Foreword to the Submission of the Treatise: *Electrodynamic Measurements, Especially Attributing Mechanical Units to Measures of Current Intensity*

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Editor's Note: English translation of Wilhelm Weber's 1855 paper "Vorwort bei der Übergabe der Abhandlung: Elektrodynamische Maassbestimmungen, insbesondere Zurückführung der Stromintensitäts-Messungen auf mechanisches Maass*", [Web55] related to [KW57] with English translation in [KW21].*

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I am submitting the aforementioned treatise, which was written by myself and Professor Kohlrausch[4] in Marburg, to the Royal Scientific Society. It consists of a continuation of three treatises that were submitted previously, and which appeared under the same general title.[5]

As was developed already in the first treatise, the general law of electrical action and the fundamental laws that can be derived from it for various branches of the theory of electricity (with the exception of the fundamental law of electrostatics) include a *constant* whose numerical value, when expressed in terms of known units, has great importance for the whole theory of electricity, both theoretically and practically. That is because although one can make numerous applications of those laws to the determination of ratios or quotients in which that constant cancels in the denominator and the numerator while having no knowledge of the value of that constant, nonetheless there will be many other applications of the above laws that are not possible without determining the values of the constants that are included in them. Up to now, the determination of that value has been lacking, and the closing of that gap in the determination of electrodynamic measurements is the next objective of the present treatise.

The simplest path to achieving that goal is to appeal to the measurements of current intensity in absolute units, which was discussed in detail in the second treatise, namely, the ones that are based upon the magnetic or electrodynamic current effects, to which the electrolytic current effects can be easily reduced with the help of corresponding observations. That is because the current intensity, when expressed in terms of either units, is nothing but the amount of positive electricity that flows through each cross-section of the conductor in one second in the direction of the current, multiplied by either $\sqrt{8}$ or 4, and divided by that *constant*, which explains the fact that when only that amount of electricity can be measured, the measurement of the current intensity in one of the two absolute units will lead to the determination of the value of that *constant*. However, that total positive electricity that flows

[1] [Web55].

[2] Translated by D. H. Delphenich, http://www.neo-classical-physics.info/index.html and e-mail: feedback@neo-classical-physics.info. Edited by A. K. T. Assis, www.ifi.unicamp.br/~assis

[3] The Notes by A. K. T. Assis are represented by [Note by AKTA:].

[4] [Note by AKTA:] Rudolf hermann Arndt Kohlrausch (1809-1858).

[5] [Note by AKTA:] [Web46] with partial French translation in [Web87] and English translation in [Web07]; [Web52b]; and [Web52a] with English translation in [Web21].

through the cross-section of the conductor in one second in the direction of the current was referred to as the *mechanical measure* of the current intensity in the second treatise, from which, it emerged that the goal of that treatise — namely, determining the value of the *constant* — would be achieved when one succeeded in *reducing the measurements of the current intensity that are obtained from both measurements to mechanical measures.*

However, the total amount of electricity that flows through the cross-section of a conductor in a certain time interval cannot be measured while it is flowing. It must then be previously measured while it is found in a state of rest. One must then previously collect a certain amount of electricity that one would like to have flow through a conducting wire — e.g., in a Leyden jar — and one must then seek to measure it while it is found in a state of rest according to *electrostatic* principles, and one must then determine the *intensity* and *duration* of the current that is produced when that same amount of electricity flows (from the Leyden jar to the Earth, for instance) through a conducting wire *in absolute units.*

Now, as far as that initial measurement of the total electricity that is collected in the Leyden jar is concerned, the *electrostatic* principles that must be applied to that measurement are indeed known, in general, but many difficulties have been found in regard to applying those principles to the electricity that has been collected in a Leyden jar. Coulomb, whom we have to thank for those principles, made applications to only very small amounts of electricity with which the small spheres of his electrical [torsion] balance were charged.[6] The solution of those difficulties was then the main problem that needed to be addressed as the goal of this treatise. Several of those difficulties were eliminated by Professor Kohlrausch in earlier investigations, and that fact was what led to the ambition for us to combine the work that we had done, and it was only by such combined efforts that we could hope to achieve satisfactory results.

As far as concerns the measurement of the *intensity* and *duration* of the electricity that is stored in a Leyden jar from the current that is created by its discharge into the Earth, it becomes clear that neither the measurement of that *intensity* nor that *duration* can be performed directly, because the intensity is not constant and the duration of the current that is created in that way is immeasurably small. The only thing that can be measured precisely is the so-called *integral value* of the current that is created — i.e., the sum of the products of each time element dt into the intensity i (expressed in absolute units) of the current that is present in that time element ($= \int idt$),

[6][Note by AKTA:] Charles-Augustin de Coulomb (1736-1806). See [Cou88a], [Cou88b] and [Pot84].

as calculated from the beginning to the end of the current. However, that integral value is nothing but the total amount of electricity in the Leyden jar that is discharged into the Earth, multiplied by either $\sqrt{8}$ or 4 and divided by the desired *constant*. Meanwhile, it must be observed in all of this that not all of the electricity that is stored in the Leyden jar flows from the jar to the Earth, but only half of it, while an equal amount of negative electricity will simultaneously flow from the Earth to the jar, and that will neutralize the other half of the electricity that is collected in it.

We must avoid going into the details of those measurements in this brief report, and therefore refer to the treatise itself[7] for the electrostatic measurement of the amount of electricity stored in a Leyden jar, as well as all things concerned with the electrodynamic measurement of the integral value of the current that is created when it is discharged into the Earth. It might suffice here to briefly cite the results of those measurements.

The measurement of the total amount of electricity E stored in a Leyden jar for five different charges gave the following results:

No.	E
1.	35 786 000
2.	41 618 000
3.	49 313 000
4.	44 007 000
5.	49 276 000

The meaning of the numbers that are quoted under E is as follows: For the *first* charge, an amount of positive electricity was stored in the jar such that if it had been concentrated into a point then an equal amount of electricity that had been concentrated into a point at a distance of 1 millimeter from it would repel it with a force that equals the weight of $(35\,786\,000)^2 \cdot 1/g$ milligrams, where g denotes the acceleration of ponderable bodies due to gravity: i.e., $g = 9\,811$ millimeters/(second)^2. The measurement of the integral value $\int idt$ of the current that is created by removing the electricity E that is stored in the Leyden jar in terms of the absolute units that are based upon magnetic current effects gave the following results in those five cases:

No.	$\int idt$
1.	0.000 119 4
2.	0.000 130 0
3.	0.000 156 8
4.	0.000 148 0
5.	0.000 158 9

[7] [Note by AKTA:] [KW57] with English translation in [KW21].

However, from the above, when one observes that only half of the *positive* amount of electricity E flows from the Leyden jar to the Earth, because the other half will be *negative* electricity that flows from the Earth to the jar in the opposite direction, which will neutralize the latter, one will have the quotient $E/\int idt = c\sqrt{2}$, in which c denotes the desired constant. As a result, one gets the five following mutually-independent determinations of the value of the unknown constant c from the five values of E above and the associated values of $\int idt$:

No.	c
1.	$423\,870 \cdot 10^6$
2.	$452\,750 \cdot 10^6$
3.	$444\,760 \cdot 10^6$
4.	$420\,510 \cdot 10^6$
5.	$438\,560 \cdot 10^6$

The mean of those five measurements yields the value of the *constant* $c = 436\,090 \cdot 10^6$.

The meaning of the *constant* c is that of a well-defined velocity, and indeed the velocity with which two electric masses must approach or separate from each other if neither attraction nor repulsion is to exist between them. Here, the velocity c is expressed by the number of millimeters that will be traversed in one second at that velocity. With 7408 meters per mile, that velocity is calculated to be 58 868 miles per second.

Finally, with the value of that *constant*, all of the current intensity measurements that are quoted in absolute units (whether they are based upon magnetic, electrodynamic, or electrolytic current effects) can be easily reduced to *mechanical units*, which might imply, e.g., that a positive amount of electricity of $16\frac{4}{9}$ billion mass units and an equal amount of negative electricity would be required in order to decompose 1 milligram of water. If that positive amount of electricity were in a cloud and that negative electricity were concentrated into a location on the surface of the Earth along a perpendicular beneath the cloud then that would imply an attraction of the cloud to the Earth that would be equal to the weight of 27 545 kilograms, or almost 551 hundredweights, when the two are separated by 1000 meters.

The *second* part of the treatise is concerned with applications that can be made, in part when one extends the laws that were developed in the previous treatises by the determination that is thus obtained, and in part when one seeks to employ the newly-obtained determination as the foundation for new investigations.

In all laws into which the *constant* c enters, it always appears as the denominator of the velocity with which the bodies actually move relative to each other or as the denominator of the velocity with which the bodies would move relative to each in the course of a unit time (viz., second) when the acceleration that is present continues throughout that time interval. It is therefore of practical interest that all actual velocities that we know — even those of the planets — can be considered to be vanishingly small compared to the velocity c. That is because the only velocity that is known to us, which comes close to the speed c, — namely, the speed of the propagation of light — is not an actual velocity with which bodies can move relative to each other. That yields some interesting applications: e.g., that one can also adapt the extension that was made to the law of electrostatics to the law of gravitation, since the change in the gravitational force that it would imply would vanish entirely for all phenomena in which one might observe it. The fact that for electricity the change in the *electrostatic force* (which corresponds to the gravitational force between ponderable bodies) does not vanish everywhere when one adds the aforementioned extension is based merely upon the total cancellations of the electrostatic forces that takes place under the neutralization of positive and negative electricity. Where no such neutralization takes place, but only free electricity is present, a consideration of the electrostatic force will always suffice for the effects of that free electricity, because its change in accordance with that extension can be likewise regarded as totally vanishing, which has great practical significance for the consideration of free electricity in closed circuits.

Finally, an important principle for new investigations is that all forces that act upon an electric mass will also act immediately upon the ponderable masses that they pertain to and from which they can be separated only by overcoming the resistance of the ponderable bodies. Now, if those electrical forces can be determined by *mechanical measures* then one will learn about the molecular forces that mediate the *mechanical* and *chemical* effects of electricity on ponderable bodies in that way. That will show how the research into the galvanic resistance of water can be employed to obtain a precise insight into and understanding of the *chemical affinity* of oxygen and hydrogen in water. For instance, if one could rigidly couple all oxygen particles to each other in the water in a mixture of water and sulfuric acid of specific weight 1.25 that occupies a column of arbitrary cross-section and one millimeter in height and move them to one side by means of a tensed string, while all of the hydrogen particles were coupled rigidly to each other and moved to the opposite side by means of a tensed string then the tensions in those two strings would amount to 1478 hundredweights if the systems of oxygen particles and hydrogen particles in 1 second were to move so far from each other that the component of 1 milligram of water would be free at the two ends of the water column.

Most likely, similar applications can also be made in relation to the mechanical effects of electricity when it jumps from one conductor to another while small ponderable particles are torn from the one conductor by the electricity. If one were to possess a more precise knowledge of all the relationships that come into play essentially in that phenomenon then it would probably be possible to determine the mass of the neutral electric fluid that exists in ponderable bodies, and under certain likely assumptions, it already seems that one can deduce an exceptionally large magnitude for that mass.

However, the larger that mass becomes, the smaller the velocity would be with which it moves in galvanic currents, and in that way, it already seems that one can assume with great likelihood that the actual velocity with which electric masses displace in closed circuits is rather small, and in no way to be confused with the large velocity with which galvanic currents propagate in closed circuits, which is what Wheatstone sought to measure.[8]

[8] [Note by AKTA:] [Whe34].

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