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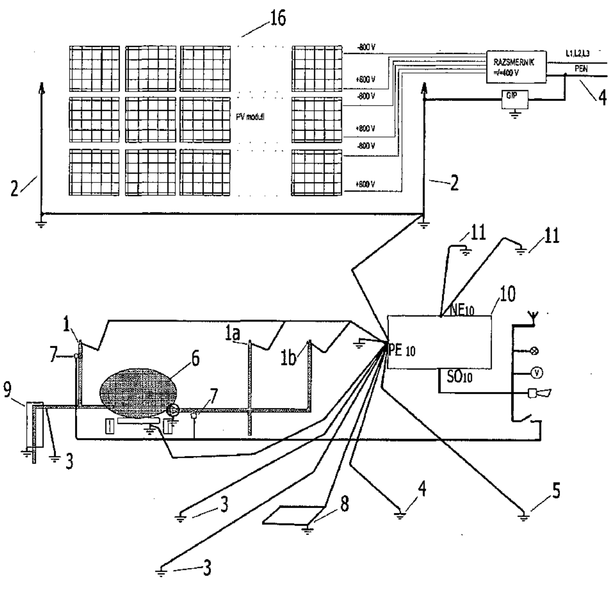


Fig. 1

(57) **Abstract**: The object of the invention belongs to the field of processes for fire extinguishing of photovoltaic power plants, specifically, it belongs to the field of electronic devices for limiting voltage contact between the fire extinguishing system and a burning photovoltaic power plant. The substance of the process and the device for safe fire extinguishing of photovoltaic power plants according to the present invention lies in that dangerous voltage contact is reduced by levelling out the potential of the entire fire extinguishing system, which includes fire extinguishing devices, tools, motor pumps, machines, ladders, water cannons, fire tank trucks, hydrants, and firemen involved in fire extinguishing. By grounding the entire fire extinguishing system, including the fireman wearing a single-layer or a multiple-layer Faraday cage, or therein a single fireman or several firemen are located, a reliable levelling out of potential on a fireman or group of firemen can be achieved.

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# Process and device for safe fire extinguishing of photovoltaic power plants

## Technical field

The present invention belongs to the field of processes for fire extinguishing of photovoltaic power plants, specifically belonging to the field of electronic devices for minimizing dangerous voltage contact between the fire extinguishing system and the photovoltaic power plant on fire.

## Technical problem

The technical problem is creation of such a process for a systematic reduction and control of dangerous voltage contact, which would enable a reduction of the dangerous voltage contact for a fireman through a water jet at extinguishing photovoltaic power plants or photovoltaic panels. The problem solved by the present invention is also creating an electronic device for the reduction and control of the dangerous voltage contact on the basis of limited current of panels by levelling the potential of the entire fire extinguishing system of Fig.1, which comprises fire-fighting devices, tools, motor pumps 6a, machines, ladders, fire - fighting water cannons fire-extinguishers, fire tank trucks 6, fire hydrants 9, as well as the firemen involved in fire-fighting. The aim of the invention as set is also a solution for solving grounding of the entire fire-fighting system, including the fireman, to achieve reliable levelling of potential of a fireman or a group of firemen.

The problem of extinguishing fires at photovoltaic power plants lies in that there can arise a dangerous voltage contact or electric shock for the fireman. The Fire Fighting Association regulation states that the resistance of the water jet – the extinguishing media - must be sufficiently high and that the voltage-drop between the photovoltaic PV module and the fire-fighting nozzle is such that the dangerous voltage contact between the fire-fighting nozzle and the ground is lower than 120 V DC. DC voltage of 120V is considered harmless and is allowed according to the regulations in force, whereby it is assumed that water used for fire extinguishing shows a conductivity lower than 2500 μScm-1 and that the extinguishing of fire ensues with one nozzle of prescribed type with prescribed water pressure. In the case of an increased number of nozzles, the distance should be greater or firemen must abandon fire extinguishing as the conditions are unpredictable. When panels, especially cables, are under fire, the total panel voltage can reach several thousand volts up to a breakdown voltage of the module to ground-housing, which at some manufacturers amounts to about 8000V. Because fire-trucks present a capacity in relation to the ground and despite the low electric current on the cistern, the electric charge can still build up, which can then during extinguishing the fire instantly emanate through the contact of a fireman or a bystander. Also lower voltages can cause an exaggerated reaction of an individual, which can present a life hazard both indirectly or even directly.

The standard fireman's equipment does not usually offer satisfactory protection of a fireman in the case of electric breakdown, which implies that we must prevent electric breakdown or current penetrating the protective clothing. The thickness of the non-conducting clothing is in proportion with the voltage, which can amount up to 8000V. This type of equipment is too expensive and too rigid to wear. There is also given the possibility of electric shock for casual bystanders or firemen through the water jet of a pierced pipe, when the pipe is in contact with the voltage of the PV panel, as well as the possibility of electric voltage shock when water spills on the ground or on the walls from the roof onto a non-conducting layer of asphalt, plastics, concrete, wood, glass, ceramics, and similar materials. Another danger for firemen or casual bystanders lies in the voltage between two puddles of water, which have not emptied, each charging from its own module or panel. or panel fields. In theory, this voltage can equal the breakdown voltage in amplitude for certain panels of 8000 V.

There is present the possibility of electric shock for people and animals in a nearby building in the case of fire extinguishing from a hydrant or tank filling, which extinguishes at the same time. The potential danger also lies at parallel connection of panels, where aggregation of currents can occur. Each water jet from the roof with installed PV modules can also represent a potential danger of being under voltage. Similarly, all metal parts, such as a metallic roof, pipes, antennas, accessories, drainpipes, subassemblies, soaked walls of a building, etc., which remain in contact with PV modules, represent a potential danger of being under voltage. The technical problem lies in the creation of a system, which enables reduction of differences in potential at various points of the photovoltaic panels themselves or power plants, as well as in the surroundings of the buildings.

Prior art

Known are safeguard processes at extinguishing photovoltaic panels on the basis of regulations currently in force, as well as on the basis of knowledge of facts of operation of solar power plants. Electro-technical professional literature prohibits and advises against working under voltage and recommends fire extinguishing at a distance depending on the voltage and fire extinguishing media. Especially known are processes for extinguishing smaller fires of switchboards, however, with the introduction of photovoltaic power plants conditions have become uncontrollable. A manual of the Fire Fighting Association of Slovenia entitled Intervention on a Building with a Solar Power Plant was made as a translation of a document based on the German brochure »Einsatz an Photovoltaikanlagen«, edited in 2010 by the German Fire Fighting Association.

Photovoltaic modules of PV 16 emit a direct current of constant value which depends on the lighting. These are the so-called current generators producing a constant current unlike voltage generators emitting a constant voltage regardless of the load. Existing modules emit a current of $I_M$ app. 8-9 A at full sunlight. The modules are connected to a series of so-called PV panels. The panels can have from 800V to 1000V of exit voltage. The characteristics of the U-I diagram show that an individual module has at least 5 $\Omega$ of inner electric resistance RM or more.

The internal resistance of panels RP is the total sum of all internal resistances of RM modules. As shown in Fig. 2, the current can flow from one electric pole of the current generator through the resistance of the modules $R_M$, through electric resistance of the jet RC at one or several nozzles, water cannons or another fire extinguishing device through extinguishing media to the grounding devices through ground resistance, conductive resistance of the $R_{SS}$ contact to the other pole. Dangerous voltage contact can occur from 0 – 800V at the nozzle, cannon or fire extinguisher. It is essential that the panels produce a current of limited power, which cannot be switched off, but can be drawn off without significant problems, because it is not too great. By draining the current through the grounding system according to the invention the dangerous voltage contact reduces. With a measuring signal device 10, the current can be stopped by interrupting the water jet of the fire extinguishing medium. The system according to the invention allows direct contact with the panel, which also enables extinguishing with chemical foam as chemical foam is conductive and fire extinguishing with foam has significant advantages. Until now, extinguishing with foam has not been allowed in such cases because firemen have not been sufficiently protected.

Description of the solution

The essential feature of the process and device for safe fire extinguishing of photovoltaic power plants according to the invention lies in a systematic reduction of the dangerous voltage contact by levelling out the potential of the entire fire extinguishing system, which includes fire extinguishing devices, tools, motor pumps, ladders, water cannons, fire extinguishers, tank trucks, hydrants and firemen involved in fire extinguishing. By grounding the entire fire-fighting system, including firemen wearing a single layer or a multiple-layer Faraday cage, which can be occupied by a single or several firemen, there can also be achieved stable levelling out of the potential on a fireman or a group of firemen.

The process and the device for safe fire extinguishing of photovoltaic power plants will be described in detail below with the aid of the drawing, which shows:

Fig. 1 Block diagram of the grounding of the fire extinguishing system according to the invention

Fig. 1a Block diagram of the pipe and automatic stop valve

Fig. 2 Electric substitute diagram when fire extinguishing photovoltaic power plants

Fig. 3 Diagram of the electronic circuit for the termination of the dangerous voltage contact

Fig. 4 Diagram of the operation of the levelling system of the fireman's potential

Fig. 4a Detail A - A

As shown in Fig. 1, all points of the fire extinguishing system, including fire extinguishing devices, tools, motor pumps, machines, ladders, water cannons, tank trucks 6, hydrants 9 and firemen, are connected to grounding points 2, 3, 4, 5, 8 and point PE10 of the measuring signalling device 10 according to the invention, which includes an antenna to transmit signals, light signalization, sound signalization, the control signal of Fig. 1 for propulsion 7a of valve 7 to turn off water supply or extinguishing media to the nozzles 1, 1a, 1b. The system enables reduction of the dangerous voltage contact when extinguishing fires at photovoltaic power plants 16 and control of the dangerous voltage contact on the basis of limited panel current.

By grounding the entire fireextinguishing system, including firemen wearing a single or a multiple-layer Faraday cage, reliable levelling out of potential on firemen can be achieved. Also possible is an embodiment with a single or several firemen in a Faraday cage connected to the system to achieve reliable levelling out of potential on the Faraday cage with a group of firemen. At the system according to the invention there are carried out measurements of the phenomenon of dangerous voltage contact, measurements of disruptions in the main grounding system, measurements of the grounding of the current between the extinguishing system and the grounding, termination of voltage contact, and closing the flow of extinguishing medium, signalling malfunctions at voltage contact occurrence and/or disruption of the main grounding and cutting off the fire extinguishing media in such a case.

The substitute electric diagram of Fig. 2 displays the electric parameters of the system, which include the photovoltaic power plant or panels, parameters of the fire extinguishing equipment and material, the measuring signalling device 10 and signalling elements for notifications. The substitute diagram of the solar panel is composed of a series of resistances RM, which represent the internal resistance of the module and of the current generator, which conveys current $I_M$ app. the size of 8A. In series with the current generator $I_M$, there is the resistance of contact $R_{SS}$

of the panel with the conductive housing of the grounding structure. On the other side of the loop, there is over the resistance of the water jet $R_C$ connected into a common connecting point the grounding of the fire extinguishing nozzle 1 from the last resistance $R_M$ and of the resistance $R_O$, which stands for resistance of all grounding . All points 1' of nozzles 1 are connected to point $PE_{10}$ of the measuring signalling device 10, which is also connected to the grounding. $R_O$ is the total ground resistance. UD is the voltage of contact measured between points $PE_{10}$ and $NE_{10}$, which is located in the neutral potential of the ground. From the measuring signalling device 10 through point $SO_{10}$ there are fed the control for the antenna for the transfer of signals, the light and sound signalization for the measuring of voltage, a signal for the automatic stopping system for closing off the water to nozzles 1. When larger fire extinguishing units cooperate or when several contacts of panels with fire extinguishing medium or grounding take place, the complexity of the electric calculation increases, however, the contact voltage as its result remains under control at all times. The voltage contact is calculated according to the following formula:

$Ud=I_O \times R_O$ max $\leq$ 120 V DC,

where:

Ud = contact voltage,

$R_O$= total grounding resistance of the parallel connected grounding resistances

$I_O$ = current, which causes a drop of voltage on the total grounding resistance with the fire extinguishing system attached.

The difference between the protection system applied in electrical engineering at low-voltage installations and the proposed invention lies in that in electrical engineering it is possible to automatically turn off the dangerous circuit, whereas with solar panels this is not possible. When a short circuit arises, the voltage generators can produce such currents that can easily destroy the fuses and thereby turn off the dangerous currents and contact voltage. With solar panels, the current cannot destroy a fuse, because in the case of a short circuit, the current does not increase. Therefore, the principle of protection applied in electrical engineering is not applicable in this case. Present invention is based on the fact that the circuit of photovoltaic panels is relatively small and stable. In the case of a fire, the current enters the ground through grounding or, in other words, the voltage contact is reduced to permitted values. There arises voltage at the grounding area, which is a by-product of the circuit and the grounding resistance, but it is lower than 120V, which is considered to be safe according to the regulations. The grounding lightning resistance at PV power plants is normally under 10 Ω. Protection of firemen is carried out by levelling out the potential as displayed in Fig. 4, which can be realized with a Faraday cage 17a in full or partially. Faraday cage 17 can fit a single or several firemen. The Faraday cage 17a can as clothing be fitted on a fireman himself. The embodiment of a Faraday cage for firemen as shown in Fig. 4a is such that it can be carried out over the clothing f1, in the clothing f2, f3 itself or under the clothing f4. In the case of a malfunction of the grounding system, firemen are still protected in this manner as there is no dangerous voltage contact possible, because all the body parts of a fireman are at equal potential and therefore preventing circuit from penetrating them. Photovoltaic currents are not that large as to cause an arc flame of greater proportions to cause overheating and burns. By measuring the current, which flows to the grounding system from the damaged PV panels, the total grounding resistance, and by measuring the dangerous voltage contact on firemen and the fire extinguishing system, the system warns of the presence of danger and at the same time interrupts the dangerous current so that within a short and defined period of time the water supply or other extinguishing material is automatically turned off. The time span of the water supply to turn off is defined in the measuring signalling device 10 depending on voltage, however, the combined time for the operation of the automatic break mode of the system and fire extinguishing media should be less than 0.4 s, which corresponds even to voltage up to 240 V.

In cases of too weak grounding, when the grounding resistance is too high, there must be applied an electronic circuit to annul the dangerous voltage contact as shown in Fig. 3. Three groups of photovoltaic panels have series-connected resistances $R_M$ and a current generator $I_M$. The dangerous PV panels are only those that have at least two contacts with the earth or water jet, because these two enable the flow of the dangerous current and, consequently, dangerous voltage contact. In the case of electric charge or contact with the grounding construction or contact via a damaged insulation with a water jet, the current flows through. Each water jet represents an electric resistance of the jet $R_{C1}$ , $R_{C2}$ and $R_{C3}$, which are connected to the common point, which is through grounding resistance Ro connected to grounding and point $PE_{10}$ of the measuring signalling device 10. The measuring signalling device 10 through a microprocessor, which measures the voltage contact, controls the two electronic switches so as to stimulate virtual zero. The electronic switches are through diodes connected in parallel charged to the positive or negative poles of the solar panels. The electronic switches release current Ik of the opposite polarity, but of the same amplitude as Ioz to the joint grounding point $PE_{10}$; that is current, which flows on the panels, when spurting water on the panel. Fig.3 clearly shows that the panels are connected with grounding in the middle. The second contact is created by the water jet, which through grounding resistance Ro and resistances $R_{C1}$ , $R_{C2}$ and $R_{C3}$ of the jets completes the circuit for the current $I_{OZ}$. The microprocessor µP measures the voltage between points $PE_{10}$ and $NE_{10}$ and in accordance with this voltage turns on the electronic switch and allows the current Ik to flow. The current Ik is of the same amplitude as $I_{OZ}$, but of opposite polarity. This makes the total combined voltage at the common grounding point 0V. Essentially, it releases a current of appropriate amplitude, which causes a drop of the voltage of opposite polarity on the grounding resistance Ro. In this manner, the drop of voltage at $R_O$ equals zero, because the sum of all currents equals zero. Many direct contacts, short circuits, will automatically annul through the grounding, and have no dangerous voltage contact as a result. The diodes prevent the contact of PV panels among themselves.

Levelling out of the potential and grounding of the entire fire extinguishing system, including the nozzle, watershed, cistern, hydrant, water cannon, ladder, fire-fighting basket, water jet, suction baskets, fire extinguishing machines, in short, the entire fire extinguishing system is carried out in a manner that it is electrically connected to the nearest existing grounding system, thereby achieving zero potential. The grounding systems can be such as shown in Fig. 1: the lightning conducting system of the burning building 2, PEN conductor from the transformer station 4, lamp posts 5, lightning insulation on a neighbouring building 3, etc. Fig. 1 schematically shows the grounding of a fire extinguishing system and attachment to point $PE_{10}$ on the signalling measuring device 10. Point $NE_{10}$ is connected to the grounding probes 11, which are nailed to the ground outside the grounding systems connected to point $PE_{10}$. Point $NE_{10}$ is attached to the neutral grounding outside the potential grounding area of the burning building.

For grounding, equipment prescribed in electrical engineering of metal wires, braids, bands, pipes, is used. Two or more connective wires are applied, which are attached to various grounding systems in the direct vicinity of the burning building or at least each to its own lightning conductor to the ground in order to ensure that there occurs no accidental breakdown of grounding. Each connective wire should have its own path. The more connective wires used and attached to various grounding systems, the lower the combined grounding resistance Ro. This reduces the dangerous voltage contact on the nozzle, the fire extinguishing systems, and on the fireman to the allowed voltage, which is less than 120V.

Levelling out of the potential of the fireman either in full with the use of partial or complete Faraday cage, grounded or ungrounded, is shown in Fig. 4. An additional levelling out of potential of parts of personal equipment and fireman's clothing is performed by placing the same in a partially or completely closed off Faraday cage 17a. There can be several cages, also one within the other. They come in different sizes, from sizes that fit several firemen in the cage 17 to the individual size. Also on a fireman Faraday cages can be mounted over the clothing, in the clothing or under the same. The outer Faraday cage f1 is the toughest to sustain current, which can appear. Faraday cages are additionally strengthened on the limbs, head – helmet, because of the expectancy of stronger currents at these locations. Inwards, Faraday cages f2, f3, f4... are made of increasingly thinner electrically conductive materials to foils or fine wires. Fig. 4a describes a detail of the composition of a Faraday cage, which is made so that between cages f1 and f2 there is insulation i1, between cages f2 and f3 there is insulation i2 and between cages f3 and f4 there is installed insulation i3. The Faraday cages are connected at one point as shown in Fig. 4. The layers can be insulated against heat and electricity. Possible electric charge moves from the inside out because of electricity laws, and in this manner electric shock is prevented, because there are no potential differences or differences in voltage on a fireman. Additional levelling out of the potential of firemen or the equipment is realized in the joint point, where all layers are connected and grounded through point PE of the OMNS device 15, connected to point $PE_{10}$ of the device 10. Higher safety is achieved by grounding as the dangerous voltage is drawn off continuously to the ground. This is significantly important for inner fire incursion or working directly on the panels on the roof. The entire equipment used by firemen has to be attached to the joint electric point of a fireman of additional levelling out of potential. Firemen can use a personal signalling device OMSN 15, which signals dangerous voltage contact and also receives the signal to turn off fire extinguishing media and grounding wire attached to a drum 15a. The wire is attached between the fireman, the device and point $PE_{10}$ of the device 10 and to the grounding system. The drum rolls forward and backward to enable the fireman's movement. It is essential that the fireman or his joint point on the equipment or Faraday cage remains connected to the grounding, fire extinguishing systems and point PE10 at all times. The equipment for additional levelling out of potential on firemen has to be manufactured in a manner to conduct and allow flow of the current without extra heating. OMSN 15 has the following functions: it warns firemen of the dangerous voltage contact and through reception enables shutting down of fire extinguishing media on a nozzle, if the same has a built-in automatic valve system. OMNS 10 has an additional wire or several wires available with a crocodile for quick setup and connection to the local grounding system to release the currents through a Faraday cage.

Measuring dangerous voltage contact can be performed with several known methods applied in electrical engineering. For a better understanding, there are according to Fig. 1 used two auxiliary probes 11 connected to point NE10 at device 10. The auxiliary probes 11 are nailed to the ground and connected to grounding 40 - 50m away from the burning building or their grounding systems. The two probes have the potential of 0V and enable measurement of grounding resistance and voltage. The measuring methods are known, and there are many instruments and devices at disposal. A single or several auxiliary probes 11 have to be nailed to the ground in the opposite direction from the fire and outside of the potential area of the main grounding systems. The measuring of voltage between the auxiliary probe 11 and the main grounding system is performed by the measuring signalling device 10 in accordance with known measuring methods. In the case of dangerous voltage contact, device 10 triggers a signal – a warning signal to the firemen of a dangerous voltage contact - and sets off the order to turn off water or fire extinguishing media supply. Turning off the water supply is carried out with the signal from device 10, which triggers the propulsion 7a of valve 7, as shown in Fig. 1a. The valve is mounted on the supply pipe for water or fire extinguishing media.

During long-term fire extinguishing there has to be checked the amplitude of voltage contact, which may be self-indicated with the appropriate indicator or measured by a voltmeter between the auxiliary probe attached to point $NE_{10}$ or the common point $PE_{10}$ of the device 10 and the fire extinguishing system. There exists a possibility of increased voltage contact if the grounding resistance increases due to a number of factors, such as a drop of groundwater, drying of the earth, the electrolysis phenomenon or as the current becomes stronger due to more sunlight on the panels, etc., even though this increase is slow. The measuring and malfunction signal warns of the dangerous voltage contact in time.

Constant measuring and monitoring of continuous connection between the fire extinguishing system and the grounding system prevents unpleasant surprises, such as the rise of voltage contact over permitted values. Measuring only the common grounding resistance gives us the information whether resistance is constant or whether it varies considerably from its initial value, which can increase due to electrochemical processes on the grounding system, a drop of groundwater, heating of the earth or other causes. The measuring signalling device 10 measures interruptions and the values of the common grounding resistance according to known methods. In the case of interrupted connection between the fire extinguishing system and the grounding system or a substantial increase of the grounding resistance, device 10 signals a warning to the firemen that the grounding is cut off , closing the water supply.

The measuring signalling device 10 measures the current between the entire fire extinguishing system and the common grounding system. The value of current Ioz is calculated indirectly from the Ro grounding resistance and voltage contact. The value Ioz helps the fire chief at deciding upon the use or perhaps preparation of new grounding material, such as nailing in grounding points, throwing grounding panels 8 into creeks, wells, lakes, or searching for more distant grounding systems.

Several measuring signalling devices 10 can be attached to one grounding point or several points. For the operation of two or more devices 10, points $PE_{10}$ and points $NE_{10}$ have to be connected. These connections save time when another fire extinguishing unit joins the task and the entire fire extinguishing system has to be connected and grounded. In this manner a number of devices 10 can be connected, they forming a type of grid or circle on any topology. Regardless of the distribution and number of devices 10, the voltage contact remains and is at all times the main parameter of danger and the basis for turning off the fire extinguishing media. After turning off all fire extinguishing media at a site of a fire, setting on is automatic, but with a time delay, which occurs when contact voltage levels are under 120V. This is why the turn - off is rather short and as such does not represent any interference for the extinguishing of fire. The sequence of activations can also have priorities, such as cooling the fire extinguishing shields near the fire, extinguishing inner fire incursion, etc. Some fire extinguishing media, which are critical or life-saving , need not be disconnected, however, firemen have to be protected from voltage contact in a different way. Several devices 10 can be interconnected pneumatically, hydraulically, mechanically, acoustically, by light, through wire or wireless communication, optical communication for the transfer of signals and parameter values, such as current, contact voltage, grounding resistance, disconnection, and other. Of all the parameters and signals, the most important data is the contact voltage and the signal to disconnect the fire extinguishing media via an automatic valve system consisting of propulsion 7a and valve 7 according to Fig. 1a. The purpose of network connections is to transfer the signal to alert the firemen of danger and to disconnect the fire extinguishing media, because this is a kind of switch that breaks contact with the dangerous voltage contact. Devices 10 can be mounted to fire trucks or can be portable with their own charging system.

The measuring signalling device 10 measures the continuous connection between the grounding system and the fire extinguishing system, it measures the values of the total grounding resistance, calculates the amplitude of the grounding current and measures or indicates voltage contact. When a signal warns of disruption or of a phenomenon of dangerous contact voltage, device 10 sets off a command to turn off the water or other fire extinguishing media supply, which takes place automatically. The signal for interruption is transferred acoustically, by light, wire or wireless communications system between the trucks or fire extinguishing systems. All devices 10 are connected by one or several wires to the common grounding point $PE_{10}$ and neutral point $NE_{10}$, and as such function autonomously. The signal to turn off water or fire extinguishing media is mandatory for everybody at the fire site and is accompanied by audio and light warning signals.

In cases of weak grounding, i.e. too large grounding resistance, the device 10 has a built-in electronic circuit, which is charged from all panels through diodes on the positive pole and through diodes on the negative pole, and which releases voltage of opposite polarity to the common grounding point of the same amplitude with the aid of electronic switches as shown in Fig. 3. This enables a total voltage at the common grounding point of 0V. Essentially, a current of adequate amplitude Ik is released, which at Ro (grounding resistance) causes a drop of voltage of the opposite polarity. Therefore, the drop of voltage at Ro is also zero because of the sum of all currents, which equal zero. Many direct contacts, short circuits through grounding will self-destroy, and there will be no dangerous voltage contact. The diodes prevent electric contact of PV panels also during operation. During regular operation of the solar power plant, the diodes may be switched off through the installation switches or fuses and can be turned on only during a fire. The device works so that it measures the voltage contact between the grounding point $PE_{10}$ and the neutral point $NE_{10}$. On the basis of this information, the μP microprocessor releases (with the aid of electronic switches) contact voltage of the opposite polarity to the grounding point, or opens the switches to the same pole, which artificially lowers voltage contact. Device 10 achieves voltage from diodes on the positive pole of the panels or negative pole of the panels. Essentially, it releases a compensative current Ik, which produces reverse voltage of the contact voltage on the grounding resistance. Only the panel, which is already short-circuited or connected to the two points of the grounding system, can enter the circuit. Therefore, the device in a way artificially sets off new contacts to the grounding and thereby balances the zero potential at grounding towards zero volts, because the sum of contact voltage at the grounding points is in theory equal to zero or is sufficiently safe. To ensure operation of the device according to the invention, there has to be foreseen an installation of switches or circuit breakers and diodes on both poles already during the construction of the solar power plant. At the positive pole, all cathodes are to be connected, at the negative pole all anodes are to be connected to achieve the two desired voltages, which are suitable to annul voltage contact. Panels, which are part of this process, have at least two malfunctions or contact with the fire extinguishing media or contact with the grounding system.

Present invention comprises measures and devices for preventing voltage contact, and enables safe fire extinguishing of photovoltaic power plants. During fire-extinguishing, the system of electric conditions is constantly under control with the aid of passive protective measures, such as the levelling out of potential and grounding of the fire extinguishing system and active protective measures, such as annulling dangerous contact voltage by electric circuit and instant breakdown or turning off of the fire extinguishing media supply with the aid of an automatic valve system. The entire system is connected or attached to a measuring signalling device 10, which, i.a., measures the contact voltage, triggers the warning signals, controls the active electronic circuit for the annulment of voltage contact and/or turns off the fire extinguishing media supply. Several devices 10 can be interconnected to a unified system for safe fire extinguishing of photovoltaic power plants.

Patent claims

1. Process for safe fire extinguishing of photovoltaic power plants for the reduction of dangerous contact voltage, **characterized in that** dangerous voltage contact is reduced in a manner of levelling out the potential and its grounding on the entire fire extinguishing system, on conductive parts, including the firemen, who are placed in partial Faraday cages and/or wear a single or several complete Faraday cages, which enable the levelling out of potential on the fireman; in that it connects the fire extinguishing system and the grounding system in a manner that it with the aid of a measuring signalling device enables the levelling out of potential; in that the measuring signalling device simulates virtual zero over a microprocessor and two electronic switches; in that the electronic switches are through parallel connected diodes charged to positive poles or negative poles of the solar panels; in that electronic switches releases current of opposite polarity of the same amplitude as the current appearing during fire extinguishing between the nozzle and grounding when spurting water on the panel; in that it releases warning signals and initiates turning-off and turning-on signals for automatic turning off fire extinguishing media supply with the aid of propulsion (7a) and valve (7) in cases of grounding cut-off, cases of increase of grounding resistance and/or emergence of dangerous voltage contact; and in that it enables connection with other devices of such kind of other fire extinguishing units in a single fire extinguishing system and communications.

2. Device for safe fire extinguishing of photovoltaic power plants according to claim 1, **characterized in that** all points of the fire extinguishing system, including fire extinguishing devices, tools, motor pumps, machines, ladders, water cannons, fire tank trucks (6), hydrants (9), and firemen are connected to grounding points (2, 3, 4, 5, 8 ) and point ($PE_{10}$) of the measuring signalling device (10), which includes an antenna to transmit signals, light signalization, sound signalization, control signal for propulsion (7a) of valve (7) to turn off water supply to nozzles (1, 1a, 1b); in that the series of photovoltaic panels have connected resistances ($R_M$) and a circuit

generator $I_M$; in that the water jet represents the electric resistance of jet ($R_{C1}$, $R_{C2}$ and $R_{C3}$), which are connected to joint point ($PE_{10}$) of the measuring signalling device (10); in that the measuring signalling device (10) over a microprocessor, two electronic switches simulates virtual zero; in that the electronic switches are charged through diodes connected in parallel to positive or negative poles of solar panels (PV); in that electronic switches release current ($I_k$) of the opposite polarity, but of the same amplitude as current ($I_{OZ}$), which is the current flowing on the panels at spurting of jet on the panel; in that panels (PV) can be connected to the grounding directly, also several times; in that; the second contact is created by a jet or jets bearing resistances ($R_{C1}$, $R_{C2}$ and $R_{C3}$) and closing the circuit for current ($I_{OZ}$), which is through the grounding resistance ($R_O$) and ($R_{SS}$) to the panel in contact with grounding; in that the microprocessor (µP) measures the voltage between points ($PE_{10}$) and ($NE_{10}$) and in accordance with this voltage opens the electronic switch and allows the current ($I_k$) to flow; in that ($I_k$) is of the same amplitude as the current ($I_{OZ}$), but of opposite polarity; in that thereby the total voltage on the joint grounding point amounts to 0V; and in that the microprocessor (µP) measures the voltage between points ($PE_{10}$) and ($NE_{10}$) and in accordance with this voltage, which equals the contact voltage, sets off the signal for turning off the propulsion (7a) for valve (7) of the fire extinguishing media supply.

3. Device for safe fire extinguishing of photovoltaic power plants according to claim 2, **characterized in that** it includes application of an automatic valve system in less than 0.4 s, whereby there is completely or partially turned off the fire extinguishing media supply to the fire on the basis of a switch-off or switch-on signal from the measuring signalling device (10) with the aid of propulsion (7a) and valve (7).

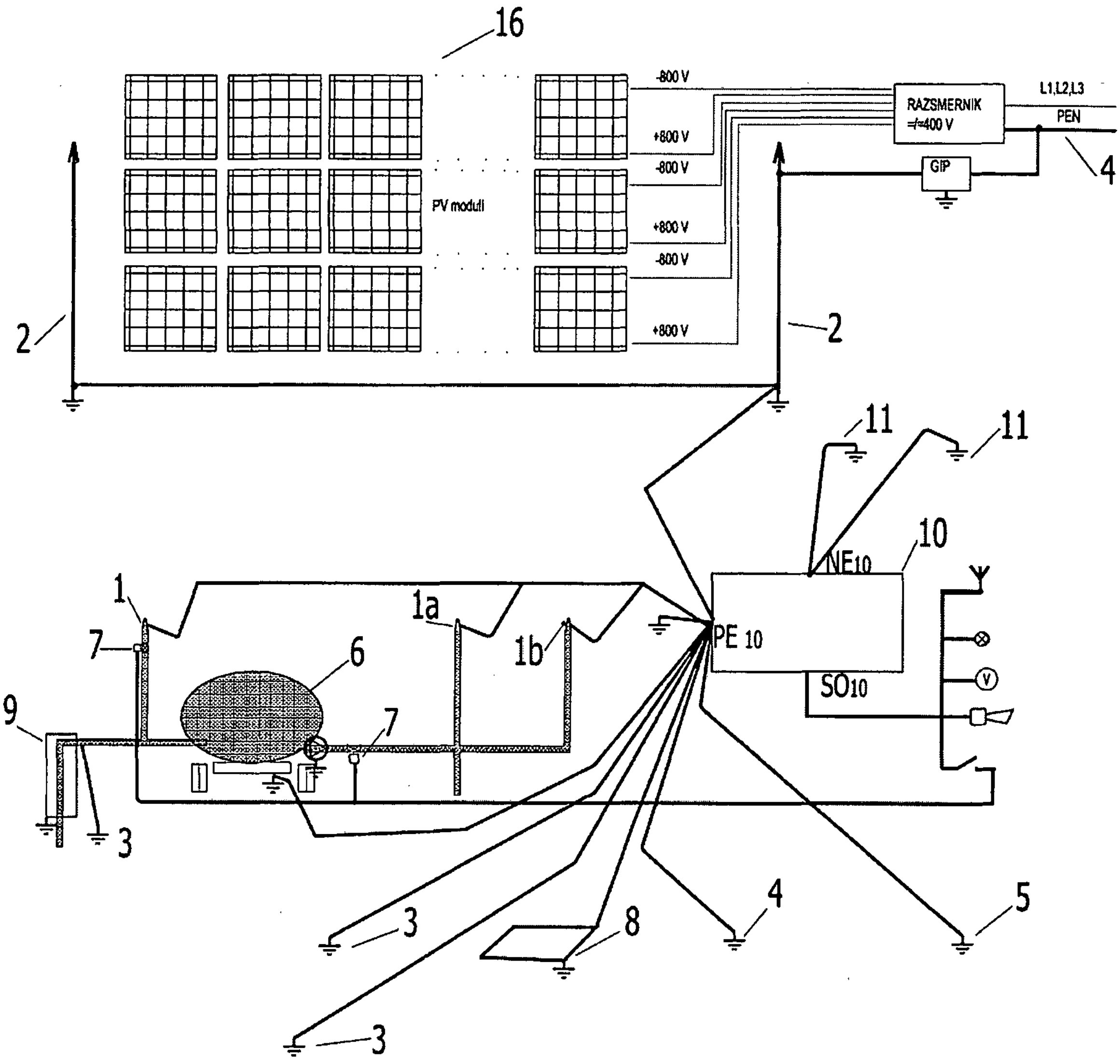

16
-800 V
+800 V
-800 V
PV moduli
+800 V
-800 V
+800 V
RAZSMERNIK
=/≈400 V
L1,L2,L3
PEN
GIP
4
2
2
11
11
10
NE10
PE 10
SO10
1
1a
1b
7
6
9
7
3
3
8
4
5
3

Fig. 1

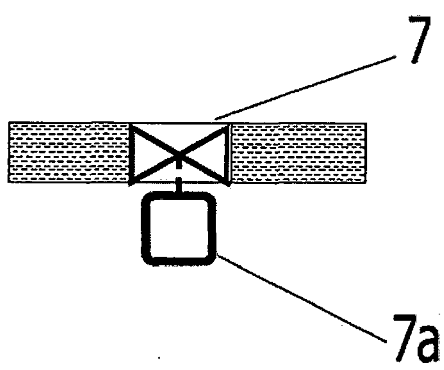

7
7a

Fig. 1a

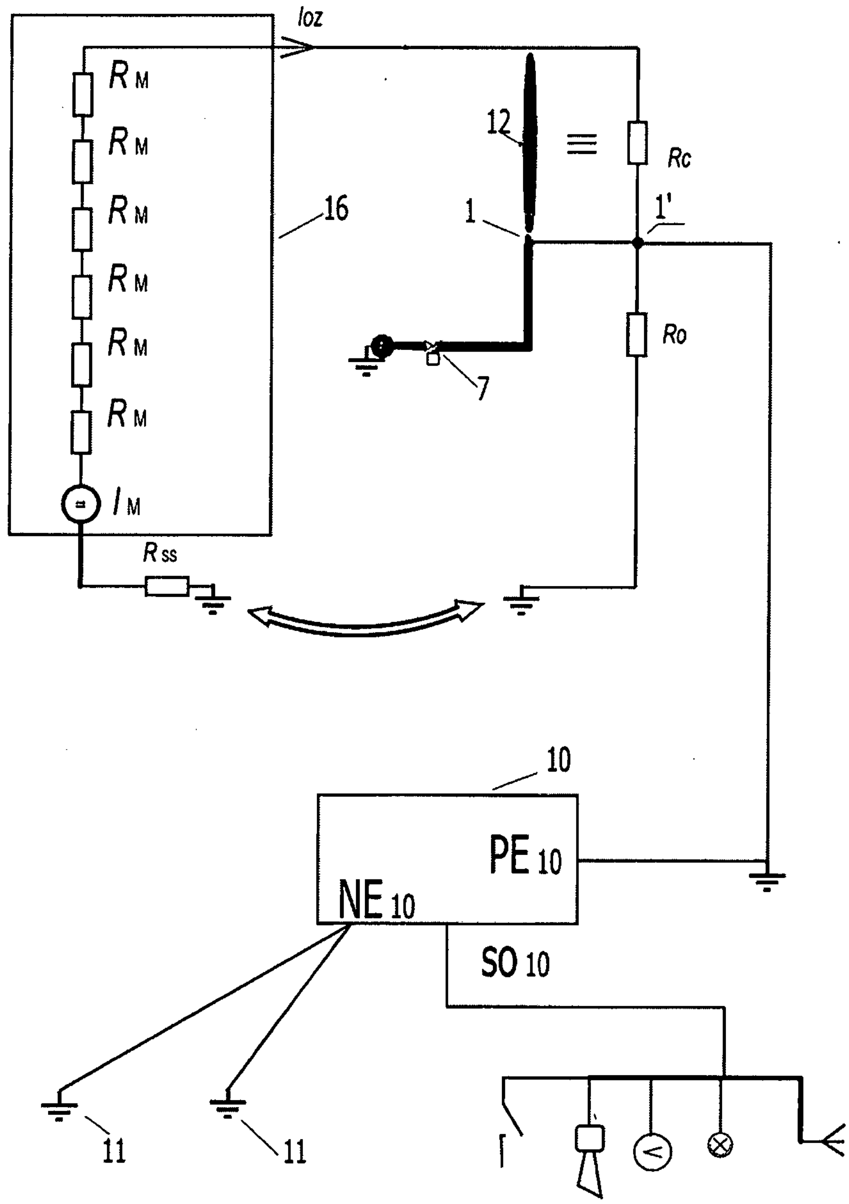
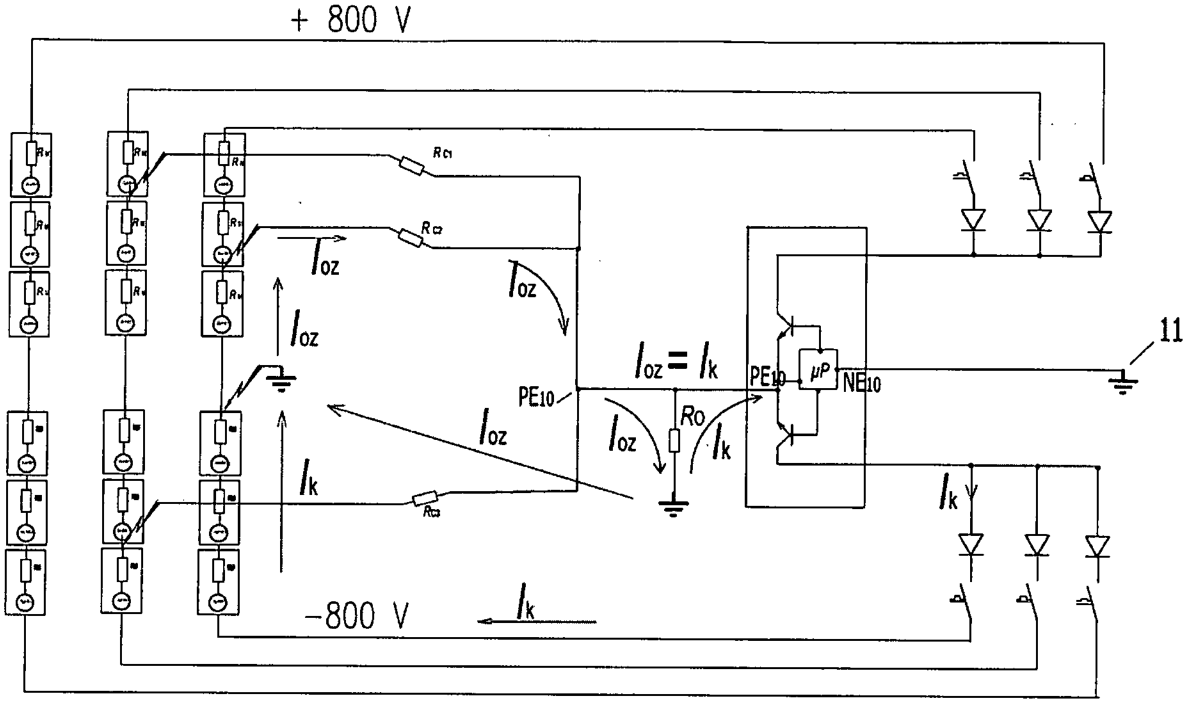



Fig. 2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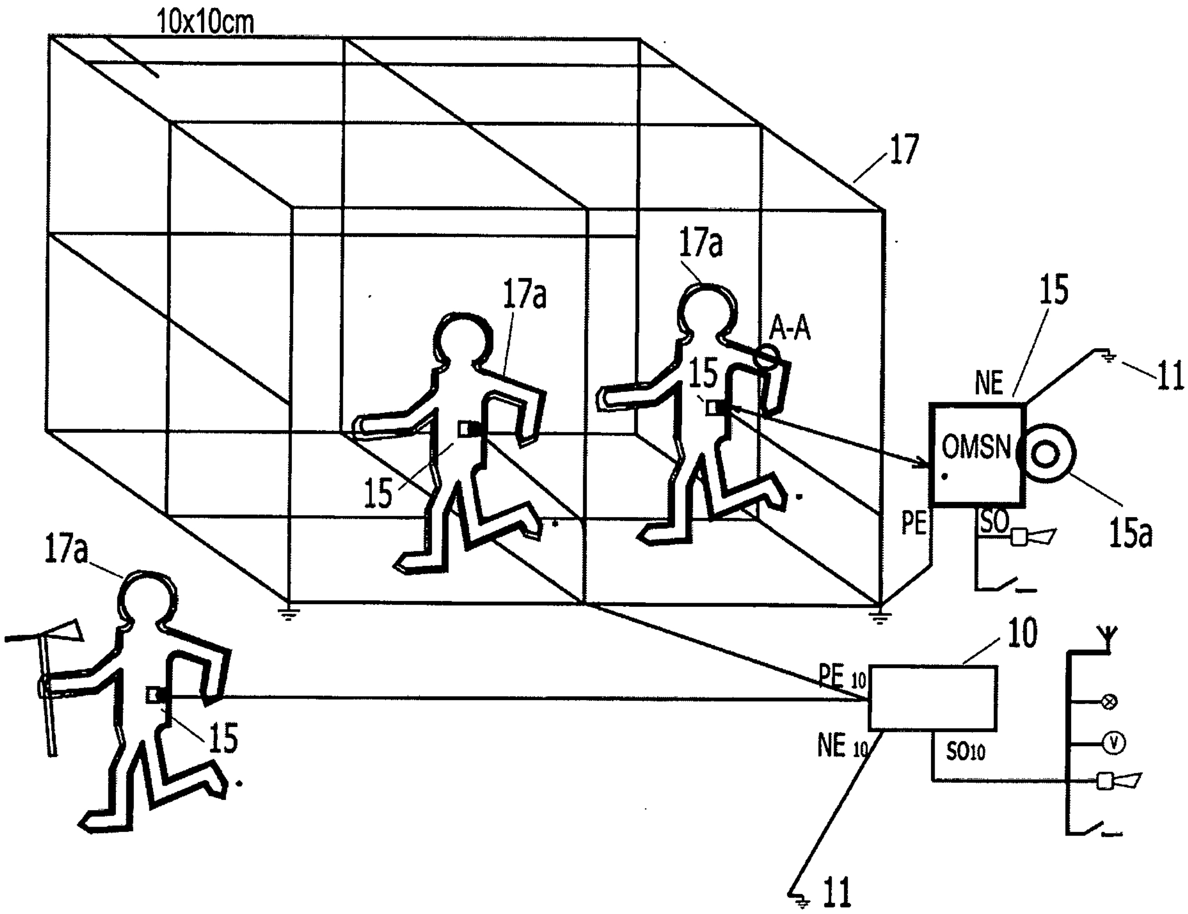
-800 V
PE10
NE10
μP
11
Ro
Rc1
Rc2
Rc3

Fig. 3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17
17a
17a
17a
A-A
15
15
15
15
OMSN
NE
PE
SO
15a
11
10
PE 10
NE 10
SO10
11

Fig. 4

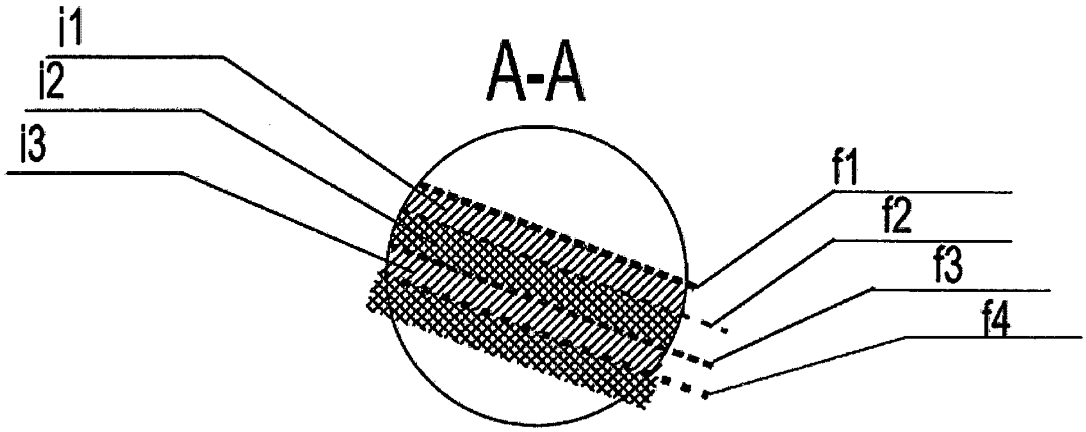


Fig. 4a