THE EXPANSIVE WORKING OF STEAM.

The ultimate quantity of mechanical power which theory assigns to steam is so great, that there is something tantalizing in comparing therewith the dynamical results attained by even our very best engines. Theory, of course, prescribes an infinite pressure, and an infinite degree of expansion. As a practical approach to such a pressure, we have the legend of Alban, the German doctor, who sent his steam upon the piston at 1,000 pounds per square inch. This was done, too, here in London; and although the performance was for no great space of time, it is not recorded that any one was blown up. Now, to obtain the greatest effect, theoretically at least, from steam, of whatever pressure, it is necessary to work it in a condensing engine, and to condense down to a perfect vacuum. Let us suppose, then, that steam of a total pressure of 1,000 pounds per square inch, as measured from a vacuum, is expanded to a final pressure of one-tenth of a pound only per square inch, as measured above the same *datum*. Here the expansion is ten thousand fold; and if the temperature of the steam be maintained during expansion by superheating or steam jacketting, the effect or power obtained will be 10·21 times greater than if the same weight of steam were worked without expansion. Thus, if an engine work, without expansion, with 5 pounds of coal per hourly indicated horse power, the rate of expansion just considered should result in a consumption of 49 pounds of coal only for the same effect, this quantity being exclusive, however, of that required to maintain the heat of the steam during expansion But, if we could impart even three-fourths of the full heating value of good coal to the water in steam boilers, we should, upon the same theoretical consideration, attain to a still greater degree of economy. Thus a pound of good coal gives off in combustion as much heat as would raise 16,000 pounds of water through a temperature of 1°, or more than enough to raise 13 pounds of water of ordinary temperature into very high-pressure steam. If, then, we attained an ordinary rate of evaporation of 10 pounds of water per pound of coal, we should be working with say 3 pounds of coal per hourly indicated horse-power, with condensation and without expansion; and, with the allowance already mentioned for maintaining the temperature of the steam during expansion, with hardly more than a ½ pound per horse-power, with an expansion of ten thousand fold. This would be a tolerably close approach to the theoretical economy of heat as referred to Joule's equivalent. For if we obtain from a pound of coal, say 12,000 "units of heat," or, in other words, as much heat as would suffice to raise 12,000 pounds of water through 1°, or 10 pounds of water through 1,200°, then the mechanical power represented by each unit of heat being 772 foot-pounds, the corresponding total power represented by a pound of coal (even when but three-fourths of its total heating power is calculated upon) is 9,264,000 foot-pounds, equal to $\frac{9264000}{1980000}$=4 67 hourly horse-power, corresponding to 0.214 pounds of coal nly per indicated horse-power per hour.

Ever one conversant with the theory of steam must have made calculations of the nature just illustrated; and it is possible that, in some instances, the whole theory has been denied because of the apparent impracticability of attaining anything approaching such results in practice. Watt understood the advantage of condensation, and the general theory of expansion; but with steam of very low pressure, his engines required from 7 pounds to 10 pounds of coal per actual hourly horse-power; a result attributable, in a great measure, no doubt, to imperfect workmanship. Now, however, marine engines worked with steam of less than 25 pounds pressure, are going by the month together, with only 2 pounds per horse-power; and it is therefore reasonable still to look for a gradual improvement even upon this economical rate of consumption. In the manufacturing districts, and indeed, generally, upon land, extreme economy of fuel is not of such great consequence; but for steam vessels it is everything. In many parts of the world coal costs £3 and upwards a tun, but even this does not stand so much in the way of economical steaming, as the very weight of the coal required to be carried, and of the boilers and engines themselves; the total weight of coal and machinery being so great as to preclude the profitable conveyance of cargoes on long voyages. The largest transatlantic steamships (not referring to the *Great Eastern*) leave port with 1,400 tuns of coal on board, while the weight of their engines and boilers, in working trim, is nearly as much more. If half the weight and cost of the coal could be saved, and space and displacement corresponding to 1,000 tuns could be liberated for the conveyance of merchandise, how different would be the result commercially. Such a saving is likely, however, to be soon generally effected, for the mechanical and commercial practicability of driving a 3,000-tun ship, at a mean speed of 13 knots, with, at most, 60 tuns of coal in 24 hours, has been virtually established, by the practice of the Peninsular and Oriental Company. The machinery by which this is effected is, however, costly and very heavy, although the increased weight of the engines is in a great measure offset by the diminished number and weight of the boilers; while a great saving of bulk and displacement in coal-bunkers remains as net gain, irrespective of the money saving in the diminished consumption of coal itself.

As far, then, as economy of fuel is concerned, very good results are already obtained with steam of from 20 pounds to 25 pounds, moderately superheated, and with surface condensation; but a further advantage remains to be obtained from steam, by higher pressure and an increased speed of piston. A good high-pressure marine boiler would, it might be supposed, be now forthcoming, since the extensive introduction of surface condensers supplying distilled water.

While dealing with expansive working, it will not be inappropriate to say a few words as to indicator diagrams from expansive engines. It is easy to set out a theoretical expansion curve for any point at which the steam is cut off, allowing also for the loss of pressure due to expansion. For those who do not care to calculate the ordinates, or refer to hyperbolic logarithms, there is (if not out of print), a very convenient diagram by Mr. Charles Cowper, published by Weale, from which any one may lay down a theoretical expansion diagram. This diagram was published as long ago as 1849, and yet it carefully allows for the loss of pressure during expansion; a loss which, indeed was pointed out by Oliver Evans, as early as 1805 But no theoretical expansion diagram will agree with that obtained in practice from the indicator, when cutting off at the same point in the stroke; nor will the indicator diagram, in many cases, afford an accurate representation of the work really obtained from the steam used. For in the case of unprotected cylinders, with a long stroke and a slow speed of piston, the internal cooling is sometimes so great that as much steam is condensed on entering the cylinder as appears on the diagram. Between two and three years ago, a "board" of American naval engineers made a series of experiments to ascertain whether there was any gain (!) in expansion; and they confined their observations to a condensing engine, having an unjacketted cylinder with an 8 feet stroke, the piston in some of the experiments making but eleven double strokes, or 176 lineal feet per minute. In cutting off at about one-third stroke, it was found that as much coal was burnt per horse-power as when following full stroke, and it was eventually decided, we believe, that there was no gain in expansion! Fortunately, however, the water fed to the boiler was measured; and by referring to the relative volume of the steam thus generated at the working pressure, it was found that about 40 cubic feet of steam was admitted at each stroke, into a space which, but for internal condensation, could have received but 20 cubic feet. The fact was that after the steam was cut off, the interior of the cylinder was so long exposed to a falling temperature—sinking at last to 100° when the communication was open to the condenser—that the inner surfaces of the bore lost a great deal of heat, and on the admission of steam of 250° and upwards on the return stroke, a great deal was condensed. If moisture once forms upon a metallic surface, the abstraction of heat from that surface in vaporising such moisture, is very rapid; but if the steam were kept dry, and the cylinder were heated to above its normal temperature, the mere internal radiation of heat into such dry steam, even at the temperature of condensation, would have been very slight indeed. A slight return for the heat actually taken from the cylinder at each stroke was, of course, made in the re-evaporation of precipitated moisture; but as most of this re-evaporation must have taken place while the cylinder was open to the condenser, the return was indeed slight. In many cases such re-evaporation is the source of an additional loss, by occasioning back pressure.

Priming, it is almost needless to say, will greatly affect the shape of a diagram. For water coming over with steam, and having a heat of, say 300°, quickly evaporates when the pressure by which it is surrounded has fallen to a point corresponding to 200° or less.

The leakage of valves also affects the shape of indicator diagrams, the extent of this influence being necessarily beyond any means of precise estimation. It is practically impossible to fit two flat surfaces of cast-iron so accurately together that, without ports or openings in either, they will move less easily with steam of great pressure upon them than in the open air.

In dealing with expansion also, it is very commonly assumed that, if the steam be cut off when the piston has made say one-fourth of its stroke, the expansion is necessarily four-fold. It sometimes happens, however, that the space in the steam ports and clearances at the end of the stroke is nearly equal to that included in the portion of the stroke of the piston for which dense steam is admitted. Thus, with an admission for one-sixth of the stroke, if the clearances, ports, &c., contained an amount of steam equal also to one-sixth of the stroke, one half of the effect of the steam, as measured before expansion commences, is lost, and the expansive effort is that only due to an admission for two-sevenths of the stroke: or only a little more than one-third, were there no other losses.

In these, and in other ways, the practical result of expansion differs considerably from that assigned by theory alone, and supposing no special circumstances to be taken into account.—*The Engineer* (*London*).

Great International Wheat Show.

A great International Wheat Show will be held at Rochester, N. Y., September 8th, 9th, and 10th, under the auspices of the Monroe County Agricultural Society. The following premiums are offered:—

For the best 20 bushels of white winter wheat..	$150 00
For the second best 30 bushels of white winter wheat..................	75 00
For the best 20 bushels red winter wheat......	100 00
For the second best 20 bushels red winter wheat	50 00
For the best 2 bushels white winter wheat.....	50 00
For the second best 2 bushels white winter wheat	25 00
For the best 3 bushels red winter wheat........	40 00
For the second best 2 bushels red winter wheat	20 00
For the best 2 bushels spring wheat............	20 00
For the second best 2 bushels spring wheat....	10 00

Competitors for these prizes will be required to furnish samples of the wheat in the ear, and with the straw attached (say fifty ears of wheat and straw); also to furnish a written statement of the nature of the soil on which the wheat grew, method of cultivation, time of sowing, quantity of seed sown, manures (if any used), and mode and time of application; also the time of ripening and harvesting, and the yield per acre, with such other particulars as may be deemed of practical importance; also the name by which the variety is known in the locality where it was grown. The wheat must be one variety, pure, and unmixed. The prize to be awarded to the actual grower of the wheat, and the wheat which takes a prize to become the property of the society.

LOCOMOTIVES AND STEEP GRADIENTS.—The power possessed by locomotives to surmount steep gradients has been lately demonstrated in a very remarkable manner, by the opening of the Bhore Ghaut incline of the Great Indian Railway. The incline attains at one long lift the great hight of 1,832 feet, which is the highest elevation hitherto attained by any railway incline. It is fifteen and a half miles long, and the average gradient consequently is 1 in 46·39.

MANUFACTURE OF GLASS.—The first glass manufactory established in California recently commenced operations at San Francisco. About thirty men and boys are at present engaged in the works—bottles being the chief articles of manufacture. All the materials required, excepting soda ash, are obtained in the State.