rooms. At night they are quickly transformed into luxurious sleeping cars.

It is now some ten or twelve years since public attention was first directed to the feasibility of sleeping cars, by the publication of engravings in the SCIENTIFIC AMERICAN, illustrative of the first improvements of this kind; and among the earliest names that we find associated with the development of these inventions is that of Mr. Woodruff. He might justly be termed the King of the Sleeping Cars. He has devoted himself to their introduction with a persistence and energy deserving of all praise, and he merits the golden reward that he is now reaping.

"The Silver Palaces are among the most brilliant vehicles that ever rolled on iron wheels. The woodwork is black walnut, polished and elaborately carved; the carpets are velvet and Brussels; the seats are covered with moquet; and the whole car is most lavishly embellished with silver. Strictly, the metal is German silver fret work heavily plated, and glittering in the purest white. The lamps are of the same metal, large and ornamental. The effect of so much silver is very novel and beautiful, and this effect is enhanced by stained glass lights overhead, which shed a flood of blue tints upon the glittering silver pillars, and the fret work below."

These superb cars will undoubtedly attract large numbers of passengers, while the route they run, passing over the richest parts of the country, through glorious scenery, which is in the highest degree interesting and enjoyable.

Science Familiarly Illustrated.

GREENWICH TIME.

If we examine the time books of our trunk railways, we shall find in some of them a distinct statement that Greenwich time is kept "on this railway and all its branches;" in others, in which no similar notice occurs, the same rule is by universal consent followed; indeed, if uniform time were not thus kept, it would be an extremely difficult task to regulate safely the great number of trains which daily travel with varying speed over many of our principal lines, some of which must wait at certain points, while others, which run quicker, pass.

But the reader may ask, what is "Greenwich time?" and what "local time?" and why does Greenwich time possess such peculiar value over that of any other place as to cause it to be, so to say, at a premium? And what is "mean time?" These matters we will endeavor simply to explain.

The sun, as everybody knows, determines what we call day and night, on account of the alternate light and darkness; the daily return of the sun is therefore used as our ordinary measure of time. Two kinds of solar time are of necessity employed—*true solar time* and *mean solar time*. But why two kinds of solar time? Because true solar time cannot be conveniently used in practice, as we will explain. We must premise that true solar time at any place is such as is furnished by a sun dial; or more accurately, at noon, by noting when the shadow of a perpendicular line or rod falls due south (the true north and south line being supposed to be known), that instant being noon—true solar time. Now, let a clock at any place be set with the sun, on, say April 15. Suppose the clock to go uniformly and accurately for a year, then about the same day of the year following, the clock and sun will again be together. But will they have been together throughout the intervening year? Only on three occasions—about June 14, August 31, and December 24. At all other times, the sun will have been either somewhat before or somewhat behind the clock, the greatest deviations being fourteen and a half minutes in February, and a little more than sixteen minutes in November; the sun being after the clock at the former time, and before it at the latter time. The difference is caused by inequality in the motion of the sun, but as it would be extremely inconvenient to make our clocks keep with the sun throughout the year, and as the inequalities are comparatively small, we, in practice, neglect them altogether; and thus comes *mean solar time*, or *mean time*, that used in the daily business of life, as distinguished from *true solar time*, which agrees with *mean* or *clock time* only on four days of the year, at the times previously mentioned. Ingenious men have in ages past constructed clocks, styled "equation clocks," to keep time with the sun; but they can be considered as little more than curiosities, and not likely ever to come into general use, could they be made ever so perfect.

We have now to consider the distinction between *Greenwichtime* and *local time*. The sun, as any one can see, travels through the sky from east to west. Evidently, therefore, to all places situated on a supposed north and south line, it will be noon, or one o'clock, or two o'clock, etc., at the same instant. Thus, when it is noon at Greenwich, it is also noon at all places directly north or directly south of Greenwich; and similarly for other hours; or, in other words, the local time at all such places will be the same as Greenwich time. And manifestly, as the sun comes from the east, it will be noon at all places east of our imaginary north and south line, before it is noon at Greenwich; correspondingly, at all places to the west of the same line it will be noon after it is noon at Greenwich; that is to say, local time precedes Greenwich time for all places to the east, and follows Greenwich time for all places to the west. The greater the distance of the place from Greenwich east or west, the greater will be the interval by which the local time will precede or follow that of Greenwich. The distinction between local time and Greenwich time enables us to explain the term *longitude*. The difference of longitude between any two places is merely the difference of their local times, and the longitude of any place is thus its difference in time from some point fixed on as standard. The selection of a place of reference is altogether arbitrary. The English count from Greenwich, the French use Paris, and similarly in other countries. Thus we see the Greenwich having long been the point from which longitudes were counted by the English, Greenwich time came to be that universally adopted when the necessity of uniform time arose.

Before the introduction of railways, every town and village in the kingdom kept its own local time. On the establishment of railways, however, any attempt to work them by local time could only lead to useless complication. Greenwich time was therefore employed, and gradually towns in the vicinity of railways also adopted Greenwich time, although at some places the "innovation" was opposed for a considerable period. At last, however, the use of Greenwich time came to be universal.

Having explained the distinction between *true solar time* and *mean solar time* or *mean time*, and also the distinction between *Greenwich mean time* or *Greenwich time* and *local time*, we will consider how, principally the clocks on railways are kept right. Now time is most accurately and regularly obtained in fixed astronomical observations. The standard points of reference to an astronomer are the fixed stars, as the positions of the principal stars are well known. The time of being due south, or, as it is called, the "time of southing," or any of them, being observed by the "transit instrument" the difference between the observed time and the time given in the *Nautical Almanac* is the error of the astronomer's clock. The clock used for such observations is a sidereal clock, one that keeps time with the stars, the length of the star or sidereal day being different from (and shorter than) that of the solar day. The error of the sidereal clock being thus found, it is mere matter of calculation (by the same indispensable aid, the ever necessary *Nautical Almanac*) to ascertain the error of the mean time clock. The astronomer being compelled to obtain correct time at every opportunity, for his own use, in order to be able to record with accuracy the instant at which any phenomenon that he may observe takes place, nothing is more natural than that he should willingly dispense to the public, for their benefit, that which he must, so to say, keep on hand. By connecting any such observatory to the electric telegraph system, this can be done to any extent. The observatories which have given greatest facilities in this way are, so far as we know, those of Greenwich and Liverpool in England, and Edinburgh and Glasgow in Scotland.

The distribution of time from Greenwich is very extensive. There is in the observatory at that place a clock which is kept showing exact Greenwich time, and this clock once each hour automatically indicates the time by telegraph to various points in London. One place at which time is thus received is the principal office of the Electric and International Telegraph Company; and in their office is a time-distributing apparatus, or "chronopher," the function of which is to distribute in many directions the signals received from Greenwich. A grand distribution is made at 10 A. M every day. The instrument so alters the connections of a great number of provincial wires used in the ordinary telegraphic work, that the Greenwich signal at that hour causes signals instantaneously to pass out on all these wires, indicating the time simultaneously at places north, south, east and west, to the extreme ends of the kingdom. All this is done certainly and promptly, entirely by automatic means. In this way, clocks on railways and in distant parts of the country become regulated, the town and village clocks being in their turn rectified by the neighboring railway clocks.

Now, before making special reference to what is done in the way of controlling clocks in these places we will speak further of the plan itself, as it is one likely to be of very considerable use, and well deserves to be generally known. Some years ago when galvanism first began to be of practical use to mankind, ingenious mechanicians invented systems for working clocks by use of this power alone, doing away with the customary weight or spring. Such clocks required only a simple train of wheels; they did not want winding up, and would go as long as the galvanic battery endured. It began to be supposed that a great advance had been made. In course of time, however, it was by universal consent allowed, that to depend entirely upon galvanic power was an unnecessary refinement at the best, if not indeed a mistake; the disadvantages (which need not be entered into here) outweighed the advantages, and galvanic clocks came into bad repute. The most valuable horological use of the power had not then been discovered—that of using it as an *auxiliary* only. But plans for its employment in this way began to be proposed, the most notably successful being one patented by a Mr. R. L. Jones about ten years ago. It consists as follows: Taking an ordinary wind-up clock, with seconds pendulum, the bob of the pendulum is removed, and a galvanic coil substituted. The coil is similar to a bobbin or reel of cotton, supposing the cotton to represent copper-wire insulated, so that the successive turns of the wire shall not touch each other: the coil is fixed with the hollow horizontal. Now if we set the clock going, it will still accumulate error as before. But let it be placed in telegraphic connection with some distant clock from which a *galvanic current* is received at each second of time, so that the current received shall circulate through a wire of the coil. While the current is passing, and no longer, the coil possesses magnetic properties, and such action is produced between it and a permanent steel magnet fixed to the clock case, and on to which the hollow of the coil swings at each vibration, that whether the clock be inclined to lose or gain on the standard clock, it will, by the magnetic action, be either accelerated or retarded as necessary, and maintained in perfect harmony with the standard clock, which has, so to say, merely to *guide* it, just as a man may steer, though he does not propel, a large ship. The first public application of the plan was made in the year 1857 to the clock of the townhall, Liverpool, which was adapted for control, and connected with a clock in the Liverpool Observatory. It had previously caused great inconvenience by its irregular performance; but since the commencement of the new system, the Liverpool merchants have had the satisfaction of possessing a clock, the first blow of the hammer of which, at each hour, is true to a second of time. The system has been extended in Liverpool, and since adopted both in Edinburgh and Glasgow. At the latter place it has been taken up in a remark able manner. Not only are three large public clocks (including the clock of St. George's Church) controlled from a standard clock in the Glasgow Observatory, but also numerous smaller clocks, showing time to seconds, and situated in different parts of the city; and the system is to be extended, or perhaps now is extended, to the Clyde, for the benefit of the shipping.

At Edinburgh, the plan is used for a novel purpose. Some years ago, the citizens of Edinburgh determined to establish a gun which should be fired every day at the instant of one o'clock Greenwich time. Now, close to the gun there is placed a clock, which discharges the gun by releasing, at the proper instant, a weight, which acts upon the friction fuse of the gun. This clock must evidently be kept right, and this is done by the plan of which we have spoken. The clock is controlled by another placed within the Edinburgh Observatory, and the daily firing takes place with the greatest certainty and accuracy. The citizens of Edinburgh may congratulate themselves on having led the way in the establishment of so useful a public monitor, for, as connected with the subject we may further mention that time-guns have since been set up at Newcastle and Shields. These guns are fired by galvanic current from the observatory at Greenwich: the fuse here employed is a chemical fuse; that is to say, it is one *ignited* by the galvanic current, and it acts rapidly and well. The reports of the time guns may be heard at a considerable distance. To take time from them with accuracy, however, it is necessary to allow four and a half seconds for each mile the observer is distant from the gun, on account of the time taken by sound to travel the intervening space. And similarly for any *sound* signal. If the *flash* of the sun can be *seen*, no allowance is necessary, as light travels through any such distance in an infinitesimally small fraction of a second.

It is impossible to overrate the advantage of a reliable knowledge of exact time in all great centers of industry; and yet although time passes daily through London to many parts of the country, the people of London have (with one exception) few clocks on which they can implicitly rely. The exception—and a notable one—is the Great Clock in the New Palace at Westminster; for although so costly a production, it turns out as respects performance, to be perhaps the finest clock of the kind in the world. In the controlled clocks of which we have spoken, nothing depends on the goodness or badness of the clocks themselves, as they are kept accurately to time by the guiding power of the respective observatory clocks. But the Westminster clock is not controled by any other, and has thus to depend on its own merits. Telegraphic communication with Greenwich exists for the purpose of enabling the clock to report automatically its state every day to the Astronomer-royal; the Greenwich record, therefore, demonstrates the goodness of the machine. It is not allowed to deviate more than two seconds from true time, and we are told in one of the Astronomer-royal's Reports, that "the rate of the clock may be considered certain to much less than one second per week." The frame carrying the various trains of wheels of this celebrated clock is 15½ feet long, and four feet seven inches wide; the pendulum, which makes one vibration in two seconds, weighs between six and seven hundred weight; the dials, of which there are four, and which are illuminated at night, are each 22½ feet in diameter; and it is a day's work for a man to wind the clock up, both going and striking parts.

When we consider what is the duration of a second of time, and that such a large machine is able to perform for a week within this above mentioned limit, we may well marvel at the result, proving as it does the advance made in horological art

To railways, and their attendant telegraphs, is the improvement so far made, in the system of time-keeping in the kingdom, due. Wheresoever they penetrate, correct time should be easily attainable; and in our days, when we live so fast, and can scarcely stem the current of our daily work, an exact knowledge and an economical use of so important an element, is not to be disputed. We trust, therefore, that our endeavor to show, in a familiar way, what has so far been accomplished, will be acceptable to our readers, if only as illustrating the benefit arising from cooperation. The astronomer, possessing a knowledge of that which is so useful to mankind, has not the means of promulgating that knowledge. The electrician, on the other hand, cannot vie with the astronomer in his vocation, but possesses facilities for disseminating that knowledge to the world; and by mutual good will, mainly do the systems which we have described exist. May such combinations ever continue to flourish and extend!—*Chamber's Journal.*

To Correspondents.

We would call the attention of our correspondents to the additional notice placed over the column devoted to their benefit. While we are at all times willing and ready to make any reasonable exertions for their interest, we would impress on them that, in their communications to us, all references to statements or facts made in back numbers of this paper should specify distinctly the volume and page. A compliance with this request will save us a large amount of unnecessary labor.