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Description

The present invention relates to apparatus for testing very high voltage power cables.

When two conducting elements having different electrical potentials are to be mutually insulated, a straight forward approach is simply to arrange an insulator therebetween and the material in this insulator should have as perfect insulation properties as possible.

For high differential potentials (say more than 100 kV) or high voltages, this first approach will, however, introduce new problems, more of practical than of a theoretical nature.

All insulating materials, no matter how well prepared they are, have some small, inherent irregularities or impurities when their microstructure is considered. When a strong electrical field is applied, there will develop at all such inhomogenities corresponding irregularities in the electrical field. Therefore, local field strength maxima will occur and a break-down process will start and develop if the local peak values of the field strength exceed the limits of the insulation material. As a matter of fact, irregularities in the surroundings also cause severe field inhomogenities at high voltages, and therefore the behaviour of an otherwise near to ideal insulator is unpredictable.

These problems have been appreciated and one proposed solution is to insert high resistance paths in insulators to control the field strength at each point along the insulator.

A solution is sought in GB—A—1 068 219 by providing a semiconducting tape wound around an insulator at its surface, primarily to avoid corrosion at the surface.

Another proposal is to introduce semiconducting layers at locations to thereby reduce electrical stress. Reference may be made to GB—A—1 371 006 and NO—A—144 003.

However, if such semiconducting layers are subjected to currents passing therethrough, they will be damaged due to the generated heat. Therefore, these solutions either concern relatively small voltages or the semiconducting layers do not introduce a current path at all, but only provide a screen.

To obtain a good insulation on cable joints or cable terminations it is also known to use housings filled with an insulating fluid. In this connection GB—A—1 139 016 and 1 251 341 should be referred to. The constructions disclosed in these patents employ ordinary stress cones or capacitor windings to distribute the field.

Generally speaking, all known methods for insulating extremely high voltages (e.g. up to 2 MV DC voltage) are time consuming, require skilled personnel and large available space.

When for example a high voltage test terminal has to be built up at a DC power cable end, the following precautions must be taken when using a conventional condenser tape termination.

The cable end must be extremely straight and it may not be moved after tape is applied, as this would result in internal tape movements which would make the termination inferior. Therefore the cable end has to be arranged at its final test position before the condensor tape is applied and the cable end also has to be positioned exactly at the test location. A scaffold must be built up around it, and the cable end must be prepared by dismantling and stripping. Then the insulator has to be built up around the exposed cable core and workers have to stand on the scaffold in awkward working positions. To prepare one cable end for testing requires approximately 2 men for 2 weeks and during all this time the test equipment is dedicated to the cable.

The problems may differ according to the cable types which are to be tested, but the example above is realistic when a power DC cable with oil insulated paper and an outer lead sheath is concerned.

GB—A—893 376 discloses an improved test apparatus for high voltage cables up to 132 kV. The described apparatus is relatively simple in that it includes premade stress cones and connectors into which a cable core may be inserted. This type of test apparatus is, however, not considered to be useful for testing very high voltage cables.

The present invention seeks to provide a test apparatus which is applicable for very high DC voltages, say up to 2 MV, which is easy to install, which gives a good control over the voltage distribution (electrically speaking an extremely "stiff" insulator), and which is easily adaptable to different types of cables.

According to the invention there is provided an apparatus for testing very high voltage electric cables including a hollow dielectric housing for containing an insulating fluid, the housing having an entrance at one end for receiving a cable core, electrically conductive means, such as a flange, to permit termination of the cable sheath or screen at the housing entrance with the cable inserted into the housing and electrically conductive means, such as a flange, at the end of the housing remote from the entrance to permit connection to the cable conductor, characterised in that the housing contains at least one semiconducting element formed by a fluid filled tube or pipe within the housing which effect electrical interconnection between the flange means and a passage in at least one of the flange means which communicates with the tube(s) or pipe(s) and permits connection to an external heat exchanger.

Preferably, the fluid filled tube(s) or pipe(s) are formed of an insulating material and contain a semiconducting fluid. The fluid may be de-ionised water.

In a particularly advantageous refinement of the apparatus the fluid in the tubes or pipes is circulated in a closed system incorporating heat exchange and pump means.

By using such an apparatus there is obtained:

— a very good, smooth and controllable voltage distribution over the insulator,

— a smooth and easily controllable temperature surveillance,

— an easy to mount and easy to adapt apparatus,

— a new design which can be used at much higher voltages than present solutions, as generated heat may be transported out of the system.

In order that the invention and its various other preferred features may be understood more easily, an embodiment thereof will now be described, by way of example only, with reference to the drawings, in which:

Figure 1 is a cross-sectional view of a testing apparatus constructed in accordance with the invention, and

Figure 2 illustrates the use of the apparatus shown in Figure 1.

Figure 1 shows a cable 20, such as a single conductor power cable for DC, having an impervious sheath 21 of aluminium or lead.

The test apparatus includes an outer insulated housing 22 having two flanges 23 and 24 and one or more insulated tubes 25 for highly resistive sometimes called (semiconducting) fluid.

To prepare the cable end for testing the following steps are undertaken while the cable end is in a proper working position and height:

— The outer protective and screening sheaths 21 are stripped off for a length L of the cable core which length depends on the voltage rating and hence the test voltage to be applied.

— A heat shrinking sleeve 26 is usually applied over the exposed core portion 19. The cable insulation is not removed from the part of the cable core to be inserted into the housing. This procedure simplifies the operation considerably and also provides an effective seal in a simple manner.

— A semiconducting tape 27 is applied both at the core (at 24) and at the sheath/screen end 28.

After preparation the cable end is inserted into the insulator housing arrangement 22, so that the sheath/screen end 28 becomes aligned with the lower flange 23 and the core end becomes aligned with the upper flange 24. The lower flange 23 is then secured and sealed to the outer sheath/screen of the cable at the end 28, and also to the semiconducting tape winding 27. If an oil filled cable is employed, the oil channel 31 is connected to an oil reservoir to feed the cable end with oil.

The insulator is brought into correct test position by lifting and tilting as shown in Figure 2.

The interior 18 of the housing 22 is filled with a suitable insulating fluid. Silicone oil is preferred due to its non-flammability. SF_6 gas may also be used as a practical fluid.

The tubes 25 are filled with a high resistance agent. Purified and de-ionised water is preferred. The tubes 25 may be connected to an externally arranged unit 50, Figure 2 for circulating the water (via a pump), to cool the water (by means of a heat exchanger) and for de-ionising the water in a de-ioniser. This external unit does not in itself represent a part of the invention. It may be manually controlled or automatically monitored. Parameters which may be changed or monitored are velocity of resistive agent, quality of resistive agent etc. In a prototype the following values were used: 6 pipes with internal diameter of 13 mm ϕ were guiding de-ionised water. The pump was circulating approx. 10 l/min. The test voltage applied was 1,5 MV. A conventional ion-exchanger was used.

The insulating fluid may also be circulated and its quality may be monitored.

The connection to high test voltages finally is obtained in a conventional manner, and by using a screen in the form of a conducting toroid 33 to reduce corona.

The mounting of the test apparatus may be completed in a few hours. If the cable end together with the insulator is arranged on a carriage with adjustable height and adjustable tilting, a very convenient plant is obtained.

Some further details of the insulating housing are shown in Figure 1. A branched tube 32 is an input manifold for a high resistive fluid which passes through the tube(s) 25 (preferably three parallel tubes) to an upper manifold section 36 within the flange 24. Here the fluid is distributed and passed back to the lower flange 23 through the upper tube(s) 25 (preferably also three parallel tubes). Finally the high resistive fluid leaves the housing through a manifold 40, and passes to an external pump, de-ioniser and purifier unit (50, Figure 2).

Distance rings 41, 42 are arranged at intervals to keep the tube(s) 25 in position.

The manifolds 32, 36, 40 are made from metal and the fluid has direct contact with their internal walls. The manifolds also are electrically connected to the flanges 23, 24.

In Figure 2 the cable end with the test apparatus is arranged on an adjustable framework 43. The mounting is undertaken when the cable end is in its lower position, and when testing is to be undertaken the framework lifts and tilts the cable end to its upper position. A test termination as a rule is arranged at indoor locations where the different parameters are easy to adjust. However, some embodiments of this invention may also be suited for field application.

By adjusting the temperature of the de-ionised water, the resistivity also is adjusted. The pipe dimensions may, however, also be altered to adapt the test termination to other voltages.

The insulating parts of the test apparatus may, if desired, be built up from transparent materials so that the interior of the insulator may be visually supervised during the process.

Distance rings 41, 42 as shown in Figure 1, are only necessary when the stripped cable core portion has to be long due to high test voltages. The strings or streams of high resistive fluid should be guided substantially parallel with the conductor in the interior of the insulator housing. The highly resistive fluid may circulate internally in a closed tube system, either due to thermal changes or due to an active pump. However, the fluid may also flow through the system without circulating. The number of the tubes or pipes with highly resistive fluid is not critical. It is assumed that the distance between two adjacent tubes preferably should be inversely proportioned to the electrical field strength. In the shown cable test application the distance is constant as the field strength is constant in each cross-section.

If the highly resistive fluid is water as suggested, the conductivity may be adjusted by adding different additives, or by adjusting the temperature. Thus the same dimensions may be used in the equipment for rather different voltages.

Claims

1. An apparatus for testing very high voltage electrical cables including a hollow dielectric housing (22) for containing an insulating fluid (18), the housing having an entrance at one end for receiving a cable core (20), electrically conductive means (23), such as a flange, to permit termination of the cable sheath or screen at the housing entrance with the cable inserted into the housing (22) and electrically conductive means (24), such as a flange, at the end of the housing remote from the entrance to permit connection to the cable conductor (30), characterised in that the housing (22) contains at least one semiconducting element formed by a fluid filled tube or pipe (25) within the housing which effect electrical interconnection between the flange means (23 and 24) and a passage in at least one of the flange means which communicates with the tube(s) or pipe(s) (25) and permits connection to an external heat exchanger.

2. An apparatus as claimed in claim 1, characterised in that the fluid filled tube(s) or pipe(s) (25) are formed of an insulating material and contain a semiconducting fluid.

3. An apparatus as claimed in claim 1 or 2, characterised in that the fluid in the or each pipe is de-ionised water.

4. An apparatus as claimed in any one of the preceding claims, characterised in means (32, 36, 40) for circulating the fluid through the or each tube or pipe (25) and through the flange means (23, 24).

5. An apparatus as claimed in claim 4, characterised in that the fluid in the tube(s) or pipe(s) is circulated in a closed system incorporating heat exchange and pump means (50).

6. An apparatus as claimed in any one of the preceding claims, characterised in that there are at least two said tubes or pipes (25) and that the flange (23) connected to the cable sheath/screen (21) includes circulation inlet(s) (32) as well as outlet(s) (40) for the fluid.

7. An apparatus as claimed in any one of the preceding claims, characterised in that there are a multiplicity of said semiconducting elements evenly distributed within the container.

8. An apparatus as claimed in any one of the preceding claims, characterised in that before filling the housing (22) with insulating fluid and insertion of the desheathed or descreened cable core (19) all the way through the housing (22), the cable core is provided with a sealing member (26) such as a heat shrinkable sleeve.

Patentansprüche

1. Vorrichtung zum Prüfen von elektrischen Kabeln für sehr hohe Spannungen, mit einem dielektrischen Hohlgehäuse (22) zur Aufnahme einer Isolierflüssigkeit (18), das an einem Ende eine Öffnung zum Einführen einer Kabelseele (20), elektrisch leitende Mittel (23), z.B. einen Flansch, die einen Abschluß des Kabelmantels oder der Kabelabschirmung an der Einführöffnung des Gehäuses (22) bei in das Gehäuse (22) eingeführtem Kabel ermöglichen, und elektrisch leitende Mittel (24), z.B. einen Flansch, am anderen, der Einführöffnung gegenüberliegenden Ende aufweist, die einen Anschluß an die Kabelader (30) ermöglichen, dadurch gekennzeichnet, daß das Gehäuse (22) mindestens ein aus einem mit Flüssigkeit gefüllten Rohr (25) bestehendes und innerhalb des Gehäuses angeordnetes halbleitendes Element, das eine elektrische Verbindung zwischen den Flanschmitteln (23 und 24) bewirkt, und einen Durchlaß in mindestens einem der Flanschmittel aufweist, der mit dem Rohr oder den Rohren (25) in Verbindung steht und einen Anschluß an einen externen Wärmeaustauscher ermöglicht.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß das mit Flüssigkeit gefüllte Rohr oder die mit Flüssigkeit gefüllten Rohre (25) aus Isolierstoff bestehen und eine halbleitende Flüssigkeit enthalten.

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Flüssigkeit in dem Rohr oder in jedem der Rohre entionisiertes Wasser ist.

4. Vorrichtung nach einem der vorhergehenden Ansprüche, gekennzeichnet durch Mittel (32, 36, 40) für den Umlauf der Flüssigkeit durch das oder jedes der Rohre (25) und durch die Flanschmittel (23, 24).

5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die Flüssigkeit in dem Rohr oder den Rohren in einem Wärmeaustausch- und Pumpmittel (50) enthaltenden geschlossenen System umläuft.

6. Vorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß mindestens zwei solcher Rohre (25) vorhanden sind und daß der mit dem Kabelmantel/der Kabelabschirmung (21) verbundene Flansch (23) Eintrittskanäle (32) und Austrittskanäle (40) für die Flüssigkeit aufweist.

7. Vorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß eine Vielzahl der halbleitenden Elemente gleichmäßig in dem Behälter verteilt ist.

8. Vorrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß vor dem Füllen des Gehäuses (22) mit Isolierflüssigkeit und dem Hindurchführen der entmantelten oder von der Abschirmung befreiten Kabelseele

(19) durch das Gehäuse (22) die Kabelseele mit einem Dichtungselement (26), z.B. einer aufschrumpfbaren Muffe, versehen wird.

Revendications

1. Dispositif de test de câbles électriques à très haute tension comprenant un boîtier diélectrique creux (22) pour contenir un fluide isolant (18), ce boîtier ayant une entrée à une extrémité pour recevoir l'âme d'un câble (20), des moyens conducteurs de l'électricité (23), tels qu'un flasque, pour permettre la terminaison de l'armure ou du blindage du câble sur l'entrée du boîtier alors que le câble est inséré dans le boîtier (22), ainsi que des moyens conducteurs de l'électricité (24), tels qu'un flasque, à l'extrémité du boîtier éloignée de l'entrée, pour permettre le raccordement d'un conducteur de câble (30), caractérisé en ce que le boîtier (22) contient au moins un élément semiconducteur formé par un tuyau ou tube (25) rempli de fluide à l'intérieur du boîtier, qui réalise l'interconnexion électrique entre lesdits flasques (23 et 24), ainsi qu'un passage dans au moins l'un des flasques, communiquant avec le tuyau ou tube (25) et permettant la connexion avec un échangeur de chaleur externe.

2. Dispositif selon la revendication 1, caractérisé en ce que le(s) tuyau(x) ou tube(s) rempli(s) de fluide (25) est (sont) formé(s) d'un matériau isolant et empli(s) d'un fluide semi-conducteur.

3. Dispositif selon la revendication 1 ou 2, caractérisé en ce que le fluide contenu dans le(s) tuyau(x) est de l'eau désionisée.

4. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce que des moyens (32, 36, 40) sont prévus pour faire circuler le fluide à travers le(s) tuyau(x) ou tube(s) (25) et les flasques (23, 24).

5. Dispositif selon la revendication 4, caractérisé en ce que le fluide contenu dans le(s) tuyau(x) ou tube(s) circule dans un système fermé incluant l'échangeur de chaleur et des moyens de pompe (50).

6. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comprend au moins deux tuyaux ou tubes (25) et en ce que le flasque (23) connecté à l'armure ou au blindage (21) du câble comprend une (des) entrée(s) ainsi qu'une (des) sortie(s) (40) de circulation de fluide.

7. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il est prévu de multiples éléments semi-conducteurs répartis régulièrement à l'intérieur du boîtier.

8. Dispositif selon l'une quelconque des revendications précédentes, caractérisé en ce qu'avant de remplir le boîtier (22) d'un fluide isolant et avant l'insertion de l'âme de câble (19), armure ou blindage retiré, tout au long du boîtier, l'âme du câble est pourvue d'une pièce d'étanchéité (26) telle qu'un manchon thermo-rétractable.

Fig.1

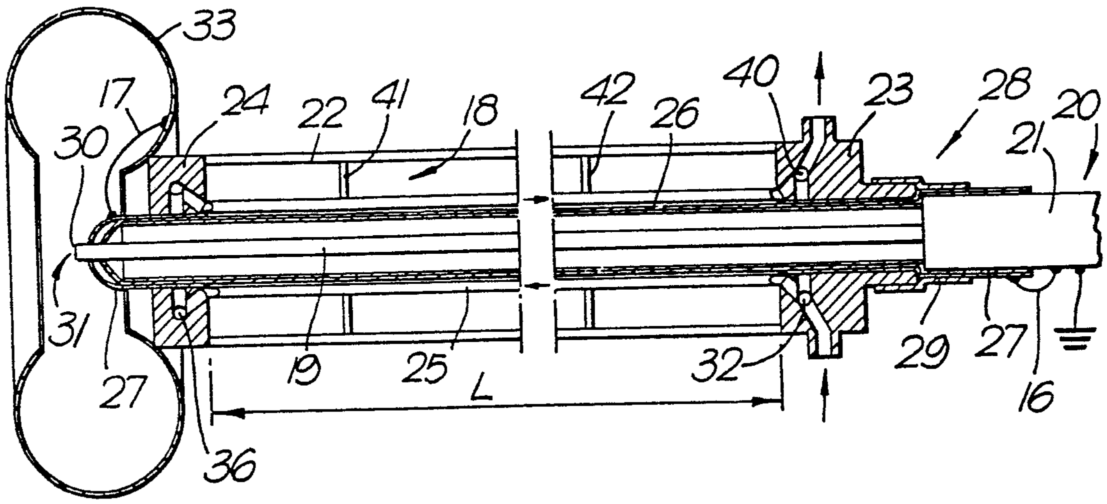
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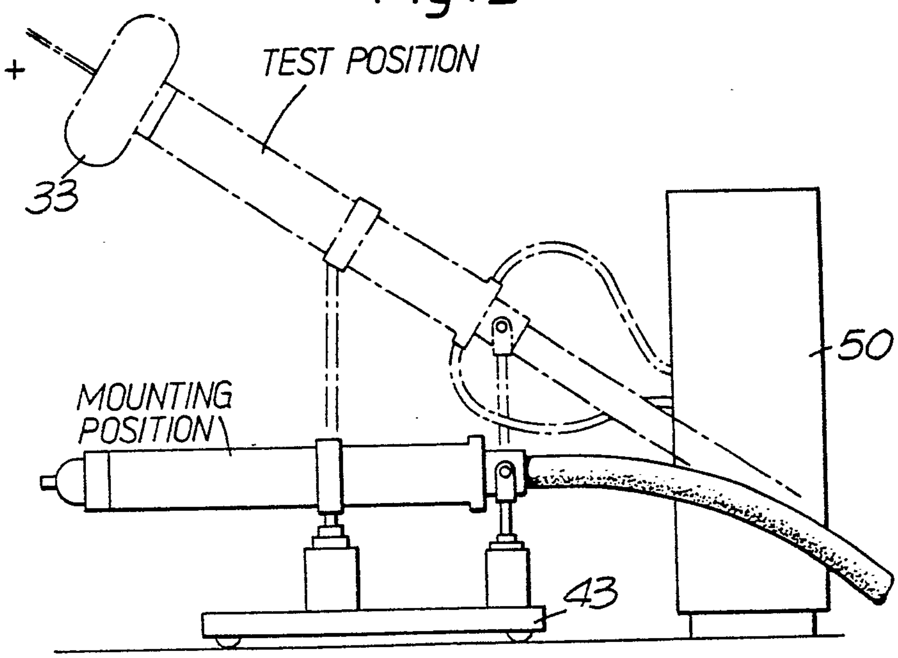
Fig.2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TEST POSITION
33
50
MOUNTING
POSITION
43