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Physics. — "*A new Electrometer, specially arranged for radio-active Investigations*". Part II. By Miss H. J. Folmer. (Communicated by Prof. H. Haga).

(Communicated in the meeting of September 29, 1917.)

In Part I, communicated by Prof. H. Haga in the meeting of May 30 1914, the following brief description was given of the electrometer which is represented in figure 1 and reproduced here once more:

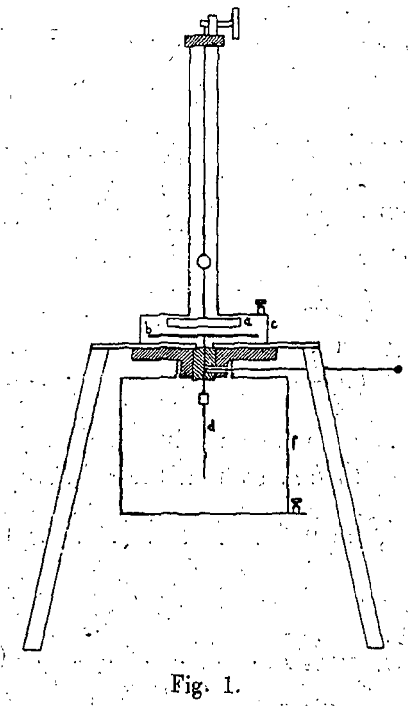

Fig. 1.

The apparatus consists of two separate spaces, viz: the measuring space *c*; a brass cylinder of small height, and the ionisation space proper *f*; a brass cylinder of volume 1 litre; the two cylinders are insulated from each other by ebonite.

In the measuring space *c* is the metal needle *b*, supported in the middle by a second needle *d*, insulated by amber; $b + d$ together form the conductor, which is charged by the ionisation current.

In *c* is also found the very thin aluminium strip *a*, which a few mm. above *b* is fastened to a thin metal rod with mirror, suspended on a Wollaston wire, which is fastened to a torsion head insulated by means of ebonite. Through a perforation in the amber and in the ebonite a rod *l* can be brought in contact with the needle *d*.

In this way, *a*, $b + d$, *c* and *f* can therefore be separately brought in a conductive connection with a storage battery or with the earth; *c* rests on a brass bottom plate to which legs are fastened which

Miss H. J. FOLMER. "A new Electrometer, specially arranged for radio-active Investigations." (II).

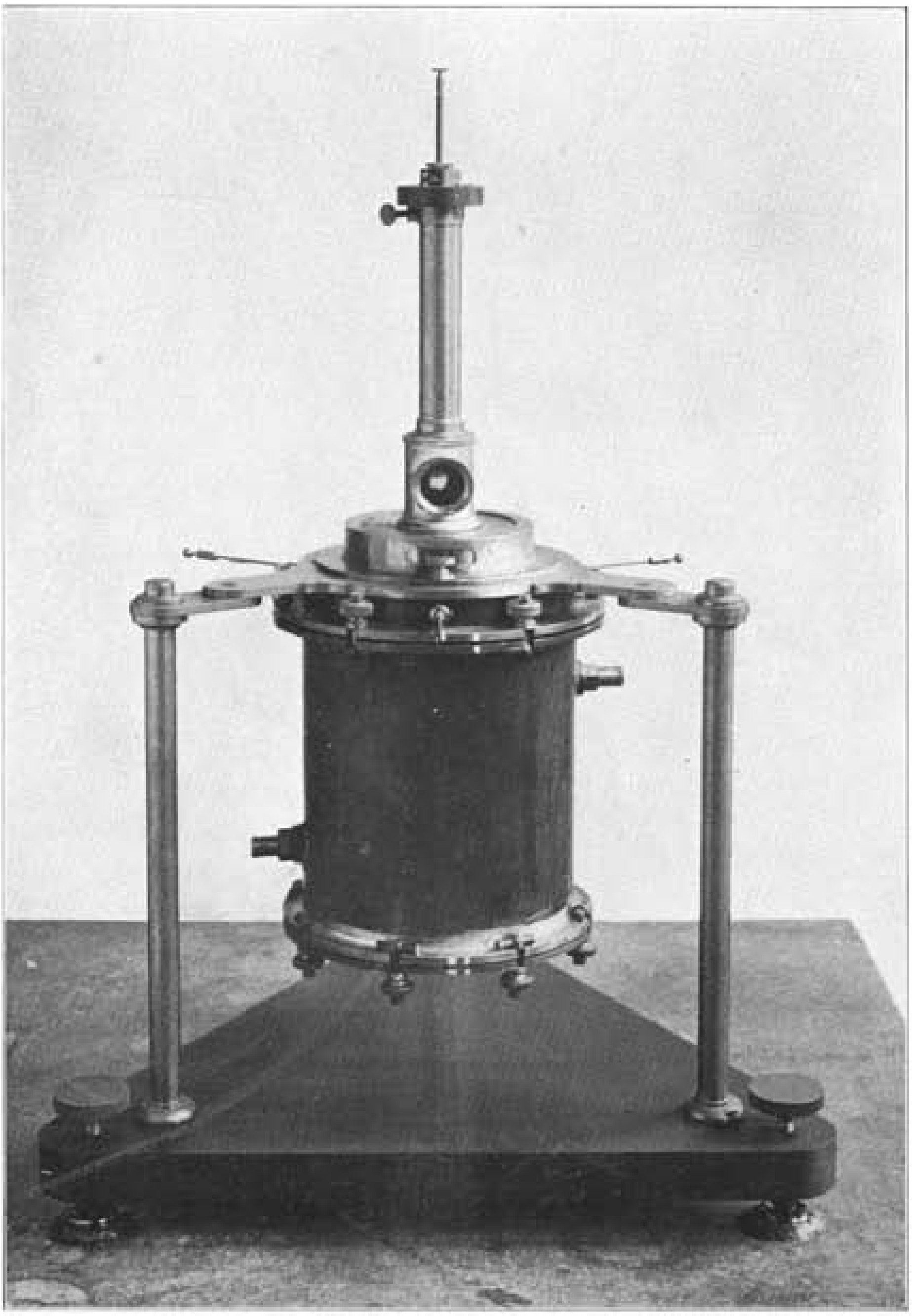

Fig. 2.

Miss H. J. FOLMER. "A new Electrometer, specially arranged for radio-active Investigations." (II).

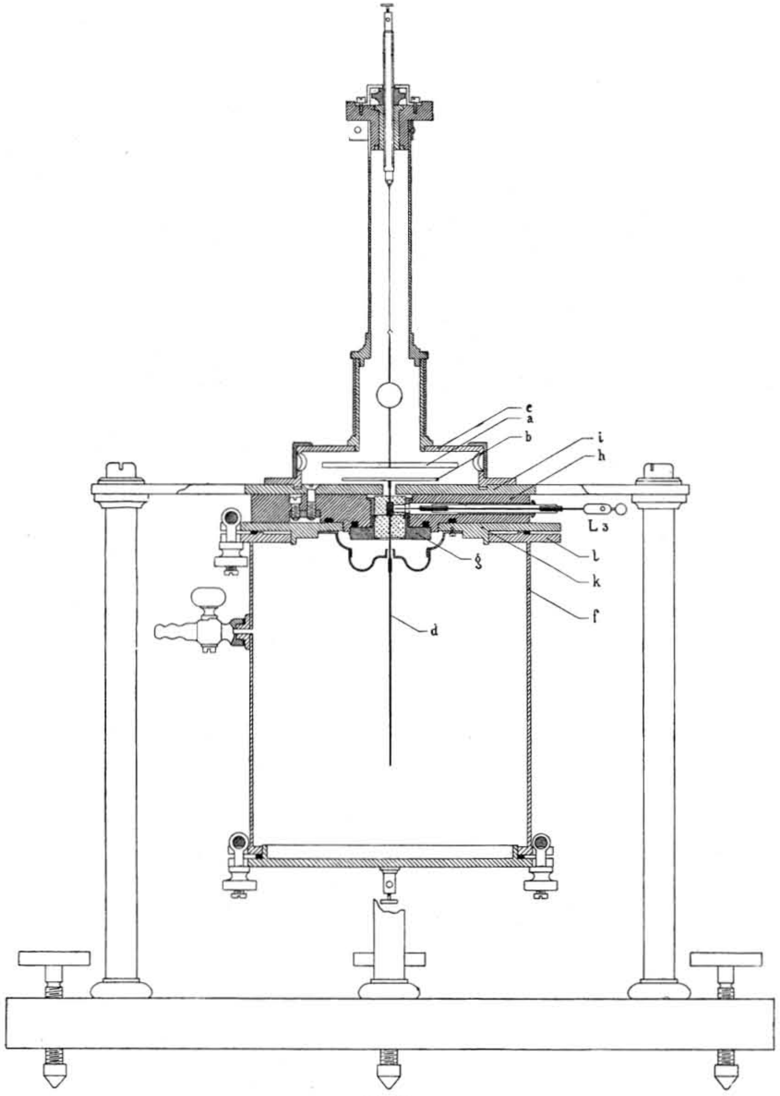

Fig. 3.

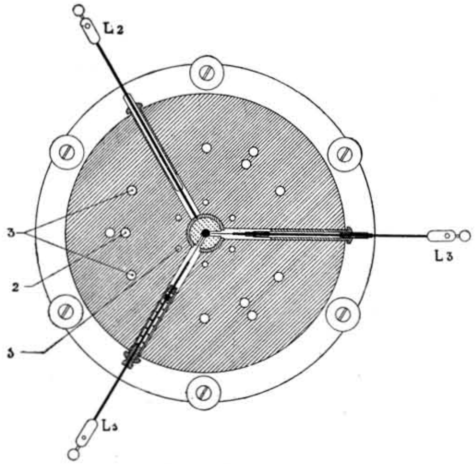

Fig. 4.

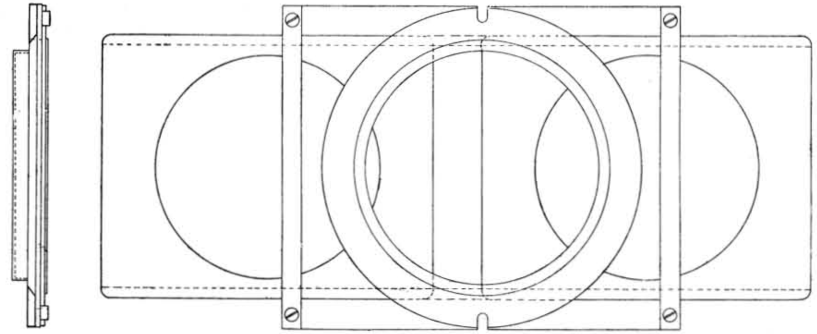

Fig. 5.

” (II).

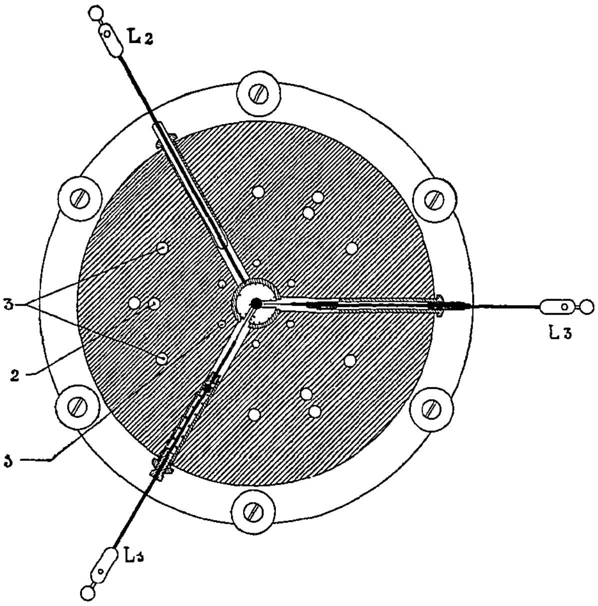

Fig. 4.

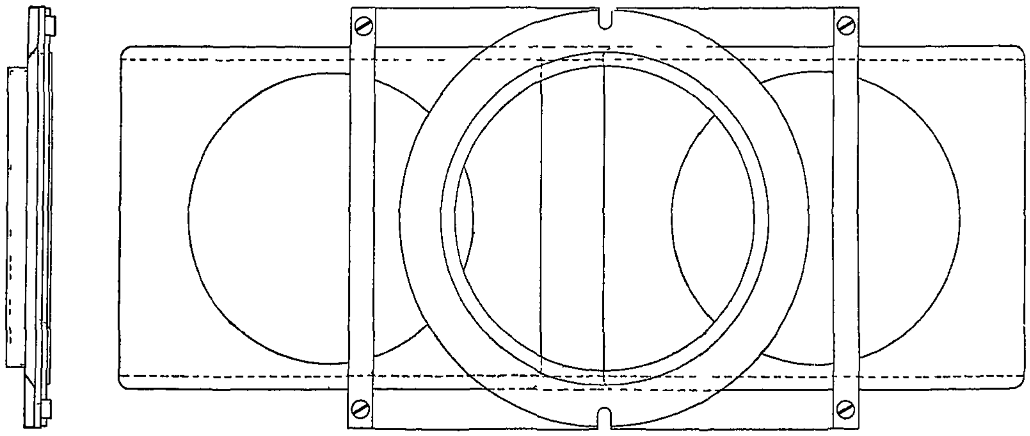

Fig. 5.

support the apparatus. Here follows a more detailed description of the arrangement [1] [2].

Description of the apparatus:

It is illustrated by the following reproductions:

Fig. 2 has been taken from a photo representing the apparatus as if seen somewhat from the top.

Fig. 3 is a vertical section through the plane of one of the rods, viz: the capacity rod l_3, while Fig. 4 shows the ebonite disc in horizontal section, the two last being at a third of their real size.

Starting from the central part of the apparatus we shall find that the needle d is exactly in the middle; it is made of platinum and consists of two parts, the lower part of which slides tightly into the upper; in the middle this upper part is surrounded by a very small cylinder, which contains two small cavities in order to promote the good contact of the needle with the two rods which touch it on two sides; viz. the charging rod l_1 and the capacity rod l_3. (Cf. Figures 3 and 4). The needle d is insulated by ambroid (dotted in Fig. 3) which consists of two cylindriform pieces, to the lower of which the needle is fastened, while the upper part, provided with two wide perforations for the rods, enclose the needle loosely. The ambroid is entirely surrounded by a brass tube serving as guardring, in order to prevent loss of charge of the needle as well as electrostatic disturbances upon it. This tube also consists of two parts: of a small lower cylinder with a thick outer rim at the bottom containing screw-perforations (in Fig. 4 : 1) by means of which the guardring with the ambroid and the needle can be fastened to the surrounding ebonite plate. The lower cylinder fits loosely in the excavation of the ebonite and slides tightly in the upper part of the guardring, which, besides two wide perforations for the rods l_1 and l_3, is yet provided with a screw-perforation for the third rod l_2, which brings the guardring to the potential value desired. (Cf. Fig. 4). The ebonite plate itself is fastened to the lower side of the brass bottom plate i of the measuring space c by means of three brass screws and nuts (Fig. 4 : 2; Fig. 3: the screws to the left of

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[1] The electrometer was constructed in the workshop of the Physical Laboratory at Groningen by Mr. H. J. SIPS, who, with great devotion, surmounted in such a masterly way the many difficulties which arose when he performed his task.

Mr. D. A. VONK, as chief of the workshop, in many respects gave also valuable indications.

[2] The Instrument-Manufacture and Trade late of P. J. KIPP and SONS, (lim.) Delft (Holland) is willing to construct the apparatus described here on sufficient demand.

the middle); the nuts are pressed against the ebonite by screws. Besides, the lid *k* of the ionisation cylinder *f* is attached to the ebonite plate; for this purpose the ebonite plate is perforated in six places, so that from the top countersunk screws can be driven into the lid; they will penetrate the lid only half way (Fig. 4 : 3). Six clamping screws cause the upper edge *l* of the ionisation cylinder to press closely against the lid. At the top the brass ionisation cylinder is partly shut off by the lid, partly by a small brass basin consisting of two parts, with an opening in the centre for the needle; bayonet closure unites these two parts, as well as the outer part with the lid. The basin is to hold $CaCl_2$, which has to protect the ambroid from moisture; at the same time the needle in the ionisation cylinder, except for the small space of air mentioned above, is thus quite surrounded by metal, which is desirable for the measurement of ionisation. The bottom of the cylinder consists of a separate brass plate, pressed against the rim of the cylinder by clamping screws. As to the upper part of the apparatus, the chief part certainly is the brass measuring cylinder *c*, the dimensions of which are chosen in such a way as to cause the upper needle to undergo a thorough damping during its motion. This cylinder fits into a ring-shaped groove of the bottom plate and is provided with a broad rim with two circular slits through which two screws with notched heads fasten the measuring cylinder to the bottom plate. This enables the measuring cylinder to move over a rather large angle. (Cf. Fig. 2). In order to be able to check the state of things inside the cylinder and to see whether the upper needle is in the right position, there are in the walls of *c*, diametrically opposed, two oval openings, covered with celluloid, which correspond with two openings of the same size in a second brass outer cylinder, which is revolvable, so that during the measurement the inner space can be entirely shut off by metal.

The bottom plate *i* of the measuring space *c* is fastened by screws to brass legs, which support the apparatus. These rest on a triangular wooden base with levelling screws fitted with ebonite insulating toes.

To the lower needle *b*, which slides tightly into an excavation of *d*, a definite position can be given with the help of a scale made on the bottom plate of *c*.

The upper needle consists of a small aluminium strip, 0.05 mm. thick, and is fastened to a thin aluminium rod with mirror and mirror-supporter; the suspension consists of a thin platinum Wollaston wire.

The needle-system is arranged so as to let vibrations, which act on the system from without bring about as little disturbance as possible[1]). In order to obtain as much symmetry of inertia as possible with respect to the suspension wire, a disc of aluminium of the same size was affixed behind the mirror by way of counterweight. Moreover particular care was bestowed on the shape of the thin connecting hooks between rod and wire; finally the planes of mirror and needle were placed perpendicularly with each other[2]). With these precautions a fine, restful motion of the needle could be successfully obtained. The brass tube with glass window that encloses it, is fitted at the top with an ebonite torsion head and with an arrangement which makes it possible to raise or lower the upper needle without making it turn round.

The following still requires to be said about the arrangement how and the way in which the three rods (cf. especially Fig. 4) can touch the needle or guardring through the ebonite: rod l_1 is the one that, touching the lower needle $b + d$, brings it to the desired potential before measuring; at the beginning of the measurement this contact is stopped and the charge of the ionisation current can be carried to the then insulated needle. The rod is made of brass and fitted with a subtle platinum point, in order to make sure of a good contact with the platinum needle. In order to bring about the insulation of the needle from the observer's place behind the telescope the rod has been placed in a brass tube which can be pushed tightly into the ebonite; this tube has been shut off at both ends by small brass covers each with a round opening through which the rod can pass freely without much friction. Round about the rod between the outer small brass cover and a thicker part of the rod a steel spiral spring has been placed which is tightened when the rod is drawn out. Now, the arrangement is chosen in such a way as to make a weight which hangs by a cord over a pulley draw the rod out and consequently break the contact with the needle, whereas by raising the weight the spring reestablishes this contact; this raising and lowering of the weight can be brought about from a distance by means of a cord over a pulley.

Rod l_3, which brings the guardring to potential, is fastened in an ebonite tube, which has been fixed by means of an enclosing small brass cylinder into the ebonite perforation. Rod l_3 does only duty when capacity has to be measured (Harms-method); it is made of brass with a platinum point; it is insulated from the enclosing

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[1]) Cf. a.o. H. E. J. G. du Bois and H. Rubens: Wied. Ann. 48 p. 236, 1933.

[2]) In Fig. III these planes were put parallel to each other for clearness' sake.

brass tube by two small pieces of ambroid; round about this we have once more a brass cylinder as mentioned above.

At the ends of the rods terminals are affixed in order to fasten the required connecting wires to the storage battery; also the screw of the torsion head, the bottom plate *i* and that of the ionisation cylinder *f* possess such screws, in order to bring the upper needle *a*, the measuring space *c*, and the ionisation cylinder *f* to the potential desired.

The arrangement of the electrometer having been explained in this elaborate way, some particulars should now be added in relation to some special purpose for which the apparatus has to be employed. If, namely, one wishes to use it for measuring the radio-activity of emanations, the ionisation cylinder must be exhausted, and therefore it must be possible to close it hermetically. Without taking particular precautions this cylinder would communicate by various ways with the air outside; among others along the axle and the walls of the ambroid cylinder; to prevent this, the needle in the lower ambroid cylinder has been cemented air-tight, while between this and the upper rim of the lower cylinder of the guardring a ring-shaped cavity has been filled with piceine (cf. Fig. 3). Thereupon, in order to prevent leakage along the lower rim of the guardring and then along the screws or to the centre, a rubber ring was inserted (in Fig. 3 the first ring mentioned from the centre) which fits closely in a ring-shaped groove in the ebonite, cut a little outside screws 1, and prevents the air to enter. In the same way a second rubber ring on the inside of screws 2 (cf. Fig. 3) prevents leakage from the cylinder along these screws or to the outer rim. At the bottom the guardring *g*, besides having a wide outer rim, still possesses a narrow rim turning inside, to prevent the ambroid, in consequence of difference in pressure of air, from being pressed inward. Further the closure of the cylinder at the top (by the lid *K*) is brought about in the same way as at the bottom (by the brass bottom plate) viz: by means of rubber rings.

In the wall of the ionisation cylinder are two hermetically closing taps of glass for the filling or exhaustion of air or emanation. With all these precautions it appeared to be possible to bring the pressure inside the cylinder down to 2 mm. with the pump (GAEDE's new single barrel air-pump), while only after three days it was raised one mm., which is quite sufficient for the purpose we have in view.

If, however, the measurement must be done with regard to solid substances (direct method), which one must be able to exchange quickly and in which renewal of air should be avoided as much as possible, then the bottom plate must be replaced by a ring (cf. Fig. 5) which bears on the lower side in two places diametrically opposed, two flat brass rails, along which one can slide a deepened bottom plate with the sides dovetailed, which forms the bottom of the ionisation cylinder. A second plate, fashioned in the same way, can be-slided along the same ways and replace the first. The ring is pressed against the cylinder by two clamping screws.

Some particulars on insulation and arrangement.

In order to make sure that the ambroid really insulates the lower needle, several experiments were still made; thus a tension of +10 Volt was given to the guardring, *f* brought to the same tension as *b*: (0 Volt) in order to avoid an ionisation current, then *b* insulated, so that the charging of *b* could only be the consequence of a transition of charge from the guardring via the amber to *b*. With a sensitive state of charge the needle displacement amounted to no more than 1 à 2 mm. per minute. If we take into consideration that in measuring, the difference of tension between *b* and the guardring is very small — the latter is kept at $V=0$ — and that the rise in potential of *b* amounts during the measurement only to a small fraction of a Volt, this will sufficiently prove how excellently the ambroid insulates the needle, and that the leak it causes is of no account. As to the arrangement of apparatus, storage-battery etc., it is such as to make it possible to perform all the manipulations necessary for the preparation of the measurements from the place at the telescope.

First of all we find here within the observer's reach the storage-battery from which our wires start, in order to bring *a*, *b*, *c*, and *f* to potential. The connection with *a*, *b*, and *f* is direct, as these conductors are always charged to a potential given by a whole number of accumulators; *c* on the other hand receives exactly that potential wanted to bring the needle back again to its untwisted state after having charged *a*. Therefore the desired potential is obtained by means of an adjustable laboratory rheostate working as a simple type of potentiometer through which a small current is carried of an accumulator, whose one pole is in connection with a storage-battery. Looking through the telescope at the position of the needle, one can at the same time regulate the tension at will by adjusting the rheostate.

If, in this way, some state of charge has been given to the apparatus, and *f* brought to potential, then the measurement can be started simply by insulating *b* from a distance with the assistance of the pulley-system described above.

Theory of the apparatus.

Of late years numberless new electrometers have been constructed which, for the greater part, possess great sensibility and are to be considered as modifications of two of the principles, known until now; viz: that of W. THOMSON's "quadrantelectrometer" and the principle realised in the "HANKEL-BOHNENBERGER" electrometer. To the first belong among others the measuring instruments of: DOLEZALEK[1]), MÜLLY[2]), HOFFMANN[3]), PARSON[4]), to the second principle those of LUTZ and EDELMANN[5]), ELSTER and GEITEL[6]), WULF[7]).

Besides the part of the measuring system which is charged to the tension to be determined, there are also in all these electrometers two conductors, which are kept at constant potential during the measurement. The electrometer described here possesses, it is true, this latter quality, but yet cannot be reduced to any of the principles mentioned; in shape it somewhat resembles the antique measuring instrument of KOHLRAUSCH-DELLMAN[8]), which also has a cylindrical measuring space with two metal needles. As these needles, however, are charged together to the tension to be determined and in consequence repel each other, so the similarity spoken of here is not mentioned with regard to the principle of measuring, but only with regard to the exterior of both instruments and the system KOHLRAUSCH-DELLMANN has to be looked upon more as a realisation of the simple gold-leaf principle, while torsion has been made use of at the same time. The electrometer which concerns us here, however, strives after the combination of the following conditions:

1. Simplicity in the arrangement of the system (Cf. I, pp. 22 and 26).
2. Great sensibility by making use of the small torsion of thin wires.
3. Utilizing as much as possible the lines of force which arise through addition of charge to the system for the motion on the movable conductor.

As to the third condition, in communication I the motives were already indicated why I thought better to abandon entirely the principle of the quadrantelectrometer[9]) (cf. I p. 26); at the same

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[1]) F. DOLEZALEK, Ann. d. Phys. 26, p. 312, 1908.

[2]) C. MÜLLY, Phys. Z. 14, p. 237, 1913.

[3]) G. HOFFMANN, Ann. d. Phys. 52, afl. 7, p. 665, 1917.

[4]) A. L. PARSON. Phys. Rev. N. S. Vol VI. p. 390, 1915.

[5]) C. W. LUTZ, Phys. Z. 9, p. 100, 1908.

[6]) J ELSTER and H. GEITEL, Phys. Z. 10, p. 664, 1909.

[7]) THEOD. WULF, Phys. Z. 15, p. 250, 1914.

[8]) Pogg. Ann. Bd. 72.

[9]) The drawback of the horizontal wing-surface holds for the measurement of a definite quantity of charge, of course not of fixed potentials.

time light was thrown upon the fact that the advantage of the system with regard to this had been obtained by the fact that the lines of force which undergo a change by addition of charge to the system, act especially on the one vertical side of the upper needle, i. e. will especially cause a *moving couple.* Let it be added that, the arrangement once having become such as to show an asymmetrical character, there had been introduced into the system at the same time the principle called by HOFFMANN the "Labilisierungs-prinzip", which, considered by itself will yield *"under certain conditions"* a decisive advantage in relation to the sensibility of the apparatus, as will become clearer yet from the following considerations.

For this it is necessary to account for the behaviour of the electrometer in the various states of charge, as these are realized before the measurement takes place. Suppose that one of the states of charge has been given to the apparatus, e g. a + 12 Volt, b 0 Volt, c — 4 Volt, *wire untwisted,* angle of needles 30° (cf. I). The equilibrium then arising is shortly due to the following: in consequence of charging a to 12 Volt — if b and c are still supposed to be 0 Volt yet — a greater density of lines of force arises between a and b than between a and c, in consequence of a slighter distance between a—b in relation to that of a—c; on account of this a resulting electric couple will act on a, which can be compensated, however, by a second electric couple in an opposite direction, which takes place in consequence of charging c to negative potential (—4 Volt); for b acts as a screen to the lines of force a—c (cf. also I pp. 24 and 25). If it is supposed that the needle has been suspended in this condition *without* torsion, then, in theory at least, the equilibrium will continue; however, this is an unstable equilibrium, for with constant potentials at a slight turning of the upper needle into the direction that will decrease the angle with b, the density of the lines of force between a and b will increase and a resulting electric couple will arise according to the direction of the movement. The equilibrium will also be unstable in the opposite direction, because with an increase of the distance a—b, there will be a decrease in the influence of b, and the influence of the negative of c will be preponderating. The torsion of the suspension wire, however, can yield a couple, if sufficiently large, which brings about a stable equilibrium; the torsion, however, can have a value too, so much so that it does not counterbalance these above mentioned electric couples, in which case the equilibrium remains unstable. Given a definite height and angle of needles there will exist two conditions by which these cases are determined:

1. the value of the force of the torsion, consequently the thickness and nature of the suspension wire;

2. the state of charge in which we can distinguish high and low states of charge, meaning that the potential a—b can be large or small thus e.g the state (a + 30 Volt, b 0 Volt, c—8 Volt) is a higher state of charge than (a + 12 Volt, b 0 Volt, c—4 Volt).

The meaning of condition 1 is sufficiently clear in itself; as regards 2, if, with a definite wire one will always try to realise higher states of charge, in the end the equilibrium from being stable will always become unstable. For with a higher state of charge, the density of the lines of force between a and b and of course also those between a and c (for there is a greater potential difference between a and c at the same time) will always be greater; then also the electric couple that occurs will increase in consequence of a supposed slight displacement of the needle, so that the torsion couple with a sufficiently high state of charge will finally be unable to compensate this electric couple any more. Of course the stable conditions are used for measurements; yet it is practically possible to approximate the unstable equilibrium with torsion, in which case, interesting phenomena occur; if e.g. under otherwise equal conditions one increases the state of charge continually, it will in the end be impossible to give a fixed position to the needle in or near the equilibrium (untwisted); seemingly the needle is at rest, yet it gradually approaches the lower needle, at first with slight velocity, but steadily increasing so that the image of the scale will shortly disappear from the field of the telescope; the parallel position of the needles is almost reached. Such conditions are meant in communication I, when we say that the needle "turns".

As the behaviour of the electrometer has been accounted for in the various *states of charge*, there still remains to examine the behaviour in the various *states of measurement* where we shall also be able to observe the importance of the "Labilisierungsprinzip". To the conception of capacity, which is connected with it, I should like to give the meaning of what PULGAR and WULFF [1]) call the "total" capacity of the conductor, which conception is used by them for cases similar to those considered here and for which the conception of capacity, as MAXWELL gives it, is not sufficient; for the conductors a and c are not at 0 Volt, nor does the angle of the needles remain constant.

Further I wish to distinguish between (cf. communication I p. 29): 1: useful, and 2: injurious capacity; meaning by useful capacity that

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[1]) J. DEL PULGAR and TH. WULFF, Ann. d. Phys. 30, p. 700, 1909.

part which influences the motion of a; by injurious capacity that part that lacks this influence and therefore means only disadvantage here. As to the measurements, the sensibility will rise together with the increased states of charge. In order to bring this out, we have to compare e.g. the measurements of the two following states: State I: (+ 8, 0, —4) Volt and state II: (+ 14, 0, —6) Volt, and suppose b to be insulated, so that a supposed ionisation current gives a positive charge to the lower needle $b + d$ (f at + 80 Volt e.q.). What then will be the effect with in both cases a definite equal increase of charge? The potential value of b will rise, the number of lines of force between a and b decrease at the same time so that the upper-needle recedes from the lower. In consequence of the fact that a, which is positively charged, recedes from b, part of the negative charge induced on b by a in the state of equilibrium, will be set free and therefore will be spread over the now insulated system $b + d$. The influence of this will, first of all, consist in a decrease of potential of b, causing the potential value of b to increase less than would follow from the addition of charge considered by itself (ionisationcurrent). This influence is felt strongest in the case of II, where in consequence of greater potential difference between a and b, a greater quantity of induced charge is set free, so that the potential decrease, caused by this will be greater. But from yet another point of view we shall have to look at the part played by the induced charge: as soon as the latter spreads from b over $b + d$, this *in itself* means again a *decrease* of lines of force between a and b, i.e. a cause of *motion* on the needle. The result of this consideration therefore is that the displacement of the upper needle a will only partly be the consequence of a direct addition of charge from the ionisation current, but at the same time must be partly considered as the consequence of the displacement of induced charge in the system.

Where, therefore, this displacement is greatest i.e. in case II, the motion on the needle will be strongest and consequently the sensibility of charge greatest.

In communication I the above mentioned explanation has been worded somewhat differently; it was namely said there, that the greater sensibility in II would be the consequence of the fact that the increase of the capacity of $b + d$ would especially mean increase of *useful* capacity in the system, by which the sensibility of charge will increase. In order to elucidate this more clearly, I shall return to what was communicated above; that, namely, by displacement of induced charge, owing to the motion of a, the rise in potential of b turns out smaller than might follow from the addition of charge considered by itself. When, however, through this influence a definite addition of charge causes a smaller rise in potential than would be the case without it, this in itself means that the capacity of $b+d$ has been increased by it. It is this increase of capacity that is of great advantage to the sensibility of charge in the system, and that because this increase of capacity means increase of the useful capacity of $b+d$. Let us first imagine the phenomenon in two phases to take place the one after the other (practically they act at the same time).

I. the *positive* increased charge is distributed over $b+d$; the upper needle describes the corresponding angle.

II the *negative* induced charge which is set free by this movement near b spreads over $b+d$.

The effect of I and II together then comes to the same, as if I had only taken place, but at the same time a greater part of the added charge goes to those places of b, where the induced charge of case II was to be set free. In my opinion it is clearly shown in this way that the influence of phase II really consists in an increase of the useful capacity of b. In the state of charge (+14,0, —6) that useful capacity is yet more increased by the movement than in the state of charge (+ 8,0, — 4); from which follows that in that state the sensibility of charge will also be greater, because, as was already said in Communication I, the sensibility of charge will of course be all the greater according as a greater part of the added charge causes a change in the lines of force between a and b, which is attended by motion. Ultimately there are limits to the use of an ever increasing state of charge; when e.g. the case of unstability as described above, sets in. An approximation as closely as possible to this unstable equilibrium is of course the most favourable condition for the sensibility, because then (see above) the motion of the needle will chiefly be the consequence of displaced induced charge and for a small part only of the increase of charge itself.

The "Labilisierungsprinzip" also occurs in some other electrometers, a. o. in those of **Wulff**, **Wilson** (Kipsystem), whereas the electrometer of **Hoffmann** aims at such a favourable variation of the binant-electrometer that the mentioned system was introduced into the system for that very reason, for which purpose the shape of the needle was chosen in a particular way. Yet the conception that the "Labilisierungsprinzip" in itself would guarantee the greatest possible sensibility in a system, is not correct according to my opinion; with the application of this principle the ratio of useful to injurious capacity will also remain of the greatest importance. If e.g. one just imagines that in the system $b+d$, d possesses a great capacity (i.e. injurious) there will be wanted near the unstable state of charge a very slight increase of charge for the variation in the course of the lines of force between *a* and *b* considered by themselves; consequently for the motion of the needle; yet at the same time the needle *d* will yet require much charge for itself; or: though the useful capacity strongly increases in the unstable state, yet the injurious capacity must be seriously taken into account. This drawback makes itself felt especially when that injurious capacity in the system undergoes the influence of the unstability as well as the useful capacity. If it is supposed e.g. that *a* consists of a horizontal disc, then part of the capacity of *b* will relate to lines of force going from *b* to the *horizontal* plane of *a* (i.e. injurious capacity). Also these lines of force will then undergo a change in consequence of the *movement*; that is. to say, that also this injurious capacity will constantly increase while passing to higher states of charge, which in itself is disadvantageous. From this consideration it follows that the advantage of unstability is still bound up with another condition; the optimum is implied in the following rule: the greatest sensibility of charge in a system will be obtained by a maximal approximation to the unstable state; at the same time the amount of the injurious capacity will have to be as small as possible and by no means to undergo the influence of unstability.

As regards further the capacity of the whole system together, peculiar relations may crop up in the case of change of the latter. We have noticed already that with a positive increase of charge the induced charge, which is displaced by the movement of the needle arrests the increase of potential in the system. Thus it may occur that the increase of potential is compensated by that very influence, i.e. the system would then possess an infinitely great capacity; this will occur among others when the injurious capacity of the system possesses a small amount of capacity. If one passes on to higher states of charge then a positive increase of charge will even bring about a decrease of potential i.e. a negative capacity for the system.

As to the electrometer described here, I think I have obtained favourable results in relation to the consideration given here. Experiments are arranged for in order to become more acquainted yet with the ratio of useful to injurious capacity in the various states of charge in this system, which cannot yet however, be considered as being put an end to; also about the influence of the thickness of the suspension wire and modification in the shape of the needle a closer investigation is still in preparation.

Physical Laboratory of the University of Groningen (Holland).