

## THE THERMOMETER.

In connection with Dr. Carus's article on thermometers in *The Open Court* for March, 1916 (p. 187), it is of interest to note that the original memoirs of Fahrenheit, Réaumur, and Celsius were collected and reprinted in No. 57 of *Ostwalds Klassiker der exakten Wissenschaften*. The subject is also referred to in the English translation of Mach's *Principles of the Theory of Heat* which is now in the press and will shortly be published by the Open Court Publishing Company. The little volume of the *Klassiker* just mentioned is edited by A. J. von Oettingen, and from it the following particulars are taken. Gabriel Daniel Fahrenheit (1686-1736) was a son of a merchant in Danzig, and went to Amsterdam to study business. Here he learned physics, and traveled to England where he wrote five memoirs for the *Philosophical Transactions* of 1724. These memoirs were the only ones he ever wrote, and though they are not at all connected immediately with his famous thermometer, they are all translated from Latin into German in the above little volume. Fahrenheit seems to have lived in Amsterdam by the making of meteorological instruments, but was of some scientific eminence, since he was elected a member of the Royal Society of London. Fahrenheit was the first to use mercury in thermometers, but Christian Wolff, who is best known as a follower of Leibniz, had used it in *thermoscopes* in 1709. René Antoine Ferchault, Seigneur de Réaumur, des Angles et de la Bermondière (1683-1757) became a member of the Paris Academy of Sciences in 1708, published much on the technical arts, and later on constructed his thermometer and took up studies connected with it. His memoirs on thermometry appeared first in the Paris *Mémoires* for 1730, 1731, and 1733, and were of great length, in contrast to Fahrenheit's short and excellent writings. Anders Celsius (1701-1744) was born and died at Upsala in Sweden, was professor of astronomy there, and his memoir on thermometers appeared in the publications of the Swedish Academy of Sciences for 1742.

The above accounts of Fahrenheit, Réaumur, and Celsius are confirmed by the biographies in the latest (eleventh) edition of the *Encyclopædia Britannica* (Vol. X, p. 126; Vol. XXII, p. 947; Vol. V, p. 609, respectively).  $\Phi$

*Comments upon the Editorial Article concerning our Thermometer.*

The recent article in the March number of *The Open Court* upon "Our Thermometer" has no doubt been read with considerable interest. Several statements in it, however, are very misleading and require to be corrected.

It is said for example on page 188: "There is no doubt that to Fahrenheit belongs the honor of having invented the thermometer; all the essentials of temperature measurement were invented by him and we shall never forget that he was the pioneer in the field." The Editor's desire to award the invention of the thermometer to a German is of course perfectly natural; if he will turn, however, to two perfectly trustworthy German authorities, Poggen-dorff's *Geschichte der Physik* (p. 225) and Gerland's more recent *Geschichte der Physik* (p. 339), he will find that Fahrenheit instead of being a pioneer was a comparatively late comer in the field of temperature measurement. Galileo, an Italian, invented the thermometer about 1592; his first instrument, based upon the expansion of air, was really a development of the work of a Greek, Hero of Alexandria. Galileo soon found air to be unsatisfactory and

in 1612 invented the alcohol thermometer in which each degree represented  $\frac{1}{1000}$  the volume of the bulb. Many of these old Galilean thermometers can still be seen in museums. Réaumur based his alcohol thermometer upon that of Galileo, and having fixed his zero at the freezing point of water let each degree above this represent  $\frac{1}{1000}$  the volume of the bulb and stem below the zero division. With the strength of alcohol which he used the boiling point of water happened to fall at the 80th division. There is no truth whatever in the statement that Réaumur graduated his scale by dividing the interval between the freezing and boiling points into 80 degrees; this method of graduation was adopted by Réaumur's successors but not by Réaumur himself.

The use of mercury for thermometers in place of alcohol was first tried in Florence and later in Paris. Fahrenheit's first experiments were made with alcohol, but about 1720 he abandoned alcohol for mercury, and his technical skill, which exceeded that of his predecessors, soon made the mercury thermometer, what it never was before, an accurate instrument of measurement.

The zero point of Fahrenheit's thermometer was based upon the temperature of a mixture of ice, water and salt (which he believed to be the lowest possible cold) and not upon that of the coldest day which he had experienced, as incorrectly stated by the Editor (see Poggendorff's *Geschichte*, p. 519).

Fahrenheit fixed the freezing point of water upon his scale and divided the interval between this and his zero into 32 divisions, probably for the reason that he was able to reach the length of a single degree mark by a simple process of bisection. (The English inch is divided in the same way into  $\frac{1}{2}$ ,  $\frac{1}{4}$ ,  $\frac{1}{8}$ ,  $\frac{1}{16}$  and  $\frac{1}{32}$ , and this method of bisection is a great convenience for many purposes.) By extending these divisions above the zero division Fahrenheit arrived at the upper register of his scale. The temperature of the human body which Fahrenheit found to be  $96^\circ$  (three times the interval from 0 to 32) formed the third fixed point upon his scale. By means of these three fixed points Fahrenheit could easily standardize his thermometers and it was in this way that his instruments were brought to their high point of accuracy. Fahrenheit did not employ the temperature of boiling water as a fixed point. Upon the scale graduated as described the boiling point of water happened to fall at  $212^\circ$ . At the present day it is customary to graduate the Fahrenheit scale by fixing the freezing point of water at  $32^\circ$  and the boiling point at  $212^\circ$ , the interval between these two divisions being divided into 180 degrees. By extending these divisions below  $32^\circ$  the lower register of the scale is reached.

The Editor omits to state in his article several advantages which the Fahrenheit scale has over other systems. In the first place by setting his zero point very low Fahrenheit obviated the necessity of employing minus degrees for most meteorological measurements. Of course we know now that a much lower cold can be produced than by a mixture of ice and salt, the absolute zero being several hundred degrees below this ( $-273^\circ$  Centigrade and  $-460^\circ$  Fahrenheit). The principle of starting with the lowest possible cold, however, is sound and many scientific measurements are based upon a scale which begins with absolute zero.

Another great advantage of the Fahrenheit scale is that it largely does away with the necessity of using fractional degrees. The one hundred divisions of the Centigrade scale are hardly sufficient to express ordinary observations without the use of fractions.

These advantages of the Fahrenheit scale and the natural inclination of most peoples to conform to natural usage explain the continuance of its use in England, Holland, the United States and other parts of the world. The statement "That America has so long followed the English conservatism is only a sign of our lack of independence" is wholly unwarranted. Would the Editor explain the use of the Fahrenheit thermometer in Holland in this way? Surely there is such a thing as persistence of natural customs! As good a philosopher as Dr. Carus must recognize this and he should be less hasty in forming his generalizations. Would it be permissible to say that the barbarous custom of the student duel, which persists in Germany notwithstanding all efforts to abolish it, is a sign that all Germans are barbarians? Would Dr. Carus call the tenacity with which the German people cling to their black letter type, when other nations centuries ago adopted the simpler and much more beautiful Roman type, a sign that the German people are unprogressive? In spite of the fact that reformers in Germany have shown their people that the old black letter produces eye-strain and myopia, and is a severe handicap in the education of young children, old custom continues to assert itself and the use of Roman type is making only gradual headway.

Adopting the reasoning which Dr. Carus has used, an unfriendly critic of German customs might retort: "The Germans, most conservative of all, cling to forms of type used by their inventor, a native of Holland. Koster selected as the model for his types the old Gothic letter, and notwithstanding the fact that the people of Holland and of other nations centuries ago abandoned the Gothic for the simpler and more pleasing Roman letter, the Gothic is still the letter for every German mind. This settled the question and no change has occurred down to the present day, for if the German mind accepts one method of action it will stick to it until the end of time." The Editor would very justly repudiate any such conclusions as these, and yet they are strictly analogous to those which he has drawn in his article upon the thermometer.

The pages of *The Open Court*, whose chief aim has been to encourage the philosophy and religion of science, should be above every display of petty nationalism.

These comments upon the article of Dr. Carus concerning the thermometer might be applied to other recent contributions of his, where strong racial feeling has apparently prevented him from looking upon many questions with his former broad-minded spirit of fairness and impartiality. The many friends of *The Open Court* dislike to see its Editor forsake his previous love for scientific accuracy and truth, for the sophistries of a partisan propagandist.

C. A. BROWNE.

NEW YORK.

*Editorial Reply.*

Mr. C. A. Browne's letter is very welcome because Mr. Albert Johnson, member of the House of Representatives, has introduced a bill to abolish the Fahrenheit thermometer and is anxious to collect the opinions of specialists on the subject. Here is the revised draft of the bill which is "submitted for criticism":

"Be it enacted, etc., That the centigrade scale of temperature measurement shall be the standard in United States Government publications, the use of the

Fahrenheit scale being discontinued, at the option of the chiefs of bureaus, either immediately upon the signing of this bill or after such interval as may in the opinion of each bureau chief seem advisable as regards the publications issued by his bureau.

"Sec. 2. During the period of transition, the Fahrenheit equivalent of centigrade degrees may be added in parenthesis or as a footnote or in any other way, if in the opinion of bureau chiefs it seem necessary in order to prevent misunderstanding.

"Sec. 3. The introduction of the centigrade scale as the standard is not intended to interfere with the use of the absolute scale, in which zero represents the absolute cold."

I must confess that the note which I had jotted down on the thermometer was merely a comment to be used in reference to the proposed bill, and that by mistake it was published prematurely; but it serves its purpose if it has called out the criticism of specialists. That is exactly what is needed.

Mr. Brown seems to be a specialist, I am not; and Mr. Browne will do a good service to the cause if he can advise our legislators whether it would be wiser to retain the Fahrenheit thermometer as being possessed of qualities which make it more desirable than the centigrade now used in scientific work on the European continent.

I feel reluctant to reply to Mr. Browne's critical remarks so far as they are directed at me personally. I am inclined to let them stand. Still I feel that I should make a few comments in explanation of my convictions.

I know very well that mankind is conservative, and the English are more conservative than other nations. They are often conservative to a fault, but we must consider that conservatism is a virtue, and England's pre-eminent position among the nations is mainly due to the conservative character of her people.

It is strange that Gothic type is frequently considered as a peculiar kind of alphabet which results in difficulties for school-children when attempting to learn German. The Gothic form of letters, often called the German alphabet, is the same as the old Roman, only it is a peculiar style which at the time of its invention was considered ornamental. You can trace in every Gothic letter the shape of its Roman equivalent, the only difference being a twist given to the straight line of its Roman prototype. It is really the same mode of tracing letters which in English is called "black letter," and it is an invention to be traced back to the monks who were the scribes and copyists in the middle ages long before Koster. I will no more belittle Koster's innovation in introducing the black letter type into print, than Mr. Browne denies the merit of Fahrenheit in making the first practical thermometer, even when insisting upon the fact that he had predecessors in Galileo and Hero of Alexandria.

Considering my partisanship for the Germans, of which Mr. Browne accuses me, I plead guilty. But I will add that I am not pro-German because I am a native German; I am pro-German because after a careful investigation I have acquired the conviction that in the present war Germany is right and the Allies are wrong. I am very sorry that the war has come upon the world. It is a terrible struggle, terrible for all, and I am sorry for every nation and for mankind in general; but I am positive that Germany did not start the war,

and I feel sure that, although greatly outnumbered by her enemies, she will hold her own on account of her efficiency.

The English are of German extraction and the English language is a modified Saxon or Low German dialect. The English are nearer kin to the North Germans than are the Danes or the other Scandinavians,—nearer even than the South Germans are to the North Germans. I have always cherished a high opinion of the English nationality as well as the English language. I am positive that if I could be shown by facts and sound argument that the Germans are wrong in this present war I would vigorously stand up against them as I did at the time of the Dewey-Dietrich quarrel when I did not hesitate to express my views on the subject in unequivocal terms. I would consider it a sign of cowardice on my part if I shrank from speaking out plainly what I have found to be the truth. Convince me that I am wrong, but do not attribute my position to "racial feeling" which makes me "forsake love for scientific accuracy and truth, for the sophistries of a partisan propagandist."

I know that most people do not take sides in this war on rational grounds but from sentimental impulse, and it is hopeless to convince any one by argument after he has once taken his stand. The large masses of people are absolutely deaf to argument. Nevertheless I would act against my conscience if I concealed my conviction.

My duty to speak out boldly is the more imperative since I see a tremendous danger threatening our national independence. I came to this country as an American, not as a German. I believe in American ideals, but I am shocked at the sight of Americans turning traitors to their own Americanism. We are not endangered by Germany, but we are endangered by England and her ally Japan. At present the Japanese danger is the more acute, but the English is the more insidious. It has poisoned the minds of our leaders, and the final result will be the loss of our independent development. I know that some of my pro-British friends would not grieve over it because they bow down before the British ideal. They think that we would gain by recognizing English superiority, by overcoming our crudeness and imbibing English civilization, yea, identifying ourselves with Anglicism. I am an American of the old style, and if the new pro-British Americanism should become our national ideal, officially recognized not only by one transient administration but with full conviction endorsed by the people, by the whole people, I would regret ever having set foot on this shore and would feel a longing to emigrate to some other country where the spirit of the old Americanism, the spirit of Washington and Franklin, of Jefferson and Hamilton, and of Lincoln, is alive. I would bid goodby to my American countrymen and would wish them God speed, but would say: You are no longer truly American! you are pseudo-American; you have lost the old vigorous American spirit; you have forsaken your own traditions; you have forfeited the blessings for which your fathers fought.

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#### WATER-POWER CONSERVATION.

While our president keeps us bewildered with his pro-British policy and while our dailies concentrate our attention on the chase our troops are giving to Villa, there are those who claim that the American people are being robbed in the most legal and thorough style by laws which are donating enormous