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(71) Applicants:
- **Union Fenosa Distribucion, S.A.**
  28033 Madrid (ES)
- **Union Fenosa S.A.**
  28033 Madrid (ES)

(72) Inventors:
- **Cristobal Dolado, Carlos**
  Union Fenosa Distribucion S.A.
  28033 Madrid (ES)
- **Fiteni Campos, David**
  Union Fenosa Distribucion S.A.
  28033 Madrid (ES)
- **Rey Rodriguez, Juan José**
  Union Fenosa, S.A.
  28033 Madrid (ES)

(74) Representative: **Carpintero Lopez, Francisco et al**
Herrero & Asociados, S.L.
Alcalá 35
28014 Madrid (ES)

(54) Integral fire safety system in high-voltage substations

(57) The invention relates to a fire protection system providing integral safety which is supported by three protection levels complementary to one another in order to ensure the efficiency of the solution:
- passive protection (provided by the containment means): physical elements for containing the fuel (oil) and retarders in the propagation of a possible fire;
- active protection (provided by the detection and extinguishing means): fire detection and extinguishing elements integrated with the typical systems of the substation (ventilation, electrical protection systems,...) to locate, confine and extinguish a possible fire depending on the sector in question; and
- remote surveillance (provided by means of digital high-definition equipment): elements integrated in the system which allow viewing the fire sector having a fire alarm at a certain time remotely and on-line as a result of the automatic pre-positioning of high-definition cameras before activations of elements of the fire detection system.

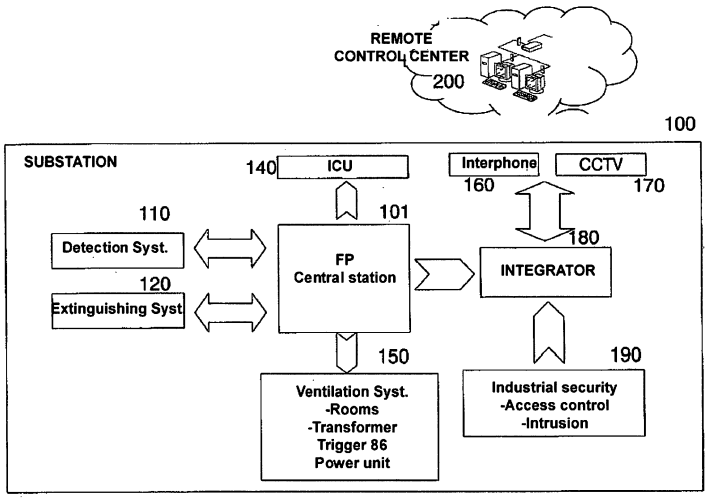

FIG. 1

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Description

Field of the Invention

[0001] The present invention is comprised within integral safety systems in high-voltage substations, and can be applied to all the risks of a high-voltage substation provided with fire protection systems.

Background of the Invention

[0002] In the last few years, the power sector in Spain has undergone a deep transformation characterized by a sustained growth in the demand for power.

[0003] This growth has given rise to the need for high-voltage substations in urban areas and communities forming a new network architecture characterized by high installed powers and high short-circuit powers, all of this in small spaces due to the high integration and compaction of the equipment used. This type of installation involves a different risk scenario than that of conventional installations, requiring specific solutions for its management and the reduction of the social impact.

[0004] Fire protection systems that are traditionally installed in urban electric power substations are typically based on using gas as an extinguishing agent. Such systems are furthermore conceived as a system independent from the rest, no interaction with the other systems of the substation being contemplated. The efficiency of this solution is conditioned by the tightness of the enclosure in which the extinguishing takes place, such that there are no extinguishing agent leakages.

[0005] Another variant which is currently used and is contemplated by the regulations is based on using water mist. This solution has a greater heat evacuation capacity and a longer actuation time. All this contributes to obtaining better results against high calorific value fires; however it still requires assurances, though not as demanding as in the previous solution, of the tightness of the enclosure in which the extinguishing takes place.

[0006] Additionally, within the different types of enclosures of transformers brought about by the typical design features thereof or by the construction solution adopted for the substation, there are solutions which are not tight due to their design and a system which can work efficiently in these risk scenarios is therefore necessary.

[0007] In addition, in extreme conditions, a transformer subjected to a short-circuit added to the functional failure of the tank can partially or completely compromise the tightness of the enclosure, considerably affecting the effectiveness of traditional fire protection solutions.

[0008] It is clearly necessary to adapt fire protection (FP) installations for the case of the new scenario described.

[0009] The fire risk of a generic substation is analyzed based on the fire load of the individual pieces of equipment it consists of, which is mainly determined by the calorific value of the combustible elements and by their mass considered per unit area. With this criterion, the main risk areas of a substation are, in order: transformers, power cables (greater depending on their accumulation), power unit and cell room.

[0010] Royal Decree 1955/2000 on Quality of Service determines the obligation of companies to carry out actions the purpose of which is to improve the quality of the supply. Having a quality of service also means that any incident must be anticipated, detected early on and as a last resort, the impact that such incident can have on the market must be minimized.

Description of the Invention

[0011] The invention relates to an integral fire protection system and process in a high-voltage substation according to claims 1 and 10, respectively. Preferred embodiments of the system are described in the dependent claims.

[0012] According to a first aspect of the invention, the latter relates to an integral fire protection system in a high-voltage substation, the substation comprising a series of functional enclosures, comprising:

- detection means for detecting a possible fire configured to detect a fire in one ore more of said functional enclosures and to send to a central system a fire detection indicating signal associated to at least said functional enclosure.

[0013] In response to receiving said fire detection indicating signal, said central system is configured to:

- act on a remote surveillance system to allow a display of said at least one functional enclosure for which said signal has been received by means of pre-positioning cameras of said enclosure with activated detection;
- act on fire extinguishing means existing in said at least one functional enclosure with activated detection.

[0014] And, according to the invention, in the event that said functional enclosure is an enclosure of a transformer with oil insulation:

- said extinguishing means are based on water mixed with a foam forming compound; and
- the central system is configured to act on an electrical protection system of said transformer enclosure which said fire detection indicating signal is associated to, and to subsequently act on said extinguishing means based on water mixed with a foam forming compound to activate the extinguishing.

[0015] If said functional enclosure is a cable cellar or vault with a certain concentration of cables per area (in cellars with a high concentration of power cables per unit

area), preferably:

- said extinguishing means are also based on water mixed with a foam forming compound; and
- the central system is configured to act on the electrical protection system of said transformer enclosure which said fire detection indicating signal is associated to, and to subsequently act on said extinguishing means based on water mixed with a foam forming compound to activate the extinguishing.

[0016] Said extinguishing means based on water mixed with a foam forming compound preferably comprise:

- generating means for generating a medium-expansion foam as a mixture of said foam forming compound and water;
- pouring means for pouring said medium-expansion foam on the functional enclosure which said fire detection indicating signal is associated to,

such that the possible fire is extinguished by means of smothering due to the effective separation of fuel and combustion agent.

[0017] Said central system can further be configured to act on a ventilation system of said functional enclosure for which said signal has been received, and cut off the air stream.

[0018] The transformer enclosures are especially relevant as regards their protections, given their fire load. The protection system of the invention preferably comprises containment means for confining the oil inside said enclosure in the event of oil leakage or massive oil spill from the transformer.

[0019] Said containment means are preferably configured to support a massive spill of said oil.

[0020] Said confining means are preferably configured to confine the oil up to a certain height within the enclosure, said height being determined according to the most unfavorable hypothesis of the calculation of a massive oil spill which must be completely contained in the fire enclosure.

[0021] Said containment means can be formed by:

- an enclosure base made of reinforced concrete, except gaps for the passage of power cable, with enough structural strength for containing oil in the event of a functional failure of the transformer tank;
- on said base, a bedplate with mortar with a slope to direct a possible oil spill towards a collection pit located under the enclosure;
- said gaps for the passage of power cables are filled with a fire-resistant solution, and
- an enclosure front which is formed by a metal structure with enough structural strength for containing oil in the event of a functional failure of the transformer tank.

[0022] According to a preferred embodiment, said enclosure base and/or said enclosure front are detachable for the case in which maintenance tasks are required in the power cables or in the transformer itself.

[0023] The present invention therefore involves an integral safety system incorporating an effective fire extinguishing system, overcoming the tightness restriction of the transformer enclosure, and considering the possible massive presence of mineral oil with a high calorific value and a high weighted fire load in the fire sector described.

[0024] In other words, the system of the invention mainly arises from the consideration of a new risk scenario and new risk factors: probability of the occurrence of functional failures with a deep hydrocarbon burning; this leads on one hand to redesigning the electric power substation and its protection systems and on the other hand, to designing the protection of the installations from the point of view of integral safety.

[0025] The fire protection system of the invention basically provides an integral safety which is supported by three protection levels complementary to one another in order to ensure the efficiency of the solution:

- Passive protection (provided by the containment means): physical elements for containing the fuel (oil) and retarders in spreading a possible fire. They are physical fire protection elements used to compartmentalize the different functional enclosures formed inside the substation (fire sectors) for the purpose of reducing the risk of spreading a possible fire in one sector over the adjacent sectors as a result of the retarding action and of the fire-resistant features of the materials used.
- Active protection (provided by the extinguishing means): fire detection and extinguishing elements integrated with the typical systems of the substation (ventilation, electrical protection systems,...) to locate, confine and extinguish a possible fire depending on the sector in question.
- Remote surveillance (provided by the integral protection control means): elements integrated in the system which allow viewing the fire sector having a fire alarm at a certain time remotely and on-line.

[0026] According to a second aspect of the invention, the latter relates to an integral fire protection process in a high-voltage substation, the substation comprising a series of functional enclosures, the process comprises:

- detecting a fire in one or more of said functional enclosures,
- sending to a central system a fire detection indicating signal associated to at least said functional enclosure;
- acting on a remote surveillance system to allow a display of said at least one functional enclosure for which said signal has been received by means of pre-positioning cameras of said enclosure with acti-

vated detection; and
- acting on fire extinguishing means existing in said at least one functional enclosure with activated detection,

and in the event that the functional enclosure is an enclosure of a transformer with oil insulation:

- firstly activating an element for cutting off the power supply to said transformer, in order to electrically cut off the supply in the transformer; and subsequently,
- causing said activation of the fire extinguishing means existing in the transformer enclosure, the extinguishing means of which are based on water mixed with a foam forming compound, and extinguishing said possible fire by means of smothering due to the effective separation of fuel and combustion agent.

[0027] If said functional enclosure is a cable vault or cellar with a certain concentration of cables per area, the process comprises:

- firstly activating an element for cutting off the power supply in said cable vault; and subsequently,
- causing said activation of the fire extinguishing means existing in said cable vault, the extinguishing means of which are based on water mixed with a foam forming compound, and extinguishing said possible fire by means of smothering due to the effective separation of fuel and combustion agent.

[0028] Extinguishing a possible fire in an enclosure based on water mixed with a foam forming compound preferably comprises:

- generating a medium-expansion foam as a mixture of said foam forming compound and water;
- pouring said medium-expansion foam on the enclosure,

such that in response to said pouring the possible fire in the enclosure is extinguished by means of the effective separation of fuel and combustion agent.

[0029] A ventilation system of said functional enclosure for which said signal has been received is also preferably acted upon and the air stream is cut off.

[0030] The integral fire protection process of the invention can further comprise:

- providing containment means in the transformer enclosure to contain the oil inside said enclosure in the event of an oil leakage or spill from the transformer.

Description of the Drawings

[0031] To complement the description which is being made and with the aim of aiding to better understand the features of the invention according to a preferred practical embodiment thereof, a set of drawings is attached as an integral part of said description in which the following has been shown with an illustrative and non-limiting character:

Figure 1 shows a diagram of the architecture of an embodiment of the system of the invention, with its essential elements.

Figure 2 shows a diagram of the essential elements of the extinguishing system based on medium-expansion foam.

Figure 3 shows an upper plan view of the transformer enclosure or niche.

Figure 4 shows a sectional view according to line A-A of Figure 3.

Figure 5 shows a sectional view according to line B-B of Figure 3.

Figure 6 shows an enlargement of the mount shown in Figure 4.

Figure 7 shows an enlargement of the mount shown in Figure 5.

Preferred Embodiment of the Invention

[0032] A preferred embodiment of the fire protection system in high-voltage substations, such as a transport substation, is described below.

[0033] A transport substation is currently divided into the following main areas:

- High-voltage compounds
- Medium-voltage compound.
- Enclosures 2 of Power Transformers 1.
- Air cooling area (depending on the design of the cooling system of the transformer)
- Power unit room
- Cable vaults and cellars
- Fire protection room
- Others (Communications, passage areas,...)

[0034] The present invention develops the concept of integral safety of installations, forming a risk management tool on a real-time, interactive, integrated platform which can be remotely managed.

[0035] As shown in Figure 1, in its preferred embodiment, the fire protection system of the invention of a substation 100 comprises:

- an analog technology fire protection FP central station 101 forming the brain of the integral safety system: it is responsible for supervising the elements

forming the detection system 110 and for the treatment of the fire detection signal, for the actuation on the extinguishing systems, for supervision, for the alarm generation and signaling part, for actuations on fire dampers 11 and the ventilation system, power unit and surveillance systems;

- a fire detection system 110, which is explained in detail below, and which essentially comprises analog intelligent fire detectors, of a different technology according to the risk to be protected, signaling elements (acoustic, luminous, signal posts...) and control modules. It is responsible for detecting fires through the detectors and sending an alarm signal to the FP central station for its processing. It also carries out the luminous and/or acoustic signaling of the risk with active extinguishing and/or detection;

- a fire extinguishing system 120, which is explained below and the main elements of which are schematically shown in Figure 2;

- an integrated control unit ICU 140 of the substation, in the event of fire detection in a transformer enclosure, receives the orders from the central station 101 and manages the opening of switches associated to the transformer for the purpose of electrically insulating the risk before the activation of the extinguishing system.

[0036] The functional block 150 represents the actuation of the central station 101 on auxiliary elements of the fire detection system (fire dampers, extinguishing systems, activation of security cameras and illumination lamps, etc., activating relay signals to auxiliary equipment, such as trip relays, ventilation and cooling systems, remote control, etc.) depending on the logics defined in the FP central station by means of activating the control modules.

[0037] The integrator 180 is formed by the following elements: microprocessor, communications card, input reader cards, digital input collection cards and digital output cards. It has the following functions:

- Supervising, centralizing and managing the different subsystems (Access Control Subsystems and Intrusion Subsystem forming the Industrial Safety Subsystem 190, CCTV Subsystem 170 and Interphone Subsystem 160).
- Detecting signals coming from the different subsystems.
- Processing the signals received from the subsystems, as well as associating actions to be carried out depending on the events received.
- Sending action signals to the different subsystems.
- Transmitting alarms, events and the state of the system to the different Remote Control Centers 200.

[0038] The integrator 180 receives from Industrial Safety 190, CCTV 170 and interphone 160 subsystems, input signals with information relating to such subsystems. They are detected by the integrator 180 through the digital input cards.

[0039] The Integrator component 180 produces actuation and positioning signals to the different CCTV 170 and Interphone 160 subsystems. These output signals are produced through digital output cards. And it also transmits alarms, events and state information of the system to the Remote Control Centers 200.

[0040] The Industrial Safety subsystem 190 produces the following outputs the receiver of which is the integrator 180:

- State signals of the different elements forming the subsystem.
- Alarm and event signals relating to the Access and intrusion detection detected by the volumetric and card readers distributed over the substation.

[0041] The mission of this Integral Safety subsystem 190 is to ensure the access to the substation of duly authorized personnel as well as to detect possible unwanted intrusions therein.

[0042] The CCTV subsystem 170 is formed by video cameras, a digital video recorder and a video transmitter.

[0043] The CCTV subsystem 170 has a dual mission: on one hand, it aids in verifying through the image any alarm of the Intrusion subsystem, checking that it is an authorized access, and further provides a remote vision of the substation.

[0044] It is also responsible for sending a video signal to the Remote Control Centers of different areas of the substation through the camera circuit distributed throughout it.

[0045] The CCTV subsystem 170 receives input signals coming from the Integrator 180. The function of these signals is to position the view camera associated to the event occurred, thus achieving a discrimination by areas of the images received.

[0046] This CCTV subsystem generates output signals the receiver of which are the Remote Control Centers, consisting of the video signals detected through the cameras distributed in the substation as well as state information of such cameras.

[0047] The component 101 is formed by a microprocessor controlling the system through several communications loops in which the different elements of the system are assembled. Its inputs are the detectors, sensors and actuators used, and its outputs are the output modules and the signaling elements. An especially important output is the activation of the extinguishing system, where appropriate.

[0048] The different elements of the fire protection system of the invention are integrated to interact, in steps and depending on the risk situation, on:

- The passive protection and ventilation systems of the different areas of the substation (closing the fire dampers).
- The cooling systems of the power transformers.
- The electrical condition of the installations, acting on the cut-off switchgear of the transformers.
- The fire detection and extinguishing systems.
- The remote surveillance systems, as a result of the pre-positioning of cameras generated upon the activation of fire detection in an area.

[0049] This system allows the interaction from several levels from the local level associated to the activation of elements directly (e.g. push-button), integrated local level (e.g. fire central station and safety microcontroller) and remote level.

[0050] The protection considered by Integral Safety is formed by:

- Passive protection: elements with fire-resistant (FR) features forming a physical barrier to fire spreading and fuel containment, all of this being compatible with the necessary cooling of the electric equipment.
- Active protection: formed by the safety and fire protection systems, namely, fire detection system 110 and extinguishing system 120 (mainly in transformer enclosures).
- System centralization and integration: integrated management of the different fire protection systems, electric equipment and switchgear protection systems, ventilation systems, signaling and remote surveillance (closed-circuit television cameras, ...).

[0051] By means of passive protection elements, fire spreading is delayed through the use of certified highly fire-resistant materials including: fireproof paints, fire-resistant surfaces, fire dampers and doors; all of this to configure a suitable sectorization according to the main functional elements forming a substation and which are explained and detailed below.

[0052] Furthermore, a massive insulating oil spill can be contained due to the special and novel design of the enclosure of the transformer 1, as shown in Figures 3-7. For the sake of greater clarity of the passive protection part, the elements of the detection system and of the extinguishing system which are inside the enclosure of the transformer are not shown in Figures 4 and 5.

[0053] Figure 6 is an enlargement of the detail of the mount shown in Figure 4, showing the detachable metal structure 12, the support structures 14 and the sliding door 13. Figure 6 shows the following elements:

- Bedplate 3.
- Mortar 4 with a slope to direct a possible oil spill towards a collection pit 5.
- Fire wall 6.

[0054] Figure 7 is an enlargement of the detail of the mount shown in Figure 5. Figure 7 shows the following elements:

- Greca sheet 7 collaborating with a gap for the passage of power cables.
- Mortar 4 for forming slopes.
- Sand filling 8.
- Fire-resistant lining 9, the function of which is to prevent the combustion of the cables, blocking the fire spreading throughout the cable.

[0055] According to the preferred embodiment of the invention, the latter includes a fire detection system 110 in all the areas of the substation, especially in the area of the transformer enclosure considered by the fire protection system as a risk area, The detection is based on a quick detection, and a safe actuation in steps by means of using different suitably programmed detection elements.

[0056] In the case of indoor assembly power transformers, each risk area has two detection areas, each of which is formed by at least two detectors. Laser fire detectors with two alarm levels are used in each of the areas, and triple infrared flame detectors with one alarm level are installed in the second area.

[0057] And in the case of outdoor power transformers, each risk area has a detection area formed by at least two triple infrared flame detectors with one alarm level.

[0058] In both cases (indoor assembly or outdoor power transformers), each of these areas is provided with a fixed extinguishing system, which in transport substations is, as explained in detail below, an extinguishing system by medium-expansion foam.

[0059] Likewise, as a supplement, manual push-buttons are installed at the entrance to each risk area to cause the electric trigger of the extinguishing system.

[0060] Once a fire has been detected in one of the transformers of the high-voltage substation, the fire detection system acts in steps according to the logics, depending on whether it is an indoor assembly or outdoor power transformer.

[0061] And, for example, the following is established in the case of an indoor assembly power transformer:

- First Pre-alarm Level: this detection is carried out (activation) with the pre-alarm actuation of any detector. As regards the actuations, this first pre-alarm level actuates the closed circuit television cameras and illumination lamps through analog control modules. These cameras allow displaying in real time the state of the enclosure to a Safety Control Center.
- Second Alarm Level: this detection is carried out with the actuation of two pre-alarm levels of the laser detectors or one of them in pre-alarm and any flame detector in alarm. As regards the actuations, an alarm circuit and a flash corresponding to the transformer niche involved are activated.
- Third Alarm Level: this detection is carried out with

the confirmation of the two pre-alarm and alarm levels of laser detector technology and an alarm level of any flame detector. As regards the actuations: the stop of the ventilation/cooling system and the stop of the oil pumps are activated. The fire dampers are closed.

- Fourth Alarm Level - Extinguishing trigger: this detection is carried out with the confirmation of two alarm levels of the flame detectors. As regards the actuations, the suitable modules are activated to cause the electric trigger of the transformer through the trip and blocking relays. At the same time, the fire extinguishing module triggering the installed extinguishing system is activated, Likewise, the module of a triggered extinguishing placard is actuated and a "general extinguishing" warning signal is sent to the Safety Control Center and a "triggered extinguishing" warning signal is sent to a Network Operation Center.

[0062] For example, the following is established in the case of an outdoor power transformer:

- First Pre-alarm Level: this detection is carried out (activation) with the alarm actuation of any flame detector. As regards the actuations, this first pre-alarm level activates the closed circuit television cameras and the illumination lamps through the analog control modules. These cameras allow displaying in real time the state of the enclosure to the Safety Control Center. The alarm siren and the flash corresponding to the transformer niche involved are also activated.
- Second Alarm Level - Extinguishing trigger: this detection is carried out with the confirmation of two alarm levels of the flame detectors. As regards the actuations: the stop of the ventilation/cooling system and the stop of the oil pumps are activated. The suitable modules are activated to cause the electric trigger of the transformer through the trip and blocking relays. At the same time, the fire extinguishing module triggering the installed extinguishing system is activated, Likewise, the module of the triggered extinguishing placard is actuated and a "general extinguishing" warning signal is sent to the Safety Control Center and a "triggered extinguishing" warning signal is sent to a Network Operation Center.

[0063] In both cases, the occurrence of an alarm level also causes the actuations of all the lower levels.

[0064] This operating philosophy can be easily modified by programming, without affecting the physical elements or their wiring at all.

[0065] In the preferred embodiment of the invention, optical detectors for detecting smoke (either by laser technology or by a linear optical beam), thermovelocimetric detectors and flame detectors are used. As a supplement to the extinguishing, flood detectors can be used to detect water leakage in the extinguishing system.

[0066] Each detector informs the central station with information and identification of its type (optical or thermal). If there are discrepancies between the information of the detector and the central station, a failure condition occurs. Each detector provides the central station with analog information related to its measurement of the fire phenomenon.

[0067] The values at which each detector is in alarm and pre-alarm can be configured; these values can be changed manually by programming or automatically by the central station based on the environment in which the detector is located, or according to a time programming of the system.

[0068] The extinguishing system 120 of the invention uses medium-expansion foam as an extinguishing agent, the foam used being suitable for solid and liquid fires, being especially used in liquid type fires.

[0069] Given that the foam conducts electricity, before triggering the extinguishing, the high and low-voltage transformer is electrically insulated for safety reasons by means of triggering the precise protection relays to thus prevent the existence of high-voltage elements or points.

[0070] The medium-expansion foam with a metering between 1% and 3% is used as an extinguishing system for transformer enclosures. A synthetic foam forming compound which has demonstrated high efficiency in extinguishing mineral hydrocarbon fires is used.

[0071] The following equipment and installations must be distinguished for installing the extinguishing system by medium-expansion foam:

- Foam generator or generators
- Control post (flow control valve)
- Foam forming compound storage tank and provider
- Foam forming compound
- Fire prevention pressure unit
- Water storage tank
- Network of pipes, valves and accessories.
- Electrical installation and control

[0072] The equipment installed inside the transformer enclosures as well as the fixing elements thereof have been mechanically designed to operate suitably in the risk scenario described.

[0073] The remaining equipment and elements of the extinguishing system installation are preferably located in the FP room.

[0074] The extinguishing operation basically consists of, once the extinguishing has been manually or automatically activated, the control post valve is opened, creating a pressure reduction in the pressurized hydraulic circuit by a jockey pump, making the fire prevention pressure unit start working, driving the necessary water pressure and flow rate for the system; and through the provider the necessary amount is aspirated from the foam forming compound storage tank, according to the selected concentration. The result is that the foamer reaches the generators in which, by being mixed with air, the foam

is produced and projected on the upper part of the transformer tank by means of aiming the foam generators.

[0075] The necessary elements for the operation of the extinguishing system (schematically shown in Figure 2) are described below:

* Medium-expansion foam generator 121: it is the equipment in which the foamer is mixed with air, giving rise to the expanded foam. It has no moving parts that can wear with operation. Its components are built in stainless steel, except for the mixture discharge nozzles which are made of brass, making them very strong and durable. The equipment, its support and anchoring elements are mechanically designed to withstand the expected conditions within the risk scenario.

[0076] In the preferred embodiment, there are four medium-expansion generators, preferably in a cross-shaped arrangement at the corners of the transformer enclosure.

[0077] Said generators are installed such that they and their supports are located above the height corresponding to the lid of the transformer tank, and pointing horizontally or downwards.

[0078] As they are installed inside the risk enclosure, they are designed to withstand fire and overpressures, like their supports and anchoring elements.

[0079] * Control Posts 122: they are formed by a fast diaphragm flood flow control valve (flood valve), with a floating flap kept in place by means of a spring and the possibility of manual or automatic replacement. The valve is an all or nothing control valve, with manual or automatic actuation, with flanged inlet and outlet, with the diameter corresponding to the flow rates and pipes required by the installation, with an automatic replacement system. The valve has an inlet chamber, an outlet chamber and a priming chamber. The inlet and outlet chambers are separated from the priming chamber by a flap and a diaphragm. The priming chamber is pressurized with the pressure of the foamer (water/foam forming compound) of the system in its rest position, the inlet and outlet chambers being separated, keeping the part of the pipes of the system "downstream" from the valve dry. A bypass is installed "downstream" from the control post with the valve at the end of the stroke, such that foamer can be introduced in the extinguishing system in the unfavorable event that the flood valves do not work.

[0080] The control posts are presented in a compact assembly protected by a cabinet, completely identified by means of placards, such that there is no doubt during its handling, either in tests, maintenance or use in the event of an emergency.

[0081] All the necessary control posts (one for each risk area) are located, whenever it is possible, in one and the same collector, in which the following is further included: a tap for filling by firefighters and a tap for the use of authorized personnel.

[0082] The activation or start-up of the control posts is either manual (electric extinguishing trigger push-button or alarm valve of the control post), or automatic (actuation of the detection system). In both ways, there is a pressure reduction of the priming chamber, which opens the flap dividing the chambers of the flood valve, allowing the foamer to pass towards the extinguishing lines (extinguishing pipes). These extinguishing pipes lead the foamer towards the foam generators of the risk or risks involved, such that foam is discharged on said risks.

[0083] The activation of the system is confirmed by a pressure switch installed in the outlet pipe of the "downstream" control post, and its signal is picked up by means of a monitor module of an input to the fire detection system and is remotely sent- with the name "TRIGGERED EXTINGUISHING"- through another six-output module, occupying one of such outputs.

[0084] The control post can be closed manually (closing the throttle valve before the input of the control post in the outlet pipe), or automatically (acting on the solenoid valve of the control post).

[0085] * Foam forming compound storage tank 123 and Provider 124: a foam forming compound storage tank and provider are installed connected to the extinguishing water network, between the collector for driving the fire prevention pressure unit and the collector feeding the control posts. This assembly provides the necessary amount of foam forming compound according to the circulating water pressure and flow rate, adjusted to a 3% percentage of foam forming compound.

[0086] It is formed by :

- Foam forming compound storage tank
- Metering unit: the metering is carried out without providing external energy different from the energy of the pressure of the water passing through the hydraulic motor. The hydraulic motor uses the energy that reaches it in the form of pressure through the water flow passing therethrough. The hydraulic motor transforms the energy of the pressure into work, in the form of rotational movement and a torsion torque. As a result, a small pressure loss, a torsion torque and a rotational speed proportional to the water flow rate are obtained. The torque/rotation is transferred by means of mechanical coupling to the foam forming compound pump.

[0087] This metering unit is basically formed by the following components:

1. Hydraulic motor: the fire prevention network water passes through the hydraulic motor. The internal mechanism of the motor can be compared to a membrane pump, it uses the pressure differences and converts them into rotational energy.
2. Metering pump (foam forming compound injecting pump): it injects the foam forming liquid from foam forming compound storage tank to the fire prevention

water network. The mixture is introduced at the outlet of the hydraulic motor.

3. Mechanical clutch

4. Mechanical coupling

5. Air purge. Every time the foam forming compound drum is changed it is necessary to ventilate the metering unit.

6.1. Pipe system; it consist of the metering line through which the foam forming liquid added to the fire prevention water.

6.2. A suction line, though which the foam forming liquid flows from the foam forming compound storage tank to the metering pump.

6.3. Washing line: it allows washing the system after each use, eliminating the foam forming liquid that may remain in the unit.

[0088] * Foam forming compound: the selected foam forming compound is PLUREX N. It is a foam forming compound obtained from the formulation of synthetic surfactants and highly stable foam forming agents,

[0089] * Fire prevention pressure unit 125: water is supplied to the fire network by means of automatic pumping equipment complying with the UNE 23.500-90, UNE 23.590-98 standards and the Technical Rule of CEPREVEN RT2.-ABA, which equipment sucks in water from a water storage tank for the exclusive use of FP and drives it to the fire network. This equipment can be configured with different combinations, although the selected combination of the fire prevention pressure unit is:

- Auxiliary jockey pump: its function is to maintain the entire installation pressurized, dealing with small demands or leakages if they exist. It is controlled by a pressure switch, with automatic start-up and stop.
- Main and back-up (electric) pumps: they are formed by two elements: a horizontal centrifuge pump and an electric drive motor.
- Hydropneumatic accumulator: it is a stamped steel container according to the maximum pressure of the equipment, provided with an insulation valve.
- Control and alarm switchboards: this switchboard includes the switchgears for starting up and controlling a single main electric pump.
- Accessories: Valves, pipe, mount, etc.

[0090] The substation has an emergency diesel unit with enough power capacity to feed the back-up pump; the main and back-up pumps can be two electric pumps, each for 100% of the necessary flow rate, or three electric pumps (two main pumps and one back-up pump), each supplying 50% of the necessary flow rate at the required pressure.

[0091] The start-up of the equipment can be manual or automatic, due to pressure drop in the network or flow demand, and the stop can only be manual according to the rule.

[0092] All the valves must be identified and if they must normally remain open, they have an electric device which allows verifying their state.

[0093] * Water storage tank 126: a storage tank manufactured in polyester reinforced with glass fiber, rigid material, insulated and resistant to corrosion (with a useful capacity of 15 m^3) is installed. The storage tank is located in the enclosure of the FP room (whenever it is possible). At its upper part, it must have a dual mechanical float valve, connected to the water supply source with a filling time that does not exceed 36 hours. Two level buoys are installed, the first of which at 5 m^3 of water reserve marks the minimum water for covering a transformer, the second of which at 10 m^3 of the inside of the cistern marks the minimum water for covering two transformers.

[0094] The storage tank is provided at the lowest part with a pipe draining to the room drainage, with a cut-off valve. And at its lower part, it has flanged taps for pipes for aspirating to the main and back-up pumps, at a minimum height of 10 cm. from the bottom.

[0095] At the upper part, the storage tank has a trough connected to the drainage box, a flanged tap for connecting the test circuit and an air inlet for preventing the compression thereof when the water is aspirated by means of the pumping equipment pumps.

[0096] * Network of pipes, valves and accessories: the dry pipes go from the control posts to the access to the transformers; the wet pipes go from the storage tank to the control posts.

[0097] The pipe starting from the aspiration collector of the pressure unit is introduced in the FP water storage tank (aspiration pipe).

[0098] Concentric cones, check valves and gate close-off rising stem valves with end of stroke are installed in the drive of the pumps.

[0099] A throttle valve with an end of stroke as well as a non-retum valve are installed at the outlet of the provider. A filter is installed at the inlet of such provider.

[0100] A collector for the control posts is arranged, designed to maintain a maximum speed of the foamer of 3 m/s.

[0101] * Electric installation and control: the extinguishing system is supported by an electric installation the purpose of which is the power supply and the control signals necessary for the operation thereof.

[0102] In turn, the FP room- where the pressure unit, the foam forming compound storage tank and the devices for actuating the foam extinguishing system (control posts)- have a series of requirements relating to:

- Construction features: it as a surface area of about 35 m^2, forming an independent fire sector with a minimum fire resistance of 120 minutes. The access door has a minimum width of 120 cm, with a minimum fire resistance FR 120, provided with an anti-panic bar. The materials used are at least class M1. The inner linings of floor, walls and ceilings are suitable for wet type premises.

- Electricity installations: the room has average illumination levels of at least 250 lux in the pumping area, switchboards and equipment of the extinguishing system; and 50 lux in the water storage tank area. It further has emergency lighting ensuring an illumination level that is not less than 5 lux in the entire room. All the lights, power take-offs and electric mechanisms that are installed in the room must be dust and water-tight, therefore they must at least have an IP-65 degree of protection.
  The electric installations inside the room are carried out according to ITC-BT-30, "Installations in premises with special characteristics". Section 2. Installations in wet premises, of the R.E.B.T (Low-voltage Electrotechnical Regulation).

- Sanitary and plumbing installations: the FP room is provided with a sanitary network for evacuating water from possible spills during the test for installing and maintaining the pressure units, possible water leakages from the water reserve storage tank or in the fire prevention installation, or the plumbing installation for filling the storage tank with water.

- Ventilation: due to the needs and features of the substation if it is necessary to install a diesel pressure unit, the room will be provided with an air ventilation and renewal of at least 600 m^3/h.

- Exclusive tap for firefighters: a dry pipe is installed from the drive collector of the control posts of the extinguishing system to the access to the Substation, where a hydrant is installed for the exclusive use of firefighters.

[0103] When any type of conduits or channels must traverse floor slabs or walls, the sealing of the joints is provided with a material the fire resistance of which is equal to the wall or floor slab it is traversing, which is impermeable and with suitable mechanical strength.

[0104] Additionally and as a result of the integration of all the elements of the system into a single management platform, in the event that the activation of any fire detector in any fire sector of the electric power substation causes the pre-positioning of cameras with high definition, activation, recording and viewing locally and remotely of the sequence of events occurring after said detection for the purpose of confirming the nature of the alarm and the efficiency of the automatic systems installed and registering the incident for a subsequent analysis.

[0105] The Integral Safety system is provided with a remote management system which can remotely manage the system, providing the capacity to act and obtain information about the different subsystems and detection and extinguishing elements. Through this management program, the system can be displayed and the fire central stations can be remotely acted upon, allowing remote actions such as resettings, siren silencing, cancellation/enabling of detection areas and elements, actuation of the extinguishing system, state reports of the elements of the system, etc.

[0106] The system of the invention is furthermore integrated with power elements of the substation, such that in the event of a serious incident, decisions affecting the network condition can be made to minimize the impact on such network and to reduce the risk of fire propagation and the electric risk.

[0107] In view of this description and set of drawings, a person skilled in the art can understand that the embodiments of the invention which have just been described can be combined in multiple ways within the object of the invention.

Claims

1. An integral fire protection system in a high-voltage substation (100), the substation comprising a series of functional enclosures, the system comprises:

- detection means (110) for detecting a possible fire configured to detect fire in one or more of said functional enclosures and to send to a central system (101) a fire detection indicating signal associated to at least said functional enclosure;

characterized in that:

- said central system (101) is configured to, in response to receiving said fire detection indicating signal:

  - act on a remote surveillance system (170) to allow a display of said at least one functional enclosure for which said signal has been received by means of pre-positioning cameras of said enclosure with activated detection;
  - and act on fire extinguishing means (120) existing in said at least one functional enclosure with activated detection;

and **in that** in the event that said functional enclosure is an enclosure (2) of a transformer (1) with oil insulation:

- said extinguishing means are based on water mixed with a foam forming compound (126, 123),
  and **in that**:
  - the central system is configured to act on an electric protection system of said transformer enclosure which said fire detection indicating signal is associated to, and to subsequently act on said extinguishing

means based on water mixed with a foam forming compound to activate the extinguishing.

2. A system according to claim 1, wherein if said functional enclosure is a cable vault or cellar with a certain concentration of cables per area:

- said extinguishing means are also based on water mixed with a foam forming compound (126, 123); and
- the central system is configured to act on the electric protection system of said cable vault or cellar which said fire detection indicating signal is associated to, and to subsequently act on said extinguishing means based on water mixed with a foam forming compound to activate the extinguishing.

3. A system according to any of the previous claims, wherein said extinguishing means based on water mixed with a foam forming compound comprise:

- generating means (121) for generating a medium-expansion foam as a mixture of said foam forming compound and water;
- pouring means for pouring said medium-expansion foam on the functional enclosure which said fire detection indicating signal is associated to,

such that the possible fire is extinguished by means of smothering due to the effective separation of fuel and combustion agent.

4. A system according to any of the previous claims, wherein said central system is further configured to act on a ventilation system of said functional enclosure for which said signal has been received, and to cut off the air stream.

5. A system according to any of claims 1-4, wherein said functional enclosure is an enclosure (2) of a transformer (1) with oil insulation:

- said enclosure further comprising containment means (3, 4, 6, 7) for confining the oil inside said enclosure in the event of oil leakage or spill from the transformer.

6. A system according to claim 5, wherein said containment means are configured to withstand an overpressure due to a massive spill of said oil.

7. A system according to any of claims 5-6, wherein said containment means are configured to confine the oil up to a certain height within the enclosure, said height being determined according to the most unfavorable calculation hypothesis of a massive oil spill which must be completely contained in the fire enclosure.

8. A system according to any of claims 5-7, wherein said containment means comprise:

- an enclosure base made of reinforced concrete, except gaps for the passage of power cables;
- on said base, a bedplate (3) with mortar with a slope (4) to direct a possible oil spill towards a collection pit (5) located under the enclosure;
- said gaps for the passage of power cables being filled with a fire-resistant solution, and
- an enclosure front being formed by a metal structure (12).

9. A system according to claim 8, wherein said base and said metal structure are detachable.

10. An integral fire protection process in a high-voltage substation (100), the substation comprising a series of functional enclosures, the process comprises:

- detecting a fire in one or more of said functional enclosures,
- sending to a central system (101) a fire detection indicating signal associated to at least said functional enclosure;
- acting on a remote surveillance system (170) to allow a display of said at least one functional enclosure for which said signal has been received by means of pre-positioning cameras of said enclosure with activated detection; and
- acting on fire extinguishing means of fire existing in said at least one functional enclosure with activated detection, and in the event that the functional enclosure is an enclosure (2) of a transformer (1) with oil insulation:
- firstly activating an element for cutting off the power supply to said transformer, in order to electrically cut off the supply in the transformer; and subsequently,
- causing said activation of the fire extinguishing means existing in the transformer enclosure, the extinguishing means of which are based on water mixed with a foam forming compound, and extinguishing said possible fire by means of smothering due to the effective separation of fuel and combustion agent.

11. A process according to claim 10, wherein if said functional enclosure is a cable vault or cellar with a certain concentration of cables per area, the process comprises:

- firstly activating an element for cutting off the

power supply in said cable vault; and subsequently,

- causing said activation of the fire extinguishing means existing in said cable vault, the extinguishing means of which are based on water mixed with a foam forming compound, and extinguishing said possible fire by means of smothering due to the effective separation of fuel and combustion agent.

12. A process according to any of claims 10-11, wherein extinguishing (120) a possible fire in an enclosure based on water mixed with a foam forming compound comprises:

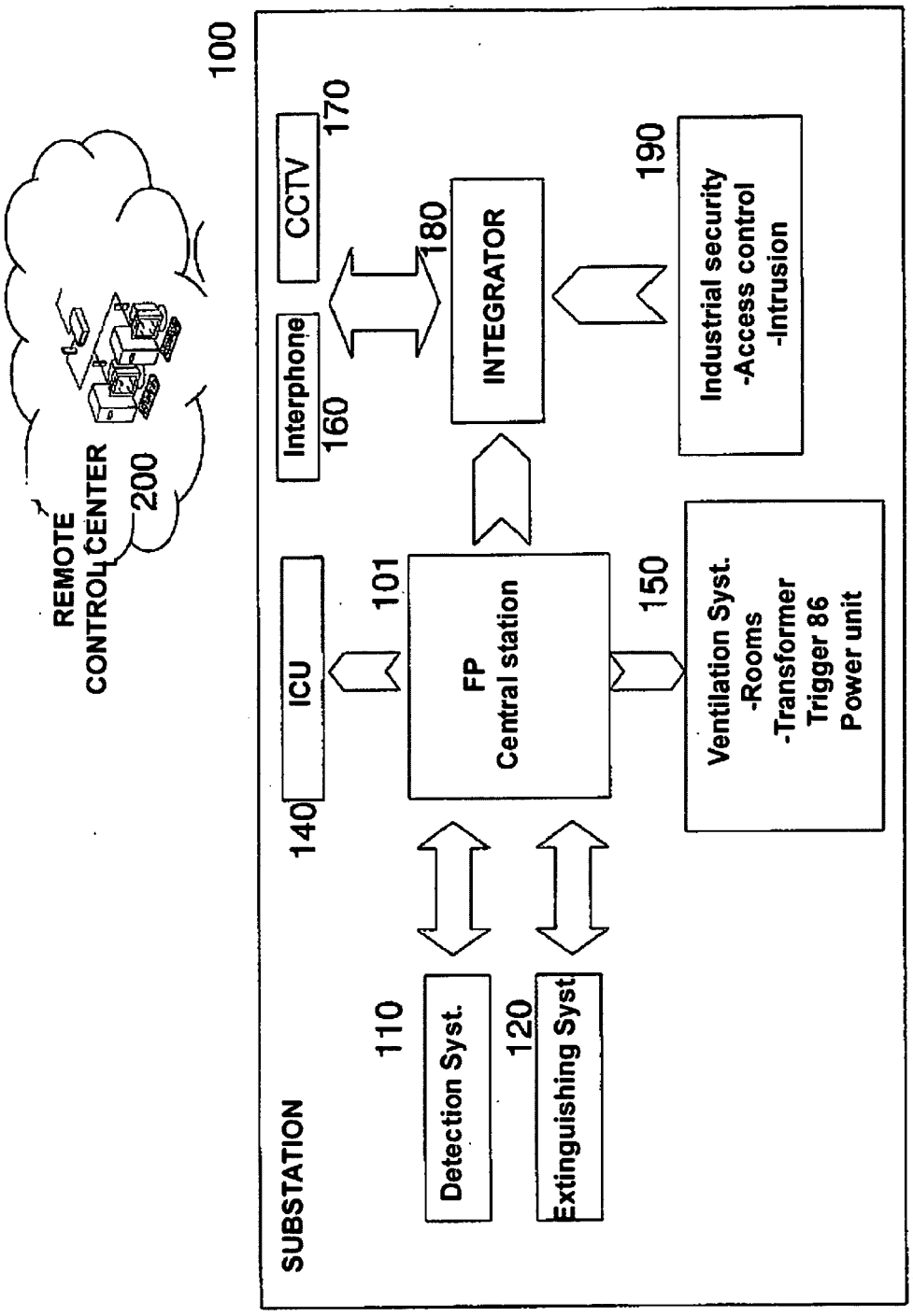
- generating a medium-expansion foam as a mixture of said foam forming compound and water;
- pouring said medium-expansion foam on the enclosure,

such that in response to said pouring the possible fire is extinguished by means of smothering due to the effective separation of fuel and combustion agent.

13. A process according to any of claims 10-11, wherein a ventilation system of said functional enclosure for which said signal has been received is furthermore acted upon, and the air stream is cut off.

14. A process according to any of claims 10-13, wherein the process further comprises

- providing containment means in the transformer enclosure for containing the oil inside said enclosure in the event of oil leakage or spill from the transformer.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REMOTE CONTROL CENTER
200
ICU
140
FP Central station
101
Detection Syst.
110
Extinguishing Syst
120
Interphone
160
CCTV
170
INTEGRATOR
180
Ventilation Syst.
-Rooms
-Transformer
Trigger 86
Power unit
150
Industrial security
-Access control
-Intrusion
190

FIG. 1

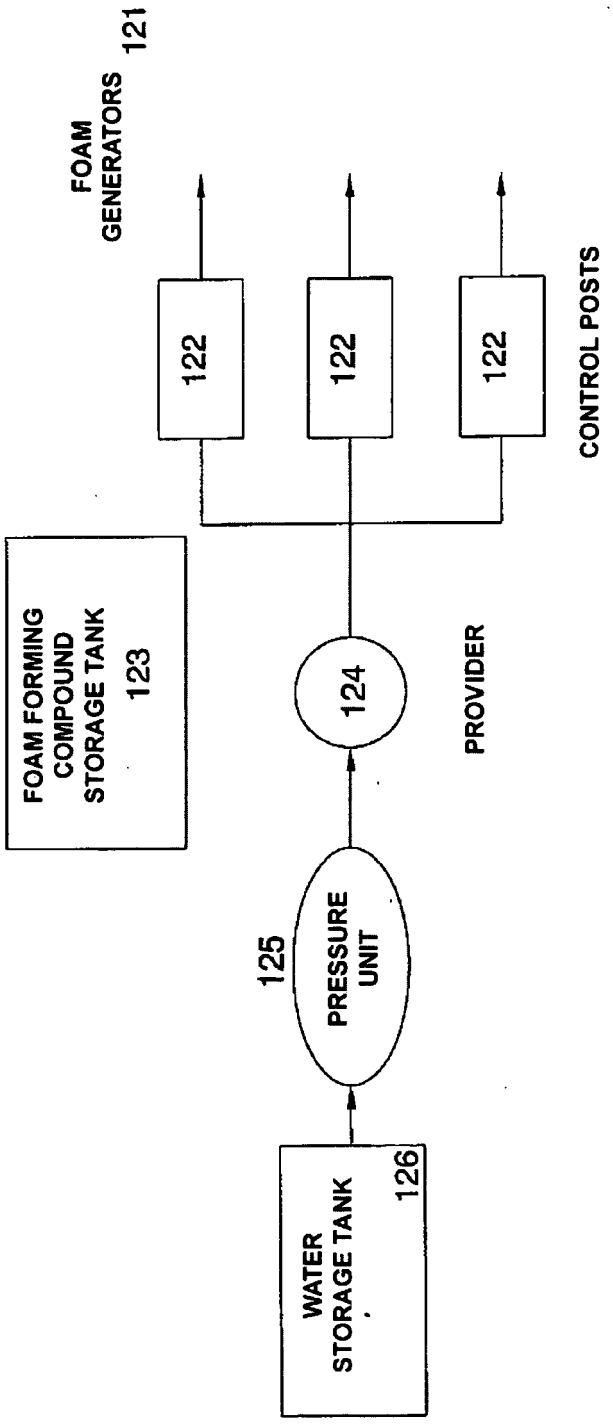
FOAM GENERATORS
121
122
122
122
CONTROL POSTS
FOAM FORMING COMPOUND STORAGE TANK
123
124
PROVIDER
125
PRESSURE UNIT
WATER STORAGE TANK
126

FIG. 2

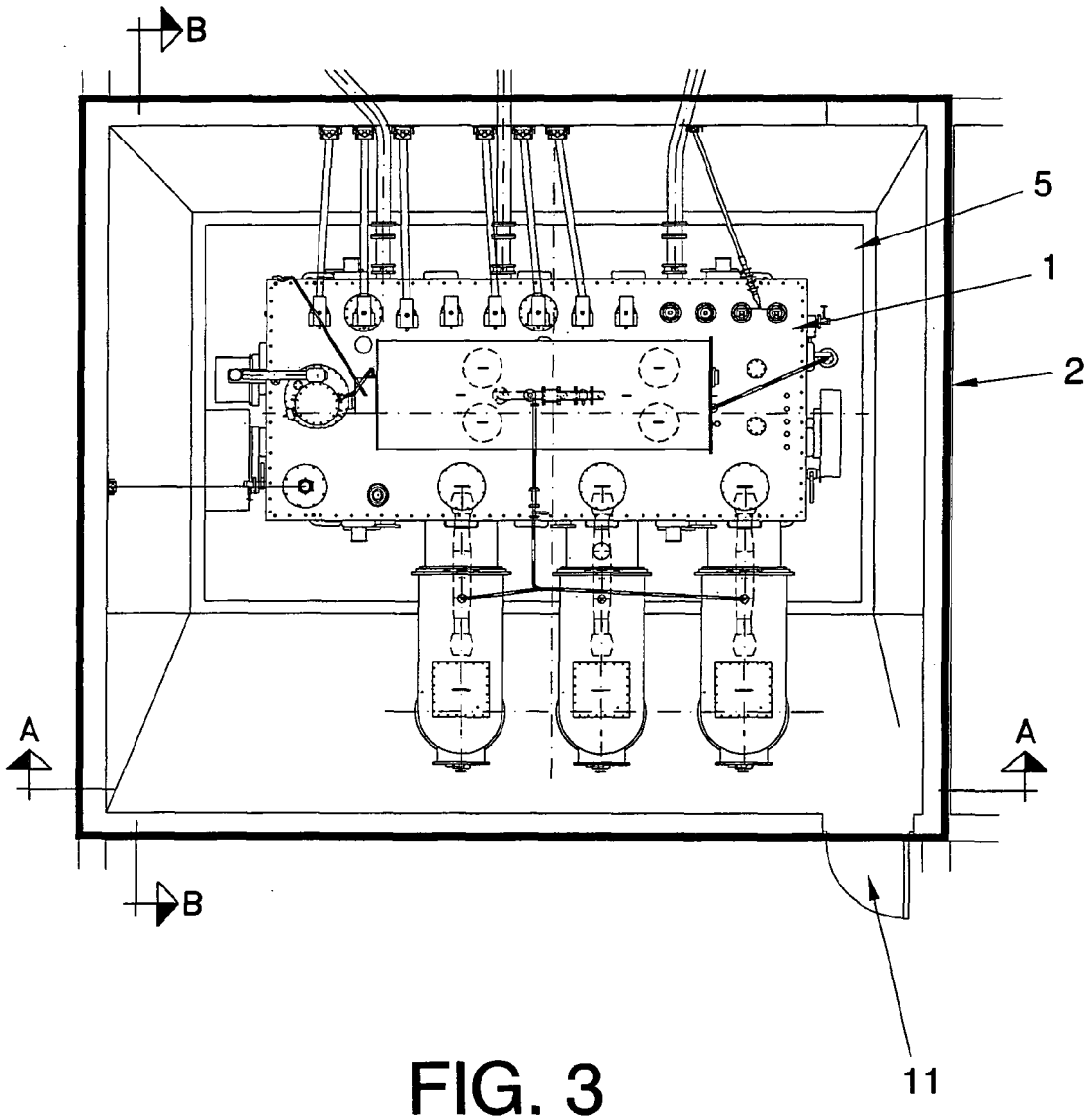

FIG. 3

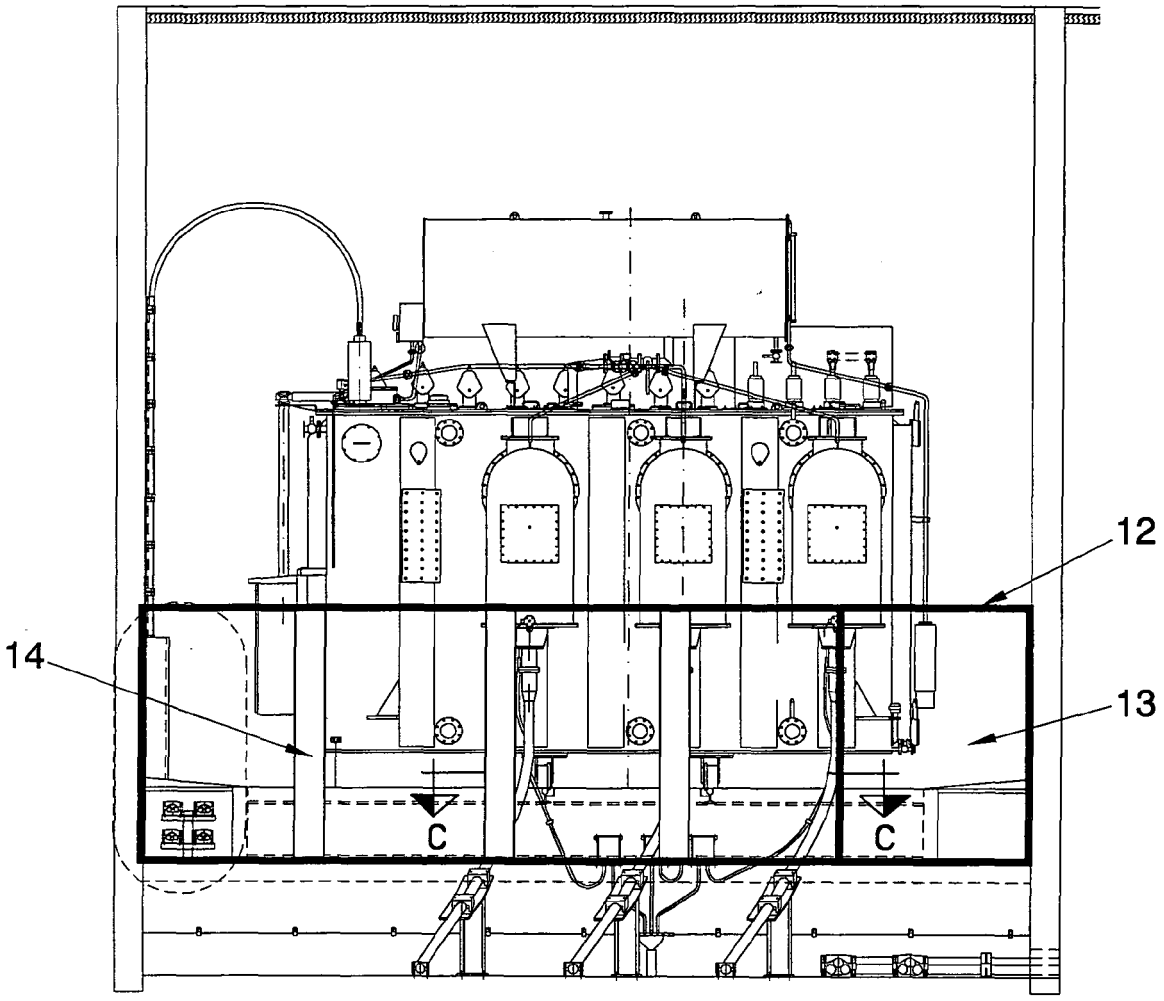

FIG. 4

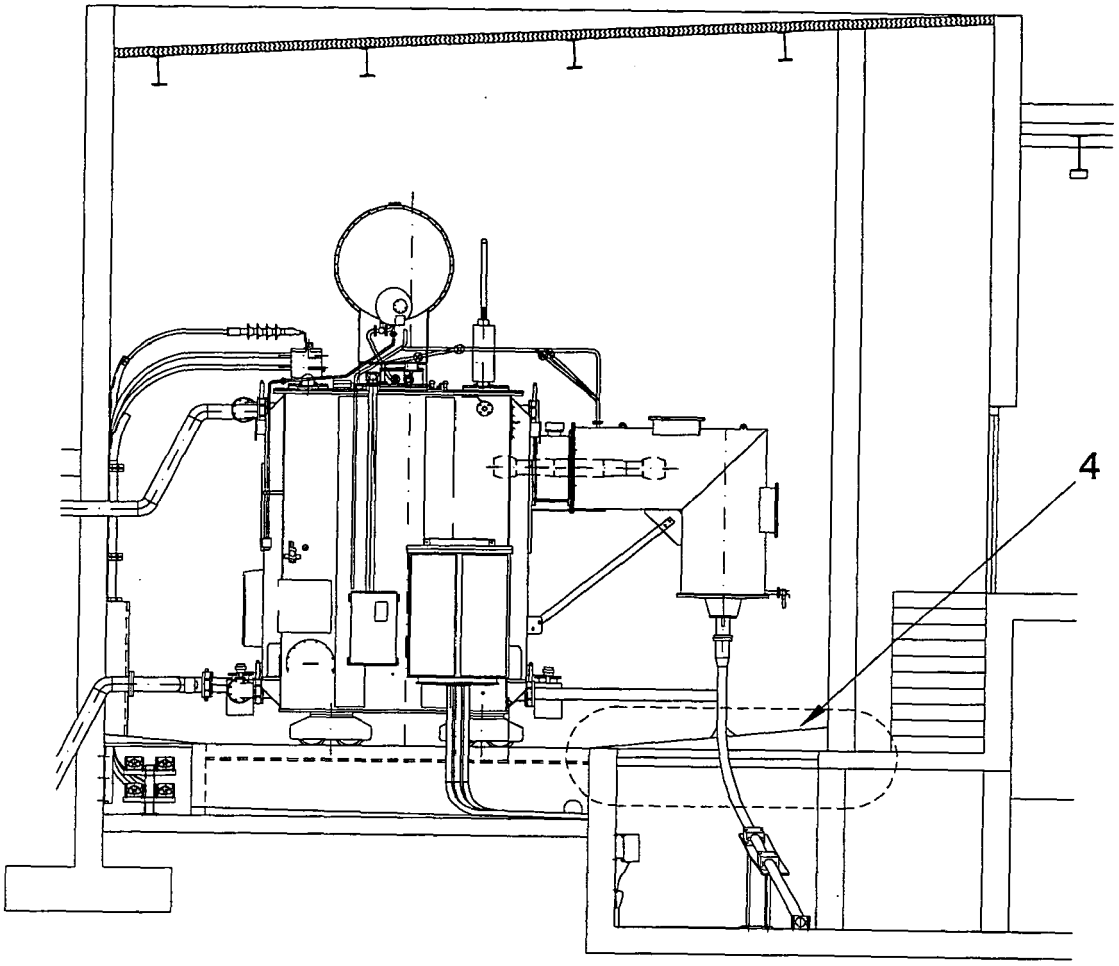

FIG. 5

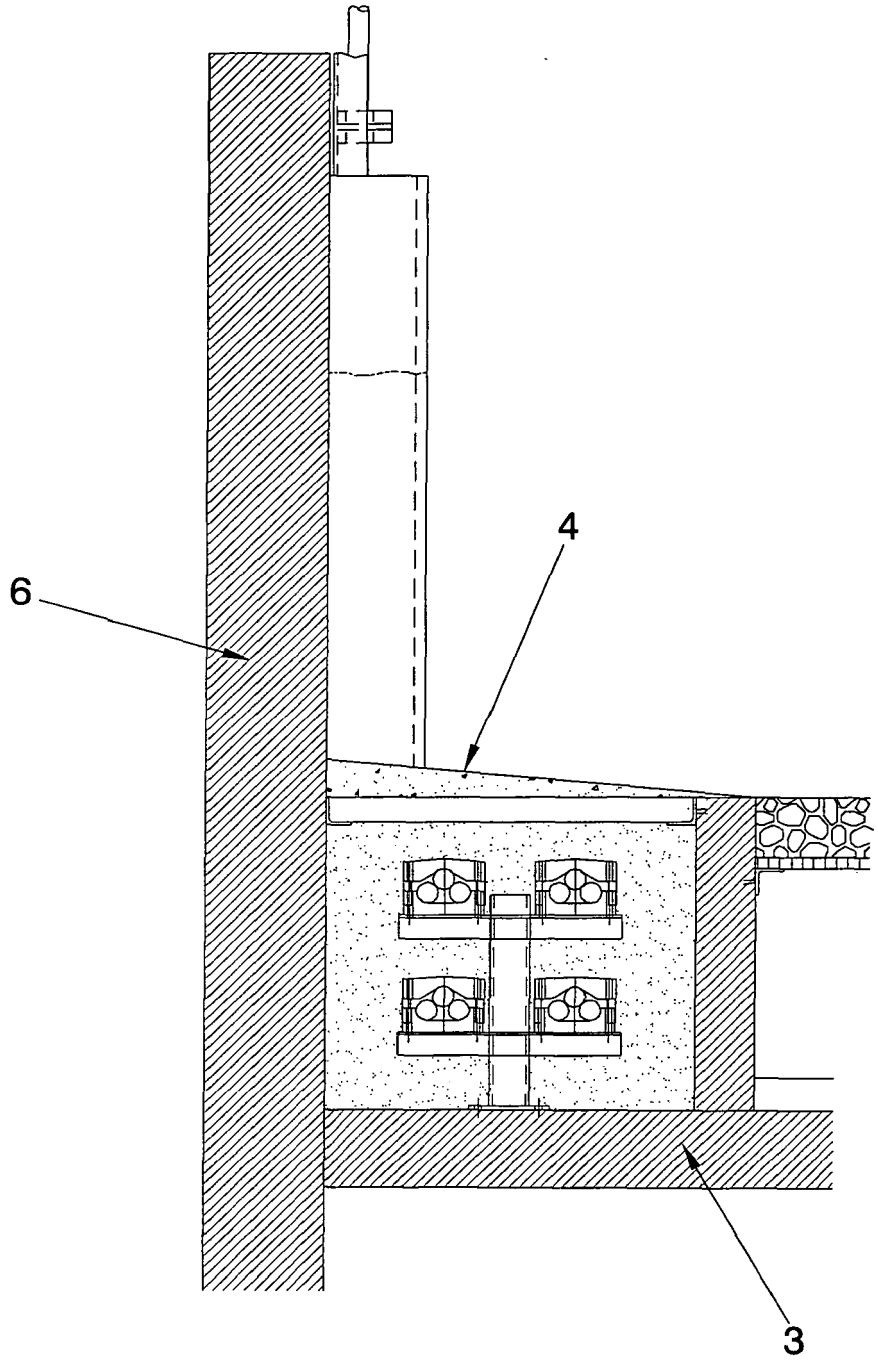

FIG. 6

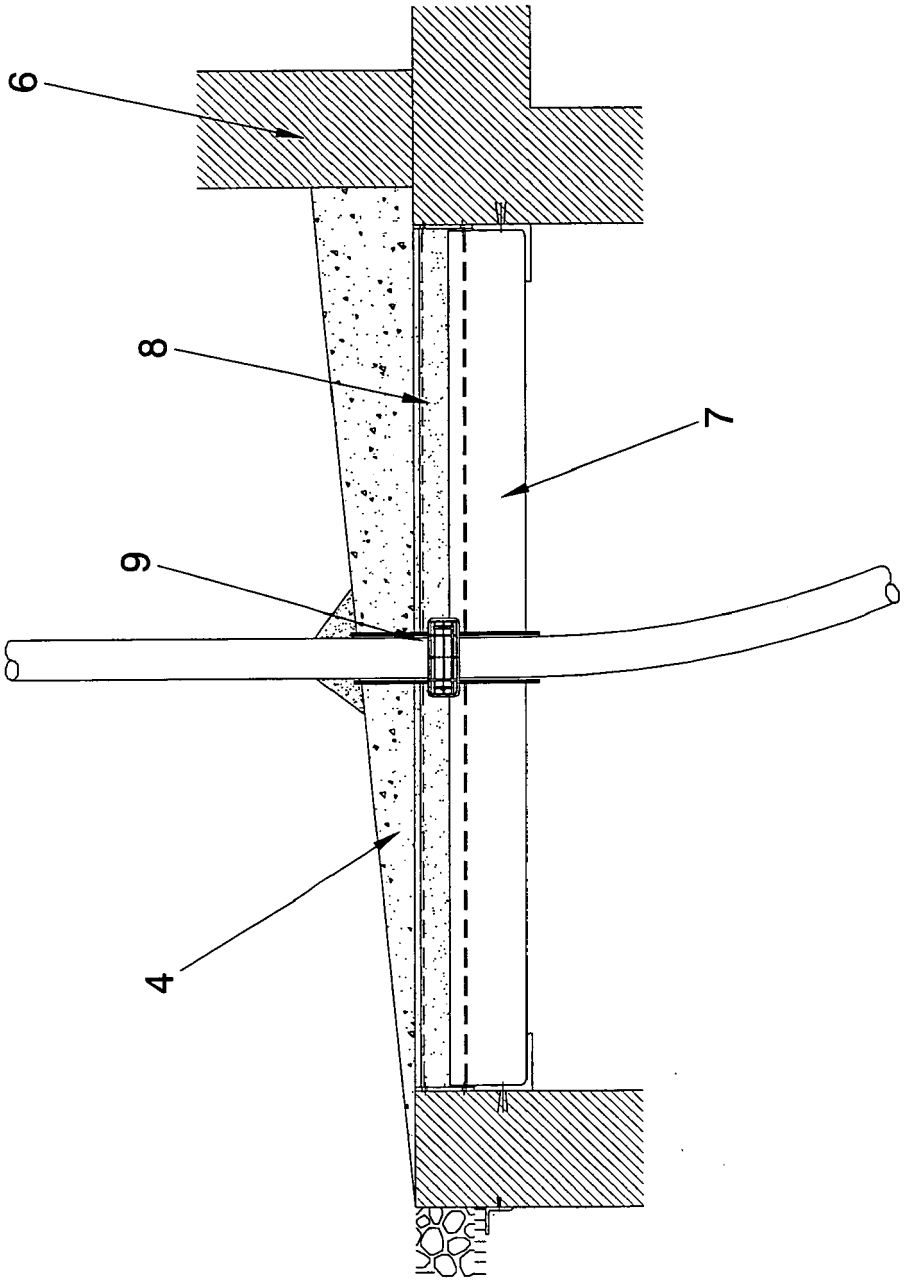

FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 38 0391

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 July 2008	van Bilderbeek, Henk

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