

ON THE
ALLEN GOVERNOR AND THROTTLE VALVE
FOR STEAM ENGINES.

BY MR. FREDERICK W. KITSON, OF LEEDS.

A steam engine Governor is required to maintain a uniform speed in the working of the engine, whilst variations occur in the amount of work done; and the ordinary Watt governor, although capable of effecting this object with a close approximation to accuracy when the variation in the power is confined within very narrow limits, fails entirely in maintaining the speed of the engine when extensive and sudden changes occur in the resistance to be overcome. In such a case, when half the load is thrown off, the governor forces the engine into a permanently higher speed of running, because the only means by which it can make the corresponding adjustment of the throttle-valve, by closing it so as to supply only steam for half the power, is by the governor balls flying out to a wider circle, and they can only be maintained in that altered position by a corresponding permanent increase of speed in the engine. Also the inertia of the heavy balls requires a considerable variation of speed to take place before they begin to operate, and maintains them in their altered position after the change of speed has ceased.

This defect becomes of serious consequence in some cases, such as in the engines driving rolling mills in iron works, where the whole power of the engine has to be exerted suddenly whilst the iron is passing through the rolls, and the work then suddenly ceases, leaving only the resistance of the friction of the machinery to be overcome. In the case of a mill for rolling solid steel tyres at the writer's works, Monkbridge, the separate engine that drives two sets of tyre rolls has to exert suddenly a power of 550 horse power whilst the hydraulic pressure is put upon the tyre rolls,

and then the engine is suddenly relieved of the whole work excepting the friction of the machinery. With the Watt governor originally used for this engine and fitted with a double-beat equilibrium valve, the speed was maintained uniformly when running light; but when rolling a tyre it was found difficult to keep up the speed, as the momentum of the flywheel became used up before the governor acted sufficiently to put on the pressure of steam necessary for carrying on the work, and the engine was often brought to a stand. To prevent loss from this cause, the engineman had constantly to stand by and handle the throttle-valve, so as to put the steam full on whenever he thought it would be required for carrying the work through; but in doing this a greater quantity of steam than necessary was very frequently put on, thereby causing destructive straining of the engine and machinery.

For regulating this engine the writer has made trial of the Allen Governor, and it has proved thoroughly successful in removing the above difficulty, and has been found completely satisfactory in work. During the time, nearly a year, that this governor has been in work upon the engine, the engineman has had nothing to do with the throttle-valve, and has only had to start and stop the engine, opening the stop-valve to its full extent at starting and leaving it so, as with this governor the engine maintains the required uniform speed so long as there is sufficient steam made in the boilers to do the work. This engine when rolling a steel tyre in the finishing mill has indicated 550 horse power one minute, and only 130 horse power in the next minute, without any change being perceptible except in the rumble of the gearing, the control of the engine being effected by the governor alone, and the stop-valve remaining constantly wide open. The indicator diagrams are shown in Fig. 1, Plate 10; the upper line indicates 550 horse power when rolling a steel tyre, and the lower line 130 horse power when no work was in the mills.

This Governor is the invention of Mr. Huntoon, of Boston, United States, and has been carried out by Messrs. Whitley, of

Leeds, who have supplied the writer with the drawings and description for the present paper. The governor is shown in Figs. 4 and 5, Plate 11, which are side and end elevations showing the governor and throttle-valve with their connection; and in Figs. 6 to 9, Plate 12, are given enlarged sections of the governor.

The governor consists of a small paddle-wheel A with six arms, Figs. 6 and 7, Plate 12, which is driven by the engine at a speed of 350 to 400 revolutions per minute, and revolves within a cylindrical casing B that is filled about two thirds with oil. The casing B is centred upon the spindle of the governor, but turns loose upon it, having at one end a stuffing-box joint C to prevent the escape of the oil, and at the other end an internal socket in which the end of the spindle revolves. The two ends of the casing have a set of radial ribs D D cast upon them on the inside, which nearly touch the edges of the revolving paddles, leaving 1-32nd inch clearance on each side; there is also a set of ribs E E round the circumference of the cylinder, which nearly touch the extremities of the paddles, leaving a clearance of 1-16th inch. The rotary motion communicated to the oil in the cylindrical casing by the rapidly revolving paddle-wheel acts upon these projecting ribs, tending to drag the cylinder round with a force dependent upon the velocity of the paddle-wheel. This tendency of the oil cylinder to rotate is resisted by a weight F, the action of which is illustrated by the diagrams Figs. 2 and 3, Plate 10, in which the weight is shown suspended by a chain coiled round the circumference of the cylinder. The weight is adjusted in amount so as exactly to balance the tendency of the cylinder to rotate when the engine is running at its correct speed; but any increase of speed causes an increase in the rotary force that is communicated to the cylinder, and the resistance of the weight being consequently overcome, the weight is instantly drawn up; the throttle-valve lever being connected to the weight, the valve is closed by the rising of the weight, and further increase of speed in the engine is prevented. In the contrary direction, any diminution of speed in the engine reduces the rotary force below the point that balances

the weight, which instantly falls and opens the throttle-valve wider. As the resistance offered by the weight to the rotation of the cylinder continues exactly the same whilst the cylinder turns round into any new position, the result of any change in the work on the engine will be that the cylinder will shift at once into the new position which gives the particular opening of throttle-valve corresponding to the change of work, so as to maintain a uniform speed of the engine.

Some modification of this action is requisite in practice, to counteract the effect of the inertia of the weight in causing the governor to over-run its true position, in the case of a sudden change in the work on the engine. The weight is therefore made to act upon a spiral, as shown in the diagram Fig. 11, Plate 13, which differs little from the mean circle in the middle of the course, but is extended considerably beyond it at the outer end, so as to increase the leverage at which the weight acts when raised to the extremity of its range, as shown in Fig. 12, and cause it to return at once to its correct position. The opposite end of the spiral similarly acts to check the inertia of the weight in descending, as shown in Fig. 10, by diminishing its leverage at the inner extremity of its range, and so allowing the rotary force to raise it again to its correct position. The spiral is arranged also to counteract the unbalanced pressure tending to close the throttle-valve when nearly shut, which arises from the effect of the current of steam passing through the contracted opening of the valve, and increases in amount as the area of passage through the valve diminishes.

The form of the spiral and extent of its deviation at the extremities from the mean circle are varied according to the extent and suddenness of the fluctuations in the amount of the work done by the engine; and a comparative diagram of the curves in two different instances is shown in Fig. 13, Plate 13. In the case of a cotton-mill engine the total resistance to be overcome by the engine is exposed to but little fluctuation in regular work and continues very uniform, and the full line in Fig. 13 shows the spiral employed for an instance of this kind in the governor at Messrs. Taylor's

cotton-mill, Wigan. The dotted curve shows the spiral used where the engine is exposed to considerable and sudden fluctuations of work.

The spiral is formed by a scroll G, Figs. 6 and 8, Plate 12, which is centred upon a short axis fixed in the end of the oil cylinder in line with the governor spindle; this axis is supported by a bearing in the governor frame. A chain carried round the scroll is attached to the suspended weight F, which consists of a set of disc weights of different thicknesses; these give the means of readily adjusting with great accuracy the speed at which the engine is to run. By removing a weight the engine speed is diminished, as a lower velocity of rotation of the paddle-wheel is then sufficient to balance the resistance of the weight; and by adding a weight the engine speed is increased correspondingly. The amount of weight that is ordinarily supported is from 6 to 12 lbs., according to the size of the governor, and it acts at a radius of 2 inches. A small pinion H, fixed on the axis of the oil cylinder, gears into a toothed sector on the upper end of a lever L, which is connected at the bottom to the throttle-valve; and the extreme range of motion of the oil cylinder, amounting to about two thirds of a revolution, gives a range of motion of the throttle-valve from full open to full shut. The pinion H is connected to the scroll G by means of a disc K, shown in Fig. 9, having a slot in it, through which passes a set-screw J fixed in the scroll; this allows of adjusting accurately the position of the scroll in relation to the required opening of the throttle-valve.

The governor spindle works through a stuffing-box C, Fig. 6, in the end of the oil cylinder, but the friction is so much reduced by the constant supply of oil from the interior, that a small pressure from the gland is sufficient to keep the packing tight, and prevent anything more than a very slight leakage of oil; this is caught in a cup N provided in the frame, and is drawn off occasionally, and the cylinder filled up again when required through a screwed plug-hole P. But the loss of oil is so small, that even in the case of the governor at Monkbridge Iron Works, which is exposed to all

the dust of the rolling mill, the oil cylinder did not require any supply of oil until after four months' work; and the governor of the shop engine at Messrs. Whitley's works has been a year and a half in constant use, and has only once required a supply of fresh oil; the oil escaping from the stuffing-box and caught in the cup has been returned to the cylinder once every two months.

For maintaining the delicacy of action of this governor, it is requisite that its friction should be small and uniform in amount. The friction is reduced to a small amount by the circumstances that a very small spindle can be used, only $\frac{5}{8}$ inch diameter in the governor for the 500 horse power rolling-mill engine, and the bearings work in a bath of oil. Uniformity in amount of friction is obtained by the use of a special packing in the stuffing-box, consisting of a series of separate rings, each made of a small roll of canvas steeped in tallow and covered with paper; a light pressure of the gland is found sufficient to keep this packing tight enough to hold the oil in the cylinder, and when properly adjusted at starting the packing is found to have scarcely any appreciable wear; the original packing continues in good order after one and a half year's work in the governor of Messrs. Whitley's shop engine.

The governor at the writer's works was originally driven by a belt from the flywheel shaft, but gearing has now been substituted, and is found to work very well, driving a light intermediate shaft at 240 revolutions per minute, from which the speed of the governor spindle is got up to the required number of revolutions by another pair of wheels. The governor is found to act quite as sensitively when driven by gearing as with a belt, and the danger arising from the belt breaking or slipping is avoided; at the same time the strain upon the governor spindle, consequent upon the drag of the heavy belt from the flywheel shaft, is removed.

The Throttle-Valve shown in Figs. 14 to 16, Plates 13 and 14, is a modification of a double-beat valve, which is arranged to work with very little friction and resistance, and reduces to a small amount the unbalanced pressure from the current of steam that tends to close the valve when nearly shut. The two valve-seats

are bored out parallel and of the same diameter, and the valve R just enters these seats when closed, entering only 1-16th inch and then resting on a stop; sufficient allowance is made in the diameter of the valve to prevent its binding from expansion. This valve, if not absolutely steam-tight, only allows so very small a quantity of steam to pass when closed, as not to have any effect upon the engine. The valve is in equilibrium, except to the extent of the difference of pressure per square inch upon the top and the bottom due to the motion of the steam in passing the valve; this difference is materially reduced by the valve being made with a tubular passage through the centre. The valve is lifted by a lever S, fixed upon the spindle T inside the valve-box, and working in a loop on the top of the valve. In the stuffing-box of the valve-spindle the same packing is employed as for the governor spindle, as shown in Fig. 14; by this means the friction of the valve-spindle is reduced to a small amount, and is kept very uniform, so as not to interfere with the delicacy of action of the governor. The spindle T has a long parallel bearing to ensure steadiness and durability, and the lifting lever S is fixed upon it by a taper screwed pin; the whole is readily accessible for removal on taking off the cover, when the valve can also be withdrawn for cleaning or examination. The lever L carrying the toothed sector that is acted upon by the governor pinion H, Figs. 4 and 5, is fixed direct upon the valve-spindle T, so that the connection is direct from the governor to the throttle-valve, thus avoiding the friction of intermediate levers, and making a very compact arrangement.

A smaller size of throttle-valve can be used with this governor than with the ordinary ball governor, on account of its more complete and prompt action. This is an advantage of importance, as it is objectionable to employ a valve larger than is absolutely necessary for the requirements of the engine; and a smaller valve that opens to its full extent has a much better control over the engine than one of larger size continually hovering over the closing point. The best results have been obtained when the diameter of the valve is one fifth to one sixth of that of the engine cylinder, for high-pressure engines with a moderate degree of expansion. In the

case of engines working at a high rate of expansion with steam of considerable pressure, a smaller proportion of valve is sufficient; and in compound condensing engines having full boiler pressure through the greater portion of the stroke, a somewhat larger proportion is advantageous. In the case of the tyre-mill engine at Monkbridge, which has a 36 inch cylinder with a piston speed of 550 feet per minute, a 5 inch throttle-valve is employed with the new governor; and this engine with 50 lbs. boiler pressure had an initial pressure of 49 lbs. in the cylinder when indicating 550 horse power, showing that the throttle-valve was large enough in area.

Five of these governors have now been applied at the writer's works since the original one in the tyre mill that has been referred to, and these are all working with complete satisfaction; they have given no trouble, and the refilling with oil and adjusting the stuffing-box packing have been done so seldom as to be found no objection in practice.

One of these governors is applied to the engine driving a large reversing Plate Mill, which had previously a ball governor and equilibrium throttle-valve similar to those of the tyre-mill engine, and had the same fault, requiring the throttle-valve to be "handled" whenever any heavy work had to be done. The steam can now be turned full on at starting, and the engine will go through any work that is put upon it without requiring the attention of the engineman at the throttle-valve. It has been found in this case that the strain upon the gearing is not so sudden as when the old governor was attached.

Another of these governors is applied to the engine of a 10 inch Rod, Guide, and Hoop Mill, in which the rolls are driven through a pair of spur wheels, the flywheel being on the second-motion shaft. With the previous ball governor much trouble was experienced from the flywheel over-running the driving shaft when the engine was lightly loaded, thereby causing great backlash on the wheels when a piece of iron was put into the rolls, and necessitating a frequent renewal of the gearing, as the teeth would not stand the hammering they were subjected to; other parts of the machinery and also the

engine-house suffered. The new governor however has not only stopped the backlash and its attendant evils, but by making the speed of the engine much more uniform it enables a greater weight of iron per week to be got out than formerly.

The engine of another Rod and Guide Mill has its speed maintained uniform by one of these governors, when rolling both large and small sized rods; but the working of the engine with the previous ball governor was very irregular, using considerably more steam than at present, and doing less work.

A large Plate Shears, in which the shear slide is unbalanced, has one of these governors applied to it, and the speed is kept quite uniform when shearing and when running light; and another of the governors has been applied to a small pumping engine, and is found to render good service by keeping the pump at a regular speed, unaffected by the slack at the end of each stroke.

These governors are now in operation at several iron and steel works, paper mills, cotton mills, and other works in this country, and have been found to give very satisfactory results.

Mr. J. WHITLEY exhibited a working model of the governor, showing its action, together with specimens of the separate parts and of the throttle-valve. He stated that the first of these governors brought over to this country from America had been in constant use on the engine at his works in Leeds for nineteen months, without having lost so much as a cubic inch of oil during the whole time, the same oil being in use as at first. The first governor made in this country was put upon the rolling-mill engine at the Monkbridge Iron Works, and it proved so entirely satisfactory in operation that several more of the governors were then applied to other engines at the same works; and the governor was now in use at many other works in this country and on the

continent, being found completely successful in keeping the speed uniform up to the maximum power that could be maintained by the boiler. With an engine speed of from 60 to 100 revolutions per minute, a variation of only one revolution per minute above or below the proper speed was instantly corrected by the governor diminishing or increasing a little the supply of steam to the engine; and so imperceptibly was this done that it was impossible to detect any variation in the speed except by watching the rising or falling of the governor weight. One modification that had been made in the construction of the governor in this country was the addition of the set-screw and slotted disc for adjusting the spiral scroll in the proper angular position relatively to the pinion working the throttle-valve lever, so as to make the governor weight act at exactly the proper leverage upon the scroll when the engine was running at its normal speed. Another improvement was the addition of a thin casing of gunmetal upon the steel spindle working the throttle-valve; the original governor supplied from America had a plain steel spindle, which became corroded in the stuffing-box and interfered with the working of the throttle-valve; this was taken out and replaced by a spindle covered with gunmetal, and there had since been no further difficulty from corrosion. The only difficulty that had occurred in the working of the governor had been in one or two instances where the stuffing-box of the valve spindle had inadvertently been screwed up too tight by the attendant, and the excess of friction had then interfered with the free working of the throttle-valve; but this had been immediately rectified by simply slackening the gland of the stuffing-box. With that exception nothing had occurred to interfere with the perfect working of the governors already in operation. The name by which the governor was known was that of the proprietor in Boston, instead of that of the inventor Mr. Huntoon.

Mr. B. WALKER said that at his works in Leeds one of these governors had been in use about six months upon the engine driving the machinery of the works; it had given no trouble and continued working with great satisfaction. The load upon the engine was

very variable, being thrown on and off rapidly, but the speed was always kept practically the same by the governor. Previously an ordinary ball governor very carefully constructed had been employed, with a good throttle-valve; but the present governor had proved much superior in action. In the case of an engine which he had lately supplied to a rolling mill, furnished with this governor and throttle-valve, the governor and valve had been returned without trial, as it was believed to be useless to attempt to control a rolling-mill engine by a governor, because the ordinary governor was known to be so incapable of acting promptly enough for controlling the engine under the very sudden changes of load which occurred in those cases, that it was the practice in many instances to regulate the steam supply by hand, without using a governor; all need of hand control however was obviated by the employment of the improved governor. He considered this governor the best he had seen, as it was the most sensitive and the least likely to get out of order. He had seen it in use upon the engines at the Monkbridge Iron Works, where it was working with complete success, and he considered it was especially useful for engines driving rolling mills, because the load in that case was so variable that it was impossible for the engineman to regulate the supply of steam promptly enough, and any want of attention on the part of the man handling the throttle-valve caused either a deficiency or an excess of steam. The use of the governor prevented the possibility of such accidents as had frequently occurred from the engine running off under an excess of steam when the load was suddenly diminished, and causing the flywheel to break in pieces from excessive speed.

The PRESIDENT enquired whether the governor had been tried with the ordinary disc throttle-valve.

Mr. B. WALKER replied that the governor at his works had the cylindrical double-beat valve shown in the drawings, but he saw no reason why it should not be used with the ordinary disc throttle-valve, provided the valve were made with sufficient accuracy, so as to work easily and without jamming itself when closed suddenly. A disc throttle-valve as usually made had too much friction to be

suitable for so sensitive a governor, and would be liable to stick if closed with a jerk; and this governor had hardly sufficient power to move such a valve promptly enough for preventing a considerable variation of speed in the engine. The hollow double-beat valve had the advantage of being comparatively small in size and with scarcely any friction, so that it required very little power to move it and was easily worked by the governor; and the trifling leakage of steam past the valve when closed was not enough to be of any consequence.

Mr. F. J. BRAMWELL asked why there was any need for the stuffing-box, as it appeared to him the weak point of the governor was that its efficiency might be impaired by screwing the stuffing-box too tight; and he suggested that this might be obviated by placing the governor spindle vertically, instead of horizontally; in that case the spindle would pass out quite freely through a boss in the top of the cylindrical casing containing the oil, without the need of any stuffing-box or packing.

The PRESIDENT remarked that the chain from the spiral on the governor spindle to the weight would then have to be led off horizontally over a pulley.

Mr. J. WHITLEY said it was not with the stuffing-box of the governor spindle that any difficulty had occurred from the packing being screwed up too tight, but with that of the throttle-valve spindle. In the event of the stuffing-box of the governor spindle ever being accidentally screwed up too tight, this would at once be rendered apparent by the cylindrical casing of the governor being carried round too far and so closing the throttle-valve; in practice the stuffing-box gland was only screwed up so slightly that no appreciable friction was caused. The stuffing-box of the valve spindle had in some cases been dispensed with by turning a small conical shoulder upon the spindle, this shoulder working in a corresponding conical seat turned in the socket through which the spindle passed in the valve-box; the spindle was then put in from the inside of the valve-box, and the conical joint was made steam-tight by the outward pressure of the steam. The best plan however he thought was to have an ordinary stuffing-box, and it

was a simple matter to take care that the packing was never screwed up too tight to interfere with the free working of the valve; the special packing that was used, as described in the paper, was found quite satisfactory.

Mr. H. BROGDEN observed that the employment of a liquid had been one of the main features also in the chronometric governor of Mr. Siemens, of which a description had been given at a former meeting of the Institution (see Proceedings Inst. M. E. 1866 page 19); and he had had one of those governors at work for some years upon an engine driving a guide mill at the Tondû Iron Works, South Wales, with the same advantageous results that had been mentioned in connection with the governor now described. The governor at these works had given no trouble whatever, and had not required any attention; the speed of the engine was readily regulated to any number of revolutions required by simply altering the quantity of liquid in the chamber of the governor, and this was a great advantage for engines where the speed had to be varied frequently.

Mr. L. OLRICK considered the governor now described was a simple and effective one, and could be applied where more complicated governors would not be suitable; and it appeared to possess several points of merit, that would be appreciated in practice, one of which was the very neat arrangement of throttle-valve used in connection with the governor. In some cases in which efficient governors had been applied, they had suffered from having to deal with a common butterfly throttle-valve that had 90° range of angular motion, and when shut leaked to a very great extent. No doubt the range might advantageously be reduced to 45° , but this alteration could only be accomplished by putting in a new throttle-valvebox, which was not always possible or convenient to be done; as the valve when shut stood then at an inclination of 45° across the steam pipe, it was necessary that the disc should be made heavy enough to ensure sufficient strength, for if made too light the disc might be broken by being closed violently by the governor. Another objection to such valves was that unless they were fitted when hot, which as a rule was not done, he did not believe they could be made thoroughly steam-

tight. In comparison with the ordinary butterfly throttle-valve therefore, the cylindrical valve now described seemed to him a great improvement; and next to a good governor a good throttle-valve was of great importance. In the governor itself he did not think any practical difficulty could arise from screwing up the stuffing-box of the governor spindle too tight, because the packing was always kept thoroughly lubricated by a little oil leaking out from the cylindrical casing. One improvement which he thought might be made would be to remove the weight from the governor and substitute a spring instead; for marine purposes this would be compulsory, and he thought it would be equally advantageous for land engines. Although the governor now described appeared to him to be one of the best he had seen for all practical purposes, he considered the differential governor with one arm invented by Mr. Siemens was a nearer approach to perfection in maintaining the speed unaltered, on account of being dependent upon the time of a pendulum, which rendered it impossible for the engine to go beyond the prescribed number of revolutions per minute; and he was surprised that that governor was not found in all spinning mills, as it would effect so great a saving by preventing waste of steam and breakage of threads through variations of speed. As an illustration of the extreme sensitiveness of that governor he might mention that in one instance where it was in use the crank shaft broke while the engine was running at 70 revolutions per minute, and though the whole of the work was thus suddenly thrown off, the number of revolutions only increased to 71 per minute.

The PRESIDENT considered the governor described in the paper was remarkable chiefly for its simplicity, and it appeared to have been found to answer well in practice. Reference having been made to his own liquid governor in connection with that now described, it was to be observed that, though both of them dealt with liquid resistance, they did so in a different manner. In the governor now described the power to act upon the throttle-valve was obtained in an indirect way; the rotating paddle-wheel did not act directly upon the valve, but impelled the oil against the corrugations in the casing containing it, and the impact tended to make the

casing rotate in the same direction ; the casing however was held back either by a dead weight, or, as had been suggested, by a spring, or really by a combination of a dead weight and a spring, because a weight alone would over-run itself if acting at a constant leverage. When therefore the velocity of the rotating paddle-wheel was so proportioned to the weight as just to hold the latter suspended, a balance was established ; but as soon as the engine exceeded its normal speed, an additional amount of impact was created in the oil casing, which accumulated until it had sufficient power to overcome the resistance of the throttle-valve and of the stuffing-box on the valve spindle. This power however to move the valve was not large, in comparison with the total force acting to support the governor weight at the normal speed ; if for instance 100 revolutions of the paddle-wheel per minute sufficed to balance a weight of 10 lbs., then a variation in speed of two or three revolutions per minute would affect the weight to the extent of only a small fraction of a pound, which would accordingly be the limit of the force available for moving the valve. It was therefore an object of primary importance that the frictional resistance in the valve and stuffing-box should be as much reduced as possible ; and this appeared to have been accomplished successfully by the construction of throttle-valve now described. If this delicacy of action could be maintained, the governor would be applicable no doubt to engines subjected to frequent and sudden alterations of load. His own liquid governor, described at a former meeting some years ago (see Proceedings Inst. M. E. 1866 page 19), consisted of a cup of parabolic section revolving upon a vertical spindle within a vessel partly filled with oil or water ; and by the rotation of the cup, which was open at top and bottom, the liquid was caused to rise up the sides of the cup, but did not overflow the edge until the speed of rotation had reached a certain limit. Up to the moment of the cup overflowing, it acted only as a flywheel, but at the moment it overflowed it became a pump, drawing in liquid through the central aperture at the bottom and discharging it over the top edge ; the external surface of the cup and the interior of the vessel in which it revolved were provided

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with a series of radial vanes, and the overflowing stream of liquid from the cup impinged successively upon the stationary vanes and upon those on the revolving cup, thus presenting a practically uniform resistance to its rotation. The cup was driven by the engine through differential gearing, with which was also connected the weighted lever of the throttle-valve, this constant weight acting always to maintain the uniform rotation of the cup. Although a weight was thus employed both in his own and in the Allen governor, there was an essential difference of action between the two, inasmuch as in the Allen governor the throttle-valve had to be moved by only a fractional portion of the suspended weight; whereas in his own governor the difference between the uniform rotation of the cup and the varying speed of the engine acted direct upon the valve through the differential gearing, the uniformly rotating cup serving as a fulcrum or abutment, while the actual amount of the weight upon the throttle-valve lever was immaterial, except as regarded the original determination of the frictional resistance for the cup. It would thus be seen that there was indeed more similarity in appearance between the two governors than really existed in their modes of action; and it was clear that the throttle-valve now described in connection with the Allen governor must be looked upon as an essential part of the governor, the prompt action of the governor depending upon the ease with which the valve could be moved with a slight amount of force. Owing to the great simplicity of this governor, and the careful manner in which the mechanical details had been worked out, he had no doubt it would meet with success in its application.

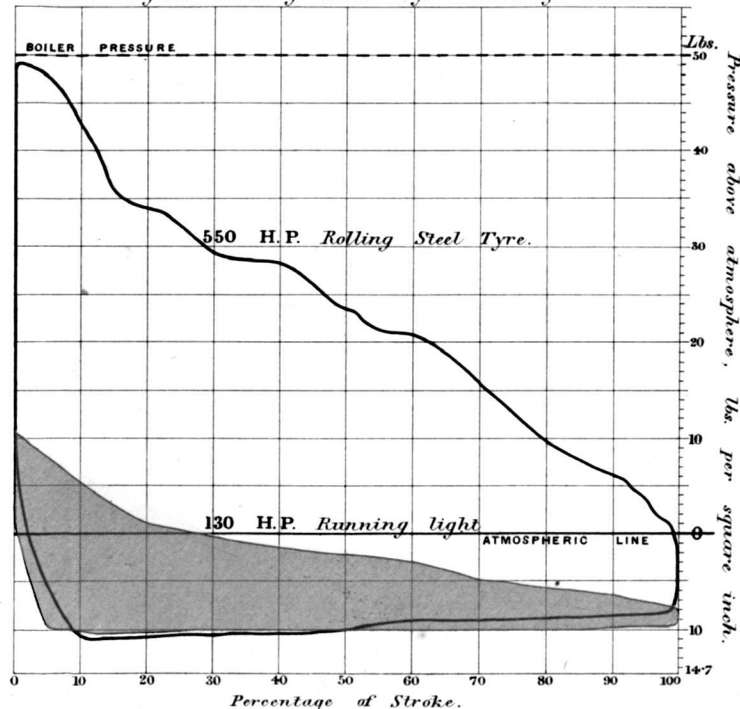
He proposed a vote of thanks for the paper, which was passed, to Mr. Kitson, who he regretted was prevented by illness from being present at the meeting.

The following paper, communicated through the President, was then read:—

ALLEN GOVERNOR.

Plate 10.

Fig. 1. *Indicator Diagrams from Engine driving Steel Tyre Rolling Mill.*



Diagrams illustrating action of Governor.

Fig. 2.

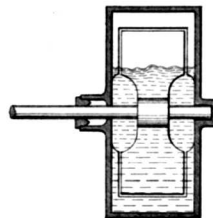
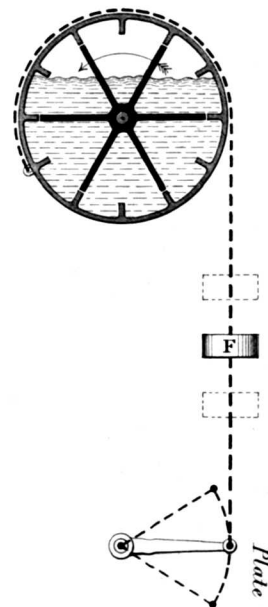


Fig. 3.



(Proceedings Inst. M. E. 1873.)

ALLEN GOVERNOR.

Plate II.

Fig. 4. Side Elevation.

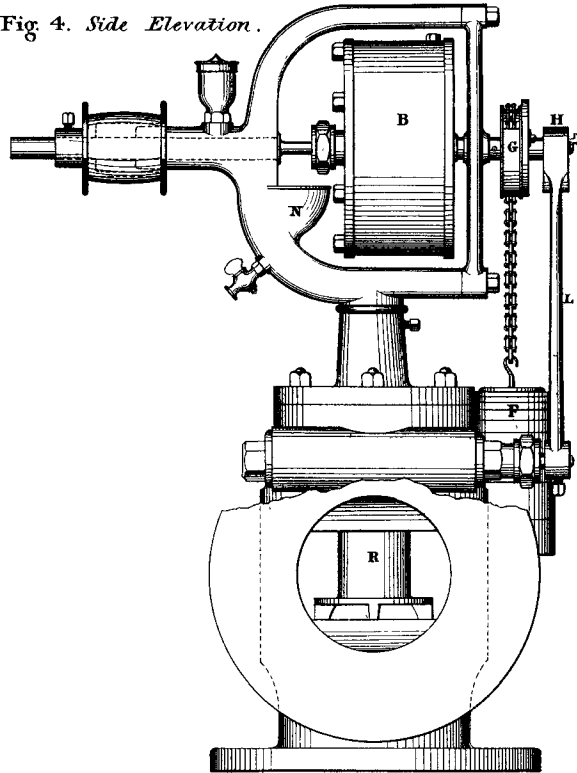
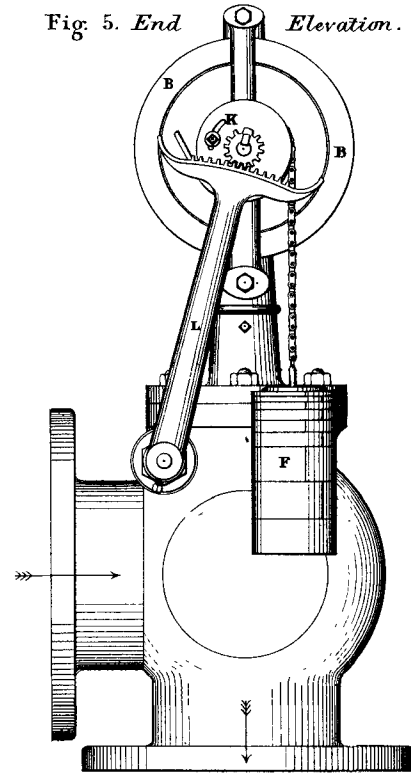


Fig. 5. End Elevation.



ALLEN GOVERNOR.

Plate 12.

Fig. 7. *Transverse Section.*

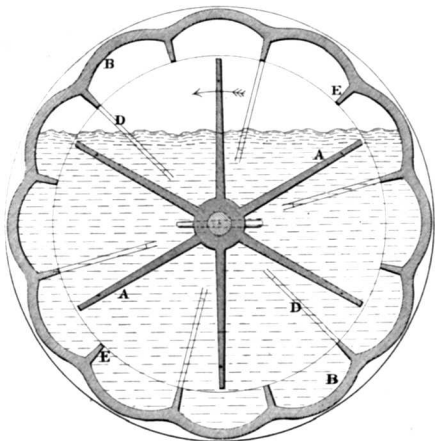
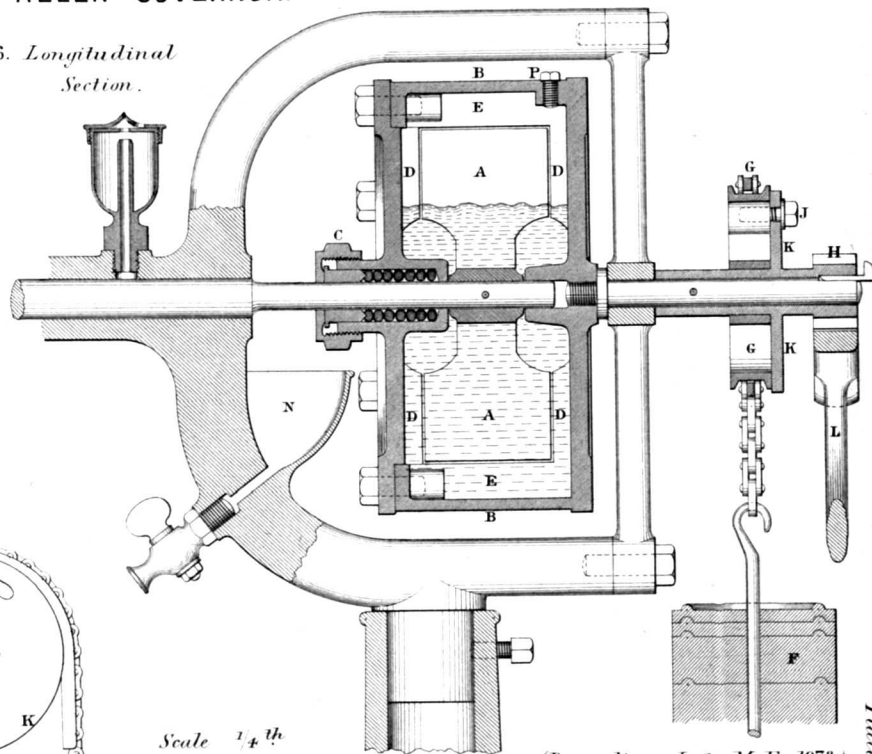


Fig. 6. *Longitudinal Section.*



Scale 1 1/4 in.

(Proceedings Inst. M. E. 1873.)
12 inches.

Plate 12.

ALLEN GOVERNOR.

Fig. 14. *Sectional Plan of Throttle Valve.*

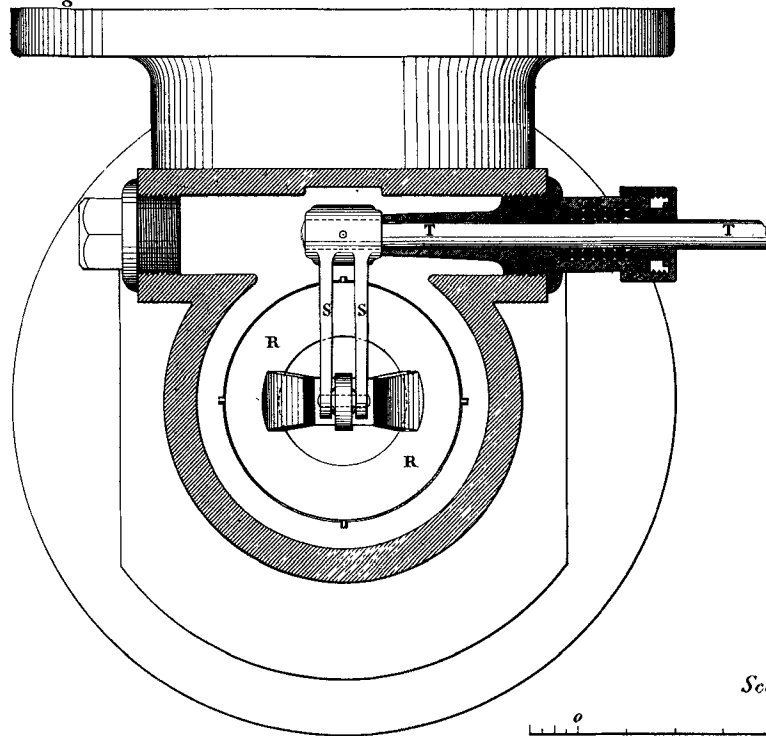


Fig 10.



Fig 11.

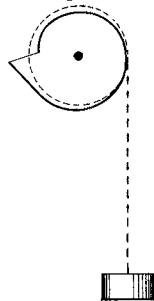


Fig 12.

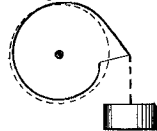
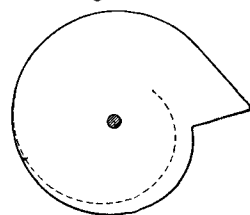
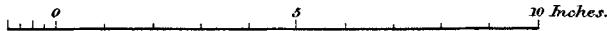


Fig. 13. *Scale 1/4 th*



Scale 1/4 th



(Proceedings Inst. M. E. 1873.)

ALLEN GOVERNOR.

Throttle Valve.
Vertical Sections.

Fig. 15.

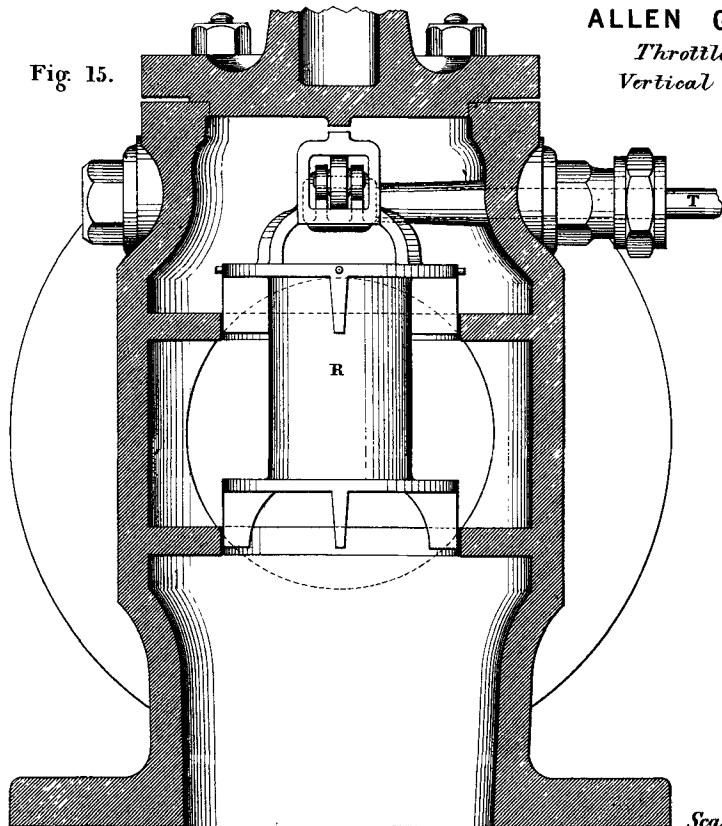
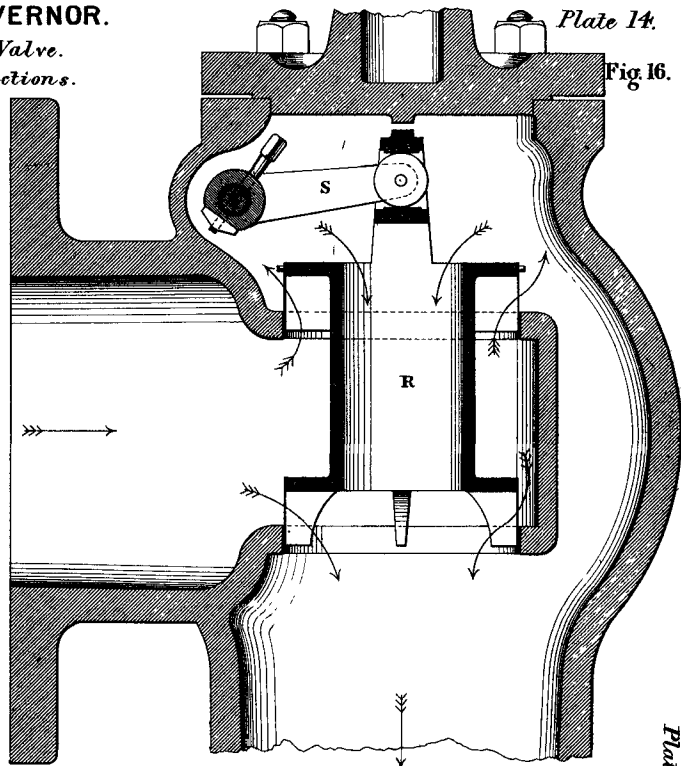


Fig. 16.



(Proceedings Inst. M. E. 1873.)

Scale $\frac{1}{4}$ in

0 5 inches.