Citation:

Haga, H., On the polarisation of Röntgen rays, in:
KNAW, Proceedings, 9 I, 1906, Amsterdam, 1906, pp. 104-109

We then notice the peculiar phenomenon that the compound is apparently quite solid till close to the melting point and we find for the vapour pressure the curve CTF, whilst the superfused liquid gives the vapour pressureline FA_1 which is situated much lower. Ramsay has found this previously without being able to give an explanation, as the situation of the three-phaseline was unknown at that period.

In the case of anilinehydrochloride, it was not difficult, on account of the great volatility of HCl, to determine sublimationlines when an excess of this component was present. In Fig. 2 two such lines are determined BE and B_1E_1. From E_1 the three-phaseline was followed over the piece E_1H_1 afterwards the liquid-vapourline H_1I_1. From E also successively EH and HI. With a still smaller excess of hydrogen chloride we should have stopped even nearer to F on the three-phaseline.

In the case of chloralalcoholate we noticed also the phenomenon that a solid substance which dissociates after fusion may, when heated not too slowly, be heated above its meltingpoint, a case lately observed by Day and Allen on melting complex silicates, but which had also been noticed with the simply constituted chloralhydrate.

An instance of the third type of a three-phaseline where the maximum and minimum have disappeared in the lower branch of the three-phase line has not been noticed as yet.

The two types now found will, however, be noticed frequently with other dissociable compounds such as those mentioned above, and therefore enable us to better understand the general behaviour of such substances.

Physics. — *"On the polarisation of Röntgen rays."* By Prof. H. Haga.

In vol. 204 of the Phil. Trans. Royal Soc. of London p. 467, 1905 Barkla communicates experiments which he considers as a decisive proof that the rays emitted by a Röntgen bulb are partially polarised, in agreement with a prediction of Blondlot founded upon the way in which these rays are generated.

In these experiments Barkla examined the secondary rays emitted by air or by some solids: paper, aluminium, copper, tin, by means of the rate of discharge of electroscopes. In two directions perpendicular to one another and both of them perpendicular to the direction of the primary rays, he found a maximum and a minimum for the action of the secondary rays emitted by air, paper and aluminium.

The difference between the maximum and minimum amounted to about 20°/₀.

I had tried to examine the same question by a somewhat different method. A pencil of RÖNTGEN rays passed through a tube in the direction of its axis, without touching the wall of the tube. A photographic film, bent cylindrically, covered the inner wall of the tube in order to investigate whether the secondary rays emitted by the air particles showed a greater action in one direction than in another. I obtained a negative result and communicated this fact to BARKLA, who advised me to take carbon as a very strong radiator for secondary rays. I then made the following arrangement.

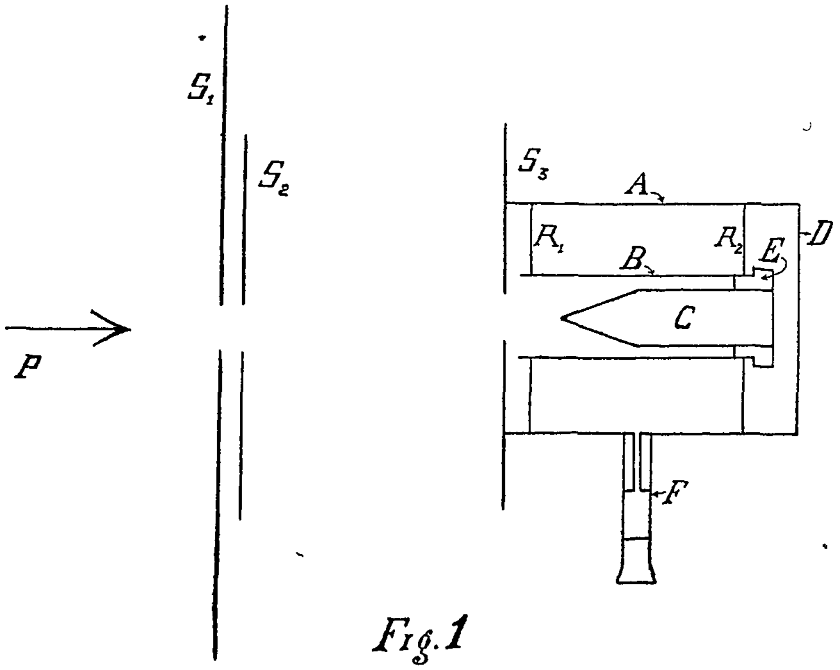

Fig. 1

Let S_1 (fig. 1) be the front side of a thick-walled leaden box, in which the RÖNTGEN bulb is placed; S_2 and S_3 brass plates 10 × 10 c.m. large and 4 m.m. thick. Their distance is 15 c.m. and they are immovably fastened to the upper side of an iron beam. In the middle of these plates apertures of 12 m.m. diameter were made. A metal cylinder A is fastened to the back side of S_3; a brass tube B provided with two rings R_1 and R_2 slides into it[1]).

An ebonite disk E in which a carbon bar is fastened fits in tube B. This bar is 6 c.m. long and has a diameter of 14 m.m. At one end it has been turned off conically over a length of 2 c.m.

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[1]) Fig. 1 and 2 are drawn at about half their real size.

The aperture in S_3 was closed by a disk of black paper; the back side of A was closed by a metal cover, which might be screwed off.

The dimensions were chosen in such a way, that the boundary of the beam of RÖNTGEN rays, which passed through the apertures in S_1, S_2 and S_3, lay between the outer side of the carbon bar and the inner side of the tube B. The photographic film covering the inside of B was therefore protected against the direct RÖNTGEN rays.

If we accept BARKLA's supposition on the way in which the secondary beams are generated in bodies of small atomic weight, and if the axis of the primary beam perfectly coincided with that of the carbon bar, then a total or partial polarisation of the RONTGEN rays would give rise to two maxima of photographic action on diametrically opposite parts of the film and between them two minima would be found. From the direction of the axis of the cathode rays the place of these maxima and minima might be deduced.

A very easy method proved to exist for testing whether the primary beam passed symmetrically through the tube B or not. If namely the inner surface of cover D was coated by a photographic plate or film, which therefore is perpendicular to the axis of the carbon bar then we see after developing a sharply defined bright ring between the dark images of the carbon bar and of the ebonite disk. This ring could also be observed on the fluorescent screen — but in this case of course as a dark one, — and the RONTGEN bulb could easily be placed in such a way, that this ring was concentric with the images of the carbon bar and of the ebonite disk.

This ring proved to be due to the rays that diverged from the anticathode but did not pass through the carbon bar perfectly parallel to the axis and left it again on the sides; these rays proved to be incapable of penetrating the ebonite, but were totally absorbed by this substance; when the ebonite disk was replaced by a carbon one, then the ring disappeared; it is therefore a very interesting instance of the selective absorption of RÖNTGEN rays[1]).

When in this way the symmetrical passage of the RÖNTGEN rays had been obtained, then the two maxima and minima never appeared, neither with short nor with long duration of the experiment, though a strong photographic action was often perceptible on the film. Such an action could for instance already be observed after one hour's exposure, if an induction-coil of 30 cm. striking distance was used with a turbine interruptor. A storage battery of 65 volts was used;

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[1]) Take for this experiment the above described arrangement, but a carbon bar of 1 cm. diameter and 4 cm. long.

the current strength amounted to 7 ampères; the **Röntgen** bulb was "soft".

Sometimes I obtained one maximum only or an irregular action on the film, but this was only the case with an asymmetric position of the apparatus.

From these experiments we may deduce: 1st that the primary **Röntgen** rays are polarised at the utmost only to a very slight amount, and 2nd that *possibly* an asymmetry in the arrangement caused the maxima and minima observed in the experiments of **Barkla**, who did not observe at the same time in two diametrical opposite directions.

With nearly the same arrangement I repeated **Barkla**'s experiments on the polarisation of secondary rays, which he has shown also by means of electroscopes and described Proc. Roy. Soc. Series A vol. 77, p. 247, 1906.

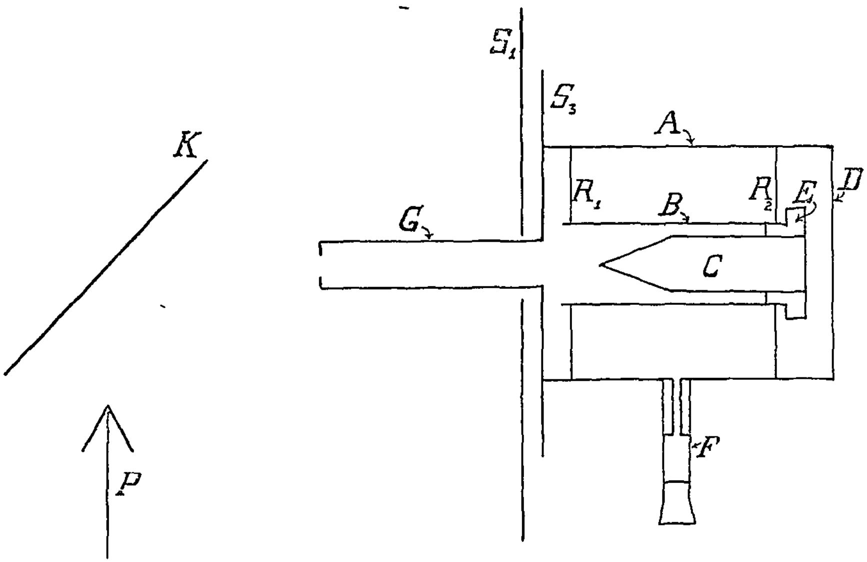

Fig 2

Let the arrow (fig. 2) indicate the direction of incidence of the **Röntgen** rays on the carbon plate K large 8 × 8 cm. and thick 12 mm. The secondary rays emitted by this plate could pass through the brass tube G, which was fastened to S_3. This tube was 6 cm. long and on the frontside it was provided with a brass plate with an aperture of 5 mm. It was placed within the leaden case at 8 cm. distance from the middle of the carbon plate; leaden screens protected the tube against the direct action of the primary rays. In these experiments the above mentioned induction-coil was used with a

Wehnelt interruptor; the voltage of the battery amounted to 65 Volts and the current to 7 Ampères. A very good photo was obtained in 30 hours and it shows very clearly two maxima and two minima, the distance between the centra of the maxima is exactly half the inner circumference of the tube, and it may be deduced from their position that they are caused by the tertiary rays emitted by the conic surface of the carbon bar.

In this experiment the centre of the anticathode, the axis of the carbon bar and the centre of the carbon plate lay in one horizontal plane, and the axis of the cathode rays was in one vertical plane with the centre of the carbon plate; the axes of the primary and the secondary beams were perpendicular to one another. According to Barkla's supposition we must expect that with this arrangement the maximum of the action of the tertiary rays will be found in the horizontal plane above mentioned. In my experiment this supposition really proved to be confirmed. In order to know what part of the photographic film lay in this plane, a small side-tube *F* was adjusted to the outside of cylinder *A*, and this tube *F* was placed in an horizontal position during the experiment. A metal tube with a narrow axial hole fitted in tube *F*, so that in the dark room, after taking away a small caoutchouc stopper which closed *F*, I could prick a small hole in the film with a long needle through this metal tube and through small apertures in the walls of *A* and *B*. This hole was found exactly in the middle of one of the maxima.

So this experiment confirms by a photographic method exactly what Barkla had found by means of his electroscopes and it proves that the secondary rays emitted by the carbon are polarised.

In some of his experiments Barkla pointed out the close agreement in character of primary and secondary Röntgen rays; in my experiments also this agreement was proved by the radiogram obtained on the film placed in cover *D*. Not only did the secondary rays act on the film after having passed through the carbon bar of 6 cm., but also the bright ring was clearly to be seen, which proves that ebonite absorbs all secondary rays which have passed through carbon ¹). The ring was not so sharply defined as in the experiments with primary rays; this fact finds a natural explanation in the different size of the sources of the radiation: in the case of the primary rays the source is a very small part of the anticathode, in the case of the secondary rays it is the rather large part of the carbon plate which emits rays through the apertures in *G* and S_3.

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¹) The ring was perfectly concentric: the arrangement proved therefore to be exactly symmetrical.

This agreement makes it already very probable that the RÖNTGEN rays also consist in *transversal* vibrations; these experiments however yield a firmer proof for this thesis. If namely we accept the supposition of BARKLA as to the way of generation of secondary rays in bodies with a small atomic weight, then it may easily be shown, that the supposition of a *longitudinal* vibration of the primary RÖNTGEN rays would, in the experiment discussed here, lead to a maximum action of the tertiary rays in a *vertical* plane and not in an *horizontal* plane, as was the case.

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Chemistry. — "*Triformin* (*Glyceryl triformate*)". By Prof. P. VAN ROMBURGH.

Many years ago I was engaged in studying the action of oxalic acid on glycerol [1]) and then showed that in the preparation of formic acid by LORIN's method diformin is produced as an intermediate product.

Even then I made efforts to prepare triformin, which seemed to me of some importance as it is the most simple representative of the fats, by heating the diformin with anhydrous oxalic acid, but I was not successful at the time. Afterwards LORIN [2]) repeated these last experiments with very large quantities of anhydrous oxalic acid and stated that the formic acid content finally rises to 75°/₀, but he does not mention any successful efforts to isolate the triformin.

Since my first investigations, I have not ceased efforts to gain my object. I confirmed LORIN's statements that on using very large quantities of anhydrous oxalic acid, the formic acid content of the residue may be increased and I thought that the desired product might be obtained after all by a prolonged action.

Repeated efforts have not, however, had the desired result, although a formin with a high formic acid content was produced from which could be obtained, by fractional distillation in vacuo, a triformin still containing a few percent of the di-compound.

I will only mention a few series of experiments which I made at Buitenzorg, first with Dr. NANNINGA and afterwards with Dr. LONG. In the first, a product was obtained which had a sp.gr. 1.309 at 25°, and gave on titration 76.6°/₀ of formic acid, whilst pure triformin requires 78.4°/₀. The deficiency points to the presence of fully 10°/₀ of diformin in the product obtained.

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[1]) Compt. Rend. 93 (1881) 847.

[2]) Compt. Rend. 100 (1885) 282.