**Botany.** — "*On the Hydrosimeter*". By Prof. J. W. MOLL.

Many years ago I published the results of an investigation on the exudation of drops and injection of leaves [1]). The greater part of this investigation was made with cut branches into which water was driven by means of pressure of mercury. The instrument used for this purpose was as simple as possible and consistedof nothing but a U-shaped tube with a short and a long leg. The branch was fixed on the short leg of the tube filled with water, after which mercury was poured into the other leg until the desired pressure was obtained. This apparatus was rather imperfect, the pressure rapidly changing on account of the falling of the mercury in the long leg and the rising in the short one, and never remaining constant for a moment; so that in the experiments taken with this apparatus after some hours the pressure was generally for the greater part or entirely neutralized. The measuring of the quantity of water driven in could take place but impeifectly; it would have given rather much difficulty to arrive at a greater precision.

In the meanwhile the apparatus was sufficient for the purpose I then had in view. Yet the question arose in my mind whether it would not be possible to construct a better one, with which the driving in of the water could take place under constant pressure, whilst at the same time there would be a possibility of measuring accurately at any moment of the experiment the quantity of water driven in. Such an apparatus being of use for various botanical investigations, I have thought it worth while to solve this problem, and in this manner the apparatus has been made which I will now describe under the name of Hydrosimeter [2]).

In this apparatus constant pressure has been obtained in the following manner.

The mercury causing the pressure is in a flask of MARIOTTE, to which an india-ruber tube is attached, so that it can be placed higher and lower. In this way a constant higher level is obtained. This tube conveys the mercury finally into a U-shaped tube, placed upright with the curve downwards and sealed into in a glass-reservoir filled with water, to which also the plant under observation has been attached. In this manner the constant lower level is

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[1]) Untersuchungen uber Tropfenausscheidung und Injection bei Blattern. Proc. and Communic. of the Royal Acad. of Sciences, Sect. Physics, 2nd Series, Vol. XV.

[2]) From ὕδωρ = water and ὦσις = thrust, so gauge of waterpressure.

formed, for if liquid is driven from the reservoir into the plant, it is replaced by the mercury which flows off over the open leg of the U-shaped tube. So in this apparatus there is neither a falling nor a rising column of mercury; the lower level of the column of mercury being always equal with the upper edge of the open leg of the U-shaped tube. The volume of the overflowing mercury is equal to that of the water driven into the plant; this mercury can be drawn off and measured at any time. These are the principles on which the apparatus is founded.

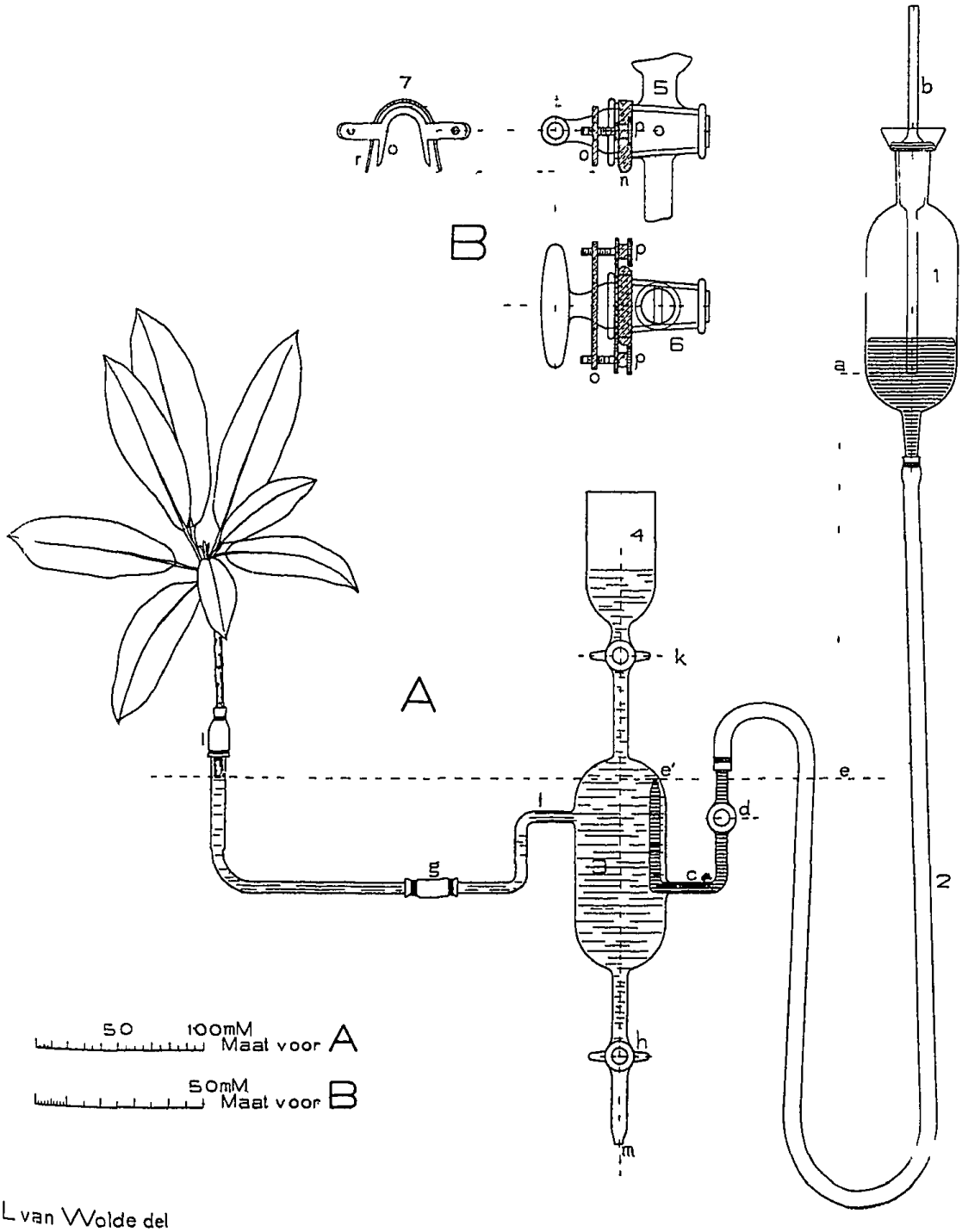
I shall now pass on to a brief description of the various parts, for which I wish to refer the reader to the plate added to this paper, and in the first place to ask his attention for fig. *A*. At the top on the right side at 1 is the mercury reservoir which can be placed at different heights. It is arranged as will be seen like a flask of MARIOTTE, so that on the level *a* there is always atmospherical pressure. The tube *b* fits on the neck of the reservoir as a stopper and to secure it better is closed wich mercury.

The mercury flowing from the reservoir passes through an india-rubber tube (2), with a wall-thickness of 2,5 mm. and a lumen of the same diameter, to the water-reservoir 3, to which also the plant is attached. Into this the mercury enters through the U-shaped tube *c* which possesses a glass tap *d* outside the reservoir. When the plant takes in water out of the reservoir 3, an equal volume of mercury will flow at *e'* over the edge of the open leg of the U-shaped tube, and collect at the bottom of the reservoir 3. So the lower level of the pressing column of mercury is always in the plane *ee'* and the distance *a e*, to be regulated arbitrarily, indicates the constant pressure under which water or any other liquid is driven into the plant.

Three tubes more are attached to the water-reservoir 3:

1°. the tube *f* leading to the plant; this tube is fixed high on to the reservoir, to let this contain as much mercury as possible thus the necessity of frequently drawing off the mercury being avoided. However, the tube soon bends downwards, passing into an open horizontal end. By this arrangement joining-pieces of simple shape can be used at *g* into which nevertheless the plant can be easily fixed with its plane of section in the level *ee'*. The connection at *g* is formed by means of the same thick-walled kind of india-rubber tube, which draws the mercury from the upper reservoir. This tube is so firm, and the surface upon which the pressure operates is so small, that even with a pressure of a full atmosphere the expansion is not of the slightest importance. The joining-pieces may have any shape,

J. W. MOLL. The Hydrosimeter.

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so that branches of any size or even entire plants with their roots can be connected with the apparatus, or pieces of wood through which fluid must be driven downwards. By using long joining-pieces it is also possible to place the plant in a glass case or any other apparatus, which if necessary can be put up at a tolerable distance from the hydrosimeter, whilst the reading of the result on the latter remains possible. On the plate the apparatus is shown as it is used for the injection of the leaves of Rhododendron.

2°. a lower tube with a glass tap (*h*); through this the mercury can be drawn off, the volume of which is to be determined.

3°. a topmost tube, likewise with a glass tap *k*, which tube ends in a reservoir 4 filled with water. This is necessary to replace the mercury which is tapped through tube *h*.

After this description of the apparatus shown in fig. *A* I wish to draw the attention to fig. *B* giving a representation of a metal clip, one attached to each of the three glass taps. The hydrosimeter is arranged for the use of one atmosphere as maximum pressure, this being at least for botanical investigations more than sufficient, whilst for the rest there are no obstacles to the use of a higher pressure, though it might make some further precautions necessary. But already with pressures of less than one atmosphere we meet with the drawback that not only do the taps leak, but that even the whole tap-stopper is pressed out. This is indeed not to be wondered at, considering the stopper being always more or less conically shaped and especially the holes being never entirely perfect at the edges. To overcome this drawback each of the taps is furnished with a clip which makes the leaking and the pressing-out of the stopper quite impossible. Fig. *B* gives at 5, 6 and 7 three different views of such a clip. It consists of two brass rings in the shape of a horse-shoe and acting like a spring, so that they can be easily fixed round the neck of the tap to fit well. The ring *o* fits round the thinnest part of the tap-stopper, the ring *n* on the contrary round the tube in which the stopper turns, the thick edge of this preventing the sliding off.

As is seen, both rings are provided with two projecting metal lips. These lips of the two rings correspond in place and size to each other, and are connected by two screws (*p*), so that they are easily adjustable at different distances from each other. It is clear that when such a clip is placed on a tap, the stopper can be fixed

very firmly by means of the screws into the tap, whilst the latter, when well greased, will remain easy to turn. As was said before, each of the three taps is provided with such a clip.

To put the apparatus into operation first of all the necessary amount of mercury must be brought into the reservoir 1, the india-rubber tube 2 and the U-shaped tube *c*, after which the remaining part is filled with water. Then the taps have to be tried, in a way I shall not describe here in details, whether they close well, and finally the plant is connected with the apparatus in the manner shown in fig. *A*.

It goes without saying that during the experiment one can measure as often as one likes the water driven into the plant during a certain time. To do so tap *d* is closed and the pressure for a moment neutralized, to which in most cases there will be no objection. The mercury is drawn off and replaced by water, when for a moment the taps *h* and *k* are opened simultaneously. The experiment can be immediately continued by causing the pressure to operate again.

In order to make the tapping of the mercury possible the tube leading off the mercury may not be too narrow at *m* and its lumen must at least amount to 3 mM. The drawn off mercury can now and again be poured into the reservoir 1, so that for lengthy experiments a limited amount of mercury is sufficient.

The size of the drops overflowing at *e'* the edge of the U-shaped tube depends on the width of the tube and can thus be regulated within certain limits according to special wants. In the apparatus I am using at present, the top of the U-shaped tube measured on the outside has a thickness of about 2 mM. The size of the drops, which is very constant, amounts to 0.02 $cM^3$. So the apparatus enables the experimentist to make very accurate observations. Moreover in such cases when one wishes to take measurements at not too long intervals without neutralizing the pressure, one can easily attain one's aim by counting the drops flowing over.

The apparatus has been made according to my directions by the firm J. C. Th. Marius at Utrecht and is brought by the same into the trade.

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**(November 21, 1901).**