(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 October 2019 (10.10.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/194754 A1

(51) International Patent Classification:
H02G 15/105 (2006.01) *G01R 31/00* (2006.01)

(21) International Application Number:
PCT/TR2018/050142

(22) International Filing Date:
04 April 2018 (04.04.2018)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **EM ELEKTRİK MALZEMELERİ YÜKLENİM SANAYİ TİCARET ANONİM ŞİRKETİ** [TR/TR]; Eski Ankara Yolu İstanbul Tuzla Organize San. Bölg. (ITOSB) 4.Cad. No:25 Tepeören, 34959 Tuzla/Istanbul (TR).

(72) Inventor: **ERDENİZ, Mustafa Sadettin**; Eski Ankara Yolu İstanbul Tuzla Organize San. Bölg. (ITOSB) 4. Cad. No:25 Tepeören, Tuzla/Istanbul (TR).

(74) Agent: **DESTEK PATENT, INC.**; Lefkoşe Cad. NM Ofis Park B Blok No:36/5 Beşevler, 16110 Bursa (TR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

(54) Title: LINK BOX WITH BUILT-IN INSULATOR TYPE VOLTAGE DIVIDER AND INDUCTIVE PARTIAL DISCHARGE SENSOR

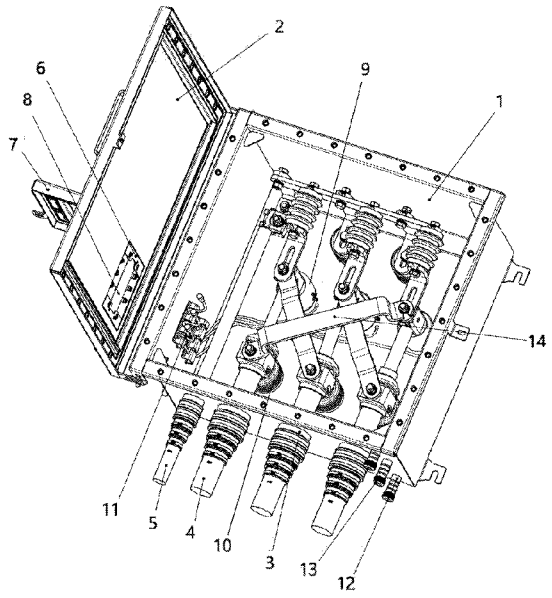


Fig. 1

(57) Abstract: The invention relates to a link box (A) which provides bonding and grounding of sheathes of cable joints (26) or cable terminations (25) and comprising voltage divider and partial discharge sensor (9) provides to pick up partial discharge pulses, measurement of induced voltages in link box (A), counting number of lightning impulses passing through sheath voltage limiters and comprises top metal fitting (23) which is used to connect to energized parts of link box (A), bottom metal fittings (24) was connected to ground body of link box (A), primary winding (16) connected to link box (A) energized components and other components of the voltage divider and partial discharge sensor (9), secondary winding (17) is used output port for partial discharge measurement, high voltage capacitor (18) and low voltage capacitor (19) provide a capacitive voltage dividing circuit, top connector (20) provides an appropriate connection point for measuring/monitoring devices and bottom connector (21) provides an appropriate connection point for measuring/monitoring devices.

WO 2019/194754 A1

Link box with built-in insulator type voltage divider and inductive partial discharge sensor

Technical Field

The invention especially relates to a link box with built-in insulator type voltage divider and inductive partial discharge sensor for use in high voltage cable systems.

State of the Art

High voltage cables are always designed with metallic sheath to controls the electric field stress in the cable insulation and also providing return path for fault current. During normal operation of cable system, AC voltages may be induced on metallic sheath due to electromagnetic coupling between core and the metallic sheath. In order to limit the magnitude of sheath voltages and also to minimize the flow of circulating currents, special bonding and grounding methods such as single point bonding and cross bonding are used in high voltage cable systems.

Link boxes are the metallic enclosures in which bonding and grounding of sheathes of high voltage cable joints or terminations made through removable links. Link boxes also may contain sheath voltage limiters to limit lightning or switching overvoltage's of cable system. Link boxes are installed close to high voltage cable joints or terminations and may be installed in places such as underground manholes, aboveground pedestals or tunnel walls and etc.

Diagnostic testing of new or service-aged installed high voltage power cable systems which include cable, joints and terminations, using partial discharge detection, measurement and locating, has a long history. After-laying partial discharge testing on newly installed cable system is an efficient method to find defects in accessories, e.g. improper positioning, cuts or scratches, contaminations etc. Partial discharge testing on service-aged cable systems is a useful indicator of insulation degradation. Partial discharge testing may be carried out on-line (at normal service voltage) or off-line (by an external voltage source). Moreover, continuous on-line monitoring of cable systems has received more attention in recent years.

Having been encountered as a result of the technical researches, Application No. WO 2016190823 A1, relates to a link box with built-in partial discharge sensor for partial discharge measurement in high voltage cable joints and terminations. High Frequency Current Transformers (HFCTs) inside link boxes is a common method to pick up partial discharge from high voltage cable screen. HFCT sensors consist of a wound toroidal ferromagnetic core that is placed around the conductor to inductively measure the magnetic field from the partial discharge current pulses.

Common types of HFCT sensors commercially available and appropriate for mounting inside link boxes have many disadvantages including occupying a lot of space inside link boxes which will affect lightning performance of link boxes, installation difficulties around bonding cables or copper link bars (especially non-split types), need to extra accessories for installation and high cost.

As a result, due to the drawbacks mentioned above and the inadequacy of the existing solutions regarding the subject matter, it is required to make a development in the related technical field.

Objects of the Invention

The invention, configured by being inspired by the current conditions, aims to solve the above mentioned drawbacks.

Present invention introduces an all-in-one solution for above mentioned problems of partial discharge measurement in link boxes.

The main object of the present invention is to overcome these problems, an insulator type inductive partial discharge sensor has been developed to be installed inside link boxes. This insulator can be used instead of support insulators inside link boxes. By using these sensors mounted in earthing/cross bonding link boxes, offline and online partial discharge measurement in cable joints and termination now is available. New product has some advantages rather than other HFTC's mounting inside link boxes including compact size, no effect on lightning performance of link box, no need to extra accessories for mounting and being low cost.

This sensor also has been equipped with a voltage divider inside for measurement of induced voltages in bonding system of high voltage cable systems. This signal can be also used to provide synchronization signals for partial discharge measuring devices.

Also, it can be used for counting number of lightning impulses passing through sheath voltage limiters inside link boxes so condition monitoring of SVL is possible. Two BNC outputs are available on the base of insulator which is voltage divider output and partial discharge sensor output. So, signals are ready-to-use for measuring systems, counters or monitoring systems.

To achieve the aforementioned objects, the present invention is a link box which provides bonding and grounding of sheathes of cable joints or cable terminations and comprising partial discharge sensors and voltage dividers provide to pick up partial discharge pulses, measurement of induced voltages in link box, counting number of lightning impulses passing through sheath voltage limiters and comprise top metal fittings which are used to connect to energized parts of link box, bottom metal fittings are connected to ground body of link box, primary windings are connected to link box energized components and other components of the partial discharge sensor and voltage divider, secondary windings are used output port for partial discharge measurement, capacitors provide a capacitive voltage dividing circuit, top connectors provide an appropriate connection point for measuring/monitoring devices and bottom connectors provide an appropriate connection point for measuring/monitoring devices.

The structural and characteristic features and all the advantages of the present invention will be more clearly understood thanks to the figures below and the detailed description written with reference to those figures, therefore; the evaluation needs to be done by taking said figures and the detailed description into consideration.

Figures for a Better Understanding of the Invention

Fig. 1 shows all components of the present invention.

Fig. 2 shows top overall view insulator type partial discharge sensor and voltage divider.

Fig. 3 shows top schematic view insulator type partial discharge sensor and voltage divider.

Fig. 4 shows schematic view of a high voltage cable system during offline and online partial discharge test.

Fig. 5 shows arrangement of current invention when it used for online monitoring.

Description of the Part References

A. Link box

1. Enclosure body
2. Enclosure cover
3. Cable gland
4. Bonding cable (coaxial)
5. Earthing cable
6. Additional housing
7. Housing cover
8. Protection box
9. voltage divider and partial discharge sensor
10. Support insulator
11. Signal cable
12. Sensor cable gland
13. Threaded cap
14. Dis-connectable link bar
15. Ferromagnetic core
16. Primary winding
17. Second winding
18. High voltage capacitor
19. Low voltage capacitor
20. Top connector

21. Bottom connector

22. Insulating body

23. Top metal fitting

24. Bottom metal fitting

25. Cable termination

26. Cable joint

Detailed Description of the Invention

In this detailed description, the preferred embodiments of the invention are described only for a better understanding of the subject without any limiting effect.

The invention relates to link box (A) with built-in insulator type voltage divider and inductive partial discharge sensor for use in high voltage cable systems.

Fig.1 shows components of the present invention. Link box (A) includes a stainless-steel enclosure body (1) and stainless-steel enclosure cover (2). Enclosure body (1) can be seen as a base frame for mounting internal parts and protection of internal parts against environmental conditions. Bonding cables (4) are used to connect metallic sheath of high voltage cable joints (26) or cable termination (25) to link box (A). Then cross bonding of cable sheathes made by dis-connectable link bars (14) inside link box (A). Earthing cable (5) is connected to earthing busbar inside the link box (A) and then it's ready to be connected to earthing electrode outside of the link box (A). Sealed penetration of bonding cables (4) (coaxial) and earthing cable (5) into enclosure body (1) made by cable glands (3). All energized parts of are isolated from ground via support insulators (10).

Partial discharge detection in current invention is made by insulator type inductive voltage divider and partial discharge sensor (9) (ITPDS). As seen on Fig.2, connection of voltage divider and partial discharge sensor (9) to link box (A) components is made via top metal fitting (23) and bottom metal fittings (24). Top metal fitting (23) is used to connect to energized parts of link box (A). Bottom metal fiftting (24) was connected to ground i.e. body of link box (A) (enclosure cover (2)). Insulating body (22) made from glass fiber reinforced polyurethane material provides an insulating environment for

electrical components inside of voltage divider and partial discharge sensor (9). Also insulating body (22) provides a reliable mechanical support for all encapsulated components.

Fig.3 shows schematic view of internal structure of voltage divider and partial discharge sensor (9). Primary winding (16) of voltage divider and partial discharge sensor (9) wound on ferromagnetic core (15) provide a pass for passing transient current pulses (partial discharge pulses). As it can be seen in Fig.3, one side of primary winding (16) connected to link box (A) energized components and other side connected to other components of voltage divider and partial discharge sensor (9).

Soft ferromagnetic core (15) is used for effective coupling between primary winding (16) and secondary winding (17). High permeability of ferromagnetic core (15) provides an ideal pass for transient partial discharge pulses. The induced voltage in the secondary winding (17) is proportional to the rate of change of current in the primary winding (16). So, terminals secondary winding (17) are used as output port for partial discharge measurement. Top connector (20) has been used to provide an appropriate connection point for measuring/monitoring devices. High voltage capacitor (18) (HV) and low voltage capacitor (19) (LV) connected in series provides a capacitive voltage divider. Midpoint of these high voltage capacitor (18) and low voltage capacitor (19) and ground provides output of capacitive voltage divider. Bottom connector (21) has been used to provide an appropriate connection point for measuring/monitoring devices.

Partial discharge output top connector (20) and voltage output of bottom connector (21) of voltage divider and partial discharge sensor (9) are transmitted to additional housing (6) via signal cables (11). As seen on Fig.4, offline or online partial discharge testing in present invention is possible just only by opening the housing cover (7) and connecting test device to protection box (8).

As shown in Fig.5, it is possible to use present invention as a part of online partial discharge monitoring systems or SVL monitoring systems. Detected partial discharge signals are sent out of the link box (A) toward monitoring system through sealed small sensor cable glands (12). When this option is not used, sensor cable glands (12) shall be covered by threaded caps (13).

In summarize, the invention relates to a link box (A) which provides bonding and grounding of sheathes of cable joints (26) or cable terminations (25) and comprises,

- at least an enclosure body (1) in which all other components are placed and protects the all components from environmental conditions,
- at least an enclosure cover (2) which is upper part for the link box (A) and protects internal components from environmental conditions,
- at least a bonding cable (4) provides to connect metallic sheath of cable joints (26) or cable termination (25) to link box (A),
- at least an earthing cable (5) is connected to earthing busbar inside the link box (A) and earthing electrode outside of the link box (A),
- at least a cable gland (3) makes sealed penetration of bonding cables (4) and earthing cables (5) into enclosure body (1),
- at least a dis-connectable link bar (14) provides a cross bonding of voltage cables sheathes inside the link box (A),
- at least a voltage divider and partial discharge sensor (9) provides to pick up partial discharge pulses, measurement of induced voltages in link box (A), counting number of lightning impulses passing through sheath voltage limiters and comprises
    - at least a top metal fitting (23) is used to connect to energized parts of link box (A),
    - at least a bottom metal fitting (24) are connected to ground body of link box (A),
    - at least a primary winding (16) are connected to link box (A) energized components and other components of the partial discharge sensor and voltage divider (9),
    - at least a secondary winding (17) is used output port for partial discharge measurement,
    - high voltage capacitor (18) provide a capacitive voltage dividing circuit,
    - low voltage capacitor (19) provide a capacitive voltage dividing circuit,
    - at least a top connector (20) provides an appropriate connection point for measuring/monitoring devices,

- at least a bottom connector (21) provides an appropriate connection point for measuring/monitoring devices,

- at least a ferromagnetic core (15) provides effective coupling between the primary winding (16) and the secondary winding (17),
- at least an additional housing (6) is located on the enclosure cover (2) which pulses of partial discharge signals are transmitted using signal cables (11) connecting the voltage divider and partial discharge sensor (9) to protection box (8) and provides carrying out of partial discharge measurement during partial discharge test just only by opening at least a housing cover (7) without opening enclosure cover (2),
- at least a protection box (8) located in the additional housing (6) intended for connecting partial discharge test device and also provides protection of test circuit using spark gaps inside,
- the housing cover (7) provides a sealed housing for the protection box (8),
- signal cables (11) provide to transmit partial discharge pulses to the protection box (8),
- at least a sensor cable gland (12) makes sealed penetration of signal cables (11) into the enclosure body (1),
- threaded caps (13) which sensor cable glands (12) are covered by when sensor cable glands (12) is not used,
- at least a support insulator (10) isolates energized parts from the enclosure body (1).

CLAIMS

1. A link box (A) which provides bonding and grounding of sheathes of cable joints (26) or cable terminations (25) and comprises;

- at least an enclosure body (1) which all other components are placed inside and protects the all components from environmental conditions,
- at least an enclosure cover (2) which is upper part for the link box (A) and protects internal components from environmental conditions,
- at least a bonding cable (4) provides to connect metallic sheath of cable joints (26) or cable termination (25) to link box (A),
- at least an earthing cable (5) is connected to earthing busbar inside the link box (A) and earthing electrode outside of the link box (A),
- at least a cable gland (3) makes sealed penetration of bonding cables (4) and earthing cable (5) into enclosure body (1),
- at least a dis-connectable link bar (14) provides a cross bonding of voltage cables sheathes inside the link box (A),

characterized in that comprises;

- at least a voltage divider and partial discharge sensor (9) provides to pick up partial discharge pulses, measurement of induced voltages in link box (A), counting number of lightning impulses passing through sheath voltage limiters and comprises
  - at least a top metal fitting (23) which is used to connect to energized parts of link box (A),
  - at least a bottom metal fitting (24) is connected to ground body of link box (A),
  - at least a primary winding (16) is connected to link box (A) energized components and other components of the partial discharge sensor and voltage divider (9),
  - at least a secondary winding (17) is used output port for partial discharge measurement,
  - high voltage capacitor (18) provide a capacitive voltage dividing circuit,
  - low voltage capacitors (19) provide a capacitive voltage dividing circuit,

- at least a top connector (20) provides an appropriate connection point for measuring/monitoring devices,
- at least a bottom connector (21) provides an appropriate connection point for measuring/monitoring devices,

- at least a ferromagnetic core (15) provides effective coupling between the primary winding (16) and the secondary winding (17),
- at least an additional housing (6) is located on the enclosure cover (2) which pulses of partial discharge signals are transmitted using signal cables (11) connecting the voltage divider and partial discharge sensor (9) to protection box (8) and provides carrying out of partial discharge measurement during partial discharge test just only by opening at least a housing cover (7) without opening enclosure cover (2),
- at least a protection box (8) is located in the additional housing (6) intended for connecting partial discharge test device and also provides protection of test circuit using spark gaps inside,
- the housing cover (7) provides a sealed housing for the protection box (8).

2. The link box (A) according to Claim 1, characterized in that comprises, the signal cable (11) provide to transmit partial discharge pulses to the protection box (8).

3. The link box (A) according to Claim 1 or Claim 2, characterized in that comprises, at least a sensor cable gland (12) makes sealed penetration of signal cables (11) into the enclosure body (1).

4. The link box (A) according to Claim 3, characterized in that comprises, threaded caps (13) which sensor cable glands (12) are covered by when sensor cable glands (12) is not used.

5. The link box (A) according to Claim 1, characterized in that comprises, at least a support insulator (10) Isolate energized parts from the enclosure body (1).

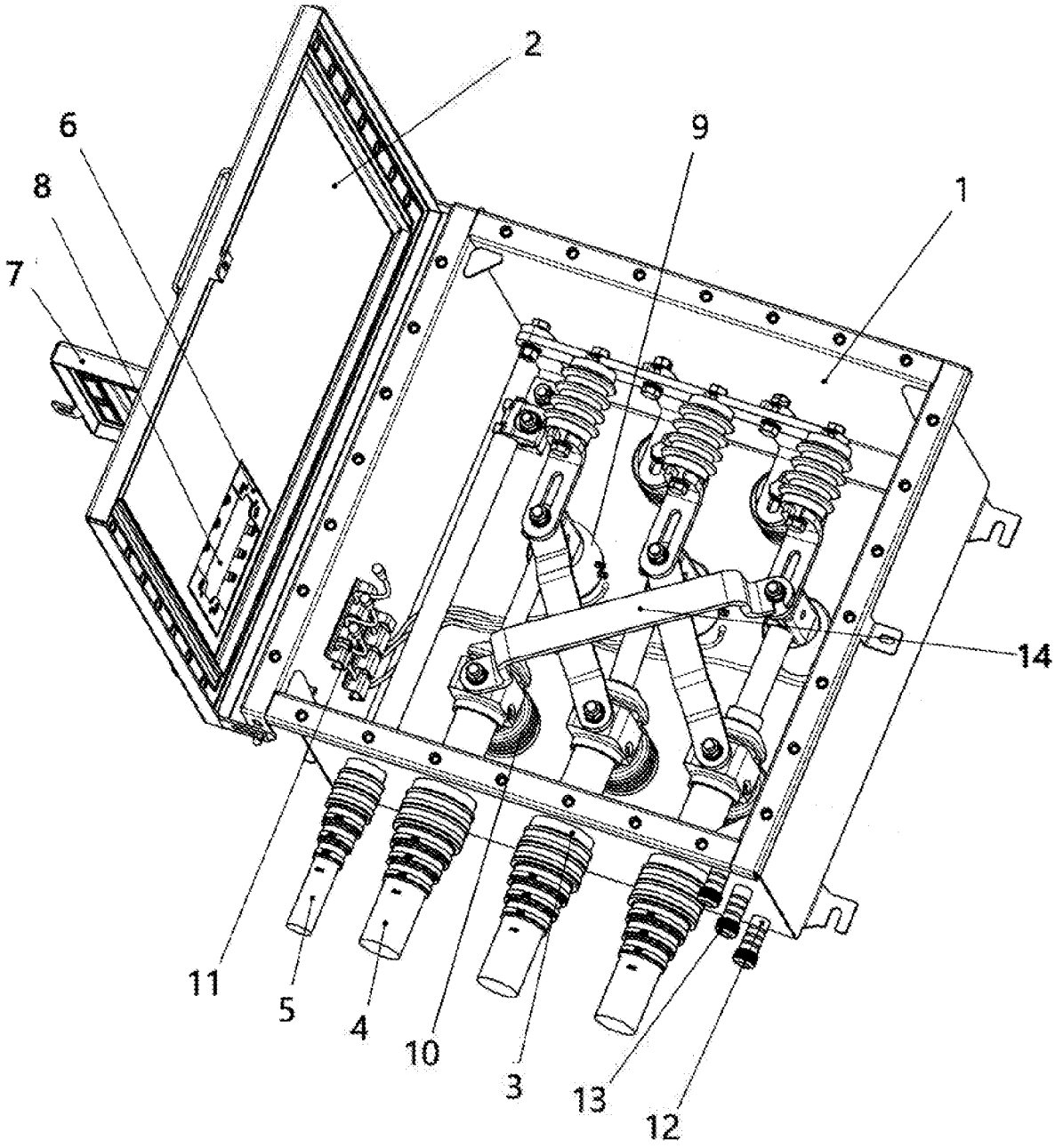


Fig. 1

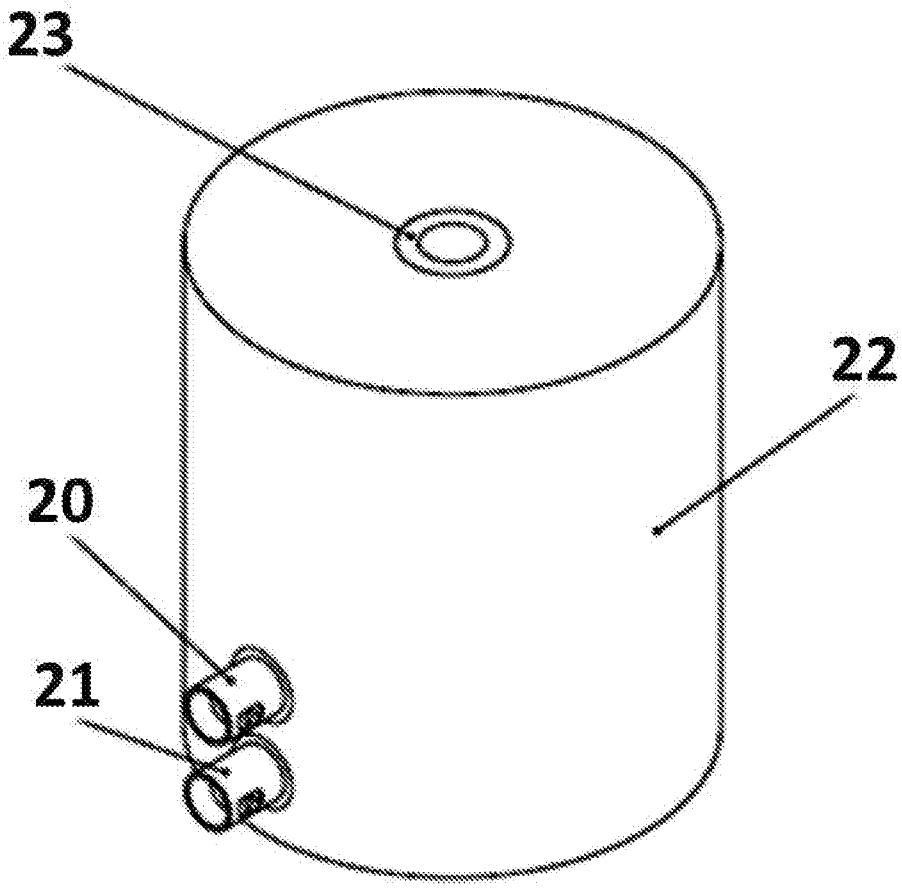


Fig. 2

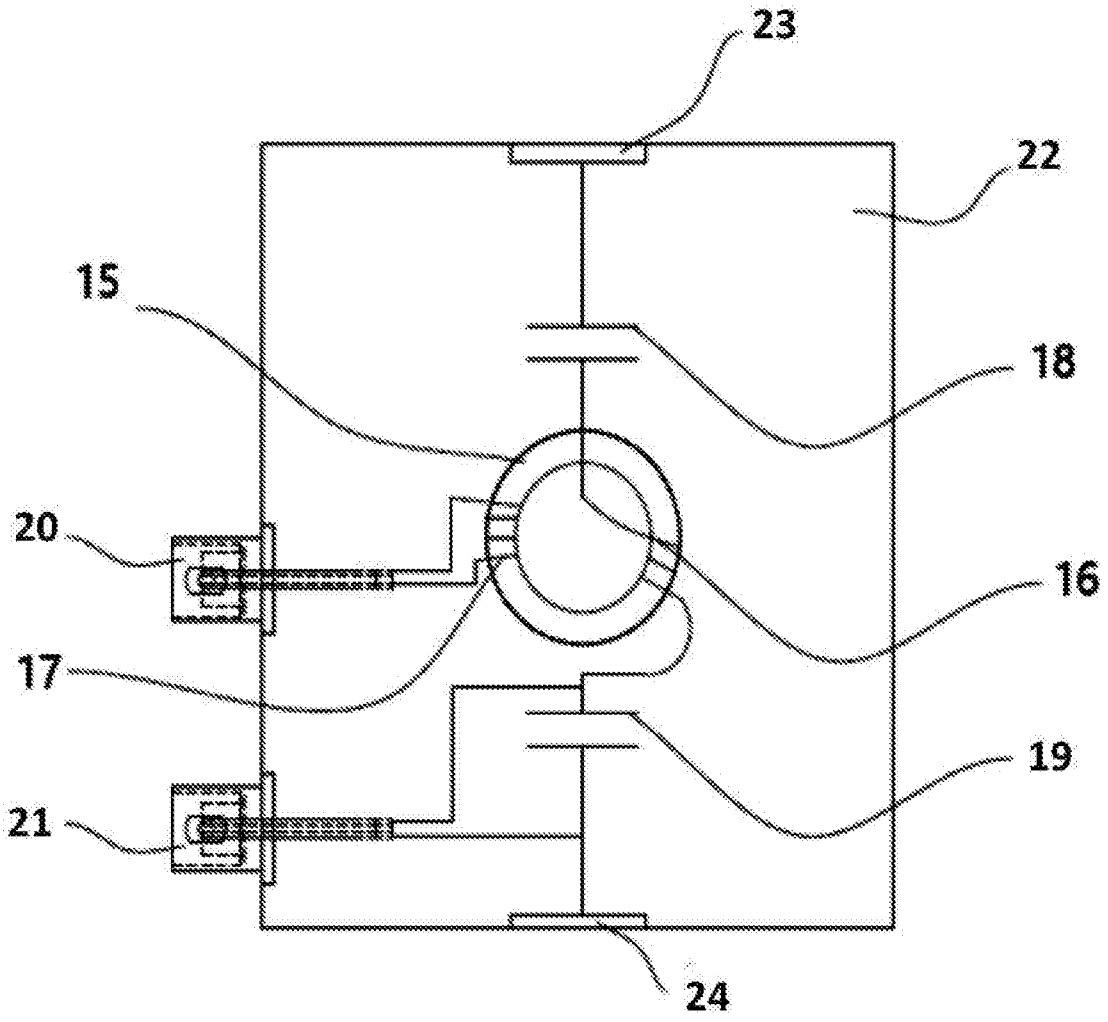


Fig. 3

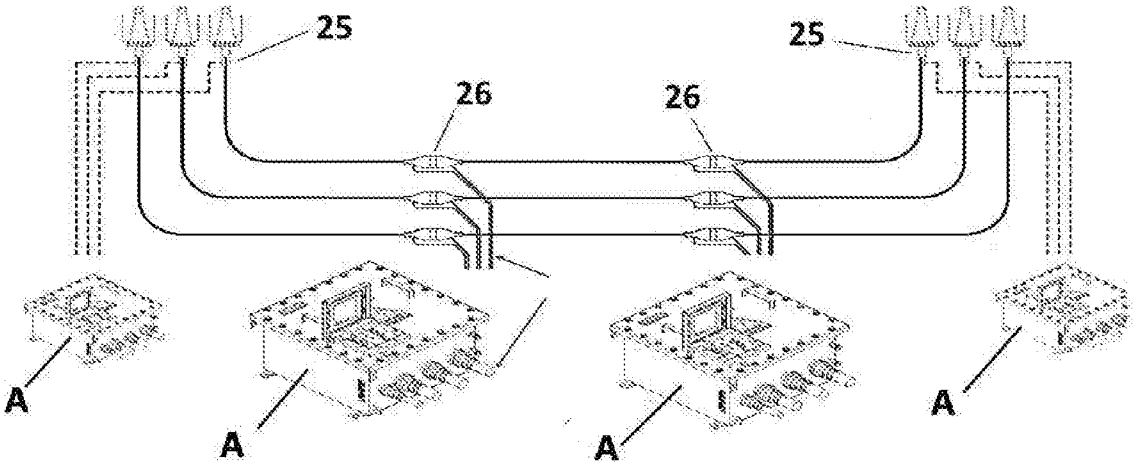


Fig. 4

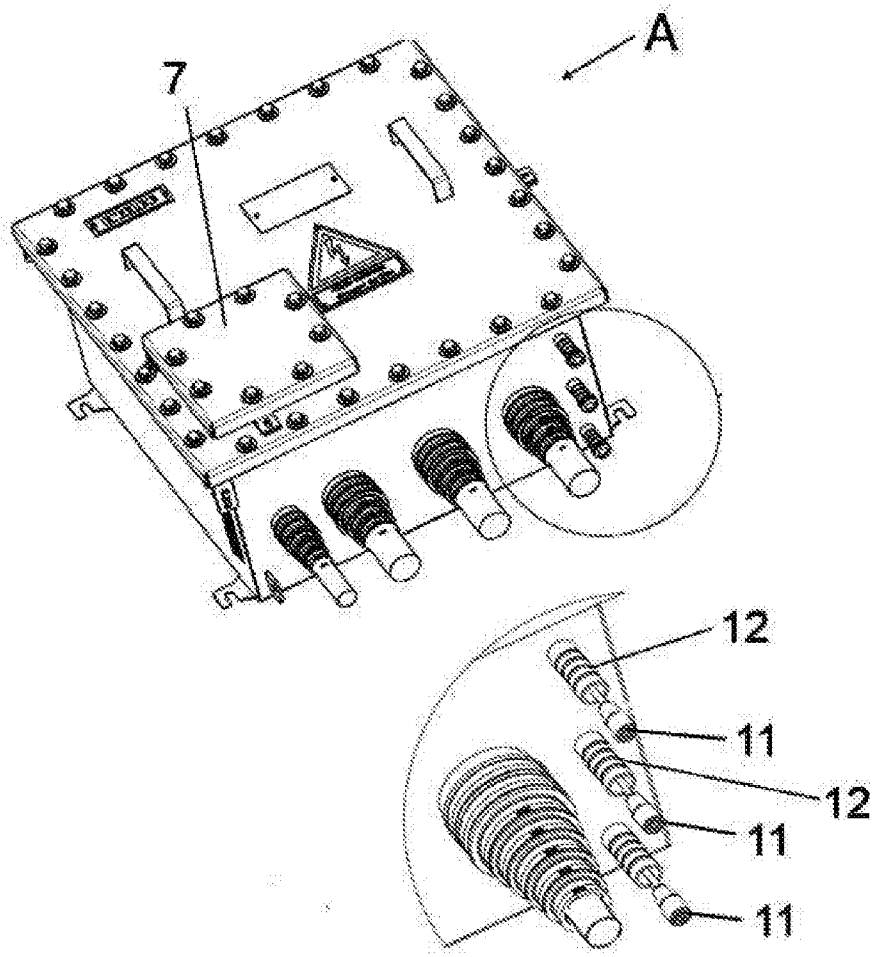


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2018/050142

A. CLASSIFICATION OF SUBJECT MATTER

H02G 15/105 (2006.01)i; G01R 31/00 (2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02G 15/105; G01R 31/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2016190823 A1 (EM ELEKTRİK MALZEMELERİ YÜKLENİM SANAYİ TİCARET ANONİM [TR]) 01 December 2016 (2016-12-01)	1-5
Y	KR 100787964B B1 (DONGWOO ELECTRIC CORP [KR]) 24 December 2007 (2007-12-24)	1-5
Y	US 2002079906 A1 (EATON CORP [US]) 27 June 2002 (2002-06-27)	1-5
Y	WO 2018006876 A1 (SHANGHAI MUNICIPAL ELECTRIC POWER COMPANY [CN]; ET AL) 11 January 2018 (2018-01-11)	1-5
Y	Chen Min, et al " Application Study of Variable PD Sensors for PD Measurement of Power Cable Circuit in Operation" 2016 International Conference on Condition Monitoring and Diagnosis- Xi!an-China, 2016 IEEE, pages 118-122	1-5

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 February 2019	**01 February 2019**

Name and mailing address of the ISA/TR	Authorized officer
Turkish Patent and Trademark Office (Turkpatent) **Hipodrom Caddesi No. 115** **06560 Yenimahalle** **Ankara** **Turkey** Telephone No. **(90-312) 303 11 82** Facsimile No. **+903123031220**	**Yavuz Öziba** Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2018/050142

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	http://www.techimp.com/products/laboratory-equipment/item/76-capacitive-divider.html ((information from " https://archive.org/web/ " web site) earliest related web page was published on 22 March 2016)	1-5
Y	Bashir Ahmed Siddiqui, et al "Novel Inductive Sensor Solutions for On-Line Partial Discharge and Power Quality Monitoring" IEEE Transactions on Dielectrics and Electrical Installation Vol.24, No.1; February 2017, pages 209-216, doi:10.1109/TDEI.2016.005908	1-5

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/TR2018/050142

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2016190823 A1	01 December 2016	GB 2543467 A	19 April 2017
KR 100787964B B1	24 December 2007	NONE	
US 2002079906 A1	27 June 2002	US 6433557 B1	13 August 2002
WO 2018006876 A1	11 January 2018	CN 106199121 A	27 December 2016