Dust Figure in Liquid Insulator.

By

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Abstract.

A dust figure is obtained on the surface of an ebonite plate immersed in a liquid insulator, by dusting it after the application of voltage with a fine powder containing mixture of red lead and resin.

There is a relation between the size of the dust figure and the break down voltage of the liquid insulator.

(1). Introduction.

As there is a certain relation between a sparkover in gases and Lichtenberg's figure or the dust figure in the gases, some connection may exist between the break down phenomena of the liquid insulator and Lichtenberg's figure or the dust figure in the liquid insulator. The dust figure in the liquid insulator, mainly ordinary transformer oil, is here studied to throw light on the break down phenomena of the transformer oil.

(2). Dust figure in transformer oil by impulse voltage.

In order to dry the transformer oil, it is heated to 105°C—110°C for two or three hours, and then filtrated with a paper filter.

Electrodes and an ebonite plate are then immersed in the oil as shown in Fig. 1. (In Fig. 1, N is a needle electrode, P is a plate electrode, E is the ebonite plate, and M_1 C C W denotes the impulse generator). When an impulse voltage is applied between N and P, and the ebonite plate is then pulled out of the oil, an electric charge will remain on its surface. By sprinkling a fine powder containing a mixture of red lead and resin on the plate, and then washing it gently in gasoline a clear dust figure is produced.

Since the particles of the powder will become electrified by mixing, the positively electrified red lead will stick to the negatively electrified surface, and the negatively electrified resin will stick to the positively electrified parts. If the dusted surface is then washed in gasoline, the negatively charged part will look redish because of red lead, and the positively charged part will look yellowish white because of the resin.

An example of a positive dust figure in the oil is shown in Fig. 2, and that of a negative figure in Fig. 3. The crest value of the applied impulse voltage in both cases is 35 K. V.. By applying an impulse voltage of 35 K. V., the mean value of the radii of 15 positive figures was 7.13 m.m., and that of the negative figures was 4.62 m.m.. The ratio $R+/R-$ ($R+$ and $R-$ denoting the radius of positive and negative figure respectively) was 1.54.

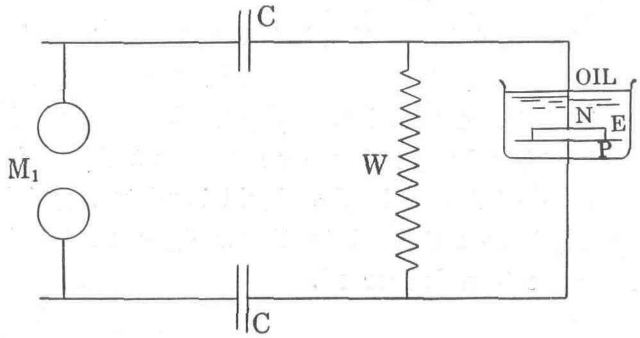

Fig. 1.

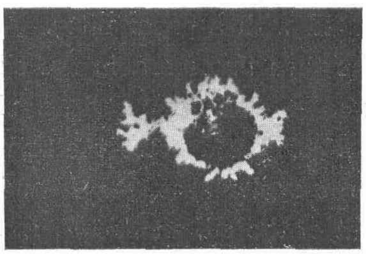

Fig. 2. Positive Figure
M_1=8 m.m.
Impulse Voltage max. 35.0 k.V.
Magnification, 1.5

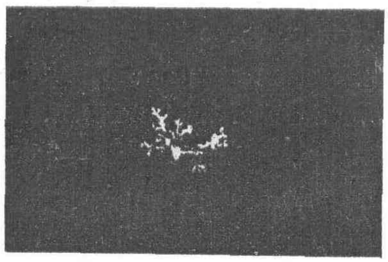

Fig. 3. Negative Figure
M_1=8 m.m.
Impulse Voltage max. 35.0 k.V.
Magnification, 1.5

As mentioned above, the diameter of the positive figure is larger than that of the negative figure. The reason for this fact may be explained somewhat in the following manner. When the impulse voltage is applied between N and P, the needle being the positive pole, the negative ions (including electrons) produced in the ionization by collision will move towards the needle, while the positive ions move radially outwards. Owing to the fact that the velocity of negative ions is greater than that of positive ions, the positive ions will remain near the needle N, so that the high potential gradient at the end of the needle will be weakened by the positive space charge. And the region of high potential gradient will move in time from the needle outwards, and the front of ionization by collision will proceed radially outwards along the ebonite surface. In other words, the potential gradient at the front of the ionization wave, spreading along the surface, will be much larger at a certain moment than the gradient electrostatically calculated.

In the case of a negative needle, the positive ions will remain at the end of the needle, so the ionization by collision may not proceed as in the former case. Accordingly, the radius of the positive figure is greater than that of the negative figure for the impulse voltage of the same intensity.

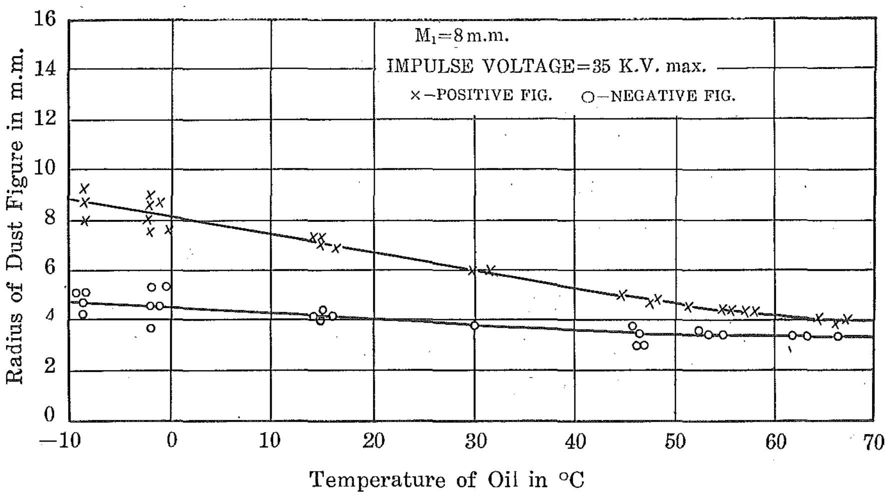

Fig. 4.

The radii of the positive and negative dust figures decrease with increasing temperature of the transformer oil, and the ratio $R+/R-$ also decreases with increasing temperature. But the form of the figure does not change. The experimental result is shown in Fig. 4.

The size of the positive and negative figures increases with decreasing atmospheric pressure. The case of a positive figure is shown in Fig. 5.

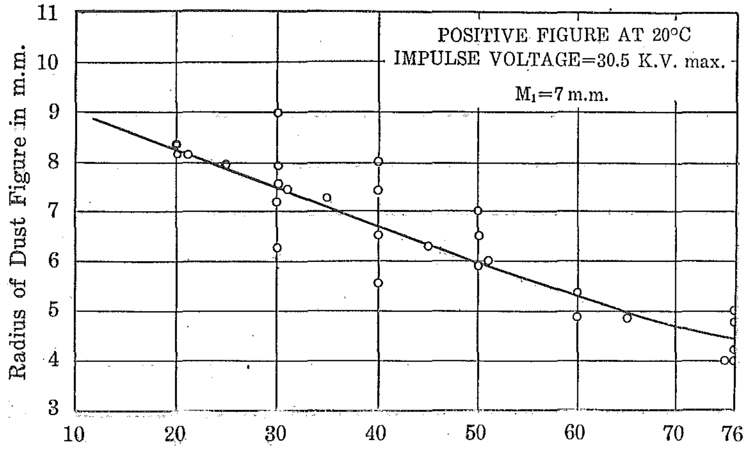

Fig. 5.

A comparison between the size of the dust figure in the oil and the break down voltage of the oil is as follows:—

(1). In the range of the temperature from −10°C to 70°C, the break down voltage of the oil increases with increasing temperature.

The size of the dust figure decreases with increasing temperature in the same range of temperature.

(2). The break down voltage of oil decreases with decreasing atmospheric pressure,(1) and the size of the dust figure increases with decreasing atmospheric pressure. Briefly, in the case of increasing break down voltage of the oil, the size of the dust figure in the oil decreases, and vice versa. Since the dust figure in the oil may be produced by the partial electric break down of the oil, the theory

(1) J. Sorge: Archiv für Elekt. Bd. 13 1924.

that there is a relation between the break down voltage and the dust figure is reasonable.

The conduction through the oil may be ionic or electrolytic. The break down voltage of the oil does not depend on the conductivity of the oil,(1) and neither does the size of the dust figure. The conductivity of the oil does not depend upon the atmospheric pressure.(2) However, the size of the dust figure changes with the atmospheric pressure. From the above two facts, it may be certain that the dust figure is not due to the ionic phenomena, but to the electronic phenomena. From the study of the dust figure it may be concluded that the break down of the transformer oil is a pure electric phenomena.

(3.) Dust figure in transformer oil by A. C. voltage.

The dust figure in the oil, applying A. C. voltage, can be obtained in the same process as in the case of an impulse voltage. An example of the figure when applying 20 K.V. eff. is shown in Fig. 6.

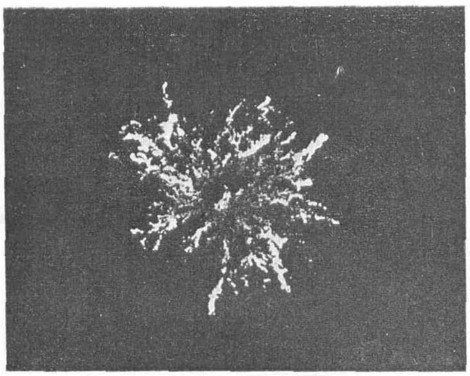

Fig. 6. Dust Figure by A.C.
Voltage eff. 20.0 k.V.
Magnification, 1.5

The radius of the dust figure increases almost linearly with the applied A. C. voltage.

(1) Y. Toriyama: Archiv für Elekt. Bd. 19. 1927.
(2) Nikuradse Zeitschrift für technische Physik. 1929. Number 12.

The relation between the radius of the figure and the applied voltage is shown in Fig. 7.

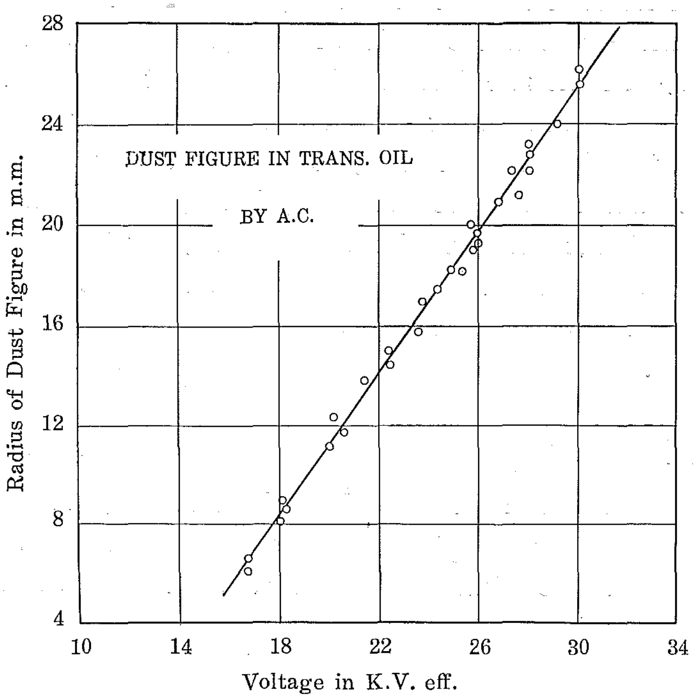

Fig. 7.

The size of the dust figure by A. C. voltage increases with decrease of the atmospheric pressure. When the oil is degased by evacuation, the change of the diameter of the figure due to variation of the atmospheric pressure is reduced evidently.