ART. XV.—*On the Dissipation of Electricity in Gases;* by DEMETRIEFF BOBOULIEFF.

[Translated from the Journal of the Russian Chemical and Physical Societies, by CLEVELAND ABBE.]*

THERE are, according to the general statement, four forms of electrical discharge manifested in gases. Three of these are accompanied by luminous manifestations, and the sudden loss of electricity; these are the following:

1. Discharge as an electrical spark.
2. Discharge as a luminous sheet.
3. Discharge as a kind of diffused light (Glimmlicht).
4. A discharge without any light, and as a gradual slow loss; this latter case is called dissipation (rassyania, dêperdition, zerstreuung) of electricity.

Coulomb has paid special attention to this dissipation, and the circumstances affecting the investigation into the distribution of electricity on conducting bodies. He has given a formula expressing the connection between the quantities Q_0 and Q of electricity, found in a given body, at the beginning and the end of an interval, t, of time, during which the dissipation continues; which is

$$(1) \qquad Q = Q_0 e^{-\frac{t}{2p}}.$$

The quantity $\frac{1}{p}$ is called the coefficient of dissipation; when it diminishes, i. e., when p increases, then the dissipation is slower, and *vice versa.*

Coulomb, making his observations in ordinary moist air, observed that the quantity $\frac{1}{p}$ was very changeable. This might arise from the changes of temperature or of atmospheric pressure, and the pressure of the aqueous vapor. Coulomb paid special attention to the action of aqueous vapor, and expressed his opinion that $\frac{1}{p}$ varies as the cube root of the quantity of vapor contained in a given volume of air. Many others after him have engaged in experiments to determine this connection between the coefficient of dissipation and all the above quoted causes; but the results of these labors harmonize but very little.

I give here, in consecutive order, the conclusions of all the following savants:—

* I have to acknowledge the assistance of Mr. H. Kalusoski in the preparation of this somewhat free translation of M. Boboulieff's interesting memoir.—C. A.

Matteuci: Memoire sur la propagation de l'électricité dans les corps isolants, solides et gazeux. Annales de Chimie et de Physique, 3me Serie, vol. xxviii, pp. 385–429.

Dellmann: Ueber die Gesetzmässigkeit und die Theorie des Electricitätsverlustes. Zeitschrift für die Mathematik und Physik, von Schlömilch, Kahl und Cantor, xi, 1866, pp. 325-354.

Charault: Recherches sur la déperdition de l'électricité statique par l'air et les supports. Comptes Rendus, vol. l, pp. 108–111.

Warburg: Ueber die Zerstreuung der Elektricität in Gasen. Poggendorff's Annalen, B. cxlv, s. 578–599.*

1. *Of the Coulomb's Law expressed in the formula* (1).

Matteuci (p. 390) says: "The dissipation of electricity in pure and very dry air and gases† does not follow the formula and laws of Coulomb." He determined his law by experiments carried on in damp air; within certain limits, the dissipation is certainly not in proportion to the quantity of electricity "contained in the body."

Dellmann (p. 336): "The absolute dissipation is proportional to the density of the electricity; that is, it is according to Coulomb's law."

Charault: "The dissipation always follows Coulomb's law."

Warburg: "The dissipation of electricity in gases follows Coulomb's law."

2. *Influence of surrounding bodies.*

Matteuci (p. 389): The dissipation of the electricity depends upon the electric condition of the bodies found near the body under examination; the smallest loss is experienced when the neighboring bodies are charged with an electricity opposite to that in the body under examination.

Charault says: "The dissipation follows Coulomb's law in limited and unlimited spaces."

3. *The influence of the movement of the gases.*

Matteuci says (p. 386): "The dissipation does not increase when the air is in motion, but, on the contrary, it diminishes; and furthermore, this diminution is in proportion to the velocity of the movement of the air in relation to the body, and to the amount of the dissipation itself."

Dellmann (p. 345): "The dissipation does not depend on the motion of the air."

* Received in Russia while the author was engaged in making his own experiments on the subject.

† The electrical dissipation for an interval dt is, according to Coulomb's law,

$$dQ = -\frac{Q}{2p}\,dt.$$

4. *Influence of the size, configuration and conductibility of the body.*

Reiss* (pp. 111–113): "The dissipation does not depend on these circumstances."

Matteuci (p. 406): "The laws and the amount of the dissipation are independent of the matter of the bodies."

Dellmann (p. 344): "The dissipation does not depend on the size, form and matter of the electrified body." (p. 346): "The dissipation is the same in conductors and non-conductors."

5. *Influence of the kind of electricity.*

Biot, repeating Reiss's experiments, came to the same opinion,† "that the coefficient of dissipation does not depend on the sign of the electricity."

Matteuci (p. 408): "The dissipation and its laws are the same for both kinds of electricities, as well in dry gases as in the air; but in strongly charged bodies the negative electricity disappears much sooner."

Dellmann (p. 346): "The dissipation does not depend on the sign of the electricity."

Warburg (p. 599): "The dissipation of electricity of both signs is completed with the same rapidity."

6. *Influence of the temperature.*

Matteuci (p. 411): "In dry air the dissipation augments with increased temperature."

7. *Influence of humidity.*

Reiss‡ testifies: "That occasionally the dissipation diminishes with the increased dampness of the air."

Matteuci (p. 421): "In air of the same temperature, and under the same pressure, the dissipation increases with the quantity of suspended aqueous vapor; but this augmentation does not increase in proportion to the cube of the suspended vapors, as concluded by Coulomb from his too few experiments."

Dellmann (p. 541): "The dissipation does not depend on the percentage of moisture in the air, but on the quantity of the vapor included in one cubic foot of the air; and in proportion to the increase of this quantity, the dissipation increases."

Besides this, Dellmann adds: "that the dissipation is especially determined by the pressure of the aqueous vapor."

Charault says: "In dry air the coefficient of dissipation is very small compared with that for damp air. The coefficient increases with the increase of the dampness of the air, if the

* Die Lehre von der Reibungs electricität, Bd. i, s. 106–147.
† Riess, Bd. i, pp. 113–114.
‡ Reiss, Reibungs electricitat, p. 117.

quantity of vapor in the given volume remains the same. The coefficient of dissipation* increases with the increase of the quantity of vapor.

Warburg: "Damp air does not cause greater dissipation than dry air."

8. *Influence of the pressure.*

Matteuci (p. 415): "The quantity of electricity that may be retained on the surface of an isolated conductor depends on the density of the surrounding air. In a vacuum this quantity is nothing. The dissipation in dry air diminishes with the diminution of the density."

Warburg (p. 599): "The coefficient of dissipation sensibly diminishes when the pressure falls from 760^{mm} down to 380^{mm}, and at the pressure of 70^{mm} is less than one-third of what it was at 760^{mm}."

9. *Influence of various gases.*

Matteuci (p. 403): "In the air, hydrogen and carbonic acid, dry and pure, having the same pressure and temperature, the dissipation is the same."

Warburg: "Dissipation is the same in the air and carbonic acid, but in hydrogen one-half as great."

10. *Influence of tobacco smoke, etc.*

Dellmann (p. 346): "Dissipation diminishes in the presence of tobacco smoke."

Warburg (p. 594) supposes "that the hard particles floating in the air exercise some influence."

On my own part, on entering into the investigation of this same subject, relative to which I have quoted so many differing data, I was assisted by some theoretical conclusions which I think I can here explain.

Not only certain authorities in physical sciences, but even several specially devoted to electrical researches, sustain the view that electricity adheres only to the surface of conducting bodies by the counter-action or coöperation of the air in contact.† Such a theory would make us believe that in a vacuum the electricity meeting no force to oppose it would leave the surface of the electrified body, and would evaporate, as it were, in empty space until it extended to the walls of the enclosing cover or vessel, and subsequently be neutralized by contact with an electricity of an opposite sign. But many experiments

* Charault says, the dissipation in both cases decreases with the volume, thus:

$$a = \frac{1}{e^{2p}}.$$

† De la Rive, Traite de l'Electricité, T. i, p. 121.

tried at different times prove that gases even of the smallest density, and under the pressure of even less than 70^{mm}, can become under certain conditions conductors of electricity, and the first three of the above classes of electrical discharge may be observed through them;* but an absolute vacuum does not conduct electricity.†

On the other hand, it is impossible to deny all reaction on the part of the air, which is illustrated, for instance, by the movement of "Franklin's wheel."‡ But such a reaction may be derived from such atoms only as, after receiving electricity by contact with the electrified body, are repelled from it; of course, the magnitude of such reaction is very inconsiderable,§ but nevertheless it is accompanied by the other manifestation, that is, the loss of the electricity.

The atoms having received from the body a portion of its electricity, carry it away as they retire, and distribute it to other bodies, either electricized with an opposite electricity or having some direct connection with the earth. This constitutes in general the process of the loss of electricity by the agency of the gases, or the partial dissipation. Such, at least, is the opinion of almost all.‖ At present, when the new theory of the constitution of gases is accepted, such an explanation of the origin of electrical dissipation inspires hope that the subsequent development of electrical statics will aid in explaining the electrical manifestations observed in gases, and particularly the discharge of electricity, whether by sparks or by silent discharge; and the dependence of the electrical conductibility of the gases on the atmospheric pressure.

Accepting the hypothesis of atomic motions in gases, it will be easy to demonstrate that the dissipation of electricity depends on the pressure of the gas; and if we disregard certain circumstances we will find that,

1. Dissipation follows according to Coulomb's law.
2. The coefficient of dissipation, $\frac{1}{p}$, is inversely proportional to the square root of the absolute temperature of the gas.
3. That it is proportional to the pressure of the gas.
4. That it depends on the nature of the gas.

* Reiss, Reibungs electricität, B. i, pp. 39, 40; Morren, Pogg. Ann., B. 130, pp. 631, 633.

† Reiss, Rebungs electricität, B. i, pp. 39, 42; Alvergniat, C. R., Tome xlv, p. 963; Pogg. Ann., cxxxiii, p. 191; Wüllner, Pogg. Ann., cxxxiii, p. 509.

‡ In a vacuum this does not move.—Tomlinson, Phil. Mag. (4), xxvii.

§ Kötteritzsch attributes the amount of this reaction to a difference that exists between the results of the experiments of Harris and the computation of Thomson.—See Electrostatik von Kötteritsch, pp. 316–327.

‖ Reiss, Reibungs-electricität, vol. i, p. 108; Dellmann, Ueber die gesetzmässigkeit. . . . Zeitschrift f. Math., xi, pp. 348, 349; Matteuci, Memoire sur la propagation de l'electricité, Ann. de Chim. et de Phys. (3), T. xxvii, p. 171.

The new theory of the gases assumes that perfect gases are composed of atoms found in a state of perpetual motion. Each atom must be considered as a center of atomic force, whose tension diminishes in proportion to the separation of the atoms in such a manner that beyond the limits of a certain sphere the atomic force of the atom at its center becomes so insignificant that it can be considered to be nothing. This sphere is called the sphere of atomic action. The volume occupied by the sphere of any atom found in a given volume of gas is indefinitely small in comparison with the volume of the gas.

The motion of each atom is in a straight line and with a uniform velocity, and so continues as long as it does not bring the atom into contact with the sphere of another atom, or until one interferes with the action of the other; when this happens there results a change of motion of both atoms—a sort of concussion, after which each atom has a new direction and a new velocity. Such a concussion is similar to the striking of elastic balls, and is performed in an infinitely short time. The same thing is experienced in the concussion of particles or balls of any kind of hard bodies.*

If among such a collection of moving atoms there be placed an electrified body, the motion of all the atoms will change, because on each of them will operate a new force, the amount and direction of which will depend on the form of the electrified body, the quantity of its electricity, the distance of the atoms from its surface, and even the size of the atoms themselves; in general this force will attract the atoms to the body; but as these atoms are very small and the quantity of electricity in them almost nothing, therefore the force acting on the atoms will be very inconsiderable, and at a distance from the surface of the electrified body will be so insignificant that in the first moments of time the change in the motions will scarcely be marked, except for those atoms which come in contact with each other.

Let, for instance, the electrified body be a metallic ball whose radius $=\mathrm{R}$; the quantity of its electricity $=\mathrm{Q}$; each atom suffers an electrical induction depending on the action of the ball R, and the action of other neighboring bodies; omitting for the present the action of the last, we find that the force operating on the atoms (represented also by their radius$=r$) in the direction from the center of the atom to the center of the body, is equal to $\frac{d\mathrm{W}}{dc}$ where†

* Clausius: Abhandlungen über die Mechanische Wärme Theorie, II, pp. 235, 261; Maxwell, Illustrations of the Dynamical Theory of Gases, Part I. Phil. Mag. (4), xix, pp. 19, 20.

† Considering the state of distribution of the electricity on two spheres under the influence of minute electrical forces.

$$(2) \qquad W = -\frac{Q^2}{2}\left\{\frac{1}{R} - \frac{r^3}{c^4}\right\},$$

and c is the distance between the centers of the ball and the atom; the equation (2) is obtained by disregarding higher powers of the fractions, as for instance $\frac{r}{c^2-R^2}$ and $\frac{rR}{c^2-R^2}$; which is allowable only in case $(c-R)$ is much greater than r.

Let us now see what will be the effect of such a force on the duration of the interval between two consecutive concussions. To this end let the velocities be u_0 and u; the distances of the center of the atom from the center of the electrified conductor at the beginning and the end of the interval be c_0 and c; then if we consider the living forces we find

$$u^2 - u_0^2 = \frac{Q^2 r^3}{m}\left(\frac{1}{c^4} - \frac{1}{c_0^4}\right).$$

Let us put $c = c_0 \pm nl$ where $l = \frac{1}{10000}$ of a millimeter, or the average length of the path between the concussions of two atoms;* and n is an abstract number of such value that the ratio $\frac{nl}{c}$ represents a small fraction, so that we can put

$$\frac{1}{c^4} - \frac{1}{c_0^4} = \pm\frac{4nl}{c_0^5};$$

thus we have

$$(3) \qquad u^2 - u_0^2 = \pm\frac{4Q^2 r^3 nl}{mc_0^5}.$$

The quantity m, the mass of the atom, can be expressed thus:

$$m = \frac{P}{Ng} = \frac{1}{Ng}\cdot\frac{\delta d H}{(1+\alpha t)760};$$

where P is the weight of the unit of volume of the gas; N is the number of atoms in said volume; $\delta = 0{\cdot}001293$ milligram is the weight of one cubic millimeter of air at 0° C. and 760^{mm}; H is the actual pressure of the gas; t is the temperature; d is the density of the gas as compared with air; $g = 9800^{mm}$ is the force of gravity expressed as a velocity per second.

Furthermore,†

$$N = \frac{1}{\lambda^3} = \frac{3}{4}\cdot\frac{1}{\pi\rho^2 l};$$

where λ is the mean distance between the atoms; ρ is the radius of action of the atoms. If now we indicate by $\Delta = \frac{Q}{4\pi R^2}$ the density of the electricity, i. e., the quantity belonging to one

* Clausius, Abhandlungen, II, p. 325.

† Clausius, Abhandlungen, II, p. 272.

square millimeter of the surface, then we will be able to write formula (3) in the following form:

$$u^2-u_0^2=\pm 48\pi\frac{R^4}{c_0^4}\cdot\frac{r^3}{c_0\rho^2}\cdot\frac{g760(1+\alpha t)}{\delta\cdot d\cdot H}\Delta^2 n=$$

$$\pm 1142927000\frac{R^4}{c_0^4}\cdot\frac{r^3}{c_0\rho^2}\cdot\frac{760(1+\alpha t)}{d H}\cdot\Delta^2 n.$$

To show how insignificant is the second part of this equation, we will make the following disadvantageous suppositions:

$$r=\frac{\rho}{10};\ \rho=\frac{l}{10^3};\ \text{where } r=\frac{1}{16\times 10^7};\ c_0=R;$$

and lastly, if for simplicity we put $t=0$, $H=760^{mm}$, $d=1$, for which there results* $u_0=485\times 10^3$ millimeters, we obtain

$$u^2=u_0^2\left(1\pm\frac{\Delta^2 n}{R}\cdot\frac{311}{10^{16}}\right)$$

or

$$u=u_0\left(1\pm\frac{\Delta^2 n}{R}\cdot\frac{155}{10^{16}}\right).$$

If we put $R=10^{mm}$, $\Delta=10^3$, $n=10^5$, which correspond well to a very strong tension of the electricity† and to a length of the path nl of six millimeters, we then obtain

$$\frac{u}{u_0}=1+0{\cdot}00155.$$

This change in the velocities will correspond to a change in the temperature of 0°·8 C. It follows that during the first moments there will fall on the surface of the electrified body—

1. Such atoms as would fall on it in case it were not electrified, and in consequence of gravity alone.
2. Such as are very near to the surface.
3. Such as may from greater or less distances accidentally pursue their paths past each other without concussion.

After the first moment, during which the falling atoms become electrized, they retire from the surface of the body and meet the non-electrized atoms, and communicate to the latter a part of the electricity received from the body; hence many atoms will remain at the surface of the body, and they will be charged with the same kind of electricity. The force acting on such atoms will direct them *from* the surface of the body, while the force acting on the neutralized atoms will attract them *toward* its surface: the former will diminish the number of atoms falling toward the body; the latter will increase that number.

* Clausius, Abhandlungen, II, p. 255.

† Compare Weber and Kohlrausch, Maassbestimmungen, Zurückführung der Stromintensitäts Messungen auf Mechanisches Maass., p. 263.

As the result of these considerations we must admit that *during the slow dissipation of the electricity the number of atoms dropping on the surface of the electrified body is nearly such as is determined by the pressure and temperature of the gas found nearest to the surface.*

According to Maxwell* the number of atoms adhering in a given unit of time to a given unit of surface is

$$\int_9^\infty dn \int_0^n \frac{nl-z}{2nl} \cdot \frac{Nu}{l} \cdot e^{-n} dz = \frac{Nu}{4};$$

where l and u are respectively the mean length of path and the mean velocity of the atom; N is the number of atoms in the unit of volume of the gas; z is the coördinate whose axis is normal to the surface; n, an abstract number, either whole or fractional, included between zero and infinity.

The number of atoms falling in the elementary space of time dt on the element ds of the surface of the body will be

$$\frac{Nu}{4} ds\, dt;$$

hence the number of atoms dropping in the time dt on the whole surface of the sphere R will be

$$\pi N u R^2 dt.$$

Each atom on striking the sphere will receive a quantity g of electricity, expressed by the equation†

$$g = \frac{\pi^2}{6} \cdot Q \frac{r^2}{R^2};$$

consequently the ball in the time dt will lose a quantity of electricity equal to

$$\frac{\pi^3}{6} N u\, Q\, r^2\, dt;$$

that is to say,

$$dQ = -\frac{\pi^3}{6} N u\, Q\, r^2\, dt;$$

whence, assuming N and u to be constant, we obtain by integration the formula of Coulomb:

$$Q = Q_0 e^{-\frac{t}{2p}};$$

in which the coefficient of dissipation will be

$$\frac{1}{p} = \frac{\pi^3}{3} N u r^2.$$

* Maxwell, Illustrations, Phil. Mag., vol. xix, p. 29.

† Reiss, Reibungs electricitat, vol. i, p. 226.

In order to demonstrate the dependence of this expression on the pressure of the gas, we will make use of the following:*

$$u=485\times 10^3\sqrt{\frac{1+\alpha t}{d}};\qquad \mathrm{N}m=\frac{\delta d\mathrm{H}}{g\cdot 760\cdot(1+\alpha t)},$$

where the letters have the same meaning as before; we then obtain:

$$(4)\qquad \frac{1}{p}=\frac{\pi^3}{3}\cdot\frac{\delta}{g}\cdot 485\cdot 10^3\cdot\frac{r^2}{m}\cdot\frac{\mathrm{H}}{760}\cdot\sqrt{\frac{d}{1+\alpha t}},$$

that is to say, the coefficient of dissipation in one and the same gas increases in proportion to the pressure.

Taking this conclusion for my base,† I undertook to investigate experimentally the dependence of the coefficient of dissipation on the pressure and properties of the gas. The apparatus that I used was constructed in the following manner:

On the copper plate of an air pump was fixed a bell glass, with an opening in its upper part. Into this opening a diaphragm was adapted, having a sliding tube plastered carefully, through which passed a copper rod, having at its upper end a glass handle, and at its lower end a curved prolongation ending with a small sphere. To the diaphragm there was attached a silk thread, from which hung by the middle a little bar (MN) made of shellac, about 100^{mm} long and 1^{mm} diameter, having on one of its ends a little ball made of elder pith covered with gold leaf, and on the other a small leaf of mica; by the middle of this bar again was fixed, also of shellac, a little rod 40^{mm} long and 2^{mm} diameter, carrying at its lower end a short magnetized needle. (*mn*). The ball was immovable, and of the same diameter as the movable one. On the outside of the bell glass on a level with the bar was pasted a scale (BB) on thin paper, divided on both sides into degrees. The position of the bar was observed from a distance of 1·5 meters from the bell glass by bringing the eye into a line with the silk thread and the corner of the mica sheet.

The air or gases were introduced into the bell glass through five drying tubes, of which one was filled with small pieces of pumice stone, wetted with sulphuric acid, and another with chloride of calcium; under the bell glass stood a small vessel containing pieces of phosphoric acid. The experiments were performed only after the bell glass had been at least three times refilled with such air or gas.

The shaft or copper rod served to charge the balls, which before being charged touched each other; in this position the

* Clausius, Abhandlungen, II, p. 255.

† Dellmann comes to the same conclusions as to the quantity of water in the air. Zeitschrift für die Mathematik und Physik v. Schlömilch. Band xl, s. 348–352.

bar which supported the needle was in the magnetic meridian. When the balls are each charged with the same quantity of electricity, the bar MN will deviate by the angle a_0; then the moment of the repulsion of the electrical forces may be expressed thus:

$$\frac{Q^2}{4L^2 \sin^2 \frac{1}{2}a_0} L \cos \tfrac{1}{2}a_0;$$

and the moment of the magnetic force,

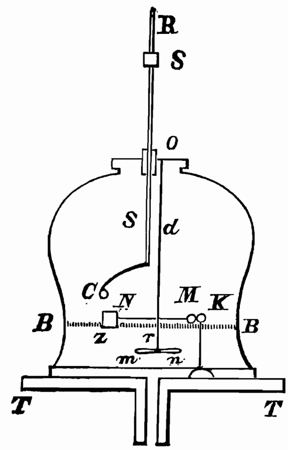
$$MT \sin a_0,$$

where L is the half length of the bar; M the magnetic moment of the needle mn, and T the intensity of terrestrial magnetism. Equating both expressions we obtain:

$$(5) \qquad Q_0^2 = 8MTL \sin^3 \tfrac{1}{2}a_0.$$

After the lapse of the time t, the quantity of electricity will become Q, and the angle of deviation will be a:

$$(6) \qquad Q^2 = 8MTL \sin^3 \tfrac{1}{2}a.$$



Eliminating the quantities Q and Q_0 from the equations (1), (5) and (6), we obtain:

$$(7) \qquad p = \frac{t \log e}{3(\log \sin \frac{1}{2}a_0 - \log \sin \frac{1}{2}a)}.$$

According to this formula I have computed p.

I am certain that each time I read the divisions on the paper scale BB, I could not make an error greater than one-half of a degree. The angle a_0 or a is the mean of four observed numbers; if in the neutral state of the balls I read the divisions X and X_1, and when they were electrified, the divisions Y and Y_1, then a is equal the half sum of the differences $X-Y$ and X_1-Y_1. In each of these four readings I could not commit an error of one-half of a degree; consequently the largest error in the determination of the angles $\frac{a}{2}$ and $\frac{a_0}{2}$ could amount only to $\frac{4}{4} \cdot \frac{1^\circ}{2} = \frac{1^\circ}{2}$.

If $\frac{1}{2}a$ and $\frac{1}{2}a_0$ be varied $\pm 30'$, then the log sin $\frac{1}{2}a_0$ and log sin $\frac{1}{2}a$ will vary, which I indicate thus:

$$\Delta \log \sin \tfrac{1}{2}a_0 \text{ and } \Delta \log \sin \tfrac{1}{2}a;$$

as a consequence of this, p will change to Δp; and we have

$$\frac{p+\Delta p}{p}=\frac{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}}{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}+\Delta\log\sin\frac{a_0}{2}-\Delta\log\sin\frac{a}{2}}$$

from this we obtain:

$$\frac{\Delta p}{p}=-\left[\frac{\Delta\log\sin\frac{a_0}{2}-\Delta\log\sin\frac{a}{2}}{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}}\right]+\ldots.$$

where we see that the term expressed in the parenthesis is less than unity.

In the worst case, when $\Delta\log\sin\frac{a_0}{2}$ and $\Delta\log\sin\frac{a}{2}$ have opposite signs, we have for the greatest value of $\frac{\Delta p}{p}$

$$(8)\qquad \frac{\Delta p}{p}=\pm\frac{\Delta\log\sin\frac{a_0}{2}+\Delta\log\sin\frac{a}{2}}{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}}$$

According to this formula I have computed the greatest possible error in the determination of the quantity p in my experiments; and have selected only those results in which $\frac{\Delta p}{p}$ is not more than 0·3: the rest I have rejected.

The electrical condition was maintained from eight to ten days, as for instance, from 30th June to 10th July, and in another case from 22nd June to 30th June.

The following are the results obtained:

I. *In dry air at the ordinary pressure.*

No.	Month.	Day.	Hour. P. M.	t	$\frac{a_0}{2}$ or $\frac{a}{2}$	$\frac{\Delta p}{p}$	p
1	July	12	1^h 38^m	----	7° 15′	----	----
	"	12	7 20	342^m	2 45	0·2	118
2	"	20	7 57	----	20 52·5	----	----
	"	21	1 40	1063	4 52·5	0·08	247
	"	21	3 37	1180	2 7·5	0·09	174
3	August	14	1 15	----	19 0	----	----
	"	14	3 34	139	15 30	0·28	238
	"	14	4 2	167	15 7·5	0·25	251
4	"	18	4 38	----	19 30	----	----
	"	18	7 5	147	13 45	0·17	144

II. *In dry hydrogen under the ordinary pressure.*

No.	Month.	Day.	Hour. P. M.	t	$\frac{a_0}{2}$ or $\frac{a}{2}$	$\frac{\Delta p}{p}$	p
1	July	13	4h 30m	----	13° 0′	----	----
	"	14	1 0	1230m	7 30	0·17	753
2	"	22	3 40	----	17 30	----	----
	"	23	12 50	1270	12 0	0·18	1147
	"	23	3 10	1410	11 15	0·16	1086
	"	23	6 37	1617	10 15	0·14	1027
	"	24	12 27	2693	3 22·5	0·10	542
3	"	26	2 25	----	14 7·5	----	----
	"	26	8 3	458	11 22·5	0·35	716

III. *In dry air at pressures between* 24mm *and* 50mm.

No.	Month.	Day.	Hour. P. M.	t	$\frac{a_0}{2}$ or $\frac{a}{2}$	$\frac{\Delta p}{p}$	p	Pressure.
1	June	30	4h 0m	----	12° 30′	----	----	24mm
	July	1	4 0	1440m	9 15	0·3	1613	--
	"	2	1 30	2730	8 22·5	0·24	2297	--
	"	3	12 45	4125	7 15	0·18	2549	--
	"	4	2 10	5650	6 22·5	0·17	2822	25
	"	5	1 0 P.M.	7020	5 7·5	0·14	2644	--
	"	6	11 40 A.M.	8380	4 7·5	0·13	2536	28
	"	7	12 30 P.M.	9870	2 37·5	0·14	2118	32
	"	8	1 15	11355	1 45	0·15	1933	34
2	"	29	2 0	----	6 45	----	----	25
	"	30	2 46	1486	3 52·5	0·3	895	45
3	August	5	4 1	----	13 30	----	----	23
	"	6	1 4	1263	8 7·5	0·2	879	55
4	"	7	2 42	----	16 7·5	----	----	48
	"	8	12 57	1335	10 45	0·18	1117	55
	"	9	1 9	2787	5 52·5	0·1	937	65
5	"	15	4 33	----	15 30	----	----	34
	"	16	3 13	1360	10 52·5	0·2	1302	40
	"	17	2 34	2761	7 37·5	0·13	1312	45
	"	18	3 15	4242	3 52·5	0·11	1028	50
6	"	19	2 30	----	13 0	----	----	34
	"	20	6 6	1356	9 0	0·2	1244	35

The mean of Series

I, Air under pressure of 760mm, $p=210$

II, Hydrogen under pressure of 760mm, $p=878$

III, Air under pressure of 30–50mm, $p=1700$

I conclude from this:

1. That the dissipation of electricity in air (and other gases) diminishes with the diminution of the pressure.

2. That the dissipation in hydrogen is less than in air [at the same pressure].