NOTES ON STONEHENGE.[1]

V.—On the Star Observations made in British Stone Circles.[2]

THE work I have tried to do so far on our British stone circles has dealt with the observations of the sun made in connection with them, and the attempt to determine a date has been based upon the slow change in the obliquity of the ecliptic which is continually taking place.

In continuation of my work in Egypt in 1891, and Mr. Penrose's in Greece in 1892, I have recently endeavoured to see whether there are any traces in Britain of the star observations which I found connected with the worship of the sun at certain times of the year. We both discovered that stars, far out of the sun's course, especially in Egypt, were observed in the dawn as heralds of sunrise—"warning-stars"—so that the priests might have time to prepare the sunrise sacrifice. To do this properly the star should rise while the sun is still about 10° below the horizon.

I stated ("Dawn of Astronomy," p. 319) that Spica was the star the heliacal rising of which heralded the sun on May-day 3200 B.C. in the temple of Min at Thebes. Sirius was associated with the summer solstice at about the same time. The equinoxes were provided for in the same way in Lower Egypt, but they do not concern us now.

Mr. Penrose found this May-day worship continued at Athens on foundations built in 1495 B.C. and 2020 B.C., on which the Hecatompedon and older Erechtheum respectively were subsequently built, the warning star being now no longer Spica, but the cluster of the Pleiades.

It is generally known that Stonehenge is associated with the solstitial year, and I have recently suggested that it was originally connected with the May year; but the probable date of its re-dedication, 1680 B.C., was determined by Mr. Penrose and myself by the change of obliquity.

Now if Stonehenge or any other British stone circle could be proved to have used observations of warning stars, the determination of the date when such observations were made would be enormously facilitated. Mr. Penrose and myself were content to think that our date might be within 200 years of the truth, whereas if we could use the rapid movement of stars in declination brought about by the precession of the equinoxes, instead of the slow change of the sun's declination brought about by the change of the value of the obliquity, a possible error of 200 years would be reduced to one of 10 years.

In spite of this enormous advantage, so far as I know no one has yet made any inquiry to connect star observations with any of the British circles.

I have recently obtained clear evidence that some circles in different parts of Britain were related to the May year, a vegetation year, which we know was general over the whole of Europe in early times, and which still determines the quarter-days in Scotland.

If the Egyptian and Greek practice were continued here, we should expect to find some indications of the star observations utilised at the temple of Min and at the Hecatompedon for the beginning or the other chief months of the May year.

Following the clue given me in the case of the Egyptian temples, such as Luxor, by successive small changes of the axis necessitated by the change in a star's place due to precession, I have looked out for this peculiarity in an examination of many maps and plans of circles.

I have already come across two examples in which the sight line has been changed in the Egyptian manner. The first is the three circles of the Hurlers, near Liskeard, a plan of which is given in "Prehistoric Stone Monuments of the British Isles: Cornwall," by H. C. Lukis, published by the Society of Antiquaries, who were so good as to furnish me with a copy, and also some *unfolded* plans on which sight lines could be accurately drawn and their azimuths determined. I am anxious to express my obligations to the council and officers of the society for the help thus afforded me.

The second is at Stanton Drew, in Somerset, consisting of three circles, two avenues, and at least one outstanding stone. These were most carefully surveyed by Mr. C. E. Dymond some years ago, and he was good enough to send me copies of his plans and levelling sections.

How can such plans help us? The easiest way for the astronomer-priests to conduct such observations in a stone circle would be to erect a stone or barrow indicating the direction of the place on the horizon at which the star would rise. If the dawn the star was to herald occurred in the summer, the stone or barrow itself might be visible if not too far away, but there was a reason why the stone or barrow should not be too close; in a solemn ceremonial the less seen of the machinery the better.

Doubtless such outstanding stones and barrows would be rendered obvious by a light placed on or near them. Cups which could hold oil or grease are known in connection with such stones, and a light thus fed would suffice in the open if there were no wind; but in windy weather a cromlech or some similar shelter must have been provided for it.

Now if these standing stones or barrows were ever erected and still remain, accurate plans—not the slovenly plans with which Ferguson and too many others have provided us, giving us either no indication of the north or any other point, or else a rough compass bearing without taking the trouble to state the variation at the time and place—will help us in this way.

The work of Stockwell in America, Danckworth in Germany, and Dr. W. J. S. Lockyer in England has provided us with tables of the changing declinations of stars throughout past time, or enough of it for our purpose.

An accurate determination of either the *azimuth* (angular distance from the N. or S. points) or *amplitude* (angular distance from the E. or W. points) of the stone or barrow as seen from the centre of the stone circle will enable us to determine this declination.

This, of course, only gives us a first approximation. The angular height of the point on the horizon to which the alignment or sight-line is directed by the stone or barrow from the centre of the circle must be most accurately determined, otherwise the declinations may be one or two degrees out.

To come back to the two cases to which I have referred, the Hurlers and Stanton Drew. I will begin with a reference to the available descriptions of the circles.

The three circles of the Hurlers, some five miles to the north of Liskeard, are thus referred to by Lukis in the valuable monograph which I have already mentioned.

"On the moor, about a mile to the south of the singular pile of granite slabs, which rest upon and overlap each other, and is vulgarly called the Cheesewring, there are three large circles of granite stones placed in a nearly straight line in a north-north-east, and south-south-west direction, of which the middle one is the largest, being 135 feet in diameter, the north 110 feet, and the south 105 feet.

"The north Circle is 98 feet, and the south 82 feet

[1] Continued from p. 393.

[2] This article is generally based upon a note communicated to the Royal Society on March 15.

from the central one. If a line be drawn uniting the centres of the extreme Circles, the centre of the middle ring is found to be 12 feet 6 inches to the west of it.

"These Circles have been greatly injured. The largest consists of 9 erect and 5 prostrate stones; the north Circle has 6 erect and 6 prostrate, and a fragment of a seventh; and the south has 3 erect and 8 prostrate. In Dr. Borlase's time they were in a slightly better condition. A pen-and-ink sketch made by him, which is extant in one of Dr. Stukeley's volumes of original drawings, represents the middle Circle as consisting of 7 erect and 10 prostrate stones; the north of 10 erect and 6 prostrate; and the south of 3 erect and 9 prostrate. The stone to the east of that marked C in the plan of the middle Circle is the highest, and is 5 feet 8 inches out of the ground, and appears to have been wantonly mutilated recently. Two of the prostrate stones of the north Circle are 6 feet 6 inches in length.

"About 17 feet south from the centre of the middle Circle there is a prostrate stone 4 feet long and 15 inches wide at one end. It may possibly have been of larger dimensions formerly, and been erected on the spot where it now lies, but as Dr. Borlase has omitted it in his sketch it is probably a displaced stone of the ring.

"If we allow, as before, an average interval of 12 feet between the stones, there will have been about 28 pillars in the north, 26 in the south, and 33 in the middle Circle.

"At a distance of 409 feet westwards from K in the middle Circle there are 2 stones, 7 feet apart, both inclined northwards. One is 4 feet 11 inches in height out of the ground, and overhangs its base 2 feet 7 inches; the other is 5 feet 4 inches high, and overhangs 18 inches."[1]

I next come to Stanton Drew.

I will begin by giving a short account of the stones which remain, abridged from the convenient pamphlet prepared for the British Association meeting at Bristol in 1898 by Prof. Lloyd Morgan.

The circles at Stanton Drew, though far less imposing than those of Avebury and Stonehenge, are thought to be more ancient than are the latter, for the rough-hewn uprights and plinths of Stonehenge bear the marks of a higher and presumably later stage of mechanical development. Taken as a group, the Somersetshire circles are in some respects more complex than their better known rivals in Wiltshire. There are three circles, from two of which "avenues" proceed for a short distance in a more or less easterly direction; there is a shattered but large dolmen—if we may so regard the set of stones called "the cove"; and there are outlying stones—the "quoit," and those in Middle Ham—which bear such relations to the circles as to suggest that they too formed parts of some general scheme of construction.

The "quoit," lying in an orchard by the roadside, has nothing very impressive about its appearance—a recumbent mass of greyish sandstone; but it seems to be a brick in the Stanton Drew building. By some regarded as a sarsen block from Wiltshire, it is more probably derived from the Old Red Sandstone of Mendip. In any case it is not, geologically speaking, *in situ*; nor has it reached its present position by natural agency.

With regard to two of the megalithic circles, at first sight the constituent stones seem irregularly dotted

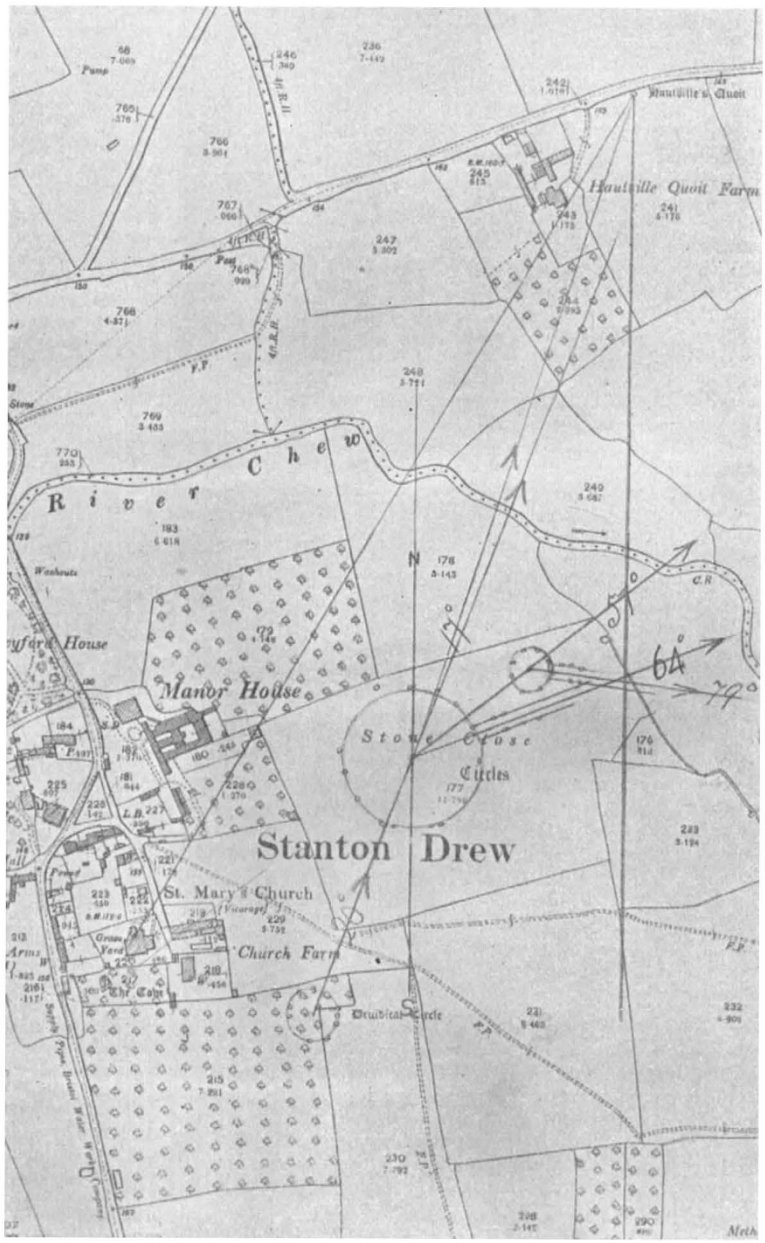

FIG. 13.—The Circles and Avenues at Stanton Drew. Photograph of 25-inch Ordnance Map, giving approximate azimuths of sight-lines.

[1] "The Prehistoric Stone Monuments of the British Isles: Cornwall." By William Collings Lukis, M.A., F.S.A., Rector of Wath, Yorkshire. P. 4.

about the field; but as we approach them the unevenly spaced stones group themselves.

The material of which the greater number of the rude blocks is composed is peculiar and worthy of careful examination. It is a much altered rock consisting, in most of the stones, of an extremely hard silicious breccia with angular fragments embedded in a red or deep brown matrix, and with numerous cavities which give it a rough slaggy appearance. Many of these hollows are coated internally with a jasper-like material, the central cavity being lined with gleaming quartz-crystals.

The majority of the stones were probably brought from Harptree Ridge on Mendip, distant some six miles. Weathered blocks of Triassic breccia, showing various stages of silicification, there lie on the surface; and there probably lay the weathered monoliths which have been transported to Stanton Drew. It is important to note that they were erected unhewn and untouched by the tool. A few stones are of other material —sandstone, like the "quoit," or oolite from Dundry.

In the great circle, of the visible stones some retain their erect position, others are recumbent, several are partially covered by accumulation of grass-grown soil. Others are completely buried, their position being revealed in dry seasons by the withering of the grass above them.

To the east of this circle a short avenue leads out, there being three visible stones and one buried block on the one hand, and two visible stones on the other. But one's attention is apt to be diverted from these to the very large and massive megaliths of the small N.E. circle. This is composed of eight weathered masses, one of which (if indeed it do not represent more than one), Prof. Lloyd Morgan tells us, is recumbent and shattered. From this circle, all the stones of which are of the silicious breccia, a short avenue of small stones also opens out eastwards.

The third or S.W. circle lies at some little distance from the others. The average size of the stones is smaller than in either of the other circles, and not all are composed of the same material.

"The Cove," which has been variously regarded as a dolmen, a druidical chair of state, and a shelter for sacrificial fire, is close to the church.

The dimensions and number of stones are as follow :—

Great Circle, diameter 368 feet, 30 stones.						
N.E.	,,	,,	97	,,	8	,,
S.W.	,,	,,	145	,,	12	,,

We now pass from general descriptions of the circles to the azimuths of the sight lines already referred to, so far as they can be determined from the published Ordnance maps.

To investigate them as completely as possible without local observations in the first instance, I begged Colonel Johnston, R.E., C.B., the Director-General of the Ordnance Survey, to send me the 25-inch maps of the sites giving the exact azimuth of the side lines. This he obligingly did, and I have to express my great indebtedness to him.

Of the various sight lines found, those to which I wish to direct attention in the first instance, and which led me to the others, are approximately, reading the azimuths to the nearest degree,

Hurlers Lat. 50° 31′ N.	Az.	Stanton Drew Lat. 51° 10′ N.	Az.
S. circle to central circle	N. 12° E.	Great circle to Quoit	N. 17° E.
Central to N. circle	N. 15° E.	S.W. circle to great circle	N. 20° E.
N. circle to tumulus	N. 19° E.		

For the purposes of a preliminary inquiry in anticipation of the necessary local observations with a theodolite, for which I am making arrangements; assuming hills half a degree high, which roughly compensate the refraction correction so that we may use sea-horizon values, we have the following declinations approximately :—

The Hurlers. Lat. 50° 31′	Stanton Drew. Lat. 51° 10′
Dec. N. 38½°	Dec. N. 37°
,, 38°	,, 36½°
,, 37°	

Here, then, we have declinations to work on, but declinations of what star? To endeavour to answer this question I prepared a diagram showing the declination of the three brightest stars in the northern heavens, having approximately the declinations in question for the period 0 to 2500 B.C. The calculations for 0 to 2000 B.C. are taken from the tables published by the Astronomisches Gesellschaft,[1] and have been completed from 2000 to 2500 B.C. by Dr. Lockyer.

Vega is ruled out as its declination is too high. The remaining stars Capella and Arcturus may have been observed so far as the declinations go. For time limits we have :—

Dec. N.	Capella.	Arcturus.
38½°	500 B.C.	1550 B.C.
36°	1050 ,,	1150 ,,

The interesting fact must be pointed out that about 1000 B.C. the declination of the two stars was very nearly the same.

Now there is no question as to which of these two stars we have to deal with, for I find by the use of a precessional globe that for about 1400 B.C. and 800 B.C. the warning stars were as follows for the critical times of the year, *i.e.* May, August, November, February.

	1400 B.C.	Az.	800 B.C.	Az.
May	Pleiades rising		Pleiades rising	
Aug.	Arcturus rising	N. 14° E.	Sirius rising	
Nov.	Capella setting		Betelgeuse rising	
Feb.	Capella rising	N. 29° E.	Capella rising	N. 21° E.
		Dec. 34° N.		Dec. 37° N.

It is quite clear, then, that we have to deal with Arcturus, and this being so, the approximate dates of the use of the three circles at the Hurlers can be derived. They are :—

	B.C.
Southern circle aligning Arcturus over centre of central circle	1600
Central ,, ,, ,, N. circle	1500
Northern ,, ,, ,, tumulus	1300

I have already pointed out that Mr. Penrose found the warning star for May morning at the date of foundation of the Hecatompedon, 1495 B.C., to be the group of the Pleiades. As the foundations of the Hecatompedon were only built some few years before the stones of the central circle of the Hurlers were used, we ought to find traces of the observations of the same May morning stars. We do; there is a stone with amplitude E. 15° N., which, when aligned from the S. circle, would have pointed out the rising place of the Pleiades in 1300 B.C., that is, the date we have already found from the observations of Arcturus. I regard this as an important confirmation of the time of the use of the temple, all the more as the high situation of the circles, not generally dominated by higher levels for some miles, renders it probable that large corrections for hills will not be required to be made.

There are alignments in connection with the N. circle which indicate the introduction of the solstitial year, but these and some others may wait until local observations have been made before more is said about them.

With regard to Stanton Drew, it is clear that we are there also dealing with Arcturus. Mr. Dymond's

[1] Dr. O. Danckworth, *Vierteljahrschrift der Astronomischen Gesellschaft*, 16 Jahrgang 1881, p. 9.

levels give an idea of the height of the hills, so with the Ordnance map azimuths, read to 1°, the dates of the use of the great and S.W. circles are approximately as under :—

	B.C.
Great Circle	1260
S.W. Circle	1075

We seem, then, to have made a step in advance. More accurate readings of the Ordnance maps and accurate determination of the heights of hills may vary the above values slightly. But that is an unimportant detail if it can be shown that we have a new method of dating what went on in prehistoric Britain at the time when the Athenians were building the Hecatompedon.

A great amount of local theodolite work has to be done, for while Mr. Lukis only referred to two outstanding stones at the Hurlers, there are many more marked on the Ordnance map; there are also others besides the "quoit" at Stanton Drew.

I am more rejoiced than I can say to know that this local work has already been begun under the best possible conditions. As it was impossible for me to leave London when the significance of the alignments was made out, I appealed to the authorities of University College, Bristol, and of the Royal Cornwall Polytechnic Society for aid. The principal of the college, Prof. Lloyd Morgan, together with Prof. Morrow and his engineering class, have already made observations at Stanton Drew, and Captain J. S. Henderson, of Falmouth, an accomplished surveyor, sent me last week from the Hurlers the angular heights along some of the alignments, the means of eight readings obtained with a 6-inch theodolite, both verniers and reversed telescopes being employed. Other students of science besides myself will, I am sure, feel their indebtedness for such opportune help. NORMAN LOCKYER.

BRITISH ASSOCIATION GEOLOGICAL PHOTOGRAPHS.

THE geological photographs committee of the British Association and its indefatigable secretary, Prof. W. W. Watts, are to be congratulated on the third issue, which completes the first series, of their admirable photographs. There are twenty-four photographs in this issue, all of great interest, showing much skill in technique, and considerable artistic power in the choice of the point of view from which the objects were taken. They treat of a variety of subjects, chiefly the action of wind and rain, frost and ice, and sea-waves, igneous intrusion, the character of sedimentary rocks, and structures due to faulting and folding.

There are two good pictures of the remarkable rain-eroded pillars of Old Red Conglomerate which occur at Allt Dearg, on the Spey, Morayshire, and remind us of the similar forms which may be seen in much younger deposits on the right side of the Brenner as we travel towards Italy. They were first figured by Sir Archibald Geikie, who provides a description to the photographs, in which he directs attention to the comparative rapidity of their formation, as shown by the fact that "some of these isolated stacks of conglomerate are capped by boulder clay, and their capitals may here and there be seen to have retained their covering of thick peaty soil."

The photograph of the tower of Eccles Church, an object made so familiar by Lyell's "Principles," is the last that was taken (in 1886), and the last that will be taken, for the tower itself was destroyed in 1895. Prof. Reynolds's photograph of the great Axmouth landslip gives a good view of the "mighty chasm which separated the foundering mass from the land." The original describers of this were Buckland and Conybeare, and a water-colour copy by Ruskin of Mrs. Buckland's drawing still hangs in the University Museum at Oxford. Of queer forms the "Rock and Spindle," St. Andrews, Fifeshire, photographed by Mr. G. Bingley and described by Prof. Bonney, and "Lot's Wife," Marsden, Durham, a "breccia gash" transformed into a sea-stack, described by Prof. Lebour, are among the quaintest; they would be good puzzles to set a student in examination. The most novel subject is the wind-worn surface of granite disclosed beneath the Keuper marl in the Mountsorrel quarry, one of the several proofs discovered by Prof. Watts of the desert conditions which prevailed in these islands and elsewhere during a part of the Trias period. We have selected this for reproduction.

FIG. 1.—Keuper marl resting on terraced granite surface; Mountsorrel Quarry, Leicestershire. Photographed by Prof. H. E. Armstrong, F.R.S.

As this is the last issue of the first series it is usefully accompanied by some introductory letterpress, which includes the names of the committee, a preface, table of contents, and other information. We learn from the preface that the idea of forming a systematic collection of geological photographs originated with Mr. Osmond W. Jeffs in 1889; to carry it out a committee of the British Association was appointed in 1890, and Mr. Jeffs acted as secretary until 1896, by which time 1412 photographs had been contributed. In 1895 Prof. W. W. Watts became secretary, and by 1903 the collection had grown to the magnificent total of 3754. It is housed in the Museum of Practical Geology, 28 Jermyn-street, S.W. The series issued to subscribers and just completed consists of a selected number (72) of these photographs, taken from negatives generously lent by their owners, and furnished with descriptions by many of the leading geologists of the day.