

The communication was illustrated by nine Drawings, Nos. 4026 to 4029, and 4336 to 4340, showing the various applications of the machine; and Mr. J. Woods presented impressions of plates 19 A and 19 B for the Minutes of Proceedings.

Mr. R. STEPHENSON said, that at a previous meeting he had made some remarks on this machine, on the supposition of its analogy to Watt's Governor; he had, however, found on close inspection of its mechanical arrangements, that the ball and rod were allowed to rotate, entirely independent of the velocity of the engine, and therefore to be governed strictly according to the laws of pendulous motion: it was therefore, he perceived, totally different from Watt's Governor, which consisted of rotating weights attached to levers, and which being governed by the laws of centrifugal motion, consequently required considerable alteration of speed, and an interval of time, before they could act upon the throttle-valve. This Chronometric Governor, on the contrary, was extremely delicate, and appreciated the slightest variation of speed, between the engine and the pendulum, and by means of a differential wheel, imparted immediate adjustment to the throttle-valve, which continued in the altered condition, until a further change of load tended to vary the speed of the engine; it consequently became a very valuable instrument, where regularity of speed was important, as in grinding grain, spinning, &c., and as an ingenious contrivance, he thought it well worthy of the attention of the mechanical world.

Mr. J. Woods observed, that in explaining the mode of action of the Chronometric Governor, he had found great difficulty in showing, that the pendulum was supplied with power by a constant weight, lifted by the engine, instead of being driven directly by the engine itself; he would, however, endeavour to make this clear, by reference to a fast and loose pulley on a shaft, having an endless belt laid over them, with a heavy weight sustained by the belt falling over one side of the large pulleys, and a lighter one to keep it stretched on the other portion; if the shaft with the fixed pulley was then driven, it would lift one half of the heavy weight, and the other half supported by the belt, falling from the loose pulley, would be employed in drawing it round with a constant effort; a precisely similar effect was produced in the model before the meeting, by a weighted lever, half of which was lifted by the engine, and the other half was employed in turning round the bevil-wheel attached to the slide crank, in which the point of the pendulum rod oscillated; the resistance of the atmosphere and the friction of the instrument was therefore counteracted by a constant

driving power, and the revolving pendulum made the same number of revolutions per minute, as an oscillating pendulum of equal length would make double vibrations; the bevil-wheel attached to the pendulum partook, therefore, of its uniform velocity, and if the engine by change of load had any tendency to alter its speed, the differential wheel between that which was driven by the engine, and the other which was attached to the pendulum, immediately moved forward, with the one which travelled fastest, and effected the adjustment of the valve, and having equalized the supply of power to the altered conditions of the load, enabled it to be overcome without further alteration of speed, and, therefore, of differential motion, and the valve continued in this adjusted position, until the load varied again. It would be evident from these remarks, that a change of speed of the engine must theoretically take place, before it could alter the position of the valve; but on examining the conditions of the question, it would be found to amount to so little, or rather that the machine acted so quickly, that the time for performing $\frac{1}{36}$ th part of a revolution of the fly-wheel completed the whole operation; or, in other words, $\frac{1}{36}$ th of a revolution was sufficient to shut the steam valve altogether, and render the error as inappreciable as it was momentary. It would be well, however, to refer to the variation of speed occasioned by the altered length of the pendulum, when revolving in varied arcs, because its length was equivalent to the vertical height between the point of suspension, and the plane of revolution described by the centre of momentum; this error amounted to $\frac{1}{16}$ ths per cent., and varied according to the square root of the length of the pendulum. Many persons, at first sight, were apt to see no advantage in this differential action of the Chronometric Governor, in setting the position of the valve beyond that which was attained by Watt's Governor; it would, however, be obvious by examining the diagram of the action of a centrifugal governor in two positions, that the angular variation, necessary to adjust the position of the valve, must be continued, by a permanent variation of speed, exactly indicated by its divergence, and a considerable time must also have been consumed, in imparting to the balls, the momentum required for overcoming the resistance. One of the principal merits, therefore, of the Chronometric Governor consisted in its perfect automatic action on the valve, rendering entirely unnecessary the constant adjustment by hand, which was always required, where regularity was of importance, and the load was subject to frequent variation.

Mr. HENRY CARPENTER said, he had used the Chronometric Governor for the last nine months at his corn-mills at Shad-Thames,

and had found it to be very superior, in regularity of motion, to any he had previously tried. It was well known, that regularity of motion was of the utmost importance in the machinery for grinding flour, for if any increase of speed took place, a greater quantity of corn necessarily passed through the stones, and consequently a greater pressure was required to grind it, which was practically obtained, by setting the stones closer together, and if this was not immediately done, much loss occurred by producing less flour and more offal; but if, on the other hand, a change of load, or of power, decreased the speed, the injury was great in several ways. First, by decreasing the speed, a smaller quantity of corn passed between the stones, and consequently less pressure was required; therefore injury was sustained, from the excess of pressure, by tearing the offal into smaller pieces, greater numbers of which particles were mixed with the flour, and the offal or bran, possessing an anti-fermentative property, caused great injury to the quality of the flour for making bread. Secondly, the decrease of speed injured the stones, by producing great pressure; the moisture existing, more or less, in all wheat, was expressed and settled on the stones, the flour became attached to it, and formed a paste on their surface, and therefore lessened their cutting properties, and unless they were taken up and cleaned, much less wheat was ground in a given time, and a less quantity of flour was obtained from a given quantity of wheat. Thirdly, an unequal speed mixed together the large and small particles of flour, produced by fast and slow grinding, which was injurious to the quality.

He had repeatedly thrown off, or put on, 40 per cent. of the power of the engine, instantaneously, and no person, either in the engine-house, or at the spouts, could know when it had been done, without looking at the valve, which, in his opinion, was conclusive evidence of the superiority of the machine as a regulator.

Mr. FIELD, *V. P.*, had seen the Governor, at Mr. Carpenter's mills, and he could corroborate the statement of its good effects, in equalizing the speed of the machinery, under the change of load made in his presence, though he did not know what proportion it might bear to the whole load on the engine. There had been several kinds of Governors proposed, one of the first of these was the Water Governor, contrived by Watt, which depended on the equal flow of water through an aperture of a given area, the water being constantly returned to the reservoir by a pump. Another consisted of an oscillating pendulum and scapement, actuated by an endless weighted band, driven by the engine, and passing over a pulley attached to the

clock movement, in the manner described by Mr. Woods, when illustrating the action of his weighted lever. Flies, fans, and other systems had also been tried, but by none of them had perfect regularity been obtained. Watt's Centrifugal Governor required, that when great nicety was demanded, the valve should be very accurately arranged, or else a certain amount of time elapsed, between the variation of the load and of the valve, in adjusting the supply of steam; consequently an inequality in the action of the machinery ensued, and if large variations took place, the absolute speed would vary with the angular position of the levers, which were required to maintain the adjusted supply of power; in corn and silk mills this irregularity of motion was very detrimental, and he thought, that in those and similar establishments, where regularity was required, the instrument would be very useful, and he should be glad to see it generally introduced.

Mr. J. Woods said, in reply to Mr. Field, he was glad that he had called the attention of the members to the necessity of having a perfect valve, in combination with a perfect governor; it was essentially requisite, that power should be provided to shut off the whole of the steam, without any leakage, as without such accuracy, the vacuum would be quite sufficient to perform a decreased duty at an increased speed, over which the governor would have no control; it was also necessary, that there should be no abruptness of action, in thus shutting off the supply; the method which was adopted, for securing this gradual action, was to make one side of a flap-valve close before the other, and to commence shutting off with an angular surface, so that at last a mere pinhole of area was left open, to allow the passage of the steam.

With respect to the Clock Governor, he had not been previously aware of such an application; but it was evident, that the use of an oscillating pendulum would not answer the condition required, of acting immediately on the throttle valve; it would act impulsively at each end of the vibration, instead of equally and uniformly at all times, as was provided for by a revolving pendulum.

Mr. THOROLD said, he had not seen any one of these governors at work, but he considered the plan which he had adopted at Norwich, and which was general in Norfolk, of applying a governor to each pair of stones, for adjusting their distances apart, so as to compensate for any alteration of speed, would do all that was proposed by the instrument under consideration, when applied to corn-mills; but for mustard-mills, he thought it might be of great value, as any varia-

tion of speed deranged the distribution of the powder upon the sieves.

Mr. C. MAY had applied one of these governors to his saw-mills, and could testify to its great value in regulating the machinery; the load on the engine was extremely variable, and consequently it was subjected to a very severe test. He had found it necessary to give the governor entire control of the engine, by providing a perfect steam-valve, and he was so satisfied with its action, that he intended applying it to two more engines as soon as possible. The great beauty of the action, consisted in its providing for the continued adjustment of the valve, so long as the load remained constant, and its immediate action in altering the adjustment for any variation of load.

Mr. AMOS had applied one of these governors to an engine of 30 H.P., working in concert with a water-wheel of equal power, at Mr. Dewdney's paper-mills, in Devonshire. He had frequently thrown off the water-wheel suddenly, without any variation in the speed of the machinery being discoverable, and he was so satisfied of the superiority of these over any other governors, that he should always employ them in future, as he considered, that in the event of an accident occurring to any of the shafting in a mill, the governor would prove of great importance, in preventing further injury to the engine, as it could not permit any increase in the speed, and he would with confidence lock up the engine and leave it entirely under the regulation of a Chronometric Governor.

Mr. R. DAVISON thought, that the adoption of a more perfect governor to the engine, would save the expense of putting additional regulators to each pair of stones, supposing that even by such means an equal quantity and quality of flour could be produced. He had tried Heinrich's Governor, which consisted of two pairs of bellows worked by the engine, and delivering the air through an aperture of constant size, from an expanding reservoir, which adjusted the valve according to the store of air contained in it; he found that machine to act very well as a regulator, but it was apt to get out of order, and he preferred the Chronometric Governor.
