For the Journal of the Franklin Institute.

On the Economy resulting from Expansion of Steam.

By ROBERT H. THURSTON.

The experiments of Chief Engineer Isherwood at the Brooklyn Navy Yard, those now in progress on board the *Michigan*, at Erie, Pa., and others lately tried, seem to be making converts to the doctrine that the principle of the expansion of steam is of no practical value. I would like to offer a word or two in regard to these experiments, and also a few facts which seem to me to furnish quite as good evidence on the other side of the question.

The experiments on the engine of the *Michigan* show the consumption of fuel to be actually greater in proportion to the power evolved when "cutting off" at $\cdot 354$, than when "following" full stroke.

At the time of the experiment under the first-named circumstances, however, the engine made but *nine revolutions per minute*. It is well known among engineers that a high speed of piston is required to enable an engine to work economically, *especially* when it is intended to obtain the full benefit of expansion. At this speed, the steam must have been refrigerated very effectually.

A writer, referring to the above experiment, in a late number of a journal devoted to engineering interests, remarks that a great gain by the use of a "cut-off" is all "moonshine," and, "engineers and scientific men have, for the last eighty years, subscribed to the greatest of fallacies," which assertion is supposed to be proved by *this single experiment*. As rebutting evidence, however, other well-known experiments of Mr. Isherwood himself may be adduced.

In his experiments on the smithery engine, at the Navy Yard, he found that by cutting off at $\cdot 22$, sixteen per cent. was gained over its full stroke performance. The gain in economy, certainly, fell far short of that called for by theory, but it was a very perceivable gain, notwithstanding. That the engine was in a most wretched condition, was proved by its extraordinary consumption of coal (15 pounds per H. P. per hour).

In the same volume in which are given the details of this latter experiment, is also given the account of another experiment on a different engine, in which the gain by cutting off at $\cdot 28$, amounts to nearly *thirty per cent.*

In this case, the consumption of coal at full stroke was 5.56 pounds per horse power, per hour, a vast improvement over the previous one, even when the difference in boilers is taken into account.

If, then, even these engines exhibit so great a gain, what may we not expect from engines in which the evils consequent upon uncovered pipes and cylinders, slow speed, long and contracted steam passages, slow closing of opening, and the many other circumstances especially detrimental to "cut-off engines," are avoided. The nearer we make our practice conform to theory, by providing against the interference of circumstances unrecognised by our theory, the nearer will our

practical results conform to our theoretical deductions. Mariotte's law provides that no heat shall be abstracted from the expanding vapor; hence, experiments conducted in a refrigerator should hardly be expected to be taken as proof of the falsity of that law. The unexpected discrepancy between theory and the result of experiment, should only render engineers more pains-taking in providing against adverse circumstances.

The most economical engine, not *special* adapted to the use of steam expansively, that I have had occasion to test, is now running in this city. It was built by a Wilmington firm, and its valve is of the "long D" variety.

The engine runs night and day the week through. The engine room is very hot. Temperature of feed probably averages 150°. The steampipe is short, and the engine runs at a tolerably high speed. The circumstances all favor economy. The consumption of coal is *four* pounds per H. P. per hour.

The engine formerly required twenty per cent. more fuel than at present. The saving was effected by giving the valve more lap, and carrying steam high enough to bring the engine up to speed. Fig. 1, Plate IV, is an indicator card, taken after the change was effected. The change in direction of the steam-line at *a*, shows the point of cut-off.

The most economical engine of which I have knowledge, *built with special reference to the use of steam expansively*, is one of a class of engines now coming rapidly into use, known as the "Greene engine," and was built at Providence, R. I. It is running in circumstances very similar to the last mentioned, and is consuming *two and a quarter* pounds coal to the H. P. per hour. The great difference between the two engines in view of the amount of coal required, is readily accounted for by the vast difference in construction. An engraving of an engine of the latter form is given in Weissenborn's "*American Engineering Illustrated*."

The steam-chest in this engine is very large, and acts to some extent as a steam jacket. The valves are four in number, and are perfectly *flat*, thus avoiding liability to leak, either from wear or by warping under the action of the steam. They are placed at the ends of the cylinder, thus securing short steam passages, and are closed either by a spring or falling weight, thus obtaining a rapid movement. The regulator acts by determining the point of cut-off, which may vary from nearly full stroke to any fractional part of the stroke, and steam is thus let into the cylinder at nearly the boiler pressure. The cylinder is carefully covered to prevent radiation, and the *ensemble*, although probably capable of improvement, is, perhaps, the best engine now manufactured.

The comparison of the last two engines represents fairly, I think, the relative merits of the two classes. The *average* consumption of coal by engines as usually built, is probably between six and seven pounds per H. P. per hour, while that of engines built like the one last referred to, is certainly not above *three and a half* pounds with engines

of fifty horse power and upward. Figs. 2, 3, and 4, Plate IV, are indicator cards from Greene engines built at Providence, and exhibit tolerably well the merits of the machine.

The Cornish engine is universally acknowledged to be the most economical engine in the world, and in it the principle of expansion is carried to the greatest extent. One instance at least has been known where the consumption of coal was *less than a pound and a half*, and the *average* of these engines is but little over *two and a half* per H. P. per hour.

An English firm is building *marine engines*, which use about two pounds only per H. P. per hour, and in them the principle of expansion is carried almost to excess.

An excellent example showing the advantage of a good opening and the rapid closing of a cut-off valve, is presented by the working of the engine of the steamer *Armenia*, on the Hudson. The engine, a 40-inch cylinder of 14 ft. stroke, was built with "Steven's valve gear." Some few months since, she was fitted with E. R. Arnold's "Attachment," at a cost which certainly could not amount to \$500. Figs. 5 and 6, Plate IV, are cards taken before and after the change. The effect of this added improvement was to decrease the consumption of coal more than a ton on each trip from New York to Albany. The point of cut-off is also now adjustable to any point from 4 feet to full stroke. Fig. 7, Plate IV, is from a fine engine having a "Sickle's cut-off," which was built and is now running at Providence.

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Strength of a Beam Fixed at Both Ends. By THEO. COOPER, C.E.

The strength of such a beam, when loaded at the centre, is stated by many to be, when compared with a similar beam *supported* at both ends, as 3 : 2.

By *theory*, however, it should be as 4 : 2, or 2 : 1.

In the case of a single beam, owing to the difficulty of perfectly fixing the ends, this theoretical result is not obtained; but there is a practical case in which we think it could be obtained, and would be of great importance:—that of a continuous beam extending over several points of support.

Let AB be such a beam, extending over several equidistant supports, *a*, *b*, *c*, &c., and loaded at the centre of the openings with weights, *w*.

The reactions at *a*, *b*, *c*, &c., will also be equal to *w*, and the convex portions, *o m*, of the beam will be equal and similar to the concave portions, *m n*; since both are acted upon by the same forces.

Evidently at the sections, *o*, *m*, *n*, of the beam, there will be no

strain of compression or extension, and were the beam separated at these points and the parts suspended from each other, the relation of the forces in the beam would not be altered.

This would divide the beam, A B, into a number of beams, with a length equal to one-half the opening, *ab*, and supported at the ends. The strength of each of these, representing the strength of A B, would be *twice* that of separated beams spanning the openings, *ab*, *bc*, &c.

We see, moreover, that the beam thus loaded would break at both the *centre* and *supports*, *simultaneously*.

If, however, we suppose the beam, A B, to be loaded *uniformly* over its whole length, the *reaction* then being greater than the force acting between the supports reduced to the centre, the relation of the forces will be different, and we shall have as follows:—

Representing the strain at the centre of the opening by	1,
that for the strain over the supports will be	2,
and that for the centre of a detached beam of the same span,	
will be	3.

A beam thus loaded would break *first* over the supports, and *then* at the centre; and its strength would be to that of a *supported* beam, of the *same* span and load, as 3 : 2. (Moseley says as 3 : 1, but he *assumes* it to break at the centre.)

The points, *o*, *m*, *n*, will be at a distance of 0.26289 of the opening from the supports.

This last case may be applied to a bridge continued over several piers, and supporting a distributed load, as a train of locomotives.

As we gain 50 per cent. in strength by thus continuing even a girder of uniform chords over the piers, we see the importance of considering these facts.

And in proportioning the chords to the strains, we would have very different results from the case of a single span; for in the parts, *o m*, of the girder, the position of the compressive and extensile forces, would be the reverse of that for the part *m n*; the chords should be the strongest over the piers, and decrease towards *o* and *m*, and then again increase to the centre, where the strength must be to that at the piers as 1 : 2.

When only one span is loaded, our assumption of a distributed load may still be considered as true, by making a proper application of a system of counter braces, to prevent the uprising of the unloaded spans.

When we have a girder extending over but two or three openings, our statements are subject to modification.

On the Preservation of Platinum Crucibles.

From the Lond. Chemical News, No. 49.

In connexion with some sensible remarks upon the use of sand in cleaning platinum crucibles,—a practice which, with Berzelius (*“Lehrbuch der Chemie,”* 1841, 4th Aufl., p. 516), he heartily commends, urging that it should be employed every time that a crucible is used,