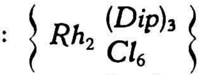
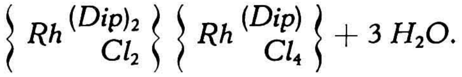
(=49,6 % *dipyridyl*) and 4,93 % H_2O. The water is readily given off at 100° C. The composition, therefore, is analogous to that of the reaction-product of sodiumrhodiumchloride + 1 dipyridyl; this complex salt must, therefore, be formed from the original one by loosing 6 HCl and a migration of the base into the complex ion. There is *no* ionogen chlorine present, so that its composition must be:  $\left\{ Rh_2 \begin{matrix}(Dip)_3 \\ Cl_6\end{matrix} \right\} + 3H_2O$, — which simultaneously explains, why the water-molecules are so readily eliminated on heating at 95° C. As in some experiments the precipitate appeared to be a mixture of two differently coloured crystalline flakes, the composition mentioned occasionally could as well correspond to a mixture of *mono-* and *di-dipyridylchlororhodium*-compounds with the one formulated above, which perhaps corresponds to the structure:



$$\left\{ Rh \begin{matrix}(Dip)_2 \\ Cl_2\end{matrix} \right\} \left\{ Rh \begin{matrix}(Dip) \\ Cl_4\end{matrix} \right\} + 3\,H_2O.$$

Hitherto we did not succeed in separating one of the salts obtained into optically-active antipodes.

Groningen, Laboratory for Inorganic and
Physical Chemistry of the University.

Physics. — *The optical properties of the "van Leeuwenhoek" Microscope in possession of the University of Utrecht.* By P. H. VAN CITTERT. (Communicated by Prof. L. S. ORNSTEIN.)

(Communicated at the meeting of April 28, 1934.)

In order to compare the optical properties of the VAN LEEUWENHOEK-microscope of the University of Utrecht with that of other simple and compound microscopes of the 18th and 19th centuries, all microscopes in care of the University Museum of Utrecht have been brought once more in a workable condition, all lenses have been cleaned as thoroughly as possible and after these preleminaries the magnifications and the resolving powers of all instruments have been determined [1].

As regards the determination of the resolving power, it was not possible to make use of the aperto-meter, as is usually done nowadays, because the numerical aperture gives the resolving power for those cases only in which both lenses and conditions for illumination are ideal. As soon as the lenses and the illumination are not ideal, the result of the aperto-meter method can only have the signification of an upper limit and the true

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[1] Full particulars about the results of these measurements are to be found in "P. H. VAN CITTERT: Descriptive Catalogue of the Collection of Microscopes in charge of the University Museum of Utrecht", to be published shortly by Noordhoff, Groningen.

resolving power corresponding to the actual state of affairs remains unknown. Even with the modern instruments of the best manufacture there is no absolute garantee that the actual conditions agree sufficiently closely with the ideal ones to permit the application of the aperto-meter method. When dealing, however, with instruments of former centuries one may be sure that the actual conditions fall so far short of the ideal ones that this method can no longer be applied. It had therefore to be replaced by a direct method, now almost forgotten, but in common use about the middle of the 19th century. This direct method gives at once the true resolving power for the actual condition of the lenses and illumination during the measurements and ought therefore, strictly speaking, to be preferred even for modern instruments to the first one. In the middle of the 19th century this method made use of the so-called "Nobert's test plate", that is, a small glass plate in which a few groups of parallel aequidistant lines are scratched, the mutual distances for each group being known. Later on the "Grayson Rulings" became in use. For the present determinations both the Nobertplate and the Grayson Rulings were used, mainly however the latter.

The measurements gave the surprising result that from the earliest simple microscope in the Utrecht collection down to the beginning of the 19th century hardly any improvement whatever is found. The VAN LEEUWENHOEK microscope proves to be one of the best simple microscopes, as regards magnification and resolving power, made until the commencement of the 19th century.

It was clear from the measurements, made on 67 lenses of the simple microscopes of the collection, that one could fix, fairly sharply the average magnification required to reach some definite resolving power. For instance, lenses with magnifications smaller than × 20 turned out not to be capable of resolving $^{1}/_{100}$ mm. For resolving powers between $^{1}/_{100}$ mm and $^{1}/_{200}$ mm, the required magnifications had as a rule values between 20 and 40, etc. In fig. 1 the resolving power of the simple microscope is plotted against the magnification (continuous line).

Here we are struck by the fact that the point L, furnished by the oldest instrument of the collection ,the "VAN LEEUWENHOEK" microscope not only fits the curve perfectly (a magnification of 270 resolves $^{1}/_{700}$ mm, i.e. the fourth group of a Nobert plate) 1) but even lies very high on the curve: it is only surpassed by a few 19th century microscopes fitted with doublets and by one, only one, small lens of Dollond dating from that same period. Considering that VAN LEEUWENHOEK's instrument attains its prominent position in spite of a badly scratched lens 2), it would in its original condition have furnished a point lying much higher than the average.

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1) P. HARTING. Het mikroskoop III page 43—44, Utrecht. 1850.
P. H. VAN CITTERT, Proc. Amst. **35**, 1062, 1932.

2) P. H. VAN CITTERT, Proc. Amst. **36**, 194, 1933.

We will now consider the development of the compound microscope as well. To all appearances, its convenient manipulation and the greater object distances, offered the observer many advantages. Here again, however, one meets the same phenomenon as in the other types of microscopes. In the course of the 18th century namely, a considerable improvement in the mechanical construction was obtained, but no progress, whatever, was made as regards the optical capacities, and moreover, the optical powers of the compound microscopes turned out to fall short, by a long way, of those of the simple microscopes. This can be seen at once from the dotted curve of fig. 1, plotted from the results of 97 measurements. A comparison, too, of the optical data of the various instruments reveals at once the fact that the optical capacities of the compound microscopes have remained the same during the whole of the 18th century. An original Culpeper microscope, for instance, shows in this respect hardly any difference from instruments constructed about 1800.

Whereas the resolving power of the compound microscope remained far below that of the simple microscope, so long as the objectives were not achromatised, this was no longer the case when once achromatic objectives were successfully made. The very first achromatic objective of BEELDSNYDER (1791) is capable, when combined with a low power eye-piece, of resolving $^1/_{100}$ mm with a magnification of 20 (fig. 1, point B). With VAN DEYL's microscope (1806) $^1/_{200}$ mm is already resolved with a magnification of 30 (point D). This proves that, though as yet

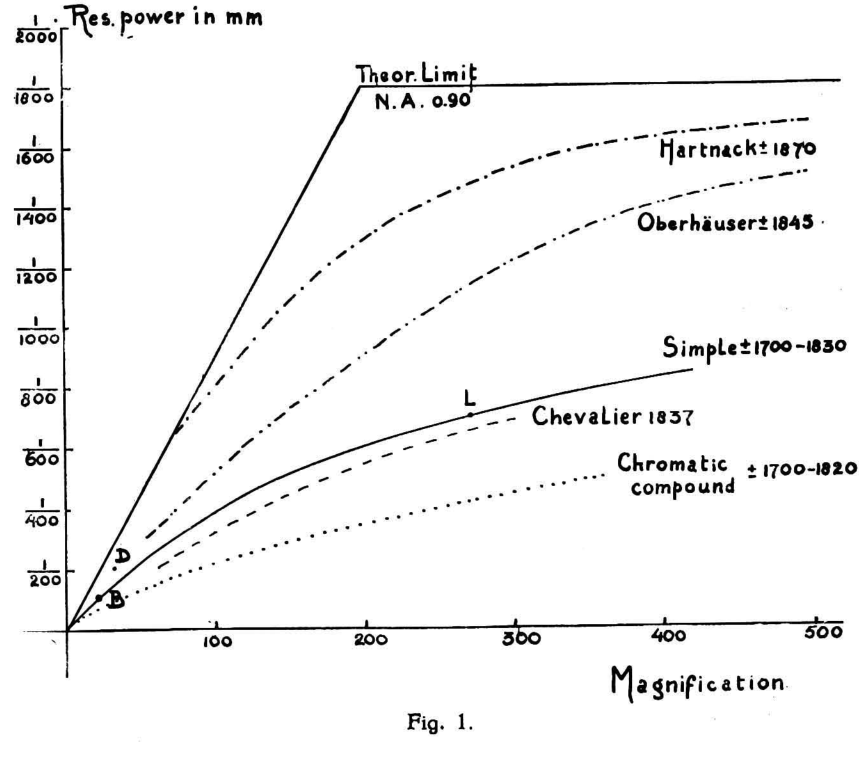

Fig. 1.

restricted to low magnifications only, the construction of the achromatic objective brought at once the compound microscope up to the level, or even above the level, of the simple microscope. The correction of stronger objectives, however, still presented difficulties so that the resolving power of the compound microscope for the larger magnifications, though increased considerably by achromatising, still remained below that of the simple microscope. This is clearly demonstrated by an instrument constructed in 1837 by CHEVALIER, one of the best builders of microscopes of his time. From fig. 1, the_ _ _ _ _line one can see that VAN LEEUWENHOEK's microscope, dated about 1700, is even superior to it!

After about 1840 the resolving power of the compound microscope went up by leaps and bounds and the cause of the simple microscope was lost! The microscope of OBERHÄUSER (about 1845) or better still that of HARTNACK (about 1870) makes this clear to us in a most convincing way (See fig. 1, the _ _ . . resp. the _ . _ line). The line referring to the HARTNACK microscope moreover shows, that, in the case of lower magnifications, this instrument has already reached the theoretical limit, represented in fig. 1 by the two continuous straight lines. The horizontal line gives the theoretical limit for $NA = 0.9$ and $\lambda = 5000$ Å; the construction of the slanting line is based on the experimental fact that the angular distance of two points must be at least $1\frac{1}{2}'$ in order to be seen separately.

We may summarize these comments on the resolving power of the microscope as follows: from 1700 to 1800 only the construction and the mechanical arrangement of the simple and of the compound microscope were improved. The optical capacities, however, show hardly any improvement. The simple microscope is, during this period far superior in optical respect to the compound one, which explains why scientific observers invariably fall back on the former type of instrument for their most important investigations. The successful construction and development of the achromatic objective opens a period of increasing resolving power of the compound microscope. At about 1830 the compound microscope definitely outdid the simple microscope, which from this time onwards loses its leading position and is nowadays only used as a dissecting microscope or as a magnifying glass.

But in this connection we draw once more attention to the remarkable fact that as regards optical powers, the "VAN LEEUWENHOEK" microscope must have been one of the best microscopes ever made before 1830. It is therefore no wonder that VAN LEEUWENHOEK, possessing all the qualities of a keen observer, was able, with this instrument, to make *such* startling discoveries, that up to the present day the scientific world is still amazed at them. Nor is it to be wondered at, that their reliability and correctness were formerly often doubted, for the simple reason, that they could not be repeated.

VAN LEEUWENHOEK possessed all the qualities that go to make a firstrate observer: keen eyesight, ingenuity, discrimination, and undeniably, an indefatigable patience, without which he could never have worked with such clumsy apparatus at all. Moreover his skill in grinding and polishing lenses must have been exceptional. And yet even all these excellent qualities do not explain his outstanding success. This can be only fully understood by taking in account that he used exactly the type of microscope, which by its high resolving power made his discoveries possible. If, at his time, the compound microscope had already offered the misleading advantages of a much more convenient manipulation and its apparent superiority over the simple microscope, instead of being at the beginning of its development, and if VAN LEEUWENHOEK should thereby have been induced to prefer the former type to the latter, he would never have obtained his startling results. In short, he made his discoveries not *in spite of*, but *thanks to* the fact that he made use of a primitive simple microscope.

Chemistry. — *The "Transition-point" of Liquid Helium.* By E. A. GUGGENHEIM, M. A. (Chemical Laboratory, University of Reading, England). (Communicated by Prof. ERNST COHEN).

(Communicated at the meeting of April 28, 1934).

The so-called "transition-point" of liquid helium discovered by KEESOM[1]) has been discussed in detail by EHRENFEST[2]) from a purely thermodynamic viewpoint. The observed properties of liquid helium are completely described by attributing the following properties to the system at the "transition-point".

1. Continuity of the thermodynamic potential Z.
2. Continuity of the first temperature derivative of Z, that is to say of the entropy S.
3. Continuity of the first pressure derivative of Z, that is of the volume V.
4. Discontinuity of the second temperature derivative of Z, that is of the heat capacity (at constant pressure) c.
5. Discontinuity of the second pressure derivative of Z, that is of the compressibility $\varkappa$.

(From conditions 1, 2, 3 it follows immediately that there is also continuity of the energy E).

The term "discontinuity of the second order", used by EHRENFEST to refer to these conditions, clearly emphasises the contrast between

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[1]) KEESOM, Proc. Amsterdam Acad. Sci., **36**, 147 (1933).

[2]) EHRENFEST, Proc. Amsterdam Acad. Sci., **36**, 153 (1933).