with a small, non condensing, slide-valve engine, may give four or five times as much power when used in connection with an engine of more improved design. To get the horse-power of a boiler, by the centennial rule, or by any other rule, the first problem is to find the heating surface of the proposed boiler, which consists of all those parts of the shell heads and tubes which are exposed to the direct action of the fire on the hot gases that come from it. We shall proceed to consider these parts in detail.

To obtain the area we should know the exact length of the shaded area and also the height of the side walls of the furnace; but in practice it is usually assumed that the shaded area is equal to one-half of the shell. The front head of the boiler is of little or no value as a heating surface, because if the boiler is well designed the temperature of the up-take does not greatly exceed the temperature of the boiler itself, and hence there cannot be any considerable absorption of heat through the front head; this should therefore be entirely omitted in the calculation. The back head is more directly opposed to the heat of the furnace, and allowance is sometimes made for such heating surface as it contains. In practice, we do not allow for the back head, however, because the only part of its surface which is available, in any case, consists in the small segments which lie between the tubes, together with a narrow strip around the flange and just under the back arch. While there might be some heating value to these parts when the boiler is new, we do not consider that they are worth taking into account after it has been used for a time, because scale is likely to form upon them. The tubes are of great importance in computing the heating surface, because their combined area is very large, as can be seen in the numerical example given below. In computing the heating surface of a tube, we have first to consider whether we should take the internal or external surface as the effective one. This question admits of discussion, and could only be settled definitely by actual measurement of the external and internal temperatures of the tube when the boiler is in operation. If it were found by experiments of this sort that the tube, as a whole, is nearly as hot as the gases within it, then the external surface should be taken; while if the tube were proved to be hardly hotter than the water in the boiler, there can be no doubt that the internal surface should be taken as the effective one. We do not know that any such measurements have been made; and some engineers base the calculated heating surface upon the internal diameter, while others use external diameter and still others the average of the two. One practice has been to take the external diameter, and this course is justified by experience.

This point being settled, the next step is to find the area of the tube by multiplying its outside circumference by its length—the circumference being found by multiplying the outside diameter by 3.1416. (The diameter of the tube is usually given in inches, so that if the surface is required in square feet, it is necessary to divide the given diameter or circumference of the tube by 12, so that it may be expressed as a fraction of a foot). The area of one tube being found, we multiply it by the number of tubes, and thus find the united surface of all of them. This, when added to the heating surface afforded by the shell, gives the entire surface upon which the rated horse power of the boiler is to be based. A numerical example will make the rule plainer. Let it be required to find the heating surface of a 72-inch boiler, 18 feet long from head to head, with 92 tubes, 3½ inches in diameter. The diameter of the boiler being 72 inches, its circumference is $72 \times 3.1416 = 226.1952$ inches. To express this circumference in feet, we divide the result by 12, thus: $226.1952 \div 12 = 18.8496$ feet. The length of the boiler between heads being 18 feet, the total area of the shell is $18 \times 18.8496 = 339.2928$ square feet, and $339.2928 \div 2 = 169.6464$ square feet, which is to be taken as the effective heating surface afforded by the shell. Passing now to the tubes, we find that the circumference of a 3½-inch tube is $3.5 \times 3.1416 = 10.9956$ inches, which is equal to 0.9163 of a foot, since $10.9956 \div 12 = 0.9163$. The surface of the tube is then found by multiplying the circumference by the length, thus: 0.9163×16.4934 square feet, which is the area of a single tube. The combined area of the 92 tubes that the boiler contains is $92 \times 16.4934 = 1,517.3928$ square feet, which is the heating surface afforded by the tubes. Upon adding this to the heating surface afforded by the shell, we have heating surface of shell and tubes. Total heating surface of boiler $169.6464 + 1,517.3928 = 1,687.0392$. In round numbers, the effective heating surface of boiler would be 1,687 square feet. It will be seen that the tubes are of far more importance than the shell.

The heating surface of the boiler being known, the next step is to find what evaporative duty may be expected of the boiler in ordinary good practice. To solve this part of the problem we have to know from experience what amount of water can be economically evaporated by each square foot of heating surface per hour. In our own practice we find that when the boiler is well designed and the draft is good, an evaporation of 2½ pounds of water per hour may be had from each square foot of heating surface. In exceptional cases the evaporation may run as high as 8 pounds; but under ordinary circumstances it is found that 2½ pounds is all that can be reasonably expected.

If the data by experience be accepted, it follows that the boiler will have one nominal horse power for every 12 square feet of heating surface; for if each square foot evaporates 2½ pounds per hour, the total evaporation on 12 square feet will be $12 \times 2½ = 30$ pounds per hour. The nominal horse power of a boiler is thus calculated by dividing the total effective heating surface (in square feet) by 12. If it is desired to calculate the actual horse power that a boiler may be expected to furnish, we must first know something about the engine that is to be used; for the boiler merely produces the steam, and it is the engine which transforms the steam into mechanical energy. Now, if the engine is of good design and economical, a good average can be expected; while if it is wasteful, the boiler will be working just as hard, and the yield will be much smaller.

A numerical example of this rule may be given, taking the boiler whose heating surface has already been given. The heating surface being 1687 square feet, the evaporative duty of the boiler per hour will be $1687 \times 2½ = 4217.5$ pounds $\therefore$ $4217.5 \div 30 = 140$ horse power, the actual horse power developed under such circumstances and data afforded by experience.—National Engineer.

PATENTS GRANTED.

The following Canadian patents, relating to the textile trades, have been granted:

Mattress for beds, couches, etc., O. R. Hunt, Minneapolis, Minn. Combination of frame, springs and mattress fabric.

Clothes dryer, W. M. Barnes, Philadelphia, Pa. Combination of heating coils and air circulating device in drying room.

Window shade fixture, F. H. Bassett, Waterbury, Conn.

Paper making machine, J. W. Moore and J. A. White, Philadelphia, Pa.

Shears, W. G. Henderson, Titusville, and E. P. Cole, Pittsburg, Pa. Extension appliance.