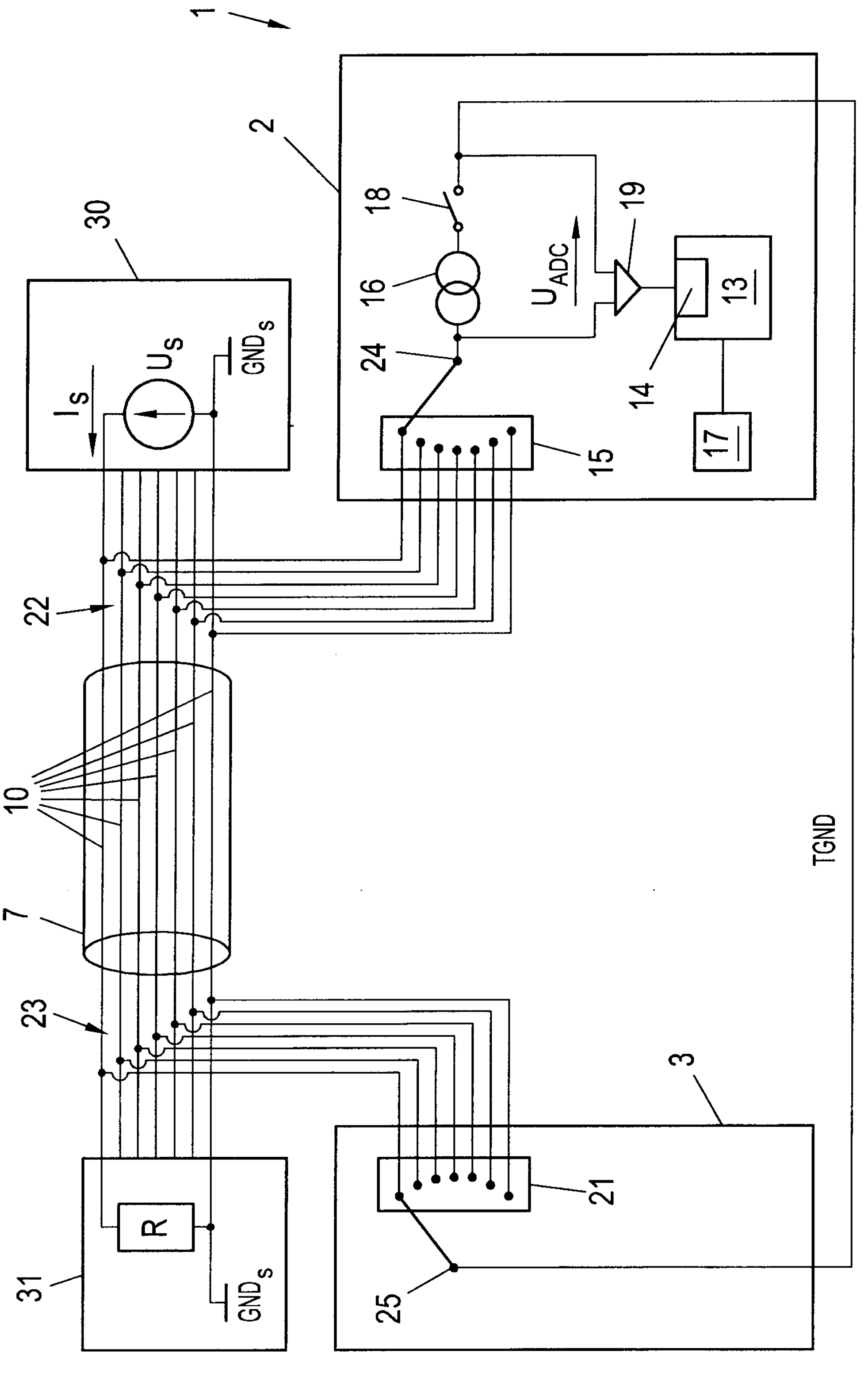
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Fig. 3

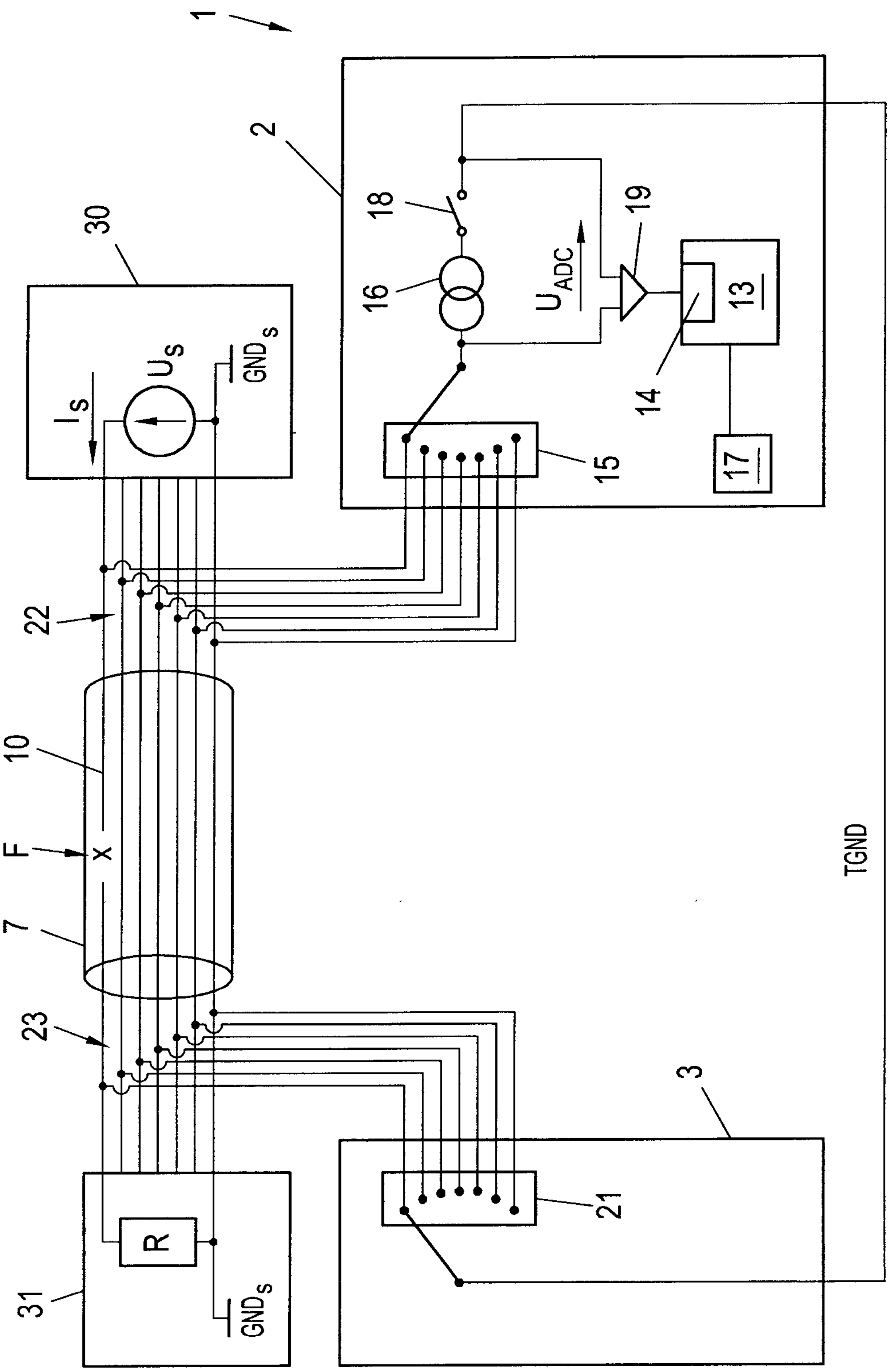
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Fig. 4

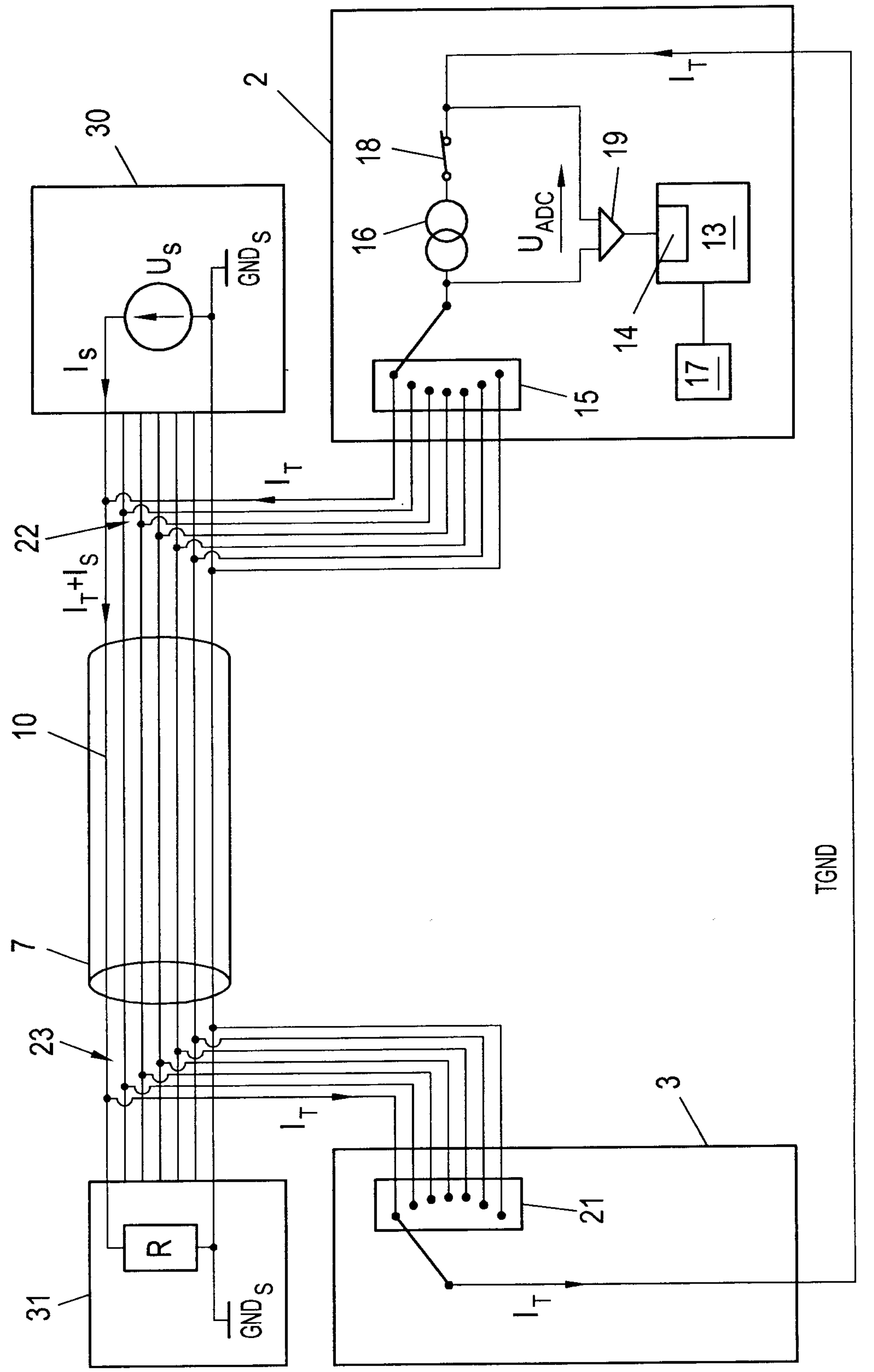
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Fig. 5

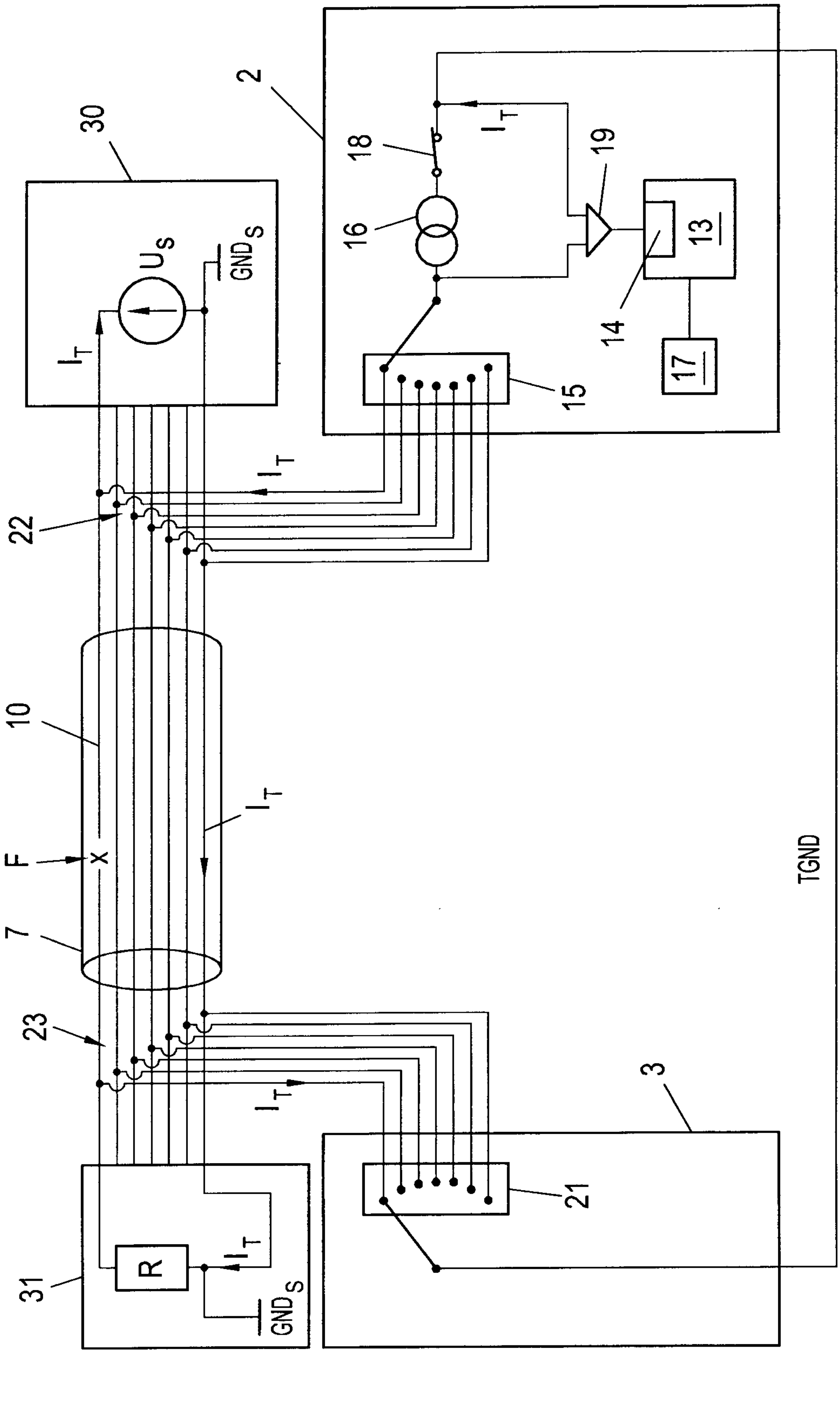
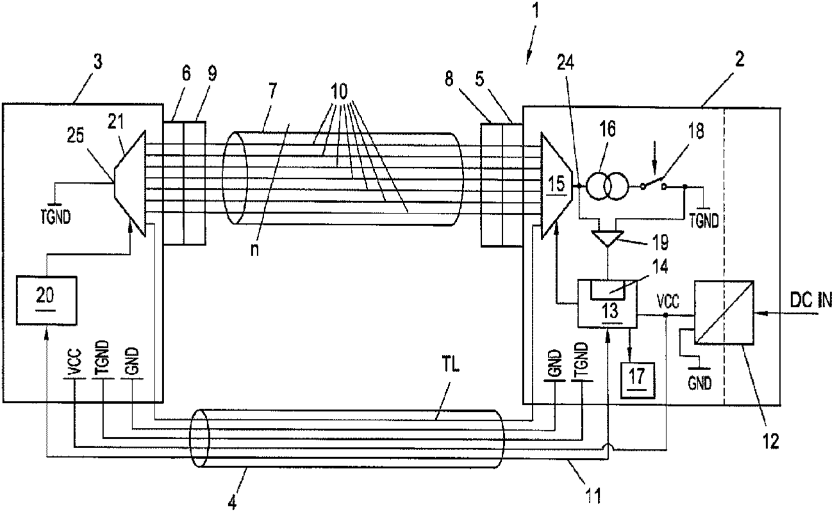


Fig. 6



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