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[54] **INSULATIVE ADHESIVE MIXTURE RESISTANT TO STRONG ELECTRICAL FIELDS**

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[51] **Int. Cl.**[2] **H01B 3/10**

[58] **Field of Search** .... 252/63.2, 63.5; 260/37 M, 260/42.22; 106/193 M, 214

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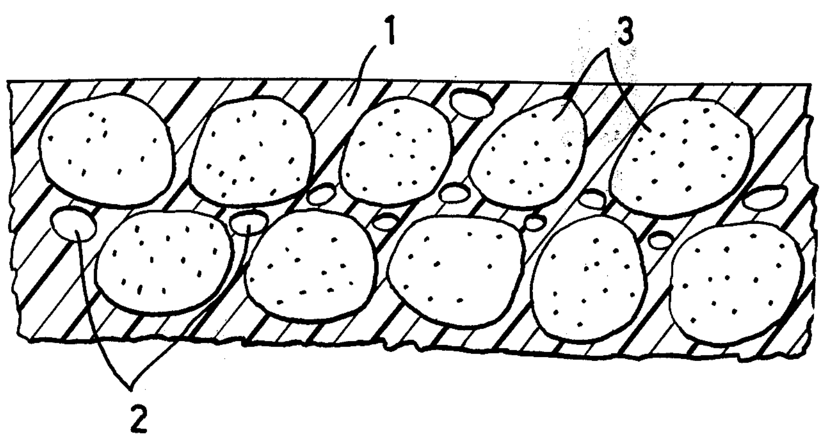
[57] **ABSTRACT**

An adhesive mixture intended to be used in objects subject to an electrical field and, in particular, to a strong electrical field, such as in connection with joints in electrical insulations of capacitors. The mixture comprises an appropriate adhesive component proper, for example one that is known per se, and particles of an insulating or semiconductive substance mixed with the same, the particle size being from 0.01 μm to a few micrometers.

9 Claims, 3 Drawing Figures



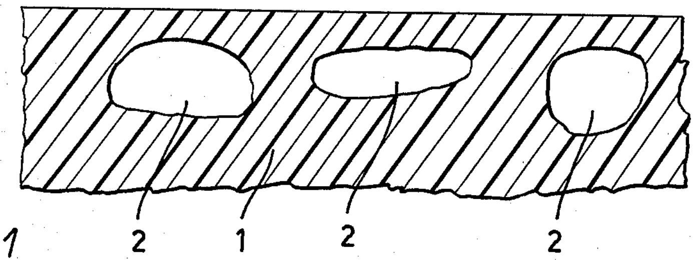


FIG. 1

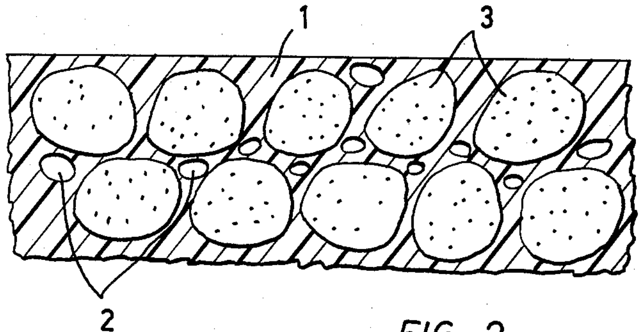


FIG. 2

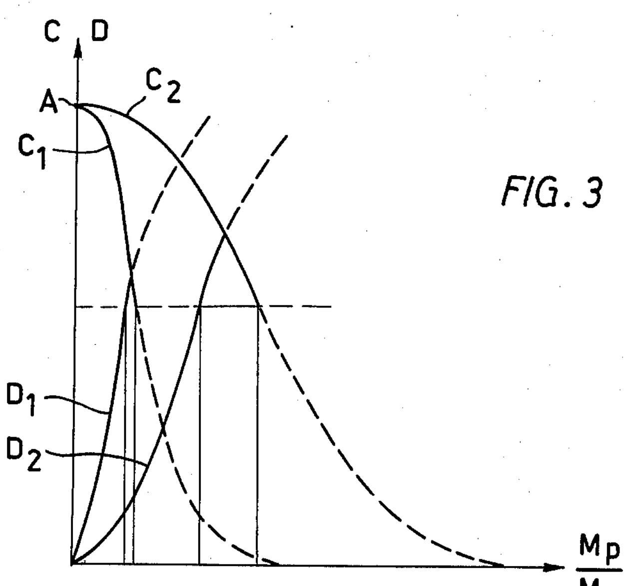


FIG. 3

INSULATIVE ADHESIVE MIXTURE RESISTANT TO STRONG ELECTRICAL FIELDS

The present invention relates to an adhesive mixture to be used in objects subject to electrical fields and, in particular, to strong electrical fields, such as in connection with electrical capacitor insulations, said mixture comprising an appropriate adhesive component proper, for example, one known, per se, such as methyl cellulose, starch, arabicum, dextrin, or plastic adhesives.

In electrical insulation structures it is desired to obtain solutions where there is a minimum of or no partial discharges at the rated loading. This attempt is due to the fact that it has been noticed that partial discharges destroy insulation at the site of discharge.

The joints of the paper webs at present used as insulations are made as adhesive seams, for example, so that when making the seam, the adhesive is by means of heat treatment converted from liquid or softened state into a solid state. It has been ascertained that in such adhesive seams partial discharges appear even at low field intensities. This is likely to result from the circumstance that, when the adhesive is converted from liquid state into the solid state, cavities are formed inside the seam of adhesive. The cavities are harmful when using insulating materials as these are usually impregnated by means of appropriate electrical insulating agents and these impregnating agents cannot penetrate into the cavities inside the solid adhesive.

FIG. 1 shows a schematic view of a conventional adhesive layer which consists of the adhesive **1** and the cavities **2**. It is essential that these cavities **2** be relatively large and, consequently, partial discharges appear in them at a relatively low field intensity, which discharges destroy the material rapidly. As is well known, this same mechanism applies to all electrical insulation.

Since it has so far been impossible to prepare seams which do not involve harmful partial discharges, for example in the production of capacitor units, requirements have started to be imposed regarding continuous, i.e. seamless paper, which has caused considerable waste of material, because capacitors with joints in their insulation have not had equally good characteristics as capacitors with no joints in their insulation.

An object of the invention is to avoid the above disadvantages and to provide such an adhesive mixture which, even after hardening, posesses at least almost equally good discharging properties as the adhesive component contained therein under ideal homogeneous conditions.

Another object of the invention is to provide such adhesive seams whose partial discharge properties are so good that the adhesive seam does not constitute the weakest point in the electrical insulation structure.

The adhesive mixture in accordance with the invention is mainly characterized by particles of a poorly conducting substance, such as a metallic oxide or silicon oxide, mixed with the adhesive component, the particle size ranging from 0.01 μm to a few micrometers, the particles being of a substantially uniform size, and the cross-section contours of the particles being evenly curved.

Thus, the basic concept of the invention is, that the adhesive is mixed with such a quantity of solid particles of an appropriate size that the adhesive properties of the adhesive mixture still remain good enough but that the solid particles prevent the formation of too large cavities in the adhesive mixture.

In this way the quantity of adhesive consisting of adhesive agents and remaining between the solid particles can be made so small that the cavities remaining therein are either broken or impregnation substances can penetrate into them or the cavities remain so small that partial discharges possibly arising in them are not harmful.

The invention will be examined hereafter in greater detail with reference to the attached drawings and the embodiments to be described below.

FIG. 1 shows, as described above, a schematic view of a conventional adhesive layer which contains adhesive and cavities.

FIG. 2 shows a layer made of an adhesive mixture in accordance with the invention and containing adhesive, small cavities and particles.

FIG. 3 shows graphically the adhesive capacity and the quality of the discharge properties as a function of the quantity of the particles.

In FIG. 3, the symbols have the following meaning:

C represents the adhesive capacity

D represents the quality of discharge properties

A represents the value of the adhesive capacity of the adhesive component

Mp/Mg represents the ratio of the quantity of particle material and the quantity of adhesive component

C_1 represents the curve of the adhesive capacity of a mixture including small particles

C_2 represents the curve of the adhesive capacity of a mixture including bigger particles

D_1 represents the curve of the quality of discharge properties of a mixture including small particles

D_2 represents the curve of the quality of discharge properties of a mixture including bigger particles

FIG. 3 shows graphically that the quality of the discharge properties is improved with an increase in the proportion of particles in the mixture. On the other hand, the adhesive capacity is in a corresponding way deteriorated with an increase in the proportion of the particles. For this reason, in order to obtain an optimum result, it is necessary to operate within a range in which both curves obtain a relatively high value at the same time. The particle content ought to be about 50 to 5,000 per cent by weight of the quantity of adhesive and preferably 100 to 1,500 per cent by weight. It is further noted that when the particle size is reduced, the range of the optimum percentage by weight is reduced. This is why one cannot go into very small particle sizes. On the other hand, when the particle size becomes too large, the discharge properties cannot be made sufficiently good.

On the basis of measurements, it has been ascertained that the particle size shall be about 0.01 μm to a few micrometers. Preferably, the particle size should be 0.2 to 3 μm. It has also been noted that the particles ought to be of a substantially equal size.

It has been ascertained further that it is important that the ratio of the maximum and the minimum dimension of each particle does not become too high. This proportion should not be higher than about 10 to 1. Further, it is important that the cross-section contour of the particles is evenly curved. Optimum shape is obviously that of a sphere.

Since, for example, mica, which is in itself an excellent insulating material, is even when ground into small particles disc-shaped, mica does not give even nearly as good results as a particle material consisting of globular particles. Needle-shaped particles are not nearly as good as globular ones.

In principle, the adhesive can be any adhesive, such as methyl cellulose, starch, arabicum, dextrin, and plastic adhesives.

As the material of the particles, zinc oxide has been ascertained to be especially good. Aluminum oxide can also be used. In principle, any insulating or semiconductive material can be used for this purpose. The particles must, however, be cleaned in some way known per se.

The following examples indicate the results which have been obtained by means of adhesive mixtures in accordance with the invention which have been used for seaming capacitor paper. Tables **1A, 1B,** and **1C** indicate results obtained by means of test capacitors made of capacitor paper in partial discharge measurements. The density of the capacitor paper used (Terox SHV) was 0.2 g per cu. cm and surface weight 18 g per sq. m. The number of insulation layers in the test capacitor was 5, capacitance 0.1 μF, impregnation agent (trichloride-phenyl) and one coil had **5** adhesive seams. The measurements of partial discharge were taken at the room temperature.

The test used for measuring the properties of partial discharge comprised the following steps:

1. The voltage of the test capacitor was increased to 5,400 V (**50** c/s) and maintained for 1 second.
2. The voltage of the capacitor was lowered to 2,500 V and maintained at this value for 10 minutes. The magnitude of the discharges was measured at the beginning and at the end of this period of time (Table 1.B., columns (*c*) and (*f*)).
3. The voltage was lowered to zero. If partial discharges appeared at the end of the period mentioned in section **2,** the extinguishing voltage of the partial discharges was measured while the voltage U_{sa} was lowered (Table 1.B., column (*g*)).
4. The voltage of the test capacitor was again raised to such an extent that the partial discharges were again ignited. The ignition voltage U_{sy} and the magnitude of the discharges at this voltage were noted down (Table 1.B., columns (*h*) and (*j*)). The voltage was raised **10** per cent above the ignition voltage and the voltage was lowered, and then the extinguishing voltage U_{sy} of the discharges was noted (Table 1.B., column (*i*)).

5. The test capacitor was loaded overnight at a voltage of 1,800 V and at room temperature. Hereupon the ignition voltage U_{sy} and the extinguishing voltage U_{sa} and the magnitude of the discharges were again measured (Table 1.C., columns (*k*), (*l*), and (*m*)).

Table 2 indicates the size distributions of the particle materials appearing in tables **1A, 1B** and **1C.** The percentage distribution of the numbers of particles with different particle sizes (μm) was established by means of an electronic microscope.

The adhesive mixture in accordance with the invention can of course be used for many different purposes. Besides the above seaming of capacitor paper, it can be used, for example, in connection with cable insulation and as an adhesive for various electrotechnical laminates. Moreover, the adhesive mixture in accordance with the invention can be used as the adhesive material for various electrotechnical tapes.

Table 1.A.

No.	Adhesive mixture Adhesive Adhes. mater. (a)	Adhes. solvent (b)	Particle material (c)	100 × quantity of particle mat. / Quantity of adhesive (d)
1	—	—	—	—
2	Methyl cell.	water	—	—
3	"	"	ZnO	200
4	"	"	"	470
5	"	"	"	670
6	"	"	"	1,330
7	"	"	Al_2O_3	200
8	"	"	"	470
9	"	"	"	670
10	"	"	"	1,000
11	Arabicum	"	—	—
12	"	"	ZnO	100
13	"	"	"	200
14	"	"	"	400
15	starch	"	ZnO	—
16	"	"	"	100
17	"	"	"	270
18	Methyl cell	"	Mica	70
19	"	"	"	200
20	"	"	"	330
21	Methyl cell.	"	SiO_2	100
22	"	"	"	170
23	"	"	SiC	330
24	"	"	"	670
25	"	"	"	1,000
26	Polycarbon.	Methyl chloride	—	—
27	"	"	ZnO	120

Table 1.B.

No.	Partial discharge properties Magnitude of discharges at beginning of 10 min period pc (e)	Magnitude of discharges at beginning of 10 min period pc (f)	U_{sa} (V) at end of 10 min period (g)	U_{sy} (V) (h)	U_{sa} (V) (i)	Magnitude of discharges pc (j)
1	169	—	—	3150	2124	233
2	2425	4150	305	757	337	405
3	400	380	775	900	750	159
4	67	38	1850	2600	2225	50
5	60	—	—	3000	2350	150
6	133	—	—	3315	2430	265
7	155	155	700	1100	900	53
8	19	—	—	3175	1650	370
9	27	—	—	3075	2140	130
10	27	—	—	3075	2075	190
11	1365	1690	645	875	635	240
12	56	56	650	840	600	44
13	1350	1100	570	770	620	37
14	170	155	2000	2500	2100	155
15	211	220	1112	1518	1185	78

Table 1.B.-continued

No.	Magnitude of discharges at beginning of 10 min period pc (e)	Magnitude of discharges at beginning of 10 min period pc (f)	U_{sa} (V) at end of 10 min period (g)	U_{sv} (V) (h)	U_{sa} (V) (i)	Magnitude of discharges pc (j)
	Partial discharge properties					
16	132	—	—	3000	2575	167
17	56	—	—	3160	2640	240
18	3100	3300	500	810	500	375
19	310	85	1000	2200	1785	107
20	680	680	840	1000	880	140
21	530	530	980	1100	880	170
22	49	—	2100	2885	2200	93
23	240	240	530	740	480	170
24	325	325	620	910	690	19
25	501	48	1800	2660	2040	133
26	552	786	982	1294	1044	302
27	141	42	2043	2420	2100	26

Table 1.C.

No.	Part. disch. prop. after night U_{sv} V (k)	U_{sa} V (l)	Magnitude of disch (pc) (m)	Remarks
1	2670	1768	148	No joint in the capacitor coil
2	675	495	183	
3	705	605	63	
4	1800	1350	86	
5	2400	1900	318	
6	2715	1970	64	
7	1100	900	15	
8	2655	1950	120	
9	2565	1985	56	
10	2275	1655	34	
11	1000	945	220	
12	790	690	56	
13	770	710	56	
14	2900	2100	170	
15	1620	1387	91	
16	2875	2365	96	
17	2950	2265	133	
18	740	635	310	
19	1375	1200	19	
20	840	700	31	
21	720	570	530	
22	2500	1870	62	
23	560	500	240	
24	695	620	107	
25	2410	1935	118	
26	1314	1184	903	
27	2380	1815	78	

I claim:

1. A glue mixture to be used in objects subject to strong electrical fields such as in glue splices of electrical capacitor tissues, comprising:
   a. a glue component selected from the group consisting of methyl cellulose, starch, arabium, dextrin and plastic adhesives; and
   b. particles of a poorly conducting substance mixed with the adhesive component,
      the particle content ranging from 50 to 5,000 per cent by weight of the adhesive material,
      the particle size ranging from 0.01 μm to a few micrometers, the particles being of a substantially uniform size, the cross-sectional contours of the particles being evenly curved, and
      the ratio of the maximum and the minimum dimension of the particles being less than 10 to 1.

2. A glue mixture as claimed in claim 1 wherein said particles are selected from the group consisting of metallic oxides and silicon oxide.

3. A glue mixture as claimed in claim 1, wherein the poorly conducting substance is an electrically insulating substance.

4. A glue mixture as claimed in claim 1, wherein the poorly conducting substance is a semiconductive substance.

Table 2

ZnO		Al_2O_3		SiO_2		SiC		Mica	
Particle μm size	%	Particle μm size	%	Particle μm size	%	Particle μm size	%	Particle μm size	%
0.1		0.3	14.1	0.1	16.0	4.0	12.5	1	64.0
0.2	4.4	0.6	24.2	0.2	16.0	5.0	12.5	2	22.4
0.3	8.9	1.0	35.9	0.3	4.0	6.0	25.0	3	7.6
0.4	8.9	2.0	14.8	0.5	20.0	7.0	12.5	4	2.0
0.5	11.1	3.0	6.2	0.6	8.0	8.0	25.0	5	2.0
0.6	11.1	4.0	2.4	0.7	4.0	9.0	12.5	6	0.7
0.7	15.7	5.0	2.4	0.9	4.0	10.0		8	1.0
0.8	8.9			1.0	8.0			13	0.3
0.9				1.1	8.0				
1.0	11.1			1.2	4.0				
1.1	4.4			1.3	8.0				
1.2	4.4								
1.3	6.7								
1.4									
1.5	4.4								
1.6									
1.7									
1.8									
1.9									
2.0									
Aver. 0.74		Aver. 1.24		Aver. 0.59		Aver. 6.62		Aver. 1.66	

5. A glue mixture as claimed in claim **1,** wherein said particle size is 0.2 to 3 μm.

6. A glue mixture as claimed in claim **1,** wherein the particle content is 100 to 1,500 per cent by weight of the adhesive material.

7. A glue mixture as claimed in claim **1,** wherein the particles are substantially globular.

8. A glue mixture as claimed in claim **1,** wherein the particles are of zinc dioxide.

9. A glue mixture as claimed in claim **1,** wherein the particles are of aluminum oxide.

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