air and flame resulting from combustion. From an examination of the best boilers, it appears to us decided that one-fifth of the area of the fire grate, gradually diminishing to a chimney, which shall have one-tenth of the area of the fire grate, is an excellent proportion. We therefore feel disposed to recommend it as a standard for steam-engine boilers : one-fifth, diminished at the chim­ney to one-tenth part of the area of fire grate.

The chimney should be of the same diameter through­out its interior; and if of 40 feet height and one-tenth part of the area of the fire grate, it will give an abundant draught. If the height of the chimney be greater than this, the area may be diminished as the square root of the height is increased.

The quantity of water to be contained in a boiler is a matter of some importance. If we consider bulk and weight as of no consequence, and if the boiler be in con­stant work, there cannot, perhaps, be too much water. On the contrary, if there be only a small quantity, many evils are encountered. In the first place, a large mass of water serves to regulate the production of steam from a boiler, much in the same way as a fly-wheel regulates the speed of an engine ; whereas with a small charge of water, the unavoidable oscillations that happen in the supply of cold water or the additions to the fire, make sudden and injurious changes in the production of steam. In the next place, it is well known that steam is a very bad conductor of heat, and has a single capacity in its gaseous state for the acquisition of caloric. Hence it is found that if the production of steam be rapid, and the water present in a smaller proportion, the caloric is not carried off from the metal heated by the fire sufficiently fast, the boiler is overheated and rapidly deteriorates, while the production of steam is greatly retarded. For these reasons, it is necessary to have a large supply of water. Eight to thirteen cubic feet are very commonly allowed by practical men. As a standard, or perhaps ns a minimum, we may assign for the quantity of water in the boiler, in its mean condition, ten cubic feet of water in the boiler for each horse power. In like manner, we will do well not to leave a smaller proportion of capacity in a boiler for containing steam than the quan­tity assigned for the water, being ten cubic feet of steam in the boiler for each horse power.

*Economy of Fuel in Steam Boilers.—*The ordinary consumption of coal by one of Mr Watt's engines is 10 lbs. of fuel for each horse power every hour. The work done by this fuel is equivalent to the power of raising 150 lbs. 220 feet high in a minute, or of raising 220 times 150, that is (220 × 150 = 33,000) 33,000 lbs. one foot high, or any equal product of mass by height in every minute, by the combustion of 10 lbs. of coal, or 3,300 lbs. of weight raised one foot high every minute, which gives in every hour 198,000 lbs., raised one foot high by the combustion of one lb. of coal. This, however, by care and economy, is often exceeded by Mr Watt’s engines ; and the following are about the standards of work done at a given expendi­ture of fuel in ordinary engines, which is called the Duty of Steam Engines.

The Duty performed by Ordinary Steam Engines is—

One horse power exerted by 10 lbs. of fuel an hour.

Quarter of a million of lbs. raised one foot high by one lb. of coal.

Twenty millions of lbs. raised one foot by each bushel of coals.

The constant aim of engineers is to increase the amount of this duty ; in other words, to make a less quantity of fuel than 10 lbs. do the work of one horse, or to obtain a greater duty than a quarter of a million of lbs. from one lb. of fuel, or more than 20 millions of duty from a bushel or 84 lbs. of fuel. To such an extent has this effort been successful, that one cubic foot of water lias been converted into steam capable of exert­ing one horse power by the combustion of less than 5 lbs. of coal ; and this steam has been so managed in the engine as to raise one million of lbs. one foot high by one lb. of coal, and in one case 125 millions of lbs. by a bushel of coals was the duty obtained in Corn­wall. Of these improvements part, is due to the economy of steam in the engine itself, and does not come under this head. That part, however, which is the result of economy in the boilers deserves our atten­tion here.

By a series of experiments, carefully conducted or collected, and ably discussed, by Mr. Parkes of Warwick, the statistics of steam-engine boilers have been placed in an aspect sufficiently clear to enable us to deduce some general results of considerable economic import­ance. These experiments are contained in the table on the opposite page.

The observations contained in this table are made upon three great classes of boilers; the Cornish high- pressure boiler, I. to IV. ; the waggon boiler and com­mon low-pressure boiler, V. to XIV. ; and the locomo­tive-engine boiler, XV. and XVI. The waggon boiler, V., was treated at Warwick in a peculiar manner by Mr Parkes himself, who is the advocate of a peculiar system of management, by which very slow combustion of the fuel is produced.

The Cornish boilers I. to IV. are distinguished from the common boilers, both in construction and treatment. The surface which they expose to. the fire is enormous, being four or five times as great as the standard of usual practice, as we find in I., where 34 horse power has a surface of 2600 feet, and in II., where 48 horse power has a surface of 3170 feet exposed to the fire. This species of boiler is invariably cylindrical, and traversed longitudinally by cylindrical iron flues. It is also sur­rounded by external flues, except on the upper surface, which is placed under a roof, and enclosed to a consider­able depth in sawdust, or other nonconducting matter. The circuit which the flame and hot gases perform, in contact with the flues, is about 150 feet long. The treatment of the Cornish boiler is as peculiar ns its structure, for instead of a strong draught, a tall chimney, and an intense fire, the fuel is laid on in large masses, it is allowed to cake and to consume very slowly, while its products pass up the chimney after having paid a lei­surely visit to the two or three thousand feet of absorb­ent heating surface that surround its long and circuitous passage towards the open air. Very perfect combustion is obtained by the thorough combination of the oxygen, and the ample time permitted for the communication of the heat thus developed. Durability in the materials used, economy in the fuel employed, and increase of useful effect, are obtained by the Cornish construction and usage, to an extent that excels every other mode of generating steam with which we are acquainted.

The economy of the Cornish boiler and its causes may be estimated by comparison with the standards we have already given of very ordinary practice.

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| **CONDITIONS.** | **ORDINARY**  **STANDARD.** | **CORNISH BOILER.** |
| Area of fire grate in square feet  Area of heating surface in do  Circuit of heat | 1  15  60 ft. | 2  60 to 70  150 ft. |
| **RESULTS.** |  |  |
| Fuel per horse power per hour  Fuel consumed per hour per ft. of grate Water evaporated by each lb. of coal | 10 lbs.  10 lbs.  6 lbs. | 51/4 lbs.  25/8 lbs.  114/5 lbs. |