

paring favourably with Pennsylvania bituminous coal, and as anthracite is also met with, the investigation was directed to determining the boundaries of the various coal-fields and to ascertaining the ages of the various coal horizons. The occurrence of gold- and copper-bearing rocks is also recorded.

The investigations of structural materials begun in 1905 has been continued, and a valuable report on Portland cement, mortar, and their constituent materials has been drawn up by Mr. R. L. Humphrey and Mr. W. Jordan (Bulletin No. 331).

The work of the survey includes investigations of underground water, and in order to furnish trustworthy information on general principles, Mr. M. L. Fuller has drawn up a very instructive summary of the controlling factors of artesian flows (Bulletin No. 319). The term "artesian" is applied in the sense adopted by the survey, namely, to designate the hydrostatic principle by which confined waters tend to rise in virtue of the pressure of the overlying water-column, whether or not this pressure is sufficient to lift the water to the surface and to produce a flow.

Lastly, there is the work of the mining division of the survey. The outcome of the work, a volume of 1307 pages, contains the report on the mineral resources of the United States for 1906. Much of the information given has already been published as advance chapters. Suffice it to say that the year 1906 was by far the most prosperous ever known in the mining industry of the United States. The total value of mineral products amounted to 380,000,000., an increase of more than 15 per cent. over the value of the output in 1905. Compared with the previous volume of the series, noticed in NATURE (vol. lxxvi., p. 257), several changes are apparent. The smaller type, which was tiring to read, has been abandoned, and several new names appear as the authors of the various chapters. This is in pursuance of the policy of the new director of the survey of assigning all subjects to members of the survey who are employed solely in the Government service. This has doubtless been conducive to economy, but there is the loss of the authority given to the reports by the signatures of such experts of world-wide reputation as Mr. James M. Swank, Mr. Charles Kirchhoff, Mr. John Birkinbine, and Dr. George F. Kunz. The annual reports of the last-named authority on precious stones were works of originality and of great literary charm, whilst the report on precious stones in the present volume is an arid catalogue of facts. The reports on gold, silver, and quicksilver are more successful, the technical knowledge of the authors as mining geologists serving as compensation for their lack of experience in statistical work.

The reports reviewed in this article cover 2239 pages. It has, therefore, obviously been impossible in the space available to do more than indicate briefly the nature of their contents in order to induce those interested in the various branches of economic geology dealt with to peruse the original reports, which will well repay careful study.

THE SYNCHRONISATION OF CLOCKS.¹

THE hon. secretary of the British Science Guild has sent us a copy of a report on the synchronisation of clocks which has been adopted by the executive committee, and is here reprinted. Steps are being taken to carry out the recommendations contained in the report.

The committee wish, in the first place, to direct prominent attention to the fact that a very large amount of most excellent work in the matter before the committee has already been done by the General Post Office in disseminating standard time in London and large provincial towns, and also to outlying districts in Great Britain, though in the latter case the arrangements, perhaps, are not quite so perfect as in the large towns.

They also wish to state that private companies, like the Standard Time Company, Ltd., are doing excellent work in the same direction in London and its neighbourhood. They are, however, of opinion that much more has still to be done before London and other parts of the country can

¹ Report of a Committee of the British Science Guild on the subject of the synchronisation of clocks in London, and in other parts of Great Britain.

be said to be in a satisfactory condition as regards the time shown by its public clocks, and they consider the time has come when public action is urgently demanded.

Greenwich mean time is of course recognised as the standard time for the whole of Great Britain, and this time emanates from the mean solar clock at the Greenwich Observatory.

The problem, therefore, is solely how to make this time available throughout the country in the widest and easiest manner possible, and at the lowest possible cost to the State or public, and also so as not to interfere in the slightest degree with any telegraphic or telephonic services at present in use.

The present arrangements as to the dissemination of this time in London and elsewhere may, perhaps, be described with sufficient accuracy as follows:—

Greenwich mean time signals are transmitted at the sixtieth second of each sixtieth minute day and night to the General Post Office, London, and daily at 10 a.m. to every telegraph office in the kingdom, when the signal then sent from the mean solar clock at Greenwich Observatory is received at the Central Telegraph Office in London upon apparatus which is known as the chronopher, the function of which is to distribute automatically the signal to the larger provincial telegraph centres.

By means of a clockwork arrangement, electrically controlled by a regulator clock, the telegraph lines are disconnected from their respective telegraph instruments and are joined to the relays of the chronopher at two minutes before ten, in readiness for the signal from Greenwich. The time current passes exactly at ten o'clock, and the normal connections are restored by the clockwork at two minutes past ten.

From the large centres the word "ten" is signalled to all the small towns and villages.

In London "nine" is signalled to all London offices connected to what is known as the "main inter-communication switch" in the Central Telegraph Office, and an hour later, when the "chronopher" signals "ten" o'clock time to provincial offices, "ten" is also signalled to the remainder of the London telegraph offices.

From the Post Office the public may in London, by arrangement and by paying a certain annual sum, obtain the hourly Greenwich mean time signals.

In other cases, one or other of two daily signals, at ten o'clock and at one, can be sent to places in the provinces, but the number of private subscribers for such signals is relatively small.

At present the signals from Greenwich sent *via* the Post Office only give the indications of the exact time by sounding bells or deflecting needles, and are not generally utilised to influence individual clocks or to control them, it being left to the individuals in charge of such clocks to make use of these signals, and to set their clocks accordingly.

It is at this point that much is to be desired in the present arrangements, for there is no doubt that many clocks are not as accurately set as they should be.

In addition, these time signals are communicated, amongst others, to private companies like the one previously referred to, and this company, or similar companies, make it their business automatically to re-distribute them to their subscribers in such a way that the electrical signals actually set the clocks of the subscribers to the correct standard time at the moment of each signal.

It would appear, therefore, that there is no general system by which the public is provided with the means of getting exact standard time, such as would be the case if there were an arrangement by which time balls in prominent positions could be electrically dropped, or time guns fired at any fixed hour. In the case of London, the area to be covered would prohibit any such treatment of the case.

The committee are strongly of opinion, and think it highly desirable and important, that arrangements should be made so that a number of public clocks in different districts of London and in other large towns, and perhaps the clock at a telegraph office in smaller towns and villages, should at certain hours be *automatically* corrected to agree with the true standard or Greenwich mean time, and that these clocks should be known as standard clocks, and be thus marked or labelled.

The committee examined the point as to whether even the best of clocks could be depended on always to show true standard time, and, after full discussion, decided unánimously in favour of some form of control of public clocks by electric synchronisation by signals from the central time authority, and decided that the control and correction of such public clocks by hand is quite out of date and untrustworthy, and should be abolished.

The committee are given to understand that arrangements exist by which, given an electrical signal at certain specified hour or hours of the day, the hands of a clock can be automatically set to indicate the absolutely correct time, and they also understand that such arrangements can be applied to existing clocks at a very small cost.

The committee are informed that there are several distinct methods of synchronising public and other clocks.

In one, used in connection with large clocks, a slight gaining rate of the pendulum is compensated by arresting the clockwork, by means of the time signals, for the number of seconds or parts of seconds gained since the previous synchronisation.

In another method, applied to smaller clocks, the hands are mechanically set forward or backwards to standard time by an electromagnet, excited by the time signals.

It would not be difficult to provide for clocks automatically to come into circuit on telephone and private wires at stated intervals, in order that the time currents might affect the electrical controlling devices of both types referred to above, if this were thought advisable.

The utilisation of telephone and private wires used for correspondence for the synchronisation of clocks would naturally involve the suspension of their use for conversations during the short periods that they would be connected to the electrical controlling devices at the hours at which the time currents were due.

The system involves, therefore, first of all, a system of wiring for the electric signal; and, secondly, the necessary apparatus in each clock. The cost will evidently depend on the charge for the signals, the charge for the use of the wires and of the apparatus in the clocks. The first and last will be small, and the second will depend on the rate per mile charged for the use of wires.

It is obvious that as such a system for communicating electric signals already exists in the telegraphic and telephonic wires belonging to the Post Office, it would be quite unnecessary to set up an independent system of wiring for the time signals. If this is accepted, and if the synchronisation of public clocks becomes general, it is obvious that such signals must not be sent too often, and that they must be sent at a time when such wires are more or less free from the ordinary traffic. It would appear to the committee that for most purposes a single automatic signal once a day, at some convenient time of the night, perhaps at 2 a.m. or 3 a.m., would be enough, but if greater accuracy were desired more frequent signals could be made. If found necessary, signals might even be sent twice or three times a day to synchronise clocks, such as at 8 a.m. and 8 p.m., or, in addition, at 2 p.m., when in the early morning and evening the wires would certainly not be overburdened with work, but such details could be considered later on.

The question of the public or private distribution of such signals was briefly discussed, and the committee considered that any recommendation on this subject would be out of place, but they would merely point out that the initial signals giving true time must come from a public source, *i.e.* Greenwich Observatory, and there is little doubt such signals must be mainly transmitted by the wires of the General Post Office, though perhaps it is an open question whether the apparatus in the clocks themselves for utilising such signals should be a public enterprise or be done privately.

As a beginning, it would probably be well to take a few large public clocks in London and have them synchronised, and these could then be set apart and considered as "standard time clocks."

The nearest approach to a standard time public clock in London at present is probably that in the Clock Tower at Westminster. From the report of the Royal Observatory, Greenwich, read at the Annual Visitation on June 8, it would appear that the maximum error of "Big Ben"

during the preceding year did not exceed three seconds, except on two occasions. This may be accepted as sufficiently accurate for ordinary purposes.

Many other public clocks, on the other hand, constantly show variations, running to minutes, and such clocks clearly should be electrically synchronised as far as possible.

Clocks like that at the General Post Office in St. Martin's-le-Grand, at the Royal Exchange, and others in large public buildings should, it is submitted, be *automatically or electrically synchronised*, and be considered as "standard time clocks." A few of them might be taken up as a commencement, and synchronised once or twice a day.

As most public clocks have no arrangement for showing seconds, the exact time to seconds cannot be shown on them, but as most public clocks are striking clocks, it might be arranged that the first stroke of the hour bell should be the signal indicating standard time, so that persons could tell the time accurately to a second from such signal.

It remains, therefore, to consider what can be done in the case of London in the first instance.

The following would appear to be the actions necessary to be taken by the Guild:—

- (1) To approach the Postmaster-General, to ask that in the case of post offices the time signals sent to the offices should actually automatically set at least one of the clocks in each public office to standard time, and not merely indicate standard time and depend upon subsequent hand correction of the clocks, as at present.
 - (2) To form a deputation to the L.C.C. to ask them to have all public clocks under them, or in any way under their influence, synchronised in the same way.
 - (3) To take similar action with reference to the clocks under the control of the Corporation of London.
 - (4) To take similar action with reference to the clocks at railway stations in London.
 - (5) To take similar action with reference to the Office of Works, which it is believed is responsible generally for the clocks in Government departments, some of which exhibit large clocks, and which, therefore, should be synchronised.
 - (6) To ask the Local Government Board to take the necessary steps to secure the passing of a bye-law calling upon persons exhibiting clocks publicly to have such clocks synchronised, or, failing this, for such clocks to be done away with.
- Similar action could be taken later on for provincial towns, and afterwards for smaller centres in Great Britain.

EDUCATION AT THE FRANCO-BRITISH EXHIBITION.

UNDER the chairmanship of Sir William Mather, the committee of the Education Section of the Franco-British Exhibition undertook to exhibit to the British public and our French visitors the principles and methods of our national education in all its branches and phases. So formidable a task has not been attempted heretofore in this country, and a very large amount of well-directed labour must have been spent in achieving such a great measure of success. We shall have occasion to point out certain respects in which the results fall short of the ideal; but the more closely one investigates the exhibits, the more one marvels at the thoroughness with which the display has been organised. The nearest approach from the Wood Lane entrance is through the hall of textile and chemical products, whence we enter the west end of the building (300 ft. x 200 ft.), devoted to British and Irish education. The chief decoration is a series of pleasing frescoes forming a deep frieze along three sides of the hall. These depict in allegorical form the virtues which schools seek to develop, and all have been designed by students of the Royal College of Art. We may mention that all the exhibits—with the exception of statistics and a few other administrative matters—are the work of children, students, and teachers, from the infant school to the University or technical college. The west wall is occupied by colossal maps showing the exact position of every public educational institution in the British Isles, with panels of statistics.