

penetrative energy, and go through a thickness of what are ordinarily considered opaque substances, but which are intercepted by the contents of the epidermic pigment cells largely developed in the African, a little more sparingly in Hindoos, and not absolutely wanting in the sunburnt excursionist or sportsman in our own country.

The Australian will tell you that he has done hard work—in a shade temperature of 100° —in the sun in a light wideawake and not felt exhausted; while continuous labour of some hours in much less heat— 75° in the shade and exposed to the sun—in Hindostan would be simple destruction of the European's powers of exertion with all a Bond Street hatter could devise on his head.

A. T. FRASER

Equator of Heat, India, October 1

The Distribution of Scientific Works Published by the British Government

I HAVE read Dr. Valentine Ball's letter in your journal of October 30 (p. 634) expressing his astonishment that the scientific Reports of the British Government are not presented to the leading American scientific institutions. It may surprise Dr. Ball to learn that the Treasury recently refused to present one of the largest scientific libraries in Dublin with copies of the *Challenger* Reports on the ground that their "free list" was too limited!

G. F. B.

A NEW METHOD OF HEATING IN THE REGENERATIVE GAS FURNACE

DURING the present age, which may be called that of Electricity, the sister science of Heat is not receiving so much attention at the hands of the natural philosopher as it did formerly. But still there remain some scientific men who are giving a life-long attention to it—MM. Hirn and Berthelot in France, Herren Clausius, Helmholtz, and Frederick Siemens in Germany, Mr. Joule and Sir William Thomson in this country. During the late Sir William Siemens's lifetime, the one brother worked here in the science of Heat, the other in Germany, and the work of both was applied everywhere; now Mr. Frederick Siemens works alone, and, from the recent evidence of that work, it promises to play an important part in the economical application of fuel. Mr. F. Siemens has recently had an opportunity given him of bringing his views forward in this country, having read a paper at the Chester meeting of the Iron and Steel Institute on a new method of heating in the regenerative gas furnace, in which he treated the practical side of the question, whilst in the discussion of the same paper he gave his views on the theory of the subject. Mr. F. Siemens's investigations have led him to the conclusion that combustion can only be perfect, and be maintained perfect, if the space in which it takes place is sufficiently large to allow the gases to combine out of contact with solid materials. Having proved by actual experiment that solid substances interfere with the formation of flame and that flame injures solid substances with which it comes in contact, he brings forward an hypothesis to account for the phenomena. According to the electrical hypothesis, which Mr. Siemens prefers, flame is the result of an infinite number of exceedingly minute electrical flashes, the flashes being due to the exceedingly swift motion of gaseous particles, and a solid body which opposes itself to these flashes is cut by them, whilst, the motion being more or less arrested by the solid body, the flame is damped.

Another important deduction from these investigations is that combustion should be considered in two stages or periods, which may be respectively called active and neutral. In the first the purely chemical combination of the gases takes place, during which, as soon as the temperature of ignition has been reached, the whole of the heat of the highest possible intensity is produced, of which a large portion is given off by radiation, whilst in the second the temperature having fallen in the proportion of

the heat given off by radiation, the remainder of the heat which is no longer of an active character, is best transmitted by conduction. For the purpose of utilising this portion of the heat, as well as for raising the temperature of the gas and air before combustion, the regenerators are requisite which form an essential feature of all furnaces worked at an intense heat on the Siemens principle, care being taken to design the furnace so that the gases shall have combined perfectly before the products of combustion are allowed to pass away.

Mr. Siemens in applying his investigations to practice insists that flame must not be allowed to impinge upon bodies to be heated, but must simply heat the bodies by radiation, and furnaces must be so constructed as to allow the flame to develop out of contact, not only with the substance on its bed, but with the walls and roof of the furnace itself; it thus follows that large furnaces must replace small ones, and to meet the objection that the loss of heat into the atmosphere must increase in the proportion of the area of the furnace, Mr. Siemens explains that the heat developed in the furnace increases in a much larger ratio than its increase in area, because flame radiates in every direction from every portion of its entire volume, while a solid substance radiates from its external surface only. The details of construction of metallurgical and glass furnaces and of steam-boilers are given in the paper in question, and need not be considered here; the main point is that furnaces heated on the radiation principle have been proved both in Dresden and at Landore to have been economical of fuel, whilst the saving in the materials treated from reduced oxidation and in the construction of the furnace has been found to be very great.

There is another point of view of this important question which is daily demanding and commanding more attention, and that is the abatement of the smoke nuisance. As is well known, smoke is but incomplete combustion, and the only way to get rid of it is not to produce it. Mr. Siemens insists that this can only be effected by not permitting flame to touch any substance whatever so long as it exists in the active condition; for, just as carbon is precipitated upon a glass rod put into an ordinary gas flame, so is it with any flame whatever its temperature; but the greater the difference of temperature between the flame and the body brought into contact with it the greater will be the amount of smoke produced. Mr. Siemens tells how in Dresden he succeeded in extending his works, without the production of smoke, by the application of the system of heating he recommends, and trusts that here also not only may smoke be abated, but that the public may also derive benefit by manufacturers being able to supply goods at cheaper rates owing to being able to economise their fuel and the material heated within the furnaces as well as that of which the furnaces are constructed.

THE PRIME MERIDIAN CONFERENCE

THE greatly extended and ever increasing intercourse, both commercial and scientific, which has grown up between different nations in modern times has naturally caused especial attention to be drawn to the question of assimilation of the different systems of reckoning employed. Weights and measures and money have been already dealt with more or less successfully, but always with steady advance in the direction of unification. More recently, and in like manner because of practical difficulties and inconveniences, unification of the methods of counting longitude and time has in its turn become a question pressing for solution by the establishment of some international agreement in regard to all matters relating thereto.

The subject became first systematically discussed at the Conference of the International Geodetic Association

held at Rome about a year ago, and the recommendations then formulated have since been further considered at a special International Conference recently assembled at Washington, the delegates at which, in some cases scientific men, in others the ambassadors accredited to the United States, were instructed by their respective Governments specially for the settlement of the questions of a prime meridian and universal time. Their final recommendations on the principal points involved are now before the world.

Unlike the related question of weights and measures, that of time becomes to a great extent simplified by the circumstance that no assimilation of units is necessary, since in the reckoning of time there exists one natural unit which already all nations alike employ, that of the solar day, divided in all centres of civilisation into twenty-four hours, each hour into sixty minutes, and each minute into sixty seconds, and reckoned generally from midnight to the midnight following. In the business and concerns of any single centre no anomaly arises, but if we travel to the east or west of our centre, say from Greenwich, we change—not our manner of counting time—not our unit—but only the zero from which we begin to count, that is, midnight in our new position will occur at a different absolute time. Thus midnight at Paris occurs nine minutes of time before midnight at Greenwich, and this difference between the natural time of the two places is their difference of longitude.

The practical navigator carries with him charts on which longitude is marked as reckoned from some particular meridian. Whilst some nations use the Greenwich meridian, others employ that of their own capital city or observatory, so that longitudes become differently reckoned on the charts of different nationalities. This, as regards practical navigation and in many questions of geography, was one inconvenience.

For many years all clocks throughout Great Britain have been regulated to Greenwich time. This causes no appreciable inconvenience in other parts of the country, because, on account of its small extent in the easterly and westerly direction, the natural time at any place (as referred to the sun) differs so little from Greenwich time that no violence is done to our conceptions of morning and evening as referred to the clock, whilst the advantage of having one standard time throughout the country is, in these days, enormous. Similarly the time of Paris is used in France, and so on. In the United States of America a more natural division into sections has been made, each having its own standard time, about which we shall have more to say further on. The standard time thus used throughout each particular country or section of country, whilst satisfying entirely internal needs, fails, on account of the difference existing between the standard times of adjacent countries, to meet international requirements, not only in questions of scientific interest, but also in matters commercial. The standard time counted in any district must continue to regulate its civil affairs, but for the efficient control of those of international concern, such as the railway, telegraphic, postal, and steamship services, an extension of the same principle to the whole globe by the establishment of some system of universal time, for use in conjunction with local standard time, became very desirable, for although such universal time could not be suitably employed in the ordinary way, the importance of its adoption in matters of international interest had become abundantly apparent. One other point. In civil affairs the day is counted from midnight, whilst astronomers count from the noon following, rendering troublesome conversions from one system to the other frequently necessary. These were other questions requiring consideration.

Clearly therefore the time had come for promoting a better understanding on points of this kind. The recommendations of the Roman Conference briefly stated

were, that the initial meridian should be that of Greenwich, corresponding to the point midway between the piers of the Greenwich meridian circle, since such meridian fulfilled all the requirements of science, being already that most used and best likely to be generally accepted; also that longitude should be counted from the meridian of Greenwich in one direction only, from west to east, that is to say, the longitude of Berlin would be *oh. 54m.*, and that of Dublin *23h. 35m.* The Conference further recommended, for purposes for which universal time would be convenient, that the universal day should commence at mean noon of Greenwich time, and be counted from *oh.* to *24h.*, as was proposed in America in the year 1879 by Sandford Fleming and Cleveland Abbe, a proposition which had received the support also of well-known astronomers. It may be added that a proposition to assimilate the astronomical day with the civil day, and adopt it as the universal day, being scantily supported, was lost.

So far as regards the Roman Conference. Their proposals served to indicate the points requiring consideration, so that, attention having been thus directed to the whole question during the year since elapsed, the delegates attending the recent Washington Conference had full opportunity of forming deliberate opinion thereon. We are not yet in possession of the full discussions of the Conference, but we know their decision on all essential points. The recommendation of the Roman Conference that the meridian of Greenwich should be the universal prime meridian was confirmed. But on the question of reckoning longitude the Conference resolved that it should be counted from Greenwich in two directions up to 180° , the east longitude to be *plus*, and the west longitude *minus*, in this particular departing from the recommendation of the Roman Conference. The Washington Conference also disagreed with the resolution of the Roman Conference in regard to universal time, declaring the universal day to be the mean solar day to commence for all the world at the moment of mean midnight of the initial meridian, coinciding with the beginning of the civil day, and to be counted from *oh.* up to *24h.*, a proposition which, as already mentioned, had been debated at the Roman Conference. Protocols were approved which will be made the basis of an international convention fixing Greenwich as the prime meridian.

Practically, therefore, the recommendations are:—

- (1) That the prime meridian be that of Greenwich.
- (2) That longitude be counted from this meridian in two directions up to 180° , calling east longitude *plus* and west longitude *minus*.
- (3) That the universal day be the Greenwich civil day, commencing at midnight and reckoning from *oh.* up to *24h.*

After full discussion at two Conferences we may believe that, regarding scientific requirements on the one hand and practical considerations on the other, the conclusions arrived at are the best which, under the circumstances, were possible. We may now proceed to consider in various ways their practical bearing.

First, as affecting matters nautical and geographical. By the adoption of Greenwich as the prime meridian (which, if that of any one place were to be selected, was clearly from its extensive use the one which had by far the strongest claim to consideration), and by the retention of the system of counting longitude east and west up to 180° , all British maps and charts (already extensively used by most other nations) and all tables of longitude as hitherto prepared remain still in harmony with the recommendations of the Washington Conference. And since foreign nations thus so largely use charts which refer to Greenwich, the use of this meridian is likely in time to become universal. This being so, some labour of calculation might also be saved, for, considering that large portions of the existing astronomical and nautical

ephemerides of different countries are prepared mainly for the purposes of navigation, and that these ephemerides are calculated generally for different meridians, should charts on which longitude from Greenwich only is counted come into universal use, such separate calculation would become unnecessary. A certain uniformity has already been arrived at, our own *Nautical Almanac*, the American *Ephemeris*, and the German *Nautical Almanac* being all alike calculated for the Greenwich meridian, with the result, however, that now a mass of information for navigators—practically identical information—is repeated in three separate works. This hardly saves labour, and it seems not unreasonable to suppose, as regards the needs of navigators, that one book might in some way be made to serve for all.

It may be remarked that the counting of longitude in both directions up to 180° instead of continuously from 0° to 360° has, as regards navigation, advantages. Because, when counted in both directions, a navigator or traveller, in journeying round the world and changing his reckoning of longitude from east to west, or from west to east, as the case may be, at the same time that he makes the change of one day in his date (of course somewhere near the 180th degree of longitude) will always correctly produce the Greenwich date, necessary when the *Nautical Almanac* has to be referred to, by simple combination of his local time and longitude, whereas if longitude be reckoned from oh. to 24h., and the navigator makes, as before, the change of one day in his date in the usual way at or near the 180th degree of longitude, which he must do if his date is to be in harmony with that of the countries which he will next approach (America if voyaging east, Australia if voyaging west) it will be necessary, when between longitude oh. and 12h. west, after subtracting the longitude (always east) from the local time, to further add one day, in order to produce the correct Greenwich date. It will be understood that a chronometer, though showing Greenwich time, does not indicate the *day*, only hours and minutes, &c., so that a voyager has to depend for the correct Greenwich date on his own numeration of days and a proper consideration of his longitude.

Then as regards the question of universal time, first in relation to our own country. Greenwich mean solar time, or Greenwich time reckoning from midnight and counting from oh. to 24h., being adopted as the international universal time, is such as is shown on all railway clocks throughout Great Britain, excepting that the railway clocks require twelve hours to be added to their indications during the afternoon hours, that is, 1h. railway time is 13h. universal time, and so on. Thus the time of any circumstance or phenomenon occurring in Great Britain will be properly given in universal time by dropping the suffix a.m. or p.m., and in the afternoon adding twelve hours. October 20, 9h. a.m., and October 20, 3h. p.m., become in universal time October 20, 9h., and October 20, 15h. But independently of this the counting of hours from oh. to 24h. is desirable also in civil affairs generally as being in itself explicit, and rendering unnecessary the distinguishing a.m. and p.m. If clocks, when convenient, were constructed so as to indicate hours in this way, instead of counting from oh. to 12h. twice over, it would tend to familiarise people with the 24-hour system without at all forcing its use; or the division into twelve might be retained in clocks and watches, and two sets of hour figures engraved. The use of the system will, however, extend on account of various practical advantages. The plan could be introduced with benefit into railway time-tables, especially those dealing with long routes, in which the distinction between morning and afternoon is far from explicit. Morning hours would be 0, 1, 2, &c., afternoon hours 12, 13, 14, &c.

In other countries in which, as in England, the standard time employed is that of some one city or observatory,

such time similarly reckoned from midnight, and counted from oh. to 24h., would be used for all internal affairs. But to give the epoch of any occurrence in universal time it would be necessary to subtract from the time noted the longitude east from Greenwich of the city or observatory whose time is used, or add thereto the longitude west.

Whilst it is absolutely necessary for the regulation of the internal affairs of a country that the time of one meridian should be employed throughout, as in Great Britain, it is also important that the time so used should not be violently out of joint as it were with the natural day. In our diminutive Great Britain no inconvenience arises, as has been mentioned; but in America, owing to the vast extent of the country in an easterly and westerly direction, it becomes necessary to make some arbitrary division. The railway companies of Canada and the United States, for regulation of the time on railways, have solved the difficulty in the following way:—Four different meridians being selected, those of 5, 6, 7, and 8 hours west of Greenwich, four separate districts are created, in each of which the time of one of these meridians is employed. By this means a great step in the unification of time has been made, because on this plan the minutes and seconds in each district are the same as the minutes and seconds of Greenwich time, and also therefore of universal time, the actual universal time in each district being at once found if required by simply adding 5, 6, 7, or 8 hours respectively to the local standard time.

But it may be asked, if the surface of the earth be divided into districts counting in each, for use in civil affairs, the time of some particular place or meridian contained therein, what is the particular need of universal time? The question has been already touched upon; but let us illustrate. A telegram received at a telegraph office in India in the afternoon for transmission to London would arrive in the morning, according to the local time reckoned at these places. Is there nothing here that for some considerations it might not be desirable to arrange differently? Would it not be useful to have the power of indicating universal time in conjunction with local time, if necessary? And so also in other affairs. And in matters of science, especially the observational sciences, the introduction of universal time for use when required would be in many ways beneficial. When an astronomer has gathered together for discussion a long series of observations of, say, a new comet, made perhaps at many different observatories, one of the first things that he has to do is to reduce the times of observation to that of one meridian. Again, observations of solar and other physical phenomena cannot be properly collated unless the times are reduced to one standard. Or, in magnetism, on the occurrence of a great magnetic storm, how much would the comparison of the records obtained at different places be here also facilitated by the use of universal time?

There might be some disinclination as regards fixed observatories to give results in universal time, because of the fractional difference of longitude. But in civil affairs, admitting the practicability of adopting the system inaugurated in America, of forming districts and employing as local standards of time secondary meridians distant from Greenwich by integral numbers of hours, as before described, the indication of universal time in conjunction with local standard time becomes a matter of great simplicity. Objection may be made to the system because of the variation, amounting to half an hour, which would exist, between the natural day and the clock time employed, at the extreme borders of the districts so formed, but the Greenwich time long used in Cornwall differs (without reckoning the effect of the equation of time) twenty-three minutes from the natural time without inconvenience arising. Indeed, taken in conjunction with what has been done at the Washington Conference, the

scheme is, outside of the Conference, the first really scientific step that has been taken in the practical unification of time throughout the world. Whether the number of meridians might be doubled is perhaps a question, but, as it stands, the scheme is extremely simple. For since the minutes and seconds counted in the several districts are the same as the minutes and seconds of Greenwich or universal time, the mere addition of another hour hand to the clocks in common use, placed in the proper position and travelling with the ordinary hour hand, would enable either local standard time or universal time to be read off at pleasure from the one clock. The ordinary hour and minute hands might be black and the additional hour hand of a lighter colour, in which way sufficient distinction would be produced. Such clocks should show hours from 0h. to 24h. Or the conversion might be made in other ways. Referring to the American division before described, all entries might be distinguished as "local standard time," and a precept added to indicate that, to obtain universal time, 5, 6, 7, or 8 hours must be added, as the case may be. Or denoting the times as "standard times on the 5th meridian west," &c., the variation from universal time is at once shown. The reader will probably now have grasped the special merit of this system, the readiness with which either local time or universal time can be together indicated.

It may be interesting to show how the American plan of division into districts defined by hourly meridians would work if applied generally to the countries of the world. A scheme in regard to some of these countries is herewith annexed.

Countries	Longitude from Greenwich of meridian to be employed for local standard time	Local time at which universal date changes
Great Britain, France, and Spain	0h.	Midnight
Norway, Sweden, Germany, Austria, and Italy	1h. east	1h. morning
Western Russia, Turkey, and Egypt	2h. ,,	2h. ,,
Western India	5h. ,,	5h. ,,
Eastern India	6h. ,,	6h. ,,
Western Australia	8h. ,,	8h. ,,
South Australia	9h. ,,	9h. ,,
Victoria, New South Wales, and Queensland	10h. ,,	10h. ,,
New Zealand	12h. ,,	Noon
California	8h. west	4h. evening
Eastern America (Washington)	5h. ,,	7h. ,,

In east longitude decrease, and in west longitude increase, the local standard time by the hours of longitude to obtain universal time.

The scheme in fact resolves itself into adopting in any country the time of the nearest integral hourly meridian. Russia would become divided in some such way as America. In each case the minutes and seconds of local standard time would be similar to those of Greenwich or universal time, change of the hour, according to the precept given at the foot of the table, converting the local standard time at once into universal time. We are quite aware that a scheme of this kind can scarcely be expected yet to take practical shape, but it seems well to point out generally the direction in which with the least inconvenience a satisfactory solution of the problem of counting universal time in conjunction with local time may be possible.

The right hand column of the preceding table indicates, in regard to the universal day proposed by the Conference, the hour of the local civil day at which, in the several districts, the universal date would change, the civil date of course changing at midnight. It will be remarked that in all countries in east longitude as far as Australia, the

change of universal date (following that of the same civil date) takes place generally in the morning hours, before the business hours of the civil day, the universal and civil dates being then in accord until civil midnight. In America the universal and civil dates are in accord from civil midnight until towards the next evening when the universal date changes (before change of the same civil date). In all these cases the change of universal date occurs at an hour well away from business hours. Only in New Zealand would there be inconvenience, the change of universal date occurring at civil noon, twelve hours after change of the same civil date. Knowing approximately the local time at which the universal date changes, a clock fitted with an additional hour hand in the way described would indicate at once the precise time of change.

The resolution of the Washington Conference further expresses a hope that as soon as practicable astronomical and nautical days may be arranged everywhere to begin at mean midnight, which would simplify any desired conversion into the proposed universal time. Passing by the nautical aspect of the question we may remark, that astronomers as a rule count their mean solar day of twenty-four hours from noon, commencing twelve hours later than the civil day of the same date, and the day is thus understood in all published observations and astronomical works. There is another consideration, somewhat fanciful perhaps, that astronomical observations being taken mostly at night it seems objectionable to make a change of date at midnight in the middle of a series of observations; but this carries now with it much less weight since attention to solar phenomena has so increased observation by day. It was perhaps felt at the Conference that the local civil and astronomical days should correspond as a matter of convenience in itself, and as simplifying the relation of both with the proposed universal day, thus promoting the use of the latter as might become convenient, either in civil or scientific affairs. To effect such correspondence, one of the days had to be altered, but since any proposition to change the local civil date at noon could not be seriously entertained, it was better that the astronomer should assimilate his day with the civil day. Indeed it was formerly the practice in France to employ the astronomical day, commencing at midnight, in the construction of planetary and lunar tables.

The proposed change in the time of commencement of the local astronomical day will involve some present awkwardness from the circumstance that the different astronomical ephemerides are calculated for astronomical time as hitherto reckoned, in addition to which our own *Nautical Almanac* is prepared several years in advance. Temporary inconvenience more or less there must be, but the new reckoning, when fully established, will be found to possess some distinct advantages. As concerns the Royal Observatory at Greenwich, the Astronomer-Royal proposes to adopt the recommendation of the Washington Conference by commencing on January 1 of next year to count the astronomical day from the midnight preceding the nominal civil date, thus bringing the Greenwich astronomical day into correspondence with the Greenwich civil day, which is the universal day of the Conference; he proposes further to alter the indication of the public clock at the entrance gate of the Observatory, so that 0h. of the clock shall also commence with midnight: all being counted from 0h. to 24h. The time reckoned within the Observatory and that shown on its external wall will then be in accord. So far the astronomer. If, in addition, the civilian would relinquish the use of the confusing a.m. and p.m., and instead count the hours also from 0h. to 24h., beginning with midnight, all parties would then be using the same system for reckoning both days and hours of the day.

WILLIAM ELLIS