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(54) **Anti-theft device for electrical cables**

(57) An anti-theft device (10) for electrical cables, which comprises two toroidal transformers (11, 12) which are arranged so that each one surrounds an end portion of an electrical line (D):

- a first toroidal transformer (11), at a first end of the electrical line, for transmitting an electrical control signal,
- a second toroidal transformer (12), at the opposite end of the electrical line, for receiving the control signal.

The first toroidal transformer (11) and the second toroidal transformer (12) are connected to a control unit (13) for controlling and managing the signals emitted by the first transformer (11) and for detecting and interpreting the signals received by the second transformer (12).

The device (10) comprises a capacitor (14) for the passage of the AC signal to be interposed between two non-connected electrical cables (E, F) of consecutive portions of the electrical line (D).

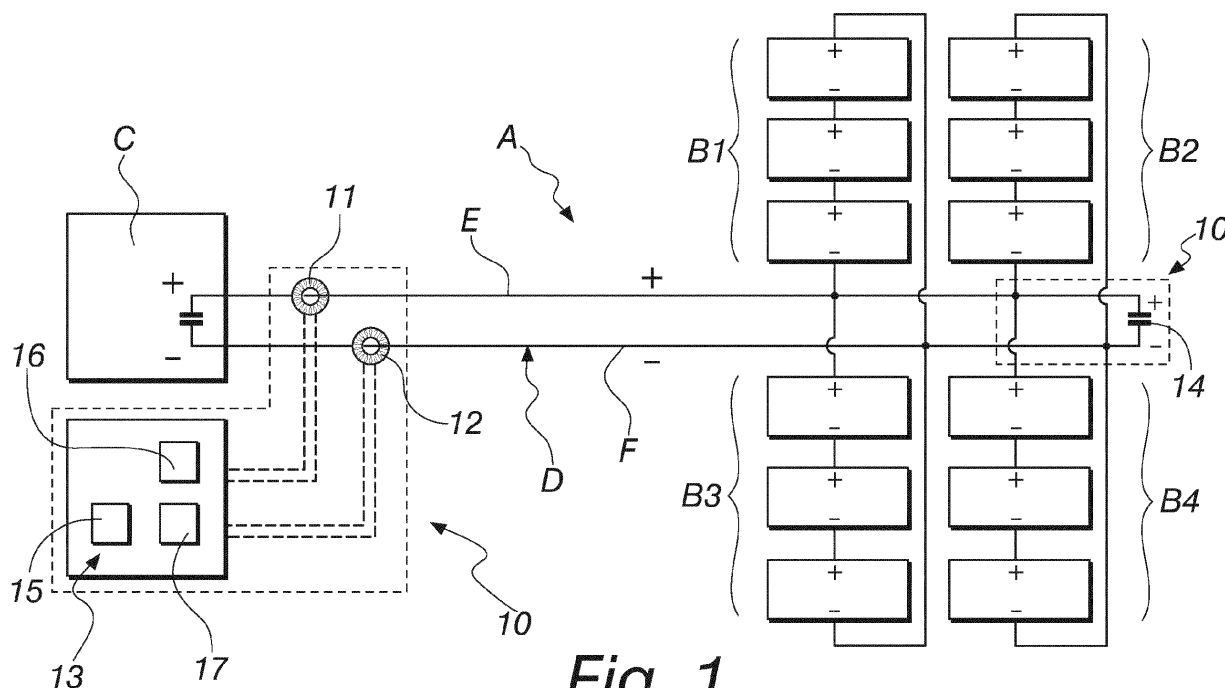


Fig. 1

Description

[0001] The present invention relates to an anti-theft device for electrical cables.

[0002] The theft of copper cables is nowadays increasingly widespread, especially from photovoltaic plants located in remote and sparsely populated regions. The electrical cables most in danger of theft are the backbone connections, which connect the various rows of solar panels; these are copper cables with a cross-section of up to 70 square millimeters, through which currents of up to 200A and voltages of 900V pass; such electrical cables have a value in the order of thousands of Euros for each plant, but are also easy to cut and extract from the protection ducting.

[0003] At present, if the photovoltaic plant is switched off, i.e. at night, no systems are known if the theft of such electrical cables is in progress.

[0004] The aim of the present invention is to provide an anti-theft device for electrical cables which makes it possible to know when such backbones of photovoltaic panel plants are removed or tampered with.

[0005] Within this aim, an object of the invention is to provide an anti-theft device which can also be applied to electrical cables of other types and other types of functionality.

[0006] Another object of the invention is to provide an anti-theft device for electrical cables specifically in order to prevent the theft or tampering of cables which form the connection backbones between rows of photovoltaic panels in photovoltaic plants.

[0007] Another object of the invention is to provide an anti-theft device that is easy to install and control.

[0008] Another object of the invention is to provide an anti-theft device for electrical cables that can be made using conventional systems and technologies.

[0009] This aim and these and other objects which will become more evident hereinafter are achieved by an anti-theft device for electrical cables, **characterized in that** it comprises two toroidal transformers which are arranged so that each one surrounds an end portion of an electrical line,

- a first toroidal transformer, at a first end of said electrical line, for transmitting an electrical control signal,
- a second toroidal transformer, at the opposite end of said electrical line, for receiving said control signal,

said first toroidal transformer and said second toroidal transformer being connected to a control unit for controlling and managing the signals emitted by the first transformer and for detecting and interpreting the signals received by said second transformer,

said device comprising a capacitor for the passage of the AC signal to be interposed between two non-connected consecutive portions of said electrical line.

[0010] Further characteristics and advantages of the invention will become more apparent from the description

of a preferred, but not exclusive, embodiment of the anti-theft device according to the invention, which is illustrated by way of non-limiting example in the accompanying drawing wherein:

- Figure 1 is a diagram of an anti-theft device for electrical cables according to the invention, applied to a photovoltaic plant.

[0011] With reference to the figure, an anti-theft device for electrical cables according to the invention is generally designated with the reference numeral 10.

[0012] Such anti-theft device 10 is shown applied to a photovoltaic plant A, which is understood to be conventional, comprising a series of strings of photovoltaic modules B1, B2, B3 and B4 which are interconnected to an inverter C by way of an electrical line D, known as a backbone, which concentrates the strings B1, B2, B3 and B4; the electrical line D comprises two electrical cables E and F; the first cable E connects the positive pole of the strings B1, B2, B3 and B4 to the inverter C, whereas the second electrical cable F connects the inverter to the negative pole of the same strings.

[0013] The anti-theft device 10 comprises two toroidal transformers 11 and 12 which are arranged so that each one surrounds an end portion of an electrical cable E and F of the electrical line D; in particular the first toroidal transformer 11 is crossed by the first cable E, corresponding to the positive pole of the group of strings, in proximity to the inverter C, and the second toroidal transformer 12 is crossed by the second cable F, corresponding to the negative pole of the group of strings, also in proximity to the inverter C.

[0014] The first toroidal transformer 11, which is placed substantially at a first end of the electrical line D, is adapted to transmit an electrical control signal, whereas the second toroidal transformer 12, at the opposite end of the electrical line D, is for reception of the control signal.

[0015] The first toroidal transformer 11 and the second toroidal transformer 12 are connected to a control unit 13 for controlling and managing the signals emitted by the first transformer 11 and for detecting and interpreting the signals received by the second transformer 12.

[0016] The anti-theft device 10 comprises a capacitor 14, for the passage of the AC signal to be interposed between the two non-connected consecutive portions of the electrical line D, i.e. if at a respective first end the electrical cables E and F are interconnected by way of the inverter C, then at the opposite, second ends the electrical cables E and F are not interconnected, and in order to allow the passage, from one electrical cable to the other, of the AC signal emitted by the first toroidal transformer 11 but not the passage of the direct current produced by the strings of photovoltaic panels, the capacitor 14 is placed between the two non-connected ends.

[0017] The first toroidal transformer 11 has a low number of turns, for example between 1 and 15 turns,

and preferably has 5 turns.

[0018] The second toroidal transformer 12 is of the type with a large number of turns, for example between 500 and 3000 turns, and preferably 1000 turns.

[0019] The capacitor 14 is of the high-voltage type.

[0020] For example, for the present application to a photovoltaic plant, the capacitor 14 is of the 10 μ F, 1000V high RMS current type, for DC-Link applications.

[0021] For a different application on an electrical cable traversed by AC, an equivalent capacitor is selected and dimensioned which is better adapted to the specific application; for example for a 230V AC grid a capacitor of class X2 is used.

[0022] The control unit 13 comprises a microprocessor 15, a power circuit 16 for emitting the signals through the first toroidal transformer 11, and an amplifier circuit 17 for reading the signals received by the second toroidal transformer 12.

[0023] Such control unit 13 is understood to be capable of being managed with serial communications protocols for serial logic controllers, or PLCs, of a conventional type, such as for example MODBUS.

[0024] The operation of the anti-theft device 10 according to the invention is as follows.

[0025] The control unit 13, at regular intervals, for example every second, generates a series of impulses at a fixed frequency, of brief duration but high energy, by way of the first toroidal transformer 1 with a low number of turns; the energy is transferred by electromagnetic induction to the electrical cable to be controlled, for example the first electrical cable E, positive, which passes within the hole of the first toroidal transformer 11.

[0026] The impulses travel through the entire photovoltaic plant until they reach the capacitor 14 placed between the two electrical cables E and F on the other side of the inverter C, pass through it and then return, travelling through all of the second electrical cable F, negative, until they return to the control unit 13 by way of the second toroidal transformer 12 with a large number of turns.

[0027] Again by electromagnetic induction, the control unit 13 detects the current impulse, measures it and compares its values with the values stored during the installation of the anti-theft device 10.

[0028] In the event of removal of one of the two electrical cables E and F of the electrical line D that forms the backbone of the photovoltaic plant, or in the event of removal of the capacitor 14, the circuit is broken and the impulse can no longer reach the second transformer 12.

[0029] In such case the control unit 13 detects an anomaly and emits information or an alarm signal.

[0030] In order to function correctly, the control unit 13 must be adapted in terms of power, frequency and duration of the energy impulse with respect to the length and the characteristics of the electrical cables to be controlled with the anti-theft device 10, such characteristics of electrical cables being variable from plant to plant.

[0031] This occurs by way of a self-calibration procedure of the control unit during the installation thereof.

[0032] The control unit 13, moreover, performs a slow correction over time of these parameters so as to adapt to the ageing of the plant, so that no false alarms are generated over time.

[0033] When the photovoltaic plant is in operation, i.e. during the day, the control unit can be deactivated since it is not indispensable, in fact any failure of the photovoltaic plant by day indicates that there is an anomaly in the system.

[0034] Voltages of 900 V are reached on the electrical cables E and F for the strings B1, B2, B3 and B4 to be controlled, and it is important to note that with this anti-theft device 10 there is no physical connection between the toroidal transformers 11 and 12 and the relevant cables to be controlled; in fact the transfer of energy between the transformers and the electrical cables occurs by way of electromagnetic induction.

[0035] In general, such method of measurement works very well because the total resistance of the electrical cables is very low.

[0036] In practice it has been found that the invention fully achieves the intended aim and objects.

[0037] In particular, with the invention an anti-theft device for electrical cables has been devised which makes it possible to know when the backbones of photovoltaic panel plants are removed or tampered with.

[0038] Moreover, with the invention an anti-theft device has been devised which can also be applied to electrical cables of other types and other types of functionality.

[0039] What is more, with the invention an anti-theft device has been devised which is easy to install and control.

[0040] In addition, with the invention an anti-theft device for electrical cables has been devised that can be made using known systems and technologies.

[0041] The invention, thus conceived, is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims. Moreover, all the details may be substituted by other, technically equivalent elements.

[0042] In practice the materials employed, provided they are compatible with the specific use, and the contingent dimensions and shapes, may be any according to requirements and to the state of the art.

[0043] The disclosures in Italian Patent Application No. PD2011A000401 from which this application claims priority are incorporated herein by reference.

[0044] Where technical features mentioned in any claim are followed by reference signs, such reference signs have been inserted for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. An anti-theft device (10) for electrical cables, **characterized in that** it comprises two toroidal transformers (11, 12) which are arranged so that each one surrounds an end portion of an electrical line (D),

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 - a first toroidal transformer (11), at a first end of said electrical line, for transmitting an electrical control signal,

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 - a second toroidal transformer (12), at the opposite end of said electrical line, for receiving said control signal,

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said first toroidal transformer (11) and said second toroidal transformer (12) being connected to a control unit (13) for controlling and managing the signals emitted by the first transformer (11) and for detecting and interpreting the signals received by said second transformer (12),

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said device (10) comprising a capacitor (14) for the passage of the AC signal to be interposed between two non-connected electrical cables (E, F) of consecutive portions of said electrical line (D).

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2. The anti-theft device according to claim 1, **characterized in that** said first toroidal transformer (11) has a low number of turns.
3. The anti-theft device according to claim 2, **characterized in that** said first toroidal transformer (11), with a low number of turns, has between 1 and 15 turns and preferably has 5 turns.

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4. The anti-theft device according to the preceding claims, **characterized in that** said second toroidal transformer (12) is of the type with a large number of turns.

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5. The device according to claim 4, **characterized in that** said second toroidal transformer (12) with a large number of turns comprises between 500 and 3000 turns, and preferably 1000 turns.

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6. The anti-theft device according to one or more of the preceding claims, **characterized in that** said capacitor (14) is of the high-voltage type.

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7. The anti-theft device according to one or more of the preceding claims, **characterized in that** said control unit (13) comprises a microprocessor (15), a power circuit (16) for emitting the signals through the first toroidal transformer (11), and an amplifier circuit (17) for reading the signals received by the second toroidal transformer (12).

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8. The anti-theft device according to one or more of the preceding claims, **characterized in that** said control

unit (13) can be managed with serial communications protocols for serial logic controllers, or PLCs, such as for example MODBUS.

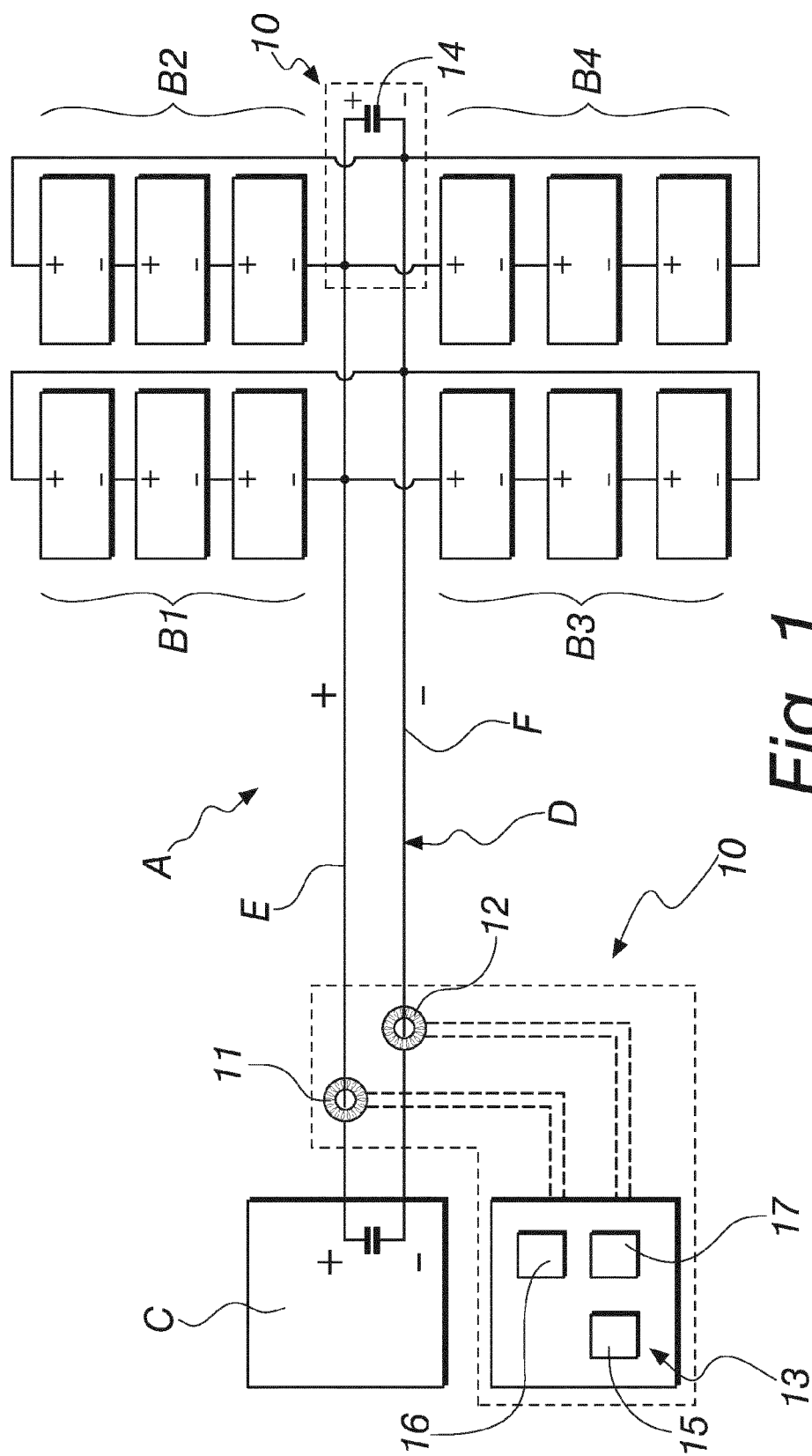


Fig. 1



EUROPEAN SEARCH REPORT

Application Number
EP 12 19 8220

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 2008/043814 A1 (ELETTRONICA SANTERNO S P A [IT]; ZANARINI SERGIO [IT]; MORICI RICCARDO) 17 April 2008 (2008-04-17) * page 3, line 8 - page 11, line 15 *	1-8	
			TECHNICAL FIELDS SEARCHED (IPC)
			G08B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 April 2013	Examiner La Gioia, Cosimo
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			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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