Art. LV.—*On New Zealand Mean Time, and on the Longitude of the Colonial Observatory, Wellington; with a Note on the Universal Time Question.*

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[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

(A.) New Zealand Mean Time.

The public attention which has been given of late to the international movement in favour of the adoption of what is known as the universal or standard time system—an extremely convenient scheme for co-ordinating the various clock-times of the world—seems to make it worth while telling how New Zealand settled the question of time-simplification for herself before any proposals for a change had begun to be agitated elsewhere. It is not as commonly understood as it should be that, in arranging a time-reckoning for her own use, this colony as early as 1868 fixed upon practically the very principle which was afterwards embodied in the reform in question, and that she was thus, apparently, the first country in the world to take up the improved system.* It is one of the purposes of the present paper to explain how this came to pass.

The question has once before been before this Society, for at a meeting held on the 12th October, 1868, it was dealt with by Dr. (now Sir James) Hector in a paper which will be referred to presently.† But that was a good long while ago, and in the interval which has elapsed the inevitable oblivion has overtaken the work of those early days. Yet the action of our colony in this matter is not without a certain modest importance for us; and, as the recent progress of the reform in other countries has lent the subject an interest wider than that which it could originally claim, I venture to hope that in discussing it now I shall not be considered open to the charge of needlessly reviving an old story.

In the first stages of the colony's existence, and for a considerable period afterwards, no special need was felt for a general system of time-observance. Each district seems to to have kept the approximate local mean solar time of its

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* See "The Observatory" for July, 1901, vol. xxiv., p. 291, paragraph on "The Time of New Zealand."

† "On New Zealand Mean Time" (Trans. N.Z. Inst., vol. i., p. 48; second edition, p. 451).

principal town (or of some other place which was judged more suitable) without reference to the times adhered to in other districts, and we thus had four distinct times. This worked well enough for many years. When communication between the different parts of the country was slow and our over-sea trade was carried on chiefly by means of sailing-vessels, the inconvenience arising from diversity of times was scarcely appreciable. But with the acceleration of the colony's coastal carrying services, with the introduction of steam navigation between Australian and New Zealand ports, and, above all, with the rise of our railway and telegraph systems, the case was altered. By the middle "sixties" it was realised that some more uniform plan was essential. The question was discussed at intervals without action immediately resulting; but at last, in 1868, Dr. Hector was asked by the Government to submit proposals for a standard time suitable for use throughout the whole colony. The subject of time reform had before this engaged his attention. In 1860—at the close of his exploration-work in the Rocky Mountains and on the Canadian-United States frontier—he had pointed out in a report to the Canadian Government the modification of the existing reckoning which would be found necessary on the long route of the Canadian Pacific Railway. Canada and the United States were ultimately forced by circumstances to adopt this modification.

Under the new system clock-times are made to change by even intervals of an hour on the journey east or west across the American Continent, the minutes and seconds of all clocks, in whatever longitude they may be situated, remaining the same. The United States and Canada were the earliest countries of importance to rationalise their times in this way, and it has been largely due to their efforts that a similar reform has been wrought in other parts of the world. Canada in particular was honourably active in pressing the question upon the attention of Europe.

I do not know if Sir James Hector is disposed to claim that his prediction may have been the germ from which the movement in North America originated; but whether the hint was fruitful or not it would appear as if in point of fact he was first in the field. The earliest advocacy of such a scheme which is reported in the ordinary accounts of the reform was contained in a pamphlet published ten years afterwards by Professor C. Dowd, of Saratoga Springs, who advanced a proposal for hourly meridians, based, however, on Washington time. But the point with which we are now concerned is that in making his recommendation to the New Zealand Government in 1868 Dr. Hector had this sensible principle of hourly meridians in his mind.

For the clear understanding of what follows, a reference to the map of New Zealand is desirable. It will be seen that the colony covers a breadth of about 12° of longitude—from about 178° 36′ east at the East Cape to about 166° 26′ east at the West Cape in the Sounds district, Fiord County. Converting these longitudes from arc into time, we get local times of about 11 h. 54 m. fast on Greenwich at the East Cape and about 11 h. 6 m. fast on Greenwich at the West Cape, a range of a little over three-quarters of an hour. The average meridian is therefore 172° 31′, or nearly 11 h. 30 m. in time.

Again, the meridian which has an equal area of land on either side of it is 172° 49′, the time-equivalent of which is 11 h. 31 m.

Finally, the average meridian of the principal ports is 173° 14′, or in time 11 h. 33 m.

If, then (it was pointed out by Dr. Hector), the mean solar time of the meridian 172° 30′ east, equivalent to 11 h. 30 m. fast on Greenwich, were selected, it would appear to afford the best standard for the colony. This time would be slow on the local mean solar time of Napier only some 17½ m., and fast on the local mean solar time of the Bluff only about 16½ m.; while in the cases of the other ports it would be even nearer to the respective local times. To obtain the local times of the several ports we should have to add or subtract from the time of the suggested meridian the following differences (I give the corrections roughly to the nearest half-minute of time):—

For Auckland	...	Add 9 minutes.
„ Napier ...	...	„ 17½ „
„ New Plymouth	...	„ 6 „
„ Wellington	...	„ 9 „
„ Nelson ...	...	„ 3 „
„ Picton ...	...	„ 7 „
„ Lyttelton	...	„ 1 „
„ Westport	...	Subtract 3 minutes.
„ Port Chalmers	...	„ 7½ „
„ Bluff ...	...	„ 16½ „

"The object being to establish for the whole colony one time the adoption of which would cause the least inconvenience," Dr. Hector recommended to the Government that the 11½ h. meridian should be adopted. In his paper above mentioned he claimed for this plan, *inter alia*, the following advantages:—

First, it is a close approximation to the average longitude for the colony.

Second, longitude 17° 30′ east is 11 h. 30 m. fast on Greenwich; and, being an even number, will be most suitable for the purpose of enabling mariners to compare their chronometer-times with true Greenwich mean time.

Once more consulting the map, we shall find that neither of the two alternative meridians possessing this special advantage for navigators and others is so convenient for the general purposes of the colony. The 11 h. meridian (165° east) falls in the ocean about a third of the distance between Wellington and Melbourne: the 12 h. meridian (180° east) lies at a corresponding distance from the East Coast, well out towards the Chatham Islands. Dr. Hector therefore had no hesitation in putting forward his proposal in favour of the 11½ h. meridian. The Government approved the suggestion, and laid it before the House of Representatives; and on the 31st October, 1868, a *Gazette* notice was published announcing that the House had passed a resolution to the effect that the time 11½ hours in advance of Greenwich mean time had been adopted as the mean time for the colony, and that from the 2nd November, 1868, the public offices of the General Government would be opened and closed in accordance therewith.*

The "Hector" time-reckoning for New Zealand has thus been in force ever since 1868. It is very convenient for all the civil purposes of the colony; it is instantly intelligible to navigators; and its adoption has enabled New Zealand to take her place in the official list of countries obeying the standard time agreement, although that agreement had not been heard of when our Legislature took this action. It may be said that the idea is a very obvious one, and that any country might have arranged to follow it in deciding upon the basis of its time system. This is perfectly true; it is obvious enough—after it has been adopted; but the fact remains that no other country did take it up for something like fifteen years after it had been adopted for New Zealand.

All things considered, the standard bids fair to be the one permanently used by the colony. Admirably, however, as it would appear to answer our needs, suggestions have not been wanting that it should be modified. The contention is that a system based on an exact hour east of Greenwich would be a more complete realisation of the standard time ideal than one having an odd half-hour in its count, and that therefore we ought to make our time either 11 h. or 12 h. fast on Greenwich. Now, it must at once be admitted that, other things being equal, the integral number of hours is preferable to the number which includes the half-hour. The question is whether, for the sake of symmetrical compliance with the letter of the standard time arrangement, it is desirable to upset our system. It appears to me that, except upon very

* *New Zealand Gazette*, 31st October, 1868, p. 505.

clear showing of necessity, it would be unwise for the colony to abandon its standard. What we have to decide is how far the practical convenience for us of our present reckoning should stand against a demand for the somewhat neater appearance which would be secured if we could write our time in almanacs and other publications as either 11 h. or 12 h. fast on the initial meridian. The following points may be submitted for consideration:—

(1.) In a country of moderate dimensions like New Zealand it is desirable that only one clock-time should be observed.

(2.) It is convenient that such clock-time should deviate as little as may be from the actual mean time of any part of the country.

(3.) It is convenient that over the whole country similar clock-hours of business should be observed.

(4.) It is desirable that the time kept for ordinary business and social purposes should be the same as that used for the railway and telegraph services. Yet—

(5.) It is important that our reckoning should, notwithstanding the above, be in harmony with the spirit of the international system which has found such wide acceptance.

All these conditions are fulfilled by our existing system.

As regards the four first, it should be noted that New Zealand has considerable range in longitude. The narrowness of the islands is apt to mislead us on this point. But from the East Cape to the south-west of Otago the trend of the country is markedly westwards. The difference between the longitude of the East Cape and the longitude of the West Cape is greater than the difference between the longitude of the extreme east coast of England and that of the extreme west coast of Ireland. Yet, though Greenwich time (which is the time of a meridian in the east of England) is convenient enough for England and Scotland, Ireland, for her railways and for all purposes except those of the telegraph service, finds it advisable to keep Dublin time, which is twenty-five minutes slow on Greenwich. To put it in another way: The difference between the longitudes of our east and west coasts is about equal to the difference between the longitude of London and the longitude of a meridian running through central Germany. Yet Germany keeps a time one hour fast on the time kept in London.

It follows that if we adopted the even-hour plan we might be obliged to have two standard meridians—the 11 h. standard for the western half of the colony and the 12 h. standard for the eastern half. Or, if only one of these meridians were taken for our official time, we might find ourselves using some local time in that part of the colony which lay too far from

the selected meridian to make the time of the latter suitable for local purposes without some alteration in the nominal hours of business. Or, lastly, if all parts of the colony adhered to one official reckoning—11 h. or 12 h. fast on Greenwich—we might have different clock-hours of business observed in different districts; which, in a relatively small country having close intercommunication, is a nuisance to be avoided if practicable.

New Zealand is not alone in its modification of the integral-number ideal. Other countries have been confronted with the same difficulty, and have overcome it in the same way. Cape Colony, Orange River Colony and the Transvaal keep a time 1½ h. fast on Greenwich. The 1 h. meridian falls too far to the west—out in the Atlantic; the 2 h. meridian is too far to the east: therefore these three countries have compromised in a practical manner by taking the 1½ h. meridian for their standard. (South Australia also keeps a time based on the half-hour principle; but for a reason which I will presently explain I do not cite her as an example to be followed.)

Now, notwithstanding this departure from literal conformity with the hour-meridian principle, the countries which I have mentioned, together with New Zealand, are recognised in all the usual lists (*e.g.*, in that given each year in the "Nautical Almanac") as coming under the standard time agreement. There has been no very earnest attempt amongst leading scientific authorities to induce the countries making use of this modification to abandon it; and it appears to be generally admitted that we are acting reasonably in adapting the system to this extent to the peculiarities of our respective geographical positions. We may claim, then, that the fifth of the conditions advanced above is, like the other four, sufficiently respected by our reckoning. Of course in a certain sense it may be said that it does not much matter what clock-time a country may keep, since ultimately our social arrangements are ruled by the sun. It is conceivable that some day one uniform clock-time will be in force all over the world, so that, while the sun may rise in one place at 6 o'clock, in another it will not rise until, say, 12 o'clock. All I mean to contend for now is that, whilst we keep a clock-time approximating to local mean solar time, the closer the approximation is, consistent with other considerations which must be studied, the better.

But it is sometimes suggested that a reform of the clock should be made for another reason. It is argued that if New Zealand adopted a time 12 h. fast on Greenwich a wholesome change would be effected in our habits. We should all get up half an hour earlier than we do at present,

and retire to rest half an hour sooner. There seems to be here some confusion of reasoning. If we wish as a community to make such an alteration in our actual times of working and resting we can easily do so; but there is no need whatever for tampering with our clocks in the process, so as to make them show that no change in our habits has taken place. The proposal is surely a trifle otiose. If a man wants to go to bed at 10 o'clock instead of at 11 he generally does so without finding it essential to his peace of mind to put on the clock an hour.

Some of those, however, who advocate this modification of our standard for hygienic reasons take rather different ground. They admit that it is absurd to suppose that before we can alter our ways we must gravely perform the ceremony of moving forward the hands of the clock; but they urge that, as people are accustomed to fulfil all their engagements of business and recreation at certain times by the clock, if we can only get them to consent to alter the clock they will continue to keep those engagements at the same nominal clock-hours, thus making earlier by the amount of the change their actual times of working and resting. The argument does not seem to me to be convincing. It is far from evident that our community is quite so subrational in its thinking as the theory assumes. The real point is missed. The question is not whether such a change in our habits is desirable, but whether it is desired by those concerned. If it is desired it will be made readily enough; if it is not desired, depend upon it that those who recommend it will have to wait until they have converted their fellows to their way of looking at the matter. Men presumably now consent to obey the indications of the clock because those indications bear a certain convenient relation to the time *realities* by which they are guided in arranging their lives. If those clock indications are altered, and people do not otherwise seek a change, they will cease to obey them to the extent of the alteration; in other words, they will amend their nominal hours of business so as to make them continue to be the same in actual time as they were before, unless, of course, the alteration in the clock is so small as to pass unnoticed—and that cannot be contended in the present case. It is the sun, and not the clock (a mere measuring-machine), which really determines our arrangements. As Sir Charles Todd, Government Astronomer for South Australia, put it a few years ago: "The name we give to an hour is not of very much consequence. What we do in practical life is to adapt our movements to the duration of daylight."

I have referred above to the case of South Australia. The people of South Australia (unlike, apparently, the people of

New Zealand at present) did desire to make such a change in their habits as our hygienic reformers aim at. They believed that they would be at a disadvantage in business matters as compared with Victoria and New South Wales unless they began business earlier, and they also considered that it would be to their benefit if they had more daylight time for recreation after business hours. Very properly, therefore, they resolved to begin and end their day's work half an hour earlier. But in doing so they must needs carry what one of their own newspapers called their "slavery to habit" to such a pitch as to falsify the clock to correspond with the change. They had originally (in February, 1895) adopted the time of the meridian 135°—viz., 9 h. fast on Greenwich—which correctly enough represented the time of the bulk of their territory; but when they decided upon making the change in question they abandoned this in favour of the time 9½ h. fast on Greenwich (going beyond their eastern border for a meridian), and this time since April, 1899, has been the standard for their State. As a South Australian paper said, "If commercial advantages are to be gained by manipulating the reckoning of time, the question occurs whether our rivals may not seek to keep what they have, and start the colonies on a war of clocks. That would be, indeed, a *reductio ad absurdum*." If one may criticize a neighbouring State, I would express the opinion that just as there is no need for New Zealand to give up the half-hour reckoning, so there was no justification for South Australia adopting such a reckoning. Circumstances alter cases. The half-hour time is correct for us, but in South Australia it meant a departure from correctness, and one for which there was no call, as there might conceivably be if one time for the whole of Australia were proposed.

The believers in the desirableness of a change in the time of New Zealand, *therefore*, are thrown back upon the original argument—namely, that a 12 h. time would represent a more complete fulfilment of the standard time idea; and with this argument I have, I hope, dealt fairly. Of course it is conceivable that at some future time the conditions of the case may be altered; and if there should then be a general and strong feeling amongst European and American reformers that we should take up an integral-hour reckoning (say, the 12 h. one), probably New Zealand would be enlightened enough to comply, and to adapt her arrangements to the change. Such adaptation would most probably take the shape of a corresponding alteration of her nominal times of business and pleasure, and where then would be the gain from the point of view of the health reformers?

What I have tried to prove is that the balance of advantage at present is with our existing 11½ h. reckoning, and that

we are not called upon to abandon this standard unless it can be unmistakably demonstrated to us that our refusal to change will appreciably affect the prospects of the time-reform movement. No attempt to show this has, so far as I am aware, been made, and reformers generally seem to acquiesce in the compromise which we, in common with the three South African colonies referred to, have been led by circumstances to make.

(B.) The Longitude of the Colonial Observatory, Wellington.

The subject of New Zealand standard time naturally leads to the cognate subject of the longitude of the standard meridian of the time-service, or, in other words, of the longitude of the Wellington Observatory. This already has a voluminous literature of its own; but the details are scattered over so many parliamentary reports and past volumes of the "Transactions of the New Zealand Institute" that it will be useful for purposes of future reference if the essential facts are brought together in one paper.

Before dealing with the question of the longitude, perhaps I may be allowed to give a few particulars about the Observatory and its origin. The present Wellington Observatory was established in 1869 as a result of the decision of Parliament to institute one uniform time for the colony. It is a time-service observatory pure and simple, and therefore structurally it is of but modest proportions, consisting merely of a transit-room and a clock-room. Its equipment, however, is of the best, and entirely sufficient for the purpose. The transit instrument, of $2\frac{3}{4}$ in. aperture and 32 in. focal length, is an excellent one by Troughton and Simms. It is substantially mounted in the usual way on a pyramidal brick pier resting on a solid foundation of rock, and is duly isolated from contact with the building and carefully protected from surface tremor. The meridian-mark is a 3 in. iron pillar, deeply set in concrete, standing about 6 ft. high on the sky-line of the Tinakori Range, a sufficient distance to the northward, near Wadestown. There are four fine clocks —one of them a sidereal clock, and the other three mean solar time clocks. They are mounted on brick and cement bases, and are fastened to substantial timber frames stayed by steel rods to prevent disturbance of the adjustments. They are good time-keepers; and, as there are three mean time clocks, by a combination of the rates practically true time can always be given, even when bad weather stands in the way of observations. The sidereal clock, by Dent, is provided with a magnetic chronograph by the same

maker. One of the mean time clocks is also by Dent, and is an instrument of the same class as the sidereal clock, with zinc and steel compensation. A second mean time clock, by Moore, of Clerkenwell, has a mercurial compensation; and the third mean time clock, by Moore, is the one which drops the time-ball and sends signals to various parts of the colony. This clock is fitted with an electro-magnetic apparatus which enables the clock to signal time automatically every hour to certain places in town (the Museum, the Telegraph Office, and the shops of the leading watchmakers) and to drop the time-ball on Waterloo Quay at noon each day. The same clock is frequently placed in direct connection with the telegraph offices at Lyttelton and Port Chalmers, and thus signals true time, without human intervention, for the use of navigators at those ports. If the time-balls at Lyttelton and Port Chalmers—and, indeed, the one at Auckland also—were equipped with the necessary electro-magnetic dropping gear, they could be operated by the clock direct from the Observatory, just as our own time-ball now is; a distinctly better plan than the present one, under which uniformity of time at the several ports is not easily secured. Still, any navigator at Auckland, Lyttelton, or Dunedin (or at any other port) can, through the co-operation of the Telegraph Department, obtain time-signals direct from Wellington Observatory in case he feels dissatisfied with the indications given him by the local time-balls; and this opportunity is frequently taken advantage of by the commanders of merchant ships and the navigating officers of men-of-war. Sometimes special signals are sent for important purposes. Thus, when H.M.S. "Penguin" a year ago wished to determine the longitudes of Tauranga and Gisborne, a series of time-signals was exchanged between the Observatory and the ship at each of those two ports; and again, when the antarctic exploring ships "Discovery" and "Morning" were in the colony and about to sail south, a succession of exact signals was sent night after night by special wire from the Observatory to the officers' cabin of either vessel as she lay at the wharf at Lyttelton.

From the magnetic signal which is sent by the clock at 9 a.m. each day to the operating-room of the Wellington Telegraph Office time is repeated by an officer of the Department (using an ordinary Morse instrument) to all the telegraph offices in the colony. This hand-sent signal is not intended for chronometer-rating purposes, and is therefore despatched merely with sufficient accuracy for ordinary office use and for the purpose of enabling all the telegraph and railway clocks in the colony to be set daily to a common time. Practically

every telegraph office and railway-station throughout the country is thus regulated frequently and uniformly to the central time.

The reasons for the selection of Wellington as the position for the Observatory were strong ones. They were set forth by Dr. Hector and the late Archdeacon Stock in 1868, and were emphasized by Chief Surveyors J. T. Thomson and Henry Jackson some three years later. On the 19th October, 1868, the Rev. Mr. Stock, who for about five years previously had been in charge of a small time-ball observatory built by the Provincial Government of Wellington on land now occupied by the General Post Office, addressed a letter to the Hon. John Hall, Postmaster-General, pointing out that the site of the Observatory was no longer suitable, and urging that the General Government should erect an improved Observatory on a more satisfactory spot. In support of this suggestion he wrote: "I need hardly say that Wellington, being the centre of the telegraph system, is the best place for the Observatory, which would have to use the telegraph wires."*

In a memorandum to the Hon. W. Gisborne, written on the 18th of the following month, Dr. Hector endorsed the suggestion of Mr. Stock and the reasons advanced in its favour, and he proposed the site which was ultimately chosen, a knoll behind the cemetery in Bolton Street.†

Again, on the 21st September, 1871—the Observatory in the meantime having been built and been doing good work—Messrs. Thomson and Jackson, in a report to the Government‡ on the subject of the longitude of the new Observatory in its relation to the longitudes of certain other places in the colony, said, "There will . . . . be three points in New Zealand, extending nearly along the whole length, two of which will have been referred to an initial meridian at Wellington. Such being the case, and actuated by the same motives which first induced us to determine the absolute longitudes in our respective provinces, we beg to submit for the consideration of the Government that there shall be an initial meridian for the reference of all longitudes in New Zealand, at Wellington, which, as its capital, and from its central position, is the most eligible site that could be chosen; and that this initial meridian be that of the Government Observatory."

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* Appendix to Journals of House of Representatives, D.-No. 39, 1870.

† *Ibid.*

‡ Appendix to Journals of House of Representatives, G.-No. 23, 1871.

Ministers gave favourable attention to the proposals submitted to them, the Hon. John Hall minuting Dr. Hector's memorandum with the remark: "As the General Assembly has directed New Zealand mean time to be kept throughout the colony, some provision for ascertaining that time with exactitude is indispensable. The arrangement here suggested seems as good as can be made" (28th November, 1868).*

The erection of the Observatory was accordingly authorised; the building was put in hand at once, and finished in June, 1868; and the instruments were placed in position by the following October. The adjusting of the transit instrument and other necessary arrangements delayed matters until the end of the year; but in January, 1870, the work of the time-service was begun under Dr. Hector as Director and the Rev. Mr. Stock as Observer; and it has been carried on continuously ever since. Archdeacon Stock was Observer until August, 1887, when failing health obliged him to retire.

Early attention was devoted to the longitude of the Observatory. There have been several determinations of this. The most reliable have been effected by means of the fixing of the meridian distance from Sydney Observatory, and the work of determining this difference has been accomplished with close accuracy. But Sydney Observatory, although its longitude, like that of Melbourne Observatory, is *now* supposed, as the result of direct telegraphic comparison with Greenwich, to be very exactly known, has been yet compelled on several past occasions to revise its assumed longitude. Wellington Observatory, dependent as it has been on Sydney as the prime meridian, has therefore had to make corresponding corrections in its assumed longitude. But these changes have not been serious. Fortunately, Melbourne, at a very much earlier date than Sydney, was able to obtain a longitude which has not called for appreciable revision; and as it was known about thirty years ago that the Melbourne determination was more reliable than the Sydney one (seeing that the Melbourne value had been arrived at by cable from Greenwich, whilst the Sydney value had been obtained from observation), and as, moreover, the difference between the longitudes of Sydney and Melbourne had been ascertained then by the use of the telegraph line, it was possible to arrive at a value for Wellington Observatory derived from the Sydney longitude corrected on the basis of the Melbourne longitude, and this corrected value has been shown by subsequent investigations to have been extremely near the mark.

* Appendix to Journals of House of Representatives, D.–No. 39, 1870.

It is interesting to note some of the alterations which have been made in the recorded longitude of Sydney Observatory during the past thirty years, and to compare them with the smaller corrections which have been necessary in the assumed longitude of Melbourne. From old volumes of the "Nautical Almanac"* and from other sources we find that since 1874 the following values have been used for these two observatories:—

Sydney.	Melbourne.
H. M. S.	H. M S.
E. 10 4 53·37†	E. 9 39 54·8
10 4 53·90†	...
10 4 50·61	...
10 4 47·3	...
10 4 50·8	...
10 4 49·6	9 39 53·8
10 4 48·9	...
10 4 48·47	...
10 4 49·54‡	9 39 54·15‡

The first reliable determination of the difference of longitude between Sydney and Wellington was effected in the years 1852 and 1854 by H.M. ships "Acheron" and "Pandora," under Captain J. L. Stokes and Commanders G. H. Richards and B. Drury, by the transport of chronometers from Sydney to Wellington during the course of the complete survey made by those vessels of the New Zealand coast. The place selected in Wellington was a spot near Pipitea Point, on what is now the railway-line (it used to be marked on the old charts as "Observation Spot"). When the Observatory was afterwards built its difference of longitude from that position (viz., 2·88 s.§) was easily ascertained by triangulation. The result thus obtained was subsequently confirmed by telegraphic determinations. In 1876 Mr. H. C. Russell at Sydney Observatory and Archdeacon Stock at Wellington Observatory exchanged a series of cable time-signals which gave a mean result accordant with that of Captain Stokes to within about half a second of time, showing how admirably that officer had done his work;‖ and again, in 1883, Mr. Russell at Sydney Observatory and

* See "Nautical Almanac" for 1883, 1889, 1894, 1896, 1897, 1898, and 1903.

† Absolute determination.

‡ Present value.

§ The transit pier of the Observatory is 5015·6 links west of Observation Spot at Pipitea, equal to 2·88 s. in time.

‖ See Trans. N.Z. Inst., vol. ix., 1876, p. 217: "On the Longitude of Wellington Observatory," by Ven. Archdeacon Stock, B.A.

Mr. C. W. Adams, New Zealand Geodesical Surveyor, at the Survey Department's observatory which then stood on the site at Mount Cook afterwards taken for the prison buildings, by another series of careful telegraphic exchanges arrived at a result almost identical with that of Mr. Russell and Archdeacon Stock, allowance, of course, being made for the difference (1·21 s.*) between the longitudes of Mount Cook Observatory and Wellington Observatory, as derived from triangulation. (The respective personal equations of Mr. Russell and Mr. Adams were tested and taken into account in the final examination of their work.) These three determinations compare as follows:—

Difference of Longitude, Sydney and Wellington.

	Wellington Observatory East of Sydney Observatory.		
	H.	M.	S.
Stokes's chronometric determination ...	1	34	15·28
Russell and Stock's telegraphic determination	1	34	15·99
Russell and Adams's " "	1	34	15·77

There was another chronometric determination—viz., by Captain G. S. Nares, of H.M.S. "Challenger" (see his memorandum to Dr. Hector, printed in vol. vii. of the "Transactions of the New Zealand Institute," 1874, p. 502). This gave the meridian distance of Wellington Observatory as 1 h. 34 m. 17·23 s. E. of Sydney Observatory; but, as Captain Nares himself pointed out, his result was not so trustworthy as that of Captain Stokes, as an interval of twenty-one days elapsed between the "Challenger's" observations at Sydney and Wellington, whereas Captain Stokes is supposed to have run his distance directly from Sydney to Wellington, and thus to have secured his observations at the two ports within a less interval of time. Captain Nares's determination was therefore not accepted.

The following table shows the several longitudes for Wellington Observatory resulting from these determinations, with the changes rendered necessary from time to time by the corrections made in the longitude of Sydney:—

* Mount Cook Observatory was east of Wellington Observatory 2097·2 links = 1·21 s., as is shown in a copy of a departmental memorandum kindly furnished to me by Mr. Marchant, Surveyor-General.

Determination.	Longitude of Sydney Observatory being assumed as	Difference of Longitude, Wellington-Sydney Observatories	Resulting Longitude for Wellington Observatory.	Remarks.
	East. H M. S	East. H. M. S.	East H. M. S.	
Stokes's chronometric	10 4 53·37 (absolute determination)	1 34 15·28	11 39 8·65	This was the value placed on the charts (*i.e.*, Pipitea Point= 11 h. 39 m. 11·53 s., deducting from which 2·88 s.—the difference between Pipitea Point and the Observatory—we get 11 h. 39 m. 8.65 s.).*
Ditto	10 4 53·90 (absolute determination)	1 34 15·28	11 39 9·18	As in Archdeacon Stock's paper "On the Longitude of Wellington Observatory," 1876, Trans. N.Z. Inst., vol. ix., p. 217.
Ditto	10 4 50·61 (depending on Melbourne)	1 34 15·28	11 39 5·89	As in Dr. Hector's letter of 9th September, 1874, to Colonial Secretary, covering memorandum from Captain G. S. Nares, of H.M.S. "Challenger" (Trans. N.Z. Inst., 1874, vol. vii., p. 502), also as in Major H. S. Palmer's Report on Longitudes, 1875–76, in Appendix to Journals of House of Representatives, H.–No. 6, 1876.
Ditto	10 4 49·54 (telegraphic determination now accepted)	1 34 15·28	11 39 4·82	
Russell and Stock's telegraphic (1876)	10 4 50·61 (depending on Melbourne)	1 34 15·99	11 39 6·60	See Archdeacon Stock's paper above mentioned.
Ditto	10 4 49·54 (accepted telegraphic)	1 34 15·99	11 39 5·53	
Russell and Adams's telegraphic (1883)	10 4 48·47	1 34 15·77	11 39 4·24	Sydney Observatory to Mount Cook Observatory, 1 h. 34 m. 16·98 s., less difference Mount Cook and Wellington Observatories 1·21 s. = 1 h. 34 m. 15·77 s.
Ditto	10 4 49·54 (accepted telegraphic)	1 34 15·77	11 39 5·31	

* See Report of Board of Longitude, Appendix to Journals of House of Representatives, D.–No. 27, 1870.

In addition to these chronometric and telegraphic determinations, there have been three "absolute" determinations —that is, determinations by means of observations of moon culminations, &c. Before the present Observatory was built, Captain Carkeek, with the view of ascertaining the longitude of the old time-ball tower, conducted for many years a series of observations in the shape of lunars, eclipses of Jupiter's satellites, lunar eclipses, and moon culminations.

Then, in 1869, 1870, and 1871, Chief Surveyors J. T. Thomson and Henry Jackson, at their respective private observatories at Rockyside (Caversham, Dunedin) and the Hutt, by observations of moon culminations determined the longitudes of those points. Having done so, they settled by means of the electric telegraph the difference between the longitudes of their two observatories, as a check upon their independent determinations. Mr. James McKerrow, afterwards Surveyor-General, assisted Mr. Thomson at Rockyside in this important branch of the work.

By triangulation from the old time-ball site to the Wellington Observatory, and from Mr. Henry Jackson's private observatory to Wellington Observatory, values were thus obtained for the longitude of Wellington Observatory.

Finally, in 1874–75, Major H. S. Palmer, R.E., chief of the English expedition to New Zealand for the observation of the 1874 transit of Venus, conducted a series of observations at Burnham (his observing-station in Canterbury) for the determination of the longitude of that place. Professor C. H. F. Peters, chief of the United States Transit of Venus party, about the same time made similar observations for longitude at his station at Queenstown, Lake Wakatipu. Then these two points, with Mr. Heale's temporary observatory at Auckland, the Colonial Observatory at Wellington, and Mr. Thomson's observatory at Caversham, were connected by telegraph, with the object of ascertaining their respective differences of longitude. Major Palmer himself came to Wellington and conducted the work necessary for fixing the longitude of the Wellington Observatory on this basis.

The results of these absolute determinations (or, to use Major Palmer's term, "approximate absolute determinations") were as follows:—

(1.) Captain Carkeek's approximate absolute,* 11 h. 39 m. 15·75 s. E.

(2.) Messrs. Thomson and Jackson's approximate absolute,* 11 h. 39 m. 15·31 s. E.

* For an account of Captain Carkeek's and Messrs. Thomson and Jackson's determinations see Messrs. Thomson and Jackson's report to Government, Appendix to Journals of House of Representatives, G.–No. 23, 1871.

(3.) Major Palmer's approximate absolute,* 11 h. 39 m. 4·81 s. E.

Major Palmer's result, it will be seen, is identical to within a hundredth of a second of time with the value which has been obtained from Captain Stokes's chronometric work when the most recently accepted longitude for Sydney Observatory is used. On the other hand, the results deduced from Captain Carkeek's and Messrs. Thomson and Jackson's observations seem at first sight a good deal out of line with all the other determinations. They were consequently not taken into account in deciding upon the longitude to be used for the purposes of the time-service. But Major Palmer showed in his report some four years later that Messrs. Thomson and Jackson's determination was susceptible of treatment which placed it in a different light. Messrs. Thomson and Jackson, in reducing their observations, had not taken into account the errors of the moon's tabular place. Major Palmer pointed out that the average of these errors for the days on which the moon was observed at Rockyside and the Hutt was about 0·25 s., which would probably cause an error of between + 6 s. and + 7 s. in the resulting longitude; † therefore Messrs. Thomson and Jackson's corrected longitude of the Observatory might be taken approximately as 11 h. 39 m. 9 s. E. This differs from the ultimately accepted longitude by less than 4 s., very little more than the error (3·29 s.) which shortly before this had had to be recognised in the absolutely determined longitude of Sydney Observatory. The problem of exactly ascertaining a longitude by observation is notoriously one of extreme practical difficulty; and Messrs. Thomson and Jackson's result, when subjected to this revision by Major Palmer, showed that their long and patient series of observations had been carried out with much skill and care, and was an honourable and worthy piece of work. The details of Captain Carkeek's calculations are not available, as they were accidentally destroyed many years ago by fire.

To sum up, it will be seen that all the foregoing determinations may be arranged in two groups—one with a value of about 11 h. 39 m. 9 s., and the other with a value of about 11 h. 39 m. 5 s. The former of these approximate values was practically known as long ago as 1874 to be erroneous; the latter by the same year was believed to be correct, and two years later was known to be correct, on the assumption that Sydney's longitude was reliable. Sydney's 1903 value differs by only about 1 s. from its 1874 value; so that Dr. Hector

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* For details of Major Palmer's work see his report to Government, Appendix to Journals of House of Representatives, H. No. 6, 1876.

† See Loomis's "Practical Astromony," p. 316 (seventh edition).

was a true prophet when in 1874 he expressed the belief that the "probable true longitude of Wellington Observatory" was 11 h. 39 m. 5·89 s.* Of course, it would be rash to say that no future revision may be necessary; but we seem warranted in thinking that any correction which may be called for will be but trifling.

But although the longitude was thus corrected so many years ago, the old value of 11 h. 39 m. 9 s. has up to the present time continued to be used by the Admiralty as the basis of its charts of New Zealand; consequently all positions in the colony as shown on these charts (with the exception of one sheet to be presently mentioned) are out in longitude to the extent of between 3½ s. and 4 s. of time, or something under a mile. In view of the smallness of this error (which would not be a source of any danger to navigators), the Admiralty has no present intention of altering its charts. There are fifteen sectional charts of the coasts of the colony, besides many sheets of individual ports and of special anchorages; and to amend the longitudes on all of these would entail much expense in erasing lines on the plates and in regraduating the charts. Seeing, then, that this old longitude has been retained on the charts, it has also heretofore been retained as the working longitude of the Observatory in computing time for general and navigation purposes,† as it has been judged highly convenient to have the time-service basis identical with the chart basis so long as there seemed any chance that the amended value of the longitude might be open to further revision.

A Board of Longitude was appointed by the New Zealand Government on the 8th July, 1869, to report upon the longitude of Wellington and of other parts of the colony in relation to the initial meridian of Wellington. The Board consisted of Dr. Hector (Chairman), the Rev. A. Stock, Mr. Henry Jackson, Chief Surveyor of the Province of Wellington, and Mr. G. A. Woods, Colonial Marine Surveyor. After going into the question thoroughly, and conferring with Mr. Ellery, Government Astronomer of Victoria, the Board reported‡ in favour of adopting provisionally the chart longitude, instead of keeping the question open longer for the sake of any small error which might ultimately be ascertained. A similar view was expressed by Major Palmer in his 1875 report, and that gentleman sug-

* Trans. N.Z. Inst., vol. vii., p. 504.

† But of course the amended longitude has been used for scientific purposes which have called for nice accuracy—such as the observations of the transits of Venus in 1874 and 1882.

‡ Appendix to Journals of House of Representatives, D.–No. 27, 1870.

gested that no change should be made until by means of the then projected submarine cable a telegraphic longitude-difference should have been obtained between New Zealand and Sydney or Melbourne.

The frequent corrections which have been found necessary in Sydney's assumed longitude since then have caused the change to be postponed longer than was originally contemplated. But circumstances now seem favourable for making it. The last alterations in the longitudes of Sydney and Melbourne were announced in the "Nautical Almanac" for 1898 (published in November, 1894); and as these were based on very careful telegraphic determinations by observers at Greenwich, Sydney, and Melbourne, they seem likely to be practically final. Moreover, the Admiralty has in one case used the latest longitude in compiling a chart.

On the sheet to which I have referred as forming an exception to the others—viz., the large-scale chart of Port Nicholson (No. 1423)—the longitude is given as 174° 46′ 20″, equivalent to 11 h. 39 m. 5·3 s. The Hydrographer to the Admiralty, in a letter written by him to Sir James Hector on the 1st December, 1902, explains that this determination (which was the one given in the report of the Australian Telegraphic Determination of Longitudes, 1886) was adopted by the Admiralty in 1890, and that, although it has not been considered necessary in the interests of navigation to alter the existing coast charts, the value 11 h. 39 m. 5·3 s. will be the initial point of any rearrangement which may ultimately be made in the Admiralty charts. He agrees that, under the circumstances (the discrepancy being so small), the determination of the Admiralty to retain the old longitude on the majority of the charts need be no further bar to our "adopting the quantity which is at present considered to be the most correct." The value given on the large-scale chart (No. 1423) is that obtained from Mr. Russell's and Mr. Adams's telegraphic work in 1883; and as this differs by only 0·2 s. from the value deduced from Mr. Russell's and Archdeacon Stock's telegraphic interchange in 1876 the way is now clear for using 11 h. 39 m. 5·3 s. as the standard longitude for computing New Zealand mean time from observations taken at the Observatory.

A similar small error occurs in the longitudes given in the Survey Department's land maps of the colony. These longitudes are based on Mr. Thomson's determination of the longitude of Rockyside (as amended in the manner above explained); consequently the values are at present practically identical with those shown in the charts. I understand, however, that the Surveyor-General purposes taking advantage of an intended reissue of the Department's maps to

revise the longitudes on the basis of Mr. Russell's and Mr. Adams's corrected determination.*

A NOTE ON THE UNIVERSAL TIME QUESTION.

The references in the foregoing paper to universal or standard time seem to render it advisable to add some particulars which may possibly be of interest to those members who have not already made themselves acquainted with the history of that scheme. For the substance of the following note I am indebted to articles which have appeared during the past few years in "The Observatory" and in "The Geographical Journal," and also to an excellent little American book entitled "A Laboratory Manual in Astronomy," published in Boston recently by Miss Mary E. Byrd, Director of the Observatory of Smith College.†

It seems to be uncertain who first suggested a universal time system. As I have mentioned already, the scheme was first heard of in America, where it was forced upon the attention of the railway authorities by the inconvenience caused by a chaotic time-reckoning on the great railway-lines of the continent. In 1870 Professor C. Dowd published his pamphlet advocating in effect the system which was afterwards adopted, except that he suggested Washington, not Greenwich, as the initial meridian. Professor Benjamin Pierce also claims to have originated the suggestion; and possibly there may be other rivals of Professor Dowd's for pioneer honours in this matter. The movement soon took definite shape. It was favoured by various railway authorities and public societies—*e.g.*, the American Meteorological Society and the Society of Civil Engineers—and in particular the Canadian Institute was energetic in agitating the question. The subject was discussed at the Geographical Congress at Venice in 1881 and at the Geodetic Conference in Rome in 1883.

In the following year (1884) a representative body called the Prime Meridian Conference met at Washington. It consisted of delegates from twenty-seven nations, and after full discussion it passed several resolutions which were intended as suggestions to the civilised Governments of the world. These suggestions included "the adoption of a universal day, which should not interfere with the use of local or other time; that it should be a mean solar day beginning at mean midnight of the initial meridian, the hours to be counted from zero up to twenty-four, and that the initial meridian

* Viz., 11 h. 39 m. 6·52 s. for Mount Cook Observatory, which was 1·21 s. east of Wellington Observatory.

† Ginn and Co., Boston, 1899.

should be that of Greenwich"; also that "longitude should always be counted from this meridian in both directions up to 180°, east longitude being *plus* and west longitude *minus*"; and finally, that "the astronomical day should begin at mean midnight."

There were therefore three distinct proposals before the Conference—(1) "The change of the astronomical day [the astronomical day at present begins at midday, not at midnight]; (2) the use of a universal day; (3) the reckoning of the hours from 0 to 24 instead of in two periods of twelve each."*

The first of these proposals has not been adopted generally, as it has been felt that it would involve too much trouble and expense in the rearrangement of astronomical ephemerides. The only work of the sort in which the suggestion has so far been acted on is the "Annuaire" of the Paris Bureau des Longitudes, which made the change in the ephemeris for 1900.†

The second proposal (that for a universal day) has been found to be in advance of public opinion, and it has therefore been adopted merely in the modified form of standard times governed by hour meridians,‡ the minutes and seconds being everywhere the same as at Greenwich (except, as already explained, in the cases of those countries which have compromised by taking the odd half-hour). The proposal to accept Greenwich as the initial meridian did not at first find favour with some nations, and it was suggested that the meridian either of Jerusalem or of some obscure island or other not belonging to any great power should be chosen instead. Ultimately, however, it was recognised that the meridian of Greenwich was in every way the most suitable, and those nations which have taken up the reformed system have been content to set their clocks on the basis of the Greenwich reckoning.

The third idea (that of having a twenty-four-hour dial) has been realised on part of the Canadian Pacific Railway and on some other railways in America, and it has also been given effect to in Italy, in Switzerland (?), in Belgium, and in Spain. Many people claim (and with apparent reason) that a great simplification of railway time-tables is effected when the letters "a.m." and "p.m." are got rid of.

The following is a list of the countries which have adopted

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* "The Observatory" for February, 1901.

† *Ibid.*

‡ The basis of the system being that for $7\frac{1}{2}°$ of longitude on either side of a central meridian one time only shall be kept.

the universal time system, with the hour meridian selected in each case :—*

Greenwich Time—	Date of Adoption.
Great Britain.	
Belgium	... 1892.
Holland	... 1892.
Spain	... 1901.
1 h. fast on Greenwich—	
Germany	... 1893.
Italy	... 1893.
Denmark	... 1894.
Switzerland	... 1894.
Norway	... 1895.
Austria (railways).	
1½ h. fast on Greenwich—	
Cape Colony	... 1892.
Orange River Colony ...	... 1892.
Transvaal	... 1892.
2 h. fast on Greenwich—	
Natal	... 1895.
Turkey (railways).	
Egypt	... 1900.
8 h. fast on Greenwich—	
West Australia	... 1895.
9 h. fast on Greenwich—	
Japan	... 1896.
9½ h. fast on Greenwich—	
South Australia	... 1899.
10 h. fast on Greenwich—	
Victoria	... 1895.
New South Wales ...	... 1895.
Queensland	... 1895.
11½ h. fast on Greenwich—	
New Zealand	... 1868.
5 h., 6 h., 7 h., and 8 h. slow on Greenwich—	
United States and Canada	... 1883.

The United States and Canada are divided approximately into four territories by the meridians 82½°, 97½°, and 112½°, and the times kept within these territories are as above, the 5 h. time being called "eastern time," the 6 h. time "central time," the 7 h. time "mountain time," and the 8 h. time "Pacific time."† The boundary-lines between these terri-

* From "The Observatory" for February, 1901, and July, 1901, and Miss Byrd's "Laboratory Manual in Astronomy."

† There is also supposed to be a time territory 4 h. fast on Greenwich, with central meridian 60°, but it is practically little used. The name given to it is "intercolonial time."

tories are not, of course, geometrically drawn meridian lines, but are lines which bend to suit the practical requirements of the districts concerned, much after the fashion in which boundaries between counties or States are drawn on ordinary maps (see the frontispiece to Miss Byrd's book).

In a pamphlet published in 1888* Dr. Robert Schram, of Vienna, threw out the suggestion that when all the twenty-four-hourly standards shall be in actual use it will be important to have a name for each which will be an easy guide to its position in the earth's circumference. The letters of the alphabet were to be used for this purpose; but as people would not probably care to speak of G time, or L time, or Z time, Dr. Schram's idea was that each time section should be called by the name of "a geographical point, so chosen that it begins with the letter representing this section. The place of the letter in the alphabet would indicate the longitude of the section's mean meridian expressed in hours, and would at once give in hours the difference between" standard time and Greenwich time. He proposed the Latin alphabet in its older form, containing twenty-three letters (the letters J, U, and W of the modern alphabet being rejected). "The un-Latin letter U would be used for the zero value—*i.e.*, Greenwich time—which would so retain its appropriate name, 'universal time.'" There would thus be "*A*dria time, "*B*alkan time," and so on. Under this nomenclature the time section falling to New Zealand would be called "Loyal-time," the assumption being that New Zealand would adopt the 11 h. meridian, which passes near the Loyalty Islands, to the east of New Caledonia. This ingenious, if slightly fanciful plan, however, does not seem so far to have been seriously entertained.

The gain effected by the extensive adoption of the standard system has been very great, even though in some cases local or other time has continued to be used alongside of the new reckoning.

In the "Geographical Journal" for February, 1899, Professor John Milne, the eminent seismologist, gave a long list, as complete as he had been able to compile it, of the times kept all over the world. The variety was bewildering, and an inspection of the list compelled one to recognise the need for something better adapted to modern requirements.

There are still a good many parts of the world which remain to be converted to the international system, but the

* See article "The Actual State of the Standard Time Question," by Dr. Robert Schram, in "The Observatory" for April, 1890, in which Dr. Schram gives an account of the nomenclature proposed in his previously published pamphlet.

prospects for the future are good. Always with the reservation that here and there a country or province may find it advisable to adopt the South African and New Zealand half-hour compromise, we may, in the enthusiastic words used by Dr. Schram over twelve years ago, but with a better hope of early realisation than was justifiable then, say that "very soon the system created by American energy will have conquered the globe, and the Greenwich minute and second will regulate the world's clocks."

The following is a list of the parliamentary documents and of the papers in the "Transactions of the New Zealand Institute" consulted in the preparation of the above paper:—

(A.) *New Zealand Mean Time.*

"Transactions of the New Zealand Institute," vol. i., p. 48 (1868), (second edition, p. 451): "On New Zealand Mean Time," by James Hector, M.D., F.R.S.

New Zealand Gazette, Saturday, 31st October, 1868: Notification of Adoption of New Zealand Mean Time.

(B.) *Longitude of Observatory.*

Appendices to the Journals of the House of Representatives:—

Vol. iii., 1870, D.–No. 27: Report of the Board of Longitude.

Vol. iii., 1870, D.–No. 39: Correspondence relative to the Establishment of an Observatory.

Vol. ii., 1871, G.–No. 23: Report of Messrs. J. T. Thomson and Henry Jackson on the Telegraphic Measurement of the Difference of Longitude between Wellington and Otago.

Vol. ii., 1876, H.–No. 6: Report of Major H. S. Palmer, R.E., on various Telegraphic Differences of Longitude.

Vol. ii., 1876, H.–No. 6A: Report on Mr. H. C. Russell's and Archdeacon Stock's Determination of the Difference of Longitude between Sydney and Wellington.

"Transactions of the New Zealand Institute":—

Vol. iii., p. 82 (1870): "Abstract of Paper by Mr. Henry Jackson on the Longitude of the Hutt Observatory."

Vol. vii., p. 502 (1874): "Memorandum on the Longitude of Wellington Observatory," by Captain Nares, R.N., with covering letter by Dr. Hector.

Vol. viii., p. 441 (1875): "On the Longitude of Wellington," by J. T. Thomson.

Vol. ix., p. 217 (1876): "On the Longitude of Wellington Observatory," by Ven. Archdeacon Stock, B.A.