Then we may say: the properties are valid, as long as the equilibria (F_1), (F_2) and (F_1F_2) are situated within the turning-line of the field (F_1F_2)

As in a P,T-diagram several fields are situated around the invariant point, we have to take into consideration the turning-line of each field; then we may say: the properties are valid as long as we consider those parts of the curves and the fields, which are situated within the corresponding turning-lines.

We have to bear in mind that "within the turning-line" means here "belonging to the same leaf on which the invariant point is situated".

The meaning of "not too far" and "not too much" in the conditions 1 and 2 is consequently indicated here somewhat more exactly.

Above we have already stated that we may imagine that the phases of the equilibrium $(F_1\,F_2)$ satisfy reaction (3) casually in the invariant point; then the point i is situated in fig. 5 accidentally on the turning-line. Then the two curves (F_1) and (F_2) come in contact with one another and with the turning-line in this point i. The corresponding P,T-diagram forms then, as we have already mentioned, a transitiontype, to which we shall refer later.

Leiden. *Inorg. Chem. Lab.*

(To be continued).

Physics. — "*On the Symmetry of the Röntgen-patterns of Triclinic and some Rhombic Crystals, and some Remarks on the Diffraction-Images of Quartz*". By Prof. Dr. H. Haga and Prof. Dr. F. M. Jaeger.

(Communicated in the meeting of March 25, 1916).

§ 1. In the following paper we wish to communicate in the first place the results of the experiments, which as a sequel to our previous studies, were made with crystals of the *triclinic system*. The crystals of each of the two symmetry-classes of this system: those of the *triclinic-pedial* and those of the *triclinic-pinacoïdal* class,—of which crystals the first mentioned are wholly *unsymmetrical*, while the second possess only *centrical* symmetry,—will of course necessarily behave in *the same way*, as far as the diffraction-phenomenon of Röntgen-rays is concerned. But because the centre of symmetry cannot manifest itself in the structure of the Röntgen-images in any way, all obtained Röntgenogrammes will appear completely *unsymmetrical,* with every orientation of the investigated crystal-plates.

Of the triclinic-pedial class we had no representatives at our disposal; of the triclinic-pinacoïdal class we investigated only the crystals of *coppersulphate* ($5H_2O$), and of *potassiumbichromate.*

Coppersulphate: $CuSO_4 + 5H_2O$, possesses the following parameters: $a:b:c = 0{,}5721:1:0{,}5554$; $\alpha = 82°5'$; $\beta = 107°8'$; $\gamma = 102°41'$. *Potassiumbichromate*: $K_2Cr_2O_7$, can likewise easily be obtained in good, homogeneous crystals. They have the parameters: $a:b:c = 0{,}5575:1:0{,}5511$; $\alpha = 82°0'$; $\beta = 90°51'$; $\gamma = 83°47'$, and a perfect cleavability parallel to {010}. Of both crystals planeparallel sections were prepared, parallel to the three pinacoïdes {100}, {010} and {001}; those of *coppersulphate* had a thickness of resp.: 1,08, 1.03, and 0.94 mm., those of *potassiumbichromate* of: 0.68, 0.67, and 0.65 mm.

The obtained Röntgen-patterns are reproduced in figs. 1, 2 and 3 on Plate I, and in figs. 5, 6, and 7 on Plate II. The unsymmetrical structure of these six diffraction-images is immediately discernible; it may be remarked, that in all six cases the superficial habit of the images is closely similar to those of monoclinic crystals, as far as those images are characterised by a single plane of symmetry. However, the distribution of the spots and of their intensity is such, that there can be no doubt whatever about the lack of symmetry in the diffraction-images.

The concordance of theory and experiment thus is proved sufficiently also for the case of triclinic crystals. It is of no importance to investigate more representatives of this kind and in the same way; thus our systematical experiments in this direction have reached an end here.

§. **2.** Only as a completion of our previous investigations we wish to publish however here again some results obtained with a number of *rhombic* minerals, namely with *bronzite, diaspore, manganite, antimonite* and *olivine.*

After that we will again draw attention for a moment to the diffraction-images of dextrogyratory *quartz,* and this with respect to the anomalies of them formerly stated by us [1]). Some remarks on the RÖNTGEN-pattern of *brucite,* and, — as a completion of our previous investigations on monoclinic crystals [2]), — of *lithiumsulphate,* will end this paper.

Bronzite is a rhombic pyroxene with the composition: $(Mg, Fe)_2(SiO_3)_2$

[1]) These Proceed., **18**, 550. (Sept. 1915).

[2]) These Proceed., **18**, 1201. (Jan. 1916).

and the parameters; $a:b:c = 0{,}9702:1:0{,}5701$. Three plates parallel to (100), (010) and (001) and resp. 1,09, 1.10, and 1.06 mm. thick, were cut from a beautiful crystal of *Kupferberg, Bayreuth.* The plate parallel to (010) showed a slight deviation from its normal orientation; the RÖNTGEN-patterns are reproduced in fig. 9, 10, and 11 on Plate III, and in stereographical projection in fig. 1, 2, and 3 on Plate V. The symmetry with respect to two perpendicular planes is immediately discernible.

For the purpose of comparison of *diaspore* and *manganite,* also from these minerals sections parallel to the three pinacoides were cut and radiated through. In the case of *diaspore*: $AlO(OH)$, with the parameters $a:b:c = 0{,}4686:1:0{,}3019$, and originating from *Emery Mines (Mass.),* only the image parallel to (010) was suitable for direct reproduction (fig. 4 on Plate I); the corresponding stereographical projections, also for an image parallel to (001), are reproduced in fig. 4 and 5 on Plate V. The thickness of the used plates of *diaspore* was resp. 0,96, 0,93 and 1,02 mm. In the case of *manganite* (from *Ilfeld,* i/d *Harz*) patterns were obtained, showing instead of *spots,* long radiating stripes. This fact was also stated by us in the case of *göthite*; it seems to be connected partially with contusions of the material, and with intergrowths and twinning of fibre-shaped individuals in these crystals. Hitherto we were not able to get undisturbed diffraction-images suitable for clear interpretation. Of *manganite*: $MnO(OH)$, whose parameters are: $a:b:c = 0{,}8441:1:0{,}5448$, only a somewhat reliable projection could be made for the image obtained parallel (100); the thickness of the crystal-plate used was here 1,04 mm., and the figure is shown in fig. 6 on Plate V.

Of *antimonite*: Sb_2S_3, with its parameters: $a:b:c = 0{,}9844:1:1{,}0110$, we had the very beautiful crystals of *Shikoku Japan,* at our disposal, the same, which were formerly used in the investigations of one of us [1]), on the influence of the light-radiation upon the electrical conductivity of this in so many respects remarkable mineral. We studied a lamella, obtained by cleavage parallel to (010), which was not thicker than 0.43 mm. Notwithstanding the presence of a number of folds parallel to the sliding-plane (001) the obtained diffraction-image yet appeared to be perfectly undisturbed; it is reproduced in fig. 16 on Plate IV, and as a stereographical projection in fig. 7 on Plate V. This fact could be used as an argument in favour of the correctness of the view, according to which such sliding along perfect sliding-planes, does *not* alter the internal arran-

[1]) F. M. JAEGER Zeits. f. Kryst. **44**. 45. (1908); these Proceed. **9**. 809. (1907).

gement of the molecules, these layers evidently remaining parallel to their original position.

From a beautiful, colourless crystal of *olivine*, originating from *Bohemia*, a crystalplate parallel to (010), and 1.33 mm. was prepared, and then radiated through. The very nice RONTGEN-pattern of this silicate, whose composition is: $n\,Mg_2\,SiO_4 + m\,Fe_2\,SiO_4$, and whose parameters are: $a:b:c = 0{,}4657:0{,}5865$ is reproduced in fig. 8 on Plate II, and in stereographical projection in fig. 8 on Plate V. Also in this case the normal symmetry can be discerned immediately, so that the results here obtained with these rhombic crystals can be considered to be a welcome completion of our previous experiments [1]), when we were able to prove the correctness of the theoretical deduction also in the case of rhombic crystals.

§ **3**. Already previously we have drawn attention [2]) to the remarkable abnormality, which was observed by us in the case of the diffraction-image parallel to $(\bar{1}\bar{2}10)$, obtained with a crystal of *quartz* from *St. Gothard*; it consisted in the image not only possessing a single binary axis perpendicular to the photographic plate, but also two planes of symmetry, perpendicular to each other. On that occasion we expressed the surmise, that this abnormality could be explained by the fact, that the studied plate was prepared from a polysynthetic twin of quartz, according to the so-called brasilian law of twinning. Indeed, on this supposition the apparent increase of the symmetry of this image can be easily explained. But at that time we were not able to give any proof of the correctness of this view, because of the fact, that the rather imperfect Röntgen-image obtained with a plate cut parallel to $(10\bar{1}0)$, seemed to be likewise symmetrical after two planes of symmetry. However since that time we have studied some other plates orientated with the utmost care parallel $(10\bar{1}0)$, and have radiated them through during very different times of exposition. By these experiments we got absolute certainty, that the images are *only* symmetrical after a *vertical* plane, perpendicular to $(10\bar{1}0)$. The photo in fig. 14 on Plate IV, and its stereographical projection in fig. 10 on Plate V can prove this. By shortening more and more the time of exposition, we succeeded e.g. in making only the most intensive spots appear: it could be clearly seen then, that in the direction of the *c*-axis at the upper end there were *two*, at the lower end *three* of such intensive spots on the

1) These Proceed., **18**. 559 (Sept. 1915).

2) These Proceed., **18**. 550. (Sept. 1915)

great circle, which is drawn in fig. 10. So with this fact also the last impediment to the formerly given explanation of the abnormality of *quartz* has been removed; thus the remarkable deviation of the image parallel to $(\bar{1}2\bar{1}0)$ can now be explained without difficulty as a result of the mentioned twin-structure of the mineral. While we moreover formerly did not succeed in obtaining good images of a quartz-plate cut parallel to (0001), we have now again made a series of systematical experiments with *quartz*-plates of different thickness; it was found that for the purpose of getting well reproducible negatives it was necessary, to radiate through rather *thick* crystal-plates. The Röntgen-pattern, which is reproduced in fig. 13 on Plate IV, and in stereographical projection in fig. 9 on Plate V, was obtained by means of a *quartz*-plate of 3,75 mm. thickness. In this way the Röntgen-patterns of *quartz* have now become complete, and the exactness of the theory is also here proved for *quartz*, — at least in normal cases.

A beautiful crystal of a pale green *brucite*: $Mg(OH)_2$, from *Heydale, Shetland Islands, Scotland,* enabled us to get also an image of a basal section of this mineral, which has so simple a chemical constitution, and the axial ratio: $a:c = 1:0{,}5208$. It is reproduced in fig. 15 on Plate IV, and in stereographical projection in fig. 11 on Plate V. A study of the influence of heating basal sections of this mineral in the furnace formerly described by us, on the Röntgen-image, is now planned.

Finally we have published in fig. 12 on Plates III and V also the results of radiating through a basal plate, 1,09 m.m. thick, of the monoclinic-sphenoidical *lithiumsulphate:* $Li_2SO_4 + H_2O$. This substance, with the parameters: $a:b:c = 1{,}6102:1:0{,}5643$, and $\beta = 87°29'$, is yet an object of the said symmetry-class, not showing an optical activity in solution, as was the case in the formerly investigated cases [1]: cane-sugar, tartric acid, etc. Therefore this experiment may be considered a welcome completion of the researches, regarding such monoclinic crystals. In this case too the image parallel to (001) appears to possess a single vertical plane of symmetry, notwithstanding the fact, that the crystals themselves have only a single binary axis. Also this fact proves once more the general justification of the conclusions drawn in that paper. [1])

Laboratories for Physics and for Inorganic and Physical Chemistry of the University.

Groningen, 15 February 1916.

[1]) These Proceed. **18**. 1201 (Jan. 1916).

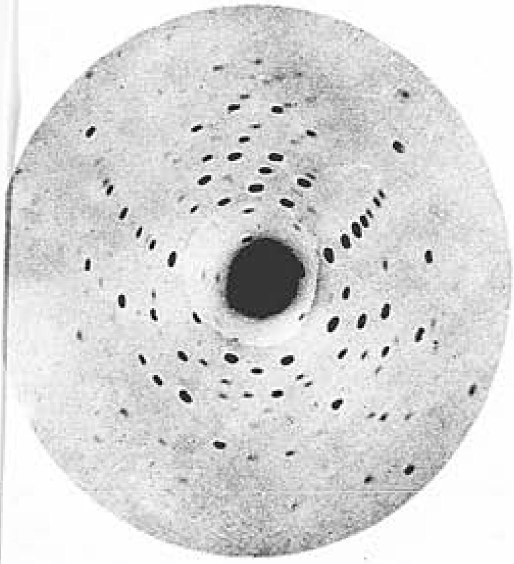

Fig. *1*.
Coppersulphate. (5 H_2O) Plate parallel to (100).

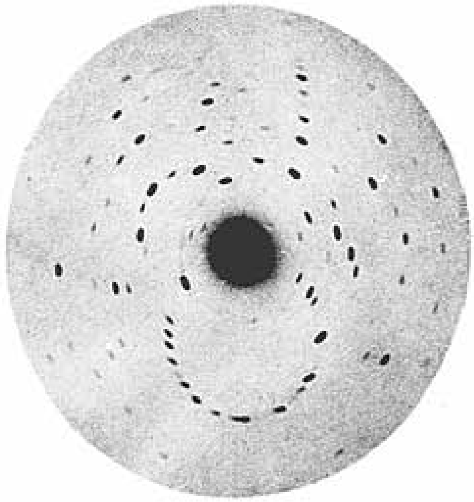

Fig. *2*.
Coppersulphate. (5 H_2O) Plate parallel to (010).

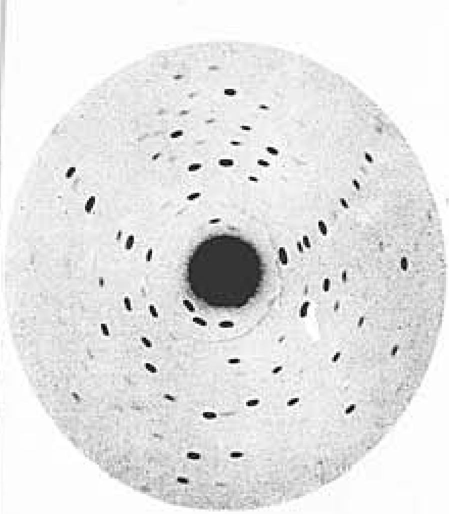

Fig. *3*.
Coppersulphate. (5 H_2O) Plate parallel to (001).

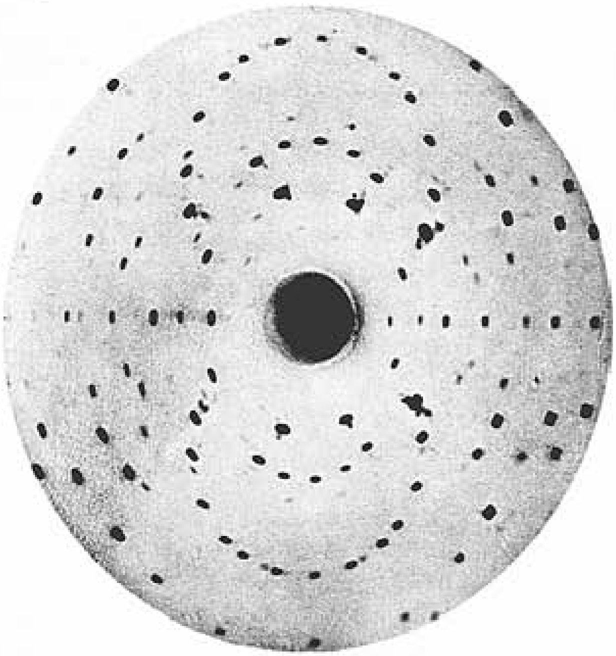

Fig. *4*.
Diaspore. Plate parallel to (010).

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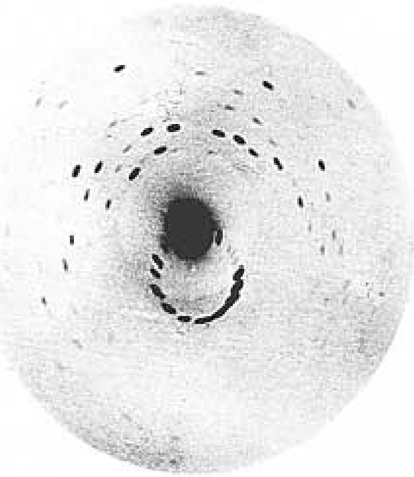

Fig. 5.
Potassiumbichromate. Plate parallel to (100).

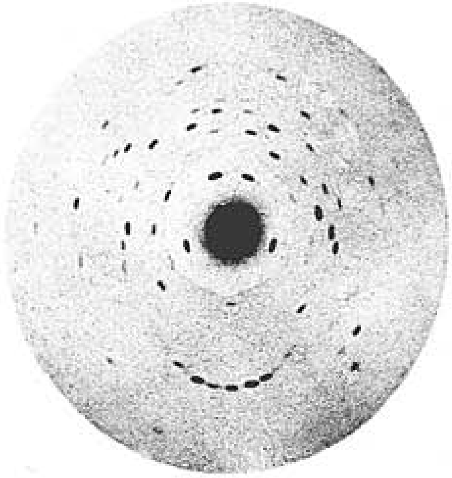

Fig. 6.
Potassiumbichromate. Plate parallel to (010).

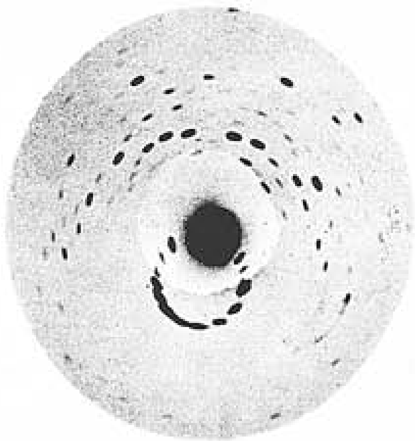

Fig. 7
Potassiumbichromate. Plate parallel to (001).

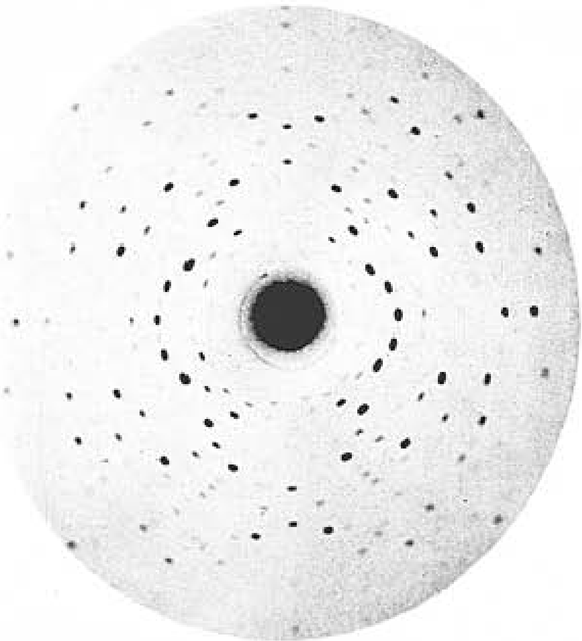

Fig. 8.
Olivène. Plate parallel to (010).

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Fig. 9.
Bronzite. Plate parallel to (100).

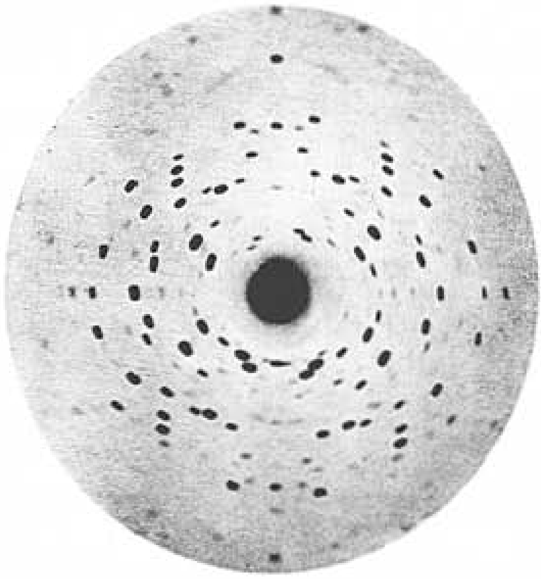

Fig. 10.
Bronzite. Plate parallel to (010).

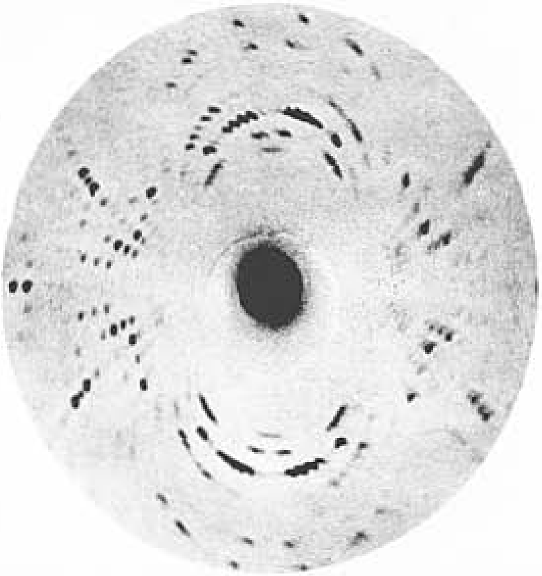

Fig. 11.
Bronzite. Plate parallel to (001).

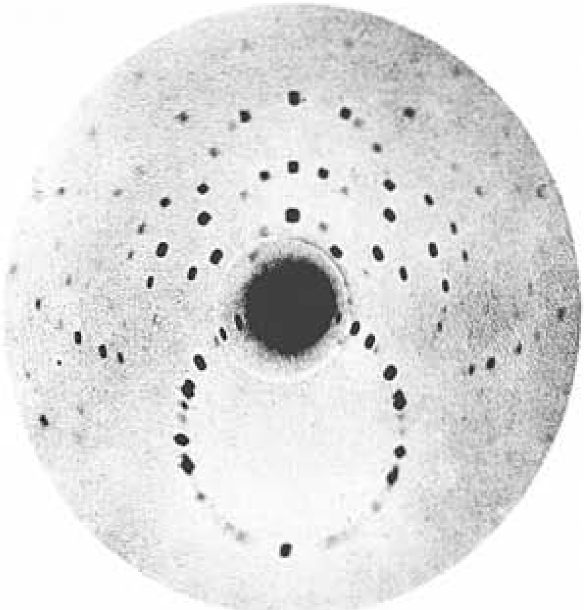

Fig. 12.
Lithiumsulphate. Plate parallel to (001).

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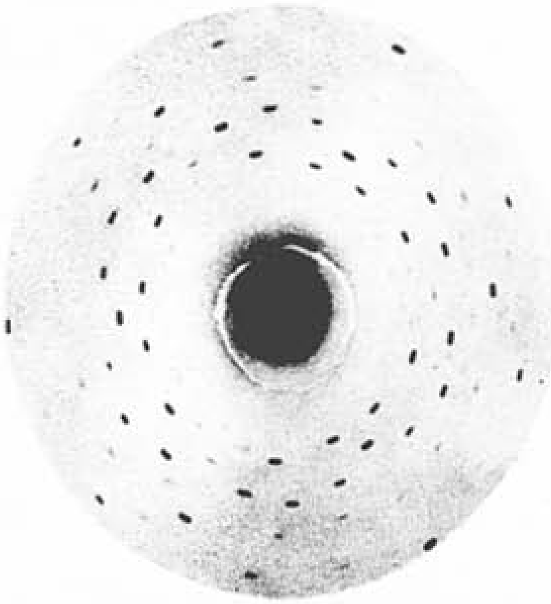

Fig. *13*.
Quartz. Plate parallel to (0001).

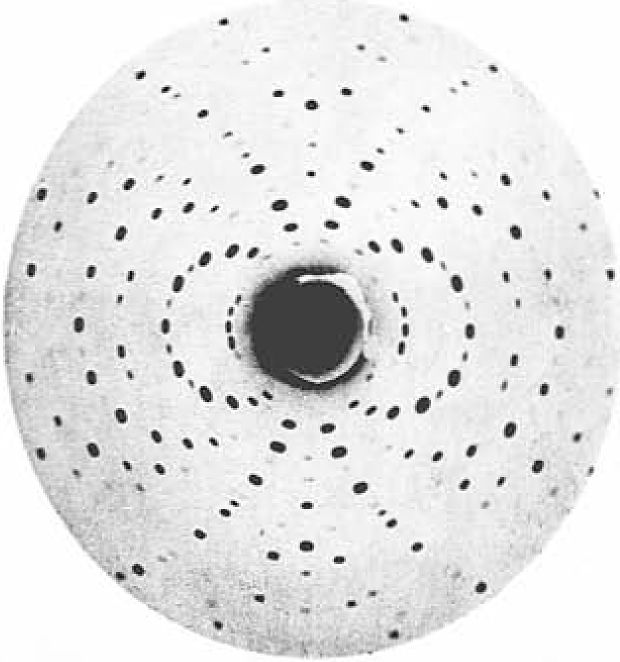

Fig. *14*.
Quartz. Plate parallel to $(10\bar{1}0)$.

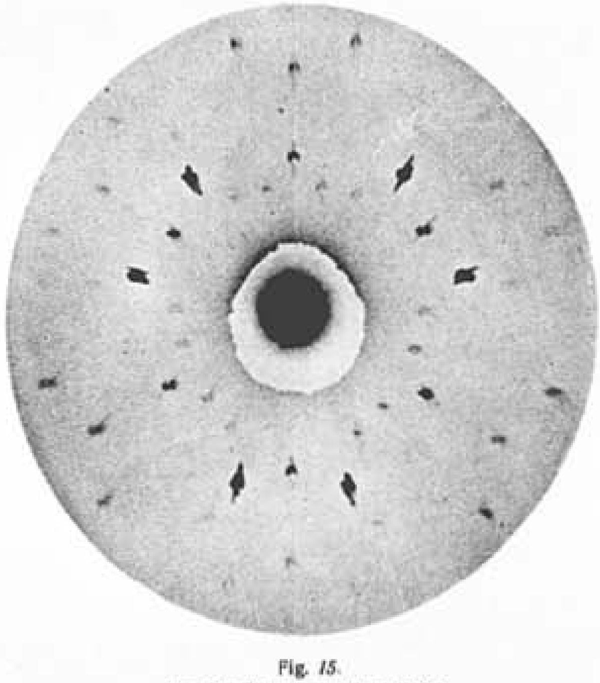

Fig. *15*.
Brucite. Plate parallel to (0001).

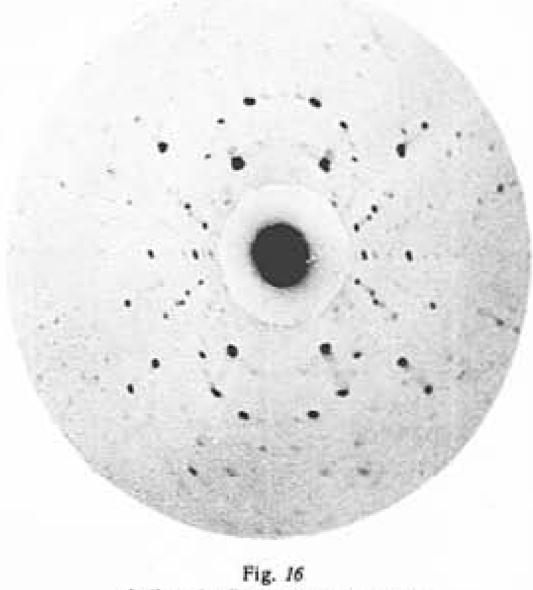

Fig. *16*
Antimonite. Plate parallel to (010).

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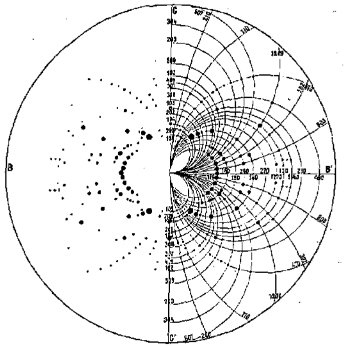

Fig. 1.
Stereographical Projection of the Röntgen-pattern of Bronzite. Plate parallel to (100).

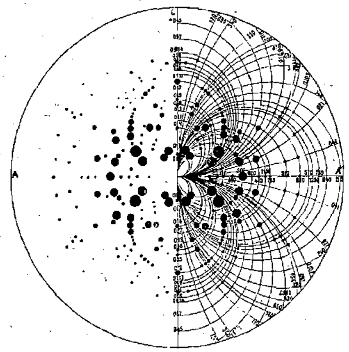

Fig. 2.
Stereographical Projection of the Röntgen-pattern of Bronzite. Plate parallel to (010).

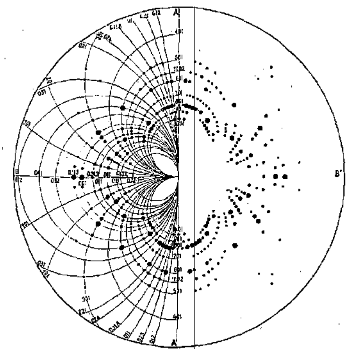

Fig. 3.
Stereographical Projection of the Röntgen-pattern of Bronzite. Plate parallel to (001).

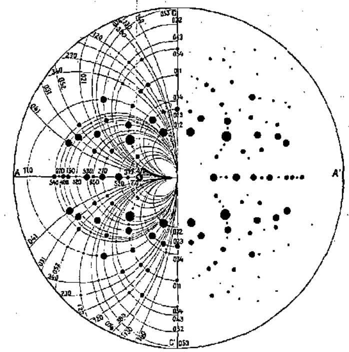

Fig. 4.
Stereographical Projection of the Röntgen-pattern of Diaspore. Plate parallel to (010).

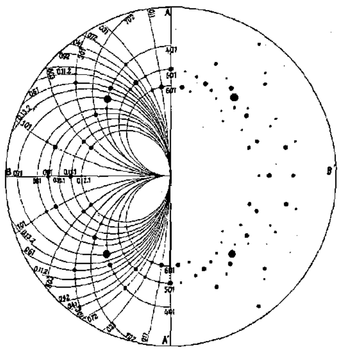

Fig. 5.
Stereographical Projection of the Röntgen-pattern of Diaspore. Plate parallel to (001).

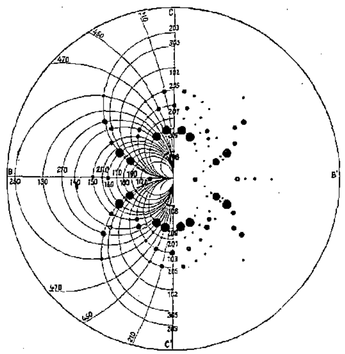

Fig. 6.
Stereographical Projection of the Röntgen-pattern of Manganite. Plate parallel to (100)

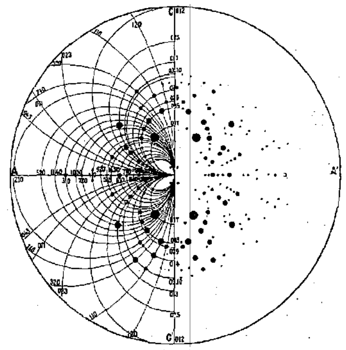

Fig. 7.
Stereographical Projection of the Röntgen-pattern of Antimonite. Plate parallel to (010).

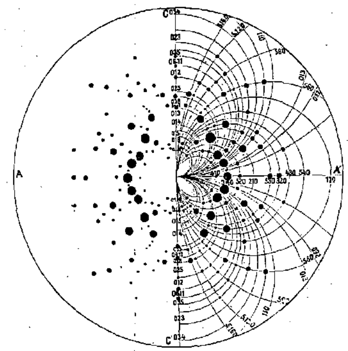

Fig. 8.
Stereographical Projection of the Röntgen-pattern of Olivine. Plate parallel to (010).

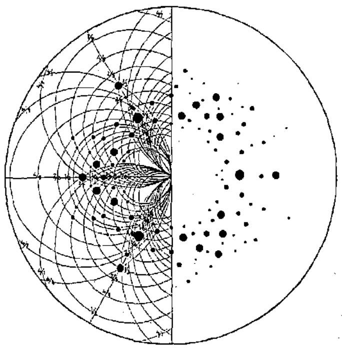

Fig. 9.
Stereographical Projection of the Röntgen-pattern of dextrogyratory Quartz. Plate parallel to (0001).

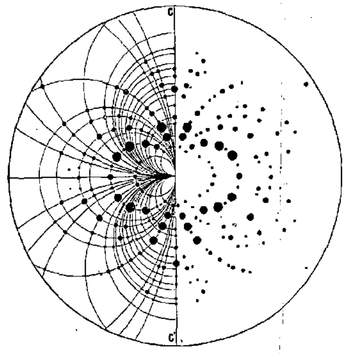

Fig. 10.
Stereographical Projection of the Röntgen-pattern of dextrogyratory Quartz. Plate parallel to (10$\bar{1}$0).

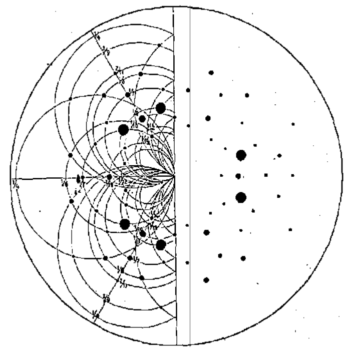

Fig. 11.
Stereographical Projection of the Röntgen-pattern of Brucite. Plate parallel to (0001).

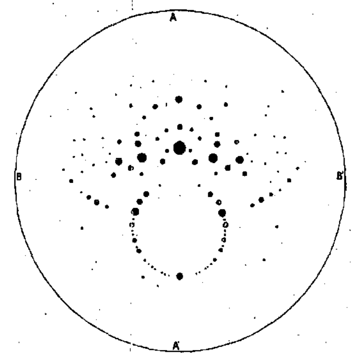

Fig. 12.
Stereographical Projection of the Röntgen-pattern of Lithiumsulphate. Plate parallel to (001).