The results of the present investigations have shown that the general theoretical basis of polarography is applicable to ethylene glycol solutions, and that current-voltage curves obtained with the dropping mercury cathode in this medium exhibit no peculiar features.

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Incomplete Breakdown : a Cathode De-ionization Effect

CONSIDERABLE interest has been taken in the phenomenon of 'stepped' breakdown in the electric spark, and experimental investigations have been made, notably by Tamm[1] and others[2], using oscillographic records of the collapse of voltage across the gap. Studies have also been made by Raether[3] of the growth of the space charges in the gap, using the cloud-chamber method. These experiments were mainly concerned with short gaps of the parallel-plate type in air at reduced densities. In many practical applications of short spark gaps, however, high gas densities are required, and if similar effects are found to occur at these high gas densities, any 'stepping' of the voltage across the gap during the initial phase of the breakdown can have serious consequences in that complete breakdown of the gas insulation is prevented. The gap can thus develop an appreciable resistance in which considerable power may be dissipated. The occurrence of this effect would render the spark gap useless in those circuits which require sudden surges of high peak-current through a low-resistance path.

During a study of the properties of short gaps of the parallel plate type, I have investigated this effect at atmospheric pressures using tungsten disks as electrodes set about 0·2–0·5 mm. apart. The voltage across the gap was measured by means of a cathode ray oscillograph, but the resistance of the spark path was calculated indirectly. For this purpose the spark was made to excite oscillations in a tuned high-frequency oscillatory circuit to which was coupled another tuned circuit. Estimates of the resistance of the spark path during the initial collapse could then be made from measurements of the magnitude of the high-frequency potentials developed across the coupled circuit when the constants of the oscillatory circuits are known.

A typical oscillogram showing incomplete breakdown is given in Fig. 1, which shows two practically identical successive traces superposed. It is seen that the sparking potential fell from its initial value of 2·5 kV. to about half that value, and then recovered to follow the shape of the applied pulse of E.M.F. after the spark was extinguished due to excessive de-ionization. The estimates made of the gap resistance showed that this did not fall to the expected low value for this length of gap.

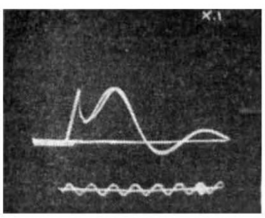

Fig. 1.

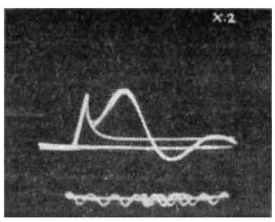

Fig. 2.

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In the preliminary experiments this effect was noticed only with clean electrode surfaces. However, it was found that if the electrodes were allowed to stand in air for some time after considerable sparking had taken place in the gap, then the resistance for subsequent sparks was low, and the oscillographic records showed that the voltage fall was not halted as before. Experiments were then made in which the electrodes were covered with a fine dust of various oxides, such as alumina or magnesium oxide, and it was found that complete breakdown could then be obtained. By examining the effects on each electrode separately, it was found that the state of the cathode surface rather than that of the anode was the controlling factor. Further, the particular state of the cathode surface which ensured complete collapse also tended to reduce the statistical time-lag of the gap on impulse breakdown. It is known that the presence of oxides like alumina can reduce the statistical lag of short gaps[4,5,6] by producing cathode emission, and the present experiments show that tungsten oxide can have a similar effect[7].

From these and other results, it was concluded that electron emission at or very near the cathode during the actual breakdown process of the spark discharge, and not, as is usually considered, during the pre-breakdown stages only, is necessary for the complete collapse of the discharge path resistance. Owing to the high current-density involved, and also owing to the low rise in temperature of the whole electrode even with recurrent discharges of about 300 per second, the mechanism of electron production at the cathode is probably that of auto-electronic emission.

When the cathode was clean and smooth, the electric field-strength at the surface just before breakdown in the gaps considered above was of the order of 10^5 V./cm., so that under those conditions auto-electronic emission was negligible, since the microscopic field was probably not very different from the macroscopic field. However, when with such electrodes a thermionic arc was allowed to follow the initial breakdown, the gap resistance was found to be low. Fig. 2, though slightly distorted, shows three traces superposed : two practically identical traces show incomplete breakdown as in Fig. 1, while the other shows the voltage fall right down to the arcing value (shown as a straight line). This showed that electron emission from the cathode, whether thermionic or auto-electronic, occurring throughout the breakdown process and not merely at the onset, maintained the spark until complete breakdown resulted ; for that reason such post-breakdown emission was probably essential. Further, any cutting off of this source of ionization at the cathode surface during breakdown then impedes the rise of current, and may even extinguish the spark.

This conclusion may have application to the electrodes of mechanical contact-making devices as well as to spark gaps used in electrical engineering.

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Particle Counts in the Ultramicroscope

WHEN using the type of ultramicroscope designed by Prof. Whytlaw-Gray[1] for the counting of particles in smoke and other aerosols, a stream of gas is passed intermittently through a glass cell of known dimensions, which is strongly illuminated. The number of particles which scatter light is noted each time the gas stream stops. The distribution of particle counts was found to follow a Poisson series very closely. Thus the number of times one would expect to find 0, 1, 2, 3 . . . *n* particles in the field is given by

$$Ne^{-\bar{x}}\left(1, \bar{x}, \frac{\bar{x}}{2\,!}, \frac{\bar{x}}{3\,!} \;\ldots\; \frac{\bar{x}^n}{n\,!}\right)$$

where N is the total number of fields counted and $\bar{x}$ is the average number of particles per field[2].

For example, when counting gum particles in coal gas, 143 fields were counted with an average number of particles per field of 1·44. The distribution found and calculated was as follows :

No. of particles in field	Number of times occurring Found	Calculated
0	34	34
1	46	49
2	38	35
3	19	17
4	4	6
5	2	2
6	0	0·4
	143	143·4

This observation may prove useful in checking particle counts. For example, on another occasion the agreement was not so good, the following results being obtained :

No. of particles in field	Number of times occurring Found	Calculated
0	81	78
1	121	136
2	121	119
3	93	68
4	17	30
5	6	11
6	6	3

Here it seems that several fields which really contained four particles have been noted as containing only three. Such a result may be due to faulty adjustment of the lighting, fatigue, etc., and a new count should be made.

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Anomalous Behaviour of Fused Cryolite

NATURAL cryolite (Na_3AlF_6), when fused in a platinum crucible, yields a typical 'wetting' melt, which gradually spreads over the interior of the crucible and may even creep over the edge. When minute amounts of lead, bismuth or thallium compounds are added, a remarkable and practically instantaneous change is observed in the nature of the melt, which becomes 'non-wetting' and forms a single large drop with sharply defined boundaries.

The effect is confined to compounds of the three metals mentioned (atomic numbers 81, 82, 83), although carbon produces a superficially similar effect due to the formation of a layer of carbon monoxide between the melt and the platinum surface. The phenomenon persists