PRESENT SCIENTIFIC POSSIBILITIES OF TIME COMPARISONS AT GREAT DISTANCES

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Recent experiments have demonstrated the possibility of obtaining 1/10,000*th-of-a-second accuracy in time comparisons at great distances by means of radio-telegraphic connections on short waves. Such results can have interesting applications to longitude determinations and a large number of other scientific problems.*

A paper presented by the author and Mr. C. Egidi to the General Assembly of the International Radio-Scientific Union held in Sydney in August, 1952, had an unexpected effect. It dealt with measurements of the duration of propagation of time signals on short waves on the Turin-Washington track which had been initiated by the National Electrotechnic Institute and carried out in May, 1951, with the collaboration of the American National Bureau of Standards and several other foreign laboratories. As these measurements were of a preliminary and selective character, the paper, with a view to wide international collaboration, aimed at taking advantage of the occasion to continue and develop these experiments which, though they presented some organizatonal difficulties, had given initial results that were sufficiently encouraging.

The two most striking features of these first experiments were :

(a) that in spite of the peculiar characteristics of propagation in the ionosphere and the multiplicity of paths of radio-electric waves on a lengthy track, the statistical examination of the results showed that, for the value of duration of propagation taken as the average of a certain number of observations made in the course of one minute, an accuracy of 0.0001th of a second could, in practice, be obtained; and

(b) that the number of « salti » (i.e., of successive reflections of radio-electric waves in the ionosphere during their propagation from one extremity of the track to the other) seemed to be about twice as much as the normal number expected on the basis of another type of deduction drawn from already long practice in communications on short waves at great distances.

The second point is of particular interest to ionospheric propagation specialists and warrants a separate and more extensive study for checking the actual existence of apparent contrast, the reasons for which are still entirely unknown.

The first point, on the other hand, leads to the broadest and most up-to-date possibilities in the more varied field of research as it shows the possibility, in 99.5 % of the cases, of determining with a variability of not more than 0.0001th of a second, the simultaneousness of, or the relation of time between, two events occurring at any two given points on the earth's surface.

One of the first important applications of the exact knowledge of the time of propagation of radio-electric signals at great distances can be to the problem of longitude determinations in relation to astronomic observations. If, as now seems decided, there should be in five or six years time new world-wide operations on longitude determination, this problem will become the topic of the day. In view of this fact, the advisability of undertaking a precise study of the duration of propagation of time signals on short waves at great distances was clearly pointed out to the International Radio-Scientific Union by Professor P. Tardi, President of the Longitude Commission of the International Astronomic Union, a short time

before the meeting in Sydney. This opportune statement undoubtedly paved the way particularly well for promoting and developing the Italian initiative. During the course of the General Assembly in Sydney, the International Radio-Scientific Union formed a special, permanent Sub-Commission of the Third Commission (Ionosphere and Propagation of Radio-Electric Waves) to promote and coordinate, during the next few years to come, with the cooperation of the largest possible number of laboratories, new experiments in various parts of the world. The Sub-Commission's first action was to consider and discuss the results obtained from the first experiments of the National Electrotechnic Institute and to settle the question of the aims of the research and of its later development. With this end in view, it was requested that, while awaiting instructions, all new experiments, as with those carried out by the National Electrotechnic Union, be conducted in such a way as to give results with statistical significance, that is, results that would give the average value of the duration of propagation in a short, fixed interval of time, such as, for example, one minute. It was also decided at the General Assembly that the news of the formation of the Sub-Commission and the results of its first activities should be brought to the attention of the General Assembly of the International Astronomic Union scheduled for September in Rome.

In Rome, a paper on this subject was presented by the author to a joint meeting of the two Commissions — No. 18 (Longitudes) and No. 31 (Time) — and great interest was aroused. Professor Zverev, of Pulkowo Observatory, pointed out pertinently that present rough estimates of astronomic observations are, even in the best instances, only of some milliseconds with a very good transit instrument or transit circle, and of the order of some milliseconds with a photographic zenith telescope. They are, therefore, much worse than those which can be obtained by comparisons of time signals at great distances by radio-electric waves. Consequently, in view of future world-wide operations on longitude revisions, maximum impetus should be given to the perfecting of methods of observation. Photo-electric apparatus would seem to call for special attention. For some time now, these have been tested in Russia and the results have been very promising. It has, however, been observed in another connection that the fact of reducing to a definitely negligible point one of the causes of variability (i.e., that concerning time comparisons) allows the statistical examination of the results to be turned entirely towards the study of those causes which are related to star observations The present inferiority of transit observation methods gave rise to a full discussion directed towards deciding whether the date of the new longitude operation should be fixed for 1958 or whether it should be postponed in the expectation of such methods being improved. Finally, the first suggestion was carried by a large majority of votes due, above all, to the able intervention of Professor Tardi and Sir Spencer-Jones, the Astronomer Royal at Greenwich. Consideration was also given to the advisability of approaching the International Council of Scientific Unions in regard to the formation of a mixed Commission — drawn from members of the three Unions (i.e., Astronomic, Geodetic and Geophysic, and Radio-Scientific) — for the study of longitude problems. There are some doubts, however, about the agreement of the International Council of Scientific Unions to this proposition, and it should be noted that, even if such a Commission were to have the opportunity of accomplishing a very useful task of coordination between the specialists of the different Unions interested in the problem, its existence, nevertheless, is not strictly necessary for the success of the project, judging from the clear position that has been established in this matter.

Another very interesting application of the results obtained in the recent determinations of the duration of propagation of time signals was envisaged by M. Laffineur in the course of the work of the International Radio-Electrotechnic Union at Sydney. It concerns the study, in correlation with solar bursts, of the shape of the wave front of particular radio-electric transmissions coming from the sun. As the front of the beginning of these radio-electric disturbancee is rather steep, it is possible to see whether or not they propagate themselves in space in spherical waves by comparing the instants of their arrival at two points on the earth which are separated by a sufficient distance. It should also be possible to check the assumption, based on considerations of another nature, that such transmissions have a clear, directional character and a course that can quickly

change, like a projector beam sweeping space. The ten-thousandth part of a second in time comparisons corresponds to a variability of 30 km., which, on the basis of several thousand kilometres, is very little.

Two applications of the modern possibilities offered by comparisons of time at great distances have here been reviewed. It is very likely that other applications will appear rapidly from other fields of physical phenomena. It is to be hoped that the Italian contribution will not be confined to a work of centralization or coordination of researches carried out elsewhere, but that it will also develop in the form of some new experimental activity.