performance of which he was assisted by Mr William Creighton. The results of these observations are con

tained in Mr Southern’s letter to me, which follows this memoir ; and, from the very great care with which the experiments were made, the known accuracy of both Mr Southern and Mr Creighton, and the agreement of the experiments with one another, I have reason to believe them as nearly perfect as the subject admits of. The method he adopted of trying the elasticities above the temperature of boiling water by a piston, accurately fitted to a cylinder, is much to be preferred to that adopted by Dr Robison, and is more manageable under great elasticities than that of a long pillar of mercury..

27. The reference which is here made applies to the following letter from Mr *Southern@@\** to Mr Watt :—

“ Dear Sir,—The experiments of which the particular circumstances are hereafter related, were made in 1803, with the view of ascertaining chiefly the density of steam raised from water under different pressures above that of the atmosphere, an apparatus having then been made for a different purpose, which seemed pretty well adapted to this object.

“ Besides the experiments now to be related, in which the temperature of steam raised under *high* pressures was observed in 1803, others had been made some years before, in 1797 and 98, for that purpose only ; and, as they were made with the greatest circumspection, both the manner of making them and their results may be here described, as may also the results of other experiments, made with equal care, to ascertain the temperature of steam raised under *low* pressures.

“ The instrument used in the former was a Papin’s digester, similar to what you had used ; the leading differences being in adapting a metallic tube to it to con tain the thermometer, or rather as much of it as coatained mercury, in the manner mentioned in the beginning of this letter, and instead of a valve, by the load on which to measure the elasticity of the contained s team, a nicely bored cylinder was applied, with a piston fitting it, so as to have very little friction, and to the rod of this was applied a lever, constructed to work on edges like those of a scale-beam, by which the resistance against the elastic force of the steam could be accurately determined ; and at your suggestion, to be assured that no inaccuracy had crept into tne calculation, by which this resistance, through the medium of the lever, was ascertained, an actual column of mercury of 30 inches high was substi tuted, and the correspondence was found to be within 1/100 of an inch.

“ The observations at each of the points of pressure noted were continued some minutes, the temperature at each being alternately raised and lowered, so as to make the pressure of the steam on the under side of the piston alternately too much and too little for the weight with which it was loaded ; and thence a mean temperature was adopted, the extremes of which were, as well as I now recollect, not more than half a degree on each side of it. The load on the piston, including its own weight, &c., &c., was calculated to be successively just equal to 1, 2, 4, and 8 atmospheres of 29∙8 inches of mercury each, and the temperature of the steam was varied as above till that of each point was determined ; the results were thus :—

|  |  |  |
| --- | --- | --- |
| Atmospheres. | Pressure in inches of Mercury. | Temperatures. |
| 1 | 29.8 | 212° |
| 2 | 09.6 | 250 3 |
| 4 | 119.2 | 293.4 |
| 8 | 238.4 | 343.6 |

“ The experiments for ascertaining the temperature of steam below the atmospheric pressure were made with an apparatus essentially similar to that which you originally used, and with scrupulous care and attention : and I met with the same incidents as you had done ; such as, the production of a bubble of air whenever, after any experi ment, the tube was inclined to refill the ball ; and also the extraordinary suspension of a column of mercury of 35 inches vertical height, and of 7 inches of water above that, although the counterpoise was only that of the atmosphere, then under 30 inches. I found also that the tube required a considerable degree of tabouring or shaking to make the column subside and leave a space in the ball. This phenomenon was not produced till after much pains taken in inverting and re-inverting the tube again and again, nor till it had been suffered, after these operations, to stand for three or four days undistm∙bed in the exhausting position, and then discharging the air that had been accumulating in the interval.

“ The results to be found in the table below, were deduced from the observations as you had done—viz., by adding to the height of the column of mercury in the tube (ascertained by a gauge floating on the surface of the mercury in the basin), that of the water above it, or rather of an equivalent column of mercury, and subtracting their sum from the height of the common barometer at the time. All these results were taken from observations made after the apparatus had been so perfectly exhausted of air as to produce the phenomenon just mentioned.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | | | |
| Temperature. |  | | |  |
|  | 1st Set. | 2d Set. | 3d Set. | Mean. |
|  | Inches. | Inches. | Inches. | Inches. |
| 52° | 0. | 0.42 | 0 40 | 0.41 |
| 62 | 0.53 | 0.52 | 0.52 | 0.52 |
| 72 | 0.73 | 0.73 | 0.73 | 0.73 |
| 82 | 1.03 | 1.02 | 1.02 | 1.02 |
| 92 | 1.42 | 1.41 | 1.42 | 1.42 |
| 102 | 1∙98 | 1.92 | 1.95 | 1.95 |
| 112 | 2.67 | 2.63 | 2.66 | 2.65 |
| 122 | 3.58 | 3.54 | 3 58 | 3.57 |
| 132 | 4.68 | 4.65 | 4.72 | 4 68 |
| 142 | 6.05 | 6.00 | 6.14 | 6.06 |
| 152 | 7∙86 | 7.80 | 7.89 | 7∙85 |
| 162 | 9∙98 | 996 | 10.04 | 9∙99 |
| 172 | 12.54 | 12 72 | 12.67 | 12.64 |
| 182 | 16.01 | 15.84 | 15.88 | 15.91 |

" The following formula will be found to give the elasticity belonging to a given temperature, and *vice versa,* with a sufficient degree of accuracy for most purposes, within the range of the experiments, at least, from which they have been formed.

Let Z = temperature, *e —* elasticity, in inches of mercury ;

T = t+52, and E=e—1/10, *m=* 94250,000000 ;

Then

T5.11

— =E

»n

β.n

V Em ≈ T

“ But as the calculation is most easily performed by logarithms, let L signify the logarithm of the quantity to which it is prefixed :

Then 5.14 LT—1097427=LE LE+10.97427

5.14  1'

“ The following table shows the observed elasticities, those derived from calculation by the formula, and the differences of the two, which appear to me to be as small as can be expected, taking a general view.

@@@\* In all these experime nts Mr Southern was assisted by Mr William Creighton.