of a good practical boiler, that, if one part should be damaged or give way, the whole should be so construct­ed that the damage done to that part must not endanger the rest. An extensive heating surface is to be ob­tained for economy’s sake ; but that large surface must at the same time remain unimpaired to resist bursting ; a property to a certain extent inconsistent with extensive surface. The surface which is thus spread as widely as possible, so as to apply the fire to the water through every part of its mass minutely and in great subdivisions, if extended beyond a certain degree, will not have over it a body of water capable of conducting heat from it with the rapidity adequate to the rapid generation of steam, and to the preservation of the intensely heated metal from the destructive action of the fire. Then, again, it is de­sirable to have long and tortuous flues, to extricate as much heat as possible from the fuel and the products of combustion ; but these, by their very length, may in­terfere with the draught of the chimney, so as to dimi­nish the efficacy and vigour of the combustion of the fuel, and produce loss instead of gain. Thus it happens that the whole question of boilers is an exact and judi­cious combination and adjustment of parts, so as to obtain each of these many points in that degree which is most advantageous for every one of the other qualities, and of all of them together. The question is a practical one of no common difficulty.

It is principally by the collection of facts, of accurately recorded statistics of boilers, of the practical experience of the most eminent engineers, that we can gather data for the solution of the question of the best boiler. We are not without such data, although it is much to be re­gretted that they are not so abundant as we should wish. We shall now examine the various points in the structure and functions of a boiler in a simple succession.

The materials of which a boiler should be formed, have been a subject much discussed. Copper, iron, brass, cast- iron, lead, and even stone, have been employed. Boilere of steam-vessels are frequently made of copper. Many steam-boilers have been made of cast-iron, and have lasted long, and been very efficient under careful man­agement. Wrought-iron-plate boilers are very common in this country ; and in America have been much used, with cast-iron ends or heads of considerable thickness. The boilers of locomotive engines have the interior, which is exposed to the direct impact of the flame, formed of copper, and sometimes partly of brass ; the exterior of the boiler being wrought-iron. Cast-iron boilers were extensively used under Mr Smeaton, towards the end of last century ; and when used with care, were employed with advantage where fuel was plentiful, from their cheapness. A stone exterior jointed with cement, the interior being copper, where subject to great heat, and when the steam has scarcely any greater pressure than the atmosphere, has also been employed ; and a dome or cupola of lead was often seen, in earlier times, when the art of working iron-plate was less common than it is now, forming the cover of the antiquated Hay-stack Boiler, which, in these times, the “ Waggon” of Watt has almost entirely removed out of use.

Copper is the best of all substances for steam-engine boilers, in a mechanical point of view. That it is not best in a mercantile point of view, is proved by the almost universal use of wrought-iron boilers. Yet it is difficult to see why this should be the case, if we remem­ber that copper lasts for ever, and is worth, when old, nearly two-thirds of its first cost, besides being a much better conductor of heat, and so saving fuel and space. The labour, too, of making a copper boiler is no greater than an iron one. The relative value of these materials for boilers may be stated thus ;—.

The efficiency of a copper boiler in genera­ting steam, is to that of iron as . 3 to 2

The cheapness of equal weights of copper

and iron boilers, are as . . SO to 130

The value of old materials diminished by

15 years’ interest, is . . . 4 to 3

Durability, . . ... 5 to 1

30 to 13

The combination of all these ratios is in favour of copper ; and if we add the trouble of replacing the new iron boiler, and detaching it from all its connexions, five times for once in the case of copper, the scale still further preponderates on the same side. We must look, therefore, for the explanation of the general use of iron to the state of mercantile affairs, and the value of money in a commercial community. It proves that a certain loss, within 15 or 20 years, in a proportion of 12 to 1, is con­sidered preferable to an original expenditure of four times the amount of capital ; showing either that the price of money is too high for such an investment, or that the contingencies of mercantile life are too great to allow the risk of so large a sum as the value of a copper boiler for the period required to reimburse the proprie­tor. Rich governments and individuals have not failed to profit by this knowledge ; but it may be noticed of a government which considers its tenure of office insecure, that it does not furnish even its war-steamers with cop­per boilers, as that would involve the expenditure of a large sum by which their successors would profit. So also the man who is shortened in means, but hopes to be rich enough by the time one boiler is done to get a new one ; or who does not know whether he shall be sol­vent so long as to see the boiler out ; or who, at any rate, cannot spare so much money at once—procures at once the cheapest boiler he can ; and finds, as usual, that in a short time the expenses of coal and of repairs have drawn from him a heavier than the usurer’s percentage. All this applies more peculiarly to steam-vessels.

Another peculiarity of copper is the greater safety which arises from the uniformity of its texture. It is scarcely possible to account for the singular differences of sheets of iron that have passed nominally through the same processes of manufacture. One plate will become deteriorated by heat in half the time of another apparent­ly identical. The parts of the same plate are frequently heterogeneous. The consequences of this heterogeneity are serious, and sometimes destructive : a single plate in a series gives way, and, having broken the chain of con­nexion, the whole fabric is destroyed ; or a latent crack developes itself in the place most difficult to restore ; or one plate, or a part of it, is burnt through when all the rest remains sound. All this tells in favour of copper. The matter of the copper is very nearly homogeneous : its durability is nearly uniform, if it is not made too thick. We have examined the part of a copper boiler exposed to most intense heat after years of action, and found, when the soot was cleared away, the smooth shining surface, produced by the rollers in the process of manufacture, remaining as perfect as the day after the boiler was started. In this case the metal was no more than one- eighth of an inch thick.

There are some forms of boiler for which copper is less suitable than iron. The strength of copper to resist flexure is not nearly so great, especially at high tem­peratures, as that of iron. A copper boiler must there­fore be well stayed, and if there be round, or any other unstayed flues in the boiler, they cannot be of more than a foot in diameter without incurring danger; they will readily collapse or bend. Thia caution in regard to