NOTES ON STONEHENGE.[1]

VI.—ON THE SOLAR OBSERVATIONS MADE IN BRITISH STONE CIRCLES.

IN my last notes I referred to the star observations which might be made by means of stone circles. I now pass to solar observations.

I have already pointed out that much time has been lost in the investigation of our stone circles, for the reason that in many cases the exact relations of the monuments to the chief points of the horizon, and therefore to the place of sunrise at different times of the year, have not been considered; and when they were, the observations were made only with reference to the magnetic north, which is different at different places, and besides is always varying; few indeed have tried to get at the real astronomical conditions of the problem.

The first, I think, was Mr. Jonathan Otley, who in 1849 showed the "orientation" of the Keswick circle "according to the solar meridian," giving true solar bearings throughout the year.

I wrote a good deal in NATURE[2] on sun and star temples in 1891, and Mr. Lewis the next year expressed the opinion that the British stone monuments, or some of them, were sun and star temples.

Mr. Magnus Spence, of Deerness, in Orkney, published a pamphlet, "Standing Stones and Maeshowe of Stenness,"[3] in 1894; it is a reprint of an article in the *Scottish Review*, October, 1893. Mr. Cursiter, F.S.A., of Kirkwall, in a letter to me dated March 15, 1894, a letter suggested by my "Dawn of Astronomy," which appeared in that year, and in which the articles which had been published in NATURE in 1891 had been expanded, directed my attention to the pamphlet; the observations had no pretension to scientific accuracy, and some of the alignments are wrongly stated, but a possible solar connection was pointed out.

I began the consideration of the Stenness circles and alignments in 1901, but other pressing calls on my time then caused me to break off the inquiry. Quite recently it occurred to me that a complete study of the Stenness circles might throw light on the question of an earlier Stonehenge, so I have gone over the old papers, plotting the results on the Ordnance map.

Now that the inquiry is as complete as I can make it without spending some time in Orkney with a theodolite, I may say that in my opinion Mr. Spence's contention in his pamphlet on Maeshowe is confirmed, although many of the alignments to which he refers in support of it prove to be very different from those he supposed and drew on the map which accompanies his paper.

The alignments on which he chiefly depended were two, one running from the stone circle past the entrance of Maeshowe to the place of sunrise at Hallowe'en (November 1), another from the same circle by the Barnhouse standing stone to the mid-winter sunrise at the solstice.

I give a copy of the Ordnance map showing the true orientation of these and of other sight lines I have made out. From this it will be seen that observations of the sun were provided for on the days in question, and that the circles and outstanding stones were undoubtedly set up to guide astronomical observations relating to the different times of the year. Of course, as I have shown elsewhere, such astronomical observations were always associated with religious celebrations of one kind or another, as the astronomer and the priest were one.

I shall not refer to all the sight lines indicated, but deal only with those, bearing upon the Stonehenge question, which I have without local knowledge been able to test and justify.

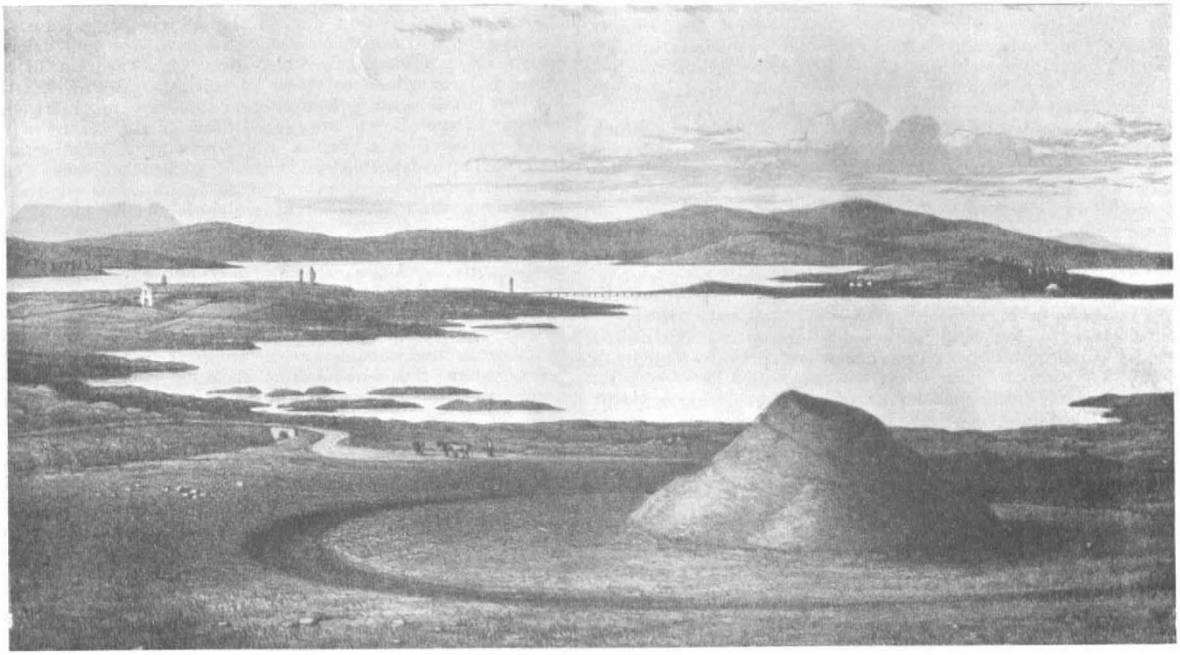

FIG. 14.—Maeshowe, in the foreground, and the Stones of Stenness. From "Notice of Runic Inscriptions," by James Farrer, M.P. (1862).

But first we must consider the astronomical differences between the rising of a star and of the sun, by which we mean that small part of the sun's limb first visible.

It is too frequently imagined that for determining the exact place of sunrise or sunset in connection with these ancient monuments we have to deal with the

[1] Continued from vol. lxxi. p. 538.
[2] See especially NATURE, July 2, 1891, p. 201.
[3] Gardner: Paisley and London.

sun's centre, as we should do with the sun half risen. As a matter of fact, we must consider that part of the sun's limb which first makes its appearance above the horizon; the first glimpse of the upper limb of the sun is in question, say, when the visible limb is 2′ high.

shown that the half-way time between an equinox and a solstice is when the sun's centre has a declination approximately 16° N. or S. In Orkney, with the latitude of 59°, assuming a sea horizon, the amplitude of sunrise or sunset is 32° 21′, the corresponding azimuth being 57° 39′.

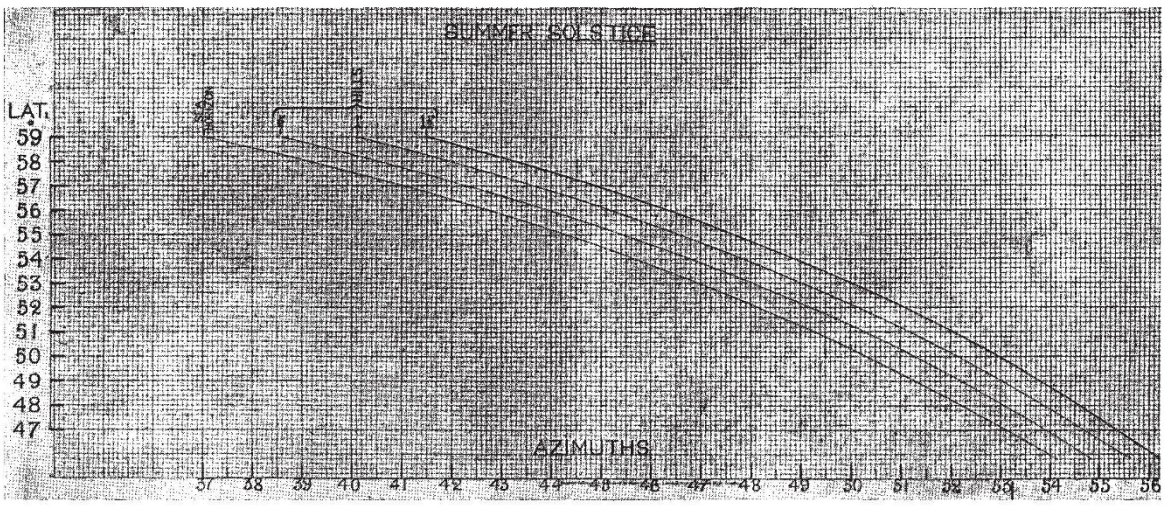

FIG. 15.—The Azimuths of the Sunrise (upper limb) at the Summer Solstice. The Values given in the table have been plotted, and the effect of the height of hills on the azimuth is shown.

To make this quite clear I give a table which has been computed by Mr. Rolston, of the Solar Physics Observatory, showing the true azimuth with hills up to 1½° high for lat. 59° N., the latitude of Stenness, and 51°, nearly the latitude of Stonehenge, of the sun's upper limb for the solstitial year.

Now the most interesting and best defined line with this azimuth on the Ordnance map is the one stretching S.E. from the centre of the Stenness circle to the Barnstone, with an azimuth of 57° 15′. The line contains between the two points I have named another stone, the Watchstone, 18½ feet high, in the

SOLAR AZIMUTHS

Summer Solstice.	Lat. 59° Rising N. of E. or Setting N. of W.	Lat. 51° Rising N. of E. or Setting N. of W.
	° ′	° ′
1. Sun's centre; uncorrected	39 16 ...	50 40
2. Upper limb; corrected for semi-diameter and refraction	37 1 ...	49 20
3. ,, ,, ,, and hill ½° high	38 34 ...	50 16
4. ,, ,, ,, ,, 1° ,, ...	40 8 ...	51 12
5. ,, ,, ,, ,, 1½° ,, ...	41 30 ...	52 4
Winter Solstice.	**Rising S. of E. or Setting S. of W.**	**Rising S. of E. or Setting S. of W.**
	° ′	° ′
1. Sun's centre; uncorrected	39 16 ...	50 40
2. Upper limb; corrected for semi-diameter and refraction	41 24 ...	52 0
3. ,, ,, ,, and hill ½° high	39 54 ...	51 4
4. ,, ,, ,, ,, 1° ,, ...	38 23 ...	50 8
5. ,, ,, ,, ,, 1½° ,, ...	36 54 ...	49 14

The first important thing we learn from the table is that although at any solstice the azimuths of the rising and setting of the sun's centre are the same, the azimuths of the upper limb at the summer and winter solstices differ in a high northern latitude by some 5°. The difference arises, of course, from the fact that the limb is some 16′ from the sun's centre, so that considering the sun's centre as a star with fixed declination, at rising the limb appears before the centre, and at setting it lags behind it.

It will also be seen that at sunrise hills increase the azimuth from N., and refraction reduces it; while at setting, hills reduce the azimuth from S. and refraction increases it.

Not only does calculation prove the worship of the May and June years, but I think the facts now before us really go to show that in Orkney the May year was the first established, and that the solstitial (June) year came afterwards, and this was the chief question I had in view.

I will begin with the May year. I have already

precise alignment; and from the statements made and measures given it is to be inferred that a still more famous and perforated stone, the "Stone of Odin," demolished seventy years since, was also in the same line within the extremities named.

If we may accept this we learn something about perforated stones, and can understand most of the folk lore associated with them, and few have more connected with them than the one at Stenness. I suggest that the perforation, which was in this case 5 feet from the ground, was used by the astronomer-priest to view the sunrise in November over the Barnhouse stone in one direction, and the sunset in May over the circle in the other.

There is another echo of this fundamental line; that joining the Ring of Bookan and the Stones of Via has the same azimuth and doubtless served the same purpose for the May year.

But this line, giving us the May sunset and November sunrise, *not* the December solstitial sunrise as Mr. Spence shows it, is not the only orienta-

tion connected with the May year at the stones of Stenness. The November sunset is provided for by a sight-line from the circle to a stone across the Loch of Stenness with an azimuth of S. 53° 30′ W.

To apply the table to the solstitial risings and settings at Stenness, and the sight-lines which I have plotted on the map, it will be seen that the table shows us that the lines marked

N. 39° 30′ E.	S. 41° 0′ E.
N. 41° 16′ E.	S. 36° 30′ W.

are solstitial lines; to get exact agreement with the table the heights of the hills must be found and allowed for. I have roughly determined this height from the 1-inch map in the case of the Barnstone-Maeshowe alignment.

On the N.E. horizon are the Burrien Hills, four miles away, 600 feet high at the sunrise place, gradually ascending to the E., vertical angle = 1° 36′ 30″. The near alignment is on and over the centre of Maeshowe. Colonel Johnston, the Director-general of the Ordnance Survey, has informed me that the true azimuth of this bearing is N. 41° 16′ E., and in all probability it represents the place of sunrise as seen from the Barnstone when Maeshowe was erected. What is most required in Orkney now is that some one with a good 6-inch theodolite should observe the sun's place of rising and the angular height of the hills at the next summer solstice in order to determine the date of the erection of Maeshowe. Mr. Spence and others made an attempt to determine this value with a sextant in 1899, but not from the Barnstone.

The Ordnance maps give no indication of stones, &c., by which the direction of the midsummer setting or the midwinter rising and setting might have been indicated from either the Maeshowe or the Barnstone.

To sum up the solar alignments from the circle.

We have the May sunrise marked by the top of Burrien Hill, from 600 to 700 feet high, Az. 59° 30′.

We have the November sunset marked by a standing stone on the other side of the Loch of Stenness, Az. 53° 30′.

June rising, Az. true 39°. The top of Hindera fiold, more than 500 feet high, the highest peak, triangulation station.

December rising, tumulus (Az. 41°) on Ward Hill.

December setting, tumulus Onston 36° 30′.

General Remarks.

It is not a little remarkable that the winter solstice rising and setting seem to have been provided for at the Stenness circle by alignment on the centres of two tumuli across the Loch, one the Onston tumulus to the S.W. (Az. 36° 30′), the other tumulus being on Ward Hill to the S.E., Az. 41° (rough measurement).

It looks also very much as if the Maeshow tumulus was an after structure to use the Barnstone for the summer solstice rising; then these two other tumuli, to deal with the winter solstice at Stenness circle, may have been added at the same time. All these provided for a new cult.

There are also tumuli near the line (which cannot be exactly determined because the heights of the hills are unknown) of the summer solstice setting; none was required for the sunrise at this date, as the line passes over the highest point of Hindera fiold, a natural tumulus more than 500 feet high, and on that account a triangulation station.

Another argument in favour of the tumuli being additions to the original design is that the place of the *November* setting from the Stenness circle is marked, *not* by a tumulus, but by a standing stone. As the stone near Deepdale and the tumulus at Onston are only about 1200 yards apart, the suggestion may be made that in later times tumuli in some cases replaced stones as collimation marks.

NORMAN LOCKYER.

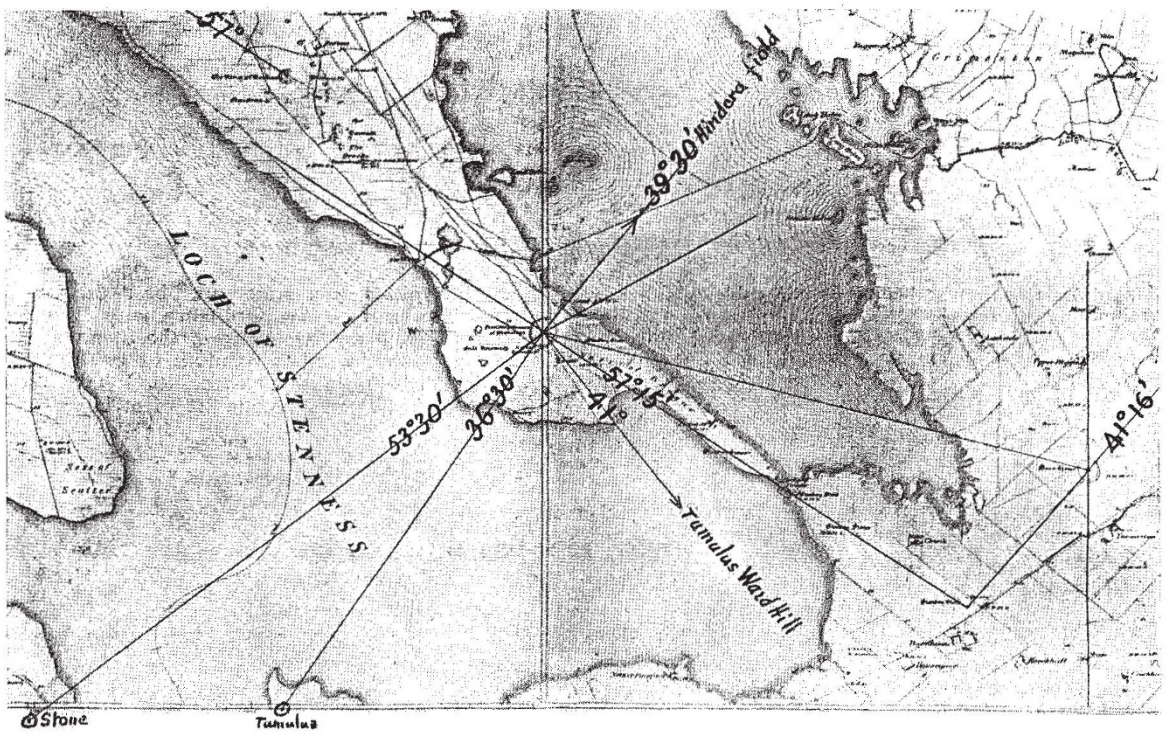

FIG. 16.—Copy of Ordnance Map showing chief sight lines from the Stones of Stenness.