Resolved, That the meeting be adjourned until Monday evening, the 27th instant, at 8 o'clock, when the meeting should proceed to elect a President, in accordance with the directions of the charter and bye-laws.

January 27, 1845.

Adjourned Annual General Meeting.

WILLIAM CUBITT, V.P., in the Chair.

The summons for the adjourned meeting was read.

The Chairman announced, that the Council continued the same nomination of Sir John Rennie as suitable for the office of President.

Messrs. R. Davison and J. Bethell were requested to act as Scrutineers of the ballot for the office of President.

The ballot having been open more than an hour, was declared closed at 59 minutes past 9 o'clock, and after examination, the scrutineers announced, that Sir John Rennie was duly elected to fill the office of President for the ensuing year.

Resolved, That the thanks of the meeting be given to Messrs. R. Davison and J. Bethell, the scrutineers, for the promptitude and efficiency with which they have performed the duties of their office, and that the ballot papers be destroyed.

February 4, 1845.

SIR JOHN RENNIE, President, in the Chair.

The following candidates were balloted for and duly elected:—

Captain Joshua William Coddington, R.E.; Nathan Gough; and Robert Ritchie, as Associates.

Sir John Rennie addressed the meeting, on taking the chair for the first time since his election as President.

Resolved, that Sir John Rennie, President, be requested to permit his address to be printed and circulated with the Minutes of Proceedings. *

No. 708. "On the Construction and Regulation of Clocks for Railway Stations." By Benjamin Lewis Vulliamy, Assoc. Inst. C. E.

The fact of all the Mails in Great Britain being regulated, by order of the General Post-Office, by Greenwich mean time, causes the accurate performance of the clocks at the different railway stations, to be a matter of more importance than it would otherwise appear, and

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* Vide page 23.

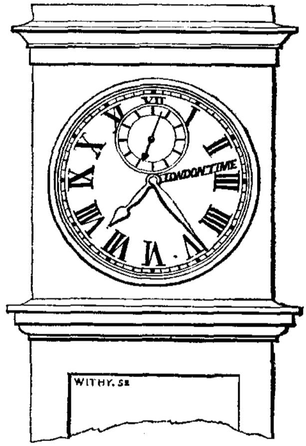
offers a sufficient reason for an inquiry as to the sort of clocks best adapted for the purpose, and which can be procured at such a reasonable cost as might be afforded for all much frequented stations.

Great practical inconvenience results from the difference between, what is commonly called London time and the correct mean time at the different railway stations on the line. It should be noticed that the term " London time " is not strictly correct, because most of the public clocks in London are intended to be kept to Greenwich mean time. According to the trigonometrical survey, St. Paul's Cathedral, the most important building near the Post-Office, is slow of Greenwich time 23·1 seconds; but in this paper, Greenwich time will always be referred to as " London time."

By a certain class of individuals the variations due to the difference of longitude of a place is perfectly well understood; but a large proportion of the travellers by railway, possess only vague notions on the subject, and many disappointments ensue from their arriving too late, in consequence of their not understanding that their own clocks show one time, while the trains work by another. For example, take the difference between Greenwich and Devonport Block-house flag-staff, which according to the trigonometrical survey, is 16 minutes 39·8 seconds (to avoid fractions of seconds, say 16 minutes 40 seconds) slow; consequently when it is 12 o'clock at Devonport, it is 16 minutes 40 seconds past 12 o'clock in London. Now, supposing a train to leave London at 8 o'clock, A.M., and to arrive at Devonport at 2 o'clock, P.M., performing the distance in 6 hours. A train to arrive in London at 2 o'clock, P.M., must leave Devonport at 16 minutes 40 seconds before 8 o'clock, by Devonport time, or the speed must be sufficiently increased to cause the train to accomplish the distance in 5 hours, 43 minutes, and 20 seconds. This unavoidable inconvenience is increased by the circumstance, that the difference is never the same at two consecutive stations, but varies constantly, unless it be in the case of a train on the meridian of Greenwich.

It appears, therefore, evident, that the difficulty just noticed, would be in a great degree obviated, if all railway clocks were made to show both Greenwich mean time, or London time, and the actual mean time at the station where the clock is placed. The difference being always the same at the same place, this could be done without any difficulty, and at very little expense, merely by applying two minute hands to the clock, one pointing to Greenwich mean time, the other showing the time of the place where the clock is situated. Greenwich time should be indicated by a gilt hand forming the words **LONDON TIME**, and the other minute hand and the hour hand would be made of steel as usual (Fig. 1).

Fig. 1.



According as the station is east or west of Greenwich, the gilt hand must be placed before or after the steel hand. Upon this plan, in the case of a clock at the Devonport station, the two hands would be 16 minutes 40 seconds apart; and when the steel hands showed 60 on the dial, the gilt hand would show 16 minutes 40 seconds past the hour; in like manner, when the gilt hand showed 60 minutes, the steel hand would show 43 minutes 20 seconds, or wanting 16 minutes 40 seconds of the hour. By this contrivance, the public would immediately understand, that the train which was stated in the railway bill to leave at any given hour, really left 16 minutes 40 seconds before that time, as shown by the clocks at the place; the time announced in the printed bill, referring to London, and not to Devonport time. On the other hand, suppose a country town, Canterbury for example, east of Greenwich. The Cathedral, as shown in the trigonometrical survey, is fast of Greenwich 4 minutes 19 seconds, so in this case the reverse would take place, and the train would take its departure 4 minutes 19 seconds after the time shown by the Canterbury clocks.

All railway clocks should be furnished with a seconds hand, which hand should be set to agree with that which shows Greenwich mean time. This is an additional reason for employing a seconds pendulum.

When clocks are required to be kept to a particular time, fast or slow of Greenwich, which is frequently the case, and that in setting the clock a difference is to be allowed; there is always some risk of a mistake being made, which is much increased by the very short time, that in many cases can be allowed for winding it and, if necessary, setting the clock, and more attention is required than can reasonably be expected from an ordinary clock winder. With the double minute hand a mistake of this sort cannot occur; moreover the two hands would afford great facilities for comparing, setting, and regulating the clocks by a chronometer set to Greenwich mean time; for this reason the seconds hand is indispensable.

Having now explained what is proposed as the most convenient mode of showing the time at the different stations, the next consideration is, which is the most preferable description of clock to be employed.

Clocks are divided into two classes, one having for maintaining power a weight, the other a spring. The latter have almost entirely superseded the former, in consequence of their occupying less space and the reduction in the cost of the case, which enables these clocks to be sold at a low price. For railway stations, the only clocks that ought to be employed are those which have a weight for the maintaining power. The superior performance of that description of clock, with a seconds pendulum, over any spring clock, however well made, ought alone to decide the question. It is, however, necessary to point out in some detail, certain practical advantages which only require to be known to be duly appreciated.

If either the spring, or gut-line of the spring clock be broken, the movement must be taken to pieces to be repaired; consequently it must be removed from the station. In the case of a broken spring, a delay of two or three days will take place, whilst a new one is being made; moreover the new spring will probably be stronger or weaker than the old one, and consequently, the maintaining power will be greater or less, which will materially affect the going of the clock, until it has been regulated with the new spring. This is an important consideration, and is a great objection to a spring clock.

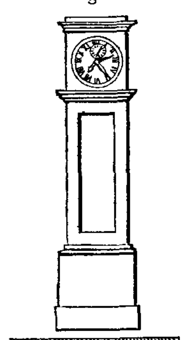
The objection to the line breaking may in a measure be obviated by employing a chain, but a chain is liable to rust and then it is apt to break; moreover it adds considerably to the cost of a clock.

Now, if the weight clock is properly made, in the case of the line breaking, it can be replaced by a new one in half-an-hour, and the clock will be set going again, the maintaining power remaining the same; thus avoiding all the disadvantages previously shown to exist in the spring clock, under similar circumstances.

The spring clock can only show seconds with a half-second pendulum, which necessarily makes two vibrations every second; consequently the second is indicated on the dial at every alternate advance of the hand. To obviate this difficulty, several contrivances in reference to the escapement have been projected, and some few have been tried to cause a clock with a half-seconds pendulum to show the seconds with a single beat, as is done with the seconds pendulum; but they are all more or less complicated, and are subject to such various objections that they have not been generally employed. In Part 1, vol. iii., page 125 of the Cambridge Philosophical Transactions,* is a description of a new escapement to show seconds with a half-seconds pendulum, by Professor Airy, Astronomer Royal. The escapement would probably answer the purpose for which it is intended, but it is complicated—difficult to make, and unless very well executed, would not perform at all; consequently it would prove very expensive. Moreover, in whatever way the escapement is made, the pendulum must be very short, and all the objections to the short pendulum remain unaltered.

A spring clock might be made with a seconds pendulum, but that would not offer any advantage; the cost would be greater than that of a weight clock, and the case would not be more than one-fourth shorter. The construction of the escapement and the short pendulum of the spring clock, cause it to be more affected by the alterations in the fluidity of the oil, produced by sudden changes of temperature, than a weight clock would be, under similar circumstances. After a spring clock has been cleaned, it requires to be attended to for two or three days consecutively, in order to regulate it, otherwise at the end of a week it will probably have varied five or ten minutes. This is not the case with the weight clock, if the pendulum remains undisturbed, the variation, after cleaning, will never exceed a few seconds per day.

Fig. 2.



The sort of weight clock (Fig. 2) best adapted for a railway station is a full-sized eight-day going movement, with Graham's dead escapement, the scape wheel to be 2·5 inches diameter. This is a size generally adopted for the best regulators, and will insure the teeth of the wheel being of sufficient strength, which is very important, and will not increase the expense so far as the wheel is concerned.

The pallets should be of steel, and be cut to an angle that will

* Read November 26, 1826.

enable the wheel to escape at an arc of vibration of the pendulum, not exceeding one degree on each side of zero.

There should be an adjustment for setting the clock in beat, by means of two screws, acting upon the end of the crutch, which is prolonged upwards. This arrangement obviates the necessity for bending the crutch, a practice which cannot be too strongly reprobated.

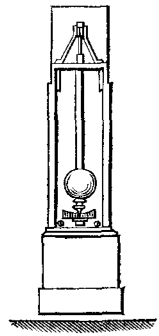
It is important, that the centre wheel pinion should have twelve teeth; the other two pinions may have each eight teeth, though pinions of ten teeth would be preferable.

The clock must have a going-ratchet, or some contrivance to keep it going whilst it is being wound up; the dial should be silvered metal with engraved figures, and should not be less than 10 or 12 inches in diameter. It may be here observed that the numbers 12 and 10 for the teeth of the pinions will probably be objected to, on the score of expense, particularly the first, because it obliges the great wheel to be much larger, and to be cut into 144 teeth instead of 96 teeth, but the advantage is so great, that the expense ought to be a secondary consideration.

The clock must be firmly fixed to the seat-board by screws, taking into three cocks screwed to the frame, and not by two screws tapped into the bottom pillars of the frame, as is commonly done, which is very apt to strain the frame and to alter the gear of the wheels and pinions.

The pendulum is a part of the clock on which its good performance mainly depends, and to which too much attention cannot be paid. A compensation pendulum is necessarily expensive to make, and unless it is good in principle and extremely well executed, it is practically worse than useless. In this case such a pendulum is not necessary, and it will be sufficient that the rod be made of a piece of very straight-grained teak wood, which is preferable to deal. Teak possesses great strength, and is less affected by moisture; but, in order to render it more efficient, it should receive half-a-dozen coats of copal varnish. The pendulum spring should be from 0·5 to 0·6 inch in length, and the suspension and parts above the spring should be made of gun metal, with an adjustment, to set the pendulum to vibrate in a plane parallel to the back of the clock. The bob may be made of two pieces of cast-iron, cast very clean and fastened together by two screws, and weighing from 11 lbs. to 12 lbs. The clock should be regulated by a nut under the pendulum bob, in the usual manner—the nut must be not less than 0·5 inch in thickness, divided into 60° on the rim, and the screw, in place of being of steel, or as is most commonly the case, of iron, should be of gun metal, cut with a fine but clean strong thread, and terminating in a point, in order to indicate the arc of vibration of the pendulum upon a degree plate, with which it is indispensable the clock should be furnished. The suspension of the pendulum must be entirely independent of the frame of the clock, and must either be hung upon an (A) cock (Fig. 3), screwed to and resting upon the seat-board, or upon a strong cock screwed to the back of the case. The (A) cock is the preferable mode; by this means the only connexion between the clock and the pendulum will be by the crutch, and the clock can be taken down to be cleaned without disturbing the pendulum. This arrangement is important, and must be strictly attended to.

Fig. 3.



The going-weight should be made with adjusting sliders, for the purpose, when necessary, of increasing or diminishing its specific weight. As many of the railway clocks are placed in situations exposed to a considerable degree of cold, this facility is a great practical convenience. The effect of cold upon the oil of a clock is to increase the friction, and, consequently, to diminish the arc of vibration of the pendulum, which can be best increased by augmenting the maintaining power.

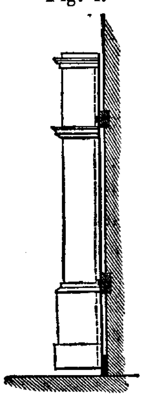
The line should be attached to a hook in the barrel, in such a manner that, should it break, the fractured line can be removed, and a new one put on, without taking down or disturbing the clock. A strong silk line will last longer, and is applied more easily, than a gut-line. Ver r ecently, brass and copper wire lines have been put to clocks. How they will answer can only be satisfactorily determined by experience.

The case of the clock should be made of solid fine wainscot or of solid Honduras mahogany, avoiding all veneering. When the pendulum is suspended to the back of the case, it is indispensable, that the back should be very stout; certainly not less, when finished, than 1 inch in thickness. The best mode of preserving the case is to give it several coats (inside and outside) of copal varnish, of the same kind as is used by the coachmakers. Wainscot sometimes contains so much pyroligneous acid as to completely rust steel work, and to cause the brass work to become quite green from verdigris: for this reason, it is always desirable to varnish as much of the inside of a clock-case as is made of wainscot.

The dial should be covered by a piece of strong plate-glass, which would not be liable to be broken by a slight blow; and it should on no account be what is termed a convex glass, which, for many reasons, is the worst that can be employed. One reason will suffice. Should the glass be broken, the door must be taken off, and be sent to London or Bristol, or some large town, for a new one, where alone it can be procured, and the dial and hands must consequently remain for a considerable time uncovered and exposed.

Having very fully described the principal parts of the clock, the works, and the case, its situation must be next considered; as it cannot be too firmly and steadily fixed. The best mode, when it is practicable, instead of allowing the clock to rest upon the floor, is to attach the case, by three strong screws through the back, to two pieces of wood let into and firmly fixed to the wall (Fig. 4); these pieces should be the width of the case in length, about 8 inches wide, and should project 1 inch from the wall. By this means there will be a constant current of air between the clock and the wall, and the floor; whereby it will be much less liable to be affected by damp than would otherwise be the case. When the wall, or partition, is not sufficiently strong to carry the clock, it may be fixed in the same manner, but resting on the floor. The great advantage of the first method of fixing is this, that the clock is not affected by any motion of the floor, caused by the removal of heavy goods, or by persons traversing it.

Fig. 4.



Such a clock, as has been described, would be what was formerly considered a very good regulator, and, when properly fixed, would answer every purpose that could be required. Taking the precaution to occasionally put a little oil to the escapement, and to clean it when necessary, the error in its rate of going would rarely exceed a few seconds in a week, and that would principally occur from the oil being affected by sudden changes of temperature. The clock could be taken down and cleaned at the station, and put up again in the space of a few hours; and it could be wound without the aid of steps, or ladders. These are considerations well deserving attention, in reference to the saving of time, trouble, and expense..

It is impossible to assign any limits to the duration of such a clock as has been described; but, reasoning by analogy, it would be very great. There are, at the present time in use, many clocks made by Tompion, and some by Quare; which perform extremely well, and 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