the great, beam, and the working perpendicular beam are now almost at their utmost height, and the pulley in the slit of the working beam has so far raised the spanner H 5, that the weight or head of the Y is brought so far from under *n,* as to be past the perpendicular over the axle; and being ready to fall over towards *m,* it will with a smart blow of its shank K, strike the pin L, and drawing the fork O N horizontally towards the working beam, will draw the end 10 of the handle of the regulator to­ward *l,* and thereby shut it, by slipping the plate Y under the pipe S. The engine in figure 25 is in this very condition ; but in figure 24 the blow is already struck, and the communication cut off ; as may be known by observing that the weight at the head of the Y is got as far as the strap will let it go.

“ The moment after the regulator is shut, the beam not immediately losing its motion upwards, the pin *s* on its outside lifts up the end I of the F, *h k i,* and opens the injection-cock ; and the jet immediately making a vacuum, the beam begins to descend, and the pin *r* (which you may put higher or lower) depressing the F, shuts the injection-cock : then the beam continuing to descend, the pulley *p,* pressing on the handle G 4, throws hack the V, whose shank D throws forward the fork, and opens the regulator to let in fresh steam, in the manner already described ; which steam is shut off, by shutting the regulator till the cock for injection of cold water is again opened,”

Newcomen, Potter, and Beighton, had thus rendered the atmospheric steam-engine an independent selfacting mechanical power of so great perfection in its principle of action, and its minor details, as to be very generally introduced as a substitute for the power of animals in draining mines and collieries, and to confer very great advantages in those important and primary sources of national industry and wealth. The saving of money resulting from this change was so great as to be continually opening up new avenues of mining enterprise; and, by the rapid progress of that enterprise, the capahilities of the engine were soon put to the severest trial. The cylinders, which had been originally of twelve and sixteen inches diameter, were increased to twenty, thirty, and forty inches, and at last even fifty and sixty inches in diameter. Along with this dimension, the other parts required to he increased in a still higher proportion ; and at last the structures became so gigantic as to demand an amount of science and practical skill which in that period of engineering science was rarely to be found. The man suited to the emergency at last arose in the father of civil engineering, the justly celebrated Smeaton, who brought to bear on this subject endowments and accomplishments seldom united; fertile ingenuity, accurate philosophic conceptions, and sound practical saga­city. He conferred upon the atmospheric steam-engine all the extent and variety of application of which it was capable, and all the perfection of proportion and execution which the state of the mechanical arts would permit.

The manner in which Smeaton proceeded to the im­provement of the atmospheric engine was one which is worthy of all praise and imitation. Unlike too many of the engineering experiments of the present day, as well as of past times, his were made at his own expense, not at the expense of his employers, and on a scale sufficiently large to ensure sound results, without being on that scale which should entail unwarrantable expense. Having encountered some anomalous results in the earlier parts of his experience with atmospheric engines, he resolved, as he says, “ if possible to make himself master of the subject, and immediately began to build a small fire-engine, which could easily be converted into different shapes for experiments.” This experimental engine was set to work at Austhorpe in 1769. With it he made a

very great number of valuable experiments, so as to ascer tain the length and velocity of stroke and return, the quantity and manner of injection, the proportion of load, the dimensions of cylinder, and the materials of construction, which were required to produce the maximum of useful effect from a given amount of fuel. Mr Farey has given us the dimensions of this model, and the results of the experiments of Smeaton as they are here set down. The cylinder was 9.9 inches in diameter, and had a working-stroke of 3 feet. The piston made 17½ strokes per minute passing over 105 feet per minute in going and returning, or over 52.5 effective feet per minute ; its load per square inch was 7.89 lbs., its total load 607 lbs. The quantity of coals consumed was 55 lbs. per hour. The work done was equivalent to 31,867 lbs. raised 1 foot high per minute = 0.966 horse power. The work of one bushel or 84 lhs. of coal was equal to 2,919,017 lbs. raised 1 foot high. The weight of water evaporated by 1 lb. of coal was 6.14 lbs., and the quantity of cold water injected was 10.66 the evaporated water.

When the engine made its stroke the mercury was raised to 23.2 inches.

Mr Smeaton found that this engine produced its maxi mum effect both as regards quantity and economy when carrying a load of 7.81 lbs. on the inch. When the load was reduced to 6.6 lbs. the power of the engine was lessened in the proportion of 100. to 94. When the load was reduced to 5.5 lbs. the power of the engine was still further lessened in the proportion of 94 to 82. In these two cases the work produced by 1 lb. of coals was reduced in the proportion of 100 to 94, and 94 to 80.

When, on the other hand, the load was increased from 7.8 lbs. to 8.8 lbs. per inch, the work done was only in creased from 100 to 107. When the load was still further increased to 9.1 lbs. the work was diminished from 100 to 96. But in both these the economy of fuel was diminished in a higher proportion, the work produced by each lb. of coals being reduced in the proportions 100 to 97, and 97 to 93.

Mr Smeaton also found, from the same engine, the best kinds and modes of burning the fuel. Round coals were found superior to small coal in the proportion of 100 to 80 nearly. Coke produced 5/6 of the effect of an equal weight of the same coal from which the coke was made, and 66 lbs. of coke were obtained from 100 lbs. of coal. Ash-wood used as fuel was found inferior to common Yorkshire coals in the proportion of 42 to 100. The performance of the kind of Newcastle coals called Team Top, was found superior to the common Yorkshire or Halton coal, in the ratio of 120 to 100. Cannel coal, from Wakefield in Yorkshire, was superior to Halton in the ratio 133 to 100. Middleton-wood coals, and Welsh coals, were superior to Halton, as 110 to 100; and Ber wick-moor coals were inferior to Halton, in the ratio 86 to 100.

In consequence of this admirable method of procedure, Mr Smeaton improved the proportions and structure of the atmospheric engine, and very soon produced ma­chines which excelled in their dimensions and efficiency every thing which had preceded them. In 1772 he erected an engine at Long Benton colliery, near New castle, which he ever afterwards considered as his stand ard. The following are its principal dimensions and performance : Diameter of the cylinder, 52 inches—7 feet stroke, 12 strokes per minute, being 84 feet useful motion per minute, and 168 feet total motion per minute. Load of water = 7.1 tons. Load per square inch = 7½ lbs. Consumption of coals, 17.63 lbs. per horse power per hour. Work of one bushel or 84 lbs. of coals = 9.45 millions of lbs. one foot high. The total power of engine was about 401/2 horsepower, and for every horse power the boiler had 52 cubic feet of total space, 27.75