errors determined during the night to form a value of the clock error for the time when the exchange of signals took place. When using this method it is advisable to select the stars in such a manner that only one station at a time is at work, so that the intensity of the current can be readjusted (by means of a rheostat) between every despatch and receipt of signals. This attention to the intensity of the current is necessary whatever method is em­ployed, as the constancy of the transmission time (x in the above equations) chiefly depends on the constancy of the current. The probable error of a difference of longitude deduced from one star appears to be@@1

for eye and ear transits ±0s⋅08, for chronograph transits ±0s⋅07 ;

while the probable error of the final result of a carefully planned and well executed series of telegraphic longitude operations is gener­ally between ±0s⋅015 and ±0s⋅025.

It is evident that the success of a determination of longitude de­pends to a very great extent on the accurate determination of time at the two stations, and great care must therefore be taken to de­termine the instrumental errors repeatedly during a night’s work. But, in addition to the uncertainty which enters into the results from the ordinary errors of observation, there is another source of error which becomes of special importance in longitude work, viz., the so-called personal error. The discovery of the fact that all observers differ more or less in their estimation of the time when a star crosses one of the spider lines in the transit instrument was made by Bessel in 1820@@2 ; and, as he happened to differ fully a second of time from several other observers, this remarkably large error naturally caused the phenomenon to be carefully examined. Bessel also suggested what appears to be the right explanation, viz., the co-operation of two senses in observing transits by eye and ear, the ear having to count the beats of the clock while the eye com­pares the distance of the star from the spider line at the last beat before the transit with the distance at the first beat after it, thus estimating the fraction of second at which the transit took place. It can easily be conceived that one person may first hear and then see, while to another these sensations take place in the reverse order ; and to this possible source of error may be added the sensible time required by the transmission of sensations through the nerves to the brain and for the latter to act upon them. As the chronographic method of observing dispenses with one sense (that of hearing) and merely requires the watching of the star’s motion and the pressing of an electric key at the moment when the star is bisected by the thread, the personal errors should in this case be much smaller than when the eye and ear method is employed. And it is a fact that in the former method there have never occurred errors of between half and a whole second such as have not unfrequently appeared in the latter method.

In astronomical observations generally this personal error does not cause any inconvenience, so long as only one observer is em­ployed at a time, and unless the amount of the error varies with the declination or the magnitude of the star ; but when absolute time has to be determined, as in longitude work, the full amount of the personal equation between the two observers must be care­fully ascertained and taken into account And an observer’s error has often been found to vary very considerably not only from year to year but even within much shorter intervals ; the use of a new instrument though perhaps not differing in construction from the accustomed one, has also been known to affect the personal error. For a number of years this latter circumstance was coupled with another which seemed perfectly incomprehensible, the personal error appearing to vary with the reversal of the instrument, that is, with the position of the illuminating lamp east or west But in 1869-70 Hirsch noticed during the longitude operations in Switzerland that this was caused by a shifting of the reflector inside the telescope, by means of which the field is illuminated, which produced an apparent shifting of the image of the spider lines, unless the eye-piece was very accurately focused for the observer’s sight. The simplest and best way to find the equation between two observers is to let one observe the transits of stars over half the wires in the telescope, and the other observe the transits over the remainder, each taking care to refocus the eye-piece for himself in order to avoid the above- mentioned source of error. The single transits reduced to the middle wire give immediately the equation ; and, in order to eliminate errors in the assumed wire-intervals, each observer uses alternately the first and the second half of the wires. Another method is in vogue at Greenwich, where each observer with the transit circle from a series of stars determines the clock error and reduces this to a common epoch (0h sid. time) by means of a clock rate found independently of personal error. The differences between the clock errors thus found are equal to the personal equations. This method cannot, however, be recommended, as the systematic errors in the right ascensions of the stars and any slight variation of the clock rate would affect the personal equation ; the first method is there­fore generally used in longitude work. It is advisable to let the observers compare themselves at the beginning, middle, and end of the operations and, if possible, at both the instruments employed. A useful check on the results is afforded by simultaneous experi­ments with one of the instruments contrived by C. Wolf, Kaiser, and others (sometimes called “time collimators”), by whieh the absolute personal error of an observer can be determined. Though differing much in detail, these instruments are all constructed on the same principle : an artificial star (a lamp shining through a minute hole in a screen mounted on a small carriage moved by clockwork) passes in succession across a number of lines drawn on oiled paper, while an electric contact is made at the precise moment when the star is bisected on each line by the carriage passing a number of adjustable contact makers. The currents thus made register the transits automatically on a chronograph, while the observer, viewing the apparatus through his telescope, can observe the transits in the usual manner either by eye and ear or by chrono­graph, thus immediately finding his personal error. On the Conti­nent these contrivances have frequently been used to educate pupils learning to observe, and experience has repeatedly shown that a considerable personal error can be generally somewhat diminished through practice.

@@@1 Albrecht, Bestimmung von Längendifferenzen mit Hülfe des elec­trisehen Telegraphen, p. 80, Leipsic, 1869, 4to.

@@@2 Maskelyne had in 1795 noticed that one of his assistants observed transits more than half a second later than himself, but this was sup­posed to arise from some wrong method of observing adopted by the assistant, and the matter was not further looked into.

*Literature.—*General treatises on spherical astronomy, such as Brünnow’s *Lehrbuch der sphärischen Astronomie (3d* ed., Berlin, 1871 ; translated into English and several other languages) and Chauvenet’s *Manual,* treat very fully of the numerous methods of determining time by combination of altitudes or azimuths of several stars. The best handbook of telegraphic longitude work is Albrecht’s already mentioned ; but any one engaging in practical work of this kind should consult the accounts of the numerous longitude determinations carried out during recent years, particularly the *Publicationen des kön. preussischen geodätischen Instituts ; Telegraphic Determination of Differences of Longitude by officers of the United States Navy* (Washington, 1880) ; *Telegr. Determ. of Longi­tudes in Mexico, Central America, and on the West Coast of South America* (Wash­ington, 1885) ; the *Reports* of the United States Coast and Geodetic Survey ; vol. ix. of the *Account of the Great Trigonometrical Survey of India* ; and vol. iii. of Dun Echt observatory *Publications.* A discussion of all the investigations on personal errors up to 1875 was published by Dreyer in *Proc. R. Irish Acad..* 2d series, vol. ii., 1876, pp. 484-528. (J. L. E. D.)

TIMOLEON. The life of Timoleon, one of the noblest and most interesting of the men of old Greece, is closely bound up with the history of Sicily (q.v.), and more par­ticularly of Syracuse *(q.v.),* in the latter half of the 4th century b.c. It is as the champion of Greece against Carthage, and of constitutional government against violence and oppression, that he stands out as such a grand figure. His early career in his native Corinth was shaped by a tragic incident. Timoleon had saved the life of his brother, Timophanes, on the field of battle ; but, when that same brother, at the head of a band of mercenary soldiers, took possession of the acropolis and made himself practically a military despot and master of the city, Timoleon, after an ineffectual protest, let him be struck down by his brother- in-law and one or two other friends who had joined in his remonstrance. By the public opinion of Corinth generally his conduct was approved as patriotic ; but the curses of his mother and the cold looks of some of his kinsfolk and acquaintances drove him from the city into the solitude of the fields, and there, it would seem, for some years he pined away, hating life and even bent on ending it by voluntary starvation. He must have reached middle life when, in 344 b.c., envoys came from Syracuse to Corinth to appeal to the mother-city for relief from the intestine feuds and foreign mercenaries under which the Syracusans, and all the Greeks of Sicily, suffered. Carthage too, their old and bitter foe, after some years of quiet, was again bestirring herself and intriguing with the local des pots. Corinth could not refuse her help, though her chief citizens declined the responsibility of attempting to estab­lish a settled government in the factious and turbulent Syracuse. By a sort of Divine inspiration, says Plutarch (*Tim*., 3), Timoleon, being named by an unknown voice in the popular assembly, was chosen by a unanimous vote to undertake the mission. He sailed for Sicily with a few of the leading citizens of Corinth and a small troop of Greek mercenaries. On arriving at Rhegium he found that his movements were watched by a Carthaginian squadron, act­ing under the advice of a Syracusan, Hicetas, who had