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Résumé de l'article

En 1884, un consensus fut établi pour généraliser l'utilisation des fuseaux horaires définis à partir de Greenwich, lesquels avaient été adoptés en Amérique du Nord un an auparavant. L'événement n'a jusqu'à présent jamais été expliqué de façon adéquate. Le présent article montre pourquoi et comment, l'accord est intervenu grâce au rôle capital joué par certains individus, parmi lesquels figure Sandford Fleming.

SANDFORD FLEMING AND UNIVERSAL TIME

Mario Creet¹

ABSTRACT

In 1884, consensus was reached to extend the system of time zones based on Greenwich that been adopted a year before in North America. The event has not been explained well in other accounts. This article shows how and why agreement came about; it was the result of efforts made by key individuals, among whom was Sandford Fleming, using professional and scientific organizations new to North America.

RESUME

En 1884, un consensus fut établi pour généraliser l'utilisation des fuseaux horaires définis à partir de Greenwich, lesquels avaient été adoptés en Amérique du Nord un an auparavant. L'événement n'a jusqu'à présent jamais été expliqué de façon adéquate. Le présent article montre pourquoi et comment, l'accord est intervenu grâce au rôle capital joué par certains individus, parmi lesquels figure Sandford Fleming.

The convention of telling time relative to a fixed meridian rather than by a local sight on the sun came into general use a century ago. In 1884, at an international conference considering the question of a universal standard, broad agreement was reached to extend the system based on Greenwich that had been adopted in North America the previous year; France rejected Greenwich in favour of Paris and held out for another twenty-five years. Why was the conference convened in Washington rather than in Paris or London? Why did the proposal succeed when a simultaneous push to extend the metric system -- which had been around for a century -- failed? Though the facts about standard time have been told and retold, the key episodes relating to its universal adoption have not been analyzed before. My analysis shows that Sandford Fleming was in part responsible for the success of the outcome. The emergence of professional societies, particularly the

1 101 Lower Union St., Kingston, Ontario K7L 2N3.

American Society of Civil Engineers, was also an important factor. The Canadian role demonstrated a southern orientation in scientific and technical matters that was beginning to displace the imperial connection.

Around the World in 80 Days by Jules Verne remains alive and well today. It began life in 1873 as a serial in the Paris *Temps* and its episodes were followed as keenly in real life as in the novel.² But the ending, when Fogg discovers that he can win his bet because he has returned a day earlier than his records show, lacks conviction for us. We are sceptical about Fogg's surprise because it is hard for us to accept that someone as methodical as he should make so obvious an error. Our frame of mind is formed by habitual acceptance of the conventions of standard time and the international date line. For Verne's contemporaries, however, the element of surprise would have been convincing because confusion over 'time' was widespread, including the experience of going round the globe. Even though the gain of a day on sailing westward was first noted during the Magellan expedition of 1522 (knowledge which had become widespread since), anecdotes abounded in the nineteenth century of sailors arriving at some remote spot from opposite directions and arguing over the date. The 'loss' or 'gain' of time would not begin to make sense until the 'standard,' or reference point, had been defined.

Apart from references in specialized monographs, there are no satisfactory accounts of the international adoption of standard time in the general literature.³

2 I.O. Evans, *Jules Verne and His Work* (n.p., 1966), 70.

3 I should point out here that the excellent article by Ian Bartky, 'The Adoption of Standard Time' in *Technology and Culture* (January 1989), 25-55, deals only with the adoption of the zone system in North America.

For example, in *Revolution in Time* David Landes makes only a brief and quite unsatisfactory reference to it, probably because his attention is given mainly to clocks and chronometers, but one would have expected more in a work with the sub-title of 'clocks and the making of the modern world.'⁴ The control of time is surely as important as its measurement for making the world. Or, to put it another way, being punctual means more than being close to a specified time; it also means agreeing on what time is specified, as we all know if we overlook a time change, of either zone-to-zone or daylight-saving. To have achieved such agreement was not easy, because it involved world-wide consensus on what was both a scientific and a practical matter in the absence of appropriate machinery. During two decades, 1879-1899, Sandford Fleming made skilful use of scientific societies, in concert with other individuals also engaged in the reforms, to bring about substantial uniformity in the world's reference to time.⁵

The term 'standard time' is ambiguous: it might mean only a set of one-hour time zones, or it could refer to a universal system of time standards based on an international date line. Fleming's aim was world-wide adoption of the latter, and he frequently referred to it as the 'universal or cosmic' day. Several individuals have an equal or better claim to the title 'inventor of standard time,' but Fleming was among the few who thought in world-wide terms, and the only one to persist in using contemporary institutions to achieve his ends against the odds of national rivalry and officious indifference. How he did this has never been examined. While our concern is mainly with these events, an introductory section will

4 David Landes, *Revolution in Time* (Cambridge, MA, 1983), 286-7.

5 The following titles are meant to assist in reading the text. They are not a complete bibliography of Fleming's publications on universal time: *Uniform Non-local Time* (published privately, 1876); 'Time-Reckoning' and 'Longitude and Time-Reckoning' in *Proceedings of the Canadian Institute, 1879-80*, 97-149; *Standard Time for the United States, Canada and Mexico* (New York, 1882); *Letter to A.A.A.S. on Standard Time* (Montreal, 1882), which contains a list of all replies received until then to the questionnaire in the 1882 works; *Universal or Cosmic Time* (Toronto, 1885) which contains the text of his address at Venice, his report on the Meridian Conference and all official correspondence relating to the first memorial as well as the Conference; 'Time Reckoning for the Twentieth Century,' Smithsonian Institution (Washington, DC, 1886), 345-60; *Time and its Notation: treatise for the use of schools in the Dominion of Canada* (Toronto, 1888); *Fixing of a Standard of Time* (Ottawa, Parliamentary Papers, 1891) which includes the article from the *Proceedings of the Canadian Institute, 1889-90*, 237; 'Reforms in Time Reckoning,' *Proceedings, 1890-91*, 128-42; *Twenty-Four O'Clock Notation; for the railways of America* (New York, 1892); see, also, annual reports to the American Society of Civil Engineers.

sketch how 'time' became widely useful during the preceding two centuries.

Until some, perhaps arbitrary, cut-off in the nineteenth century, the economic history of Europe and its science and technology can be presented as if time in its many aspects were the focal point of activity. Construction of time-pieces calls into being the finest craftsmanship in the making and shaping of metals; the motives behind accurate time-keeping open to our view the activities of monastery and business house; time is also the datum for mapping land and ocean, and a unique measure for ship's navigators; and the possession of accurate maps - the leading information of the day - provides leverage for conquest and consolidation of power. Thus church, trade and empire may be projected through the pinhole of time, and a few eminent historians of technology have done so. 'The clock, not the steam-engine, is the key machine of the modern industrial age,' says Lewis Mumford.⁶ In another epigram, Carlo Cipolla tells us that '[t]he simultaneous appearance of the gun and the mechanical clock was both a testimony to the character of European development and a forecast of things to come.'⁷ To which may be added David Landes' judgement: 'It is the mechanical clock that made possible, for better or worse, a civilization attentive to the passage of time, hence to productivity and performance.'⁸ All of which is another way of saying that the measurement of time had an importance in early modern Europe which it does not have today because we take for granted a highly reliable technology of time. But what is merely routine now was in the vanguard of scientific development for three centuries.

Beginning with the first efforts of the observatories at Greenwich and Paris, astronomy and instrument making had grown together; the science-based techniques of cartography were one result of that growth. The core problem in making maps is the determination of longitude, as it is also in reading them if the reader's position is unknown. Longitude at an unknown place is most easily determined by comparing local time (based on the noon sun corrected for the Earth's wobble) to that of an observatory, as one hour equals fifteen degrees longitude. The problem of the eighteenth century was to make a timepiece which literally stood the test of time, or was accurate enough in the harsh situation of

6 Lewis Mumford, *Technics and Civilization* (New York, 1963), 14.

7 Carlo Cipolla, *Clocks and Culture, 1300-1700* (New York, 1977), 40.

8 David Landes, *op. cit.*, 7.

an ocean voyage to give the longitude of a ship within some acceptable limit of error. This limit was first specified as half a degree (or two minutes) for the voyage from London to the West Indies in the unprecedented reward offered by the British Parliament in 1714 to 'discover the longitude at sea.'⁹ Many took up the challenge, but only John Harrison eventually won the reward in 1765 after a half-century of effort dedicated to improvement of the design of his time-pieces. The Harrison chronometer is probably the most famous time-piece in the world, and a tribute, in Landes' words to 'raw talent married to tenacity and self-confidence.'¹⁰ By the 1760s measurement of longitude through astronomical observation had also become feasible through the invention of the sextant and the publication of tables of sun, moon and stars (the annual *Nautical Almanac*) by the Astronomer Royal. As the *Almanac* was based on the longitude at Greenwich, it was inevitable that ships at sea would adopt its time to fix their position. From the annual *Nautical Almanac* it was a logical step to provide a time service for mariners. The official signal for 1 pm at Greenwich began in 1833.¹¹

Though European culture placed a high value on time and timekeeping, for most purposes 'the time' was a local affair; only astronomers and their clients needed a common reference. For civic use each locality set its time by the noon sun and was unconcerned by the time in a neighbouring one, at least so long as the fastest communication between them was on horseback. The railways changed that, as they did so much else in everyday life. The first to encounter change from railways was Britain. The 1851 Exhibition, planned as the showcase of Britain's industrial arts, also showed off her railway development; the rail network had made possible both the Exhibition and its widespread patronage.¹² But the network of railways also made obvious the need for a different system of stating the time. So long as each rail company was separate it could operate on any time base it found convenient, whether of London or Liverpool, but once frequent connections began to be made, the great inconvenience to travellers of having to keep track of the different times of each company became apparent, and even before 1851 most of the network had become based on Greenwich time, which was sent by the telegraphs running alongside the rail. The Post Office had also

9 Derek Howse, *Greenwich Time* (Oxford, 1980), 50-2. This excellent monograph is the source for my statements about Greenwich.

10 Landes, *op. cit.*, 145-57.

11 Howse, *op. cit.*, 79-80.

12 Harold Perkin, *The Age of the Railway* (London, 1970), 99-101.

adopted Greenwich time. By 1852 the futility of keeping two sets of time -- Greenwich and local -- had persuaded civic authorities to drop the latter; and as cities switched one by one to Greenwich time it became the standard for all of Britain, but only by practice as parliamentary authority for standardization was not enacted until 1880.¹³

In the contemporary use of the term 'global village' there is more than a hint of the novelty of the unification of the globe. But the phenomenon is more than a century old. In the 1870s the world was being drawn together by railway, steamship and telegraph cable. International agreements were being evolved to regulate ocean traffic. The International Telegraph Union was formed in 1865 and The Universal Postal Union was established in 1875.¹⁴ The problems which growth of the rail network had caused in Britain thirty years before were becoming world-wide. They were most acute in countries which were large -- the US, Canada, Russia and the newly-unified Germany. Already by 1871, time zones in the US had been proposed to the railroad corporations, and the Russian Post Office had adopted the time of the capital St Petersburg (based on the observatory at Pulkova) for the whole of Russia. In the same year, extensive use of the meridian at Greenwich in nautical almanacs, notably by the US Naval Observatory in Washington, had prompted consideration of its universal usage at the first International Geographical Congress. Thus, the need for reform was recognized, but standardization of time on land and at sea was being treated as if it were two separate problems; and despite continuing pressure for reform, on neither problem was any decisive action taken during the decade because the suggestions were both piecemeal and ducked the question of how to arrive at an international consensus.

In 1879 two similar reports prepared quite independently of each other and each taking a global approach, were presented at two separate institutions. The topic for both was, of course, the conventions which should govern the use of time throughout the world. Few of the ideas were wholly original; e.g., time zones had been proposed ten years earlier by Charles Dowd, and since taken up by others without success. However, the new proposals were more comprehensive and their authors, Sandford Fleming and Cleveland Abbe, formed an effective lobby.

13 Howse, *op. cit.*, 86-96.

14 William Woodruff, *The Impact of Western Man* (London, 1966), 222-3.

In 1879, Sandford Fleming (1827-1915) was chief engineer of The Intercolonial Railway and of surveys for the new railway that the Government of Canada was planning to push across the country, the Canadian Pacific. He had recently been surveying the Rockies and was all too conscious of the change of time on the immense distances of the westward journey. What should be done seemed reasonably clear, but how it was to be achieved was altogether more difficult to see. He had written his thoughts down and published them privately; then, in the summer of 1878 he had been snubbed during the meeting of the British Association for the Advancement of Science at Dublin, where he had been denied a hearing after having been invited to present his paper.¹⁵ During the following winter he revised that paper and added another to it. Both papers were then presented to The Canadian Institute.

The Canadian Institute of Toronto was one among a handful of aspiring scientific societies in Canada. It had begun in 1849 as a putative professional society for architects, engineers and surveyors, but soon changed into an organization for generally promoting science when its original ambition was seen to be premature.¹⁶ After remodelling itself along the lines of the early Royal Society, the Institute received its charter in 1851, which included the objective of fostering 'the Arts of Opening up the Wilderness ... and otherwise smoothing the path of Civilization.'¹⁷ Its active members were drawn from Toronto's small university sector, or were lawyers and others with no direct interest in the problem, except for one person, Charles Carpmael (1846-94), an astronomer and soon to be in charge of the Meteorological Service of Canada, who was to take a very active part in the project of time reform. Fleming himself had been a founder member of the Institute, but had allowed his membership to lapse after moving to Ottawa.

Fleming's paper on 'Time-Reckoning' began by remarking that all divisions of time except the rising and setting of the sun must be artificial and arbitrary. The most reliable reckoning of time treated the earth itself as a clock, i.e., replaced the sun by the earth. If each daily revolution were divided into 24 equal parts with each corresponding to a meridian of longitude and one hour of time, the set of 24 standard meridians would together define universal time, 'the electric telegraph affording the means of securing perfect synchronism all over the

15 Sandford Fleming Papers, National Archives of Canada, MG 29 BI, Volume 6, BAAS correspondence. [Hereinafter cited as Fleming Papers].

16 W.S. Wallace, ed., *The Royal Canadian Institute, Centennial Volume 1849-1949* (Toronto, 1949), 127-36.

17 *Ibid.*, Charter, 131.

earth.' One meridian designated as the prime would become the standard for all the others, and letters of the alphabet would be assigned to each of the hours, thus avoiding am and pm. Alongside this universal or 'cosmopolitan' time which would everywhere be the same, there would be a 'local' time based on the standard meridian closest to the locality, i.e. that time would be the same in the zone between meridians. Separate public clocks would display local time in roman numerals and cosmopolitan time by letters; minutes and seconds would always correspond and only the hour hand would differ between the two. Anyone who needed to know both times could attach a special dial he had designed to be set under the watch glass so that both were shown by the hands of the same watch. In justification of reform Fleming drew

special attention to the fact that the application of steam to locomotion by land and sea, and of electricity to the telegraph, literally without limit, has rendered the present practice of reckoning time ill suited to modern life. It cannot be supposed that these agents of progress have completed their mission.

The difficulties already met in North America would increase as the railway system was extended. Nor would they be confined to that continent; the entire world would soon feel the effects of railways, as had already happened in Great Britain, where Greenwich time had become standard for the island. Also, meteorologists and navigators needed reference meridians and they too would benefit from adoption of a universal time. Finally, 'the barbarous custom of dividing the day in two sets of twelve hours, as if 12 were the limit of arithmetical knowledge' must sooner or later be abandoned.¹⁸

In the second paper, on 'Longitude and Time-Reckoning', Fleming observed that a prime meridian was the recognized starting point of time measurement for all nations. Its choice was the crucial element of any system and had 'to be approached in a broad, cosmopolitan spirit to avoid offence to national feeling and prejudice.' Previous attempts to establish a prime common to all nations had failed; most proposals had come from astronomers who ignored the havoc which would be caused by a change of date during normal business hours. To overcome national rivalry and avoid the inconvenience caused by a date change, the prime meridian should not pass along any populous area. The meridian passing through Behring's strait satisfied these conditions and it was diametrically opposite six major European observatories, any one of which could provide sufficiently accurate time services. However, the most common time base for navigation was that of Greenwich, which was used by 72 per cent of the world's

18 Sandford Fleming, 'Time-Reckoning,' *Proceedings of the Canadian Institute* (1878-79), 97-126. Quotes are from 114, 122 and 125 respectively.

ocean shipping (by tonnage); next was Paris at 8 per cent and the rest were hardly significant. The reason for the dominance of the Greenwich standard was its adoption in nautical almanacs published by the United States, Russia, Norway, Holland, Belgium and Japan. Hence, the meridian 180 degrees from Greenwich would be the right choice as prime because it would mean the least recalculation of data in these almanacs and in the observatories around the world which provided time signals for civic and naval use, and no nation need be upset at its adoption. Fleming concluded by referring to an article in *The Times* of 17 January 1879, which had caught his attention while preparing the paper, on the need for a universal meridian. It remarked that the existing variety of first meridians was embarrassing to geographers, because they had discussed the matter at several international congresses without result; it favoured the position taken by Otto Struve, the Imperial Russian Astronomer, who argued for the same choice as Fleming himself.¹⁹

The Council of The Canadian Institute decided that Fleming's proposals were sufficiently important to take the unusual step of petitioning the Governor-General of Canada to bring the matter to the attention of the Imperial Government.²⁰ The arguments for so unprecedented a step was that the geographical extent of Canada made Canadians sensitive to progress and the 'peculiar political status of the Dominion' enabled 'the representatives of Canadian science to mediate...in the various countries more immediately interested in the questions at issue.'²¹ The Governor-General, the Marquis of Lorne, was glad to do so and he sent the papers to the Colonial Office with a recommendation for appropriate action. Thence, copies were sent to the Home Office for scientific advice in Britain and to the Foreign Office for the same abroad. By the end of the year the Institute had received contradictory replies from Britain. The current Astronomer Royal, George Airy, was wholly negative and advised that it had

19 Ibid., 138-48. Quote from 138.

20 Decisions and correspondence relating to Fleming's first papers to the Institute are available in printed form appended to the publication of his report on the Washington conference, 1884. See S. Fleming, *Universal or Cosmic Time* (Toronto, 1885). Their original records are at the Fisher Rare Book Library, University of Toronto.

21 Ramsay Wright in letter of transmittal to societies abroad, in *ibid.*, 29.

been the custom of Her Majesty's Government to abstain from interfering to introduce novelties in any question of social usage, until the spontaneous rise of such novelties [had] become so extensive as to make it desirable that regulations should be sanctioned by superior authority.²²

The Colonial Office endorsed this position, in somewhat more elegant language. However, The Royal Society was entirely sympathetic to the reforms proposed by Fleming, though not optimistic about the adoption of a prime meridian because of the 'susceptibilities of individual nations.'²³ But Airy was soon to retire in 1881 and be replaced by W.H. Christie, who would then campaign for Fleming's ideas; and the Home Office was soon to legalize standard time for all public use in Britain.

Meanwhile, Fleming himself had heard about and had been in touch with Cleveland Abbe, who had reported in May 1879 to the American Metrological Society, as chairman of its Committee on Standard Time. Abbe wrote back in March 1880 to say that the printing of his report had been delayed, and he would ask the President of the Society, Dr Barnard, to forward a sufficient number of copies when ready; Fleming was free to use them in any way he thought fit.²⁴ Abbe was then chief of the first weather bureau at the US Signals Office in Washington. He was unusually well-trained and had spent two years of advanced study with Otto Struve, the Russian astronomer, who (as we have seen) was active in the matter of universal time.²⁵ The Metrological Society had been functioning since 1873 when a group of scientists headed by F.A.P. Barnard, the President of Columbia College in New York, gave formal structure to their goal of unifying all weights and measures. Their primary objective was universal adoption of the metric system and they worked hard to overcome resistance to it in the English-speaking countries.

Abbe's report focused on both the accuracy and uniformity needed for standard time. He noted that telegraphs now enabled the distribution of accurate time from observatories, something which had occurred independently in Europe and America. Some eight observatories in North America, including one each in Toronto and Quebec City, had the means to 'furnish astronomically accurate time by telegraph to any customer on this continent,' and the first recommenda-

22 George Airy, in *ibid.*, 34.

23 G.G. Stokes, *ibid.*, 39.

24 Fleming Papers, Vol. 1, correspondence from Abbe.

25 *Dictionary of Scientific Biography* (New York, 1970), Vol. 1, 6.

tion of the report was that individuals or corporations who needed accurate time should arrange to get it from one of them. He then observed that Britain and Russia were already on standard time, the former on Greenwich and the latter on Pulkova. In America 'the necessities of railroad service' had already forced a partial standardization, but even so there about seventy-five different local times in use on the railroads, some of which did not differ among themselves by more than a few minutes, and many were 'of very doubtful reliability', being furnished by jewellers employed by the railroads. Five standards should be adopted as soon as possible by the railroads; i.e., the meridians at 60, 75, 90, 105 and 120 degrees or 4, 5, 6, 7 and 8 hours west of Greenwich; and these were to be known as Eastern, Atlantic, Valley, Mountain and Pacific. This step, however, was to be followed some time later by the full reform of adopting a single standard for the continent at 90 degrees west or six hours slow of Greenwich. For standardization to prevail, state and national legislatures were to be petitioned to make railway and telegraph time legal for all public and private business. And for international purposes the meridian precisely 180 degrees from Greenwich should serve as a zero or prime.²⁶

Barnard did send Abbe's pamphlets and approved Fleming's offer of joint action between the Canadian Institute and the Metrological Society. The Institute sent out a fresh batch of both pamphlets for dissemination to foreign embassies and the Governor General duly complied. Fleming drafted new resolutions as a common platform for the Metrological Society and the Canadian Institute, and both bodies adopted them formally.²⁷ Barnard and Fleming were soon corresponding regularly; it was most important, wrote Barnard, that they make a common front on both substance and strategy; they should put pressure first on governments, and if that failed to yield results, they should go for the railway companies. They were already agreed in principle on what should be done and only in detail did they differ, wrote Barnard. Abbe and he himself thought all Fleming's suggestions sound except for the idea of using letters of the alphabet for naming

26 Cleveland Abbe, *Report on Standard Time* (New York, 1879). Quotes from 3, 5 and 8. In the event the names, Eastern and Atlantic were reversed, so that the time at 75 degree meridian came to be known as Eastern, while that at 60 was first called Intercolonial, after the railway, before Atlantic was fixed upon. The origin of Mountain was 'Rocky Mountain,' named after the observatory at Denver on the meridian at 105 degrees longitude from Greenwich: Report of the Standard Time Committee, *Proceedings of the American Metrological Society*, Vol.II, 233.

27 *Proc. A.M.S.*, Vol.II, 172-4.

meridians, because they were not universal. And rather than call the universal time 'cosmopolitan' why not refer to it as 'Greenwich', assuming the latter or its opposite were to be the universal prime?²⁸

From Europe, Otto Struve's reply on behalf of the St Petersburg Academy of Sciences, was wholly favourable. He agreed with both, though Fleming's memoir was more general than Abbe's. He himself had advocated the universal use of Greenwich as prime meridian some ten years before, but had found French scientists to be resistant to the idea. Hence, though he supported the principles of the two proposals, he thought that widespread use of universal time was unlikely, and would settle for its limited application to the concerns of scientists.²⁹ Struve's personal tie with his former pupil, Abbe, might have been partly responsible for the speed and warmth of his reply.

During the year 1881 Barnard and Fleming contrived together and separately to generate wide support for their project of time reform. Two circulars issued by the Metrological Society in March were distributed to scientific bodies, transport companies and chambers of commerce; the first solicited their views on the proposed reforms, while the second informed them of the service that the US Signals Office could provide for accurate time. In June the American Society of Civil Engineers met in Montreal and Fleming took advantage of the occasion to enlist that body in the cause. In August Barnard travelled to Cologne to present his proposals to the Association for the Reform and Codification of the Law of Nations, and in September Fleming was in Venice at the International Geographical Congress, along with George Wheeler of the US Geodetic Survey. Wheeler was delegated by the American Metrological Society, while Fleming represented both it and the Canadian Institute. For the Venice meeting Fleming had revised his earlier paper, earning as praise from Barnard: 'you have proposed resolutions which no reasonable man can hesitate to accept at once.'³⁰ But hesitate they did and that Congress produced no more result than its predecessors.³¹ Of the activities of this year only one had a direct effect:

28 Fleming Papers, Vol. 2, correspondence from Barnard to Fleming, March to December, 1880.

29 Otto Struve in S. Fleming, *Universal or Cosmic Time*, 45-8.

30 Fleming Papers, Barnard to Fleming, 8 September 1881.

31 See *Proc. A.M.S.*, Vol.II, 285-93, for details of the Congress, and Fleming Papers, Vol. 53, letters of Wheeler, for its outcome.

Fleming's invasion of the Civil Engineers, whose Committee on Standard Time was to be the main actor in 1882.

The American Society of Civil Engineers had been active for some fourteen years, holding their annual meetings in New York and mid-year conventions elsewhere, when it convened in Montreal in June 1881. It was then in the throes of defining what was involved in professionalization.³² The Society was dominated at the time by men like Fleming who were associated with railways, as managers of the organizations or as designers of the roads, bridges and other structures involving innovative engineering. They were ripe for a public cause. Fleming's paper seemed tailored for them with its title: 'On Uniform Standard Time for Railways, Telegraphs and Civil Purposes Generally.' 'His eloquent plea found receptive ears.'³³ He was appointed chairman of their standing committee, along with six other members three of whom were senior railroad officials and another was Thomas Egleston, professor at the Columbia School of Mines and already familiar as secretary of the Metrological Society. Fleming decided that the Committee's first task was to amplify and complement the circulars already sent out by Barnard. He designed a questionnaire covering all contentious aspects and prepared an explanation because, in Egleston's words, 'most of the railways ... have very little idea of what standard time means.'³⁴ He meant, presumably, that railwaymen did not know about the fine detail to which the questions referred.

Fleming's draft and his plan to circulate it among railwaymen were approved at the meeting in New York in January 1882. But his original aim of reaching all railroad officials proved too costly, and on the advice of W.F. Allen, permanent secretary of the General Railway Time Conventions, they were reduced to 'every general manager or general superintendent, and to the presidents of the trunk lines' with a request to each that the task of replying to the questions be delegated to a competent subordinate.³⁵ Also, they were to go to a select number of scientific groups listed by Abbe.³⁶ The mailing in mid-March went, in the

32 W.H. Wisely, *The American Civil Engineer, 1852-1974* (New York, 1974), 64-5.

33 *Ibid.*, 229.

34 *Fleming Papers*, Vol. 14; Egleston to Fleming, 27 July 1881.

35 *Ibid.*, Vol. 1; Allen to Fleming, 25 February 1882.

36 *Ibid.*, Vol. 14, Egleston to Fleming, 30 January 1882.

words of the Secretary of the Society, John Bogart, 'to two classes of people: the bright, practical railroad men and the men of a theoretical turn of mind. We are sending to ten of the former in proportion to one of the latter.'³⁷ Despite the curtailed numbers the cost of printing and posting was beyond the resources of the Society, and Bogart asked Fleming to reimburse him for the amount (\$ 223.51) which he had paid out of his own pocket.³⁸ Fleming had already offered to pick up the tab.

Once the questionnaire was out of the way, Fleming began working on a petition to the US Congress for an international conference to be authorized for the purpose of deciding on a prime meridian. At the May convention of the Civil Engineers he received approval for it. It was to join one already on the way from the Metrological Society which had been inspired by the energy of the Civil Engineers. They were being bolstered by yet others which were being put to Congress -- from the New York State Legislature and from the American Geographical Society.³⁹ The combined pressure worked; the US Secretary of State enquired of the nations with whom the US had diplomatic relations whether they would approve holding such a conference. But the pace of the White House seemed too slow for Fleming who felt that the need for reform had become urgent.

The replies to the questionnaire he had sent out were coming in by mid-year. They showed overwhelming (more than 95 per cent) support for standardization in general, and of specific schemes the most popular at 76 per cent was the one based on one-hour zones, followed by only 36 per cent in favour of the single standard time for the continent considered to be ideal by Abbe and other astronomers. Such clear results enabled Fleming to enliven the discussion of time reform at the Montreal meeting in August of the American Association for the Advancement of Science, which then set up its own committee for the purpose. And he used the same leverage to introduce the topic to the newly-minted Royal Society of Canada. He reported in January 1883 to the annual meeting of the American Society of Civil Engineers that though Congress had approved convening an international conference, the necessity for reform on the North American continent was so urgent that they should not wait for other nations.⁴⁰

37 *Ibid.*, Vol.2; Bogart to Fleming, 13 March 1882.

38 *Ibid.*, Bogart to Fleming, 8 May 1882.

39 *Proc. A.M.S.*, Vol. III, 3-13.

40 Report of the Standard Time Committee, ASCE, January 1884.

Fleming and Egleston discussed the prospects if a meeting were to be called by the Civil Engineers, and they explored the timing, venue and other details; eventually, they involved Barnard in the planning. In May Fleming wrote to the American Metrological Society with the suggestion that scientific societies with committees on standard time should be invited to coordinate their activities; they could aim for a convention in November, possibly, to promote a decision. He himself could list the following organizations, but there might be others he did not know about:

1. The American Metrological Society
2. The Canadian Institute
3. The American Society of Civil Engineers
4. The American Association for Advancement of Science
5. The Association of Railway Superintendents
6. The International Institute, Cleveland
7. The Royal Society of Canada.

The proposal was referred to the Committee on Standard Time, where it died.⁴¹ That trick had been trumped by the railwaymen.

Railway officials had been meeting since the 1860s to agree on timetables and other matters requiring consensus. Since 1875, when W.F. Allen was made permanent secretary, their meetings had acquired regularity (twice-yearly) and structure (agendas etc.), and had become known as the Railway Time Conventions. These Conventions, or their earlier forms, had been addressed on standard time by Charles Dowd on several occasions between 1869 and 1873, by which year he had elaborated the idea of one-hour zones based on Greenwich in much same form as was to be adopted. But a rate war among the trunk lines forced the idea off-stage until it was revived by Abbe and Fleming. The revival began with inclusion of Abbe's Report in the agenda for the Time Conventions of 1881.⁴²

41 *Proc. A.M.S.*, Vol. IV, 6-8.

42 For a full account of the role of Abbe and Allen, see Ian R. Bartky, 'The Adoption of Standard Time,' *Technology and Culture* (January, 1989), 25-56. My account of this episode draws largely from his paper.

Allen was asked at the October Convention to report back with practical recommendations the next year. However, no convention was held in 1882 because of exceptionally severe warfare among the railroads.⁴³

For the Time Conventions of April 1883 Allen was exceptionally well prepared. At the meeting of the Metrological Society in the previous December (if not earlier), he had learnt the most recent news on the subject; in particular, the results from Fleming's questionnaire, the failure of a bill requiring Washington time in all government work and a paper on how to display the proposed reforms on maps.⁴⁴ He himself was convinced that the time for reform was due; the last of the eight principles with which he introduced his report condemned 'the "Hard Scrabble" system now in use, with its fifty different standards intersecting and interlacing each other, is an abomination and a nuisance which cannot be too soon remedied.'⁴⁵ The other principles were put in language as clear and direct. But he did not let his report speak for itself; he enhanced it by the brilliant stroke of comparing by coloured maps the simplicity of zones of one-hour intervals based on Greenwich and complexity of the 'hard scrabble' system.

Apart from skilful presentation there was one unique feature to Allen's report. He differed from others by drawing the zone boundaries neither along state lines nor on medians between the hour meridians, but along the natural break points between railroad corporations, thus reducing the inconvenience to them. His report was approved unanimously for circulation to all corporations with a view to adoption the next October. But he left little to chance. At the May meeting of the Metrological Society he asked for help and was given it in the shape of a committee to petition the railroad corporations.⁴⁶ It was the same meeting which shunted Fleming's suggestion for a continental convention to the siding.

Then, in August Allen himself followed up with a letter to the senior officials of

43 See the interpretation of railroad competition in Alfred Chandler's *The Visible Hand* (Cambridge, MA.), 145-70.

44 *Proc. A.M.S.*, Vol. III, 25-31.

45 W.F. Allen, *Report on National Standard Time* (New York, 1883), 2.

46 *Proc. A.M.S.*, Vol. IV, 8.

the corporations asking which side they on. By the opening of the Convention Allen was sure of winning. The vote was greatly in favour of converting to the new system and Sunday, 18 November 1883, was set for the change. It was remarkably tranquil. In Canada, of the major dailies of 17 November, only *The Globe* of Toronto made any reference to the event and it was a single column praising Fleming and the Canadian Institute. In New York, where civic pride may have caused a problem although the shift would only be four minutes, Allen had done his homework and the change was made to the cheers of a 'little group of interested spectators.'⁴⁷ By Spring 1884, reported Allen, all of Canada except for St John (NB) and 90 per cent of the US were on standard time.⁴⁸

We should pause here to assess what had been achieved. As Allen had foreseen, railway time became public time so that local time vanished in Canada and the US except in pockets, which flare up or continue even today.⁴⁹ For there were (and continue to be) people believing in true or divinely-appointed time like the member of Ottawa's Parliament who wrote of his opposition for many years to Fleming or the Astronomer Royal for Scotland, Piazzi Smyth, who thundered on about disobeying the Bible.⁵⁰ So the change had been more far-reaching and painless than anyone had any right to expect before it happened, even though most of the actors were well aware of the dominance of railways in urban everyday affairs even for those who did not travel much.

What was surprising then, and still needs explanation today, was how swiftly the change occurred, particularly when compared to the length of the much simpler change in Britain. As for Fleming, though enthusiastic in public over 'the revolution in the usages of sixty millions of people ... silently effected with scarcely a trace' that it happened, he grumbled privately about 'the matter of standard time getting the cart before the horse.'⁵¹ Reform needed to be, for him, both universal

47 W.F. Allen, *Proceedings of the General Time Convention, April 1884* (New York, 1884), 3.

48 Ibid.

49 For contemporary opposition in the US see Ian R. Bartky and Elizabeth Harrison, 'Standard and Daylight Saving Time,' *Scientific American* (May 1979), 46-53; in Canada 'Newfoundland Time' is a case in point.

50 Fleming Papers, G.W. Wicksteed to Fleming; Smyth in Fleming, *Universal or Cosmic Time*, 37.

51 Fleming, *Universal or Cosmic Time*, 17.

and in a definite order: first, consensus on the prime meridian; second, adoption of one-hour meridians; third, conversion to the 24-hour clock; and, finally, uniformity of civil, nautical and astronomical days. Now he had to pursue them simultaneously.⁵²

'But the crowning point of Mr. Fleming's scheme, and that which he yet hopes to attain,' wrote *The Globe* on Saturday, 17 December 1883,

is the establishment of an absolute time for the whole world. That is, he would discharge Old Sol from the position of the world's timekeeper which he has so long and faithfully filled and would give the work into the hands of Old Father Time himself.⁵³

The international meeting for which the Metrological Society and the Civil Engineers had petitioned had been set for October 1884. Delegations composed of diplomats and scientists from twenty-five countries arrived in Washington at the start of the International Conference on the Prime Meridian and Universal Day. As Canada was then part of the British Empire, Fleming could not represent it directly, and only by lobbying through the Royal Society and its patron, the Governor General, was he appointed as part of the British delegation.⁵⁴ The first two days were spent in wrangling over procedure and the task of the Conference.⁵⁵ The issue of the prime meridian itself was left unresolved even after the third session, because French insistence on searching for a 'neutral' meridian, one which was untainted with use by any nation, had put in motion the political undertow of this 'scientific' question.

Then the delegates were left to cool for a week while a bilingual stenographer was sent for from Ottawa, to satisfy the initial accord that copies of the proceedings to date would be available in both English and French before each session.⁵⁶

52 Fleming Papers, Vol. 14, correspondence with Egleston.

53 Toronto, *The Globe*, 17 December 1883, 12.

54 Address to Senate, 14 March 1883.

55 The proceedings of the conference were published in December, 1884, as Document #14 of the 48th US Congress.

56 *Ibid.*, 44.

When formal discussions resumed, Fleming introduced a set of resolutions (with copious notes) which he had submitted at the beginning of the conference, the only delegate to have done so. Although opposed in his bid for the prime meridian opposite Greenwich, he persuaded the conference to abandon the quest for a neutral one. And as the consensus was that further talk would not alter anyone's position, the vote showed all but France, Brazil and San Domingo in favour of the prime meridian at Greenwich.⁵⁷ A spokesman for Spain frankly remarked that if the US and Britain were to adopt the metric system, it would be a fair exchange for the prime just adopted.⁵⁸ Further resolutions, however, on the universal day and how it was to be counted had the effect of endorsing in practice the Fleming proposal, which in its essentials conformed to the ideas he had elaborated at the Canadian Institute in 1879. In the words of his report to Parliament, the Meridian Conference had the following result:

1. The advantages of Universal Time are recognized.
2. The Universal Day is defined.
3. While the Meridian of Greenwich is chosen as the Prime Meridian and the zero of longitude, the anti-Prime Meridian becomes the zero of Time.
4. The hours of the hours of the Universal Day are to be counted in one series from zero up to twenty-four.
5. The zero of the hours is the moment of mean solar passage on the anti-Prime Meridian. The first hour is at the moment of mean solar passage on the Meridian 15 degrees west of the anti-Prime Meridian; the second and remaining hours of the Universal Day come in turn at the solar passage on successive Meridians 15 degrees of longitude apart, each Hour-meridian being an exact multiple of 15 degrees from zero.⁵⁹

The adoption of standard time based on Greenwich in North America, coupled to the ubiquity of Greenwich time for nautical almanacs, had virtually assured its universal acceptance. Those questions which had been settled neither at Rome

⁵⁷ *Ibid.*, 45-72.

⁵⁸ *Ibid.*, 51.

⁵⁹ Fleming, *Universal or Cosmic Time*, 71-2.

nor at the Railway Time Convention received a much less decisive vote at Washington, than the decision on the prime meridian.⁶⁰ Among them was the fifth resolution urging use of the 24-hour clock.

Elimination of 'am and pm' had been Fleming's hobby horse since he became interested in time, and by his own account it was the origin of his campaign for time reform. He had spent large sums in buying custom made watches with 24-hour dials.⁶¹ When Fleming reported in January 1884 to the Civil Engineers in New York on the adoption of railway standard time, he reminded them that the 1882 questionnaire had shown almost as much support for the 24-hour clock and he now put it to the top of the agenda. The recent change was the first step.

The second important step in regulating time throughout the world, is to abandon the division of the day into ante-meridian and post-meridian hours, separately numbered, and to substitute a single series of hours numbered from 0 to 24.⁶²

By January 1885 Fleming could report the happy outcomes of both the Washington conference and the secretary's enquiry: of 171 senior railway officials, 98 per cent were for the 24-hour clock; and there were various European signs of approval, including the announcement of its internal use at Greenwich. But two years later, in 1887, only the Canadian Pacific Railway had adopted the change, and optimism was sustained only by the enthusiastic testimonials of Van Horne, his dispatchers and CP passengers.⁶³ By 1891 there was more progress to report -- on telegraphs throughout the British Empire and the award official seal of approval in Britain, on railways elsewhere -- but none in the United States, despite his intense lobbying. His final attempt was a comprehensive pamphlet on *Twenty-Four-O'clock Notation* for the American railways published in 1892, which again failed in its immediate objective.

The continuing failure with the 24-hour clock began to worry Fleming, par-

60 The Russian astronomer, Otto Struve pointed to these facts in his report; see Fleming, *Universal or Cosmic Time*, 89-94.

61 Fleming Papers, correspondence with Barnard and clock maker, Edward White, 1883.

62 *Proc. C.I.*, 1889-90, 230. Although this quotation is from a retrospective piece, it reflects exactly Fleming's thinking of five years before.

63 *Proc. A.S.C.E.*, Vol 12 (1887), 2-5.

ticularly when coupled to suspicions about the legality of standard time. If time of occurrence were to be an issue in a court case, which of 'local' and 'standard' time be accepted. Moreover, moves by the White House to give official sanction to the resolutions of the Meridian Conference, both soon after and again in 1888, had come to naught. There seemed to be a real danger of reverting to the chaos on time from which the American continent had just emerged. He decided that if the change were to become permanent, it had to be taught to the younger generation. Accordingly, he prepared a 'treatise' on *Time and its Notation: for the use of schools in the Dominion of Canada*, which was presented to the Canadian Institute and adopted by its president for 1887-90, Charles Carpmael. Carpmael (1846-1894) was director of the Meteorological Service of Canada and resident astronomer at the Toronto Observatory, one of the earliest and best known on the continent.⁶⁴ An enthusiastic Fleming ally, he petitioned first the Minister of Education in Ontario, George Ross (who was a member of the Institute), on 15 March 1888, and then on 7 May 1888, the Governor General, for their support in distributing the pamphlet to schools in Canada and abroad. Ross asked for 500 copies which he would distribute to the public schools in Ontario. Lord Landsdowne was pleased to follow the example of his predecessor, Lord Lorne.⁶⁵

While this piece was percolating through the system, Fleming wrote another entitled 'Movement for Reckoning Time on a Scientific Basis...' at the request of the Astronomer Royal which he read a meeting of the Institute on 30 November 1889.⁶⁶ Christie then endorsed it as chairman of the British Committee, and it became the basis of a petition to parliament. The idea of a petition to governments had been born out of the frustration of the Civil Engineers over the business of 24-hour notation, which was aggravated by their disagreement on how to introduce concepts of time reform into the American schools. Passing the buck

64 For information on Carpmael in the context of astronomy in Canada, see Richard Jarrell, *The Cold Light of Dawn* (Toronto, 1988), 47-52; see also, Malcolm Thomson, *The Beginning of the Long Dash* (Toronto, 1978), 25-40.

65 Thomas Fisher Library, University of Toronto, Royal Canadian Institute, Minutes of Council, 29 May 1888, 26.

66 Proc. C.I., 1889-90, 6 and 227-42.

to Congress seemed like a good idea.⁶⁷ Fleming had also sent the school pamphlet to the Metrological Society where it was consigned to committee.⁶⁸ Lack of response from that quarter was another reason for giving the reforms to date the authority of law. During 1890 both the Civil Engineers and the Canadians were busy preparing petitions to their respective governments, with Fleming as the main draughtsman. Egleston was nominated to lobby in Washington while Fleming himself would pull strings in Ottawa. Both bills failed to be enacted.⁶⁹ But the Colonial Office did ask the Dominion of Canada (Carpmael) to respond to the circular on schools which the Governor General (Carpmael) had sent out, which was reassuring; if the government would not do the job, its bureaucracy would.

Another item of unfinished business from the Washington conference was the adoption of the universal day for civil, nautical and astronomical purposes. Both Fleming and Carpmael had been active on this front too; they joined in one last try to challenge astronomers to fall into line for adoption of the universal day on 1 January 1901, by means of a joint memorial (again via the Governor General) from the Canadian Institute and the Astronomical and Physical Society of Toronto. Familiar ground was covered again.⁷⁰ Once again the Astronomer Royal declared himself willing if others were. Most of the European astronomers were in favour of the shift (except in Germany where they were remote from the issue), as also in the United States, except for one person. The American exception was Simon Newcomb, by then the doyen of American astronomy.⁷¹ The attempt failed. Fleming made no bones about identifying him as the culprit in the follow-up report of 1896, but by then it was too late to make any difference. The union was not effected until 1925, long after the contestants had died. The sailors, meanwhile had shifted one by one to the civil day.

67 *Proc. A.S.C.E.*, 1889, 10-13.

68 *Proc. A.M.S.*, 1888-89, 180. Allen was the active member of the committee.

69 All relevant documentation, including the US bill, is in a Canadian Government document issued for the 1891 session, with the title *Fixing of a Standard of Time*.

70 *Fleming Papers*, Vol. 107, Bound printed matter.

71 Newcomb had consisted derided the idea of standard time, and when it became a reality in North America, he opposed universal time. Fleming became quite bitter about Newcomb. Yet Newcomb's article on 'Standard Time' in the 1911 edition of *Encyclopedia Britannica* gives the lion's share of the credit to Fleming.

As for the railways, Fleming tired of repeating the message: 24-hour counting was alive and well in Canada, and it was catching on everywhere else, even in Germany. Annually, he would ask the Civil Engineers to discharge their Committee on Standard Time; then he skipped a report and when prompted said he was signing off. That was in 1899. One of the older members joked about feeling lonesome without that committee.⁷² But it was already fading away. France went on Greenwich time in 1911. Canada and the United States both legislated on 'time' in 1918, as a wartime emergency, but by then they needed coercive power only for daylight-saving provisions, as the main features of universal time were well established through custom and by bureaucratic usage. The Canadian measure was temporary, and it was invoked again during WWII.⁷³ Since then regulation of time in Canada has been left to the provinces, and on borders to municipalities. Legal usages differ from country to country, but radio and TV have made 'time please' a universal habit.

In the conventional accounts of standard time we are given a chronology of events and a list of actors, one being more prominently featured than the others. For example we are often told that Sandford Fleming invented standard time. That comes close to rubbish: many men preceded him (e.g. Dowd, Abbe and Struve) and their ideas evolved gradually; universal time was a constellation of ideas rather than an invention; and it was the whole rather than the part -- standard time -- to which Fleming directed his effort. The adoption of standard time by railways in North America, a key event, was carried through by Allen, while Fleming was marking time. It was only when Fleming accepted the situation that reforms would occur piecemeal that he gained ground. But worst of all, that story ignores the institutional role or at best mentions an institution as if it were the only one.

Fleming deserves to be remembered for his brilliant use of institutions and his alliance with key individuals (Barnard, Carpmael, Christie, Egleston and Struve). The institutions which were his bases, for crucial periods at least, were the Canadian Institute, the American Society of Civil Engineers and, in the early years, the American Metrological Society. He used the one to goad the others into action, and then united them to capture the attention of officialdom, but his

72 *Proc. A.S.C.E.*, 1899, 28.

73 Thomson, *The Beginning of the Long Dash*, 176-7.

use of them but not merely opportunistic. He cared deeply about what they stood for, and as well believed that innovative technologies called for matching social responses.

Canadian engineers active in seeking professional status and roles would continue the pattern of joining their neighbours in a common cause so vividly displayed in lobbying for universal time. To achieve that goal Fleming exploited continental connections as readily as imperial ones, and that southern orientation came to typify the promotion of engineering in Canada. The imperial tie that had brought into being the Royal Society of Canada was being elbowed out by bonds being established with US institutions.⁷⁴ The British connection would remain important for honours and the arts, but for science and engineering Canadians were turning more and more to the US. Fleming himself faced both ways: south in technical matters, and to Britain for honours and allegiance (as in the development of an imperial cable around the world). He was honoured by Columbia University before being knighted by a grateful sovereign. Were we to honour him we do so because he saved time from the fate that befell the metric system.

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74 Vittorio de Vecchi, 'The Dawning of a National Scientific Community in Canada, 1878-1896,' *Scientia Canadensis* 8 (1984), 32-58. The paper emphasizes the British tie; while that connection was important in founding the RSC, the scientific community grew more ties to the US than across the Atlantic.