An important point in setting the valves is what is called the lead on the centres. What is the best instant of time at which to allow the steam to enter or escape from the cylinder? At first sight we should say, precisely at the instant of reversing the direction of the motion. This is not the case. Great advantage is gained by letting the steam out of the condenser before the end of the stroke. A little of the force of the steam in the cylinder may thus be sacrificed; but it is a very little, say 1/50th of the stroke, and is much more than compensated by this, that the steam escaping thus early into the con­denser, time is allowed for effectual condensation, and there is an excellent vacuum in the cylinder by the time when the back-stroke begins. In like manner, the steam-port may be slightly opened before the engine comes to the centre; and as there are vacuities at the top of the cylinders to be filled, and as time is wanting for the passage of the steam, this is allowed. By the same means also the steam is cut off a little before coming to the end of the stroke, which allows the engine to work expansively ; and the vacuum port may in like manner be shut, as the vapour will have been perfectly condensed in the cylinder long before the end of the stroke. Much of the efficiency of an engine depends on the adjustment of the slide.

The eccentric of the marine engine is generally a loose eccentric, capable of turning the valves either so as to give the engine motion forwards or backwards. By placing the eccentric loose upon the axis, only with a projection on one side, which is carried round by a corresponding projection on the axis, it is left free, ex­cept when this check comes in contact with the projec­tion at either end of the stroke. To effect this, it is necessary to open the valves by hand through at least one half-stroke.

*The Hand-Gear.—*The hand-gear is generally a lever or series of levers, which enables the engineer to shut and open the valves by hand before placing them in con­nexion with the eccentric. By this means he places the machine either in the condition to keep moving forwards or backwards. For examples see the Plates.

*The Expansive Valves—*It is of advantage to cut off a part of the steam which would be required to fill the cylinder, so as to allow that quantity which has partly filled it to expand with its elastic force, and fill the rest of the cylinder without further supply from the boiler. The advantage of doing this, especially in long voyages, has now become pretty generally known. A stop-valve V, fig. 25, is placed on the steam-pipe S S', before it joins the casing of the com­mon valves, which are applied as usual. The prin­cipal axis A of the engine carries a cam, with two pro- jections *aa* oroportioned in Breadth to the extent of the stroke which is cut off. On this cam rolls a small pulley *b,* pressed close by a weight *w;* and by a simple connecting rod the cam opens and shuts the valve with great velocity twice in each revolution. On this cam there may be various grades at which the steam may be cut off in the stroke of the engine. This apparatus is used in all vessels calculated for long voyages.

*The Proportion of Power to Tonnage* Large power

or small power has always been one of the *υexalte ques­tiones* of steam navigation. The early steam-boat en­gines had but a small power proportioned to the ton­nage of the vessels in which they were placed. The Comet had 25 tons burden and only three horse power; being about one horse power to eight tons, or a pro­portion of power to tonnage amounting to one-eighth.

On this subject modern practice and modern opinion seem to offer no guide. A low proportion of power and a high proportion of power have both their advo­cates. The East India Company have advocated and used low proportions of power to tonnage, and in this they appear to have followed the general maxims of southern engineers. The Government also appears to have adopted the same course; but without going to the same extreme. The Clyde engineers adopt the oppo­site maxim, and place ns much power in their vessels as can be conveniently applied. There appears at the pre­sent moment to be a strong feeling in favour of a high proportion of power to tonnage. It has been found by some of the best mercantile companies, that a high pro­portion is not only better for expedition, but also more economical of fuel and of capital than a smaller propor­tion ; and instances are frequent of an increase in the power of a steam-vessel, producing a diminution in the consumption of fuel.

As this question is becoming every day of greater importance, it is proper to examine it carefully. In the first place, it is well known that the proportion of power must be very much increased to gain a given increase of speed. Thus, if 120 horse power propel a vessel through water five miles an hour, it will require forty horse­power to propel the same vessel ten miles an hour, or it will require a quadruple power to obtain a double speed; and, in like manner, it will require a ninefold power to triple the speed. In fact, the increased speed requires an increased power in a duplicate ratio of the increased speed; or if the speeds be as the numbers 1, 2, 3, 4, 5, 9, 10, &c., the power required to attain those speeds must be 1, 4, 9, 15, 25, 81, 100 horses ; or according to the well known law of the resistance of fluids, the re­sistance which the water opposes to increased speed is nearly in the duplicate proportion of the speed. Thus, to increase the speed in a given proportion, the fire of the engine and the consumption of fuel, which is nearly as the power of the engine, must be increased in a very high proportion. Hence the seeming great economy of a low power of engine and a small consumption of fuel.

Thus a large power of engine occupies much of the useful space of the vessel, which might have been filled with cargo. It consumes much coal, and the speed is by no means proportioned to the expense of fuel and machinery. But this is a very limited view of the sub­ject. If time as an element, and a very important one in the value of mercantile conveyance, be calculated, then it will in many cases be found, that high speed at any expense of fuel will compensate for that expense. This is the case to a great extent in Britain, and especially in America, where a quarter of a mile an hour between the speed of two vessels ruins the fortune of one owner, and makes the fortune of another. But it is not on the value of speed at the present day, that wo proceed in this enquiry ; that can at once be appre­ciated by the local peculiarities of a given case. We are to enquire what may be the best proportion of power to tonnage in sea-going vessels, apart from the mere price of speed in the market.

We have seen that the lowest speed in a steam-vessel is the most economical, and that it requires great and expensive additions of power to gain high velocities.