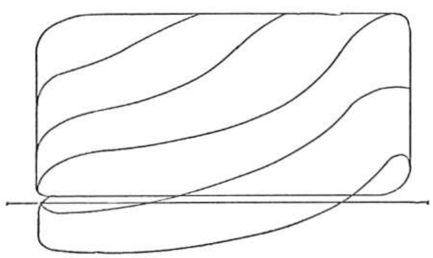
DISCUSSION.

MR. STIRLING: I am glad this subject has been introduced, because it is one of great interest just now. My experience leads me to believe that we have gone altogether too far in the direction of automatic cut-offs. By means of cards I can show some points in connection with this which I found in my experience with a large 42″ × 42″ Corliss engine. About forty or fifty puddling furnaces were attached to it. The work was very irregular—about six sets of rolls, and sometimes two pieces in each set of rolls, and sometimes nothing at all. In tracing indicator-diagrams it would first mark a full-stroke card. Then the cut-off would begin to get gradually shorter and shorter, as in Fig. 1, showing that a great deal of the work was being used in pulling the engine back. It cannot be said that this card was an economical one. Very frequently during the working of the engine will be found on the indicator a full-stroke card, and one of the most wasteful possible; and then perhaps will be traced expansion-cards wasteful in the other direction, *i. e.*, from pulling back.

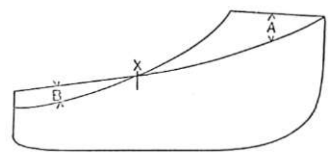
FIG. 1.



I do not think it was the best sort of engine for the work, because there was no object in having it run so very regularly. I think this matter which Professor Thurston has introduced is one which should occupy our attention. I do not think we have got to the bottom of it.

PROFESSOR ROBINSON: As I have studied the question of wire-drawing, I think much less credit is given to the ordinary wire-drawing governor than is due to it. The steam which escapes through the wire-drawing valve must be superheated by that wire-drawing operation. Whenever steam expands without doing work, it must retain its intrinsic energy according to theoretical considerations, and this is found practically to have been sustained. Steam which escapes from an orifice is found never to deposit moisture on anything that is laid in its course—under ordinary circumstances at any rate—indicating a superheating of the steam; that is, it is carried far beyond the point of condensation. It has more heat at this particular instant of expansion than is necessary to hold it in a saturated condition. Now, the steam which passes through the wire-drawing governor-valve must pass into the cylinder in this condition, and although the first portion of the diagram is lowered, the latter part is elevated. To indicate, in Fig. 2 the portion B is recovered from the steam by wire-drawing, while along the space A, the pressure is lowered from beginning of stroke to X by the wire-drawing governor. If this steam were admitted to the point of cut-off, and then expanded, the expansion-curve would be elevated more and more from the point of cut-off forward.

Fig. 2.



Mr. Cloud: Is there economy connected with the use of the wire-drawing governor?

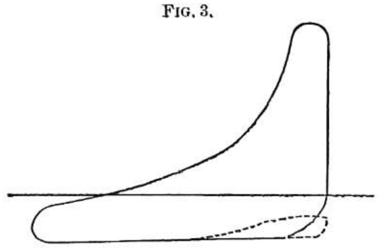
Professor Robinson: I aimed to have it understood that the wire-drawing governor should have more credit given to it than is sometimes done. Although I think it is extravagant, yet I think it is not quite so extravagant as we might imagine it to be. When the steam is wire-drawn, say from 50 to 25 pounds pressure, or from 100 to 50 pounds pressure, there will be retained the full energy, theoretically; and if we were using this steam in a condensing engine, there would be but a very slight loss, so that the wire-drawing governor would be a far better governor for a condensing than for a non-condensing engine.

Mr. Stirling: I will show some other indicator cards that I have got lately from condensing engines with wire-drawing governors which might be of interest on the blackboard.

The President: Everything is of interest in this connection.

Mr. Stirling: This matter is very interesting to me because I have been into it lately. I think Professor Robinson is getting down to a pretty safe basis when he opines that with a condensing engine the wire-drawing governor is about right. The engine from which these cards were taken was a slide-valve engine of the very best construction. We put on this engine what is known as the Fargo cut-off. It did not call for the use of an additional eccentric at all. The cut-off is made by a plain plate of metal on the back of the valve. The duty of the engine is hoisting coal from the mines. The card printed when the coal is coming up is a good deal like the full line of Fig. 3. When the car is on top of the breaker no work is wanted—the object being only to keep the speed of the engine down, and that is done by shutting the throttle. In fact it could not be shut tight enough to keep the engine at a moderate speed. The card printed with the throttle shut is shown in the dotted portion of Fig. 3. That is the card when the engine is running light. I do not see how that engine can be made to work more economically.

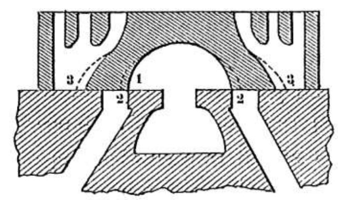
FIG. 3.



DR. GRIMSHAW: How about the compression?

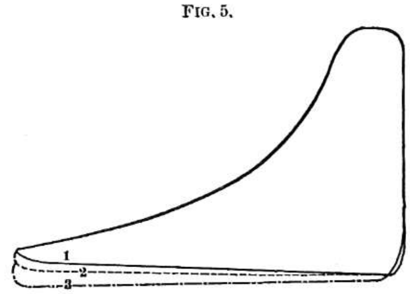
MR. STIRLING: We do not get any great degree of compression. You will see how this is accomplished when I explain. The valve and its seat are shown in Fig. 4. On first adopting this form, I found that it did not exhaust freely, and in order to get rid of the steam and establish a vacuum, I cut away the exhaust edges at 2 and 2, and that enabled me to make the difference shown in diagram 2 of Fig. 5, and I immediately saw I was on the right track. I added pieces of steel at 3 and 3, and the effect was to produce a card like diagram 3 of Fig. 5. In my judgment that is more economical than it would be, if the card remained like diagram 1 of Fig. 5.

FIG. 4.



PROFESSOR THURSTON: Comparing the two methods of regulation, I think it would be found, on consulting anybody who has had experience of the two methods, that we may obtain a large increase of efficiency by the use of the automatic adjustment of the point of cut-off. I can speak rather feelingly on the subject, because some twenty years ago, when Corliss was building his engine, our people were building an engine on the other plan, and Corliss beat us out of the market entirely. This to a certain extent was no doubt owing to the fact that he was a little more careful in building his engines, because he was trying to work into the market; while we had held the market a long time and were getting careless. But behind that was the fact that he determined the point of cut-off by the action

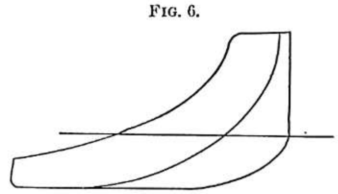
FIG. 5.



of the governor. We tried to adhere to our old methods and to our old design, but we had to give them up; and the upshot of the whole matter was that the introduction by Corliss of that method led to a complete revolution in our methods of manufacturing steam-engines, and that revolution simply came from its higher economy, as a matter of course. But there is no question I think to-day in the mind of any engineer who has had much experience, that it is easy in any given case to determine the point of cut-off that shall be the best point of cut-off for that case, according to the amount of work done, the cost of fuel, and expenses, and the style of engine. Usually it is governed pretty largely—it is governed perhaps exclusively by the mean amount of work to be done, and by the pressure of steam. That point found, it should be retained. Now, if with an unjacketed engine we set our engine at a quarter, and then vary the speeds at different times from one-tenth to nine-tenths, we will find that at nine-tenths we use about as much steam as at one-tenth. If, however, we regulate by means of the compression or exhaust, we do not meet the same losses. If we can make the cut-off uniform, and then diminish the area of the card by means of the compression line, we shall have no losses from the variations of the point of cutting off, and obtain some incidental advantages. I have not thought enough of this matter to be very confident as to the desirability of making such a change as is presented here, as a suggestion, and as indicating a direction in which, probably, economy is to be obtained. The action of the locomotive is an example of that method. Whenever an engine is running at high speed we shall find it making a curve on the expansion line which is a very good expansion curve.

With a card like that of Fig. 6 we have a variation like that of the locomotive, in which we have a very good expansion line, but on the lower side of the card we always find a large amount of compression. Thus in spite of all the disadvantages under which it labors, we find in the locomotive a much greater economy than would be expected, especially when we consider the low efficiency of its boiler.

FIG. 6.



MR. PORTER: The method of regulating the steam-engine, which I understand to be presented in Professor Thurston's paper, is that of having a fixed point of cut-off and varying the compression.

There seem to me to be two objections to that mode of working the steam-engine. One is that the range of variation would be very slight; only a small variation of resistance would be provided for. In many cases we should have sufficient, probably. In cases of mills which run with an almost unvarying load all day, a variation of ten or twenty per cent., possibly sometimes five per cent. is all that is necessary to be provided for in practice. But engines cannot be made with reference to that requirement only, they must be made with reference to whatever requirements may arise in any case whatever, and very generally the range of variation is quite extreme, so much so, that the variation of the compression line would not by any means provide the requisite variation in the power exerted by the engine. The use of the throttle valve, if the point of cut-off remained fixed, would have to be adopted, unquestionably, to supplement this means of adjustment. The locomotive, as Professor Thurston has observed, gives us a very remarkable illustration of the value of a varying compression line, when combined with the varying cut-off. Where the throttle valve is not used at all, and the engine-driver controls the engine entirely by the quadrant, he may set his cut-off at an exceedingly early point in the stroke, and then the compression will commence at the mid-stroke, in fact, a little before the mid-stroke, and if the waste-room is not excessive, the expansion curve and the compression curve are separated but by a very narrow interval, so that the inclosed area of the diagram is a narrow band; and under those conditions the engine works with the very highest economy with which an engine doing nothing at all can work.

There is another objection which occurs to me against the employment of this mode of regulating an engine, and this is that it varies the point of compression, while in point of fact, for the attaining of the greatest economy, we would like to have always all the compression we can get. However much the point of cut-off may be varied by the action of the governor, the compression, starting from the same line—in a non-condensing engine the atmosphere—will necessarily rise to the same point if the exhaust action is invariable—if the exhaust valve closes at the same invariable point—and for the attainment of the highest economy it is desirable that this closure should be effected early, so that if there is a small waste-room to be filled, the compression line may rise to the boiler pressure, and also that the interior surfaces of the cylinder, piston, heads, ports, valves, etc., may all have their temperature raised, as the pressure cannot rise without the temperature of the surface rising also to a corresponding degree. That is one advantage which the non-condensing engine undoubtedly possesses. With a fixed point of closing, and a small percentage of waste-room, so that the compression line can rise to the boiler pressure, I suppose that the best way of regulating the engine, the most economical and advantageous in all respects, is by varying the point of cut-off.

I must say that I should be very much interested personally to become acquainted with the mechanism to which Professor Thurston alludes, by which the point of compression is varied, assuming that the point of release is not also varied.

Professor Thurston: I referred there to a form of valve that is used a good deal among the mines in the West—O'Neill's, I think, is the name. There is an opportunity for adjustment of every part. The experiments referred to were made on such an engine, the point of compression being determined without any change of expansion line or exhaust line. I have drawings of it, and some day when Mr. Porter is in my study I shall be glad to show them. It is the only case, however, in which I have seen the thing done, and I shall be happy to get the results of experiments with these engines and present them to the Society. I think they will prove interesting, not in this connection only, but in a number of ways.

Mr. Porter: I suppose that if the compression starts from the line to which the expansion has already been carried, we may consider the confined steam to behave as a constantly acting spring—that steam which fills the waste-room giving out by its expansion exactly the force that is required to compress it back again to the density of the boiler pressure; so that no steam whatever is used to fill the waste-room, and the surfaces of the metal have their heat restored to them. While in a condensing engine the early closing of the exhaust valves can do no harm, in a non-condensing engine it certainly is always advantageous. I think that a fixed point of closure, and the earliest point practicable, is, from economical considerations, the best.