

XXIX. *A Description of a new Thermometer and Barometer : In a Letter to the Right Honourable George Earl of Macclesfield, President of the Royal Society, from Keane Fitzgerald, Esq; F. R. S.*

My Lord,

Read May 7, 1761. **I** Took the liberty of addressing a paper to your Lordship last year, with an account of an instrument, which was intended to answer, in some measure, the purposes of a thermometer and pyrometer. The degrees the index had pointed to, during the absence of an observer, were marked by a pencil applied to it. But I found great inconvenience from the friction of the pencil, which must be strong, or it does not mark distinctly; besides the trouble of rubbing out the mark, every time a new observation was intended.

I must beg leave to trouble your Lordship with the description of an instrument on the same principle, as a thermometer only, with registers to mark the least variation that can happen during the absence of an observer, which are set for any future observation, with the greatest ease. As this instrument is, in part, like the former, I shall only mark the variations from it.

The first bar A is fixed at the upper end, by three screws *b, b, b*, and joined at the lower end to the arm of the first lever, by a pin *c*, which passes through both. [*Vide Tab. V.*]

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fig. 1.

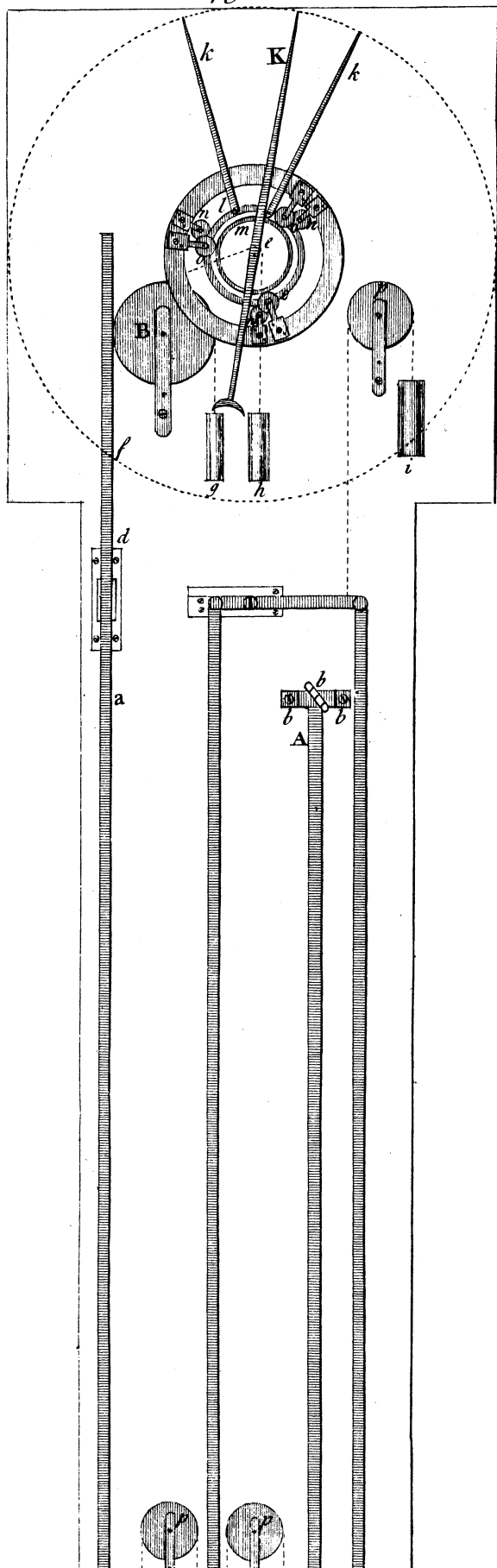


fig. 2.

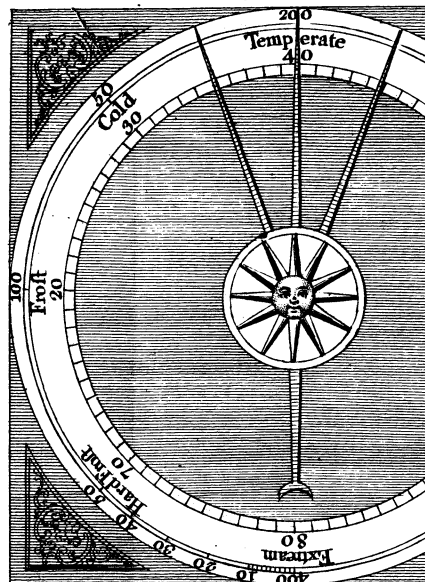
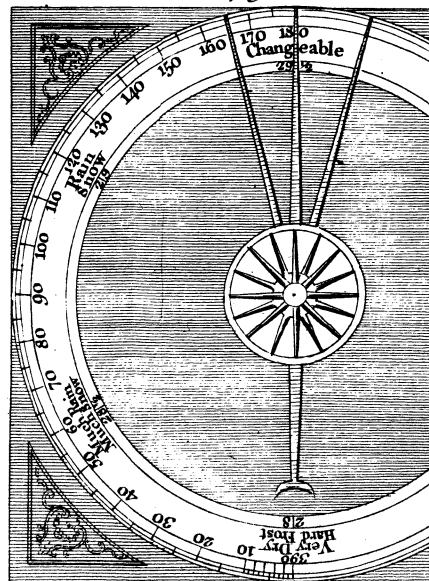
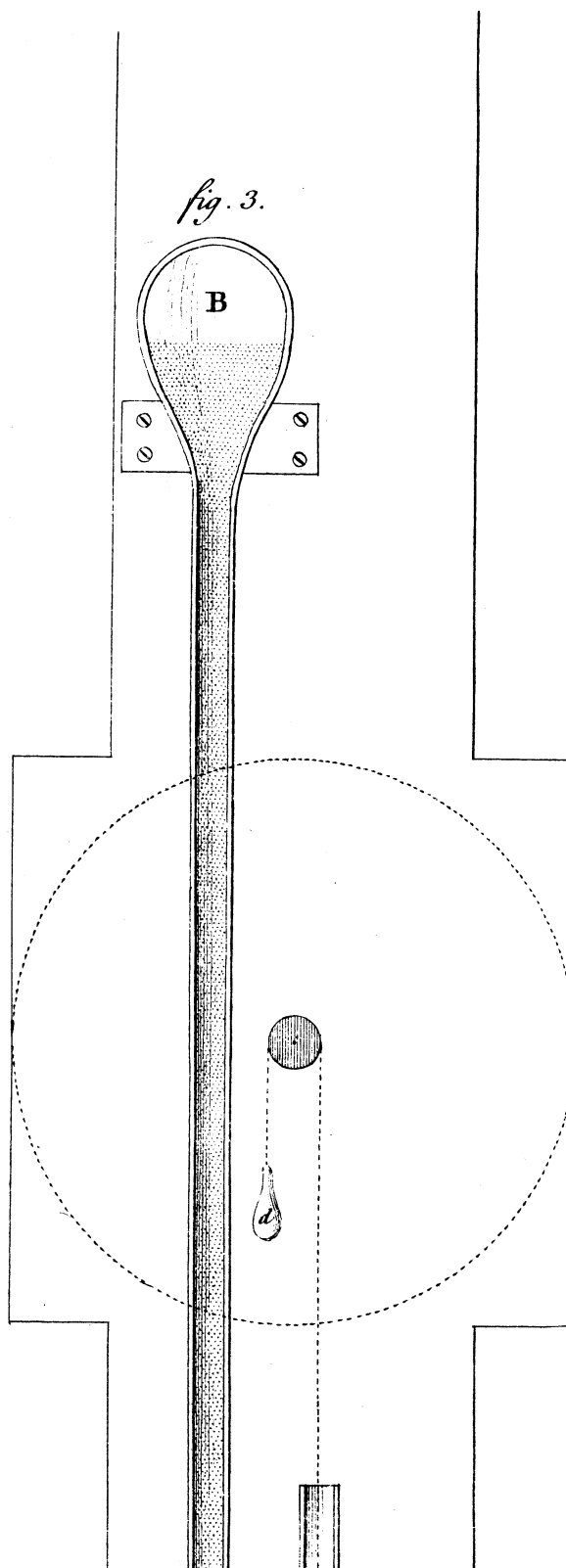
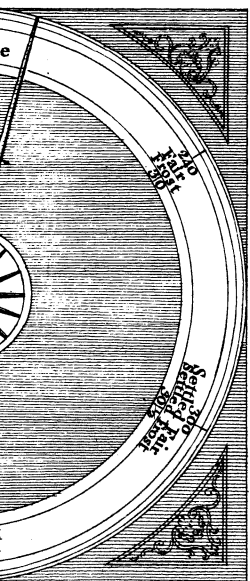
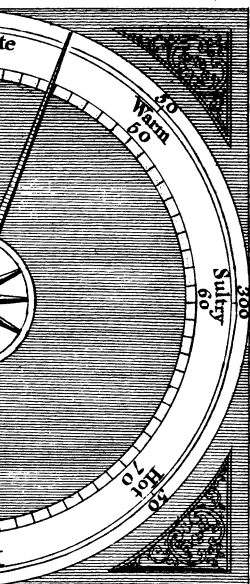
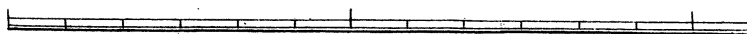
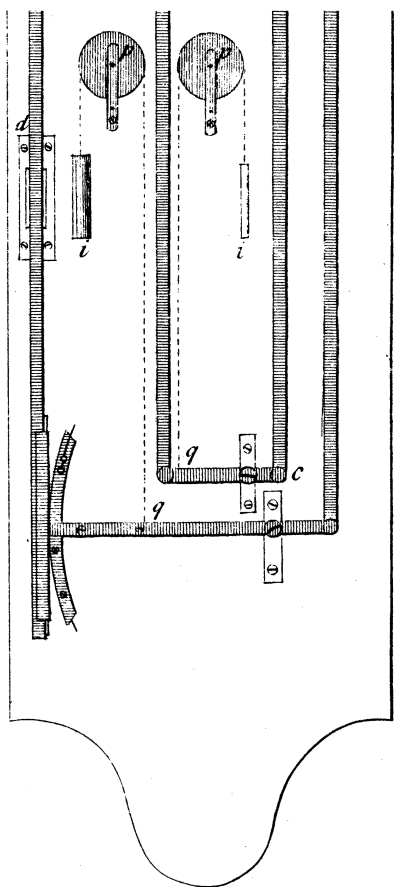
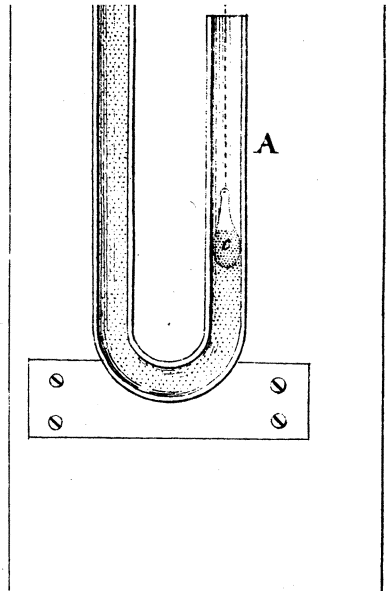


fig. 4.









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The fourth bar *a* moves upon two small pullies *d*, *d*, placed under it, and also a large pulley *B*, placed at the side of the bar, towards the upper end. In each of these pullies, there is a deep groove for the bar to pass freely, without touching the sides; and on each side of the groove of the pulley *B*, there is a channel cut for a thread to pass, which is fixed to the fourth bar, by a hook at *f*, and has a weight suspended at the other end. The thread placed in the inward channel, passes also over a small pulley *e*, about $\frac{1}{2}$ inch diameter, on the axis of which the index *K* is placed. The two weights *g* and *h*, suspended to these threads, serve as a counterbalance to the fourth bar, and keep it in contact with the pulley *B*, which turns with the bar as it moves.

Each of the levers is counterbalanced by a weight *i*, at the end of a thread, which passes over a pulley *p*, placed above the lever, towards the end of its longer arm, and fastened to it by a hook at *q*. In adjusting these weights, it is necessary, that each lever should preponderate a little towards the shorter arm, in order to keep that end close to the bar placed on it. The counterbalance weights of the fourth bar are so much lighter, as to allow a superior gravity to the bar, sufficient to turn the index and registers; by which means, all the levers bear the same way, whether the bars are contracted or expanded.

The axis of the small pulley *l*, on which the index is placed, moves on friction wheels applied to each end. There are two registers, or slender hands, *k*, *k*, each of which is placed on a circle of brass *l* and *m*, *l* about $2\frac{1}{2}$ inches diameter, and *m* $2\frac{1}{4}$, placed a little more forward than *l*, so as to admit each to

move freely, without touching the other. These circles turn, each upon three friction pullies *n, n, n,* and *o, o, o.* The registers, which are very slender, are counterballanced by a small weight placed on the opposite side of the circle, and moved by a pin, which passes through the index, and takes one along with it, as it moves one way, leaving it at the extreme point it has moved to, and, on its return, carries the other along with it, leaving it in the same manner at the other extremity. The index and registers are carried round the dial-plate very freely, by a weight of 8 grains.

As this instrument was intended only to mark the common degrees of heat and cold of this climate, which, according to Fahrenheit's scale, is seldom above 80, or below 0, I regulated its range by the following proportions, founded on Mr. Smeaton's table of the expansion of metals, the experiments I had made on spelter and brass corresponding pretty exactly.

Greatest expansion of the first bar of spelter from freezing to boiling water $\frac{353}{10,000}$ parts of an inch per foot, 2 feet long, $\frac{706}{10,000} \times 3$, the power of the first lever, $= \frac{2118}{10,000}$.

Ditto of the second bar of hammered brass, 2 feet 2 inches long, $\frac{487}{10,000} + \frac{2118}{10,000} = \frac{2605}{10,000} \times 3$, the power of the second lever, $= \frac{7815}{10,000}$.

Ditto of the third bar, 2 feet 3 inches long, $\frac{506}{10,000} + \frac{7815}{10,000} = \frac{8321}{10,000} \times 4$, the power of the third lever, $= \frac{33,284}{10,000}$.

Ditto

Ditto of the fourth bar, 2 feet 6 inches to the place where the threads are hooked on, $\frac{562}{10,000} + \frac{33,284}{10,000} = \frac{33,846}{10,000}$, almost $3\frac{4}{10}$ inches, the sum of the greatest expansion of the several bars, increased by the powers of the levers. This is $\times 30$ by the pulley, on the axis of which the index is placed, and carried round a dial 10 inches diameter.

I take somewhat less than $\frac{1}{3}$ of the greatest expansion from freezing to boiling water, to be about a medium of the common degrees of heat and cold of this climate, which makes one revolution of the index. The inward circle, Fig. 2. is divided into 80 parts, corresponding with 80° of Fahrenheit's. Each of these is divided into 5 parts on the outward circle, one of which is as large as 2° of Fahrenheit's.

I have compared this instrument with a mercurial, and spirit thermometer along with it, for some time past; and have observed, that it constantly begins to mark the change before either; though the mercury, in some time, when the room becomes warm by fire, or otherwise, rises a degree or two above it. When the room is warmed to any great degree, it rises somewhat higher than the mercury, and, at the same time, the spirit rises higher than either, though, on the first degree of warmth, it does not rise as fast as either.

The metalline thermometer has this advantage over any other, that its range may be increased to any degree intended. I have one which carries the index 72 inches, by the common changes of the weather, which may be raised 50 or 60°, by blowing
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one's breath five or six times on the first bar. It marks the 282,000th part of an inch per foot expansion, and the powers of the levers, are so easily increased, by the help of counterballance weights, that the millionth part of an inch expansion, or contraction, may be shewn; and an instrument formed to point out every state of the cold or warmth of the air so minutely, as scarcely ever to remain stationary.

The bars are placed on a board of white deal, straight grained, and free from knots, which was thoroughly well seasoned and dry. I had it varnished over several times with strong varnish, or japan, to secure it from the moisture of the air, which it seems to have done effectually. I have placed it several times in the open air, when it has rained incessantly for many hours, without perceiving any difference in its operation.

I found the registers to the thermometer so satisfactory, and the operation so light and easy, that I have also applied them to the wheel barometer. I had the tube A, Fig. 3. made somewhat above $\frac{1}{2}$ inch diameter in the hollow of the tube, with a ball B at the top, above 3 inches diameter, to the middle of which the mercury rises at a medium. — $\frac{1}{10}$ inch mercury in this part of the ball, is sufficient to fill 3 inches of the tube; so that by making one round of the pulley, on which the index is placed, $\frac{1}{10}$ inch less than 3 inches, it makes the rise and fall of the mercury with more exactness, than any barometer, where there is not an allowance made for the sinking or rising of the mercury in the cistern, the distance between the two surfaces being the exact height

height of the mercury. This, I believe, is seldom attended to in common barometers; but it requires this exactness in a barometer of this kind, as $\frac{1}{10}$ inch rise or fall in the tube, is increased to an inch in the range of a dial-plate 10 inches diameter.

The axis of the index pulley, as also the registers, are placed on friction wheels, as those of the thermometer; but it requires, that the work be made with greater nicety, in order to lay the least weight on the mercury. I therefore employed Mr. Vulliamy, a watch-maker, and very ingenious mechanic, to make the machinery, which, on trial, has exceeded my expectation, as it requires but the weight of two grains to turn the register and index freely.

The weight *c*, which rests on the mercury, is made of ivory, in the shape of a cone, hollow within, and made narrowing towards the bottom, with a screw in the middle to open; so that by pouring in a small quantity of mercury, you may readily adjust its weight, which is to be so much heavier than the counterballance *d*, as serves to turn the index and registers. The bottom of the weight *c* is made convex, in order to meet the first rise of the mercury, which is observed to swell in the middle of the tube, before it can overcome the friction occasioned by the sides of the glass, and also to sink in that part first; by this means, a rise or fall of 3 or 4 degrees is often observable, by the index of this instrument, when the mercury in the common barometers seems to continue stationary.

The weights *c* and *d* are suspended on silk threads, as wound off from the cocoons. This kind of silk, which is not twisted, and has the natural gum on it,
probably

probably is not in any degree affected by the moisture or dryness of the air. The pulley, on which these threads are placed, is made double: that on which the weight e is suspended, surrounds one part; and the thread on which the counterballance weight d is suspended, surrounds the other: so that when the position of the index is properly adjusted, it cannot easily be misplaced, the weight will always keep in its proper position on the surface of the mercury, carrying the index and register, as the mercury rises or falls in the tube.

The inward circle of the dial-plate is divided into three parts, corresponding with 3 inches generally allowed for the rise and fall of the mercury in common barometers. Each inch is divided into twelve lines, and each line subdivided into ten parts, on the outward circle. The registers are very slender, and mark very distinctly half of these divisions, which is the 240th part of an inch rise of the mercury in the tube.

Many sudden changes of the temperature of the air, and pressure of the atmosphere, have probably passed unnoticed, for want of some easy method of marking the variations with sufficient precision. It has been accidentally remarked, that the mercury has sunk to a great degree, and rose very suddenly, during the shock of an earthquake; but, from the suddenness of the motion, the degrees could not be ascertained. Any such sudden alteration, or even the common changes, will appear with so much certainty by the registers, that I should imagine, instruments of this kind will greatly assist those, who are obliged to a daily attention, in order to minute the changes

that happen with any accuracy ; and yet the variations in the night-time, which I have often found greater than in the day, have generally passed unnoticed ; particularly, in one or two stormy nights, I found the index point in the morning near the same degree it did, when I placed the registers ; and yet it appeared, by the register it carried with it, that it had fallen several degrees during the storm.

I should imagine the metalline thermometer might be employed to some useful purposes, and at no very great expence. For instance, a very plain instrument of four spelter bars, and three levers, might very easily be contrived for hot-houses, which, by a pin fixed in the fourth bar, at a proper place, adjusted by the botanical thermometer, might be made to raise a click, whenever the heat of the house raised the bar to that point, so as to let a ventilator operate by weights, until the air within the house became cool to the degree intended, by which the bars would be contracted so, as to draw back the click, and stop the ventilation ; by which means, the house might always be kept within any two intended degrees of heat. The weight, which operates the ventilator, might be made to bear on a spring, when it comes near the ground, to ring an alarm bell, to warn the attendant to wind up the weight, or awake him for the purpose, if asleep.

A like instrument might probably be applied, with great benefit, to rooms where large assemblies are collected, and obliged to remain a long time. The unwholsomeness of an over-heated air in such places, has been very fully proved, by the late most worthy and ingenious Dr. Hales ; and yet the danger of

suddenly throwing in too great a quantity of cold air, when the pores are opened by so great a degree of heat, has probably hindered the application of ventilators to this purpose. But, by this means, all danger on that account would be avoided with certainty, as the bars could be adjusted to any two degrees of heat, within which, there could be no danger.

I have ventured thus far on speculation, as I can have no doubt of the power of metals by expansion ; and imagine it will readily be allowed, that a ventilator may be worked by a weight, as well as by wind.

I send your Lordship a drawing of the barometer and thermometer, and have placed the instruments for the inspection of the gentlemen of the Royal Society, in their meeting-room ; where, if agreeable, I shall leave them for some time.

There have been some very ingenious methods contrived, to mark the variations that happen during the absence of the observer ; but I do not know, that any attempt has been made in this manner. I wish these registers may be found to answer the purpose ; and am, with great respect,

My Lord,

Your Lordship's most obedient

humble servant,

Keane Fitzgerald.

Poland-Street,
May 6, 1761.

