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Maylandt et al.

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[54] **SELF-HEALING ELECTRICAL CONDENSER**

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[51] **Int. Cl.**.....**H01g 3/215**

[58] **Field of Search**.....317/258, 260

[56] **References Cited**

UNITED STATES PATENTS

3,596,152 7/1971 Allison 317/258

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[57] **ABSTRACT**

A first and at least two second electrodes are provided, with the latter flanking the former. First dielectric separating means is provided between the first electrodes and one of the second electrodes and has *n* paper strips and *m* synthetic plastic strips with *n* being a whole number excluding zero and one, and *m* being a whole number including zero and one, and with n being greater than *m*. Second dielectric separating means is provided between the first electrode and the other of the second electrodes and comprises N plastic strips and M paper strips with N being a whole number including one, M being a whole number including zero and N being greater than M. The electrodes are each applied to one side of two paper strips and the latter have uncovered sides facing one another, with the first and second dielectric separating means being electrically connected in parallel with each other.

8 Claims, 3 Drawing Figures

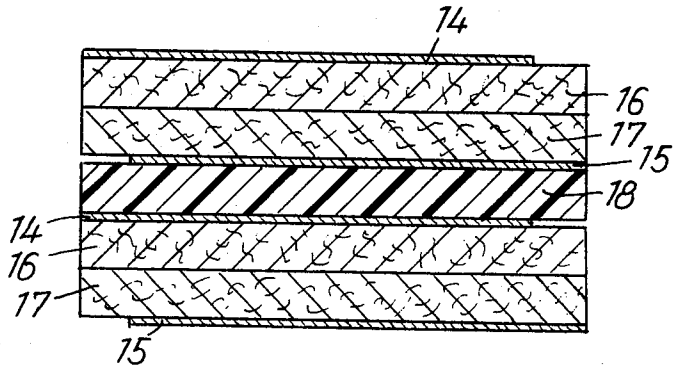


Fig. 1

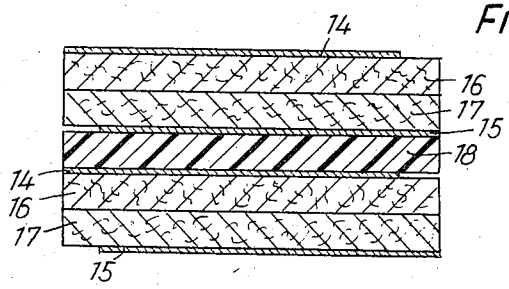


Fig. 2

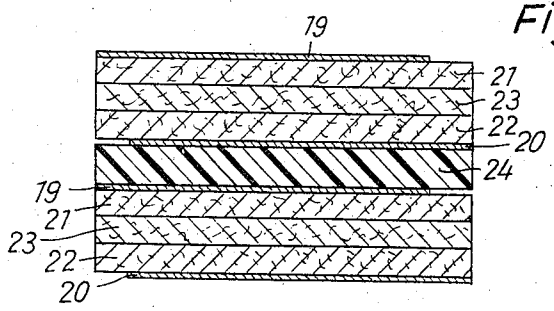
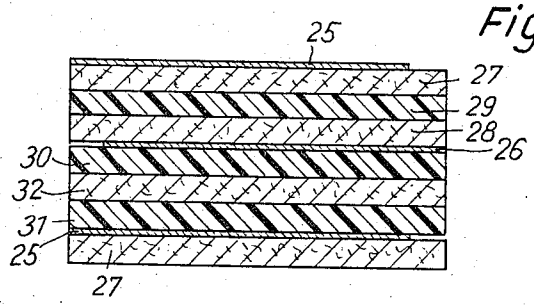


Fig. 3



SELF-HEALING ELECTRICAL CONDENSER

BACKGROUND OF THE INVENTION

The present invention relates generally to electrical condensers and more particularly to self-healing electrical condensers.

Self-healing condensers are already well known in the art and are not believed to require any detailed explanatory discussions. Among these it is known to provide a construction having a paper strip which carries a metallic coating as an electrode, with a synthetic plastic layer being juxtaposed with the paper strip at the side remote from the electrode and with another electrode being applied to the exposed side of the synthetic plastic strip. Between two electrodes of opposite sign there are thus interposed the paper strip and the plastic strip.

Another known construction utilizes two electrodes of opposite sign between which there are dielectric of polyethylene-terephthalate, or of a laminate of such material with paper. In addition, there is a further undefined laminate of paper and polyethylene-terephthalate provided, and the construction may vary depending on whether the electrodes are applied to the exposed surfaces of papers or polyethylene-terephthalate strips.

Other constructions are also known but they share with the aforementioned ones the characteristic that the sequence and arrangement of paper and plastic strips is selected irrespective of the strongly different dielectric characteristics of these materials. Evidently, this is not satisfactory and further improvements are therefore desirable and have been sought in the art.

SUMMARY OF THE INVENTION

It is, accordingly, a general object of the invention to provide such improvements.

More particularly it is an object of the present invention to provide an improved self-healing electrical condenser which has incorporated the aforementioned desirable improvements.

In pursuance of these and other objects which will become apparent hereafter, one feature of the invention resides in a self-healing electrical condenser which, briefly stated, comprises at least one first electrode, at least two second electrodes flanking the first electrode, and first and second dielectric separating means. According to the invention the first separating means is between the first electrode and one of the second electrodes and comprises *n* paper strips and *m* synthetic plastic strips wherein *n* is a whole number excluding zero and one, and *m* is a whole number including zero and one, with *n* being greater than *m*. Furthermore, the second dielectric separating means is located between the first electrode and the other of the second electrodes and comprises N plastic strips and M paper strips wherein N is a whole number including one, M is a whole number including zero, with N>M, said electrodes being each applied to one side of two of said paper strips and the latter having uncovered sides which face one another, and said first and second dielectric separating means being electrically connected in parallel with each other.

An electrical condenser constructed in accordance with the present invention provides for a fuller and more effective utilization of the advantages to be obtained from a composite use of paper strips and synthetic plastic strips as the dielectric of the condenser. In such a construction the number of paper strips between the electrodes is always greater at one side than the number of synthetic plastic strips, whereas at the other side the number of synthetic plastic strips is always greater than the number of paper strips, meaning that at the one side there is predominantly paper and that at the other side there is predominantly synthetic plastic material. The advantage obtained in this manner resides in the fact that the novel self-healing electrical condenser has the electrodes provided exclusively on paper strips, with no electrodes being provided on the synthetic plastic strips and in that the exposed sides of the electrodes are under all circumstances contacted by the plastic strips.

In this connection it is important to take into consideration that it is considerably less expensive to deposit the electrodes—as by vapor deposition—on paper strips than on synthetic plastic strips. The vapor deposition of the metallic material of the electrodes on the paper strips can be carried out more rapidly than would be possible on synthetic plastic, the metallic material will adhere better. There is further a lesser incidence of rejects. In fact, the deposition of metallic material (to form electrodes) on synthetic plastic strips is considerably more difficult than on paper strips and in some instances cannot even be carried out to the necessary thickness required for the electrodes.

A further advantage of the construction according to the present invention is inherent in the contact of the plastic strips to the metal-coated paper strips, because the gap width between the strips is very small so that after self healing breakdowns a high potential can be reached before the danger of corona discharge occurs.

It should be recalled here that the gap widths are determined by the roughness of the surfaces which contact one another. When paper strips surfaces contact one another the gap width is equal to twice the so-called "rough depth" of the contacting surfaces, with the term "rough depth" referring to the distance between the highest and lowest points of the paper strip surface. On the other hand, the gap width between contacting paper and synthetic plastic surfaces (in the condenser according to the present invention) is smaller than the single "rough depth" of the paper surface because the synthetic plastic material has a very smooth surface and additionally has a tendency to swell under the influence of impregnating media so that it at least partially fills any depressions in the surface of the paper strip which it contacts.

The invention also provides for optimum utilization of paper and synthetic plastic material in accordance with their voltage resistance and/or provides for optimum permissible operating field strength by correct choice of the strip thicknesses. If, for instance, in a specific application one side of a condenser is composed of two metallized paper strips having a thickness of 12 microns, with between them a polycarbonate strip having a thickness of 15 microns, and if the other side of the condenser is composed of two polycarbonate strips having a thickness of 8 microns and between them a paper strip having a thickness of also eight microns, then a condenser or capacitor so constructed and subsequently impregnated with mineral oil

will have in its rolled-up dielectric components a specific volume of 28 $cm^3/\mu F$. Of course, this exemplary condenser according to the present invention is constructed asymmetrically with respect to its dielectrics, as are all ones according to the present invention. If, however, the dielectric were arranged in accordance with the prior art as a symmetric mixed dielectric, meaning that at each side of the electrodes there were provided two paper strips having a thickness of 12 microns and intermediate them a synthetic plastic strip having a thickness of 15 microns and for instance consisting of polycarbonate, then a corresponding volume of 41 $cm^3/\mu F$ would be obtained. It is readily evident therefore that the volume of the condenser constructed according to the present invention is approximately 32 percent smaller than that of a similar condenser constructed in accordance with the prior art. In addition, the condenser according to the present invention has lower dielectric losses because on the side in which the dielectric is predominantly composed of synthetic plastic strips are smaller than the losses at the other side.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims.

The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial section through a rolled self-healing condenser according to one embodiment of the invention;

FIG. 2 is a view similar to FIG. 1 but of a further embodiment of the invention; and

FIG. 3 is a view similar to FIG. 1 but of still another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing now the drawing in detail, and firstly the embodiment illustrated in FIG. 1, it will be seen that this Figure illustrates a self-sealing condenser according to the present invention having three dielectric strips, a synthetic plastic strip and two paper strips each of which latter carries on one exposed side a electrode which is provided by metallic vapor deposition and whose uncoated sides contact one another. As pointed out earlier, this condenser thus has the electrodes provided exclusively on paper strips.

FIG. 1 shows that there is provided one first electrode **15** and a second electrode **14** which, when the assembled strips are rolled up to the configuration of FIG. 1, actually constitutes with its different portions two second electrodes **14** which flank (are located at opposite sides of) the electrode **15** as illustrated. The electrodes **14** and **15** are provided on one side each of two paper strips **16** and **17**, as by vapor deposition. The non-coated or metallized sides of the paper strips **16** and **17** contact one another, a construction which is particularly advantageous if the condenser is to be used for higher winding potential and to be particularly resistant.

Located between the exposed side of the electrode **15** and that portion of the electrode **14** which will face the exposed side of the electrode **15** when the assembly is rolled up to the configuration of FIG. **1**, is a strip of synthetic plastic material, identified with reference numeral **18**. In this embodiment, as in the others to be discussed, it should be understood that various different synthetic plastics well known to those skilled in the art are suitable. This includes in particular low-loss synthetic plastic foils which may be made of polycarbonate, polypropylene, polyphenylene oxide, polytetrafluoroethylene, polysulfone and other plastics.

It is quite evident that at one side of the condenser of FIG. **1**, that is at one side of the electrode **15**, the number *n* of paper strips **16** and **17** is greater than the number *m* of plastic strips **18**, namely in the illustrated embodiment there are at this side no synthetic plastic strips at all. On the other hand, on the other side of the electrode **15**, between it and the facing portion of the electrode **14**, the number N of plastic strips **18** is greater than the number M of paper strips, namely in the illustrated embodiment there are at the side no paper strips at all.

If the condenser according to the present invention is constructed with a synthetic plastic material having particularly high potential resistance, then it may be advantageous to so construct the condenser that the paper component of the dielectric is not in form of two layers or strips but is in the form of three layers. FIG. **2** shows such an embodiment in which there are provided two paper strips **21** and **22** analogous to the strips **16** and **17** of FIG. **2** and each carrying at an exposed side one of the vapor-deposited electrodes **19** and **20**. Located between the juxtaposed non-coated surfaces of the paper strips **21** and **22** is a further non-coated paper strip **23**. This assembly is then rolled up to the configuration of FIG. **2**, with again a synthetic plastic strip **24** being provided which is located between the exposed side of the electrode **20** and that portion of the electrode **19** which on rolling up will become juxtaposed with the exposed side of the electrode **20**.

FIG. **3** shows an embodiment of a condenser which is suitable if still higher voltages are to be utilized than are permissible in the embodiments of FIGS. **1** and **2**. In this case there are provided two paper strips **27** and **28** analogous to the strips **21** and **22** of FIG. **2** and each provided on an exposed side with one of the electrodes **25** and **26** which is vapor-deposited thereon. The non-coated surfaces of the paper strips **28** and **27** face one another and juxtaposed with them and sandwiched between them is a synthetic plastic strip **29**. When this assembly is rolled up so that again a portion of the electrode **25** will face the exposed side of the electrode **26**, there will be located between this exposed side of the electrode **26** and the aforementioned portion of the electrode **25** a dielectric component composed of two synthetic plastic strips **30** and **31** one of which is in contact with the exposed side of the electrode **26** and the other of which is in contact with the exposed side of the portion of the electrode **25** which is juxtaposed with the electrode **26**. Located between these plastic strips **30** and **31** and sandwiched between them is a paper strip **32**.

If the novel condensers are to be used with alternating potential, they are saturated with an auxiliary liquid dielectric, for instance mineral oil. In such an embodi-

ment the lowest increase of the loss factor and the highest potential resistance before the beginning of corona discharge and breakdown is obtained when the gap for the saturating liquid (adjacent one of the electrodes) has intermediate the electrode and the adjacent strip contacting the electrode the smallest possible extension in the direction of the electric field. This inhibits the movement of charge carriers and prevents the formation of damaging gas bubbles at the electrodes. The requirements for affording these characteristics exist in the novel condensers to an almost ideal extent, because the electrodes are always firmly adhered to two different paper strips so that the formation of gas bubbles between the electrodes and the paper strips carrying them is reliably precluded.

It will also be evident that the exposed surfaces of the electrodes which are deposited on the respective paper strips will under all circumstances bound one side of a gap which is filled with the liquid saturation dielectric and whose width or depth is dependent upon the roughness of the paper strip surface, with the other side of the gap being delimited and bounded by a synthetic plastic strip, that is the strip **18**, **24**, **30** or **31**. Because of this the width of this gap is narrower than a gap which would exist between two juxtaposed paper strip surfaces, for the reasons discussed earlier.

The width of this gap can be still further reduced, and any depressions or roughnesses in the surface of the paper strip be at least partly filled, if synthetic plastic material is used for the plastic strips which swells during saturation with the liquid dielectric and thus at least in part fills these depressions. Such synthetic plastics may be given the swelling characteristic by preliminary heat treatment which in each case will depend upon the synthetic plastic material utilized. For instance if an electrical condenser according to the present invention utilizes synthetic plastic strip or strips of low-swelling polycarbonate, it is advantageous to impregnate them (after the usual vacuum-drying process) with mineral oil at temperatures of between 90° and 130°C, and of course it is understood that dielectric other than mineral oil can be utilized for this purpose in accordance with the teachings of the prior art. Subsequently, the thus impregnated condenser is maintained at the above temperature range for several hours before it is cooled off. On the other hand, if the condenser utilizes plastic strips of for instance polypropylene, which has a higher swelling tendency, then the condenser may for instance be dried in vacuum at temperatures of 90°–130°C, and may subsequently be cooled down to temperatures of between 60° and 90°C to be impregnated with a liquid dielectric whose temperature may be below the temperature of the condenser itself. Only when the dielectric has entered into the condenser winding or roll, will the condenser then be maintained at the temperature of impregnation or at a higher temperature for some hours before it is subjected to cooling or is permitted to cool.

It will be understood that each of the elements described above, or two or more together may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a self-healing electrical condenser, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that from the standpoint of prior art fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is set forth in the appended claims:

1. A self-healing electrical condenser, comprising at least one first electrode; at least two second electrodes flanking said first electrode; first dielectric separating means between said first electrode and one of said second electrodes, said first separating means comprising *n* paper strips and *m* synthetic plastic strips wherein *n* is a whole number excluding zero and one, and *m* is a whole number including zero and one, with $n>m$; and second dielectric separating means between said first electrode and the other of said second electrodes, said second separating means comprising N plastic strips and M paper strips wherein N is a whole number including one, M is a whole number including zero, with $N>M$, said electrodes each being applied to one side of two paper strips and the latter having uncovered sides which face each other, and said first and second dielectric separating means being electrically connected in parallel with each other.

2. A condenser as defined in claim **1**, wherein said electrodes are metallic coatings.

3. A condenser as defined in claim **1**, wherein said first dielectric separating means comprises two overlying paper strips having sides facing away from each other, said electrodes being applied to said sides, and an additional paper strip sandwiched between two paper strips; and wherein said second dielectric separating means comprises a plastic strip sandwiched between said first and said other of said second electrodes.

4. A condenser as defined in claim **1**, wherein said first dielectric separating means comprises two overlying paper strips having sides facing away from each other, said electrodes being applied to said sides; and wherein said second dielectric separating means comprises a plastic strip sandwiched between said first and said other of said second electrodes.

5. A condenser as defined in claim **1**, wherein said first dielectric separating means comprises two overlying paper strips having sides facing away from each other, said electrodes being applied to said sides, and a plastic strip sandwiched between said paper strips; and wherein said second dielectric separating means comprises two overlying plastic strips having sides facing away from each other and respectively contacting said first electrode and said other second electrode, and a paper strip sandwiched between said plastic strips.

6. A condenser as defined in claim **1**, wherein said plastic strips are of polycarbonate.

7. A condenser as defined in claim **1**, wherein said plastic strips are of polypropylene.

8. A condenser as defined in claim 1, wherein said plastic strips are of polysulfone.

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