

are very little injured by wear. It is true that these clocks were very well made, and have been carefully preserved. But as these mechanics lived in the reign of William the Third, who died in 1702, they cannot have been made less than 142 years.

To record the age of clocks, the date of their construction should always be put on the dial.

The expense of these clocks, always supposing a certain number to be made at one time, would be very moderate; taking into consideration the durability, non-liability to get out of order, the great facility with which they could be kept in repair, and the convenience that would result from establishing one general system for the measurement of time, in every part of Great Britain. At the same time, their cost must not be estimated upon the same principle as that of articles renewed at stated intervals, and which are only required to last a given time; but they should be valued in relation to the service they are required to render, and the length of time they are expected to last. Viewed in this light, these clocks would prove much cheaper than the lowest-priced clocks now in use upon any railway. It may be added, that where expense is not an object, they might be made to show the time on the exterior of the building, as well as in the interior, or office.

The general use of clocks of a superior description, all showing Greenwich mean time, in addition to the mean time of the station, and, consequently, showing the same time in every part of Great Britain, would be an immense convenience to individuals in every situation in life. The clocks at the railway stations would become so many standards for true time, and, as a necessary consequence, the country clocks could be set to Greenwich time, or the mean time of the locality, choosing that time which was most convenient; and the remark so constantly made, and too often with much truth, of want of correctness in the country clocks, would soon cease to be heard.

The details of this paper may probably be thought tedious, and, perhaps, unnecessary; but the object has been to collect together the principal facts which bore upon the subject, in such a manner as to render the whole as intelligible and useful as possible, and, above all, to direct the attention of Civil Engineers to this important subject.

Mr. WHISHAW was of opinion, that the plan of marking different times on the same dial would create confusion, and that it would be better, that Greenwich mean time should be adopted for ordinary purposes throughout the kingdom.

Four years ago he proposed, that by means of the electric telegraph, all the clocks along the line of a railway should be regulated to

similar time, and it was to be hoped, that now the electrical communication was complete between London and Gosport, the plan would be adopted.

Mr. HORNE thought the subject of considerable importance to the public, and to the railway companies. If one uniform rate of time keeping was adopted on railways, it would tend greatly to diminish the risk of collision of trains. He hoped, therefore, that the suggestions of the paper would be attended to.

He had paid much attention to the manufacture of turret and other clocks, and he thought the practical directions given in the paper were sound and valuable. In suspending clocks, he found the simplest method to be, by passing a stout bolt through the back of the case, traversing the wall against which the clock was to be suspended, and screwing it up with a nut on the outside; the case could thus be adjusted with great exactness, and being isolated from the wall and from the floor, was not subjected to any vibration.

The paper recommended occasionally oiling the pallets. Now Mr. Horne always found that however small a quantity of oil was applied, the rate of going of the clock was altered. He would rather recommend, that railway clocks should be placed under the care of a competent person, who should wind them regularly, examine and correct their rate of going, and at the same time clean the pallets, so that they would rarely require oiling.

Mr. VULLIAMY was quite aware that oiling the pallets altered, for a time, the rate of going; but he found, practically, that unless unusual care was taken to clean the pallets occasionally, so much dust accumulated upon them, that a certain amount of abrasion ensued, and that a greater variation of time was occasioned, than could arise from oiling them. He had frequently tried the method of suspension from a single point, and approved of it, but it was not always practicable, and it was more expensive than the system he had proposed.

Mr. WALKER said, that he entirely agreed with Mr. Vulliamy in proposing that the clocks at railway stations, in all parts of the kingdom, should keep Greenwich mean time; but he thought, that Mr. Vulliamy did not go far enough, for it appeared to him that a misunderstanding might still arise, particularly to strangers, who would be unacquainted with the difference between the clocks in the town and those at the railway stations. This would be entirely removed, by all the public clocks in the kingdom being made to keep Greenwich mean time. He had recommended this measure in a report on the Communication with Ireland, made to the Government in October 1843,* when it was also suggested that the true time, at the

* Vide "Communication with Ireland;" Mr. Walker's Report and Plans, 1843. Page 9.

different towns, might also be shown for astronomical purposes. The dial of the clock upon Granton Pier, Edinburgh, made by Mr. Bryson and which had been finished for some time, was, by Mr. Walker's orders, made upon this principle; but for all ordinary purposes one minute hand, showing Greenwich mean time, would be sufficient and no more inconvenience would be experienced, than was now felt by the difference between mean and solar time, by which clocks are a quarter of an hour before the sun at one season of the year, and as much after the sun at another season. He thought that engineers, particularly those who had the management of railways, would confer a public benefit, by advising and promoting an uniformity of time, until that measure should be effected by an Act of Parliament, which would be the most effectual mode of accomplishing that desirable object.

Mr. HORNE said, that with regard to the material of the pendulums of clocks, he had tried almost all the hard woods, and also glass; but he had obtained the best result from using straight-grained white deal, well baked, then painted and varnished, and lastly covered with gold-leaf, with a coat of copal varnish over all. This preparation had the additional advantage of preventing the effects of damp.

Mr. GILES stated, on the opinion of the late Mr. Troughton, that straight-grained white deal, when well dried, was less subject to variation than any other wood. When Mr. Giles was instructed by the late Mr. Rennie, to take the preparatory measurements for setting out the foundations of Waterloo Bridge, as he could not take them directly across the river, he constructed a platform of a quarter of a mile in length along the shore, and upon that platform he laid down a line with extreme accuracy, by using three deal rods, which he found retained their dimensions better than any other measuring instruments.*

Mr. VULLIAMY said, that he had recommended teak for pendulums, because it really was an excellent wood, and it was frequently more easy to be procured of a proper quality, than to find deal which

* On the subject of the use of deal rods for measuring distances, *vide* 'La Figure de la Terre déterminée par les Observations de Messieurs Maupertuis et autres; faites par ordre du Roy, au Cercle Polaire;' par M. de Maupertuis; 12mo., Paris, 1738. P. 50:—"Nos perches une fois ajustées, le changement que le froid pouvait apporter à leur longueur, n'était pas à craindre; parceque nous avions observée qu'il s'en fallait beaucoup que le froid et le chaud causassent sur la longueur des mesures de sapin, des effets aussi sensibles que ceux qu'ils causent sur la longueur des mesures de fer.... Toutes les expériences que nous avons faites sur cela, nous ont donné des variations de longueur presque insensibles." Le thermomètre était à 37° Réaumur (51·25 Fahrenheit) au-dessous de zéro.

could be depended upon; but he principally approved of teak, because it resisted the attacks of the white ants in India and as it was not possible to foresee where clocks might be sent to, it was better to provide for the possibility of their going to the East, where a deal pendulum would probably not last above a few days. He frequently used deal for pendulums of clocks that he knew would not leave England, and he thought it, if properly prepared, a sufficiently good material for pendulums.

Mr. DAVISON stated, in reply to some remarks on the difficulty of perfectly drying timber even when cut into small dimensions, that in his process for seasoning casks, the wood was frequently subjected to a current of air heated up to 600° Faht. He was of opinion, that if wood for pendulums was seasoned by a similar process, and while hot was plunged into oil, the result would prove very successful.

Mr. DENT stated, that he had constructed, for Mr. Airy, the escapement which had been mentioned, and he believed that its action was perfectly satisfactory.

He then drew attention to the causes of the variation of time in clocks, which in his opinion was not to be attributed entirely to an alteration of length in a part of the pendulum spring, but in some degree to a change in the amount of elasticity in that spring, arising from a variation of temperature. The subject had been fully treated by Mr. Dent, in a paper read at meetings of the British Association at Cambridge in 1833, and at Newcastle-upon-Tyne in 1838. He extended the inquiry to pendulums and succeeded in separating and demonstrating the respective amounts of effect, which changes of temperature produced upon the elasticity of the spring and the length of the rod. When the temperature was increased the clock lost and when a current of cold air was introduced the clock gained. By careful analysis it had been shown, that of a loss of 12 seconds in a given time, $8\frac{1}{2}$ seconds were attributable to the elongation of the rod, and the remaining $1\frac{1}{2}$ second to the decreased elasticity of the spring. His experience induced him to recommend straight-grained split American deal as the best material for pendulums. He found much difficulty in seasoning it. On one occasion he had prepared some wood by partially exhausting the air, and boiling it for three weeks in a mixture of turpentine and wax; but even at the end of that time air bubbles still rose to the surface. He had also tried boiling the wood under pressure, but with the same result. He was induced to believe that a very good pendulum could be constructed, by a combination of a zinc tube $\frac{1}{4}$ inch in diameter, with a small steel rod. The expense would not be considerable, and he thought the effect would be good.

He approved of the proposed plan for adopting Greenwich mean time generally throughout the kingdom; in some lectures, delivered at the United Service Museum in 1844, he had strongly insisted on the advantages of that system, suggesting its being termed "British time."

Mr. BROCKEDON suggested the possibility of some portion of the variation being due to an enlargement of the diameter of the rod, from the increased temperature, and thus opposing a greater surface to the air during its oscillation; this was in reality very slight, but with such delicate machinery as clock-work, the smallest causes produced unexpected results.

Mr. HORNE stated, that the weight used as a moving power, for well-made clocks, was generally too great, occasioning wear and destruction of the oil. He had a month-regulator, which had gone well for many years, with a weight of only 6 lbs. upon the train, which was equal to $1\frac{1}{2}$ lb. upon an eight-day clock. He was of opinion, that the power impinging on the pendulum should be at, or very near to the point of suspension, so as to interfere as little as possible with the natural gravitation of the bob, the principle which is admitted as the most accurate for the admeasurement of intervals of time. In making this statement he considered, that in the best kind of time-pieces the pendulum spring should be entirely discarded, substituting a well-hardened knife edge moving upon agate.

Mr. BIDDLE believed, that the general working of a line by London time, had been first introduced upon the Great Western Railway, and the effect had been to oblige two clocks to be kept at the inns adjacent to the line—one showing London time, and the other the correct time of the place. He could not approve of the system proposed, as although it might be observed correctly along the line, it would not be adopted in the tracts of country between the railways, and hence constant errors would occur. Those errors would be still aggravated, by the London time differing both from the solar time and the mean time of the various localities. He thought, that the time-tables of the railways should be calculated in accordance with the real mean time, consistent with the longitude of the stations; then, by causing all the railway clocks to be corrected, at given periods, by a person appointed for the purpose, accuracy would be insured, without disturbing the present system of local time.

If the proposed system were applied to a railway of the length of those on the continent, the difference of time between the two termini would be immense, and the plan would disturb all existing arrangements as to time. However the plan might be found to answer practically upon our comparatively short lines, it must not be supposed to be advocated by engineers for more extensive lines.

Mr. G. C. B. CURTIS drew attention to the effect of an uniform time in deranging all calculations as to tides ; if the proposed system was adopted, an almanac would be required for every town.

Mr. WALKER could not agree with Mr. Bidder in the position he had taken up. The proposal for keeping one uniform time, was not applicable to countries whose great extent would render variation between the two extremities of a line so great as to be objectionable ; the plan only applied to the railways in Great Britain, and upon them he must contend, that the general adoption of London time, for the periods of the arrival and departure of the trains, would induce a regularity which did not now exist. He was glad when that plan was adopted on the Great Western Railway, as it showed that the necessity for it, was already felt. If the system was established on all the railways, it would by degrees extend to the tract of country situated between the lines, and even all the private clocks would have the two minute hands showing the London time and that of the locality. As solar time had been mentioned, it should not be forgotten, that a difference now existed between that and mean time, and that therefore no argument could be deduced from an aggravation of error, as regarded the time shown by the sun-dials.

At present, great discrepancies existed ; for instance, on the Great Western Railway, London time was observed along the line. On the London and Birmingham Railway, he believed that at Birmingham, Liverpool time was observed for trains going down and London time for trains going up ; so that the passengers who stopped at Birmingham for a short time, frequently arrived at the station too late for the trains, relying upon their watches, which had proved correct on the first part of the journey.

Mr. Walker must still adhere to the opinion, that for all except astronomical purposes, London time might be advantageously adopted ; and even where the tides were concerned ; because the difference of time on such a limited extent as the coasts of Great Britain, could not be of any practical disadvantage ; he thought, that the recommendation of Mr. Vulliamy's paper should be adopted, and he drew particular attention to the arrangement of the hands on the dial ; which was practically the same as that which had been placed on Granton pier some time since ; but he thought it a great improvement in having one of the hands formed of the letters composing the words **LONDON TIME**.

Mr. VULLIAMY regretted, having omitted in the paper all notice of solar or true time. Formerly, when the use of clocks was very limited, and that sun-dials supplied their place, solar time was constantly referred to, and the best clocks were made with two minute

hands, one with a sun at the end indicating solar time, the other marking mean time. These machines were called "equation clocks," because they showed the difference between solar and mean time; they were, however, complicated, and consequently expensive; their great convenience consisted in the hand showing solar time, necessarily agreeing with the time shown by the sun-dial.

The ordinary equation tables indicated the difference between the time shown by the two minute hands, which was constantly varying; at certain periods of the year the difference was only a few seconds, at others it was upwards of 15 minutes; during part of the year the clock was "fast of the sun," which was indicated by the hand showing mean time, being in advance of the hand showing the sun's time; the remainder of the year the contrary was the case. The sun-dial only showing the solar time, there was always an equation table engraved on all good horizontal dials, without which precaution it would have been impossible to compare the time shown by a watch with the time shown by the sun-dial. From this it is sufficiently obvious, that for all practical purposes, mean time could alone be employed.

The principal public clocks at Paris, including that at the Hotel de Ville, which cost the city of Paris 90,000 francs (£3,600), were originally made to show solar time; this had long been felt to be a great inconvenience, and on the 24th of December, 1826, they were made to show mean time.

Previously, to this being done, an inquiry was made of Mr. Taylor of the Royal Observatory, Greenwich, to know at what period the public clocks in London ceased to show solar time. Mr. Taylor applied to Mr. Vulliamy on the subject, who, having examined three of the oldest Palace clocks, arrived at the conclusion that they never had shown any other than mean time, and he did not believe that any other time was ever shown by the public clocks in this country.

February 11, 1845.

SIR JOHN RENNIE, President, in the Chair.

No. 720. Mr. J. B. Redman, Grad. Inst. C. E., exhibited specimens of timber from fender piles from the new Terrace Pier at Gravesend, in which considerable inroads had been made by the pipe-worm "*Teredo Navalis*."

He described the specimens as portions of one of the temporary fender piles, driven in May, 1843, near low water mark, and which had been cut off in July, 1844; so that they exemplified the effect of