FG, figs. 21 and 22, was placed near the back end. This pump was of the ordinary construction, with a solid plunger and conical valves ; the diameter of the pump was one inch, and the play of the piston one inch and three-quarters. The diameter of the pipe F G, by which the water was conveyed from the pump to the boiler, was three-hundredths of an inch. By a coupling screw, this pipe could be connected with either of the stop cocks *d e,* fig. 22, in the back end of the boiler : the opening of these cocks was two-hundredths of an inch in diameter.

To ascertain the elasticity of the steam within the boiler, a closed steam gauge (H, figs. 21 and 22), was used, a particular description of the construction, &e. of which will he given. This instrument was placed upon the same stand (I, figs. 21 and 22) which supported the pump, so that the same experimenter could observe its indications and attend to the working of the pump. The cistern of the gauge was connected by a flexible pipe *f g,* with the upper part of the boiler.

The safety-valve is shown on the top of the boiler (K, fig. 21), midway between the ends. The graduation of it required much pains, and will receive a separate discussion.

Near the safety-valve is represented (at L, fig. 21,) the fusible plate apparatus, consisting of a sliding plate of iron, moved by a lever. On the other side of the safety-valve are the thermometers (M and N, fig. 21) plunged into iron tubes to give the temperature of the steam and water within the boiler. Above this appears the reservoir O, containing the water intended to maintain the scales of the thermometers at a constant temperature. All these parts require a more detailed description.

The steam gauge consisted of a glass tube closed at the upper, and open at the lower end, which passed steam tight into a reservoir for mercury : when this reservoir was connected with the boiler the pressure of the steam raised the mercury into the gauge tube, compressing the air which the tube contained. The first mercurial gauge which was made, was broken by a sudden access of sur charged steam, in the experiments upon that subject, and was replaced by a second one. The method of graduation, and in general the description of the second gauge, will serve also for the first ; the details, only varied slightly.

The glass gauge tube was 26.43 inches in length. To the lower end was connected an iron ferule, terminated above by a projecting ring. This ring was pressed upon the upper end of the pipe A, by a coupling screw, which served to form a tight juncture between the gauge and the cistern. The cistern *i* was a cylindrical vessel of cast iron, having the two projecting tubes *h* and *k,* upon which screws were cut : the first of them has been alluded to as giving a passage to the glass tube of the gauge; the second was coupled, by the pipe *f g,* to the boiler.

The gauge tube was not of precisely equal diameter throughout, and it was judged more accurate to graduate small portions of it into equal volumes. This was done by introducing equal measures of air from the point of a sliding-rod gas measure (Hare’s) ; this operation was performed repeatedly, and by multiple measures, to verify the results, until the marks made for the equal volumes, on a paper scale attached to the tube, coincided, in the various trials. The lengths of the spaces occupied by the equal volumes were then carefully measured upon the brass scale to be used with the gauge. The slight differences between the lengths given by adjacent parts of the tube, showed that it might be considered as divided into so many small portions of uniform diameter. The mercury rising into the gauge tube from the cistern when pressure is applied, the level of the cistern is necessarily depressed ; the amount of the correction for this depends upon the relation between the areas of the cistern and tube, supposed uniform. The areas of the cistern were found to be, within the limits of its use, sensibly the same ;

those of the tube might be so assumed for such a purpose : the ratio was therefore found by filling the gauge tube with mercury, and pouring this into the cistern, noting the rise produced ; comparing this with the mean length of of the tube, the ratio of depression in the gauge for elevation in the tube was found to be as .01 to 1. The air within the tube was next carefully dried by the introduction of a receptacle of chloride of calcium, of the same length with the tube ; the air having been in contact with this substance for a sufficient time, the receptacle was withdrawn through the mercury over which the drying had been effected ; the tube was next placed over a dish of mercury, in the receiver of an air-pump, and the air withdrawn, until, on readmitting air to the receiver, the mercury rose in the tube above the iron ferule.

The gauge tube was next introduced into the cistern, the level of which, corresponding to the zero of the brass scale was then arranged, and tne point of the scale at which the mercury stood was ascertained, the barometer and thermometer being noted.

It was intended in the experiments to keep the pipe from the gauge to the boiler cool, so that it might contain water, and thus give a nearly constant pressure upon the mercury of the cistern, besides preventing the exposure of the apparatus to heat ; the height of this column, above the level of the cistcern, was therefore ascertained, after the gauge was put in its place by screwing the cistern i to the stand.

All the elements for calculating the elasticity of the steam within the boiler, from the height of the mercury of the gauge, were thus known ; the temperature of the apparatus being supposed constant.

The elastic force of the steam within the boiler, together with the column of water in the steam-pipe, balances the elasticity of the compressed air within the guage, together with the column of mercury above the level of that in the cistern. This level is not the original zero, but lower than that, by the depression produced by the rise of mercury in the gauge tube. The depression of the mercury changes the level above which the pressure of the column of water in the steam-pipe is measured, but the change in the pressure, by the column of water, is altogether inconsiderable. The law of the elastic force of dry air, which has been recently shown, by Dulong and Arago, to be accurate, at pressures from one to fifty atmospheres, was made use of in determining the elasticity of the air in the gauge : this elasticity is inversely as the space occupied by the air. From the data already obtained, and upon the principles just stated, a table was calculated, by which the observed heights of the gauge were converted into the corresponding pressures in inches of mercury or in at­mospheres. The calculations were rendered rather tedious by the unequal diameter of the bore of the tube, on ac count of which equal lengths did not correspond to equal volumes. The usual method of calculation was resorted to, namely, to determine, by rigid calculation, the pres sures, for points sufficiently near each other, and then to interpolate for intermediate heights.

The foregoing remarks take for granted that the temperature of the air in the gauge, as well as that of the mercury, remains constant ; to secure this, an arrangement was adopted similar to that employed by Dulong and Arago for the same purpose. The gauge and scale were surrounded by a glass tube *l,* cemented below into a brass cap *m,* which had an opening in the side, communicating with a discharge pipe n, fig. 21. The tube was attached above, by an airtight juncture, to a tin vessel P, of considerable capacity, compared with the tube. Water being introduced into the glass tube surrounding the gauge, the flow through this tube was regulated by a stopcock o, placed at the end of the dis charge pipe, the cistern above being filled with water.

To ascertain the temperature of the column of water