SURVEYING FOR ARCHÆOLOGISTS.[1]

V.

Why the Measurement of Altitude is Necessary.

It is now time to enter more into detail on a point to which reference has already been made, as it is one of great importance to all British archæologists, as Britain lies in a mid-latitude. If a star or the sun did not rise or set every day in Britain as happens at the poles, or rose and set vertically, as happens at the equator, the height of the horizon would not come into play.

As a matter of fact, however, in Britain some celestial bodies do rise and set, and *not* vertically; their paths, as we have seen, are inclined to the horizon, and therefore the azimuth of the rising or setting place depends upon the height of the horizon, and I may add that the zenith distance must be less than 90° if the horizon is raised by hills.

In order to consider this matter more closely, I give in the accompanying figures the actual facts of the sunrise on the N.E. horizon at the longest day of the year in two British latitudes, Stenness, lat. 59° N., and Cornwall, lat. 50°. They will illustrate the effect of latitude upon azimuth as well as the change of azimuth in presence of hills which now specially concerns us.

[1] Continued from p. 544.

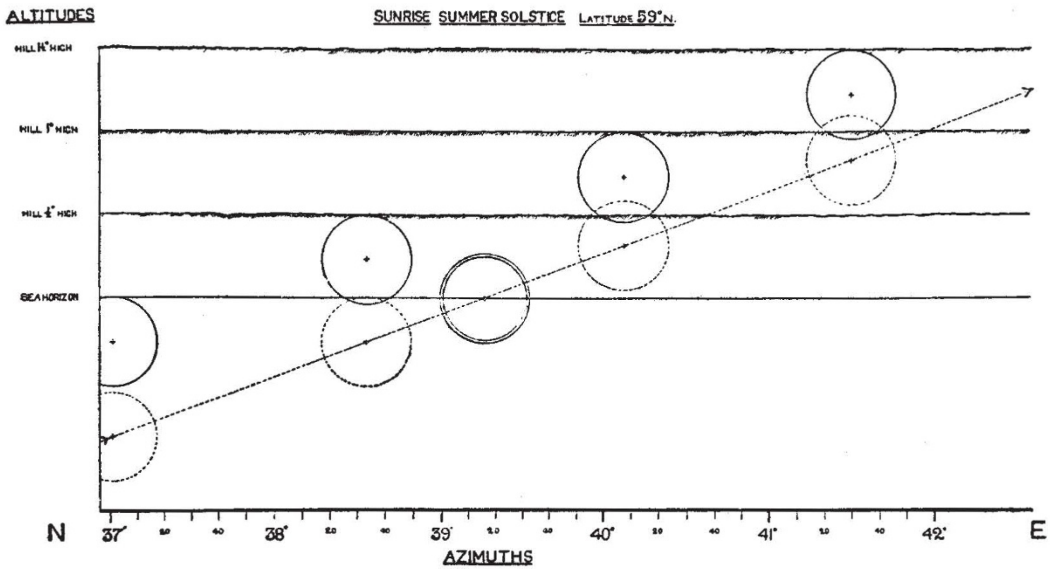


Fig. 19.—The conditions of "sunrise" at the summer solstice in lat. 59° N.

But before we consider them, I must refer to another matter.

The light from sun or star when it enters the earth's atmosphere is refracted or bent out of its course, and the more slantingly it enters the atmosphere, as happens near rising and setting, the greater the refraction. In consequence of this the sun or a star appears higher in the heavens than it really is, and therefore appears to rise earlier and set later.

In Fig. 19 we see, diagrammatically, the effect of hills and refraction on the azimuth of the summer solstice sunrise in lat. 59° N. The long dotted line shows the slanting direction of the sun's path in relation to the horizon. The double circle indicates the position of the sun's *centre*, at the sea horizon and neglecting refraction. The azimuth, as shown by the scale at the bottom of the diagram, is N. 39° 16′ E.

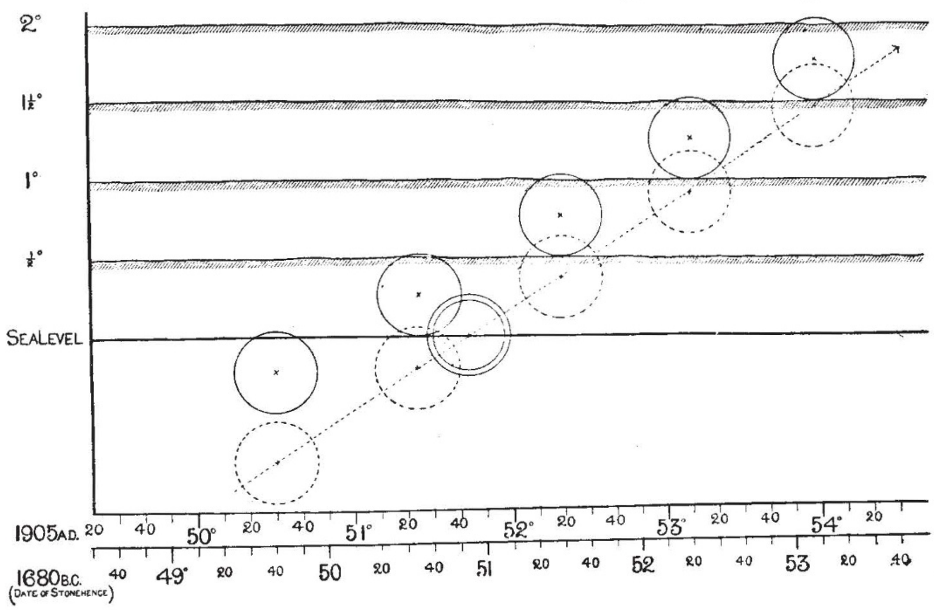
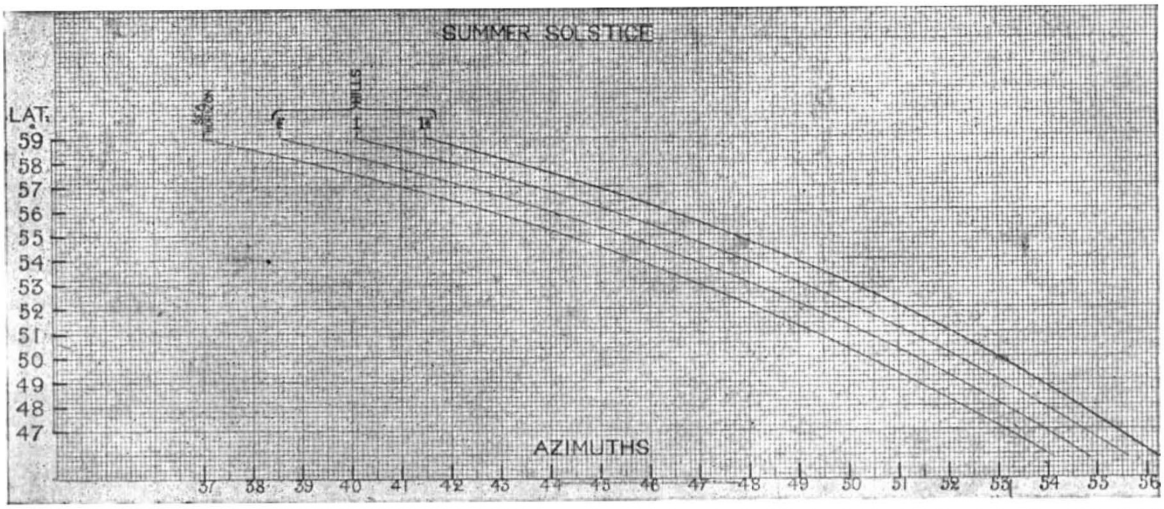


Fig. 20.—Showing azimuths in lat. N. 50° for the summer solstice sunrise, with different heights of hills for 1905 A.D. and 1680 B.C. (From "Stonehenge," p. 290.)

The full circles show the *apparent* positions of the sun due to refraction, at different horizons, if we apply the refraction correction and consider the sun visible degree of apparent change of place brought about in this way; and how the difference between the true and apparent places rapidly diminishes as the true



G. 21.—The Azimuths of the Sunrise (upper limb) at the Summer Solstice. The values given in the table have been plotted, and the effect of the height of hills on the azimuth is shown. The range of latitude given enables the diagram to be used in connection with the solstitial alignments at Carnac, Le Ménac, and other monuments in Brittany.

with 2′ of its diameter showing, whilst the dotted circles show the *real* position of the sun at the same moment. Thus, considering the lowest full circle, horizon is left behind. Thus at the sea horizon the true and apparent suns are just separated; with the horizon 1° high they interlock.

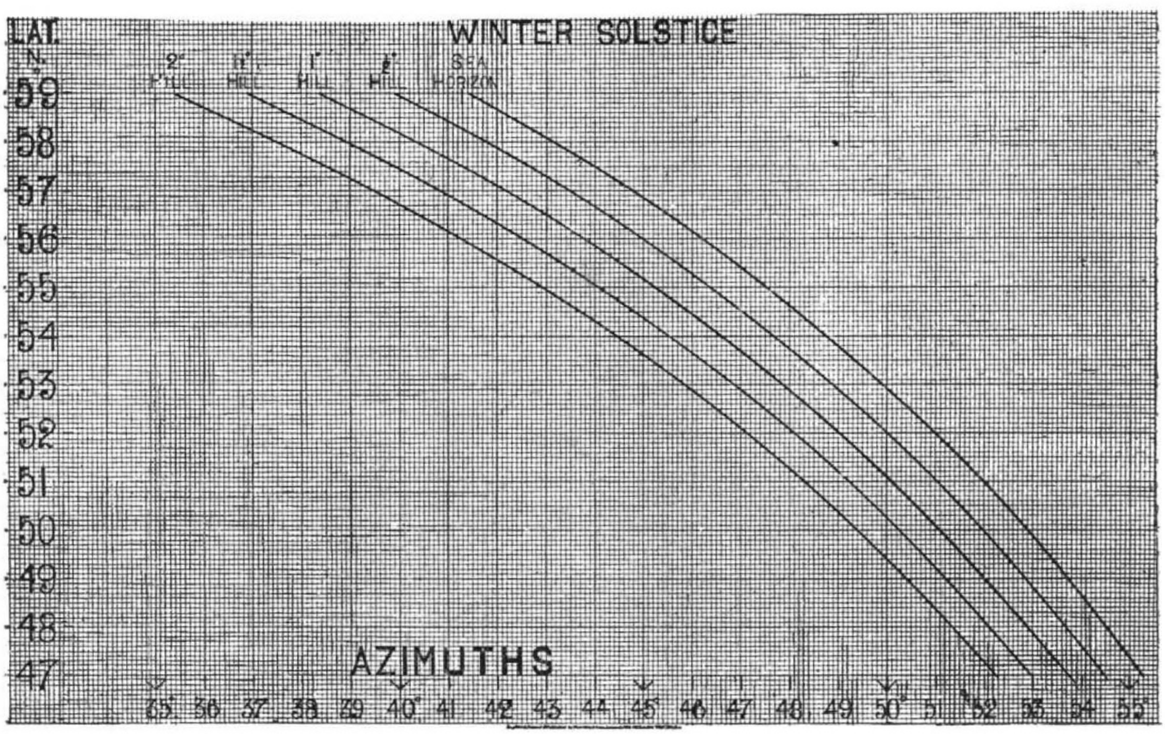


FIG. 22.—Azimuth of Sunrise (upper limb) at Winter Solstice.

in Fig. 19 we see that the azimuth of apparent sunrise, with a sea-horizon, is N. 37° 1′ E.

A comparison of the full-line circles with the lower dotted circles in the diagram will give an idea of the

The next diagram gives the conditions for lat. 50°. In this latitude, while the sun appears to rise at the present time over the true sea horizon at azimuth N. 50½° E., instead of N. 37° E., as at Stenness, with a hill 2° high the azimuth is very nearly N. 54° E.

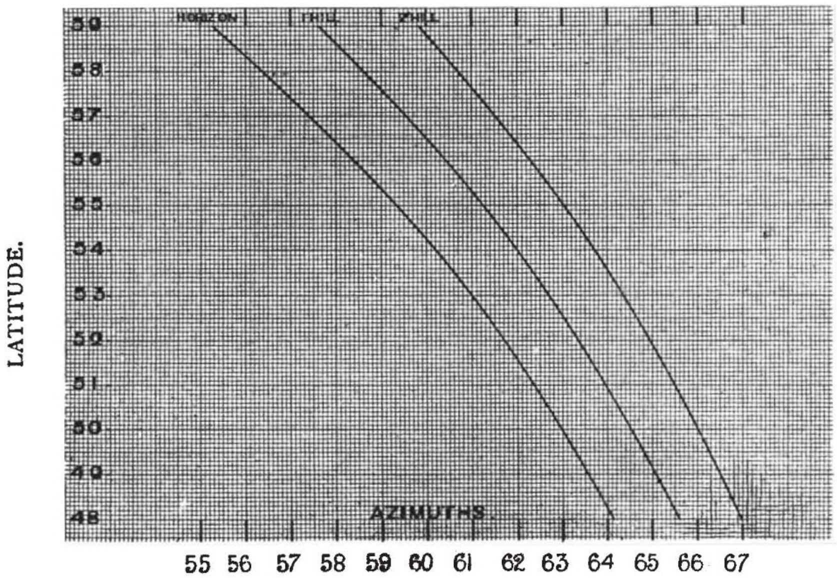


FIG. 23.—Azimuths of the May Sunrise. Sun s declination 16° 20′ N.

The above diagrams show very plainly the great variation in azimuth the archæologist has to reckon with when he roams Britain to determine the orientation of his monuments, whether outstanding stone, recumbent stone, avenue or cromlech. What happens with the solstitial sun also happens with the May and November suns, and warning- and clock - stars. Thus we find, in the case of the summer solstice sunrise, it is seen, with a sea horizon, in az. N. 37° E. at Stenness and N. 50° 30′ E. in Cornwall. A hill $1\frac{1}{2}$° high in lat. 59° changes 37° to $41\frac{1}{2}$°; a hill 2° high in lat. 50° changes $50\frac{1}{2}$° into 54°.

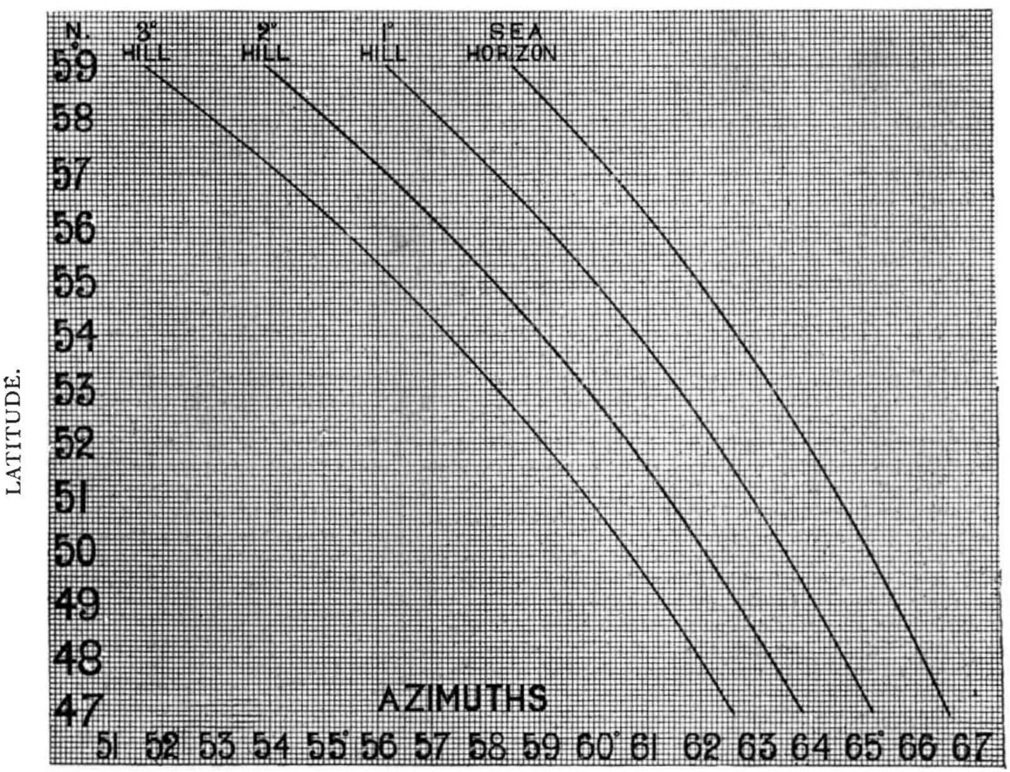


FIG. 24.—Azimuths of the November Sunrise Sun's declination 16° 20′ S.

Having now indicated the importance of the measurement of altitude as well as of azimuth, I give diagrams showing the azimuths of the sunrises at the solstices and in May and November, the changes in azimuth caused by varying heights of the horizon being also indicated.

These diagrams are good for the whole of Britain and for part of Brittany. They have been computed by Mr. Rolston, of the Solar Physics Observatory.

There is a relation between the height of the horizon and the refraction correction which may be found useful. If the horizon is half a degree high, the refraction is practically compensated, as the following table will show:—

Elevation of actual horizon		Bessel's refraction		Combined effect
° ′ ″		′ ″		′ ″
0 0 0	...	34 54	...	− 34 54
0 10	...	32 49	...	− 22 49
20	...	30 52	...	− 10 52
30	...	29 3·5	...	+ 0 56·5
40	...	27 22·7	...	+ 12 37·3
50	...	25 49·8	...	+ 24 10·2
1 0	...	24 24·6	...	+ 35 35·4

In the absence of measurements, it is convenient, therefore, to assume, in the first instance, that the height of the horizon is half a degree; then no refraction correction need be applied.

This relation is utilised in the preparation of general tables and curves, as it provides us with a convenient approximation to the actual azimuths before the height of the horizon has been measured.

Now, while the summer solstice sun thus rises in different azimuths with different heights of the horizon, its position in the heavens, that is, its declination, is unchanged. It is clear, then, that we cannot, by our azimuth measures alone, obtain the true position of the sun in the heavens, that is, in the celestial sphere. The same remark also applies to every star which rises and sets in the latitude of Britain. In addition to the azimuth of the rising or setting place, *we must also take the height of the horizon into account.* When we do this, the determination of the true position in the heavens, whether of sun or star—the declination—is easy.

As I shall show in the sequel, we have now the means, as the result of astronomical calculations, of determining the dates at which the sun or a star occupied declinations in times past different from those they occupy at present. All the archæologist has to do is to consult certain tables in which the sun's declination at the solstice and the varying declinations of the stars are shown for the past six thousand years. This is enough for the purpose the archæologist has in view.

NORMAN LOCKYER.

THE GROWTH AND SHRINKING OF GLACIERS.[1]

THE interesting publications referred to below show that the study of the fluctuations of glaciers is making good progress. Those of the Swiss Alps have been watched systematically for nearly thirty years, and similar work is now being carried on, not only in all parts of that chain, but also in the Pyrenees, Scandinavia, Bokhara, the Altai, the Tian Shan, and the North American chains, and has been started in the Himalayas. In the European Alps a general retreat of the glaciers began about 1861. At first rapid, it slackened after a time, but, though here and there a glacier has slightly retraced its steps and an advance became more general towards the end of the last century, the majority are still either slowly shrinking or at best stationary. In the French Alps, we learn, sundry small glaciers have quite melted away during the last few years. It is to be hoped that these places will be carefully watched in order to ascertain more precisely the conditions (temperature, precipitation, &c.) under which the formation of a glacier becomes possible. That, as I pointed out in 1894 (see "Ice Work," part iii., ch. i.), would enable us to estimate the mean temperature in certain localities during the Glacial epoch, and thus to obtain one firmer footing in that most slippery subject. This shrinkage of the world's ice mantle, we may add, appears to characterise all the countries observed, for only in Scandinavia, and perhaps at Mount St. Elias, are glaciers beginning to advance in notable numbers.

Prof. Forel contributes to the special report on the Swiss glaciers a valuable discussion on the relations of their changes to the meteorology of the region, founded on observations which have been taken continuously at Geneva for the last eighty years. The advance or retreat of an ice-stream depends mainly on two factors: the annual snowfall and the general temperature, the one chiefly affecting its upper part, the other its lower. The effects, especially of the former, obviously cannot be immediate, and a glacier may continue its advance when the conditions are adverse, or *vice versâ.* As forty-three years elapsed before the relics of members of Dr. Hamel's party, who perished in a crevasse on the Ancien Passage, were discovered on the Glacier des Bossons, after travelling about five and a half miles, we must expect changes and their results to be separated by an interval, depending on the length, slope, and other characters of an ice-stream. It is perhaps too soon to generalise from Prof. Forel's discussion of the Geneva observations, and the distance of that observatory from the higher parts of the chain will always be a drawback; but the results are already suggestive, and his method of smoothing off the irregularities of individual years, by taking the mean of the decade which they close, enables us to form a better estimate of the real climatal changes. Time will render the work of the professor, his coadjutors, and all members of the International Commission increasingly valuable; for this is one of the cases where one generation must plant the tree and another gather the fruit.

T. G. BONNEY.

[1] "Les Variations périodiques des Glaciers." xii^me Rapport, 1906, de la Commission internationale des Glaciers. Résumé par F. A. Forel. *Arch. des Sci. Phys. et Nat. Quatr. Pér.*, t. xxv., pp. 577–587.

"Les Variations périodiques des Glaciers des Alpes Suisses." By F. A. Forel, E. Muret, P. L. Mercanton and E. Argand. 28^me Rapport, 1907. Extrait de l'Annuaire du S.A.C., xliii^me année. Pp. 302–331.

INTERNATIONAL CONFERENCE ON ELECTRICAL UNITS AND STANDARDS.

BY invitation of the British Government an International Conference on Electrical Units and Standards will be held in London at the rooms of the Royal Society during this month. Eighteen countries are sending delegates to the conference; the names are given below.

The first meeting of the conference will be held on Monday, October 12, at 11.30, when the delegates will be received by the President of the Board of Trade; in the evening there will be a reception by the Royal Society. The meetings of the conference are expected to last until October 22, but this date is not fixed, as it will entirely depend on the progress made with the work at the conference.

The main object of the conference is to obtain international agreement on the three electrical units, the ohm, the ampere, and the volt, so that the realisation of these units in all the countries of the world shall be as near as possible identical. The best method of setting up the mercury ohm, the silver voltameter, and cadmium cell will be considered, and it is hoped that detailed specifications may be issued with the authority of the conference.

The delegates will be entertained at an official banquet, and will lunch with the Lord Mayor; they will also make an excursion to Cambridge on the invitation of Trinity College, and pay a visit to the Cavendish Laboratory. The Board of Trade Government Standards Laboratory will be open to inspection by the delegates, and the National Physical Laboratory at Teddington will be visited. The delegates will also dine at the Franco-British Exhibition with the "Dynamicables," and are invited to the annual dinner of the Institution of Electrical Engineers.

List of Delegates.

America (United States).—Dr. Henry S. Carhart, professor of physics at the University of Michigan; Dr. S. W. Stratton, director, Bureau of Standards, Washington; Dr. E. B. Rosa, physicist, Bureau of Standards, Washington.

Belgium.—M. Gérard, director of the Montefiore Electrotechnical Institution and president of the Consultative Commission on Electricity; M. Clément, secretary of the Consultative Commission on Electricity.

Denmark and Sweden.—Prof. S. A. Arrhenius, Nobel Institute, Stockholm.

Ecuador.—Senor Don Celso Nevares, Consul-General.