$$I_1 = nC(E - RY) + nY(T - \tau) + n\int_0^\tau y_1 dt. \qquad (8)$$

Now it should be noted that the quantity nT is independent of the speed, since the geometrical dimensions of the commutator, which is of the rotating type, are fixed. The value of nT is $1/p$, — this quantity $1/p$ being the part of the whole circumference of the commutator occupied by the charge segment. Replacing nT by its value $1/p$, we have

$$I_1 = \frac{Y}{p} + n\{CE - RYC - Y\tau + \int_0^\tau y_1 dt\}. \qquad (9)$$

In equation (9) τ is arbitrarily defined as the time for a practically complete charge. Let us be a little more specific and suppose that τ is of such value that when substituted for t in the exponential expression $e^{-\frac{t}{RC}}$ it reduces this exponential to .006. This would make the charge complete so far as measurements of the accuracy of the present experiment would show. If

$$e^{-\frac{\tau}{RC}} = .006,$$

$$\tau = 5RC \text{ (by tables of exponentials).} \qquad (10)$$

With this definition of τ equation (9) becomes

$$I_1 = \frac{Y}{p} + n\{CE - 6RYC + \int_0^{5RC} y_1 dt\}. \qquad (11)$$

This is the equation of current-reading of the galvanometer in the leads to the crystal during *charge*.

Let us next examine briefly the theoretical problem of the *discharge* of the crystal condenser.

A mathematical treatment similar to that of the charge shows that the current-reading of the galvanometer in the discharge circuit, if there are n discharges per second, is

$$I_2 = nCE_0 - n\int_0^{5RC} y_2 dt, \qquad (12)$$

in which y_2 is the leak current during discharge and E_0 is the potential of the condenser at the beginning of the discharge. The potential

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of the condenser at the beginning of the discharge is less than E the applied e. m. f. for two reasons; first, because on account of the leak, the crystal was not charged to the applied e. m. f.; and second, because there has been a small loss of charge during the insulation time while the commutator was changing from charge to discharge.

As may be seen by reference to equation (5) the deficiency of potential due to the first of these causes is RY. The fall of potential due to the second of these causes is $\frac{1}{C}\int_0^{T_2} y_3 dt$, in which y_3 is the leak current during insulation, and T_2 is the length of time of the insulation period during each cycle. Therefore the current reading of the galvanometer in the discharge circuit is

$$I_2 = n\left\{CE - RYC - \int_0^{T_2} y_3 dt - \int_0^{5RC} y_2 dt\right\}. \tag{13}$$

This is the exact equation on *discharge*.

As an approximation let us suppose that the leak current during insulation was constant and equal to its value at the end of the preceding charge. This is approximately true, because the insulation time was short. With the approximation we have

$$n\int_0^{T_2} y_3 dt = nYT_2 \tag{14}$$

$$= \frac{Y}{m},$$ in which $\frac{1}{m}$ is the part of the commutator circumference occupied by the insulation segment. With this approximation equation (13) becomes

$$I_2 = -\frac{Y}{m} + n\left\{CE - RYC - \int_0^{5RC} y_2 dt\right\}, \quad \text{(approx.)} \tag{15}$$

in which the first term Y/m is a little too large.

Examination of the Data of Experiment I.

In order to compare the data of Experiment I. with the theoretical equations for charge and discharge current derived above, let us write the charge equation (11) in the form

$$I_1 = \frac{Y}{p} + nEC'_1, \tag{16}$$

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in which C'_1 is related to the capacity C by the equation

$$C = \frac{C'_1}{1 - \frac{6RY}{E} + \frac{1}{CE}\int_0^{5RC} y_1 dt}. \tag{17}$$

Likewise writing the discharge equation (15) in the form

$$I_2 = -\frac{Y}{m} + nEC'_2, \tag{18}$$

in which C'_2 is related to the capacity C by the equation

$$C = \frac{C'_2}{1 - \frac{RY}{E} - \frac{1}{CE}\int_0^{5RC} y_2 dt}. \tag{19}$$

Let us now tabulate the values of C'_1 and C'_2 obtained from the experimental data. These quantities which we shall call approximate values of capacity are obtained by dividing the coefficients of n of the equations of Table II. by the corresponding values of E, and are collected in Table III.

In the attempt to get a nearer approximation to the capacity in terms of these coefficients C'_1 and C'_2, it should be noted that the integral terms of equations (17) and (19) are greater than would be obtained by putting y_1 and y_2 respectively equal to zero, and are less than would be obtained by setting y_1 and y_2 equal to their greatest value Y; whence it may be seen from equation (17) and equation (19) respectively that

$$\frac{C'_1}{1 - \frac{6RY}{E}} > C > \frac{C'_1}{1 - \frac{RY}{E}}, \tag{20}$$

and

$$\frac{C'_2}{1 - \frac{6RY}{E}} > C > \frac{C'_2}{1 - \frac{RY}{E}}, \tag{21}$$

in which C is the capacity.

It is, therefore, evident that C, the capacity of the crystal, is greater than the coefficients C'_1 or C'_2 of Table III.

In the attempt to ascertain whether or not the resistance terms could influence the coefficients sufficiently to account for the large

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excess of these coefficients with B positive over the corresponding values of A positive, or whether on the other hand it is necessary to assume different capacities in the two opposite directions, we have computed approximate values of the integrals in the denominators of equations (17) and (19). These computations were made by omitting

TABLE III.

Applied Voltage E, Volts.	Approximate Value of Capacity of Specimen I.			
	With A Positive.		With B Positive.	
	C'_1 Farads Charge.	C'_2 Farads Discharge.	C'_1 Farads Charge.	C'_2 Farads Discharge.
.2	$.560 \times 10^{-8}$	$.550 \times 10^{-8}$	$.600 \times 10^{-8}$	$.600 \times 10^{-8}$
.4	.562	.560	.612	.615
.6	.555	.580	.623	.623
.8	.503	.600	.603	.681
1.0		.585		.666
1.2		.560		.656
1.4		.520		.632
average	.545	.565	.619	.639

second-order effects and assuming that the electromotive force on charge is $v_1 = E(1 - e^{-\frac{t}{RC}})$, and on discharge $v_2 = Ee^{-\frac{t}{RC}}$. With these values of the e. m. f. as functions of t/RC and with the steady current-voltage curves of Figures 3 and 4, y_1 and y_2 were plotted as functions of t/RC and integrated by measuring areas, with the result, which is only an approximation, that on charge [3]

$$C'_1 = C\left(1 - \frac{2.6R}{\rho}\right), \tag{22}$$

[3] An independent investigation of the problem imposing the condition that the leak resistance obey *Ohm's law* (i. e. is independent of voltage) leads also exactly to equation (16) for charge and to equation (18) for discharge, with, however, $C'_1 = C'_2 = \dfrac{C}{\left(1 + \frac{R}{\rho}\right)^2} = C\left(1 - \frac{2R}{\rho}\right)$, approximately.

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and on discharge

$$C'_2 = C\left(1 - 1.5\frac{R}{\rho}\right), \tag{23}$$

in which R is the resistance from the impressed e. m. f. into the condenser, and ρ is equal to Y/E and is the resistance to steady e. m. f. of the circuit from the source of e. m. f. through the leads and through the plates and dielectric of the condenser. The resistance ρ is a function of E and is smaller the greater E is.

These equations are consistent with the fact that the coefficient C'_2 on discharge is greater than the coefficient C'_1 on charge. This is seen from Table III. to be true both for A positive and for B positive. Now the current-voltage curves of Figures 3 and 4 show that ρ is smaller for A positive than for B positive. This would make the coefficients for B positive smaller than those for A positive, whereas the converse is the case. In order to explain this discrepancy it is necessary to suppose either

(1) that the capacity of the crystal condenser is actually greater in direction B positive than in the opposite direction, or

(2) that the resistance R is also a function of E and decreases with increasing E more rapidly than ρ does.

The second of these propositions is entirely consistent with previous experiments with carborundum crystals, which showed that if the electrodes were plated to the specimen a large part of the dependence of resistance on current disappeared.

We cannot, however, be sure that the apparent inequality of capacity in the two opposite directions is entirely an effect of leak current; for we give next data obtained with another specimen with which the leakage through the crystal is almost entirely absent, and yet the capacity given by the measurements is different in the two opposite directions.

Experiment II. Specimen with very Small Leakage.

Mounting in Wood's Metal. — This specimen of carborundum was mounted in a metallic cup in a matrix of Wood's metal. The Wood's metal which served as a solder was placed in the cup and was melted. The specimen was pushed into the molten solder and held with all but its upper face submerged until the solder solidified, forming a close-fitting mold about the specimen. The cup served as one electrode. The other electrode was a pointed brass rod brought down upon the crystal and held by a spring. The cup containing the specimen was

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TABLE IV.

Data in Measurement of the Capacity of Specimen II.

No. of Charges or Discharges per Second, n.	Impressed e. m. f. E. in Volts.	Current in Amperes × 10^{-7}.			
		Point Positive.		Point Negative.	
		Charge.	Discharge.	Charge.	Discharge.
11.0	.3			.787	.787
	.6	1.43	1.43	1.66	1.64
	.9	2.07	2.06	2.71	2.54
	1.2	2.68	2.66	4.48	3.52
16.7	.3			1.16	1.16
	.6	2.14	2.14	2.46	2.43
	.9	3.18	3.17	3.98	3.81
	1.2	4.05	4.03	6.20	5.34
22.5	.3			1.59	1.59
	.6	2.92	2.92	3.30	3.27
	.9	4.30	4.29	5.41	5.22
	1.2	5.61	5.59	8.04	7.26
30.9	.3			2.16	2.16
	.6	3.97	3.97	4.42	4.39
	.9	5.92	5.89	7.17	7.02
	1.2	7.64	7.60	10.7	10.0
38.3	.3			2.60	2.60
	.6	4.81	4.78	5.40	5.37
	.9	7.15	7.15	8.72	8.54
	1.2	9.18	9.10	12.75	12.08
46.2	.3				
	.6	5.67	5.67	6.37	6.33
	.9	8.30	8.34	10.17	10.00
	1.2	10.67	10.67	14.76	14.10
54.6	.3			3.48	3.38
	.6	6.41	6.40	7.35	7.34
	.9	9.50	9.50	11.41	11.27
	1.2	12.50	12.30	16.45	15.85

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carried by a mechanical microscope stage, so that the specimen could be moved around under the point terminal until a point of contact that gave the capacity effect was located by the capacity measurements. The pressure of the point electrode was then increased so as to avoid accidental disturbance of the connections during the measurements of capacity.

Data. — Current-readings on charge and discharge were taken with the crystal charged so that the point electrode was positive and then with the point electrode negative. Table IV. contains the record.

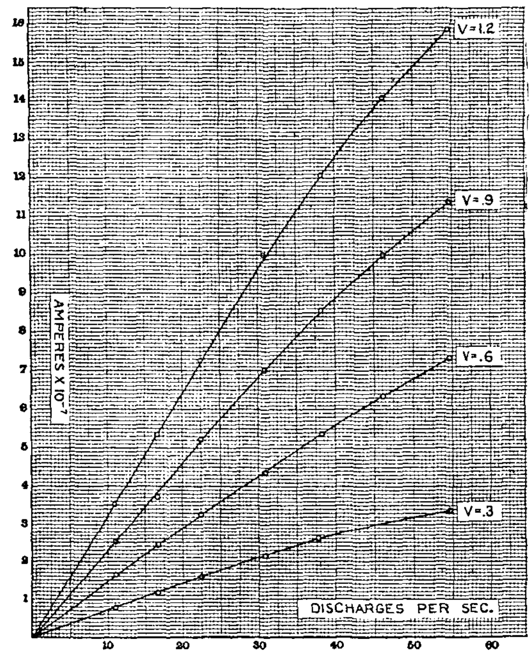

FIGURE 10. Point negative. Discharge current *vs.* n, for various applied voltages v.

By a reference to Table IV. it will be seen that with the crystal charged so that the point was positive this specimen gives the same current on discharge as on charge. With this direction of charging *the crystal condenser shows practically no leak.* Table V., which contains the steady current-voltage data for this specimen, shows also that with this direction of application of the e. m. f. the crystal lets through only $.09 \times 10^{-7}$ amperes at 1.2 volts. With the e. m. f. applied in the opposite direction (point negative) the charge and dis-

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charge currents (Table IV.) differ by about 5 per cent, at the highest voltage, 1.2 volts. At .9 volts, and lower, this difference is one per cent or less. With the point negative the steady current at 1.2 volts amounts to 1.79×10^{-7} amperes as is seen in Table V. Therefore the crystal with the point charged negative is not non-leaky as with the opposite direction of charging, but the leak is so small as to make the analysis of the problem much more satisfactory than with Specimen I.

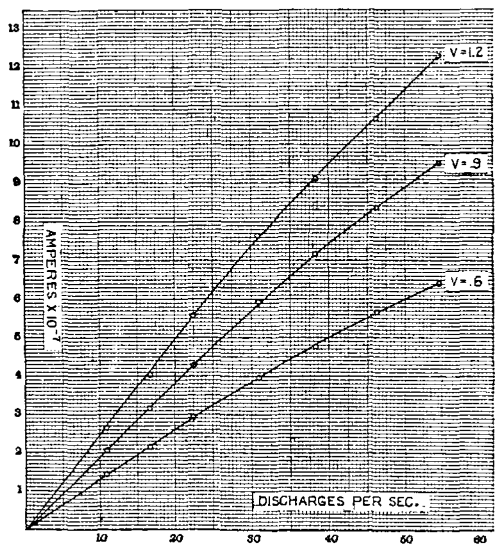

FIGURE 11. Point positive. Discharge current *vs.* n, for various applied voltages v.

Figures 11 and 10 show the discharge current plotted against n, the number of discharges per second, obtained with point positive and point negative respectively. The corresponding charge curves depart so slightly from the discharge curves that they are not here reproduced.

All of the charge and discharge curves for this specimen pass through the origin. This is a result such as one obtains with an ordinary condenser possessing no leakage.

The curves all droop at higher values of n, but are nearly straight for small values of n. Now this fact is in agreement with results obtained with good condensers provided they possess such high resistance in the charge or discharge circuit that the charge and discharge are incomplete. It is interesting that the treatment of the experimental curves of Figures 10 and 11 as due to a condenser with incomplete

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charge and discharge leads to the result that the capacity is independent of n but is dependent, as in Experiment I., upon the magnitude and *direction* of the impressed e. m. f. We shall give a brief derivation of the formula for multiple incomplete charge and discharge.

Sketch of Theory of Multiple Incomplete Condenser Discharge.

Let a condenser of capacity C be alternately charged and discharged through a resistance R which is so great as to permit only a partial charge or discharge in the time T of one connection of the condenser into the charge or discharge circuit.

Let the applied e. m. f. on charge be E, and suppose that the charge and discharge have been repeated until a final state is reached.

Let q_1 = quantity of electricity in the condenser at the end of a charge,
q_0 = the quantity in the condenser at the end of a discharge.

If we write down the differential equation for the quantity in the condenser on charge and integrate it subject to the conditions of the problem, we obtain

$$q_1 = q_0 e^{-\frac{T}{RC}} + CE\left(1 - e^{-\frac{T}{RC}}\right). \tag{24}$$

Similarly from the differential equation for discharge we get

$$q_0 = q_1 e^{-\frac{T}{RC}}. \tag{25}$$

Eliminating between equations (24) and (25) we have

$$q_1 = \frac{CE}{1 + e^{-\frac{T}{RC}}}.$$

$$q_0 = \frac{CEe^{-\frac{T}{RC}}}{1 + e^{-\frac{T}{RC}}}.$$

The quantity of electricity flowing into the condenser during one charge, or out of the condenser during one discharge, is

$$q = q_1 - q_0 = CE\frac{1 - e^{-\frac{T}{RC}}}{1 + e^{-\frac{T}{RC}}}. \tag{26}$$

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This equation by expansion becomes

$$q = CE\,(1 - 2e^{-\frac{T}{RC}} + 2\,(e^{-\frac{T}{RC}})^2 - 2\,(e^{-\frac{T}{RC}})^3 + \ldots). \quad (27)$$

If we may neglect $2\,(e^{-\frac{T}{RC}})^2$ in comparison with unity, equation (27) becomes

$$q = CE\,(1 - 2e^{-\frac{T}{RC}}) \qquad \text{approximation.} \quad (28)$$

If there are n charges per second, the current-reading of a galvanometer in the charge or discharge circuit is

$$I = nq,$$

and the time of charge or discharge is

$$T = \frac{1}{pn},$$

where $1/p$ is the fraction of the circumference of the commutator occupied by the charge segment or discharge segment, the two being equal.

With these substitutions equation (28) becomes

$$I = nCE\,(1 - 2e^{-\frac{1}{pnRC}}). \quad (29)$$

With the commutator used in these experiments $1/p$ was .48, whence

$$I = nCE\,(1 - 2e^{-\frac{0.48}{nRC}}). \quad (30)$$

Examination of the Data of Experiment II.

The curves of discharge current of Figures 10 and 11 with current plotted against number of discharges per second are accurately described by equation (30), as may be seen by reference to Tables VI. and VII., which contain a comparison of observed and calculated values.

The equations of Table VIII. were obtained as follows : Consistent with the theoretical equation (30), the slope of each of the curves of Figures 10 and 11 was taken at the origin. This slope is the coefficient of n in equation (30), and the corresponding coefficient in Table

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VIII. Having obtained the slope term, the exponential was next obtained by assuming the upper end point of one of the experimental

TABLE V.

Steady Current-Voltage Characteristic of Specimen II.

E. m. f. Volts.	Current in 10^{-7} Amperes.	
	Point Positive.	Point Negative.
.3	.004	.012
.6	.02	.083
.9	.04	.45
1.2	.09	1.79
1.5	.165	6.13

curves to satisfy equation (30). This gave the exponent $-165/n$, and by trial the same exponent was found to apply approximately to all of the other curves. That is, all the equations of Table VIII. were ob-

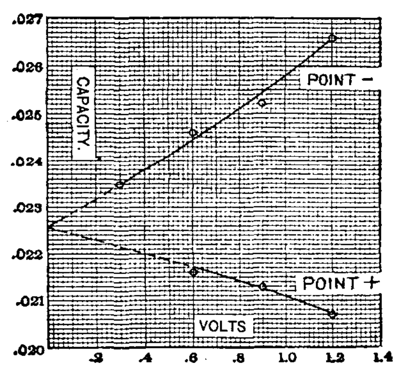

Figure 12. Capacity in microfarads of Specimen II. for different values of applied e. m. f.

tained by employing the slope at the origin of each of the experimental curves, and in addition assuming the exponential equation to be correct for one other point of one of the curves. All of the points of all the curves were then found to be closely given by the equations so derived.

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The conclusion is that the droop of the several curves of Figures 10 and 11 may be reasonably explained as due to incompleteness of charge and discharge. On this assumption it will be seen that the capacity of the crystal, obtained by dividing the coefficients of the equations of Table VIII. by the corresponding values of E, are functions of the applied

TABLE VI.

DATA OF EXPERIMENT II. COMPARED WITH EQUATION (30).

No. of Discharges per Second, n.	Point Positive. Discharge Current in 10^{-7} Amperes.					
	E = .6.		E = .9.		E = 1.2.	
	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.
11.0	1.43	1.43	2.06	2.11	2.66	2.73
16.7	2.14	2.15	3.17	3.17	4.03	4.09
22.5	2.94	2.94	4.29	4.32	5.59	5.58
30.9	3.97	3.99	5.89	5.90	7.60	7.62
38.3	4.78	4.85	7.15	7.18	9.10	9.26
46.2	6.40	6.42	9.50	9.50	12.30	12.30

e. m. f. and of the direction of charge, while the product of R by C, as given by the exponent, is constant. These quantities are collected in Table IX., and plotted in the curves of Figure 12.

The curves of Figure 12 show that the capacity, as given by equation (30), is changed by a mere reversal of the direction of charge. The capacity is the greater when the point electrode is negative, and with this orientation the capacity increases with increase of applied e. m. f. With the opposite direction of application of e. m. f. the capacity is less and decreases with increasing applied e. m. f.

Whether this result is evidence of a unilateral dielectric constant of the carborundum — which seems improbable — or whether the result is due to an imperfect comprehension of the various factors that may enter into the phenomenon and appear in the final coefficient as capacity, we are at present unable to say.

Among the various factors neglected in the mathematical discussion of the data there is the possibility that heat effects may be important. It looks at first glance as if a thermoelectromotive force at the junction

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of the electrode with one of the laminae of the crystal might aid the charge in one direction of charge and hinder it with the opposite direction of charge, and might, hence, cause differences in the capacity coefficients in the two directions, and might also account for the form of the curves of Figure 12. We have submitted the thermoelectric hypothesis to a mathematical treatment, assuming that both Joulean

TABLE VII.

Data of Experiment II. Compared with Equation (30).

No. of Disch. per Sec., n.	Point Negative. Discharge Current in 10^{-7} Amperes.							
	E = .3.		E = .6.		E = .9.		E = 1.2.	
	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.	Calc.
11.0	.78	.77	1.64	1.59	2.54	2.52	3.52	3.52
16.7	1.16	1.17	2.43	2.42	3.81	3.80	5.34	5.35
22.5	1.59	1.58	3.27	3.26	5.22	5.11	7.26	7.20
30.9	2.16	2.22	4.39	4.58	7.02	7.17	10.00	10.10
38.3	2.60	2.61	5.37	5.38	8.54	8.45	12.08	11.92
46.2			6.33	6.32	10.00	9.95	14.10	14.30
54.6	3.38	3.48	7.34	7.18	11.27	11.25	15.85	15.85

heat and Peltier heat act at the junction of one of the electrodes with the crystal, and have arrived at the result

(1) That the assumption of Joulean heat alone in combination with capacity gives a capacity coefficient that is *the same in the two opposite directions, and for both directions the effect of the heat term is to make the capacity coefficient diminish with increasing applied e. m. f.*

(2) Peltier heat and Joulean heat, if both present in combination with the capacity, would give different capacity coefficients in the two opposite directions, but the effect of the heat would still manifest itself as *an apparent decrease of capacity with increase of applied e. m. f. for both directions of application of the e. m. f.*

Neither of these results is in complete accord with the experimental facts.

Various other possible explanations of the apparent unilateral capacity of the crystal condenser have suggested themselves, but we have

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decided to make further measurements before entering into an attempt to consider more of the factors of the problem.

Specimen with Soldered Attachment under Test. — We have succeeded in soldering on the electrodes to one specimen now under test, and are able to preserve the condenser for a more extensive study of its characteristics. Up to the present this study has not added any-

TABLE VIII.

EQUATIONS USED IN CALCULATING VALUES IN TABLES VI. AND VII.

E.	Point Positive. Equation.	Point Negative. Equation.
.3	....	$I = .0703 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$
.6	$I = .13 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$	$I = .144 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$
.9	$I = .192 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$	$I = .227 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$
1.2	$I = .248 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$	$I = .320 \times 10^{-7} \times n\,(1 - 2e^{-\frac{165}{n}})$

thing to the results given above. The new condenser leaks badly in one direction but very little in the opposite direction of charge. We are putting it through an ageing process before submitting it to final measurement.

MICROSCOPIC AND ELECTRICAL EXPLORATION OF THE SPECIMENS.

Illumination and Magnification. — Plate I. contains some micrographs of fragments of the crystals. These pictures — which are reproduced with a magnification of 20 diameters — were obtained by reflected light, with the aid of an illuminating objective. The light, which entered the side of the objective, was reflected downward by a prism so that it fell nearly perpendicularly upon the face of the crystal. This vertical illumination from above is most favorable for showing the stratifications in the crystals. Viewed by transmitted light the characteristics are hardly discernible.

Micrograph *a*, Plate I, shows two of the crystallographic angles of the carborundum crystal. The distance between these two vertices is 1.6 mm., and will serve as a convenient standard of reference for the dimensions of the other pictures, which were magnified to the same scale.

Conducting and Insulating Strata. — Micrograph *c* shows very clearly the characteristic stratification, which we have found to be the founda-

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tion of the electrostatic capacity of the carborundum. The black lines running in a general horizontal direction across the surface of the specimen are outcroppings of conducting dykes of the crystal; while the white spaces separating the black lines are outcroppings of the insulating matrix in which these dykes are imbedded. The lines which

TABLE IX.

Values of C, RC, and R for Specimen II.

Applied e. m. f. E.	Capacity C, in Micro-farads.	RC in Ohm-farads.	R in Ohms.
For Point Positive			
.6	.0216	.0029	1.34×10^5
.9	.0213	.0029	1.36
1.2	.0207	.0029	1.40
For Point Negative			
.3	.0234	.0029	1.24×10^5
.6	.0246	.0029	1.18
.9	.0252	.0029	1.14
1.2	.0267	.0029	1.08

are black and white in the pictures are really merely *differently colored* in the crystal. The white regions are generally a transparent blue in the crystals, and the regions reproduced as black are usually seen as brown or red in the specimen.

The difference in electrical conductivity of the dark and light strata was discovered by mounting the specimen in the field of the microscope, and exploring it with two pin-points serving as electrodes. The pin-point electrodes were connected with a battery and galvanometer, or telephone, and were moved about over the surface of the specimen by means of two independent mechanical microscope stages insulated from each other. By means of the slow motion of the mechanical stages, the two pin-points could be put down upon the same dyke or on two different dykes, or one pin could be placed on a dyke while the

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other was placed on one of the lighter colored strata separating the dykes.

It was found that the insulation resistance of a very thin layer of the lighter colored material was so great that the current through it under an impressed e. m. f. of 7 volts did not give a perceptible deflection on the galvanometer, that is, the resistance was more than 7000 million ohms, whereas the resistance of the circuit when both pins were upon the same dark-colored dyke was only a few thousand ohms at this voltage.

It was not possible with some of the specimens to get into electrical contact with all of the dark-colored outcroppings, because in some cases it was evident that the outcroppings were in depressions or were coated over so that the electrodes could not be brought against them. With other specimens and with the aid of a telephone receiver in the exploring circuit, we could make attachment of one electrode to a solder-bed in which the crystal was mounted and could draw the other electrode across an exposed face of the crystal in the field of the microscope and hear a click in the telephone as the moving electrode passed over each of the dark-colored outcroppings.

Outcrop of Conducting Points. — In addition to the linear outcroppings of the conducting dykes, there are also with some of the specimens minute points of outcrop of conducting material. Some of these points are visible in Micrograph *d.* They are the globular markings near the left-hand side of the picture. Each globular marking is a minute darker speck surrounded by a whitish circle. In some cases we found an outcrop in the form of a minute speck, which evidently communicated with one or more conducting layers within the crystal, and which showed measurable capacity when one electrode was brought into contact with the speck while the other electrode was in contact with a distant corner of the crystal. In fact, with the specimen of *d* many of the apparently linear outcroppings are made up of discrete points of conducting material.

A Visible Condenser in Micrograph b. — As an illustration of a condenser completely visible, reference is made to Micrograph *b.* The left half of the picture shows two nearly parallel lines running up through the center and down along the left-hand side of the specimen. These lines, which run out of the field at the bottom and top of the picture, were seen, by moving the specimen in the original examination of this specimen, to be really two closed curves, one inside of the other. They are the outcroppings of two practically flat parallel strata nearly perpendicular to the direction of vision. By exploration with the pin-point electrodes these strata were found to be conducting, whereas the whitish

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