difficulties, which render it impossible to obtain even such a tube as that of a common thermometer, which shall possess the uniformity necessary to a good instrument. To make the proper allowance for this inevitable imperfection, the academicians easily might have adopted the same method as that used in the case of thermometer tubes, by determining the volume of successive small portions of its interior ; but even this would have furnished a very partial remedy for the evil, because it had not been ascertained that the space occupied by the air in the manometer would diminish in bulk exactly in the proportion of the increase of compressing force, or of the corresponding increase in the height of the equivalent column of mercury. Two problems were therefore to be resolved at once, the elimination of the error of the tube, and the determination of the elasticity of air under high pressures. Both of them were satisfactorily accomplished, by the following 1abori ous research.

As a preliminary measure, it was resolved to graduate the manometer, and determine the law of the elastic force of air under high pressures, by direct comparison with a column of mercury, from 75 to 80 feet in height. Such an experiment required a suitable *locale* and a stupendous apparatus. Among tire buildings of the Royal College of Henri Quatre, there may be observed an old square tower, sole relic of the ancient church of Sainte Genevieve : there exist still in the interior three vaulted floors, pierced in the centre, and affording the very supports that were required for the erection of this stupendous mercurial gauge. In the centre of this opening there was raised a squared tree of the required height, and to this it was determined to attach the glass tube of 80 feet in height. To form a single glass tube of so great length was impossible ; its own weight, when constructed, under the pressure of the mercury, would have endangered its existence. The glass column was built of separate portions, united in mastic, with great care, in viroles of steel. Each portion of tube was suspended in the air by an exact counterpoise, acting over pulleys fixed to the tree ; and the whole of the parts were so united in equilibrio, that each sustained only its own weight, and the pressure of the mercury due to the height of the superior portion of the column. A homogeneous metallic scale was attached, and its divisions read by a vernier, as in the common barometer.

The manometer to be graduated, and this column of mercury, were both connected by tubes with a strong cylindrical vase *f* holding about 100 lbs. of mercury. When thus placed in communication, a column of water was forced into the vase above the mercury by a hydraulic pump, and the pressure thus produced raised the metal with equal force up into the glass tube column on the one hand, and into the manometric tube on the other. The point to which the air was compressed was read off by a vernier, and the corresponding height of the mercury having been determined, it was manifest that the same degree of compression of the less instrument would ever after serve as the index of an equivalent column of mercury. In this manner the whole tube was graduated by careful experi ment. The result of this graduation was satisfactory and very instructive. In forming the scale of the manometer, no room was left for errors of practical execution ; and the comparison of the volume of the air with the height of the mercurial column demonstrated the diminution of the volume of the air to be precisely in the ratio of the pres sure, so that the law of Marriotte is rigidly correct, even when extended to the extreme case, where the air is reduced to less than 1/25 part of its usual volume.

This preliminary process having been successfully terminated, the enormous column of glass was now laid aside, and the manometer, with its reservoir of mercury, transported to the court of the Observatory, for the purpose of being attached to the experimental boiler. Figure 18 shows the manometer *in situ.* An iron tube *d d',g',* com­

posed of gun barrels welded together, connects the cover of the boiler *a*, with the reservoir of the manometer *f,* so as to conduct the pressure of the steam to the surface, which formerly had sustained the mercurial column. The vacant space above the mercury was filled with water, which, by condensation from a stream of water on the outside, was kept full to the constant height v. A column of water contained in the glass tube *z z,* and constantly replenished, preserved the column of air, and other parts of the apparatus, at a constant temperature, indicated by a thermometer. A tube o *p,* of glass, communicating with the reservoir of mercury above and below, indicates, on the scale *I, m,* the variation of level arising from the recession of the mercury into the manometer tube.

To ascertain the temperature of the water and steam of the boiler, it had been considered sufficient in the ruder experiments of earlier observers to insert thermometers directly into the boiler itself. Every one who has an acquaintance with these instruments knows, that any difference of pres sure on the glass produces a false indication of the instru ments, so that even the few inches of mercury in the instrument itself, when inverted, alter its indications, and a slight pressure of the finger would raise it a degree ; the inaccuracy of the old method, when used under a pressure of 70 or 80 feet of mercury, or 450 pounds on every inch of the immersed surface of the instrument would have been great. The French academicians avoided this error, by immersing strong iron tubes *t t,* (figs. 18 and 19,) in the water and steam, in which the thermometers, surrounded by liquid metal, were kept in close communication with the heat of the fluids, without exposure to their force. By adopting only very slow variations of temperature, the error arising from the motion of heat was rendered insensible.

*The following Table contains the results of Thirty of the most unexceptionable Experiments :—*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 1. | 2. | 3. | 4. | 5. | |
|  | Smaller  Centigrade  Thermo­  meter. | Larger  Centigrade  Thermo­  meter. | Elastic Forcemeters, in feet of Mercury at 32 degrees. | In Atmospheres of 76 degrees. | Condition in which the Observations were |  |
|  |  |  |  |  | made. |  |
| 1 | 122∙97 | 123∙7 | 1∙62916 | 2∙14 | max. | 1 |
| 2 | 132∙58 | 132∙82 | 2.1767 | 2∙87 | a | 2 |
| 3 | 132∙64 | 133∙3 | 2∙1816 | 2∙88 | p. max. | 3 |
| 4 | 137∙70 | 138∙3 | 2∙5386 | 3∙348 | a | 4 |
| 5 | 149∙54 | 149∙7 | 3∙4759 | 4∙584 | max. | 5 |
| 6 | 151∙87 | 151∙9 | 3∙6868 | 4∙86 | a | 6 |
| 7 | 15364 | 153∙7 | 3∙881 | 5∙12 | a | 7 |
| 8 | 163∙00 | 163∙4 | 4∙9383 | 6∙51 | max. | 8 |
| 9 | 168∙40 | 168∙5 | 5∙6054 | 7∙391 | max. | 9 |
| 10 | 169∙57 | 169∙4 | 5∙7737 | 7∙613 | a. s. | 10 |
| 11 | 171∙88 | 172∙34 | 6151 | 8∙114 | a | 11 |
| 12 | 180∙71 | 180∙7 | 7∙5001 | 9∙893 | p.mαx. | 12 |
| 13 | 183·70 | 183·70 | 8∙0352 | 10∙6 |  | 13 |
|  |  |  |
| 14 | 186∙80 | 1871 | 8∙6995 | 11∙48 | a. s. | 14 |
| 15 | 188∙30 | 188∙5 | 8∙840 | 11·66 | max. | 15 |
| 16 | 193·70 | 1937 | 9·9989 | 13·19 | a | 16 |
| 17 | 198∙55 | 198·5 | 11·019 | 1453 | a. s. | 17 |
| 18 | 20200 | 20175 | 11∙862 | 15∙65 | a | 18 |
| 19 | 203∙40 | 20417 | 12·2903 | 16·21 | a. s. | 19 |
| 20 | 206·17 | 206∙10 | 129872 | 17∙13 | a | 20 |
| 21 | 206∙40 | 206∙8 | 13·061 | 17.23 | max. | 21 |
| 22 | 207∙09 | 207∙4 | 131276 | 17.3 | p.max. | 22 |
| 23 | 20845 | 208·9 | 13∙6843 | 18.05 | a | 23 |
| 24 | 209·10 | 209∙13 | 13·769 | 18.16 | a | 24 |
| 25 | 210·47 | 210·5 | 14∙0634 | 18.55 | p.max. | 25 |
| 26 | 21507 | 215∙3 | 15∙4995 | 20∙44 | a | 26 |
| 27 | 217∙23 | 2175 | 161528 | 21∙3l | a | 27 |
| 28 | 218∙3 | 218∙4 | 163816 | 2I∙6 | p.max. | 28 |
| 29 | 220∙4 | 220∙8 | 17∙1826 | 22∙66 | a | 29 |
| 30 | 223∙88 | 224∙15 | 18·1894 | 23.994 | max. | 30 |