THE EXPANSION OF STEAM.

BY PROFESSOR R H THURSTON.

A correspondent writes me asking the following question, and requesting me to reply by sending an article to the SCIENTIFIC AMERICAN, "which," as he says for himself and shopmates, "we all read, and where we shall all be sure to see it:" "What *is*, really, the proper point of cut off in steam engines to give maximum economy in dollars and cents?" . . . .

"Some people say one thing and some another. In your History of the Steam Engine, page 475, you say about one-half the square root of the steam pressure is about right 'in general;' and a writer in the *Journal of the Franklin Institute*, for June, who ought to understand the matter, says that the steam pressure divided by the back pressure gives the number of times to expand to secure maximum efficiency.

"Now, your rule would give, for a Corliss engine with 90 pounds of steam, a cut-off at one-fifth, while the last would make it one-seventh. Then again, for an old-fashioned engine with condenser, cutting off steam at 25 pounds, your rule makes it about one-third, and the other says one-fifteenth or even one-twentieth, which I know by experience cannot be right."

Ans. The point of cut-off giving maximum economy in steam engines is never precisely the same in any two engines. It will vary with every change of type, with every change of pressure of steam, with every difference in piston speed, and even in two engines built from the same drawings and made from the same patterns, the degree of expansion being the same, the two machines will demand different quantities of steam.

Could all the conditions affecting the expenditure of heat in the production of power be made absolutely invariable, the point of cut-off for maximum efficiency could be determined for those conditions—not by calculation, but by experiment; and it would remain the same just as long as those conditions could be maintained absolutely the same. But this never occurs in practice.

Steam enters the cylinder sometimes barely dry, sometimes superheated, sometimes damp with watery vapor, and often mingled with water to the extent of ten or twenty per cent; it even sometimes carries with it more than its own weight of water. It sometimes comes in contact with hot and nearly dry metallic surfaces, which aid in keeping it in a state of maximum efficiency; but it oftener, in fact usually, meets an interior filled with damp chilling vapors and surrounded by walls cool enough to condense a considerable part of the steam supplied up to the point of cut off. During expansion the steam never follows precisely the law of expanding permanent gases—with which the pressure diminishes precisely in the proportion in which volume increases—but, by condensation at first and by re-evaporation later in the stroke, the expansion line falls below at first and then rises above the curve expressing Mariotte's and Boyle's law, although frequently approaching that curve pretty closely. If the engine speed increases the steam is usually less affected by causes producing loss; if the speed decreases a loss of economy generally ensues. Large engines are less subject to such losses than small ones, and every reduction in the amount of engine friction permits a closer approximation to theoretical conditions.

It is easy to determine the proper point of cut-off for any defined set of conditions provided they are such as can be mathematically expressed, and the larger the engine, the hotter the steam used, the higher the piston speed, the less the friction, and the more perfect the system of lagging and steam jacketing, the more nearly will the actual correspond with the estimated value; but the theoretical rate of expansion is rarely very nearly attained in our very best practice, and experience shows that we must usually content ourselves with a vastly smaller degree of economy by expansion than would be mathematically predicted.

Instead of cutting off at one-twentieth when using steam at 45 pounds pressure in a single cylinder condensing engine, we find that a cut-off of at most one-fourth gives, in practice with ordinarily good engines of moderate size, the best results.

In handling non-condensing engines of two or three hundred horse power, with steam at 60 to 90 pounds and a speed of piston of about 500 feet per minute, and using the standard forms of "drop cut-off" familiar to American engineers, we can barely gain by expanding more than five times.

"In general," taking engines of the best makers, as I have known and handled them, the best results have been, so far as I have observed them, obtained by expanding as many times as is represented by the product of one-half into the square root of the steam pressure in pounds on the square inch measured from the vacuum line, that is, $E = \frac{1}{2}\sqrt{P}$.

As pressures increase the benefit of condensation decreases, and it happens that this rule applies pretty closely both to the old-fashioned condensing steam engine with low steam, and to the modern American type of high pressure "automatic" cut-off engine.

Sometimes an engine is found to give maximum economy when expanding fifty per cent more, that is, $E = \frac{3}{4}\sqrt{P}$.

No *theoretical* determination of the proper point of cut-off has ever been made that is of any service to the engineer. In "compound" engines of large size and high speed expansion can be carried much farther than in the older forms with single cylinder; but even they depart very greatly from the conditions assumed in calculation.

It thus happens that the benefit of expansive working has a limit which is very soon reached, and that the most radical practice, in which condensing engines are driven by steam of 450 pounds pressure, instead of expanding a hundred times, as would be indicated as proper by the purely mathematical analysis referred to by my correspondent, is limited to an efficient expansion of about twenty times, and probably gives best results with still less expansion. The fact is that no device yet invented has ever given even a rough approximation to the efficiency indicated on purely theoretical grounds.

We are gradually learning more and more about the behavior of steam in the engine, and are in our every-day practice, as illustrated by the best builders, keeping very close to what is, all things considered, the line of true economy.

Single cylinders are still doing, at their best, about the same work as the best compound engines, and are rarely made to expand, when condensing, nearly to the back pressure, and the best non-condensing engines hold the expansion line at its termination well above the atmospheric line. To double the rate of expansion in these engines would increase the weight and frictional resistances per horse power developed to so great an extent that this consideration alone forbids maximum expansion.

Steam jacketing and moderate superheating the steam are always sources of economy. A good single cylinder engine, with thorough steam jacketing, has been known to give an economy that is generally considered excellent at as low a rate of piston speed as 100 feet per minute, the coal consumed being but two pounds per horse power per hour.

Increased steam pressure benefits usually, but has its limits. I have known an engine of reputation, working with 250 to 300 pounds of steam, to require over 2½ pounds of good coal per hour per horse power, and its steam jacket proved quite unequal to the task of checking internal condensation. I have no doubt that a "longer cut-off"—the steam was expanded only one-half as much as unchecked calculation would dictate—would have been better, and, *perhaps*, a less piston speed would have made the steam jacket more effective.

All these matters must be finally settled by experience.

LONDON FOGS.

The dense fogs which so frequently convert London day into night, while the surrounding country is bright with sunshine, are commonly attributed to the smoky coal which London burns; and it has been proposed to import Pennsylvania anthracite as a remedy. Doubtless smoke has something to do with the density and blackness of London fogs; but we very much doubt the possibility of largely dispelling them by any change of fuel. It is, we believe, not so much the smoke of London fires as the great volume of water vapor which they produce that serves as the primary cause of the fogs. A necessary product of combustion is water; and the million or more fires of London must send into the air of the city enormous volumes of heat vapor in addition to the steam of boiling water incident to cooking, manufacturing, and similar operations.

While the atmosphere of London is thus being kept at the point of saturation, the manner in which the city is laid out prevents any free passage of wind to sweep away the super-abundant moisture. London is made up of a congeries of towns scattered over a hundred square miles or more of area, each with its peculiar net-work of streets and roads, and all grown together into such a snarl of passages, all short and nearly all crooked, that a hurricane would be confused and lost in an attempt to pass through the city. No other large city in the world bears any comparison with London in this respect. All other large cities have long thoroughfares through which the winds can sweep their entire length or breadth. In most cities such avenues are not only long and broad but measurably straight. The nearest approach to such a thoroughfare in London begins at Shepherd's Bush and runs along the Uxbridge road, down Oxford street to Holbert Viaduct. This allows the west winds to penetrate to the very heart of the metropolis, and it is a fact well established by observation that this route is singularly free from fogs.

The native Londoner is apt to deride the chess-board plan of most American and many European cities, with streets crossing each other at right angles and running in monotonous straight lines, mile after mile. This plan may not lend itself so readily to architectural effects as the short and tangled streets of London, but its sanitary and commercial advantages are beyond question. It may be that after all is said and done London may have to choose between enduring an almost ever-present fog or the breaking up of its beloved labyrinths by cutting broad and straight avenues, in various directions, across the length and breadth of the city.

Oyster Canning in New Orleans.

The oysters of the Gulf coast are not only very abundant, but also, if their local reputation is just, of exceedingly fine flavor. It is gratifying to note that an enterprising firm in New Orleans has undertaken the development of this long neglected source of wealth, and has set up a canning establishment with the intention of disputing with Baltimore for the oyster trade of the South. Morgan City, commanding as it does the famed Lake Pelto oysters, is also spoken of as a good site for an oyster cannery. Another promising location is Lock Port, or some point further down on Bayou Lafourche.

THE BUTLER COLLIERY FIRE.

On several occasions notice has been taken in this paper of the fire in the upper vein of the Butler Colliery at Pittston, Pa., which has now been burning for four or five years. Many attempts have been made to extinguish the flames, but without success. At present the plan of Mr. Conrad is being tried. The plan contemplates nothing less than the isolation of the burning mine by means of a broad open trench around the area of fire. In some places this ditch has to be nearly if not a hundred feet deep, and correspondingly wide. At one place, owing to the elevation and the rapid progress of the fire in that direction, a tunnel about a hundred yards in length was dug instead of an open trench. There was some danger that the fire might pass over the tunnel by or through the strata of impure coal overhead, and so reach the workings beyond; but although the fire is raging fiercely at this point it is hoped that its further progress will be stopped. A *Herald* correspondent says that just now the greatest danger is that encountered by the miners who are working the second vein, directly under the burning mine. The heat is so intense that the men are compelled to work in chambers almost naked, and the sulphurous nature of the atmosphere has prostrated many of their number within the last year, while several have been compelled to quit and seek work elsewhere. A few months ago the water from the roof came down upon them boiling hot, and after Mine Inspector Jones visited the scene he caused a suspension of operations and had an air shaft sunk outside the burning area so as to introduce a fresh supply of air to the workmen. But even this is ineffectual now owing to the terrible heat overhead, and again the sulphur and caloric are unbearable. Men are in peril of their lives every time they fire a shot, and in some places it is impossible to blast because of the sulphur and great volumes of dangerous gases generated from above. The vein of coal being worked at present is so intensely hot at some places as to be unbearable to the touch, and frequently the workmen are compelled to let the coal lie for hours before they can land it on the cars, owing to its blistering heat.

Georges Pierson.

In the untimely death of Georges Pierson, in Paris, lately, France loses a brilliant genius and a hard working scientific student. Four years ago he commenced a vast series of researches and experiments upon the natural rhythm of many languages and succeeded in discovering and establishing highly important relations, hitherto unknown, between rhythm and melody—*i. e.*, between the rapidity of vocal music and its modulations. These laws once established and systematized, he was naturally led to apply them in elucidation of the fundamental basis of harmony itself, and found that they constitute a new and perfect theory of harmony, without any of the manifold irregularities and exceptions which encumber all previous theories. It amounted, in fact, to the creation of one more exact science, and the world will soon have the opportunity to test the claims made on M. Pierson's behalf by some of the most competent authorities, his work on "The Natural Rhythm of Language" being announced for speedy publication at the expense of the French Government. M. Pierson had gained renown as a philologist in the course of his studies on the philosophy of music, and had been offered a professional chair in the Dutch University of Groningen on the recommendation of Ernest Rénan. He had been employed by the Department of Public Instruction upon scientific commissions in Austria, and had been tendered his Algerian appointment in the hope that the climate of the colony would restore his health, shattered by too constant labor. He died at the early age of twenty-nine years.

Culture of Food Fishes.

Mr. Eugene G. Blackford, of this city, one of the New York State Fish Commissioners, has just received from the United States Fish Commission one thousand German carp for gratuitous distribution in New York State. These carp were brought from Germany three years ago, and placed in the national carp ponds at Washington, D. C.

From them were raised last year 60,000 young fish, which were distributed throughout the United States. This year they have produced 300,000, which are in process of distribution. Some sent last year to the Brooklyn ponds have weighed two pounds and upward. This is a remarkable growth, trout taking as long as four years to attain the same size. Of the one thousand in Mr. Blackford's possession, each applicant having a suitable pond is entitled to five pair, which will be sent on receipt of a proper vessel for transportation with expressage prepaid.

To illustrate the rapid growth of these fishes, a gentleman placed one dozen carp, measuring from three to four inches in length, in a muddy pond on Orange Mountain, N. J., last July. A few days ago the pond was drawn off and the fishes were captured. They had attained the extraordinary growth of fifteen inches within four months.

Borax to Prevent Mildew.

We understand that experiments lately made by Whewell, of Blackburn, on the employment of borax for preventing mildew in cotton goods, show that it cannot be employed with flour paste, as it turns the paste yellow. It can be used with advantage with farina, as it does not color the paste, and also increases its tenacity. A six per cent solution can be employed, which, at the present price of borax, namely, £65 per ton, is equal to about £4 per ton.—*Textile Manufacturer.*