to the stock of knowledge ; the useful practical treatise of Mr Armstrong has given us an instructive view of the state of practice in the busy district of Lancashire; the treatises of Mr Wood and M. de Pampbour on Railway Locomotives ; and the papers, in the Transactions of the Institution of Civil Engineers, on the statistics of Boilers and Combustion, have supplied and discussed a large collection of important facts, that will materially assist the future investigation of the best construction of steam boilers.

During the first period of the history of the steam engine, the danger of bursting the boiler, and the difficulty of making it strong enough to resist the internal force acting towards explosion, and also of making the joints tight against the leakage of highly elastic steam, formed the chief obstacles to the introduction of steam as a mechanical mover.

The first important point in preparing a steam-boiler is to secure strength, without unnecessary expense of mate rials. If we take the simplest form of vessel: suppose a simple rectangular watertank—suppose the vessel on a small scale, made of sheet-iron, and soldered at the edges so as to form an airtight box; then, by simply blowing into it, we shall manifest its weakness ; for the sides will first of all bulge out, and, if the materials yield and allow the vessel to change its shape, it will at last swell into a globular form, with angular knobs upon it at the cor ners, from which pyramidal extremities, the globular parts, will finally he torn away with an explosion which will, in all probability, take place long before the vessel has attained the shape mentioned above.

The globular or spherical shape was very early adopt ed, as one of greatest capacity, as a shape in which, the pressure at every point being equal, there remained no force tending to produce flexure, or destroy the equilibrium of strength and strain at any point. A fire was then lighted below the boiler, and the steam confined until the heat had raised it to the temperature required for the given pressure. This form was accordingly adopted by Hero, Savary, and others, as may be seen in the representations of their boilers, which we have given in the historical portion of the article Steam Engine.

lt was soon found that a spherical boiler, being set upon an open fire, required an enormous consumption of fuel to raise a small quantity of steam, the heat being co piously radiated not alone to the water in the boiler, but also in very great quantity to the surrounding objects, besides being rapidly carried off by the air. To surround the spherical boiler with nonconducting substances, and to keep the flame throughout its whole extent in contact with the surface of the boiler, so as to prevent radiation to surrounding objects, and also to diminish the size of the fire by making it wind round the boiler, were the first steps towards improvement ; and we accordingly find in the work of Dr Desaguliers the subsequent form of a boiler. Fig. 198 is a front

view of the boiler *set* in a

building of brick, a substance

which is good as a non-conductor of heat, and calculated

to withstand the destructive

action of fire. A deep *ash­*

*pit* lies immediately under the

fire, which rests on a number

of parallel iron *bars,* placed

so close to each other as to

prevent the fuel from falling

through, and at the same time

to admit between them the air requisite for combustion ;

and the *door of the furnace* being kept closed at all times, except when fuel is to be added to the fire, the whole **of** the matter of the fuel is in this way supplied with air, which passes up through the interstices of the bars. The flame, after having passed along lhe bottom of the boiler, winds in a corkscrew form around its sides, in contact with the surface of the boiler, in a spiral chan­nel formed by the bricks, and called a *flue,* by which the smoke and hot air are at last conveyed into a *chimney. A damper,* as it is called, is formed by a small plate of iron, admitted through a slit into the opening where the flue joins the chimney ; so that, by pushing this plate into the opening, the passage of the smoke out into the chimney, and consequently of the fresh air into the fire, may be obstructed, the combustion of the fuel retarded, and the too rapid generation of steam prevented. In this simple way, the attendant is enabled, by merely pushing in or drawing out the damper, to regulate with great precision the generation of the steam. The pipe which conducts the steam to its ultimate destination, is called the *steam-pipe ;* and there is another pipe neces­sary to the continued action of the boiler, called a *feed­pipe,* through which water may be made to enter the boiler, as it is evident that otherwise the water, being continually boiling off in the shape of steam, would soon leave the boiler empty; so that a constant supply of an inch of water forevery foot of steam, or six gallons of water for every horse power, is required to enter the boiler through the feedpipe.

The form of boiler next in simplicity to the spherical boiler is the cylindrical. From the facility with which a cylinder is made, it was introduced at a very early period. It stood upright, as in fig. 199, the fire being

placed at the bottom, and the flue winding round that part of the sides covered with water. This form of boiler was found, however, to have the disadvantage of weakness in the bottom part.

For the prevention of these two evils, the cylindrical form of boiler was very soon modified and improved by two opposite expedients, one applied at the top and the other at the bottom of the cylinder. The top being made hemispherical, possessed all the advantages of a spherical boiler; and the bottom being arched upwards, so as to present a large concave dome to the impact of the flame, this dome being sustained by the cylindrical belt round its spring, a very strong and extensive surface was obtained, as in Fig. 200.

In this cylindro-spherical boiler, it was found that the action of the flame on the upright round sides produced a very slight effect in raising heat. It was therefore desirable that the flame should he brought somewhat under the sides, by inclining them a little outwards. The boiler then assumed a form which has since become very common, and from its shape, has not inaptly been named the naycock boiler, fig. 201.