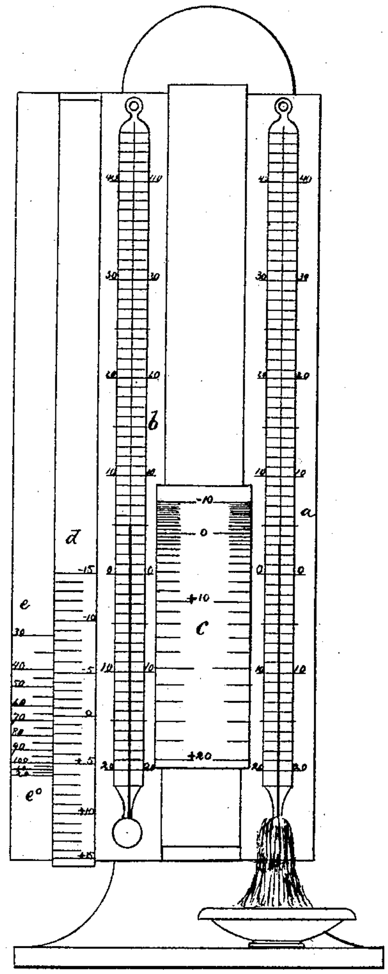
W. KLINKERFUES.

Psychrometer.

No. 168,505. Patented Oct. 5, 1875.



Witnesses.

Otto Hufeland
Chas. Wahlers.

Inventor.

William Klinkerfues
per
Van Santvoord & Hauff
attys

UNITED STATES PATENT OFFICE.

WILLIAM KLINKERFUES, OF GÖTTINGEN, PRUSSIA.

IMPROVEMENT IN PSYCHROMETERS.

Specification forming part of Letters Patent No. **168,505**, dated October 5, 1875; application filed August 20, 1875.

To all whom it may concern:

Be it known that I, WILLIAM KLINKERFUES, Doctor of Philosophy, Professor and Director of the Royal Observatory of Göttingen, Prussia, in the Empire of Germany, have invented a new and Improved Self-Reducing Psychrometer, which invention is fully set forth in the following specification, reference being had to the accompanying drawing, which represents a face view of my psychrometer.

Of the three meteorological instruments—barometer, thermometer, hygrometer—the last one is the least adapted for the use of the layman. In consequence thereof one generally finds hygroscopes of a very questionable value among them. If the popular weather-prognosis, which chiefly depends upon the fluctuations of the barometer, is to be improved by the simultaneous use of the hygrometer, the difficulty arises that the point of saturation, or the absolute humidity of the atmosphere, is to be determined, for it is the latter, or also the tension, which is of importance, owing to the fact that the relative humidity indicates at the same time the degree of humidity of the air as well as that of temperature.

A layman who is not able to reduce the relative humidity into the absolute is in the same position as the proprietor of an aneroid-barometer with imperfect vacuum, which, therefore, gives fictitious indications, only showing the variations of the temperature. The great part, however, played by the absolute humidity of the temperature of saturation follows from the perfectly-well confirmed theory that, owing to the diffusion of the watery vapor, a decrease of the temperature of saturation takes place before the anti-polar current goes over in the polar current. This change is followed by the ascending movement of the barometer, which generally ensues after an interval of several hours. This transaction even fails to take place if the corresponding movement of the hygrometer does not take place.

With the reverse change from the polar to the anti-polar current it is the same case. In Göttingen the barometer fell, from the evening of the 18th of December to the evening of the 20th of December, 1874, from 752.2$^{mm.}$ to 737.0^{mm}. To judge from this observation alone, the occurrence of the anti-polar current or thawing weather would have been predicted; but the temperature of saturation sank at the same time from −3°.0 to −5° Celsius, the polar current predominating with increasing power in spite of the falling of the barometer.

Herewith is combined one of the most useful applications that can be made of the hygrometer—*i. e.*, the estimation of the minimal temperature of the following morning, in winter, even twenty hours in advance. As examples of this prognosis, I give here a table for warm winter days:

Time in Gottingen—Morning.	Prognosis for the following day.	Observation.
November 1, 10½	0°.	+ 0°.6 Reaumur.
" 2, 9¼	− 1.0	− 1.6 "
" 3, 9	− 1.0	− 0.2 "
" 4, 9¼	+ 1.0	+ 4.5 "
" 5, 9¼	+ 3.0	+ 1.5 "
" 6, 8¾	+ 2.0	+ 2.4 "
" 7, 9	+ 3.0	+ 3.1 "
" 8, 10½	+ 3.0	− 0.7 "
" 9, 10½	+ 1.0	− 0.4 "
" 10, 8¾	+ 4.0	+ 0.3 "
" 11, 9¼	0.0	0.0 "
" 12, 9	0.0	− 3.0 "
" 13, 9	− 2.0	+ 0.2 "
" 14, 8½	− 3.0	− 1.7 "
" 15, 8½	− 2.0	+ 0.3 "
" 16, 9	+ 1.0	+ 1.3 "
" 17, 9½	0.0	+ 1.1 "
" 18, 8¾	− 1.0	+ 1.0 "
" 19, 10¼	0.0	+ 1.3 "
" 20, 9½	0.0	− 0.8 "
" 21, 9½	− 6.0	− 4.3 "

For colder winter days:

Time in Gottingen—Morning.	Prognosis for the following day.	Observation.
December 24, 9	− 4° 0	− 5°.5 Reaumur.
" 25, 9	− 5.0	− 4.0 "
" 26, 8¾	− 5.5	− 3.6 "
" 27, 9	− 7.0	− 9.1 "
" 28, 8¾	− 9.0	− 7.6 "
" 29, 9½	− 8.0	− 8.2 "
" 30, 9	− 6.0	− 6.5 "
" 31, 9	− 7.0	− 7.0 "

It is true that in many cases the observation of the course of the air temperature will allow us to judge just as well; but in many other cases it will not, and these are those which are of importance for the several branches of agriculture, as horticulture, the cultivation of fruits and vegetables, &c.—*i. e.*, the cases of unexpected night-frosts. On April the 27th, owing to the high temperature of the air, one would probably not have expected a night-frost, but the temperature of saturation being only $+1°.6$ Reaumur at $6\frac{1}{4}$ in the afternoon, this hint was made use of to protect the vegetables in the garden of the royal observatory from freezing.

With regard to the experience made, it would be very useful if the temperature of saturation, or the thawing-point temperature, could be ascertained with the same facility which is required to take the observations of a barometer. This is accomplished by a hair-hygrometer constructed by the undersigned; but the result may be attained in a still simpler manner by my new self-reducing psychrometer, which is an improvement of the well-known psychrometer of August.

If t signifies the air temperature, t' that of the moist thermometer, S' the maximum of the tension of the vapor for the latter temperature, S the required tension of the atmospheric vapor, or the maximum of the tension for the thawing-point temperature, B the atmospheric pressure, we have $S = S' - 0.000\,783\,B\,(t - t')$ according to August, supposing that the scale of Celsius be chosen, and pressure as well as tension be measured in millimeters.

In most cases, and without making too great a mistake, the average barometer pressure of the place can be substituted for B, so that 0.000 783 B will be equal to the constant c. The above formula of August may, therefore, be written $\frac{S}{c} = \frac{S'}{c} - (t - t')$.

If the value of the tension, divided by c, is transferred on a straight line in divisions and for all values of the temperature, and if from the point corresponding to the value $\frac{S'}{c}$ the length $t - t'$ is transferred in falling numbers, one gets the point corresponding to $\frac{S'}{c}$. But there is nothing in the way to designate these points produced by the transferring of $^1/_c$ of the tensions also with the corresponding temperatures, and to place this scale between the two thermometers, so that it can be moved to and fro, and in such a manner that the figures indicating the temperature run in opposite direction to those of the thermometer. If, as usual with the psychrometer, the two thermometers have equal degrees, the thawing-point temperature is then found according to the following rule:

If, by moving the sliding scale, the number indicating the temperature of the moistened thermometer is placed at the same height with the same number of the sliding scale, the figure of the sliding scale which is opposite to the end of the mercury-column of the dry thermometer shows directly the temperature of thawing-point.

Aside from the possibility that it is very easy to set the instrument right, the latter indicates the thawing-point without any calculation. The name "self-reducing psychrometer" might, therefore, not be improper.

In constructing the sliding scale it is also very easy to regard the variations of the barometer. All conditions are fulfilled if, for every two barometric indications between which the height of the barometer of a place lies, the scales are traced and if the corresponding points are combined by means of transversal lines. The division-points of the transversals yield then as many intermediary scales as one intends to apply with regard to the barometer height. If, for instance, the scales for an atmospheric pressure of $700^{mm.}$ and $800^{mm.}$ are traced on the slide parallel to and in a medium distance from each other, it is only necessary to draw the transversal lines between their analogous points to divide one of them in ten equal parts, and to draw through the division-points parallel lines with the scales for the barometric height 700—$800^{mm.}$, in order to have the scales for $710^{mm.}$, $720^{mm.}$, $730^{mm.}$, &c.

If one would attain the same end by tables, 11 tables would be necessary with double entry, which could be much less conveniently used.

The annexed drawing shows my psychrometer in detail. If the temperature of the moist thermometer sinks below 0° it is proper to use the value 0.000 689 instead of the co-efficient 0.000 783, which may conveniently be done by means of a reserve slide. Without that the whole arrangement needs to be changed.

In the drawing, the letter *a* designates the moist thermometer, the letter *b* the dry thermometer, and the letter *c* the sliding scale.

The temperature indicated by the dry thermometer is + 5, that indicated by the moist thermometer + 3. By moving the + 3 of the sliding scale opposite to the + 3 of the moist thermometer it will be seen that —2 of the sliding scale comes opposite to + 5 of the dry thermometer, and consequently the thawing-point is at —2°.

For the purpose of determining the relative humidity of the atmosphere at any time I use a second slide, *d*, which carries a scale obtained in the following manner: Let f be the maximum of the amount of water, or the absolute humidity for the air temperature t,—*i. e.*, the number of grams which may be contained in a cubic meter of air at this temperature; and f^0 be the same for the thawing-point temperature; then is $\frac{f_0}{f}$, the so-called relative humidity, a fraction which generally is expressed in per cents. Let p be this fraction; hence, $p=\frac{f_0}{f}$; log. $f^{0}=$ log. $f+$ log. p.

The subtraction of two logarithms necessary for calculating p from f_0 can be accomplished by means of two scales, which can be moved side by side of each other. On one scale are the logarithms of the maxima of the watery vapor, the corresponding points being indicated with the temperatures themselves. On the other scale there are the logarithms of p for the per cent. series of the relative humidity, and designated with the percent.—number. Hence, the relative humidity is found mechanically by placing the slide in such a manner that the air temperature of the one scale is placed in the same line with 100 on the per cent. scale. The thawing-point temperature of the former is then also opposite the number giving the per cent. on the latter. There is a short continuation beyond the point 100, the division of which corresponds to degrees of the difference $t-t_0$, for the purpose of finding by the mechanism also the absolute humidity of the air, a value which may here be designated by h. According to the principal formula of the science of hygrometry there is, for the centigrade-scale,

$$h=f_0\,\frac{1+0.003665\,t_0}{1+0.003665\,t},$$

wherefor we can substitute, without any essential error,

$$h=\frac{f_0}{1\times 0.003665\,(t-t_0}=\frac{p\,f}{1+0.003665\,(t-t_0)},$$

or log. $h=$ log. $p+$ log. $f-$ lg. $\{1+0.003665\,(t-t_0)\}$.

In order to simplify the subtraction of log. $\{1+0.003665\,(t-t_0)\}$ this logarithm is transferred from the number 100 by marking according to degrees of that difference $t-t_0$. After the relative humidity p has been found in the above-described manner the temperature of the air on the large scale is once more set opposite the dash for $t-t_0$ on the appendix belonging to the present scale. The temperature which is then opposite the dash for p has for its maximum the searched amount of vapor of the air.

An example may serve for the explanation of this method. On a self-reducing psychrometer, which, however, was arranged for Reaumur, the following was read: $t=+5^{\circ}.0$ R., $t_0=-2^{\circ}.0$ R. Opposite to the number 100 on the per cent. scale $e+5.0$ of the slide d was set, in order to find the relative moisture p. This one stood opposite the temperature $-2^{\circ}.0$ and amounted to fifty-five and a half per cent. Now, $t-t_0$ being equal to $+7^{\circ}.0$ the number 5.0 of the air temperature was once more set opposite the number 7.0 in the small scale e^{0}. Opposite to the number $55\frac{1}{2}$ of the per cent. scale was now $-2^{\circ}.4$ of the temperature-scale. For $-2^{\circ}.4$ we find in the known tables, as maximum amount of the humidity of the air, 4.14 grams per cubic centimeter, which was also the amount of water of the examined air of $5^{\circ}.0$ R.

In the above description of my self-reducing psychrometer it was supposed that the two thermometers had equal degrees. This, however, is not absolutely necessary. We may, for instance, mark the temperature of evaporation at the moist thermometer, and place then the described scale of $\frac{S}{c}$ to the thermometer-scale of the dry thermometer in such a manner that the dashes of the temperature of evaporation fall on both scales in one and the same line. In using this method the $\frac{S}{c}$ scale needs evidently only to be adapted to the length of the degrees of the dry thermometer, those of the moistened thermometer may have any length.

Again, the reduction arrangement of the psychrometer—viz, the one which indicates the thawing-point as well as that which yields the relative moisture and the amount of water in the air—may be separated from the thermometer. For the former arrangement a thermometer-scale, having any length of degrees, is combined with a proper $\frac{S}{c}$ scale to a sliding arrangement; but in the form of two concentric circles, which may be placed above each other. If the temperature of evaporation read from the moist thermometer is placed on the same radius, the thawing-point temperature will be in one line with the air temperature.

What I claim as new, and desire to secure by Letters Patent, is—

1. The combination of a movable scale, c, bearing marks, the relative position of which are obtained in the manner herein-described, with two scales, a b, one of which serves to indicate the temperature of a moist thermometer, and the other that of a dry thermoneter, all as set forth.

2. The combination of the moving scale d with the percentage scale e e^{0}, both of these scales being provided with marks, the relative position of which is obtained substantially in the manner herein described.

In testimony that I claim the foregoing I have hereunto set my hand this 11th day of May, 1875.

W. KLINKERFUES.

Witnesses:
FRANZ WIRTH,
FRANZ HASSLACHER.