HOW TO MAKE A MERCURY THERMOMETER.

The first thing to be considered in the making of a thermometer is the character of the glass to be used. The thermometer maker always selects a length of annealed glass, so hard that it melts with readiness only in the blowpipe, and absolutely uniform in bore. The length of glass is held in the blowpipe at the point where it is to be severed until it becomes so thoroughly plastic in the flame that it almost drops apart. When the glass has been thus softened it is withdrawn from the flame, grasped at each end, and quickly pulled apart. The result is two tubes, sealed at one end.

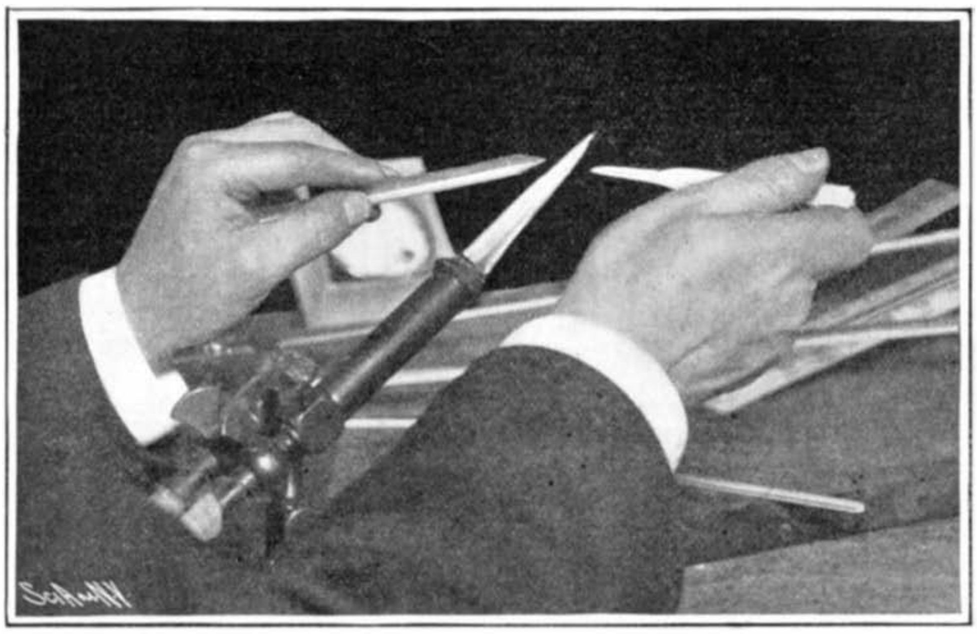
The next step is the formation of the bulb. One of the two tubes obtained by the process just described is held in the blowpipe, the sealed end being subjected to the heat. When the glass has been melted sufficiently, the tube is removed from the blowpipe. By blowing through the open end, a bulb of any size can be formed.

After the bulb has been blown, the next step is the filling of the tube with mercury. To effect this, the open end is plunged in a vessel of mercury. The liquid metal rises slightly in the tube. The tube is then reversed, so that the mercury runs down into the bulb. By heating the bulb in an alcohol flame or Bunsen burner, the mercury is made to boil. The vapors given off drive out the air, thereby creating a vacuum. When this point has been reached, the open end of the tube is plunged into mercury, which in order to fill the vacuum, rushes up and completely fills the tube. The open end is now closed with sealing wax in order to prevent the entrance of air. Hermetic sealing is effected by holding the tube in the blowpipe beyond the wax-plugged open end, by drawing the molten end off.

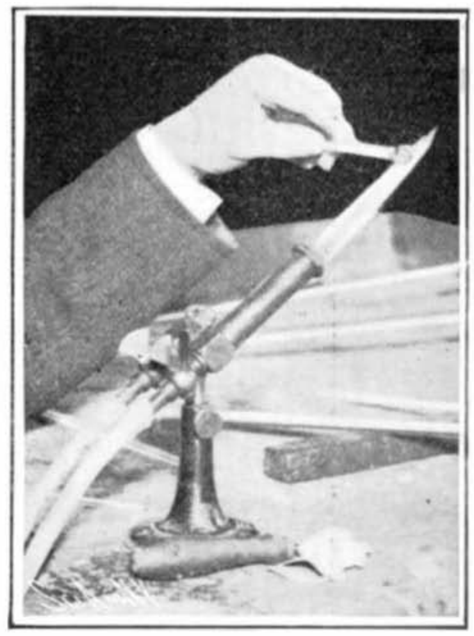
Two fixed points must now be taken. The lower is usually taken first. The thermometer is placed vertically in finely-pounded melting ice, or preferably snow, contained in a vessel which will allow the water to drain away. The whole of the mercurial column should be immersed in the ice. After from twenty minutes to half an hour the thermometer may be raised until the top of the mercury is seen just sufficiently for its position to be noted. This is the freezing point—32 deg. on the Fahrenheit thermometer, 0 deg. on the Centigrade.

The temperature of water boiling is the higher fixed point. To determine this the tube of mercury is held in the steam of boiling water, which can be done by running the tube through a cork and suspending it by a wire or other means in the vapor. As the boiling point depends upon the pressure of the atmosphere, the height of the barometer must now be taken. If it stands at 760 millimeters, the temperature is 100 deg. C. If not, a calculation will be necessary; 1 deg. C. or 1.71 deg. F. must be added or subtracted for every 26.7 millimeters above or below 760 millimeters. The interval between the two fixed points is then divided into 100 parts or degrees for a Centigrade, or 212 parts for a Fahrenheit thermometer. To graduate the scale above 100 deg. a column of mercury is measured below that point, then made to pass above step by step; the portions of the tube filled by the column are then divided into the number of degrees which it represents.

A thermometer made in the manner described is not an absolutely scientific heat-recording instrument. Still, it will be found sufficiently accurate for use in ordinary life.



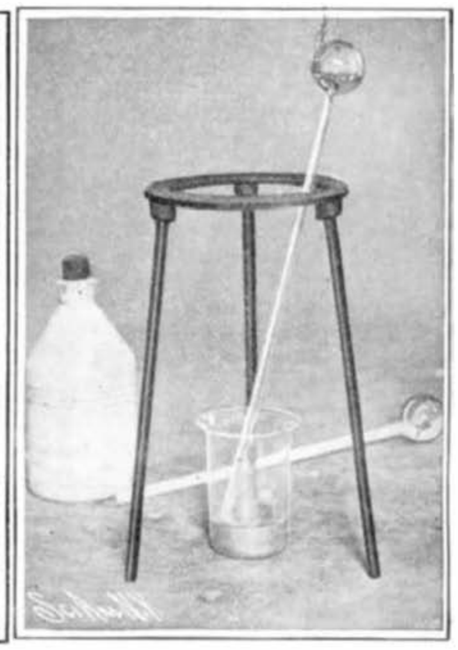
Melting the Glass and Drawing It Apart.



Heating the End Before Blowing.

After the End Has Been Heated in the Blowpipe the Bulb is Blown.

Creating a Vacuum by Boiling Mercury in the Bulb.



Immersing the Tube in Mercury so That the Metal Rushes Up to Fill the Vacuum.

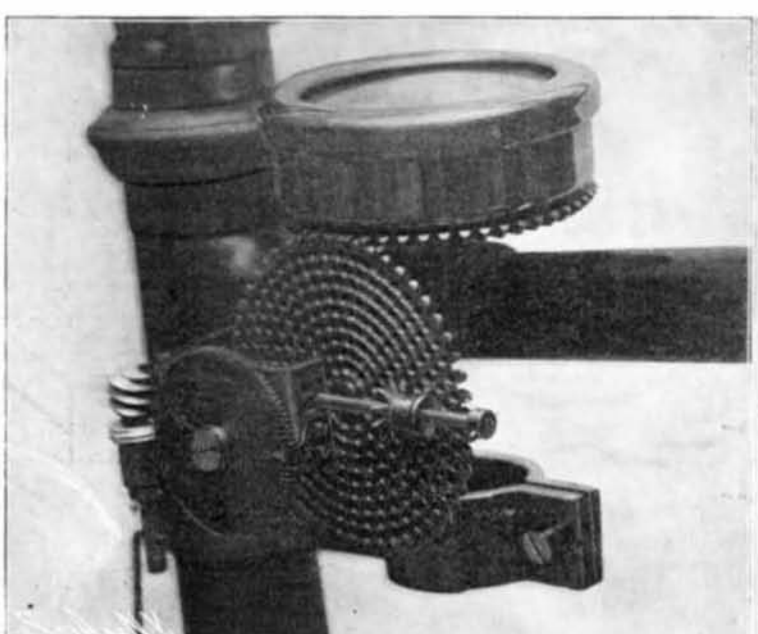
HOW TO MAKE A MERCURY THERMOMETER.

A TACHOMETRIC WATCH FOR BICYCLES AND OTHER VEHICLES.

BY EMILE GUARINI.

The principle of the tachometric watch, illustrated herewith, is very interesting and very simple. It consists in causing the case of a watch to be revolved by the wheel of a vehicle in a direction contrary to that of the hand of the watch and at the same rate of speed.

(*Continued on page* 162.)



Tachometer Attached to Steering Head Below the Top Bar of Frame.

View Showing the Complete Apparatus Applied to a Bicycle.

Tachometric Watch Shown Mounted Upon the Post of Handle-Bar.

A TACHOMETER FOR SHOWING THE SPEED OF VEHICLES.

this allowance of coal, and a load equivalent to the prescribed weight of ammunition, guns, etc., the vessel was required to steam continuously for eight hours, at a speed of 25 knots an hour. In the cruising speed trials it was found that one ton of coal was sufficient to carry the ship for 11 sea miles. On the eight hours' full-power trial, the engines worked up to a collective indicated horse-power of 17,500, and the mean speed for the whole run of 202 knots was 25.24 knots per hour. Incidentally, it may be mentioned that the load thus propelled is more than five times the average weight of a freight train making about the same speed on the rails.

As a measure of the cost of high power, it may be mentioned that the records of the trial show that to increase the speed from 22½ knots to 25 knots involved doubling the power required for the former speed. And further, that the last knot, that is the advance from 24 to 25 knots, involved a quarter of the maximum power, or an addition of over 4,000 horse-power, which, by the way, proved sufficient to drive the vessel at 19 knots an hour.

As showing how largely the great increase in horse-power and speed of modern warships has contributed to their cost, it may be mentioned that during the course of the trials, the new scout steamed around one of the armored cruisers of sixteen years ago, which was being taken under tow to her moorings, where she is to lie as an obsolete ship until she is sold. This cruiser of sixteen years' standing cost only about 25 per cent more than the modern vessel, although she has a displacement tonnage three times as great as that of the "Sentinel." In the case of the cruiser, the proportion of power to tonnage is barely 1 horse-power to 1 ton; whereas the "Sentinel" has 5¾ horse-power per ton; and consequently, her cost per ton is very much greater than that of the older but larger ship.

MY SCIENTIFIC EDUCATION.

BY THE RT. HON. LORD KELVIN.

I am a child of the University of Glasgow. I lived in it sixty-seven years (1832 to 1899). But my veneration for the ancient Scottish University, then practically the University for Ulster, began earlier than that happy part of my life. My father, born in County Down, was for four years (1810 to 1814) a student of the University of Glasgow, and in his Irish home, as first professor of mathematics in the newly-founded Royal Belfast Academical Institution, his children were taught to venerate the University of Glasgow. One of my earliest memories of those old Belfast days is of 1829, when the joyful intelligence came that the Senate of the University of Glasgow had conferred the honorary degree of Doctor of Laws on my father. Two years later came the announcement that the Faculty of Glasgow College had elected him to the professorship of mathematics. My father's experiences as a Glasgow student are naturally of supreme interest to myself. There were no steamers, nor railways, nor motor cars in those days. Can young persons of the present time imagine life to be possible under such conditions? My father and his comrade students, chiefly aspirants for the ministry of the Presbyterian Synod of Ulster and for the medical profession in the North of Ireland, had to cross the channel twice a year in whatever sailing craft they could find to take them.

At the beginning of his fourth and last university session, 1813-14, my father and a party of fellow students, after landing at Greenock, walked thence to Glasgow. On their way they saw a prodigy—a black chimney moving rapidly beyond a field on the left-hand side of their road. They jumped the fence, ran across the field and saw to their astonishment Henry Bell's "Comet" (then not a year old) traveling on the river Clyde between Glasgow and Greenock. Their successors five years later found in David Napier's steamer "Rob Roy" (which in 1818 commenced plying regularly between Belfast and Glasgow) an easier, if a less picturesque and adventurous way between the college of Glasgow and their homes in Ireland. Those students who had experience of cross-channel passages before and after the advent of the "Rob Roy" may well have been grateful to their college, not only for what it did for themselves but for what sixty years before it did for steam navigation in giving to James Watt a scientific home and congenial friends, and a workshop in the old University territory adjoining to the High Street of Glasgow. In the course of his four student years my father attended the classes of humanity, moral philosophy, mathematics, natural philosophy, anatomy, divinity. Though his passion was for science, and especially mathematics and natural philosophy, he attended during his first three sessions and won prizes in the Latin class, then happily, as now, called humanity. It is scarcely possible to overestimate the life-long good gift presented to a scientific student one hundred years ago, as now, by universities in giving something of the *literæ humaniores* to all who can and will take it.

In 1834, two years after my father was promoted from Belfast to the Glasgow Professorship of Mathematics, I became a matriculated member of the University of Glasgow. The little tinkling bell in the top of the college tower, calling college servants and workmen to work at six in the morning; the majestic tolling of the great bell wakening at seven o'clock professors (and students, too, I believe, in the olden times, when students lived in college); then, again, the lively little tinkling bell calling the professors and students of moral philosophy and senior Greek and junior Latin at half-past seven to work in their classrooms. Woe to the student of Latin who reached the door ten seconds after the quick little bell's last stroke. He was shut out by the door-keeper, unfailingly ruthless, by inexorable order, and had to wend his way through the darkness to his lodging, sorrowfully losing the happy hour's reading of Virgil or Horace or Livy with his comrades, under their bright young professor, William Ramsay, and knowing that he had got an indelible black mark against his name. Rarely did even a single student of a large class experience this disaster. It was a sharp, healthy, beneficial discipline, rigorously maintained by one of the kindest and most considerate of all the professors who have ever guided students in the Scottish universities.

As to Latin, I followed my father's example and attended divisions of the class during three sessions. To this day I look back to William Ramsay's lectures on Roman antiquities and readings of Juvenal and Plautus as more interesting than many a good stage play that I have seen in the theater. Happy it is for myself that his name and a kindred spirit are with us still in my old friend and colleague our senior professor, George Ramsay, Greek, under Sir Daniel Sandford and Lushington, logic under Robert Buchanan, moral philosophy under William Fleming, natural philosophy and astronomy under John Pringle Nichol, chemistry under Thomas Thomson (a very advanced teacher and investigator), natural history (zoology and geology) under William Cooper, were, as I can testify by my own experience, all made interesting and valuable to the students of Glasgow University in the thirties and forties of the nineteenth century. Sandford, in teaching his junior class the Greek alphabet and a few characteristic Greek words, and the Scottish pronunciation of Greek, gave ideas and something touching on philology to very young students, which remains on their minds after the heavier grammar and syntax which followed have vanished from their knowledge. Logic was delightfully unlike the Collegium Logicum described by Goethe to the young German student through the lips of Mephistopheles. Even the dry bones of predicate and syllogism were made by Prof. Buchanan very lively for six weeks among the students of logic and rhetoric in Glasgow College sixty-seven years ago; and the delicious scholastic gibberish of *Barbara celarent* remains with them an amusing recollection. A happy and instructive illustration of the Inductive Logic was taken from Well's Theory of Dew, then twenty years old. My predecessor in the Natural Philosophy Chair, Dr. Meikleham, taught his students reverence for the great French mathematicians, Legendre, Lagrange, Laplace. His immediate successor in the teaching of the Natural Philosophy class, Dr. Nichol, added Fresnel and Fourier to this list of scientific nobles; and by his own inspiring enthusiasm for the great French school of mathematical physics, continually manifested in his experimental and theoretical teaching of the wave theory of light and of practical astronomy, he largely promoted scientific study and thorough appreciation of science in the University of Glasgow. As far back as 1818 to 1830 Thomas Thomson, the first professor of chemistry in the University of Glasgow, began the systematic teaching of practical chemistry to students, and by aid of the Faculty of Glasgow College, which gave the site and the money for the building, realized a well equipped laboratory, which preceded, I believe, by some years Liebig's famous laboratory of Giessen, and was the first of all the laboratories in the world for chemical research and the practical instruction of University students in chemistry.

In the province of the humanities the working power of the University for instruction and research has been largely augmented during the last fifty years by the foundation of new professorships, conveyancing, English language and literature, Biblical criticism, clinical surgery, clinical medicine, history (in my opinion the most important of all in the literary department), pathology, political economy. In mathematics and in the science of dead matter, professorships of naval architecture and geology; lectureships of electricity, of physics, and of physical chemistry; and demonstratorships and official assistantships in all departments have most usefully extended the range of study, and largely strengthened the working corps for research and instruction.

A plan is under consideration by Salt Lake City authorities to provide automobile street sweepers.

A TACHOMETRIC WATCH FOR BICYCLES AND OTHER VEHICLES.

(*Continued from page* 160.)

The hand, then, does not budge relatively to the vehicle, and remains in an invariable position with respect to the handle bar of the bicycle, for instance, if the instrument is mounted on one of these. Since the velocity thus communicated to the case by the wheel does not vary, the rider is sure that he is moving at a constant velocity as long as the hand does not appear to have moved. If, after the hand has appeared to have moved, it is turned back to its original position, the rider is sure to have run on an average at a constant speed. This speed corresponds to the ratio of the gearing existing between the case and the wheel. The tachometric watch, therefore, supposing that it is proposed to travel at so many miles an hour, permits of gaining speed in a descent or of losing it in slowing up or stopping. If, afterward, the rider, by increasing or decreasing the speed, succeeds in bringing the hand back to its initial position with respect to the handlebar, he will be sure of having run at the mean speed corresponding to the ratio of the transmission. The hand considered is the hour one, or, generally, that of the seconds placed in the center of the dial. In this case, it is possible to read the deviations in speed to within a minute. It must be recalled, however, that the hand has lost or gained several revolutions, in order to bring it behind or before the exact number of revolutions by which it has varied. The mean speed that is obtained by keeping the hand apparently stationary depends upon the reducing ratio of the transmission. This ratio may be changed at will, without dismounting from the machine, in such a way as to cause a variation in the speed that it is desired to preserve on a gradient or on a level. With this object in view, the manufacturers, MM. Chateau et Fils, of Paris, are constructing two kinds of tachometric watches, one of them operating with a movable pinion and the other having a rubber belt for actuating the case.

The first type gives no error of transmission, since everything is done by gearing. To the axle of the front wheel of the bicycle is fixed a star-wheel, and a rod actuated by this controls an endless screw that drives a horizontal shaft having keyed to it a sharp-toothed pinion which can be slid along it. This pinion gears with a disk at different positions through apertures arranged in circles. Each circle is provided with a different number of apertures, and equal to the number of millimeters of its diameter. It is necessary, according to the circle with which the toothed wheel gears, to run with greater or less speed in order to keep the hand inoperative. Figures from 1 to 9 are marked upon a division, and the toothed wheel is arrested opposite figures corresponding to the speed in kilometers per hour, indicated opposite each figure upon a reckoning device. There can be no error except by reason of the imperfect regulation of the watch. If the latter varies 5 minutes a day, the error committed in the estimation of the speed will be 1-144, which error is therefore practically of no consequence.

The second type is more simple, but gives rise to errors due to slippage, amounting to about 0.02 at the most. The star-wheel is the same as in the other type. The watch is inclosed in a revolving case mounted on a collar which is screwed to the handlebar and is operatively connected with a drum actuated by a rubber belt passing over different channels, each of which corresponds to a determinate speed. The principle of the apparatus is the same as that of the preceding type.

Both types may be provided with a differential counter formed of two disks of 99 and 100 teeth that gear with the endless screw that actuates the case. The disks revolve in unison, and one of them is graduated from 0 to 100 and the other from 0 to 10,000. These numbers represent every twelve meters made by the wheel. A stationary index indicates up to 100 dekameters, and a movable one up to 10,000. The accuracy is within about 10 centimeters.

A 100-Mile Automobile Road Race in Cuba.

On the 12th instant the automobile racing invasion of Cuba was completed by the running of a 160-kilometer (99.36-mile) road race. The race was run over a fine stretch of road from Havana to San Cristobal and return, there being one neutralized stop at the turning point. On account of a collision a few days before, in which he was injured slightly and his mechanic Hawley rather seriously, E. R. Thomas was unable to compete with his 90-horse-power Mercedes. Tracy drove Major C. J. S. Miller's (formerly Mr. W. Gould Brokaw's) 30-horse-power Renault racer, and Fletcher drove an 80-horse-power De Dietrich. The race was won by Mr. E. K. Connill's 60-horse-power Mercedes, driven by Ernesto Carricaburn, a young Cuban. His time was 1 hour, 50 minutes, 53 3-5 seconds. The Renault was second in 1:52:26. This machine had trouble with the battery shaking loose, which delayed it somewhat. Otherwise, it would have undoubtedly won.