A TREATISE ON WORKING THE STEAM ENGINE ECONOMICALLY

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The following is an extract from small booklet published by Mr Lumb, possibly about 1900, describing and promoting the supplementary governor patented by Richard Wilby. Lumb himself made and patented a number of improvements to Wilby's design in 1900 and 1909 and the "Lumb" system became one of the most widely-adopted of the supplementary governors. So much so that Wilby's name has been rather overlooked. Hundreds of "Lumb governors" were retro-fitted to engines, particularly in the textile industry where reducing speed variation was of particular importance.

Considering that steady turning of almost all kinds of machinery is so very essential to good work, and that where it is secured the production is also increased, we think we shall be excused for offering the following remarks on so important a subject.

We have for some time made the Regulating of Steam Engines a speciality and this is the reason why we have undertaken to point out a few facts relating thereto. In an age of progress like the present, it is essential that we should be alive to every advantage.

It is well known that several classes of Machinery to do their work at the best, require adjusting to the speed at which they are running; but when the speed at which they are driven is irregular, it is neither convenient nor practicable to regulate them every time a variation takes place, so they are generally adjusted or set to the average speed. It follows that they fall short of their best work when the engine is running either above or below that to which they are adjusted. Moreover, the speed at which machinery is driven when its speed is uniform may be allowed to be one percent quicker that the average speed when irregular, thus increasing the production or turnover without incurring the slightest disadvantage. These are items of great moment in these days of keen competition.

Formerly, very little was thought about regularity of speed, but now in modern mills owned by intelligent manufacturers who are alive to the improved quality of work produced by regular turning, scarcely anything better than perfection will satisfy. This can only be attained however by careful attention to matters of detail in connection with the governors, and also by the application of suitable supplementary governors.

Conventional governors

The type of governor that is almost universally used on stationary engines is the conical pendulum form, which years of experience and hundreds of experiment with other contrivances, have decidedly proved to be best adapted for the work they have to do. Although they greatly minimise the irregularities of speed they are, as we shall presently point out, thoroughly incompetent (under variations of load and steam pressure) to maintain a uniform speed when unassisted. They depend for their action on an increase in their centrifugal force with increase of speed and vice-versa, but their centrifugal force is increased and diminished not in proportion to the speed, but to its square; a fact that accounts for those governors that are run at a high rate of speed (and are heavily centre-weighted to bring down their plane of revolution to a working level), being so much more effective in overcoming the resistance of the valve-gear than if they would run at their normal speed without centre weight.

There is a great variety in detail form of pendulum governors, but all are alike in the broad principle of their action; and no doubt engineers in giving their own designs some special feature are all aiming at the great essential quality, viz: sensitiveness to small changes in the speed of the engine. It is self-evident that a governor which responds promptly to changes of load will be capable of maintaining a more regular speed than one which is sluggish.

Governors have a job to do; either they have to operate a throttle valve or trip-gear, or they have to actuate some sort of mechanism for altering the point of the cut-off. In the great majority of cases, governors are situated a long distance from their work and therefore have to perform through the medium of long rods, bell cranks and levers, all with a great many joints, most of which are out of reach and only accessible via a step-ladder, so that their oiling is neglected, sometimes to such an extent that they are all rusted. No governor can operate in such conditions because they cannot move until the speed has altered so much that the difference in the centrifugal force of the two rates of speed equals the force necessary to move the valves. In scores of cases, a change of speed of 4 to 5 per cent is required before the governor acquires sufficient force to overcome the resistance. Then again, the studs in the joints and connections are frequently worn so that there is some slack in each of them such that the valve-gear cannot respond to the governor until the cumulative effect of the play has been taken up.

These are causes of irregular running that have been very common, but engineers are now becoming alive to all this and many are now taking precautions that the valve-gear shall work with the greatest possible freedom. But as we have said before, governors alone under variations of load and steam pressure cannot maintain an exact uniform speed.

Even the best can only approximate to this because to give additional steam to compensate for additional load on the engine, the governor must lower its plane of revolution, and to keep this additional steam on during the time the extra load continues they must remain lower. On the other hand, to give less steam for diminished load the governor must rise, and to continue compensating for this change as long as it lasts the governor must remain in the higher position. But if the governor remains higher, it must be running at a higher speed than it was before the change since it is bound by the law of the conical pendulum which requires that each particular plane of revolution corresponds to a given speed.

This clearly shows that additional steam can only be given to the engine by a diminution of the governor speed and vice-versa. This is all well understood by most engineers, though there are a few (both engineers and mill-owners) who thoroughly believe that provided that a governor is constructed on sound principles it will maintain an exact uniform speed without any form of supplementary mechanism.

These people have got an idea of this sort: - that when an increase in load pulls down the engine speed, the governor lowers and gives more steam and the engine speed rises back to normal. They fail to see that if the speed was brought back again to what it was before, the governor would regain its normal height and the steam valve would be returned to exactly the same position that it occupied before the extra load came on. The engine would now be using exactly the same amount of steam that it used before, but which would be insufficient for the greater load. This is impossible and these good men need only to reason out the matter, to find that in all cases where the governor gives more steam it does so by lowering its plane of revolution, which means a diminished engine speed.

Supplementary governors

As exact controllers of speed, governors are incomplete of themselves; they are imperfect and defective and require the aid of a mechanism which will overcome their defects and make their action full and complete; a regulator which will automatically adjust the valve-gear when the load changes so that however much, or little, the engine is turning, it will always allow the governor to revolve at its normal speed and consequently the engine to run at its normal speed. The essential requirements that such a Regulator should meet are:-

1. That it should be perfectly certain and reliable in its action so that it can always be depended upon.

2. No attention from the engineer, other than oiling or cleaning.

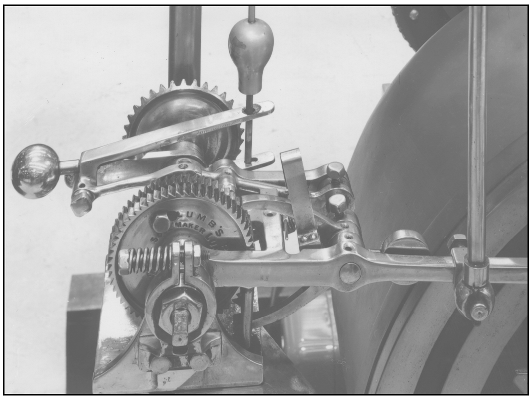
3. That it should be sensitive so that it would promptly compensate for small changes in engine speed

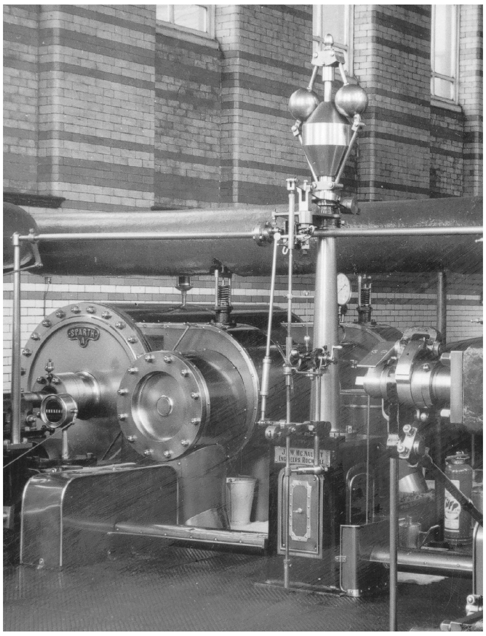
4. That it should in no way interfere with the motion of the governor, but allow it to be as free in all its movements after the Regulator is applied as it was before

5. That it should be capable of automatically suspending its own action by the time it has opened the valves fully, when steam pressure is down; it should do this for two reasons. (a) That it might not endanger the mechanism by turning the parts till they become locked. (b) That it might not endanger the engine by locking the parts with the valves wide open, which if it did, would probably cause the engine to run away when the steam pressure got up again.

We have great pleasure in stating that all these requirements are satisfactorily met by Wilby’s patent Speed Regulator. (Patent No 14431 of 9th November 1886).

It has been remarked by several engineers that this Regulator is just the thing that has been for a long time very much needed and that the great sale that it has already had, coupled with the fact that a large percentage of these sales have been repeat orders, goes far to prove the truth of these remarks. The Regulator needs to be examined, or to be seen working, to convince anyone interested in the governing of steam engines that it possesses several merits that speak in its favour; and one of these is the absolute certainty of its actions. Being actuated by pawls, whenever a change is made in the speed of the engine, the engaged pawl always takes hold at the bottom of the tooth, even if the change be only slight, and the teeth of the ratchet wheels being slightly under-cut, the turning is always certain.





A Lumb governor fitted to the J&W McNaught engine at the Sparth Mill Rochdale

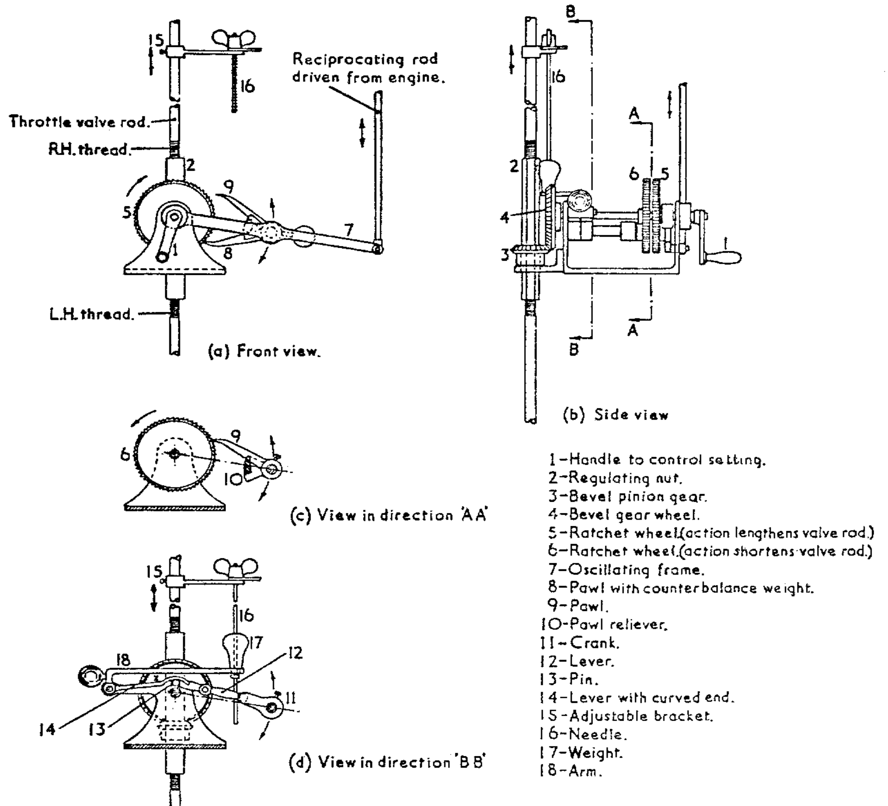
Then again, the Regulator does not interfere with the free action of the governor, for the work of turning the Regulating Nut, or of actuating the cut-off valves-gear, is not performed by the governor, but by some reciprocating part of the engine; the pawls only being actuated by the governor and, these being gravity pawls requiring no springs, are easily worked in and out of gear. The Regulator is completely automatic and is extremely sensitive to variations in the speed of the engine. A movement in the height of the governor of 1/16th inch is sufficient to engage one of the pawls and to cause the mechanism to compensate for the change.

One great advantage of this Regulator is the fact that it is fitted up with an excellent arrangement whereby its action is suspended in case steam pressure should fall below that necessary to turn the engine at full speed after the valves have been open fully; an arrangement that no supplementary contrivance should be without. This consists of a left-hand threaded worm, fixed on the ratchet wheel shaft, which gears on a wheel on whose shaft is secured a finger that normally lies between the pawls, but by the time the admission valves have become open to the full, the free end of the finger has risen to lift the steaming pawl out of gear, stopping further action.

J Lumb

Method of operation

The detailed operation of the "Lumb" governor system is quite complicated to describe and the best way to understand it is undoubtedly to see it in operation. However, for those not already familiar with it, the following brief description and diagram (reproduced from a paper prepared by the Birmingham Science Museum some 30 years ago) may assist.



Richard Wilby's Speed Regulator showing modifications by James Lumb.

Let us suppose that the engine speed has risen above its normal speed due to an increase in steam pressure or because of a reduction in load. The governor balls will be flung outwards, raising the sleeve. The sleeve works a lever which causes the throttle valve rod to descend, thus reducing the admission of steam to the engine. At the same time, bracket **15** descends with needle **16**, allowing weight **17** to bear on lever arm **18**. Since arm **18** is an extension of lever **14**, pin **13** is forced downwards, causing the opposite end of lever **12** to move upwards, carrying with it crank **11**. Pawl reliever **10** is keyed to the same shaft as crank **11** and follows its movement. Therefore, pawl **9** is lifted clear of its respective ratchet wheel **6**, and pawl **8** is allowed to engage with ratchet wheel **5**. A reciprocating rod which is driven continuously by the engine is joined to frame **7** that oscillates about the centre-line of the ratchet-wheels, so causing ratchet wheel **5** to index round a few teeth at each downward movement of frame **7**. By means of bevel gears, this motion is communicated to the regulating nut **2**. Because the nut has a left-hand and right-hand thread at its ends, the effective length of the throttle valve rod is increased. The admission of steam is reduced, having the effect of slowing the engine down and bringing the governor back towards its normal position.

Whilst the engine speed is higher than normal, the ratchet wheel **5** will continue to index by pawl **8** on each revolution of the engine. When the engine reaches normal speed, the weight **17** is lifted clear of arm **18** by needle **16**, pin **13** is allowed to rise, crank **11** and pawl reliever **10** turn in an anti-clockwise direction by an amount that allows pawls **8** and **9** to settle in a mid-position so that neither of them are engaged with their respective ratchet wheels. The regulator then ceases to be operative until a further speed change occurs.

Let us now consider a reduction in engine speed. The balls on the governor will move inwards causing the sleeve to lower, so lifting the throttle valve rod and increasing the steam admission. The upward movement of the throttle valve rod will also have the effect of causing pawl **9** to engage with ratchet wheel **6**, turning the regulator not **2** so as top shorten the effective length of the throttle valve rod. This action increases steam admission. The ratchet wheel **6** continues to index on each revolution of the engine until normal speed is regained.

The handle is provided for manual adjustment to the throttle valve whilst the engine is running.