Megalithic Astronomy: Indications in Standing Stones

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SUMMARY

An account is given of a number of surveys of stone circles, alignments, etc., found in Britain. The geometry of the rings is discussed in so far as it affects the determination of the azimuths to outliers and other circles. Small scale reproductions of enough of the surveys are given to enable the reader to form an idea of what is to be found at these sites. The declinations corresponding to the indicated azimuths and horizon altitudes are tabulated. From a study of the histograms of these declinations it is shown that there are definite declination concentrations round values showing:

1. The Sun's declination at sixteen dates equally spread throughout the year.
2. The maximum and minimum declinations of the Moon at the solstices.
3. The declination of certain stars early in the second millenium B.C.

It is shown that indicated natural foresights are worthy of special attention. An attempt is made to deduce the extinction angle of a star, i.e. the smallest altitude at which it is visible.

INTRODUCTION

MUCH has been written for and against the astronomical significance of the stone circles, stone alignments, etc., which are scattered throughout these islands and indeed much further afield. There is, however, universal agreement that the erectors, herein called for convenience Megalithic man, marked the rising and setting points of the solstitial Sun. It has become increasingly clear that, in a similar manner, he also marked other dates throughout the year. It is the object of this paper to attempt to give a definite meaning to these solar points and to examine the remaining indications, bearing in mind that they may be stellar or lunar.

It has proved impossible for a single individual to collect enough data to be able to say with certainty that this or that explanation best fits all British sites. This would need a team of surveyors working for perhaps years. Very often, when the survey is plotted possible sight lines become apparent which were not noticed at the site. This may entail a second visit to measure the missing horizon altitudes. The author assumed that an outlier had to be viewed from the circle. So for the reverse direction the hill horizons are often not available. At present we do not know if this is important.

It is hoped that the material is presented in such a manner that lines or pointers whose inclusion was dictated by purely objective considerations can be separated from those introduced to support some particular hypothesis. By this arrangement other investigators working on, perhaps, quite different lines will be able to use the surveys and data given. Unfortunately practically all existing surveys, good though some of them may be, are by themselves useless for our present purpose. No claim is made that the surveys here presented are perfect; it is intended that this paper should be looked on as a preliminary review of the material available.

1.0. The Material in the Field

In spite of the wanton destruction of prehistoric sites we still find in perhaps a thousand places throughout Britain remains consisting of stone circles, stone alignments, menhirs, etc. Most are in a ruinous condition but many have sufficient stones left to enable us to form a fairly good idea of the general layout. In examining these sites we may be in danger of forming a totally wrong idea of the scope of the original monument. This difficulty can be partially overcome by measuring up what is left at as many sites as possible and then submitting the data so collected to statistical examination and comparison. In this way the author demonstrated that the builders used, throughout all Britain, a standard unit of length of 2·72 ft which for convenience may be called the Megalithic Yard (MY). This was sometimes divided into four, but never into three, equal parts. For the longer lengths 10 MY was frequently employed, again subdivided where necessary into four. Fortunately there is so much evidence for these units that they can be accepted without question.(14,15)

1.1. A typical stone circle consists of a number of stones set in a ring. The stones may be simply boulders or they may be tall shaped pillars. Sometimes there are two or more concentric rings of stones and sometimes there are stones set up outside the ring or rings called outliers. There is in a few instances a stone set near the centre, but it is never at the exact geometric centre. Presumably a wooden pole stood there as a centre for setting out purposes or to provide an accurate sighting mark. There may be other constructions inside the ring such as graves or cells. The rings vary in size from a few feet across to 370 ft diameter.

1.2. While the majority of the rings are circular other types were used. We find about 30 flattened circles of two types,(11,12) 8 or more egg-shaped rings of two types(13) and about 20 ellipses. A brief description of the flattened circles will be found in section 2.7 and there are several examples among the surveys. The eggs are all based on an exact Pythagorean triangle or on a close approximation thereto. The two ways in which this was done are typified in the examples in Figs. 32 and 34 (Type I) and Fig. 18 (Type II) but other examples are shown.

1.3. Woodhenge (Fig. 32) is a particularly interesting example of Type I. It is based on a 37, 35, 12 triangle set out in $\frac{1}{2}$ yd units, but it differs from all other known examples in that the radii are not integral. Most egg-shaped rings have the perimeter close to a multiple of $2\frac{1}{2}$ yd. At Woodhenge this condition is satisfied in that the perimeters are 40, 60, 80, 100, 140 and 160 yd. Obviously it would not be possible to satisfy even approximately both conditions (radii and perimeter) for a whole series of eggs all based on the same triangle. A little trigonometry gives the relation between radii and perimeter and this relation was used to draw the construction superimposed on an accurate survey of the concrete posts which now mark the holes originally occupied by wooden posts. Further details will be found in Ref. 13, but for our present purpose the interest lies (1) in the fact that the axis of the construction points to the rising position of the midsummer Sun's upper limb, and (2) in the position of the two outliers G and H. The azimuth of G as seen from A is the same as that of H viewed from B and this azimuth gives the rising of Capella in 1800 B.C.

1.4. Of the 20 or so rings known to be ellipses nearly all are based on a Pythagorean triangle in that the major axis, the minor axis and the distance between foci are arranged to be integral. A good example is the ring above Penmaen-Mawr of which the survey is being published elsewhere. This has, major axis 31, minor axis $29\frac{1}{2}$,

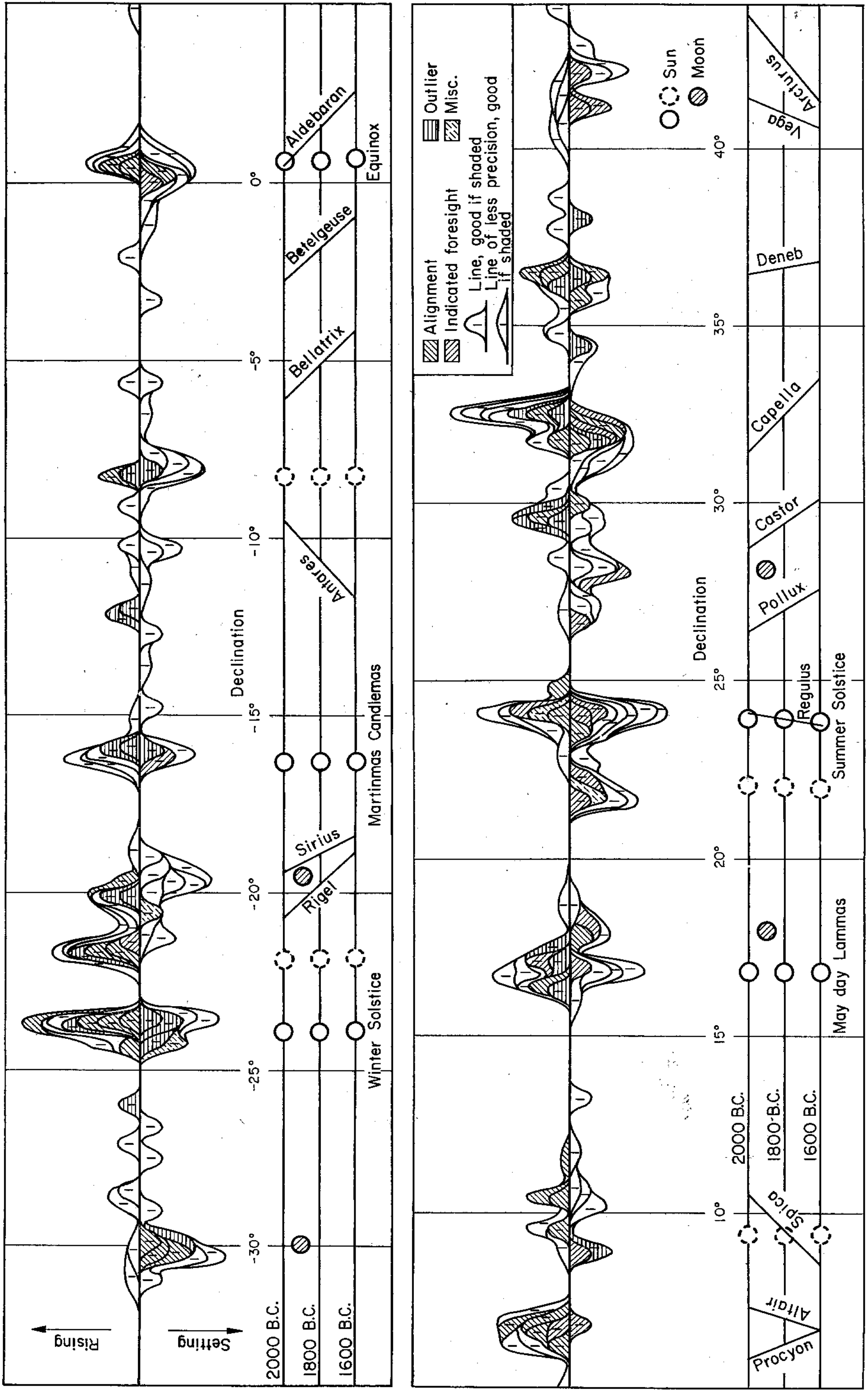


FIG. 1. Histogram of declinations of all indicated lines.

distance between foci $9\frac{1}{2}$ and so a perimeter of 95. The builders' success here and elsewhere in incorporating a near Pythagorean triangle and at the same time getting the perimeter to be a multiple of $2\frac{1}{2}$ is remarkable. There are several with an eccentricity of 0·5 (See Ref. 8).

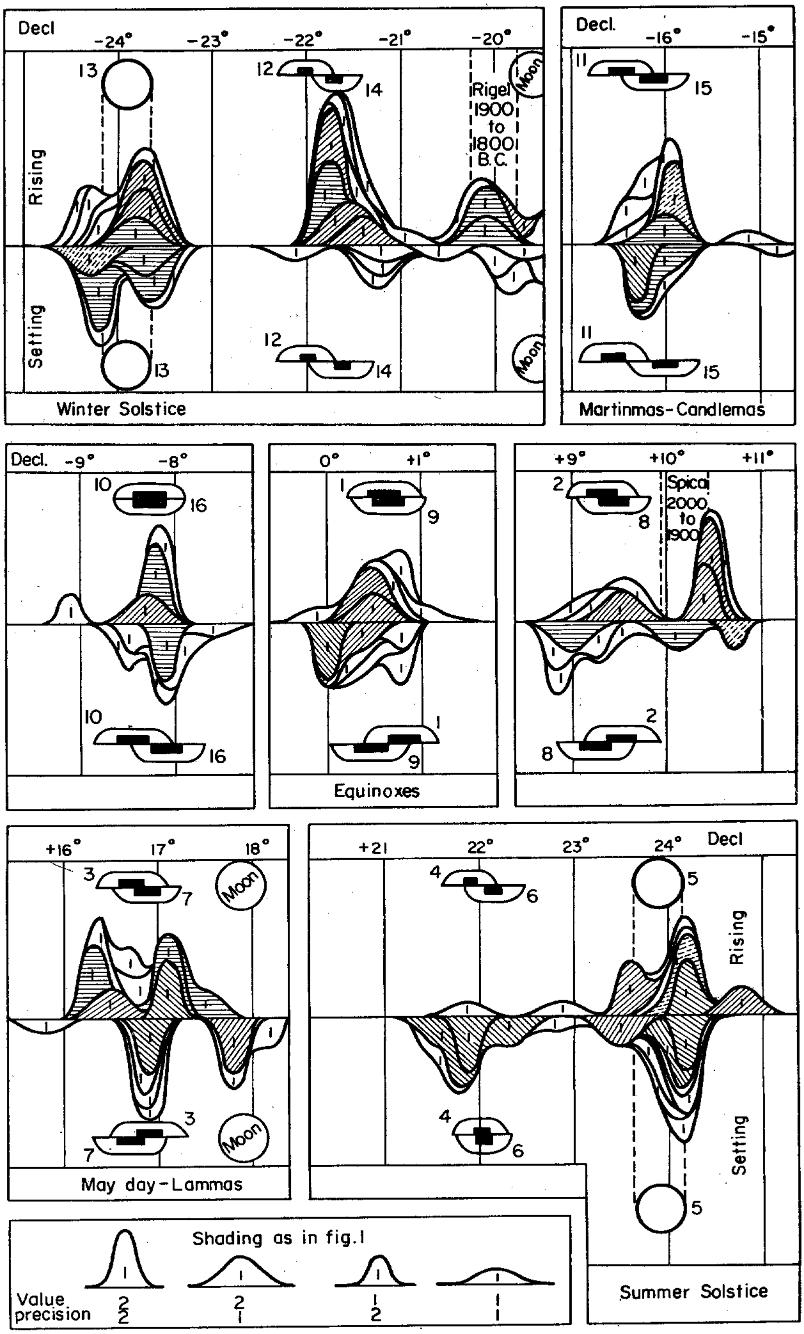


FIG. 2. Histogram of solar lines.

While a knowledge of the geometry of these peculiarly shaped rings is necessary for the location of the centre, a knowledge of the units of length may help even with the purely circular rings. An example is found at Sheldon of Bourtie (Fig. 12). On the ground there is no clue to the construction but looking at the survey and knowing that 20 and 40 MY (54·4 and 108·8 ft) are likely diameters it seems safe to accept the suggestion of two concentric circles. The fact that the outliers are placed almost exactly 40 and 100 MY from the assumed centre clinches the matter and allows us to accept with confidence the declinations shown.

2.0. ASTRONOMICAL INDICATIONS

An analysis published in 1955(11) showed a high probability that the sites contained lines with an astronomical significance. In the intervening years many more surveys have been made with the result that we now have a much better idea of the motives behind these enormous undertakings. The present paper contains the results to date, collected and presented in such a manner that other workers will have an idea of what is to be found at the sites.

Table 1 contains a list of the sites considered to have possible astronomical indications and Table 2 shows the azimuths, horizon altitudes, declinations, etc.

TABLE 1. SITES

A = Argyleshire south of Firth of Lorne, Bute & Arran
B = Aberdeen, Kincardine, Banff etc.
D = Derbyshire and surroundings
G = Scottish Lowlands
H = Outer Hebrides and Skye
L = North of England
M = Mull and neighbourhood
N = Caithness and Sutherland
P = Perthshire, etc.
S = South of England

	Site	Fig. No.	Lat.	Long.	Description
A1/2	Loch Nell, Lorne		56° 24′	5° 24′	2 Circles, Menhir etc.
A1/4	Loch Seil, Lorne	10a	56 20	5 33	Alignment etc.
A2/1	Inverary		56 14	5 04	Menhir
A2/6	Carnasserie		56 09	5 29	2 stone alignment
A2/8	Temple Wood	5	56 07	5 30	Circle, alignments etc.
A2/12	Duncracaig	6	56 07	5 29	Alignments, Circle etc.
A2/14	Dunamuck S		56 05	5 27	2 stone alignment
A2/21	Dunamuck N		56 05	5 28	3 stone alignment
A2/23	Craigen-tairbh		56 10	5 27	Large broken menhir
A3/4	nr Tayvallich	7a	56 01	5 39	Rings, and alignment
A4/1	Escart		55 51	5 26	Five large uprights
A4/4	Ballochroy	9	55 43	5 37	Alignment etc.
A5/8	Scalasaig, Colonsay		56 04	6 12	Alignment
A6/1	Camus an stacca, Jura		55 48	6 03	Large menhir
A6/2	Strone Farm, Jura	8g	55 48	5 59	2 stone alignment
A6/4	Knockrome, Jura	10b	55 52	5 55	Three upright slabs
A6/5	Tarbert, Jura		55 58	5 50	Two uprights
A6/6	Carragh a Chlinne	8c	55 49	5 58	Two uprights

Table 1—*continued*

	Site	Fig. No.	Lat.	Long.	Description
A8/1	Mid Sannox, Arran		55° 40′	5° 09′	Menhir
A8/2	Sannox Manse		55 40	5 09	Menhir
A9/7	Stavanan Bay, Bute	7b	55 45	5 04	3 Stone alignment
A10/2	Lachlan Bay		56 06	5 12	Slab
A10/3	Ballimore		55 58	5 18	Passage Kist and Stone
A10/6	Stillaig	8a	55 52	5 18	3 uprights
A11/1	Blanefield		56 00	4 21	Alignment, ruinous
B1/8	Sheldon of Bourtie	12	57 19	2 18	Circles, outliers
B1/18	Ardlair		57 20	2 44	Circle, outliers
B1/26	Loanhead, Daviot	13	57 21	2 25	Circle, outliers, etc.
B2/4	Esslie		57 01	2 28	2 circles (Ref. 13)
B3/3	Raedykes		57 00	2 16	2 circles etc.
B3/5	Kempston Hill		57 00	2 12	2 uprights
B7/1	Clava	11	57 28	4 04	Circles and cairns
B7/3	Dulnanbridge		57 18	3 38	Alignment etc.
B7/10	Easter Delfour		57 09	3 54	Circle and outlier
D1/3	Nine Ladies		53 10	1 38	Circle and outlier
D1/6	Sydnope Stone		53 09	1 33	Slab
D1/7	Barbrook		53 17	1 35	Circle and outliers
G1/4	Ballantrae		55 05	5 00	Alignment etc.
G2/4	Port Logan		55 44	4 57	Scattered uprights
G3/12	Drumtroddan		54 46	4 32	Alignment (re-erected?)
G3/17	Balsmith, Whithorn		54 44	4 23	2 stones
G4/1	Carsphairn		55 13	4 16	Ruinous Circle, and outlier
G4/2	The Thieves		55 01	4 30	Earth ring, 2 menhirs
G4/3	Drannandow		55 00	4 30	Circle
G4/13	Kirkmabreck		54 53	4 20	Alignment etc.
G4/14	Cauldside	19	54 53	4 18	Circle etc.
G5/10	Communion Stones		55 06	3 47	4 rows
G6/2	Auldgirth		55 09	3 42	Circle etc. Re-erected
G7/4	Loupin Stanes		55 15	3 10	2 circles and outliers
G8/5	Dere Street I	20a	55 26	2 24	Alignment etc.
G8/9	Eleven Shearers	17a	55 28	2 20	Alignments
G9/10	Borrowstor Rig	18	55 46	2 42	Circle, outliers etc.
G9/13	Kell Burn (644642)	10c	55 52	2 34	Alignment (not on O.S.)
H1/1	Callanish	16	58 12	6 45	6 separate sites
H1/10	Steinacleit		58 24	6 27	Complex
H1/12	Clach an Trushel		58 24	6 30	20 feet menhir etc.
H1/13	Dursainean		58 13	6 13	Ruinous complex
H1/14	Clach Stein		58 12	6 14	Fallen menhir & stone
H1/15	Stone near H1/13		58 13	6 13	Slab (not on O.S.)
H2/2	Clach Mhic Leoid	15d	57 52	6 59	Menhir
H2/3	Borvemore		57 50	7 01	Slab etc.
H3/1	Cladh Maolrithe		57 43	7 11	Grass ring and menhir
H3/2	Clach an't Saigairt	15c 8d	57 40	7 14	Large stone
H3/3	Clettraval Stone	15e	57 37	7 27	Not visited
H3/5	Fir Bhreige		57 36	7 25	2 stones
H3/6	Barpa nan Feannag		57 38	7 16	Very large barp
H3/8	Na Fir Bhreige		57 38	7 13	3 stone row
H3/9	Ben a Charra	15f	57 36	7 23	Menhir
H3/11	Leacach an Tigh Chloiche	15g	57 35	7 21	Complex

Table 1—*continued*

	Site	Fig. No.	Lat.	Long.	Description
H3/12	Clach Mhor à Ché		57° 35′	7° 24′	Menhir
H3/15	Claddach illeray		57 33	7 21	Ring not on O.S.
H3/17	Pobull Fhinn		57 34	7 17	Ring with "entrance"
H3/18	Sornach Coir Fhinn	14 8b	57 33	7 18	Circle with slabs
H3/21	Craig Haston		57 34	7 27	Natural Rock with slabs below
H4/2	Gramisdale (S)		57 28	7 18	Circle and outlier (?)
H4/4	Rueval Stone	15b	57 27	7 19	Slab not on O.S.
H5/1	An Carra	15a	57 16	7 22	Menhir 15 ft. high
H5/9	Pollachar Inn		57 06	7 23	Menhir (not visited)
H6/3	Brevig, Barra		56 58	7 27	Alignments
H6/5	Berneray		56 47	7 38	Remains of Circle etc.
H7/4	Clach Ard, Skye		57 27	6 18	Carved stone
H7/5	Clachan Erisko		57 27	6 15	Poor alignment
L1/1	Castle Rigg	21	54 36	3 05	Circle, outlier
L1/3	Sunkenkirk		54 17	3 16	Circle with "entrance"
L1/6	Burnmoor	22 23	54 25	3 17	5 circles
L1/7	Long Meg etc.	24	54 44	2 40	Circle and outlier
L1/10	Seascale		54 24	3 30	Circle and outlier
L1/11	Giants Graves		54 13	3 20	3 stone alignment
L3/3	Five Kings		55 18	2 04	Alignment
L6/1	Devil's arrows		54 06	2 23	Alignment
M1/4	Dervaig A	8e	56 36	6 11	Alignment
M1/5	Dervaig B	7c	56 35	6 10	Alignment
M1/9	Ardnacross		56 34	6 00	2 rings, alignment
M2/6	Ross of Mull	8f	56 19	6 17	Menhir
M2/7	Dail na Carraigh		56 19	6 13	Complex
M2/8	Bunessan		56 19	6 13	Menhir
M2/9	Ardlanish		56 17	6 14	2 stones, one with ring
M2/10	Uisken		56 18	6 13	Menhir etc.
M2/14	Loch Buie		56 21	5 51	2 circles, 4 outliers
M3/1	Coll		56 37	6 37	2 stones
M8/1	Loch Creran		56 31	5 21	Circle and menhirs
M8/2	Barcaldine	8h	56 32	5 18	Double stone
N1/8	Loch of Yarrows		58 22	3 10	2 stones
N1/13	Latheron Wheel Burn		58 18	3 24	Circle, outlier etc.
N1/15	Watten (223516)	35	58 27	3 20	2 stones
N2/1	Learable Hill	25	58 11	3 53	Alignments etc.
P1/1	Muthill		56 19	3 54	Alignment
P1/2	Dovne		56 11	4 00	Alignment
P1/8	Comrie		56 23	4 01	2 stones
P1/10	Fowlis Wester		56 24	3 45	Ring & outlier
P1/13	Monzie		56 24	3 49	Circle, outliers
P1/14	Tullybeagles		56 30	3 36	2 circles
P1/18	Clachan an Dirion		56 41	3 45	Slabs etc.
P2/8	Shianbank	26	56 26	3 22	2 Circles
P2/12	Dunkeld		56 33	3 33	2 stone alignment
P3/1	Glen Prosen	20b	56 44	3 04	Alignment etc.
P7/2	Galabraes		55 55	3 27	2 stones
S1/1	The Hurlers	27 28	50 31	4 27	3 circles etc.

Table 1—*continued*

	Site	Fig. No.	Lat.	Long.	Description
S1/2	Nine Stones		50° 34′	4° 30′	Circle and outliers
S1/5	Treswigger		50 33	4 39	Circle and outlier
S1/6	Leaze		50 34	4 38	Circle and outlier
S1/7	Rough Tor		50 35	4 37	Circle and outlier (Ref. 12)
S1/9	Merry Maidens	29	50 28	4 54	Good alignment
S1/11	Nine Maidens		50 10	5 35	Circle and outliers
S2/1	Grey Wethers	30	50 38	3 55	2 Circles
S3/1	Stanton Drew	31	51 22	2 34	3 Circles etc.
S5/3	Avebury		51 26	1 51	Complex
S5/4	Woodhenge	32	51 12	1 48	6 Rings
W2/1	Penmaen-Mawr		53 15	3 55	Circle, small circle and complex alignment
W5/1	Moel ty Ucha		52 55	3 24	Circle and outliers etc.
W5/3	Mein Hirion		52 50	4 06	2 stone alignment
W6/2	Rhos y Beddau	17b	52 52	3 24	Circle and alignments
W8/1	Rhosygelynnen	33b	52 15	3 36	Alignment
W9/5	St. Nicholas		51 59	5 02	Circle (?) and alignments
W9/7	Parc-y-meirw	33c	51 59	4 55	4 stone alignment
W11/1	Saeth-Maen	33a	52 14	3 32	Alignment
W11/2	Y Pigwn		51 58	3 42	2 circles etc.
W11/3	Maen Mawr	34	51 52	3 40	Circle, outliers etc.
W11/4	Usk River		51 55	3 43	2 circles etc.

2.1. An azimuth may be defined on the ground in a variety of ways. When this azimuth is combined with the altitude of the horizon and the latitude a declination is uniquely defined. The following pointers to the azimuth of a line will be accepted:

1. An outlying menhir from the centre of a circle.
2. An outlying circle from the main circle.
3. An alignment of stones.
4. A slab (or slabs) set upright with its longer faces pointing to a foresight which may be (a) a second stone, (b) a mountain peak, (c) a large natural boulder on a ridge or (d) a notch in an elevated horizon.

It will be found that all these were used singly or in combination. A large slab or a line of slabs was often used to define the meridian. In several places these can still be used with the shadow cast by the Sun to give local apparent noon to within a few minutes of time. A study of these lines is not a part of this paper but the point is made that the erectors could find the north–south direction and could cut, move and erect slabs with faces sufficiently plane to define a direction to within a degree or so. Many are of course much cruder but with two or more in line the condition of the faces is of less importance.

2.2. The accuracy with which method 4 can be used is very great. If the mountain peak has its apparent right-hand slope nearly parallel to the apparent path of the setting Sun then we have a definition of a declination limited only by our knowledge of refraction at low altitude.(10) The author has experimented with such a foresight and found that it was possible to see the green flash several times as the Sun set by moving a foot or two to the right to bring the edge of the disc again into view after it had "set". If the mountain is a long way off we are here dealing with

TABLE 2. LIST OF KNOWN OR SUSPECTED LINES

Value 2 = Well indicated line
1 = Poor indication
0 = Little or no indication but reasonable precision.

Descriptions of Lines:—

CC	Circle to circle	P	Along tumulus passage
CO	Circle to definite outlier	OS	Stone orientated on far stone
CS	Circle to stone which may or may not be an outlier	SO	Far stone orientated on assumed backsight
A	Alignment	IF	Indicated foresight
A3	3 stone alignment	AIF	Foresight indicated by an alignment
SSS	3 Stones in line but not orientated along line		

Az = Azimuth from north through east
h = apparent altitude of horizon
h_E = apparent extinction angle

Where a date is given this is the date at which the star had the declination shown. It is not necessarily a suggested date for the site.

	Site	Type	Az.	h	h_E	Decl.	Value	Star	Date B.C.	
			°	°		°				
A1/2	Loch Nell	CO	147·5	6·6		−21·8	2	Sun		
A1/4	Loch Seil	AIF	326·1	5·3		+32·1	2	Capella	1880	
A2/1	Inverary	IF	23·7	11·1		41·2	0	Vega	1900	Poor ind
A2/6	Carnasserie	AIF	168·7	2·4±		−30·8±	1	Moon?		Poor
A2/8	Temple Wood	SSS	21·0	1·8		+32·7	1	Capella	1760	$S_5S_1S_2$
,,	,, ,,	SSS	26·1	2·6		+32·3	1	,,	1830	$S_4S_1S_3$
,,	,, ,,	SSS	206·1	0·3		−30·3	2	Moon		$S_3S_1S_4$
,,	,, ,,	CC	136·6	4·4		−20·1	2 }	Moon or Rigel		
,,	,, ,,	CO	135·0	3·7		−20·1	2 }			
,,	,, ,,	A	149·6	2·0		−27·1	1	—		
,,	,, ,,	A	329·6	5·8		+34·0	1	—		
,,	,, ,,	CO	115·9	7·1		−8·2	2	Sun		
,,	,, ,,	CA	141·2	1·8		−24·4	1	—		
,,	,, ,,	AC	321·2	4·5		+29·7	1	Castor	1730	
A2/12	Duncracaig	A4	140·7	2·3		−23·7	2	Sun		
,,	,,	A4	320·7	3·1		+28·2	1	Moon		

Table 2—*continued*

	Site	Type	Az.	h	h_E	Decl.	Value	Star	Date B.C.	
			°	°		°				
A2/12	Duncracaig	A2	151·9	1·1		−28·8	1	—		
,,	,,	A2	331·9	3·1		+32·2	2	Capella	1850	
,,	,,	IF	42·3	9·2		+32·5	1	,,	1800	
A2/14	Dunamuck	A2	138·2	3·4		−21·7	2	Sun		
A2/21	,,	A3	347	3·0		+35·7	2	Deneb		
A2/23	Craigantairbh	IF	254·4	11·2		0·8	1	Sun		
A3/4	Tayvallich	CA	32·8	1·9		29·5	2	Castor		
,,	,,	IF	34·1	2·1		29·3	2	,,		
,,	,,	IF	27·7	1·3		30·4	1	Moon		
A4/1	Escart	A5	28±	4±		34±	—			Bad line
A4/4	Ballochroy	IF	315·5	0·9		24·2	2	Sun		Ben Cora
,,	,,	AIF	44·2	6·2		29·4	2	Castor	1750	Rock
,,	,,	AIF	226	−0·1		−23·6	1	Sun		Cara fall
A5/8	Colonsay	AIF				24±	—			Poor foresight
A6/1	Camus an Stacca	IF	340·6	4·8		36·6	0	Deneb		Poor orientation
A6/2	Strone	AIF	298·3	7·5		21·6	1	Sun		Ruinous
A6/4	Knockrome	SSS	73·7	1·9		10·4	2	Spica	1970	
,,	,,	IF	203·4	1·0		−30·4	1	Moon		Stone to peak
A6/5	Tarbert, Jura	SS	106·7	1·5		−8·1	0	Sun		
A6/6	Carragh a Chlinne	IF	228·0	2·6		−20·0	1	Moon		
A8/1	Mid Sannox	IF	229·3	6·2		−16·3	2	Sun		
A8/2	Sannox Manse	IF	224·0	15·3		−10·2	1	Antares	1880	Poor
A9/7	Stavannan Bay	AIF	135·3±	2·7		−21·4	2	Sun		
A10/2	Lachlan Bay	IF	43·0	0·6		+24·2	2	Sun		
A10/3	Ballimore	PS	228·2	1·8		−20·6	1	Rigel	1970	
,,	,,	SP	48·2	2·8±		24·2	0	Sun		To passage
A10/6	Stillaig	OS	325·5	0·8		+27·9	2	Moon		
A11/1	Blanefield	A4	56·7	7·2		24·0±	1	Sun		Ruinous
B1/8	Sheldon of Bourtie	CO	119·3	−0·2		−16·0	2	Sun		
,,	,, ,, ,,	CO	55·9	0·0		+17·1	2	Sun		
B1/18	Ardlair	CSSS	116·0	1·1	1·9	−12·3	2	ζ Orionis		
B1/26	Loanhead	CC	41·6	0·7		+24·0	1	Sun		
,,	,,	CSS	144·0	0		−26·0	2	—		
,,	,,	CSS	139·0	0·2		−23·8	2	Sun		

			°	°		°				
B2/4	Esslie	CC	43·1	1·1		+24·1	2	Sun		
B3/3	Raedykes	CS	259·2	0·8	1·7	−4·4	1	Bellatrix	1660	
,,	,,	CC	314·2	2·1		+23·9	1	Sun		
B3/5	Kempston Hill	SS	231·4	0·6		−19·8	1	Moon		
B7/1	Clava	PP	216·5	1·7		−24·3	2	Sun		
,,	,,		311	4·1		+24·2	1	Sun		See Text
,,	,,	CO	153·4	5·1		−24·0	1	Sun		,, ,,
,,	,,	CSS	46·1	2·1		+23·6	1	Sun		,, ,,
B7/3	Dulnanbridge	AS	230·9	0·9		−19·5	1	Moon		
B7/10	Easter Delfour	CO	219	2		−23·6±		Sun		
D1/3	Nine Ladies	CO	245·8	3·5±		−11·3±		—		Horizon near
D1/6	Sydnope Stone	SS	80·3	1·1		5·9	0	Procyon		To Wyre stone
D1/7	Barbrook	CO	118·6	2·2		−15·1	1			
,,	,,	CO	284·8	2·3		+10·5	1	Spica?	2000	
G1/4	Ballantrae	SSS	11·8	2·7		+36·5	2	Deneb		
G2/4	Port Logan	SSS	240·5	2·4		−14·8	1	—		
G3/12	Drumtroddan	A3	43·3	0·4		+24·8	2	Sun		Re-erected?
G3/17	Whithorn	SS	254·3	0·9		−8·5	0	Sun		
G4/1	Carsphairn	CO	100·4	3·2		−3·5	—	—		Ruinous
G4/2	Thieves	SS	228	−0·4		−23·4	1	Sun		
G4/3	Drannandow	CC	35·0	4·2		+31·7	1	Capella	1950	To G4/2
G4/13	Kirkmabreck	SSS	5·9	3·1		+37·7	2	—		Meridian?
G4/14	Cauldside	CSSC	156·8	8·7		−23·7	2	Sun		
,,	,,	IF	59·5	0·3		+16·8	1	Sun		Diameter to peak
,,	,,	IF	78·2	0·3	0·9	7·2	1	Altair		,, ,, cairns
G5/10	Communion sts.	A	220·4	−0·2		−26·6	1	—		
G6/2	Auldgirth	COIF	281·2	3·3		+8·9	0	Sun		Reported Fake
G7/4	Loupin Stanes	CC	306·5	5·1		24·1±	1	Sun		
,,	,, ,,	CSS	201·2	1·5		31·0	1	—		
G8/5	Dere Street I	A	213·5	1·1		−27·5	1	—		Reverse?
G8/9	Eleven Shearers	A18	94·7	4·1		0·5	2	Sun		
,,	,, ,,	A	109·2	3·1±		−8·3±	2	Sun		
G9/10	Borrowston Rig	CSS	333·3	2·0		+31·8	2	Capella	1930	
G9/13	Kell Burn	A4	309·8	2·9		23·5	2			
,,	,, ,,	A4	129·8	1·9		−19·7	2	Moon		
H1/1	Callanish I	CA	9·2	1·5		32·5	2	Capella	1800	
,,	,,	CA	10·6	1·6		32·5	2	,,	,,	

Table 2—*continued*

	Site	Type	Az.	h	h_E	Decl.	Value	Star	Date B.C.	
			°	°		°				
H1/1	Callanish 1	AC	189·2	1·5		−30·2	1	Moon		See Text
,,	,,	AC	190·6	1·3		−30·2	1	,,		,, ,,
,,	,,	CA	See Som	merville		0·3	2	Sun		
,,	,,	CA	,,	,,		7·1	2	Altair	1800	
,,	,,	CC	141·8	0·4		−24·3	1	Sun		To V
H1/2	Callanish II	CC	127·5	0·4		−18·8	1	Sirius	1800	To VI
H1/3	,, III	CC	133	0·2		−21·3±	1	Sun		To VI
H1/4	,, IV	CC	89	1·0		1·0±	1	Sun		To VI
H1/5	,, V	CC	321·8	−0·1		23·8	1	Sun		To I
,,	,, V	A3	346	0·5		31±	1	—		
H1/6	,, VI	CC	269	1·2		0·2±	1	Sun		To IV
,,	,, VI	CC	304·5	0·0		16·9±	1	Sun		To I
H1/10	Steinacleit	CO	89·1	0·7±		0·7		Sun		
H1/12	Clach an Trushel	AC	77·9	0·9		6·8	2	Altair	1700	To H1/10
,,	,, ,, ,,	AS	79·0	1·0		6·2	1	Procyon	1840	To outlier at H1/10
H1/14	Clach Stein	CC	24·8	0·4		28·5	1	Moon		To Dursainean
H1/15	Dursainean	SC	227·9	2·0		−19·3	1	Moon		,, ,,
H2/2	Clach Mhic Leoid	IF	283·7	0		0·0	2	Sun		To Boreray
H2/3	Borvemore	IF	317·2	−0·1		+22·3	2	Sun		To Gasgier
H3/1	Cladh Maolrithe	IF	296·6	−0·2		+13·2	1	—	—	To Spuir Isd. Reverse(?)
H3/2	Clach ant Saigairt	IF	287·6	−0		+8·8	2	Sun		To Boreray
H3/3	Clettraval		126·7	−0·3		−19·5	0	Moon		To H3/11 not verified
H3/3	Clettraval	—	289·5	0		9·8	0	Sun		St. Kilda
H3/5	Fir Bhreige	IF	121·8	0±		−16·0	0	Sun		To H3/9
H3/6	Barpa nan Feannog	—	160·7±	0·7		−29·8	0	Moon		Stone on hor
H3/8	Na Fir Bhreige	SSS	288·9	2·3		11·7	1	—		
,,	,, ,, ,,	IF	253·2±	1·3		−8·2±	1	Sun		To Marrival
,,	,, ,, ,,	IF	271·8	+0·4		+0·8	1	Sun		To peak
H3/9	Ben a Carra	IF	255·7	−0·3		−8·1	2	Sun		To Deasgeir
H3/11	Leacach an Tigh Choiche	IF	304·7	−0·2		+17·0	0	Sun		To Haskeir
,,	,, ,, ,, ,,	CCC	131·8	−0·3		−21·7	2	Sun		To 2 sites
H3/12	Clach Mhor à Ché	IF	281·9	+0·4	0·9	+6·8	2	Altair	1700	To Craig Hasten
H3/15	Claddach illeray	CS	288·3	0·0		9·3	0	Sun		,, ,, ,,
H3/17	Pobull Fhinn	CC	255·5	0·3		−7·9	1	Sun		Some Indication

			°	°		°				
H3/18	Sornach Coir Fhinn	IF	313·2	+0·6		+21·6	2	Sun		To Cringraval
,,	,, ,, ,,	IF	318·5	0·8		24·0	2	Sun		To H3/11
H3/21	Craig Hasten	IF	90·4±	0·6		−0·1	0	Sun		Poor indication
H4/2	Gramisdale (S)	CS	71·3	0·6	1·2	10·6	—			Poor
,,	,,	CC	120·7	0·3		−16·2	1	Sun		To Hacklett
,,	,,	—	50·0	2·1		+21·9	0	Sun		To Ben Eval
H4/4	Rueval Stone	IF	303·8	−0·1		16·9	2	Sun		To Boreray
H5/1	An Carra	—	314·4	−0·1		21·9	2	Sun		,, ,,
H5/9	Pollachar Inn	—	227·6	−0·1		−22·1	0	Sun		To Fiaray fall
H6/3	Brevig, Barra	A	135·0	−0·3		−23·6	2	Sun		
H6/5	Berneray, Barra	CS	342·0	4·8		+35·9	1	Deneb		Poor
H7/4	Clach Ard	—	332·6	4·0		+32·2	0	Capella	1850	Prominent notch
,,	,, ,,	IF	110·5	1·2	1·2	−10·2	1	Antares	1870	Poor
H7/5	Clachan Erisco	IF	136·2	1·7		−21·6	0	Sun		Poor alignment
L1/1	Castle Rigg	CO	251·5	3·2		−8·1	2	Sun		Good outlier
,,	,, ,,	SS+	127·0	5·3		−15·9	2	Sun		
,,	,, ,,	—	157·0	2·8		−29·8	0	Moon		See text
L1/3	Sunkenkirk	—	128·8	0·5		−21·5	—	Sun		Entrance?
L1/6	Burnmoor	CC	348·0	7·5		+42·1	2	Arcturus	1900	E to A
,,	,,	CC	343·5	7·6		41·3	2	Vega	1930	E to B
,,	,,	CC	292·3	6·2±		17·8±	1	Moon(?)		E to C
,,	,,	CC	243·6	−0·5±		−16·0±	1	Sun		D to C
,,	,,	CC	131·9	+2·5±		−21·0±	1	Sun		D to E
,,	,,	CC	49·5	6·7±		27·0±	1	Pollux	1800	B to A
L1/7	Long Meg etc.	CO	223·4	1·1		−24·2	2	Sun		
,,	,, ,, ,,	CO	333·5	0·4	0·5	31·2	1	Capella?		Trees?
,,	,, ,, ,,	CO	320·2	−0·1	1·2	27·1	1	Pollux?		Trees?
,,	,, ,, ,,	CC	65·1	3·4		16·7	1	Sun		To Little Meg
L1/10	Seascale	CO	354·0	1·0	1·3	36·3	2	Deneb		
L1/11	Giants Graves	SSS	30·8	2·1		31·8	2	Capella	1930	
L3/3	Five Kings	A4	252·0	4·5±		−6·5	1	—		Uncertain
,,	,, ,,	IF	312·6	21·3		+41·1	2	Vega	1820	
L6/1	Devil's Arrows	A3	331·2±	0·7		31·2	1	Capello?		Trees?
,,	,, ,,	A3	151·2±	0·4		−30·7	1	Moon?		Trees?
M1/4	Dervaig A	A3	342·0	0	0·5	31·7	2	Capella	1950	
M1/5	Dervaig B	A7	334·0	0·7		29·9	1			See Text §9

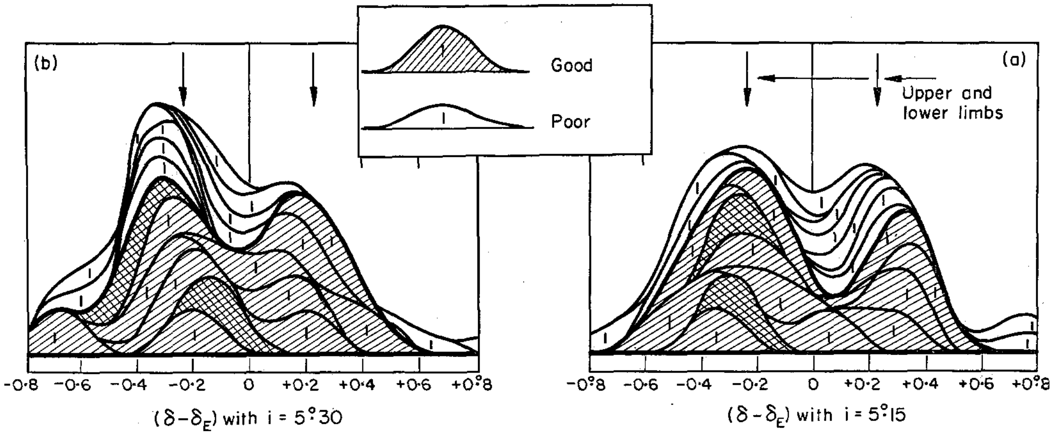
Table 2—*continued*

	Site	Type	Az.	h	h_E	Decl.	Value	Star	Date B.C.	
			°		°	°				
M1/5	Dervaig B	A7	334·0	—	1·5	30·7				See Text §9
,,	,,	A7	154·0	1·6		−28·5	1			,, ,, ,,
M1/9	Ardnacross	A3	339±	2·0		32·7	1	Capella	1760	Ruinous
M2/6	Ross of Mull	IF	59·5	1·5		17·1	2	Sun		
M2/7	Dail na Carraigh	IF	24·6	2·0		32·0	0	Capella	1890	
M2/8	Bunessan	IF	330·9	0·2		28·6	0	Moon		
M2/9	Ardlanish	SS	282·4	2·6		9·0	2	Sun		Ring on stone
M2/10	Uisken	IF	229·6	0·3		−21·3	1	Sun		
M2/14	Loch Buie	CO	123·4	6·8		−12·0	2	—		
,,	,, ,,	CS	223·6	0·4		−23·7	2	Sun		
,,	,, ,,	CS	237·0	2·1		−16·0	1	Sun		
,,	,, ,,	CS	330·8	14·1		+42·1	1	Arcturus	1740	High horizon
,,	,, ,,	IF	348·5	10·3		42·9	1	,,	1860	Unlikely
,,	,, ,,	SC	324·7	16·8		42·4	1	,,	1780	,,
,,	,, ,,	OS	245·1	3·9		−10·4	1	Antares	1840	
,,	,, ,,	SC	150·8	5·1		−24·2	0	Sun		
M3/1	Coll	SS	18·2	0·5		31·6	0	Capella	1970	Poor
,,	,,	IF	102·3	0·2	1·7	−5·6	1	Bellatrix	1900	
M8/1	Loch Creran	CO	113·1	4·2		−9·1	1			
,,	,, ,,	IF	129·1	4·7		−16·4	1	Sun		
M8/2	Barcaldine	IF	319·5	2·3		26·6	2	Pollux	1930	
N1/8	Loch of Yarrows	SS	343·0	0·0		+29·6	1	—		
N2/1	Learable Hill	A	92·8	2·4		0·3	2	Sun		Multiple rows
,,	,, ,,	A	61·6	2·4		16·6	2	Sun		,, ,,
,,	,, ,,	AIF	75·0	2·2		9·5	2	Sun		Single row
N1/13	Latheron Wheel	CO	196·1	1·0±		−29·7	2	Moon		
P1/1	Muthill	A3	57·4±	1·8		18·7±		Moon?		
P1/2	Doune	A3	13·5±	0·5		32·7±	1	Capella	1770	
P1/8	Comrie	SSIF	296·8	5·3		18·2	2	Moon		
P1/10	Fowlis Wester	CO	29·3	0·9	1·5	29·9	1	Castor	1670	
P1/13	Monzie	CS	305·5	4·8		22·8	1	—		Far off stone
P1/14	Tully beagles	CC	264±	3·7		−0·5±		Sun		
P1/18	Clachan an Dirion	A?	17·4	3·5		+34·8	0	—		

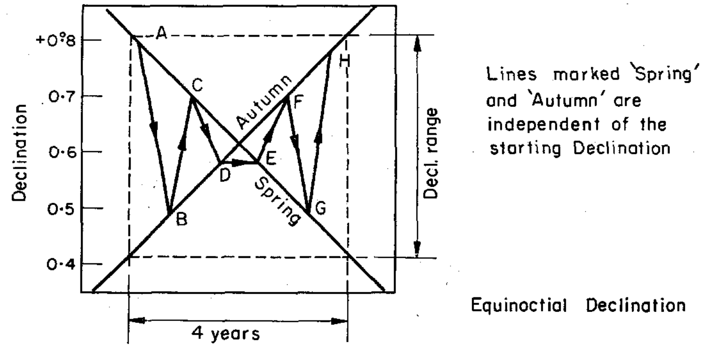
			°	°		°				
P2/8	Shianbank	CC	317·5	0·6		24·2	1	Sun		
,,	,,	CC	137·5	2·6		−21·9	1	Sun		
P2/12	Dunkeld	A2	310±	3·7		24±				
P3/1	Glen Prosen	A4	198·1	1·9		−29·9	2	Moon		
P7/2	Galabraes	SO	86·8	5·6		6·2	1	Procyon	1840	
S1/1	The Hurlers	CC	12·4	3·3		41·5	1	Arcturus	1800	
,,	,, ,,	CC	10·1	2·4		41·9	1	,,	1870	
,,	,, ,,	A4	256·3	0·5		−8·6	1	Sun		
,,	,, ,,	A4	76·3	0·8		+9·0	1	Sun		
,,	,, ,,	SCC	16·5	3·4		40·7	1	Vega	1650	
S1/2	Nine Stones	CA	63·6	1·5		17·5	2	Moon		
S1/5	Treswigger	CS	317·2	1·9		29·3	1	Castor	1840	Poor
S1/6	Leaze	CS	59·1	1·7		16·3	2	Sun		
S1/7	Rough Tor	CS	351·5	5·2		43·9	—			Poor
S1/9	Merry Maidens	A9	26·1	2·0		36·5	2	Deneb		Good line
S1/11	Nine Maidens	CSS	331·7	0·5		34·4	2	—		
S3/1	Stanton Drew	CC	232·7	1·6±		−21·2±	1	Sun		Trees?
,,	,, ,,	CC	52·7	1·3±		22·9	1			
,,	,, ,,	CA	75·5	0·7±		9·2	—	Sun		Conjectural
,,	,, ,,	CA	94·0	1·6±		−1·5	—	—		,,
,,	,, ,,	CC	20·1	1·7±		37·2	—	—		
,,	,, ,,	CC	31·4	2·0±		33·7	—	—		
S5/3	Avebury	CCC	339·2	0·5	1·3	36·5	2	Deneb		
S5/4	Woodhenge	CS	31·0	0·4	0·5	32·5	2	Capella	1800	From both crs.
S6/1	Rollright	CO	29·0	0·0	0·5	32·6	2	Capella	1780	
,,	,,	CC	94·9	−0·2	0·8	−2·7	0	Betelgeuse?		
W2/1	Penmaen-Mawr	CC	60·9	−0·2		16·4	1	Sun		
,,	,, ,,	A?	18·6	0		35·5	1	—		
W5/1	Moel ty Ucha	IF	256·7	0·1		−7·6	0			
,,	,, ,, ,,	CS	17·3	−0·2	1·3	36·1	2	Deneb		
,,	,, ,, ,,	CC	298·6	+0·6		16·9	1			To circle below
,,	,, ,, ,,	CS	349·8	−0·2	1·3	37·3	0	Deneb?		
W5/3	Mein Hirion	A	345·3	2·5		37·7	—			Poor
W6/2	Rhos y Beddau	A	79·1	5·0		10·5	2	Spica	2000	
W8/1	Rhosygelynnen	A	262·1	2·2		−3·3	1	—		
,,	,,	A	82·1	0·6		+4·9	1	—		

Table 2—*continued*

	Site	Type	Az.	h	hE	Decl.	Value	Star	Date B.C.	
W9/5	St. Nicholas	CSS	71·0°	0·3°		11·4°	2	—		
W9/7	Parc-y-meirw	A3	121·4	3·1±		−16·4	1	Sun		Hor. near
,,	,, ,, ,,	A3	301·4	−0·5		+17·8	2	Moon		
W11/1	Saeth-Maen	A8	83·5	3·6		6·6	1	—		
,,	,, ,,	A8	263·5	3·8		−1·2	1	—		
W11/2	Y Pigwn	CA	245·8	1·6±		−13·6	1			Along "avenue"
,,	,, ,,	CC	233·3	1·0±		−21·0±	—			
,,	,, ,,	CS	334·8	0·6		34·0	—			Uncertain
,,	,, ,,	CS	325·8	1·2		31·4	1	Capella		
,,	,, ,,	CS	131·0	0·9		−23·5	1	Sun		
,,	,, ,,	CS	125·2	0·9		−20·4	1	Rigel?		
W11/3	Maen Mawr	CO	335·2	4·9		38·0	2	—		
,,	,, ,,	CO	4·5	4·6		42·4	0	Arcturus	1950	
,,	,, ,,	CO	8·0	3·1		40·6	0	Vega?	—	
,,	,, ,,	AIF	22·0	4·1		38·6	1	—		
W11/4	Usk River	CO	285·0	1·5		10·1	2	Spica	1920	
,,	,, ,,	A3	78±	3·3		9·7	1	Sun		Poor
,,	,, ,,	CC	295·3	1·2		16·0	1	Sun		



Lunar Lines



(c)

Fig. 3. (a), (b) Histogram of lunar lines. (c) Equinoctial declination.

seconds of arc rather than minutes. With the backsights so beautifully arranged as they are at Ballochroy a vernier device was available for observing the midsummer setting Sun. The layout is shown in Fig. 9. The general line of the stones and the kist showed the midwinter Sun setting over Cara Island. The western fall of the island gave the upper limb as it sank below the sea horizon. But more important is the fact that the flat face of the large centre stone is orientated exactly on Ben Corra in Jura, 19 miles distant. The right-hand slope of the mountain is slightly steeper than the path of the setting midsummer Sun so that when the declination was between 23°52′ and 23°55′ the Sun viewed from the centre stone would appear to vanish near the top of the peak, but would reappear briefly further down the slope. (In 1800 B.C. the obliquety of the ecliptic was 23°54′.) Perhaps the observing technique was for the observer to stand at the extreme north-east stone and watch the Sun vanish at the top of the slope. When it reappeared lower down he could move along the line of the stones keeping the edge of the Sun just visible on the slope till he reached an extreme position and the Sun vanished. He would mark this position on the ground. A comparison of this position obtained on successive evenings would appear to be the most sensitive indication of the day of the solstice which was available to these people.

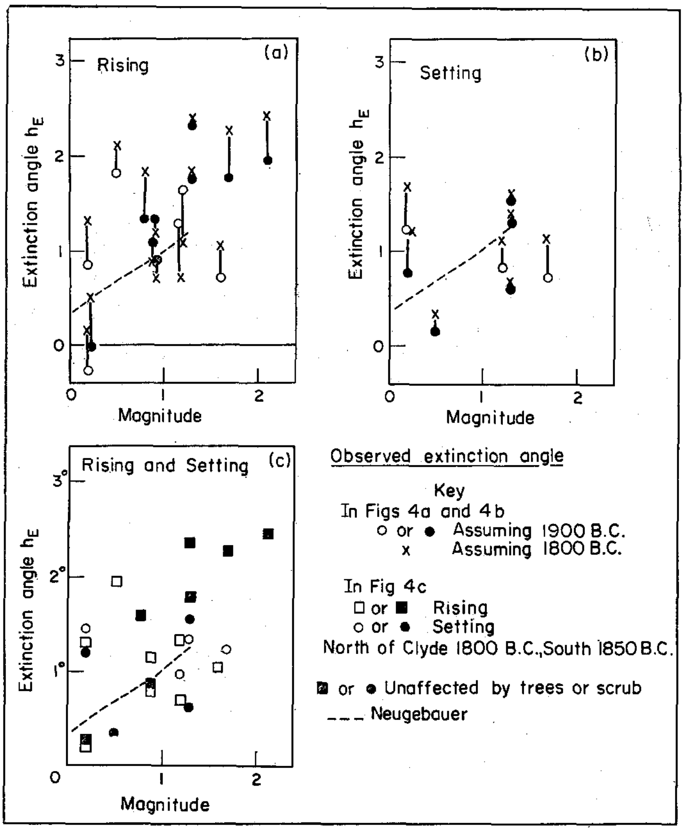


FIG. 4. Extinction Angle.

The accuracy attainable is probably much better than the possible changes in refraction from day to day.

The particulars concerning the mountain outline have been checked. The outline shown was constructed from the O.S. maps. Individual points were obtained at the site by theodolite using time/azimuth technique. These points will be seen to be within a minute or so of the O.S. outline. Further details concerning this and other similar sites (not yet fully checked) will be found in Ref. 10.

2.3. Some of the multiple circle sites in flat country are not suitable as records of declination. For example, at *The Hurlers* (Figs. 27 and 28) in Cornwall there may have been trees or scrub on the horizon in Megalithic times, whereas there are none today, and at *Stanton Drew* (Fig. 31) the trees are there today and may or may not have been there when the circles were built. The same difficulty arises with some outliers and alignments, but often the horizon is mountainous and so distant that trees would have little or no effect.

In some cases the passage out of a tumulus was used. This is brought out very clearly at the Clava Cairns (Fig. 11). It is seen that the passages in the north and south cairn are exactly on the same line and this line points to the setting point of the midwinter sun. This site, incidentally, seems to contain pointers to all four solstitial rising and setting points. One of the slabs forming the south circle, instead of being tangential is slewed round on to the line from the little ring which lies to the north of the circle. Looking to the stone from the ring gives a declination very close to that of the midwinter Sun's lower limb. Two slabs in the centre circle are slewed so that they lie on a line which gives the upper limb at midsummer sunset. There does not seem to be any backsight so this may be a coincidence. The fourth solstitial line is probably that shown from the ring tangential to the north circle. The tumuli do not interfere with any of these lines; that from the north passage passes above the south tumulus.

Possibly all the larger circles originally had outliers, but farmers and contractors have no compunction about removing these. Three have certainly been removed since 1939 and many are mentioned in the literature which now have vanished.

The greatest difficulty in a study of this kind is to know when a doubtful line qualifies for inclusion. In the previous analysis terms of reference were set up and as far as possible adhered to. But experience has shown that no definitions are satisfactory. The borderline cases are still there and so the policy adopted here is to describe a line as important and give it a value of 2 if on the site or on the survey it looks impressive. This is still subjective but there seems to be no way of formulating an entirely objective criterion.

Ambiguity sometimes exists as to the direction in which an alignment was used. In many of these cases both directions are tabulated. The suspicion is growing that some alignments were used in both directions. This would, in general, only be possible in hilly country where, by clever choice of the position of the alignment, it could be made to define wanted declinations in both directions (Section 9.0). In several cases the alignment is blocked at one end by local high ground. In sites with outliers the assumption is made that one looks from the circle to the outlier, but here again we do not yet know enough to exclude the reverse direction in future work.

2.4. In all some 500 sites have been visited and examined. Surveys were made where there was anything to survey. In most cases the orientation of the survey was determined astronomically but when weather made this impossible a distant well-defined mark was included so that its azimuth could be found later from the O.S. Where accuracy was required the coordinates of the peak could be obtained from the 6 in. O.S. and the azimuth determined by a geodetic calculation. In many sites the important lines are not known until the survey is plotted. If the site cannot be revisited it is often possible to get the missing horizon altitudes from the O.S. contours.

Let H = height of the observed point above the observer.
D = distance of the point from the observer.
K = coefficient of terrestrial refraction.
= 0·075 for rays over the sea and 0·081 for rays over land.
R = radius of curvature of the spheroid.
h = apparent altitude of the observed point.

Then

$$h = H/D - D(1-2K)/2R$$

With H in feet, D and R in statute miles and h in minutes this becomes:

$$h = 0{\cdot}651H/D - (0{\cdot}369 \text{ to } 0{\cdot}364)D$$

This method is generally satisfactory if D is greater than 2 or 3 miles especially in the Hebrides where the contours on the 6 in. O.S. maps are spaced at 25 ft. Ridge behind ridge may have to be tried till the maximum is found. When the extinction angle (see later) for the star concerned is greater than the horizon altitude then the latter does not affect the calculation of the declination, but for the Sun or the Moon we must use the measured or calculated altitudes.

2.5. In the absence of indications to the contrary the assumption is made that the outlier is viewed from the centre of the circle but at a site like *Sornach Coir Fhinn* the backsight is obviously a slab orientated on the foresight (Fig. 14). Where an egg-shaped ring is involved the main centre has been taken. On Burnmoor there are five circles. It is too much to assume that all the possible directions defined by the five points could have been significant. In fact we can only consider two of these as important. These are the lines from the main circle (Fig. 22) to the two *distant* circles A and B (Fig. 23). The axis of the main circle is directed to these two which, while being close together, give declinations which belong to Vega and Arcturus about 1900 B.C. We are here assuming that fire was lit in the foresights as they are too far off to be otherwise seen in starlight, except perhaps just before dawn.

Until we know more about the uses of multiple circle sites it does not seem desirable to attach too high weight to the line joining two circles, but the azimuths have in some cases an astronomical meaning. There are at least two examples of a north–south positioning (e.g. the *Grey Wethers* on Dartmoor: Fig. 30) and there are several giving a solstitial azimuth (see, for instance, Fig. 26). But where there are more than two circles at a site the position is less clear (e.g. *Clava Cairns, The Hurlers,* and *Stanton Drew*).

2.6. *The Nine Maidens* is a good example of an alignment (Fig. 29). Here the azimuth can be determined to within a few minutes and the altitude of the horizon to the north is above the extinction angle. The declination is 36°·5 and this could well be Deneb since Deneb's declination only changed from 36°·49 to 36°·64 between 2000 B.C. and 1800 B.C. But perhaps the most interesting set of alignments are those on Learable Hill in Sutherland (Fig. 25). The azimuths differed so much from those on the official survey that a second visit was necessary for a complete check. The circle to the west which existed earlier was not found but the wife of the gardener at Suisgil Lodge pointed out a ruinous circle some distance to the north which ought to be properly surveyed. The significance of these alignments will become apparent later in the paper. A somewhat similar site is *The Eleven Shearers* shown in Fig. 17a. This site also might well repay further study.

One of the most intriguing sites is shown in Fig. 5, but future workers will have to depend to some extent on this and other earlier surveys since part of the structure is now removed. Forming an essential part of the site is the beautiful little circle *Temple Wood.* The work of the vandals is shown here by a comparison of the author's survey (1939) with earlier surveys. Only a short distance away stand the impressive alignments at Duncracaig (Fig. 6). The solstitial meaning of the four large menhirs is obvious but the reverse direction also had a use. The hole-stone is broken but standing beside it one can only conclude that it was intended as a backsight for the high hill to the north-east which dominates the site. The impression is strengthened when one discovers that the associated declination is that of Capella in 1800 B.C.

The interpretation given in Fig. 34 to the site at *Maen Mawr* may well be quite wrong and no weight can be attached to the two lines shown. The site is dominated by the menhir which gives the structure its name. Since one cannot look through the

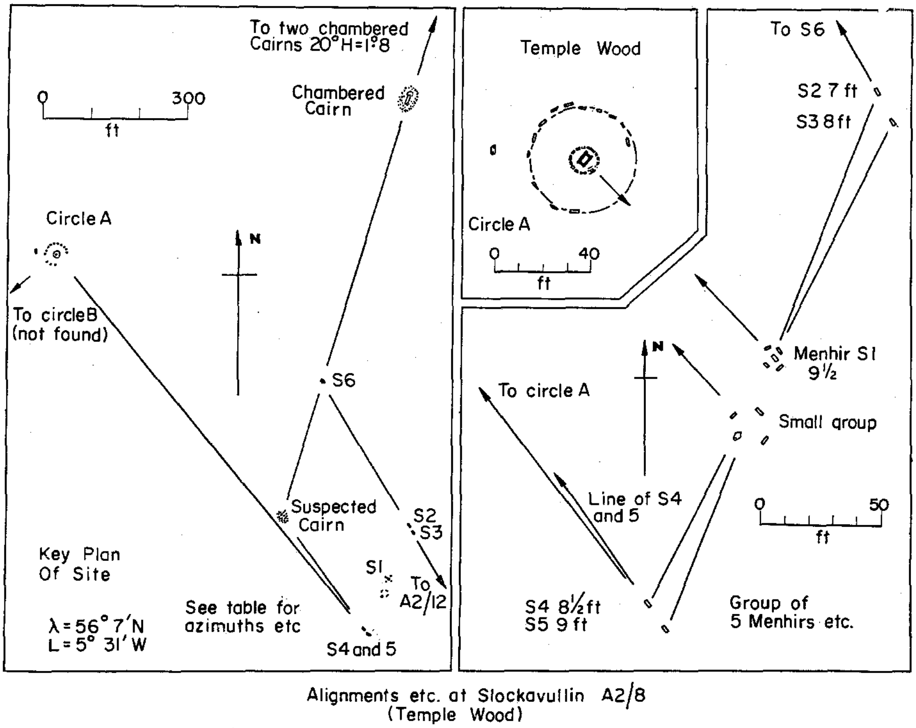

To two chambered Cairns 20° H=1°8
0 300 ft
Chambered Cairn
Circle A
N
To circle B (not found)
S6
Suspected Cairn
S2
S3
Key Plan Of Site
S1
To A2/12
See table for azimuths etc
λ=56° 7′N
L=5° 31′ W
S4 and 5
Temple Wood
Circle A
0 40 ft
To S6
S2 7 ft
S3 8 ft
Menhir S1 9½
To circle A
N
Small group
Line of S4 and 5
0 50 ft
S4 8½ ft
S5 9 ft
Group of 5 Menhirs etc.
Alignments etc. at Slockavullin A2/8
(Temple Wood)

FIG. 5.

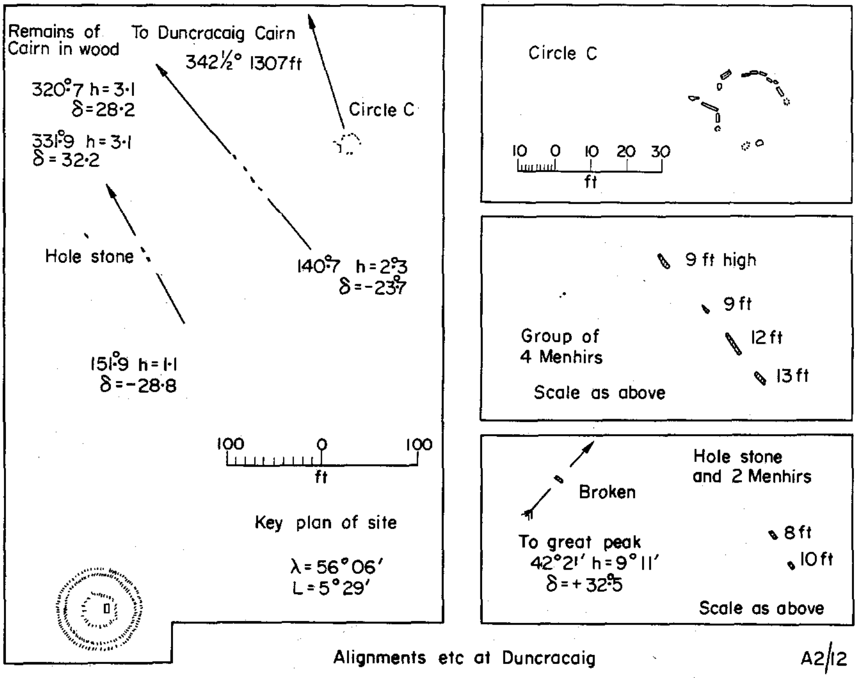

Remains of Cairn in wood
To Duncracaig Cairn
342½° 1307 ft
320°7 h=3·1 δ=28·2
331°9 h=3·1 δ=32·2
Circle C
Hole stone
140°7 h=2°3 δ=-23°7
151°9 h=1·1 δ=-28·8
100 0 100 ft
Key plan of site
λ=56°06′
L=5°29′
Circle C
10 0 10 20 30 ft
9 ft high
9 ft
Group of 4 Menhirs
12 ft
13 ft
Scale as above
Broken
Hole stone and 2 Menhirs
To great peak 42°21′ h=9°11′ δ=+32°5
8 ft
10 ft
Scale as above
Alignments etc at Duncracaig
A2/12

FIG. 6.

pillar perhaps the intention was to look past its left edge as indicated by the two small aligned stones beyond. From the main centre this gives Arcturus in 1950 B.C. Using the secondary centre is less likely still; the only explanation is Vega in 1600 B.C. ± 50 years.

2.7. Two of the most important circles in the north of England are *Castle Rigg* and *Long Meg and Her Daughters*. Castle Rigg (Fig. 21) is one of the best of the many Type A flattened circles(11,12) in which 240° of the circumference is circular. The remaining part of the ring consists of two short arcs drawn with radius one half that of the main portion. These arcs are connected by an arc drawn with centre at the mid point of the 240° arc. It will be noticed that at Castle Rigg all the 30° points round the 240° arc are marked by stones. Thus we have a number of parallel lines across the circle, two of which have been dotted in. The importance of these lines is that they show the rising point of the Moon when it had its greatest possible southerly declination. The largest stone in the circle marked B is at one of the changes of curvature (all four are marked by stones) and is at one end of a diameter passing through one of the auxilliary centres C, the main centre and the stone at A. Looking from B to A showed the midsummer setting Sun and looking from A to B showed the upper limb of the Sun on one of the important calendar dates defined in section 4.2. The line from the stone D through the main centre to the outlier gives another calendar date and makes this perhaps the most important outlier left in Britain. It is just possible that the four parallel lines spaced 2, 4 and 6 MY apart were intentionally laid out to show the rising point of Altair. If they are real then we have an explanation of the peculiar cell through which two of them pass. It may be remarked that here again the stone at C is kept just clear of the auxilliary centre. (See Fig. 39.)

The circle *Long Meg and her Daughters* is the largest Type B(11) circle known to the author. In this type 180° is circular. The east–west diameter is divided into three equal parts and the subdivision points used as centres for the two small arcs which are, as in Type A, joined by an arc drawn with centre on the far side. From the main centre Long Meg, the 12 ft outlier, shows the setting point of the lower limb of the midwinter Sun. Since the ground slopes down towards the east some earth movement may have taken place but it is difficult to see how the large stone in the north-north-west could have got outside the ring unless it had been deliberately placed there. Trees or scrub would affect the declination of this stone so we cannot be certain of its exact value. It is interesting to note how very large many of these stones are. In this plan, as in nearly all the others, upright stones are shown hatched and fallen stones are left blank. A second circle existed not far away, but of this there is now no trace (Fig. 24).

2.8. At Borrowstone Rig (Fig. 18) the ring is a Type II egg. The stones are all small, being in fact boulders, but although they are partially buried it is possible to decide which are in their original position and which have fallen. The importance of the site only became apparent after the first survey was plotted. A second survey was made and the ground prodded but it is felt that clearing the ground might reveal much more. On the nearby plateau there are many upright stones spread irregularly over a wide area. A careful survey might reveal their use. Once the construction of the main ring was established it became apparent that the two outliers were on a line radiating from the main centre.

An account of the excavation and re-erection which took place at the recumbent stone circle at Loanhead of Daviot will be found in Ref. 3. The author's survey of what was there in 1962 is given in Fig. 13. The interpretation put on the areas of buried small stones revealed by the excavation is confirmed when it appears that the axis of the suggested ellipse and circles points to the rising midsummer Sun. The major axis of the ellipse, the distance between its foci and its minor axis were evidently intended to be 14, 5 and 13 MY and these numbers roughly satisfy the Pythagorean relation. The perimeter is 42·54 MY. If the excavators had determined accurately the original positions of the outliers D and E we might interpret the original design but the National Trust considered these so unimportant that the railings exclude them.

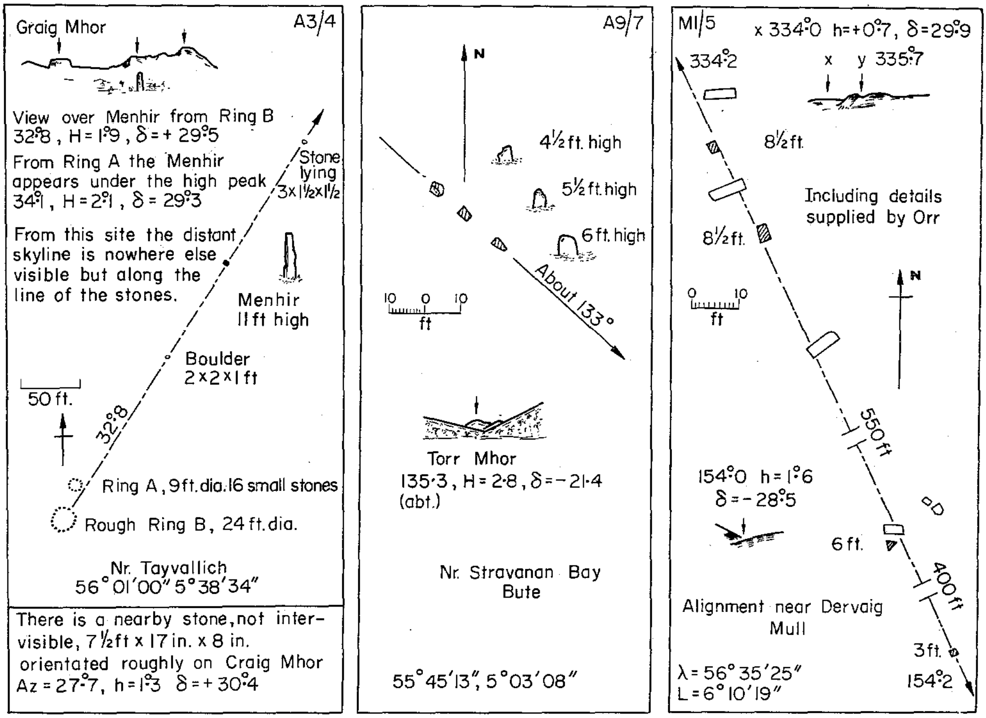


FIG. 7. Three alignments

Figures 7, 10, 20 and 33 show a number of alignments in various parts of the country. In two cases, A9/7 (Fig. 7b) and A1/4 (Fig. 10a), the alignment points to a clearly defined natural feature. We might also say the same for A3/4 (Fig. 7a). In the others the azimuth depends on the alignment itself. This does not matter for a long alignment like M1/5 (Fig. 7c) or W9/7 (Fig. 33c), but for the short alignments we cannot now be sure of the exact direction. Where the azimuth is near to the north very little effect is produced on the declination by an uncertainty in azimuth but this is not so for the east–west lines like W8/1 and W11/1 (Fig. 33) where we cannot obtain an accurate declination.

Usually the longer axis of the individual stone in the plan lies along the alignment but there are some places where this is not so. For example in Knockrome in Jura (Fig. 10b) the three stones are seen to be in line to within 5 min of arc but the stones stand at various angles. The middle stone is roughly orientated on a small peak

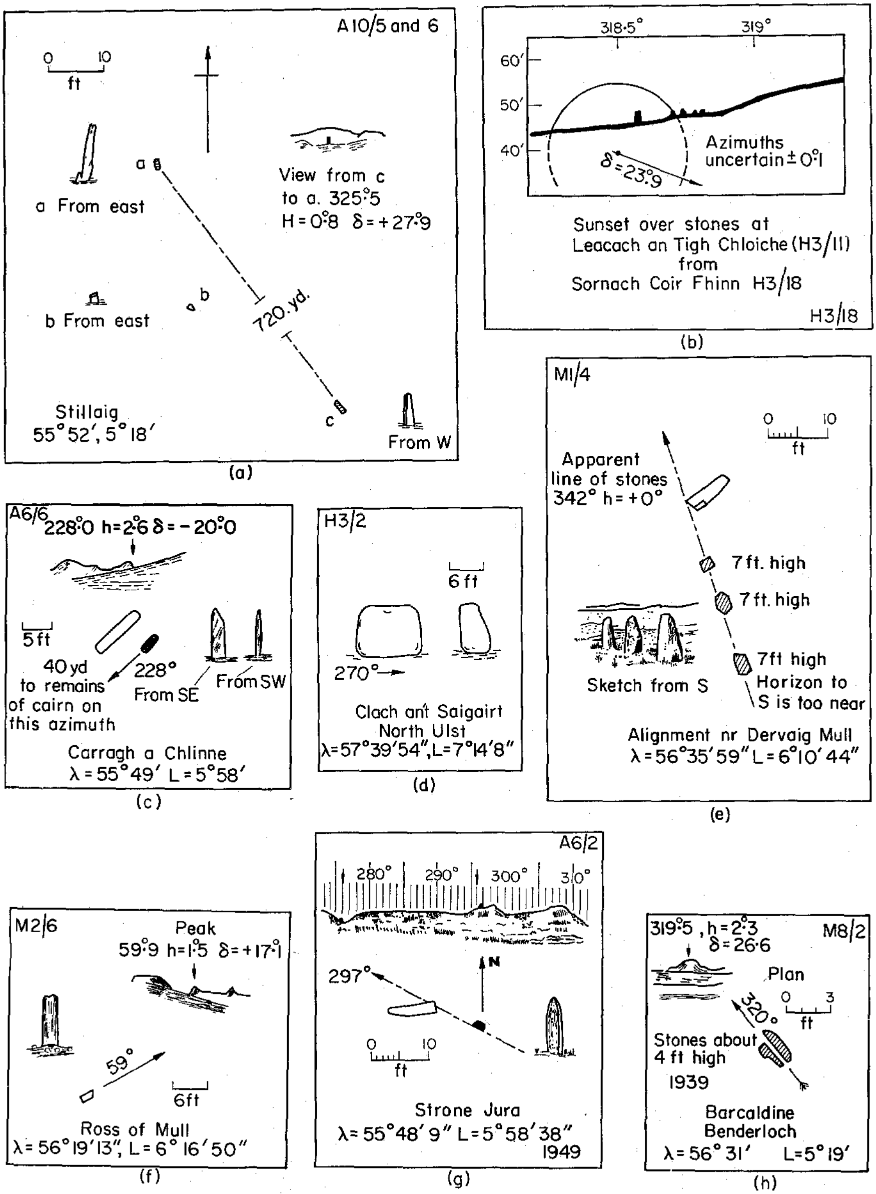


FIG. 8. Some sites in West Scotland.

giving a declination of −30°·4 which, corrected for parallax, is almost exactly the lower limb of the Moon at its furthest south position. This in itself would mean nothing, but in other places this duality of purpose is clear, e.g. at Ballochroy, already discussed. Another example is at Na Fir Bhreige (H3/8) in North Uist (see Table 2). It will be noticed that the lines just discussed are of a different nature to those, for example, on Learable Hill (Fig. 25) or at Rhos y Beddau (Fig. 17b). At Learable Hill the lines are formed of boulders but at many places the alignments are much more impressive, consisting, as many of them do, of large uprights or of slabs.

Nevertheless when a good survey is available the boulders are today often capable of giving as accurate an azimuth as the more impressive menhirs.

The site at Cauldside on Cambret Moor (Fig. 19) is interesting in that it is another of the very few circles where we can read anything into the stones of the circle. Many of the Cauldside stones are on opposite ends of a diameter. In most true circles one would think that the builders had gone out of their way to avoid diametrically opposite stones. (This may have been to prevent future users from reading more into the circle than was intended). The grass ring would not be noticed were it not for the two small stones on the line (solstitial), but the cairn now blocks this line completely and so is presumably a later construction.

Hitherto we have been discussing chiefly lines which could have been used at night with perhaps a little dim illumination, but the very important class of line we call "indicated natural foresights" could not have been illuminated and so must have been used for either the Sun or the Moon and as we shall see they were so used. A discussion of the uses of these sites belongs to a later section.

3.0. Collected Declinations

Table 2 contains particulars of the lines collected by the author. Column 3 contains an indication of the type of line in the code shown at the head of the table. The apparent horizon altitude is given in the column headed h. The next column contains, if required, the estimated extinction angle h_E. The declination is calculated

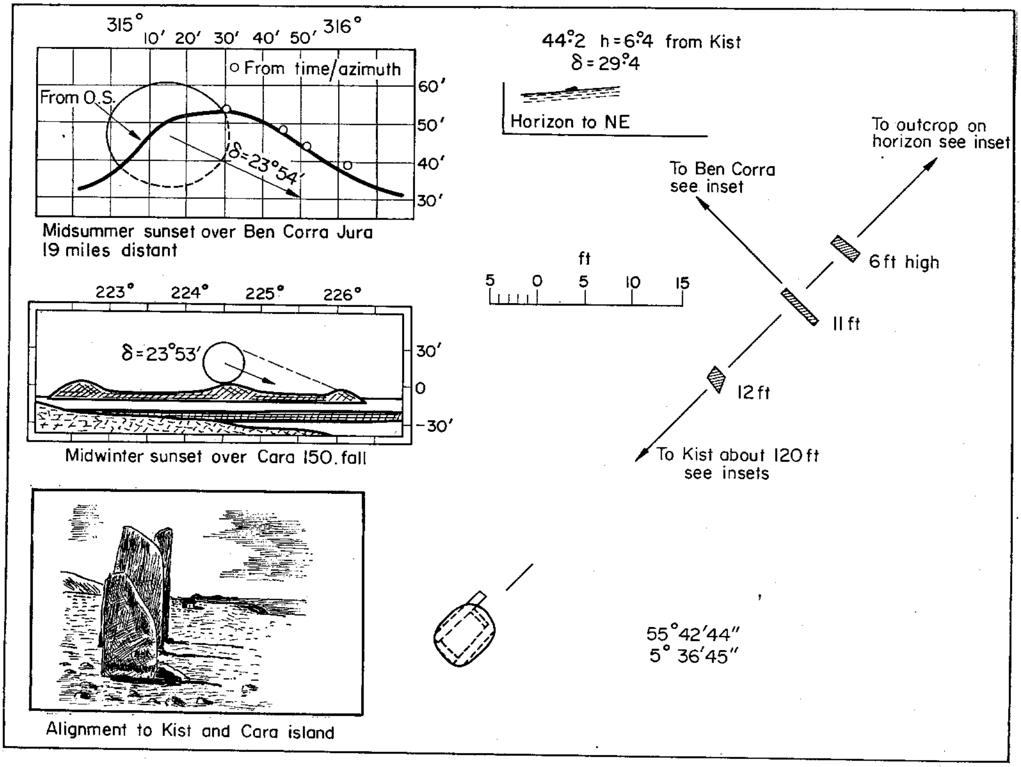


Fig. 9. Ballochroy.

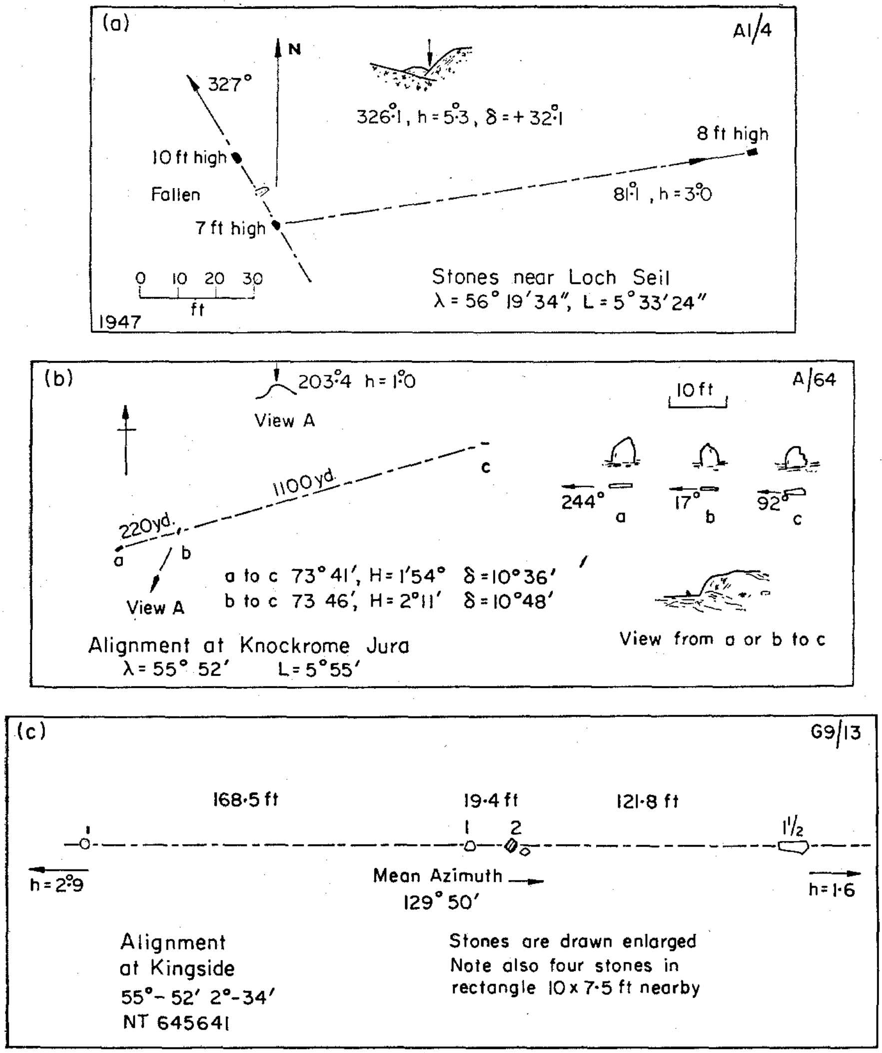


Fig. 10. Alignments.

from h or h_E whichever is greatest, mean refraction having been applied. If the line is definitely solar (or lunar) then h and not h_E is used. In one or two doubtful cases both declinations have been given. The reader can judge for himself the value of many of the important lines by a study of the surveys given here or in the references. The figure of value (2, 1 or 0) given in the table indicates the importance attached to the line by the author when he drew up the list. It is doubtful if anyone could be consistent and objective in assessing these lines, but some indication must be given to assist anyone who wishes to attach a weight. The *weight* would depend also on other considerations such as the precision and the quantity sought. A star like Deneb has almost a constant declination and so is quite useless if we are trying to date the remains, but it is ideal for determination of the extinction angle. A value of zero has been given to lines which are based on such a poor indication that they would be inadmissible in a statistical assessment of the astronomical significance of the sites. Nevertheless the precision of these lines may be such that one may want to make use of them. If no value is given then the line is poor or of such low precision that it cannot be used in calculation of date or extinction angle.

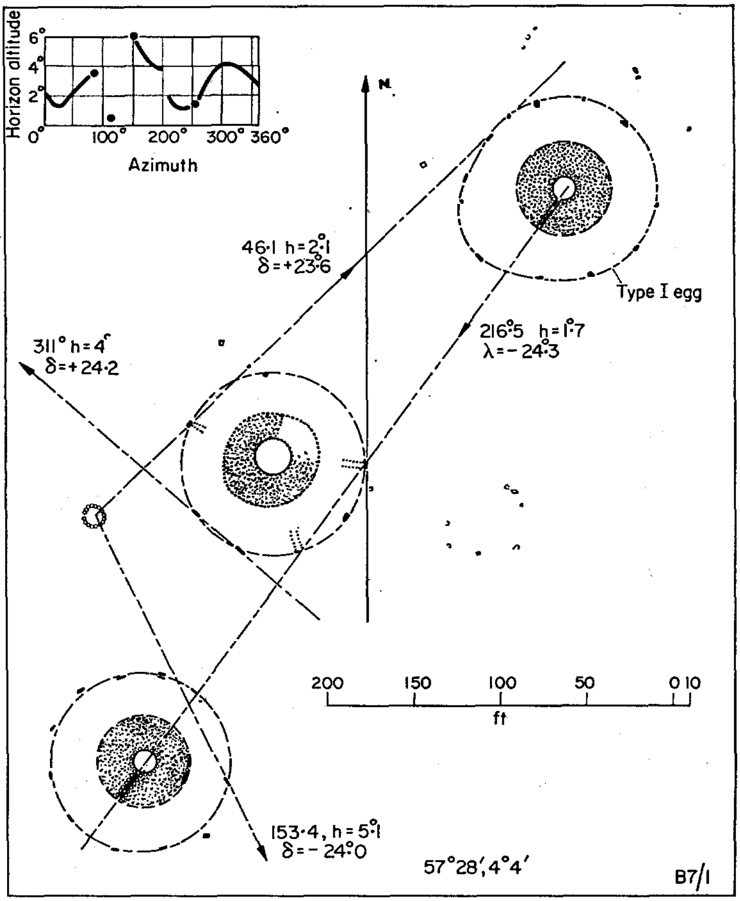


Fig. 11. Clava Cairns.

3.1. There are not enough data to produce a conventional histogram. Accordingly in Fig. 1 each line is shown by a small Gaussian area plotted at the appropriate declination. The shapes of Gaussians used are in accordance with the key shown at the right of the figure—less precise lines have a wider spread. Important lines which, it is considered, no one would exclude are shown shaded. The others are mostly of value unity. No lines of "value" zero are included. In going through the surveys the question may arise as to why this or that apparently attractive line was not included. The answer may be that there was no intervisibility or else that the horizon altitude was not measured at the site and the horizon is too near for an estimate from the map to be possible.

The declination of all stars, brighter than magnitude 1·5, which crossed the horizon in these latitudes is shown on the histogram from 2000 to 1600 B.C. The values are from Neugebauer(5). It is immediately evident that some stars carry a considerable concentration of lines. Looking at the similar histogram prepared in 1955(11) it will be seen that the position is now much clearer. The concentration at −21½° which in 1955 was mostly assigned to Rigel has increased and is accompanied by a group at +21½°. At the same time as these concentrations at ±21½° began to assume serious proportions those at ±(8° to 9°) also showed up. No stellar explanation of these was possible, but the whole position clears up when we assign a solar meaning to the concentrations near to 0°, ±8½°, ±16°, ±21½° and ±24°. These are the Sun's declination at 16 epochs equally spread throughout the year.

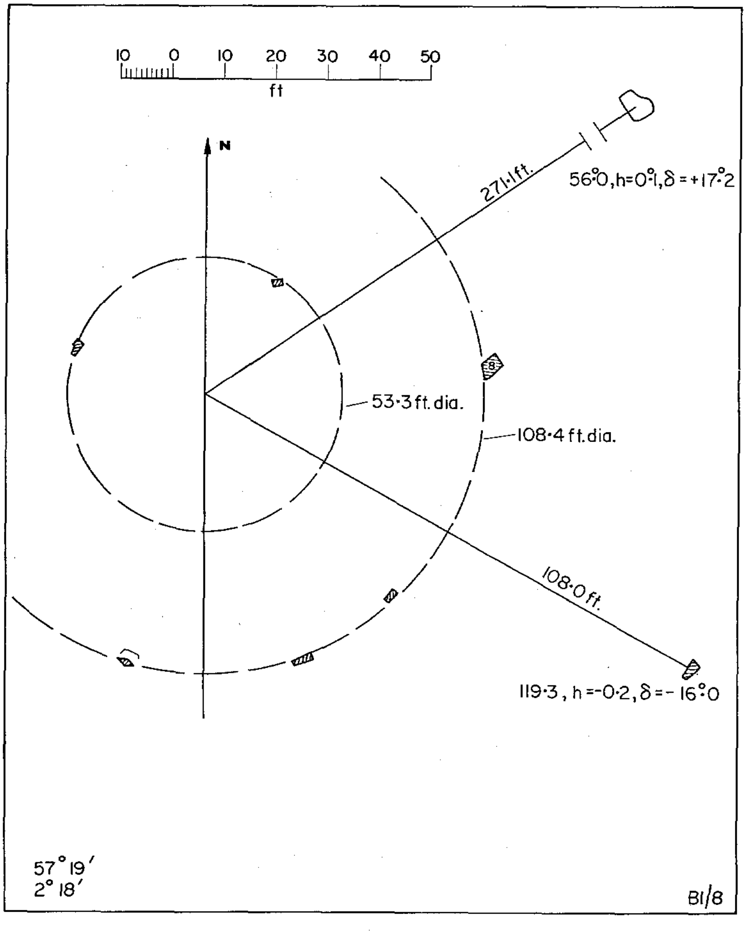
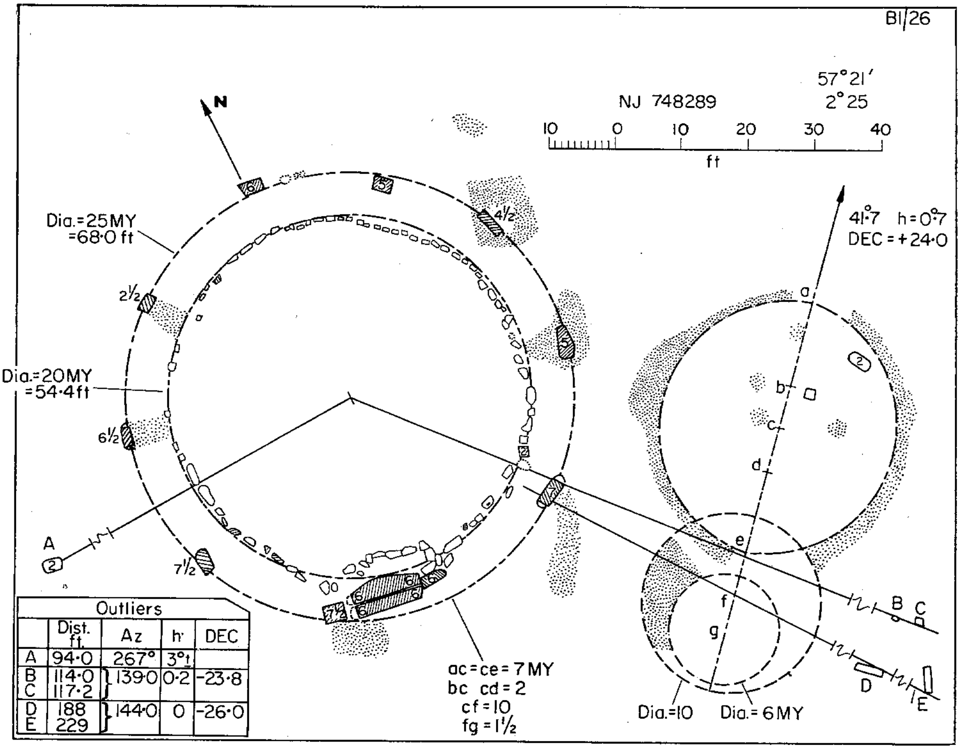


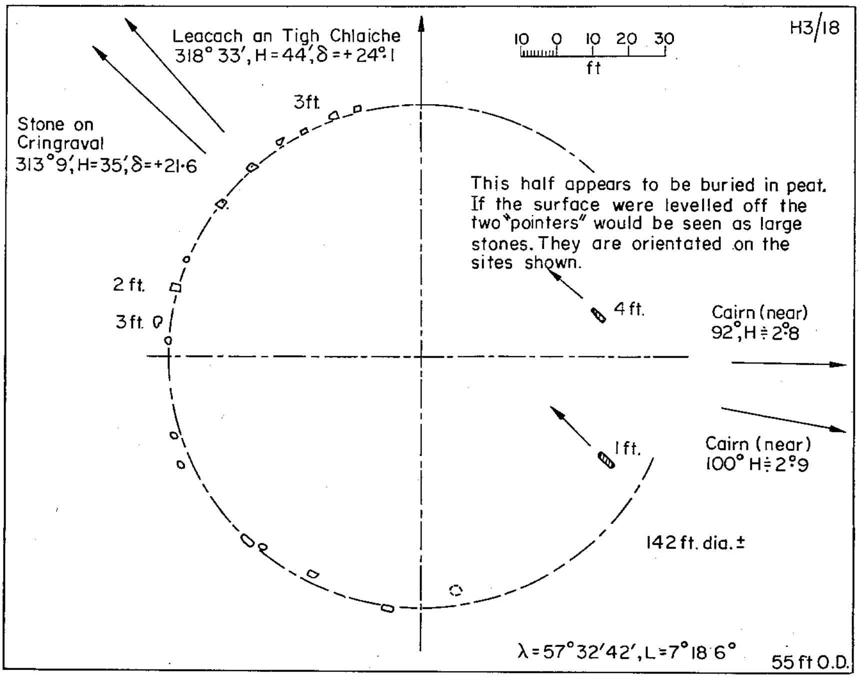
FIG. 12. Circles at Sheldon.



Outliers

	Dist. ft.	Az	h	DEC
A	94·0	267°	3°±	
B C	114·0 117·2	139·0	0·2	-23·8
D E	188 229	144·0	0	-26·0

Fig. 13. Loanhead of Daviot.



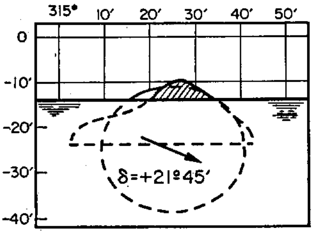
This half appears to be buried in peat. If the surface were levelled off the two "pointers" would be seen as large stones. They are orientated on the sites shown.

Fig. 14. Sornach Coir Fhinn, N.Uist.

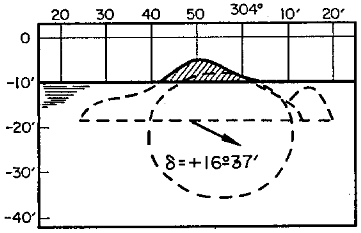
Before we consider the Moon or the stars it is proposed to examine in detail the arguments for assigning all these nine concentrations to the Sun.

4.0. The Calendar

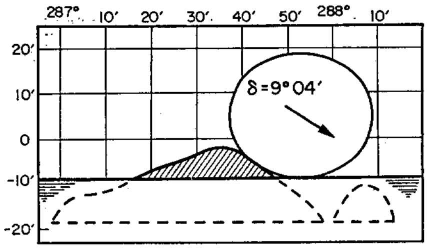
While Fig. 1 gives an overall picture the scale is too small for our present purpose. Accordingly Fig. 2 has been prepared to show the concentrations round the declinations which are mentioned above. Here again each observed line is shown by a Gaussian area according to the key at the foot of the figure. Important lines which cannot be ignored are shown shaded. The type of line is shown by the kind of shading, the convention being that of Fig. 1, but lines of value 0 are now included.



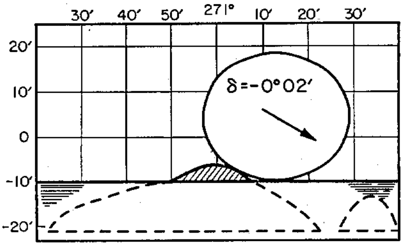
Boreray 59·4 mls
From An Carra H5/1
187 ft - Fig 15a



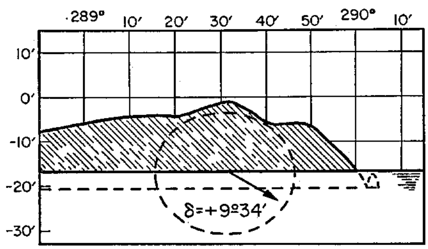
Boreray 52·3 mls
From orientated stone H4/4
100 ft Fig 15b



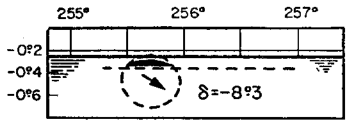
Boreray 48·5 mls
From Clach An't Saigairt H3/2 (orientated)
90 ft Fig 15c



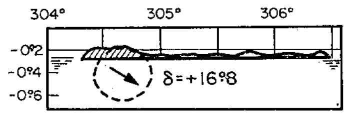
Boreray 55·2 mls
From Clach Mhic Leoid (orientated) H2/2
100 ft Fig 15d



St. Kilda 44·9 mls
From stone on Clettraval H3/3
290 ft Fig 15e



Deasgeir from B.a Carra H3/4 (orientated)
233 ft Fig 15f



Haskeir from Leacach an Tigh Chloiche H3/11
250 ft Fig 15g

Fig. 15. Sunset from stones on West Coasts of S. Uist Benbecula, N. Uist and Harris.

The solstitial values are shown in the first and last diagrams of Fig. 2. At 1800 B.C. the obliquity of the ecliptic was 23°·91 and this declination is shown by a circle with a diameter chosen to show the range of declinations between the upper and lower limbs. Undoubtedly both were used as is shown by the tendency at both solstices for the declinations to form double peaks.

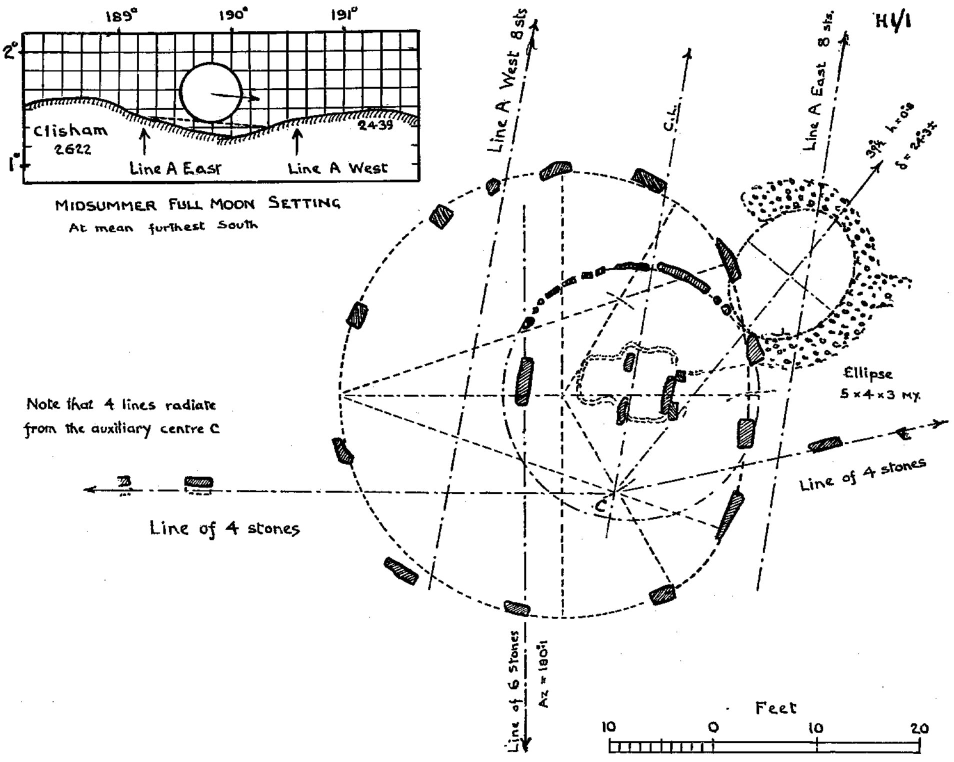


FIG. 16. Tursachan Callanish Stones after Sommerville.

But the solstices could not have been used for fixing a calendar date. The Sun's declination is changing so slowly that an exact day could not be defined. On the other hand the equinoxes are ideal for this purpose, especially in the northern latitudes where the movement of the Sun, at rising, along the horizon is about 0°·7 per day (latitude 55°). Any alignment set up to mark a day in the spring will also serve for another day in the autumn and it is this duality of purpose which provides us with a clue as to what was intended.

The most fruitful approach to the problem is to ignore, for the moment, the observations and to consider what would be the ideal epochs, assuming there were 16 uniformly distributed throughout the year—absolute uniformity of length of month is no more possible with 16 "months" than it is with 12. The declinations found in this way can then be compared with those given by the sites. Possessing, as they did, a number of sites capable of showing up very small changes of declination the erectors could not have continued working for more than a few years, as we shall see, without

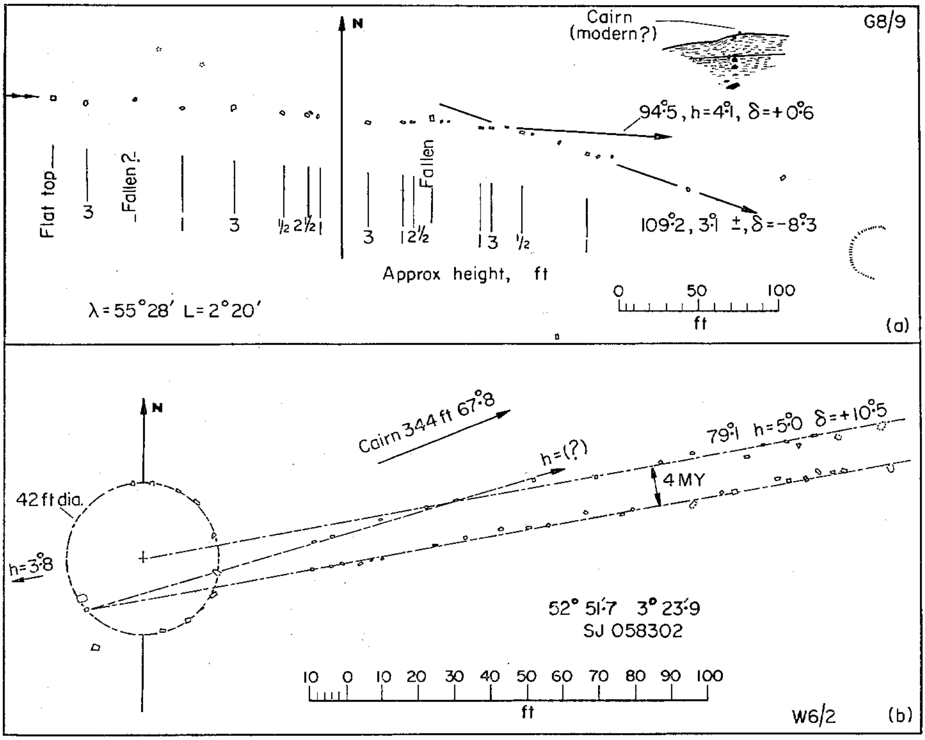


FIG. 17. Two long alignments.

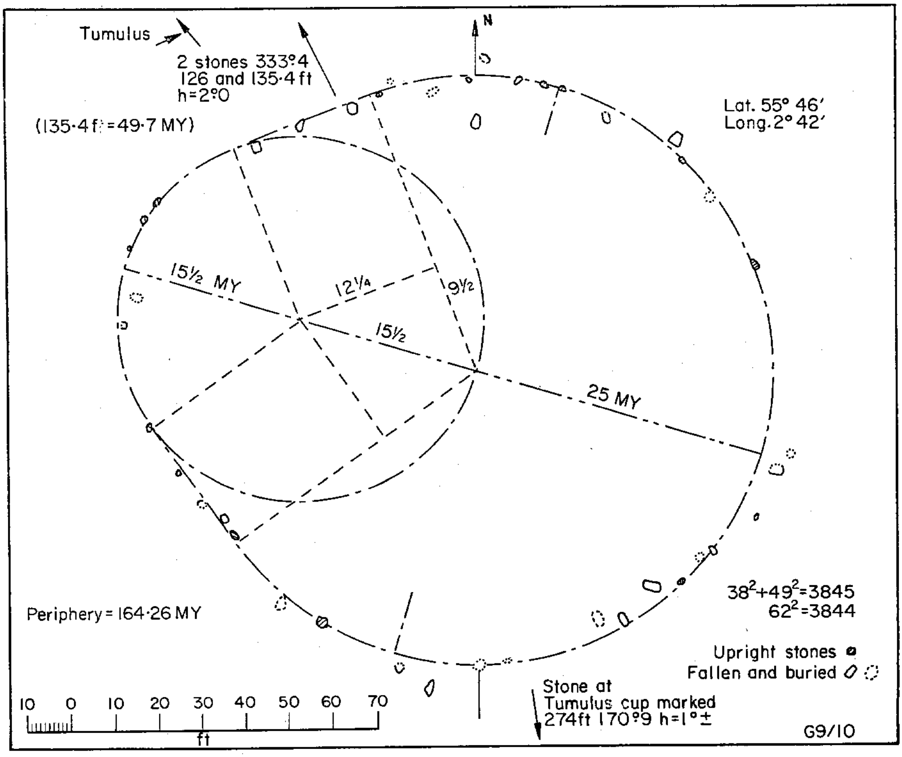


FIG. 18. Circle at Borrowston Rig.

discovering that the year was greater than 365 days and certainly a long period of experimenting and testing must have preceded the erection of these impressive monuments which were obviously intended to be permanent.

It may seem extravagant to claim that in 1800 B.C. our forefathers knew that there were $365\frac{1}{4}$ days in the tropical year but it is difficult to come to any other conclusion.

4.1. THE MONTHS OF THE YEAR

A year of 365 days can be divided into 13 months of 23 days and 3 of 22. Our immediate problem is to arrange these in such a sequence that the epochs can be divided into pairs, each member of a pair having as nearly as possible the same declination. The lack of symmetry or antisymmetry in the Sun's declination curve complicates the problem to solve which we must find and use the Earth's orbit at the date of the erection of the stones, which we shall assume was in the early part of the second millennium B.C. A hundred years either way will introduce no appreciable error, so we can use 1800 B.C. De Sitter's value for the obliquity does not differ appreciably from Newcombs. So we can take:

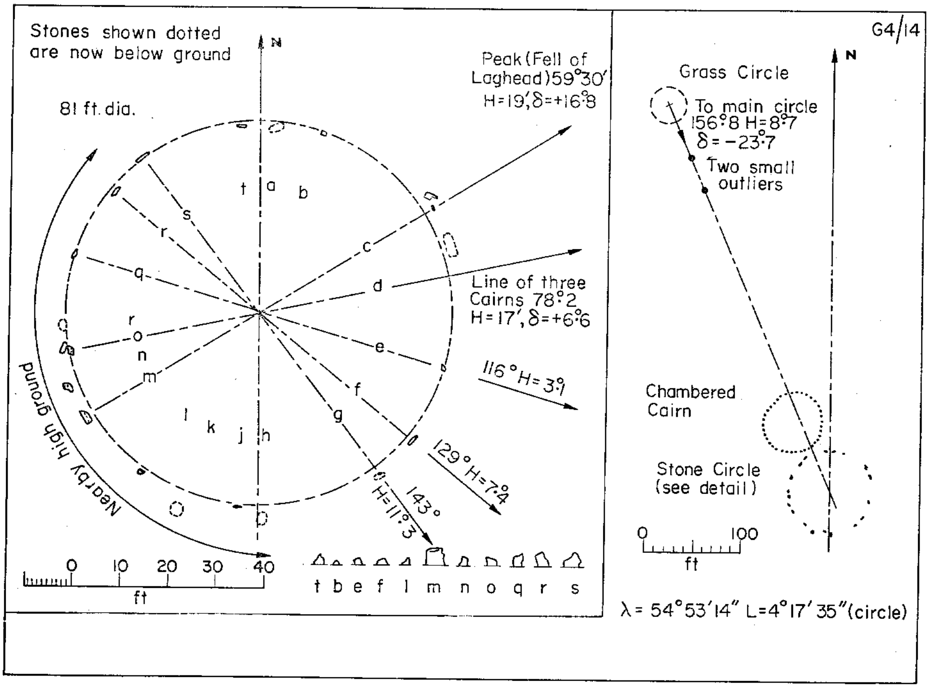


FIG. 19. Circles etc. on Cambret Moor—East Group, Cauldside.

ε = obliquity $= 23°\cdot906$

π = longitude of perihelion $= 218°\cdot067$

e = eccentricity $= 0°\cdot0181$

These, with Sun's longitude $= l + 2e \sin(l - \pi)$ where $l =$ longitude of mean Sun, give the data from which the declination was calculated and tabulated throughout the year. It appears that when $l = 0$ and again when $l = 180°$ the declination is 0·51° and this is the value which for many years the author considered the most likely to be found from the equinoctial pointers. But the matter is more complicated because the interval from the Vernal Equinox of Megalithic Man to his Autumnal Equinox is not half a year but may be either 182 days (Scheme A) or 183 (Scheme B).

After some experiment the two solutions set out in Table 3 were considered to be the two arrangements of the months most nearly satisfying the terms of reference, i.e. each month must have either 22 or 23 days and the declinations must, as nearly as possible, pair. For simplicity in presentation the zero epoch in neither scheme is the instant of zero longitude of the mean Sun but is the time when the declination had a value depending on the following exposition.

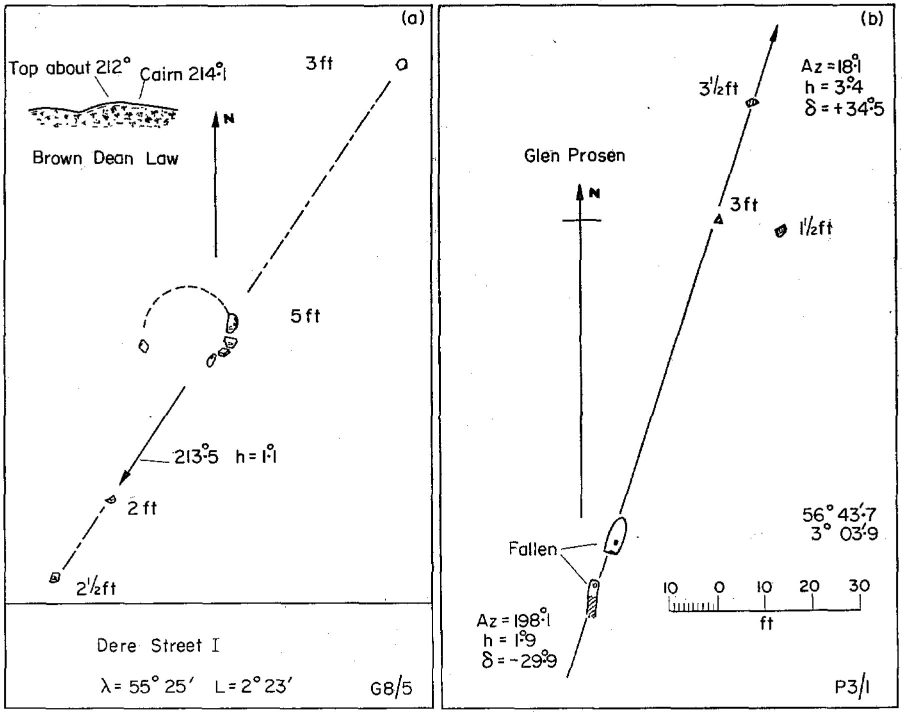


FIG. 20. Alignments.

4.2. We cannot know the actual exact declination on the morning when any particular site was aligned on the rising Sun. It will depend on the position in what we shall, for convenience, call the leap year cycle (4 years). Starting with any assumed declination near zero the declination after 182 days (Scheme A) can be found. For example, start on the line marked "spring" in Fig. 3c with declination = 0°·78 at A.

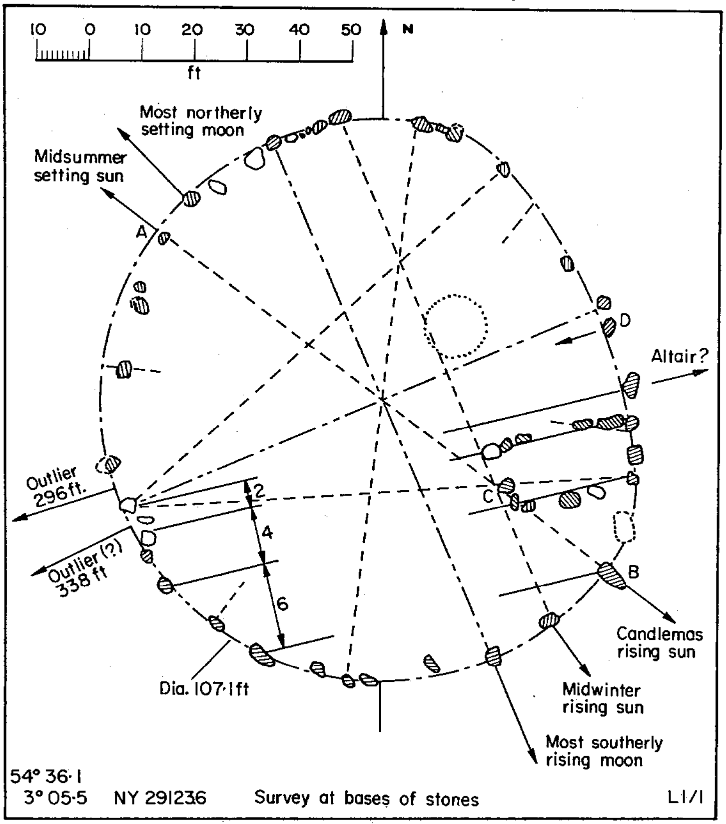


FIG. 21. Castle Rigg.

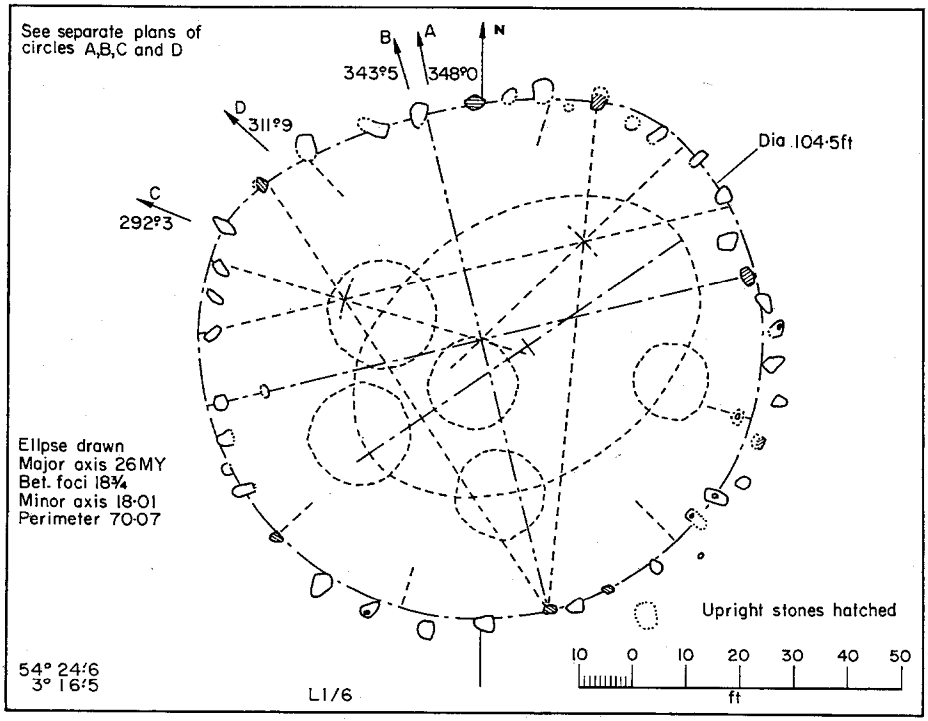


FIG. 22. Circles on Burnmoor.

TABLE 3. TWO POSSIBLE ARRANGEMENTS OF MEGALITHIC MAN'S 16 MONTH CALENDAR WITH SOLAR DECLINATIONS (δ)

Scheme A						Scheme B						
Epoch No.	Days in Month	Epoch		δ_m (morning)	δ_e (evening)	Epoch No.	Days in Month	Epoch		δ_m (morning)	δ_e (evening)	Range of Decl.
		Nominal	Exact					Nominal	Exact			
1	23	0	0	+0°61	+0°81	1	23	As Scheme	A	+0·41	+0·61	±0·18
2	23	23	22·96	9·32	9·53	2	23	,, ,,	,,	9·14	9·35	0·17
3	23	46	45·93	16·72	16·91	3	23	,, ,,	,,	16·58	16·76	0·14
4	23	69	68·91	21·91	22·03	4	23	,, ,,	,,	21·83	21·95	0·07
5	23	92	Solstice	23·91	23·91	5	23	,, ,,	,,	23·91	23·91	—
6	23	115	114·91	22·15	22·05	6	23	,, ,,	,,	22·23	22·13	0·07
7	22	138	137·93	16·89	16·70	7	22	,, ,,	,,	17·03	16·84	0·14
8	22	160	159·96	9·45	9·23	8	23	,, ,,	,,	9·63	9·41	0·18
9	22	182	182·00	+0·66	+0·45	9	22	183	183·00	+0·46	+0·25	0·18
10	23	204	204·03	−8·27	−8·45	10	22	205	205·02	−8·47	−8·65	0·18
11	23	227	227·07	−16·45	−16·55	11	23	As Scheme	A	−16·31	−16·41	0·14
12	23	250	250·09	−22·01	−22·07	12	23	,, ,,	,,	−21·93	−21·99	0·07
13	23	273	Solstice	−23·91	−23·91	13	23	,, ,,	,,	−23·91	−23·91	—
14	23	296	296·10	−21·70	−21·64	14	23	,, ,,	,,	−21·80	−21·74	0·08
15	23	319	319·08	−16·11	−16·01	15	23	,, ,,	,,	−16·25	−16·15	0·14
16	23	342	342·04	−8·28	−8·09	16	23	,, ,,	,,	−8·46	−8·27	0·18
		365	365·00	+0·52	+0·72					+0·32	+0·52	

After 182 days the declination is 0°·48, i.e. B on line marked "autumn". After a further 183 days (365 in all) the declination will not have returned to A but will be at C. So we zig-zag up and down between "spring" and "autumn" till after 3½ years we get to H. If we do not now insert an intercalary day the oscillation will become larger and larger and any mark set to show the rising Sun at the *two* equinoxes would soon be quite useless. The intercalary day will start the cycle again at A provided it is inserted in the half year following H. The value of 0°·78 above was chosen arbitrarily for illustration because it gives a symmetrical figure. But with any start inside the square we need never be further than ½ a day or 0°·2 declination from the crossing point of the lines which is at declination +0°·61 for Scheme A and 0°·41 for Scheme B. So for Scheme A we take zero time as the instant when the Sun's declination was 0°.61 and proceed to calculate the declination after 23, 46, etc., days. In making the calculation allowance was made for the fact that as the spring advances the time of sunrise becomes earlier in the morning. Thus for the next epoch we take $t = 22{\cdot}96$ days instead of 23 and so with the others. In this way columns 5 and 6 in

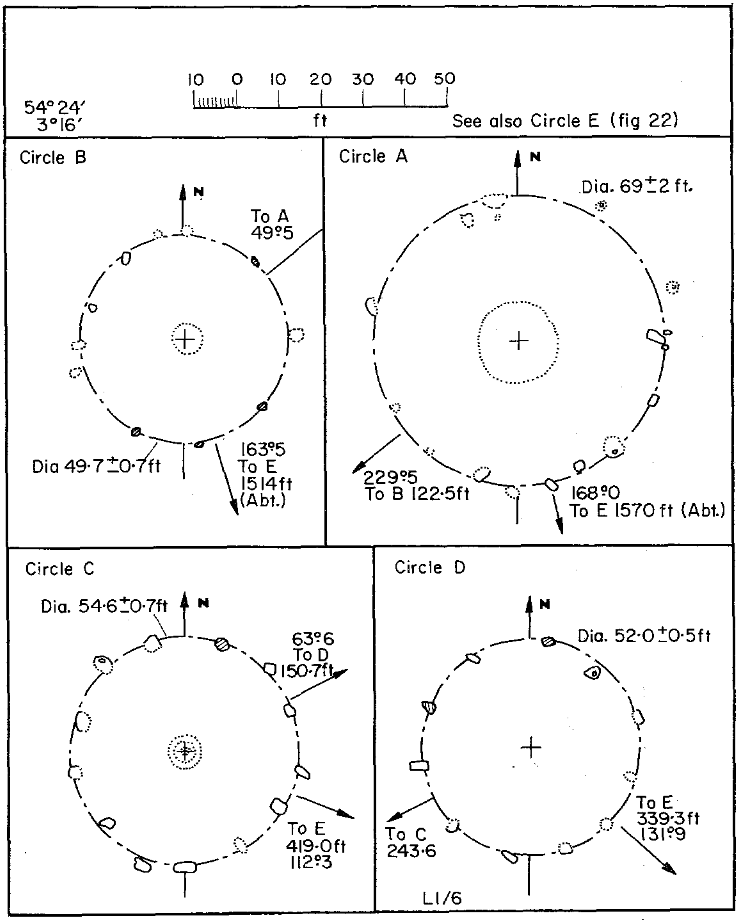


Fig. 23. Circles on Burnmoor.

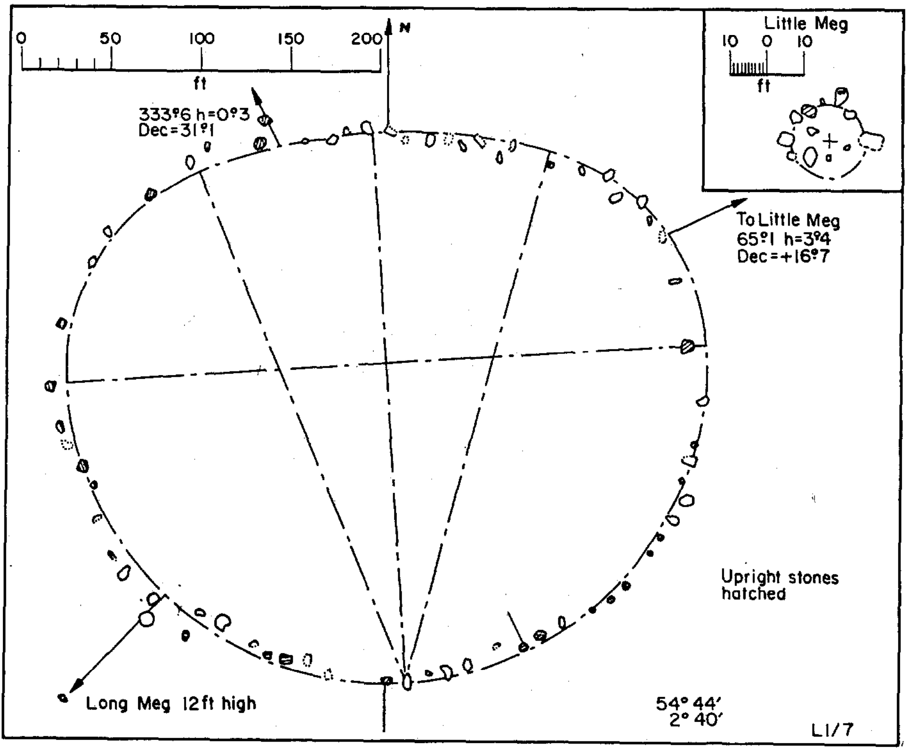


FIG. 24. Long Meg and Her Daughters.

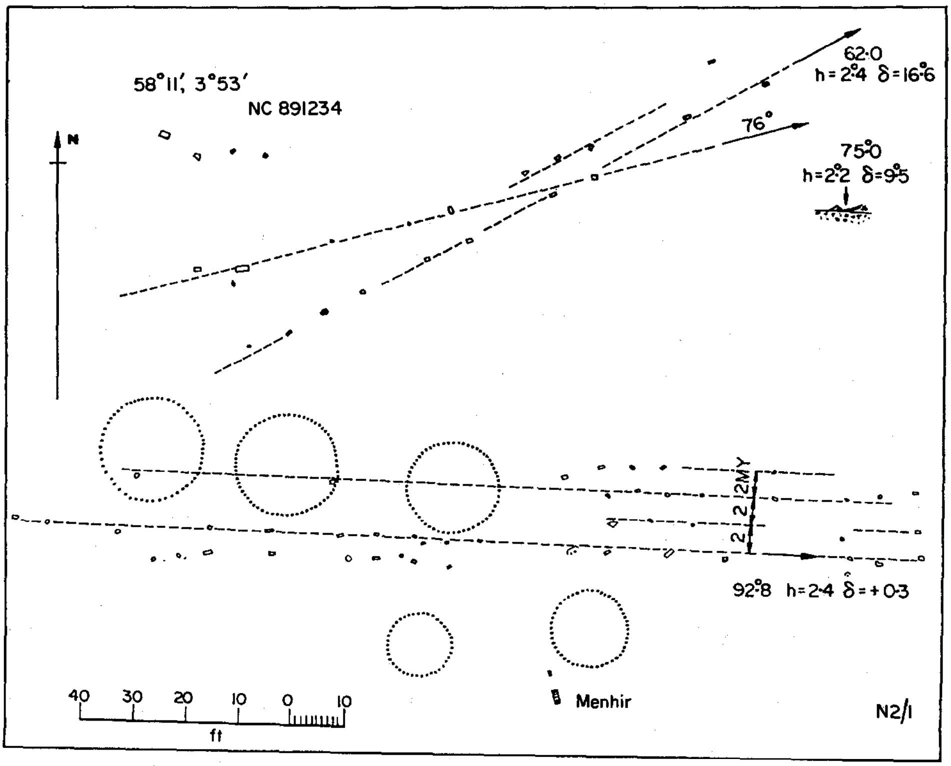


FIG. 25. Alignments on Learable Hill.

Table 3 were obtained. We saw above, however, that these values are subject to a possible spread of $\pm\frac{1}{2}$ day in the argument. The resulting spread in the declination is given (for both schemes) in the last column.

4.3. We now examine to see how successful we have been in pairing the declinations. For example, on the 1st day of the 2nd month the declination is 9°·32 and on the 1st day of the 8th month it is 9°·45 a difference of only 0°·13. It will be found that on the whole Scheme A is slightly better than Scheme B both in maximum difference and in mean difference. So we shall, perhaps arbitrarily, adopt Scheme A and proceed to compare it with the values found in the field. The calculated declinations are shown in Fig. 2 for each epoch by a black rectangle which has a length equal to the possible declination spread in the 4-year cycle. All this refers to the Sun's centre.

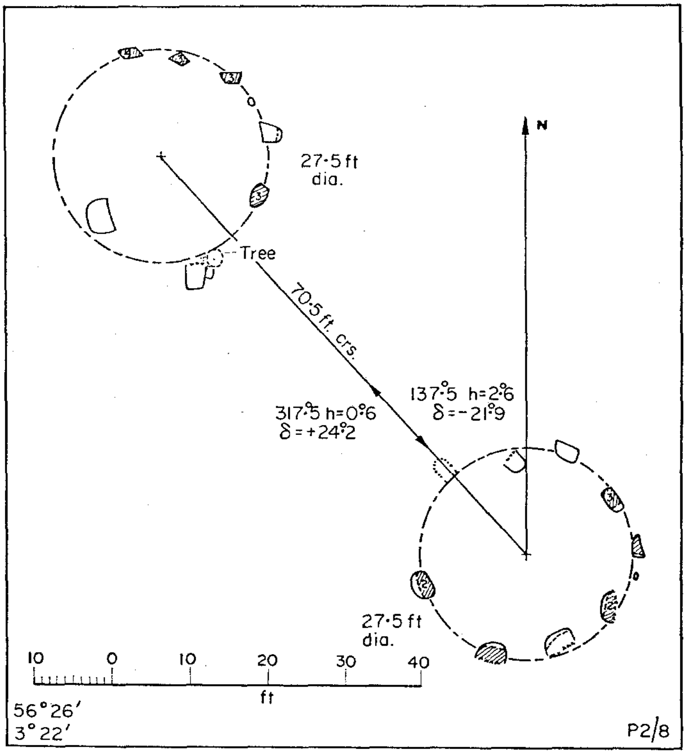


Fig. 26. Circles at Shianbank.

The limits for the upper and lower limbs are shown by the ends of the curve embracing the rectangle. The rectangles placed above the histogram refer to rising conditions and those below to setting. The epoch number of each rectangle is written near it, No. 1 being allotted to the Vernal equinox. The relative displacement of the rectangles in juxtaposition shows the amount of the failure in pairing.

The rectangles should now be considered in relation to the observed declinations. The accuracy of the azimuths and horizon altitudes on which these depend is usually of the order ±0°·1, but in some cases where the horizon depended on map work an error of $\pm 0^\circ{\cdot}25$ may be present. Until an independent check is obtained by other workers it would not be safe to say that at this or that site the erectors were badly out. What can be said is that the agreement is as good as can be expected from a mass of observations some of which were made under difficult weather conditions. It will be seen that practically all the shaded areas are inside the limits.

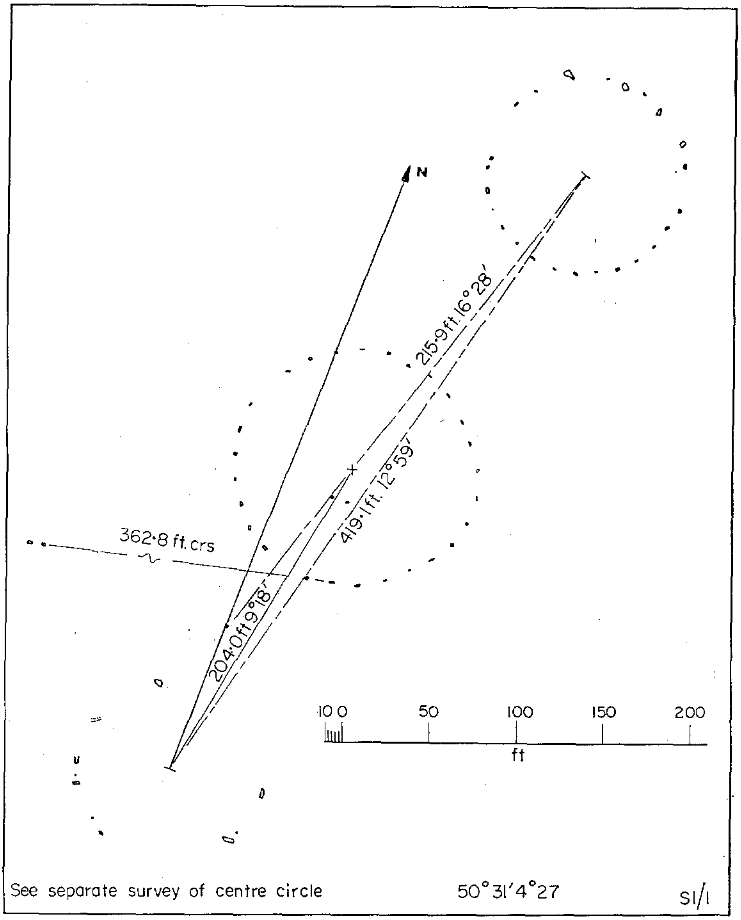


Fig. 27. The Hurlers.

4.4. The most impressive groups of calendar sites so far found is that on the west coast of the Outer Hebrides. Here Megalithic Man took advantage of the peaked islands of St. Kilda and Boreray which lie so far out in the Atlantic that, although they are 1397 and 1245 ft high respectively it is necessary to be above sea level before the tops become visible. It appears that by using these islands and some of the outlying reefs as foresights an almost complete series of calendar lines was established. The author's attention was first drawn to the importance of Boreray as a foresight by a small upright slab close to the south side of the track over Benbecula (latitude 57°27'20", longitude 7°18'46"), which might be called The Rueval Stone. It is not marked on the Ordinance Surveys but it points unequivocally to Boreray apex which is the only part of the island showing above the sea horizon (Fig. 15b).

It is seen that when the Sun's declination is $+16°37'$ the upper limb will run down the right hand fall before setting on the sea horizon. In South Uist at the large stone *An Carra* the distance to Boreray is greater (59 miles) so the backsight had to be placed higher up. It is not orientated (it probably also served another purpose) but there is little doubt, judging from its altitude and the declination, that it forms one of the series (Fig. 15a). It seems almost impossible that the large stone *Clach an't Saigairt* in North Uist can have been put there by human hands but the packing at the base has suggested to some writers that it was artificially erected. It is orientated roughly on Boreray but bad weather prevented a full check of the line (Figs. 8d and 15c). It will be seen how exactly the declinations from these three stones fit the values required for the calendar. Coming further up the coast we find in Harris a large flat stone about 15 ft high, *Clach Mhic Leoid* (Macleod's Stone). It is orientated very nearly on Boreray which, using the lower limb (Fig. 15d) gives a declination of almost exactly zero. From this stone on the autumnal equinoctial evening only once in the 4-year cycle would the Sun's lower limb graze Boreray. It would thus give a clear indication of the position in the cycle and so could control the insertion of the intercalary day. On the remaining 3 years of the cycle the Sun would set slightly to the north and this perhaps explains the fact that the stone points a little to the right.

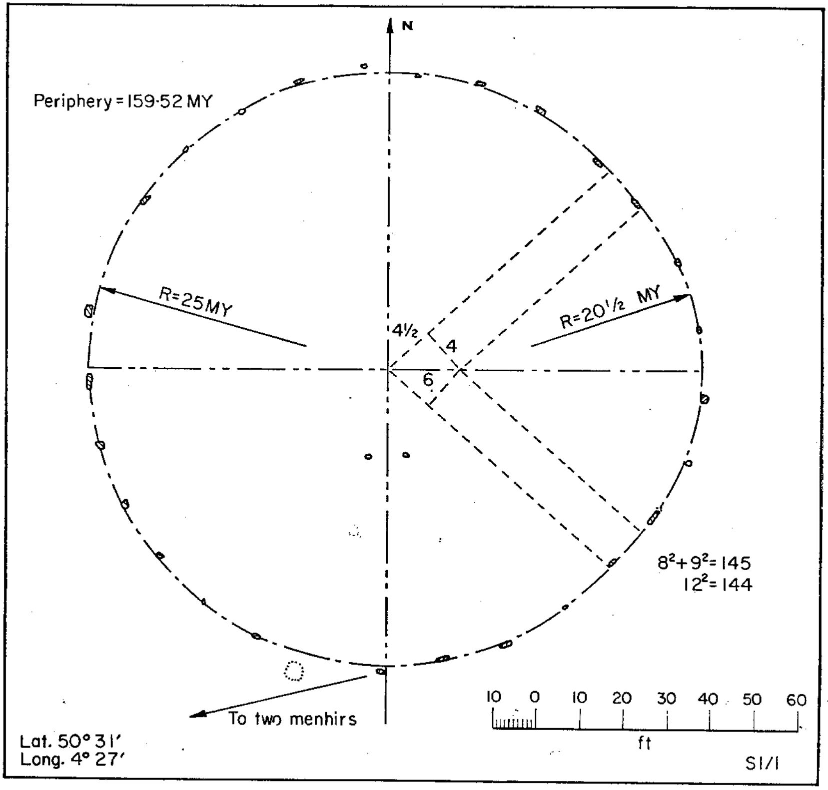


FIG. 28. The Hurlers, Middle Circle.

Figure 15e shows St. Kilda as seen from a stone high up on South Clettraval, one of the hills of North Uist. The orientation of this stone is not known, but as the declination shown lies inside the required range it is tentatively suggested as one of the series. Two other sites in North Uist may have been used. The large stone on Ben a Carra (11 ft high) is roughly orientated on the reef Deasgeir (Fig. 15f) and so gives the 10th and 16th epochs. It will also be seen how closely the high part of Haskeir Island (Fig. 15g) gives the May Day/Lammas epochs as viewed from the important site Leacach on Tigh Chloiche (H3/11).

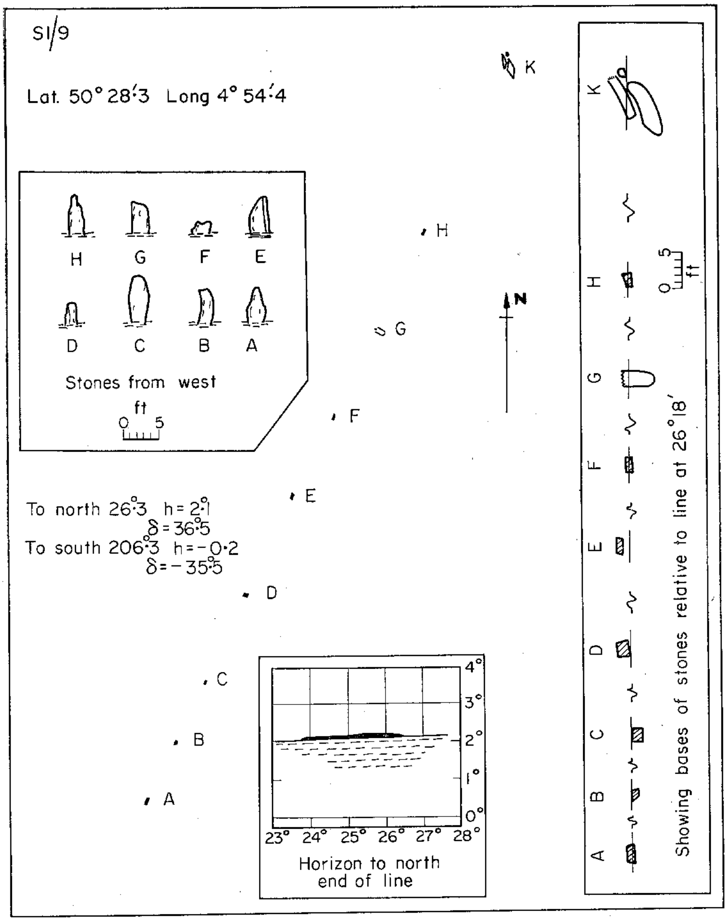


Fig. 29. Alignment, Nine Maidens.

The author has seen a photograph of a large stone beside Pollachar Inn, South Uist. The sight line has not been verified but on the O.S. it appears that from this stone the right-hand fall of Fiary Island gives a declination of −22°·1. Finally at Borvemore in Harris an upright slab is orientated on the right-hand fall of Gasker Island with a declination of +22°·3 which satisfies the 4th and 6th epochs. Thus facing out to the west we have six of the required epochs. The other three depend on

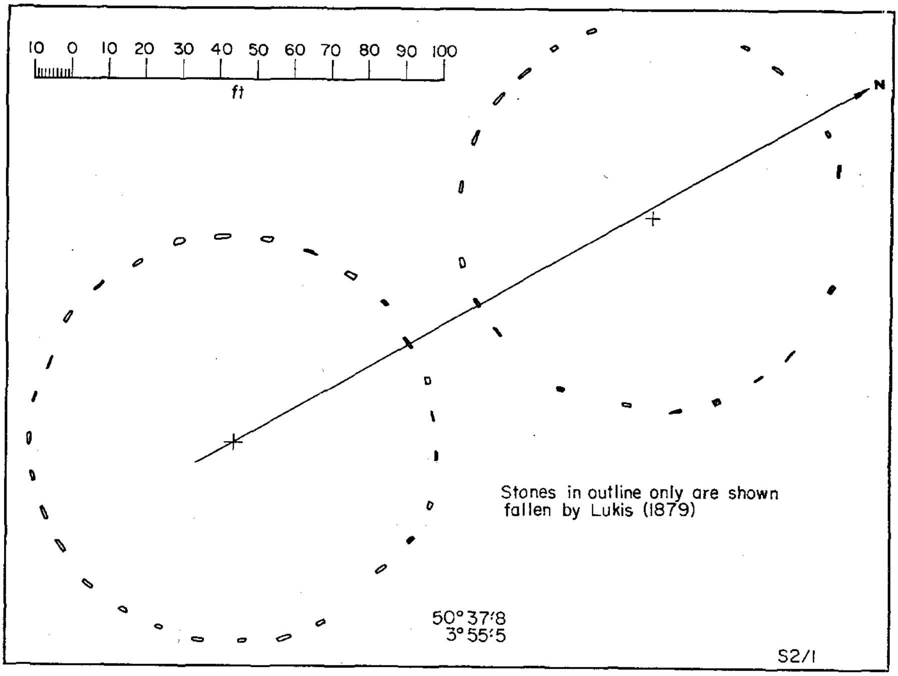


Fig. 30. Grey Wethers.

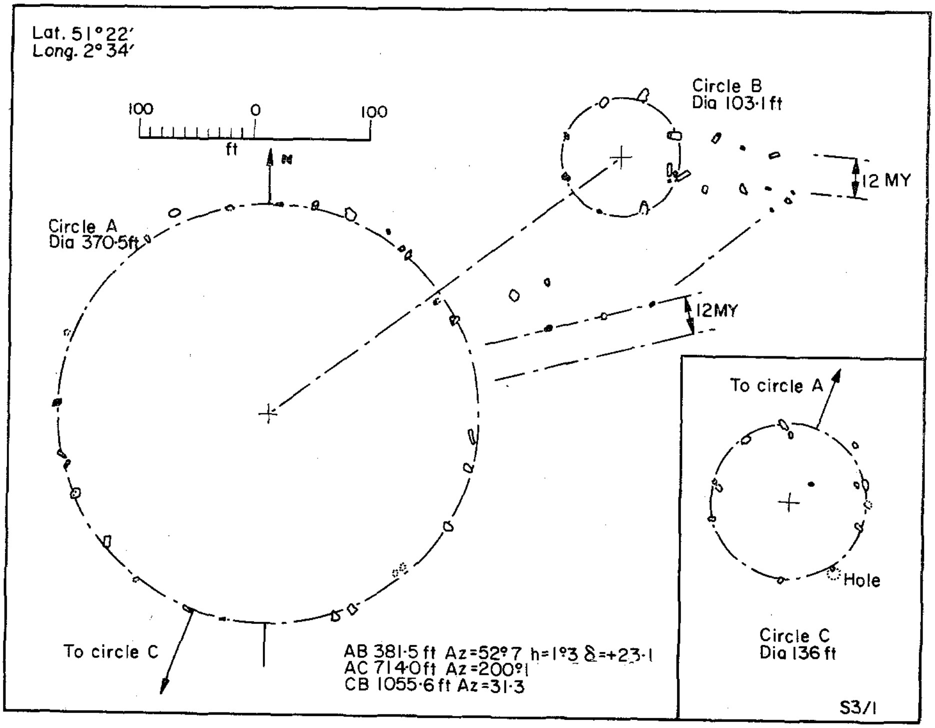


Fig. 31. Stanton Drew.

site to site lines and are given in Table 2 (H1/1, H1/5, H4/2). So in the Outer Hebrides it appears that we still have sight lines which could have been used for all the sixteen calendar dates.

4.5. A very impressive line is that given by the large stone at Mid Sannox in the Island of Arran. Standing at this stone, which is roughly orientated, the Sun with a declination of $-16°\cdot 2$ will set behind The Goatfell massif and an hour or so later will reappear briefly in the col at the head of the glen. Looking at Fig. 2 it is seen that the lower limb would be used for the 15th epoch. At the 11th epoch the upper limb might appear momentarily but perhaps only once in the 4-year cycle.

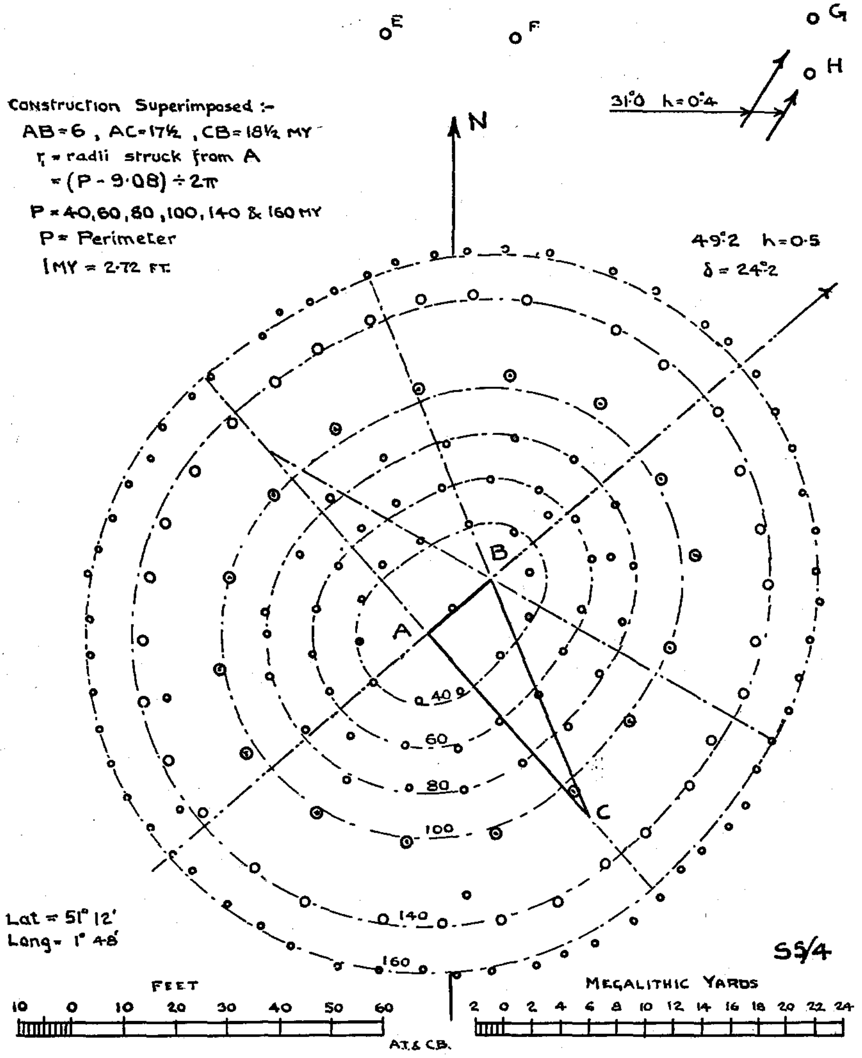


Fig. 32. Woodhenge.

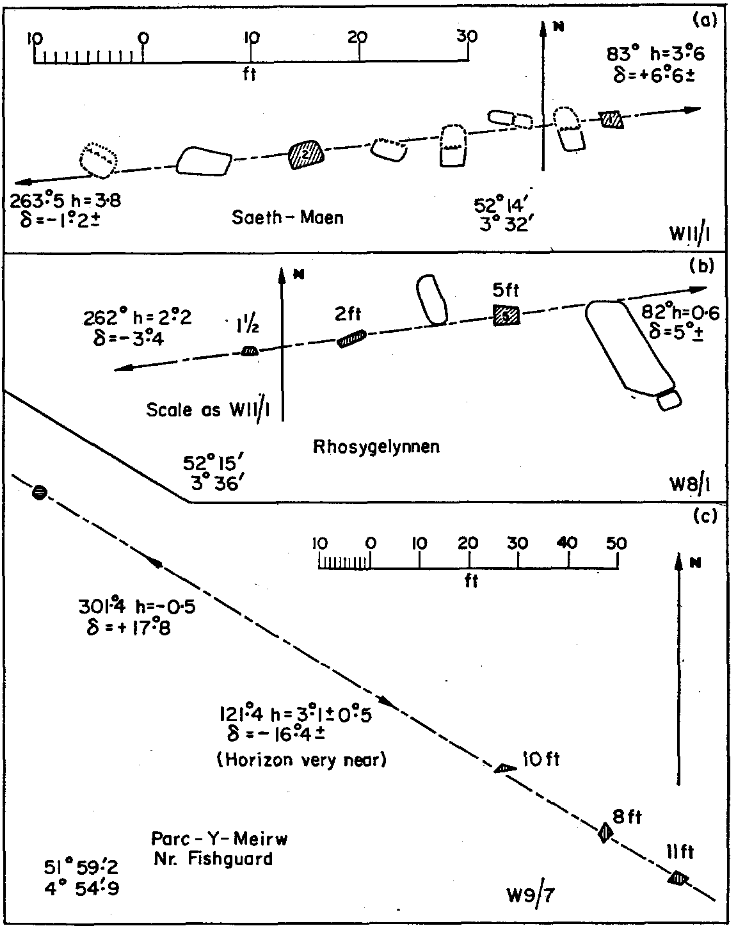


FIG. 33. Three Welsh Alignments.

The site near Watten in Caithness presents an interesting possibility. There is no alignment or other indication to catch the visitor's eye, but what does do so is the horizon to the south-west. The middle distance shows an almost level horizon, but sticking up beyond is a row of distant peaks, several sharp and well defined. If anywhere in Britain nature has provided a series of natural foresights it is here. The author was so struck by the possibilities of the position that the most impressive were measured. A sketch of the outlook is given in Fig. 35. The right-hand fall or slope of the peaks was observed together with two apices by which the azimuths could be fully checked. The results are:

Peak	Azimuth	h	Declination	Epoch	Required Mean Declination
Smean	217°–25′	43′	−24°·32	13	−24°·10 (l.l.)
Morven	222°–43′	52′	−22°·21	12	−22°·01
Small Mount	224°–45′	32′	−21°·74	14	−21°·70
Ben Griam Beg	254°–15′	23′	−8°·28	10, 16	−8°·27

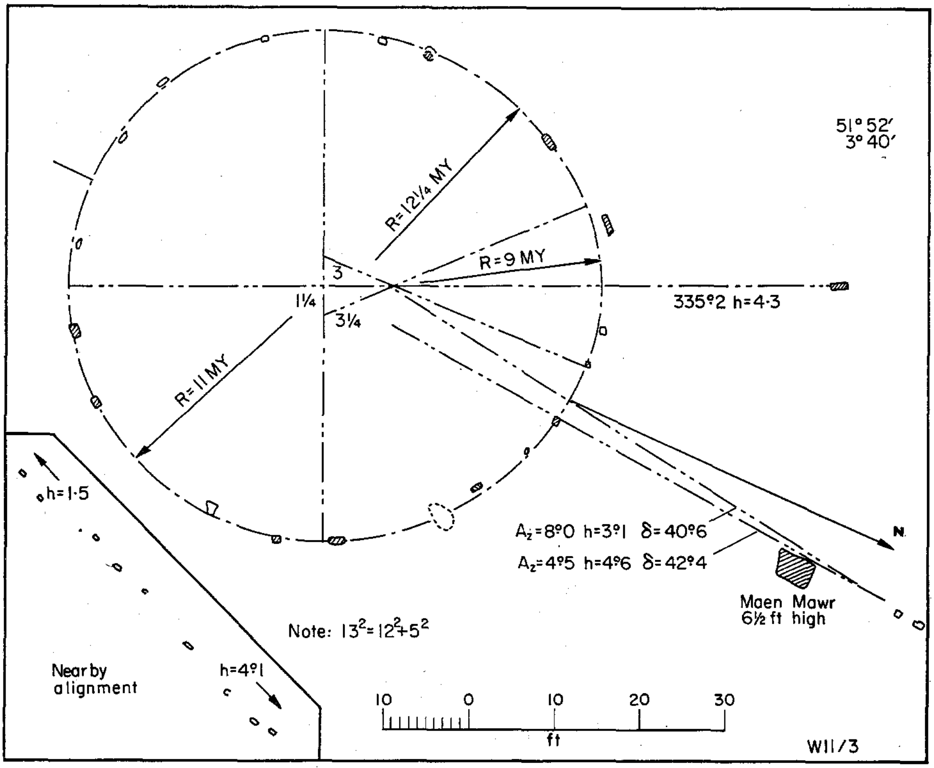


Fig. 34. Maen Mawr and Circle.

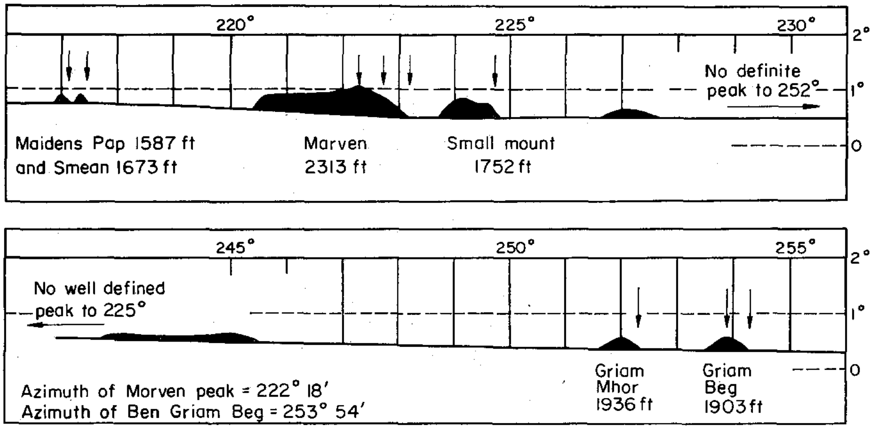


Fig. 35. Horizon to S.W. from stones near Watten. ND 223516.
Arrows indicate measured points.

It is evident that in a position like this one can move about the flattish country till a position is found from which two of the peaks will give wanted declinations. At these stones Ben Griam Beg gives the required mean declination on the 10th and 16th epochs, and Small Mount on the 14th. Morven may have been used for the 12th, but Smean gives too low an azimuth for the solstitial Sun. According to the 6 in.

O.S. there were, and perhaps still are, other two stones slightly further east, from which Smean would probably show the solstitial setting.

At the site there is one standing stone, one fallen and a large artificial hole. The fact that from here we get three calendar declinations would by itself mean little or nothing, but when we remember what we found in the Hebrides we see that it is very probable that we have here a genuine calendar site. The Watten lines are not included in the histograms.

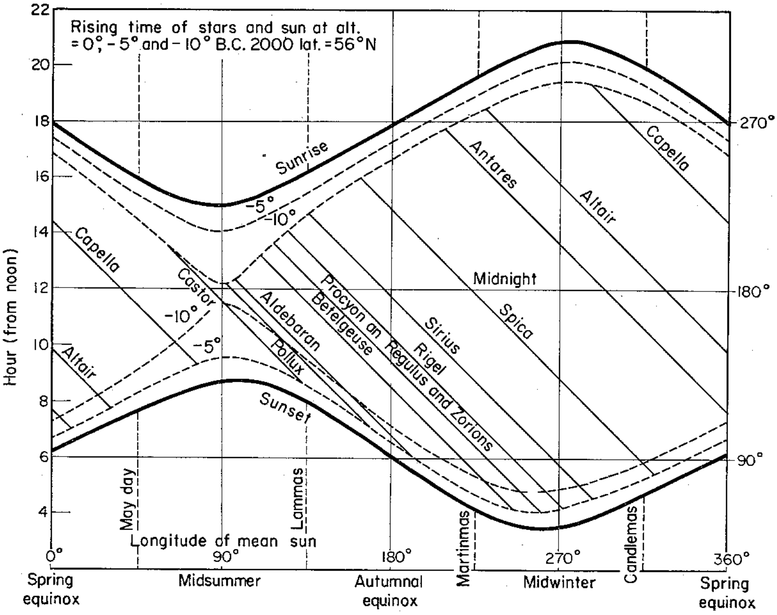


FIG. 36. Rising times of stars.

Table 2 shows that there are many other sites in Scotland supporting the proposed calendar. Among the English sites there is the very definite outlier at Castle Rigg. The fact that only a few others have so far been discovered in England is probably due to the absence of natural foresights. Reliance had to be placed on outliers and these have been removed.

4.6. The case for the 16 month calendar presented above seems clear cut and conclusive. What other explanation can be found for the concentrations of reliable lines round the declinations indicated by this hypothesis, and is it by chance that we find these declinations cropping up at so many other sites which have no orientation and so are not shown shaded on the histogram?

While we may not be able to say whether the erectors used Scheme A or Scheme B or some other closely similar scheme, we can be sure that they divided the year into 16 parts. When we think about the difficulties which they inevitably encountered we realize how much thought and experiment preceded the task of the erection of these huge stones which in many places still mark the carefully selected backsights.

But the Calendar by no means explains all the lines. In the next sections the other concentrations will be examined.

5.0. Lunar Declinations

Astronomers consider that the inclination of the Moon's orbit to the ecliptic has remained constant at 5°·15. At 1800 B.C. the obliquity of the ecliptic was 23°·91. So at the solstices the extreme values of the Full Moon's declination were:

$$\pm(23^\circ{\cdot}91 + 5^\circ{\cdot}15), \qquad \text{i.e. } \pm 29^\circ{\cdot}06$$

and

$$\pm(23^\circ{\cdot}91 - 5^\circ{\cdot}15), \qquad \text{i.e. } \pm 18^\circ{\cdot}76$$

A number of otherwise unexplained declinations near to these values will be found in Table 2. So it is necessary to consider the hypothesis that the erectors recorded these extreme values just as they recorded the extreme declination values for the Sun.

The declinations in Table 2 are not corrected for parallax which for the Moon has a mean value of about 0°·95. The easiest way to get a comparison with the observed values in the table is to apply this parallax to the above four values to get what might, for present purposes, be called the apparent declination. The parallax must first be multiplied by the appropriate values of d (decl.)/d (alt.) which are about 0°·94 and 0°·87.

This gives for the winter solstice:

$$+29^\circ{\cdot}06 - 0^\circ{\cdot}95 \times 0^\circ{\cdot}94, \qquad \text{i.e. } 28^\circ{\cdot}17$$

and

$$+18^\circ{\cdot}76 - 0^\circ{\cdot}95 \times 0^\circ{\cdot}87, \qquad \text{i.e. } 17^\circ{\cdot}94$$

Similarly for the summer solstice we find −29°·93 and −19°·58. These four values might be called the "expected values" (δ_E).

In Table 4 are given all the declinations from Table 2 which lie within 0°·8 of the above expected values, together with their deviations in the sense $(\delta - \delta_E)$. The limit of 0°·8 was taken because one of the four values (17°·94) is only separated by about 1° from the nearest calendar declination. This is shown on the May/Lammas histogram on Fig. 2 where one line might be ascribed to either group. The values of $(\delta - \delta_E)$ are shown in Fig. 3a in the usual type of histogram.

Dr. Roy drew the author's attention to the fact that the inclination of the Moon's orbit used above is a mean value which carries a main periodic term with amplitude 0°·15. So perhaps we ought to use 5°·30 instead of 5°·15 in the above calculation. But it must have been very difficult to observe this absolute maximum. Having waited for the year when the full Moon occurred at or near the equinox the erectors might just as easily strike a time when the inclination was at a minimum.

The material in Table 4 was recalculated using 5°·30 and a new histogram plotted. This is shown in Fig. 3b. If the horizon is assumed to be flat then the difference in declination produced by the Moon's semi-diameter is (semi-diam) × $d\delta/dh$ and this value is shown by arrows for upper and lower limb.

5.1. There is not much to choose between the results for the two inclinations. Perhaps, especially for the "good" lines, the figure is a little tidier with $i = 5^\circ{\cdot}15$, but the remarkable thing is that from the limited material available we get a peak for each limb for either assumption. There are only two lines (A10/6 Stillaig and H1/1 Callanish) from which we might expect precision (see Figs. 8a and 16). These are shown cross-hatched and both are better with the assumption $i = 5^\circ{\cdot}15$. That at Callanish has, however, a peculiarity which must be mentioned. Callanish ranks in importance with Stonehenge. There are at least eight sites in this neighbourhood at the head of Loch Roag. Four contain circles. Sommerville has published a good

TABLE 4. DECLINATIONS ASSOCIATED WITH THE EXTREME POSITIONS OF THE MOON AT THE SOLSTICES

Summer Lowest			Summer Highest			Winter Lowest			Winter Highest		
$\delta_E = -29^\circ\!\cdot\!95$			$\delta_E = -19^\circ\!\cdot\!58$			$\delta_E = +17^\circ\!\cdot\!94$			$\delta_E = +28^\circ\!\cdot\!17$		
Site	δ	β	Site	δ	β	Site	δ	β	Site	δ	β
A2/8	$-30^\circ\!\cdot\!3$	$-0^\circ\!\cdot\!35$	A2/8	$-20^\circ\!\cdot\!1$	$-0^\circ\!\cdot\!52$	L1/6	$+17^\circ\!\cdot\!8$	$-0^\circ\!\cdot\!14$	A/2/12	$+28^\circ\!\cdot\!2$	$+0^\circ\!\cdot\!03$
A6/4	−30·4	−0·45	A6/6	−20·0	−0·42	P1/1	+18·7	+0·76	A10/6	+27·9	−0·27
H1/1	−30·2	−0·25	B3/5	−19·8	−0·22	P1/8	+18·2	+0·26	H1/14	+28·5	+0·33
H3/6	−29·8	+0·15	B7/3	−19·5	+0·08	S1/2	+17·5	−0·44	M2/8	+28·6	+0·43
L1/1	−29·8	+0·15	G9/13	−19·7	−0·12	W9/7	+17·8	−0·14			
L6/1	−30·7	−0·75	H1/2	−18·8	+0·78						
N1/13	−29·7	+0·25	H1/15	−19·3	+0·28						
P3/1	−29·9	+0·05	H3/3	−19·5	+0·08						

δ = Observed declination, δ_E = Expected declination, $\beta = \delta - \delta_E$

survey of the main site *Tursachan Challanish* (Tursachan = sorrowful) which however seems to require correction in azimuth.* The inner part is shown in Fig. 16. The intervisibility of some of these sites provides seven of the lines in Table 2. We know that after the peat was removed from the main site many of the fallen stones were re-erected. The only clue as to which stones have not been interfered with comes from a comparison of Sommerville's survey with that of Macculloch (1819)(4). Unfortunately this last is far from accurate—he seems to have measured in links and assumed these to be feet—but he shows which stones were lying flat in his time and which were upright. It is important to obtain the azimuths of what Sommerville calls Line A West and Line A East. According to his interpretation these both give the same declination (although not parallel) when viewed towards the north. Hawkins has recently suggested that these lines are Lunar and ought to be viewed towards the south. There is no problem about Line A West. Macculloch shows eight stones upright and enough of these can be identified today. Line A East is the problem. Macculloch shows two stones standing and seven fallen. If these two are stones (4) and (8) of Sommerville's survey then presumably the lines are not parallel. On the other hand the positions of the re-erected stones show the lines to be parallel and exactly 11 MY apart. Parallel alignments are always spaced an integral number of yards apart (e.g. see Fig. 25) but unfortunately 11 MY is almost exactly 30 ft, so perhaps the re-erectors put the one line 30 ft from the other. The horizon to the south is so far away that it is possible to construct an accurate hill outline (see Fig. 16) and on this the two assumptions regarding the lines are shown. If the lines are parallel they would of course point practically to the same place marked Line A West. It will be seen that, assuming the lines are not parallel, the Moon's lower limb in the mean lowest position reappears near Line A East and resets near Line A West. The bottom of the dip in the horizon to the right of Clisham gives almost exactly the lowest possible declinations of the lower limb, and the variation in the inclination of the Moon's orbit is looked after by the slope to the dip. Whether or not this is considered to be a coincidence the circumstances are remarkable enough to demand a completely independent survey with accurate determination of azimuths and hill horizons.

5.2. Enough has been said to show that there is little doubt that lines were set up in various parts of the country to show these extreme positions of the Moon. Why this was done is another matter. To try to find the period of revolution of the line of nodes by observing the Moon on these lines would be about as useless as to try to find the length of the tropical year by observing the Sun at the solstices. A much better method would have been to use the passage of the rising full Moon at midwinter through the mark for the rising midsummer Sun. The erectors were fully equipped with solstitial solar marks so they had, as it were, the necessary instruments ready to hand. We have here at first sight a reason for these solstitial marks but why did they erect similar lines for the extreme positions of the full Moon?

6.0. The Extinction Angle

Only two stars, Sirius and Canopus, are bright enough to be seen to rise or set on a low horizon. Any star of less brilliancy must have an apparent altitude of h_E

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[*] In Ref. 12 it is stated that Sommerville's azimuths should be increased by 0°35′. This should read "decreased". The azimuth of the North/South line is correctly given as 0°·1.

(the extinction angle) before it becomes visible. Neugebauer has given values of h_E for the principal first magnitude stars as determined from early written records of heliacal risings. In the present section an attempt is made to show that values deduced from the material collected in Table 2 do not differ significantly from Neugebauer's values.

Theoretically it is possible to deduce both date and extinction angle from lines with $h < h_E$. As an experiment this was tried by assuming a linear relation between extinction angle and magnitude and obtaining a least squares solution for the mean date and the two constants defining the extinction angle. The attempt was reasonably successful in that it gave values not greatly different from Neugebauer's. It is mentioned here to rebut the possible criticism that we use the date to get h_E and then h_E to get the date. In fact the process is convergent because each star has a different rate of change of declination with time, and also of course because we can include lines with $h > h_E$. In Table 2 when h_E was required Neugebauer's values were used. It must be clearly understood that the dates in the table are not intended as final values for the sites. They were, however, used to obtain a reasonable mean date for use in calculating h_E. If they mean anything (the decision about this rests with the reader) they show that the sites in the Outer Hebrides were later than the mean date for the country as a whole. We might, in fact, take 1800 B.C. for sites north and west of the Clyde and 1850 for the remainder of the country, but in order to illustrate the effect of date on h_E the calculations were made for 1800 and 1900 for all the material.

6.1. THE ANALYSIS

Let h_E = extinction angle, i.e. the apparent altitude at lowest appearance of the star.
h_T = corresponding true altitude.
A = declination of the observed line as determined from the latitude and azimuth with $h_T = 0$.

Then, with sufficient accuracy, we can write

$$\text{Declination} = A + ah_T$$

where A and a are obtained from the spherical triangle or from previously prepared tables.

Let δ be the stars actual declination at the assumed date. Then if we are correct in associating the observed azimuth with the star

$$\delta = A + ah_T$$

from which

$$h_T = (\delta - A)/a$$

h_E immediately follows by applying the appropriate refraction.

6.2. In Table 5 the above calculation is applied to those lines with low horizon altitudes, excluding of course lines which are already accounted for by the Sun or Moon. No line is omitted which gives a value of h_E in the range $0 < h_E < 3°$. The calculation is given for two assumed mean dates namely 1800 and 1900 B.C. It is thus possible to show the kind of error resulting from the assumed date being wrong.

TABLE 5. EXTINCTION ANGLE

	Site	Az.	A	a	Star	Mag.	1900 B.C.			1800 B.C.			Horizon
							δ	$\frac{\delta - A}{a}$	h_E	δ	$\frac{\delta - A}{a}$	h_E	
Rising Stars	B1/18	116·0	−13·67	0·87	ζ Orionis	2·1	−12·24	1·64	1·95	−11·80	2·15	2·43	C
	G4/14	78·2	+6·76	0·82	Altair	0·9	+7·16	0·49	0·90	+6·98	0·27	0·27	C
	H1/1	77·5	6·58	0·87	,,	,,	,,	0·67	1·06	,,	0·46	0·88	C
	H1/12	77·9	+6·30	0·87	,,	,,	,,	0·99	1·34	,,	0·78	1·17	C
	H7/4	110·5	−10·84	0·86	Antares	1·2	−10·08	0·89	1·27	−10·61	0·27	0·70	
	M3/1	102·3	−6·74	0·83	Bellatrix	1·7	−5·55	1·43	1·75	−5·07	2·01	2·29	C
	M3/1	18·2?	31·52	0·98	Capella	0·2	+31·94	0·43	0·85	+32·47	0·97	1·34	
	P1/10	29·3	28·84	0·95	Castor	1·6	29·12	0·29	0·74	29·47	0·66	1·06	
	P1/2	13·5	32·77	0·99	Capella	0·2	31·94	−0·84	−0·22	32·47	−0·30	0·24	
	S3/1	75·5	9·00	0·78	Spica	1·2	10·02	1·31	1·65	9·53	0·68	1·08	
	S6/1	94·9	−3·01	0·77	Betelgeuse	0·8	−2·26	0·97	1·33	−1·82	1·55	1·86	C
	S5/4	31·0	32·48	0·92	Capella	0·2	31·94	−0·59	−0·01	32·47	0·01	0·50	C
	W2/1	18·6	34·56	0·98	Deneb	1·3	36·56	2·04	2·30	36·64	2·12	2·40	C
	W5/1	17·3	35·15	0·98	,,	,,	,,	1·44	1·76	,,	1·52	1·84	C
	W8/1	82·1	4·90	0·77	Procyon	0·5	6·06	1·50	1·82	6·28	1·79	2·08	
Setting	B3/3	259·2	−5·84	0·84	Bellatrix	1·7	−5·55	0·29	0·74	−5·07	0·77	1·16	
	H3/12	281·8	6·39	0·87	Procyon	0·5	6·06	−0·38	0·16	6·28	−0·13	+0·38	C
	L1/7	320·2	26·33	0·91	Pollux	1·2	26·71	0·42	0·84	27·02	0·76	1·15	
	L1/7	333·6	31·14	0·96	Capella	0·2	31·94	0·82	1·20	32·47	1·39	1·72	
	L1/10	354·0	35·36	1·00	Deneb	1·3	36·56	1·20	1·54	36·64	1·28	1·62	C
	M1/4	342±	31·64	0·98	Capella	0·2	31·94	0·31	0·75	32·47	0·85	1·23	C
	S5/3	339·2	35·64	0·96	Deneb	1·3	36·56	0·96	1·33	36·64	1·04	1·40	C
	W5/1	349·8	36·41	0·99	,,	1·3	36·56	0·15	0·62	,,	0·23	0·68	C

The spread due to this is shown by the heavy vertical lines joining the 1800 and 1900 B.C. values (Figs. 4a and 4b). In examining these figures bear in mind that some of the lines may be spurious and some of the horizons clear today may have been raised above the extinction angle by trees in the better weather of Megalithic times. Unfortunately the author did not particularly note all the horizons which might have been so affected, but *from memory* those marked with a *C* in the last column are too far off for trees to get above the extinction angle. These lines are also marked in the figures by black circles.

It seems from the figures that there is a tendency for h_E to be greater at rising than at setting. This is to be expected. The eye can follow a setting star right down to extinction but there may be a lag in picking up a rising star. The use of ζ Orionis may be criticized. Some support for its inclusion will be given later.

In Fig. 4c the data is again plotted with a mean date of 1800 B.C. allotted to sites north and west of the Clyde and 1850 to the remainder. Both rising and setting values are included. The dotted line in all three figures shows Neugebauer's values. The scanty data available perhaps does not allow a very definite opinion to be formed but it looks very much as if we are here looking at a real effect. The future will certainly bring to light many more sites here and in Ireland. When these have been properly surveyed it ought to be possible to make a thorough statistical examination to decide if we are really obtaining values of the extinction angle.

7.0. Possible Uses of Star Risings and Settings

Today with Polaris forming a centre it is comparatively easy to use the northern sky as a clock face. With no Pole Star this would be more difficult. Apart from this, in prehistoric times a rotation would not be so readily associated with time. The only alternative methods of finding the time at night would be by observing upper or lower transits or by watching for stars as they pass through the horizon.

The fact that we do not find pointers for Sirius need not surprise us. Sirius is so well indicated by Orion's belt at either rising or setting that no terrestrial pointers would be necessary. Deneb, on the other hand, needed pointers, but why was Deneb used at all? The answer may be that at midwinter Deneb's lower transit was just after midnight. It would transit just above or just below the horizon, depending on the latitude and horizon altitude. So either its rising, setting or transit was available throughout almost the whole of the winter half of the year.

The approximate rising and setting times of the stars in which we are interested are given in Figs. 36 and 37 for a level horizon. They are shown in relation to the hours of darkness. We ought to look at these figures along with the main histogram in Fig. 1. We see that Capella is more widely used than any other star. Capella having a high declination was only below the horizon for 2 or 3 hr. Its usefulness at setting is seen to begin in the late autumn and then at either setting or rising it was available until just before midsummer. Procyon set about the same time as Capella so its setting would not be required. This may be the reason why we find no indicators for Procyon setting. The autumn is well looked after with rising stars. Note that Regulus needed no special pointers. It had the same declination as the Sun at midsummer. Pollux rising would be almost useless and we find no pointers, but notice particularly that Castor, though perhaps less bright, had an important part to play. It was the only star approaching first magnitude which was available in

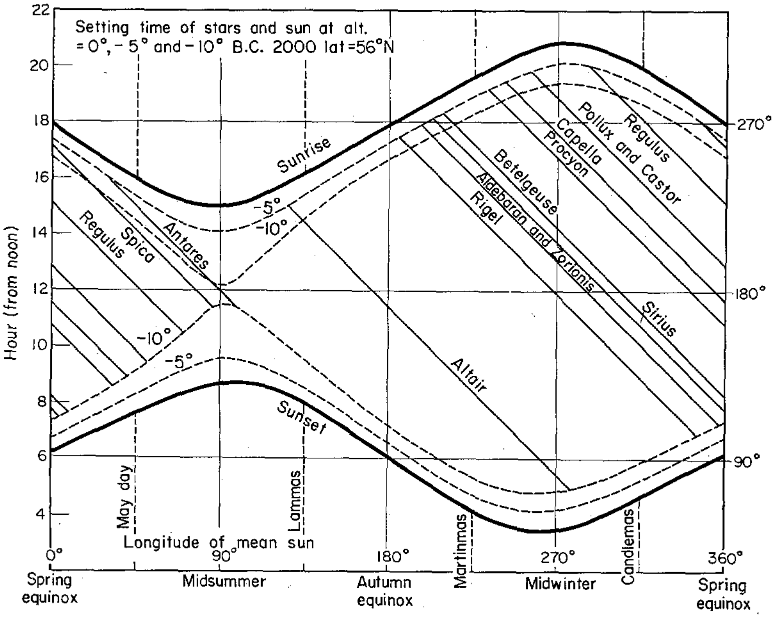

FIG. 37. Setting times of stars.

certain situations at midsummer. Antares might or might not be available; extinction angle or an elevated horizon would delay rising times and accelerate setting, but Spica at setting had a chance of being seen at midnight. It carries a few pointers for both rising and setting. Its rising time filled a gap in the autumn.

Apart from any ritualistic use the most important time for a clock to be working is in the early mornings at midwinter. We see that then there was a very complete sequence:

Sirius setting	2 a.m.
Altair rising	4 a.m.
Capella setting	$5\frac{1}{2}$ a.m.
Pollux setting	7 a.m.
Dawn	7–8 a.m.

Except Sirius we have the other three indicated at one site or another. The sequence of course got earlier by 4 min every day but soon would be joined by Regulus setting and Capella rising.

8.0. CUP AND RING MARKINGS

Cup and ring markings are usually found in association with standing stones. If the latter have an astronomical meaning what about the former? Other writers have claimed, perhaps with some success, that these marks may represent the constellations (see Ref. 1).

To discover the meaning of cup and ring marks we must try to imagine possible uses. We might suppose that a marked stone near a circle acted as an outlier and showed the rising or setting of stars indicated by the marks. So all outliers and nearby stones must be reexamined for marks as well as the stones of the ring itself. There is a large cup and ring marked stone lying just to the south-west of the circle at Monzie (P1/13). This can hardly be thought of as a fallen outlier partly because of its size and shape and partly because if it ever were upright then the cup and ring marks at one end or the other would have been buried. Against this Ritchie (7) has pointed out places where the cup and ring marking is hidden. Assuming that it is in its original position it may be noted that the azimuth of the setting of Orion's belt passes through amongst the marks.

Some confirmation comes from the setting time. In the last section it was pointed out that the important stars are those which give the longest run of usefulness. From the circle at Monzie, Orion's belt set within a few minutes of midnight at the winter solstice, and so the setting could have been seen for nearly 6 months in the year which is about the longest possible run.

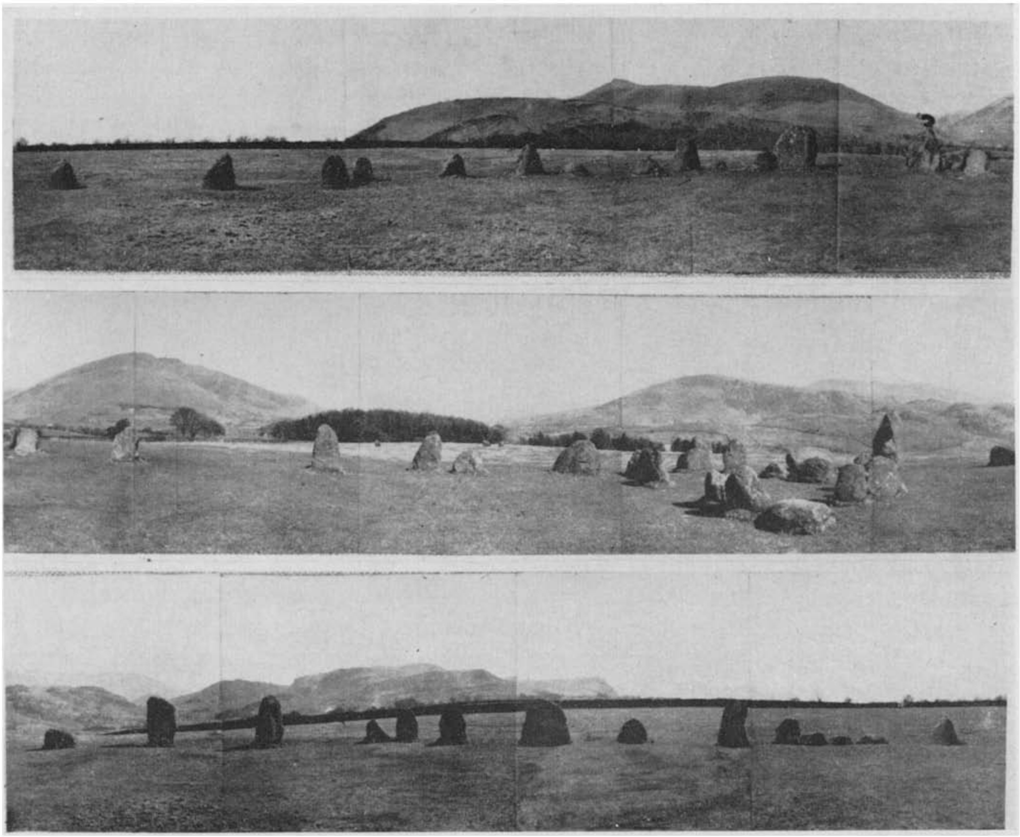

Fig. 38. Castle Rigg as seen from centre.

It is to be hoped that now we know what to look for other sites will turn up with similar pointers, but at present we can only regard the idea as an interesting possibility.

9.0. In looking over Table 2 it will now be seen that there are only a few lines which do not fit one or other of the three explanations—Solar, Lunar or Stellar. We need only consider lines with a value 2. Taking them in order of importance we have the long alignment M1/5 Dervaig B. The horizon altitudes were at this site measured with the theodolite in the middle of the line. From the higher ground at the south end of the line the altitude would certainly be less and the line might fall into the lunar group. The horizon to the south is (from memory) fairly near and would therefore decrease viewed from the north end. So this direction may also be lunar. The two Welsh alignments in Fig. 33 are also unsatisfactory but these are short and the direction is quite uncertain, depending in both cases on small stones. We are thus left with only one completely unexplained line. That is W9/7 (St. Nicholas). Here we have a very poor circle. The direction given really depends on the line of the two outliers. Of the poorer lines the "avenue" at Stanton Drew is entirely conjectural. The Dartmoor avenues have been entirely excluded. These seem (like the recumbent-stone circles of Aberdeenshire) to form a class by themselves and possibly have an entirely different meaning.

The possibility was mentioned earlier that the erectors sometimes chose positions so that sight lines could be used in both directions. In this connection Callanish is particularly interesting in that the avenue seems to serve a dual purpose. Other sites in Table 2 which have this property are: Ballochroy (A4/4), Kell Burn (G9/13), Shianbank (P2/8) and Ballimore (A10/3). Perhaps three other sites might be included namely, Stravanan Bay (A9/7), Devil's Arrows (L6/1), and Dervaig B (M1/5).

Many more of the lines may be found to operate in reverse when the horizon altitudes are measured. In future the possibility ought to be kept in mind not only in connexion with alignments but for the sight lines to as well as from the main circle.

CONCLUSION

This is not a rigid statistical analysis of the Standing Stone sites in Britain. It is an attempt to bring together those features of the sites visited which appear to have some astronomical relevance.

The author's conviction regarding the Calendar hypothesis put forward stems from the fact that over the years certain groups of reliable lines appeared so definitely that in the absence of any explanation the whole position was unsatisfactory. There are still some unexplained features but the number has been so much reduced by the explanations suggested that these explanations must be taken seriously.

As our knowledge grows so will our ability to form mean dates for large districts. It seems that there may be a possibility of giving an accurate date for one or two special sites.

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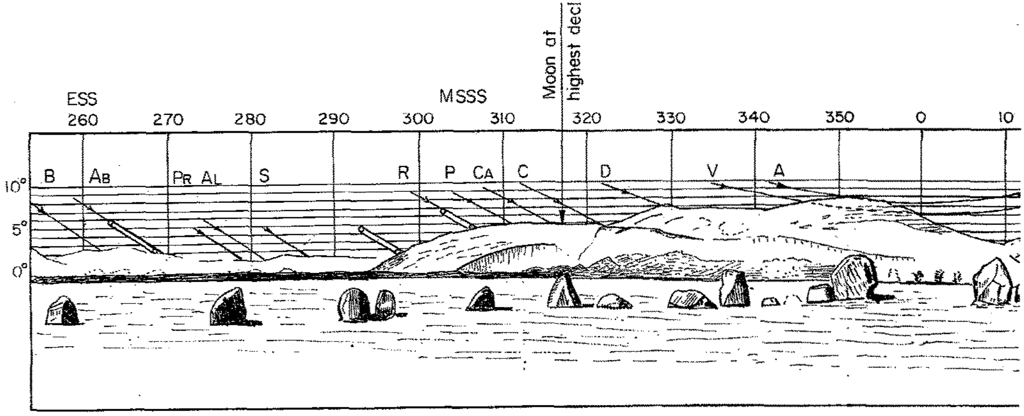

ESS
MSSS
Moon at highest decl.
260
270
280
290
300
310
320
330
340
350
0
10
10°
5°
0°
B
AB
PR
AL
S
R
P
CA
C
D
V
A

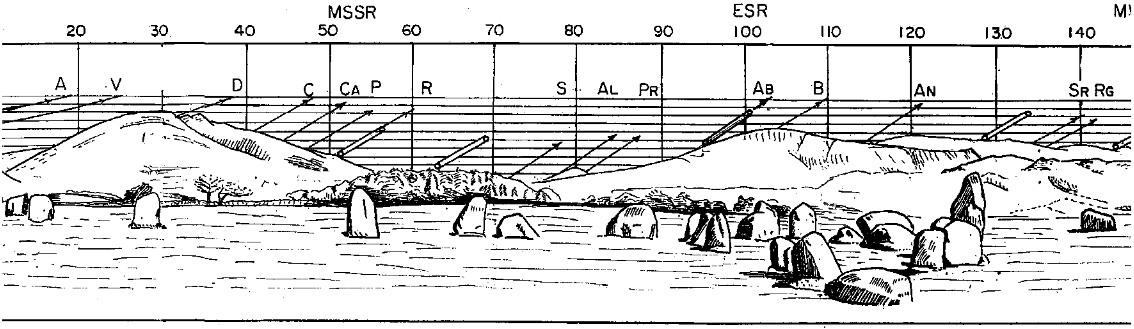


FIG. 39. The stones and horizon at Castle Rigg as seen from the centre of the circle.

A = Arctunus
V = Vega
D = Deneb
C = Capella
CA = Castor

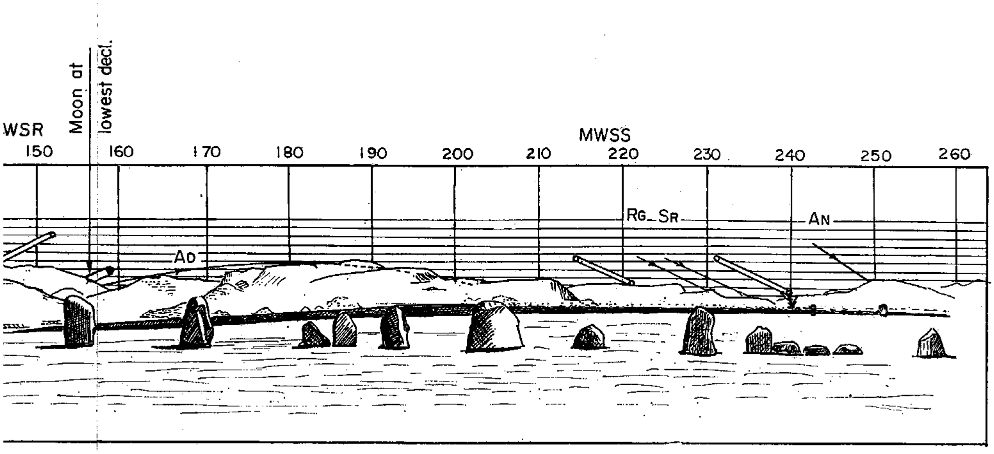
P = Pollux
R = Regulus
S = Spica
AL = Altair
PR = Procyon
AB = Aldebaran

B = Betelgeuse
AN = Antares
SR = Sirius
RG = Rigel
AD = Adhara

ESS = Equinoctial Sun setting
MSSS = Midsummer setting Sun
MSRS = Midsummer rising Sun
ESR = Equinoctial Sun rising
MWSR = Midwinter Sun rising
MWSS = Midwinter Sun setting

Compare with Fig. 21 and note:

(1) The outlier at 251° showing the first of the tenth and sixteenth months.
(2) The largest stone in the ring at 127° showing the dual purpose line AB.
(3) The large stone at 157° showing the cross axis and the farthest south rising of the moon.
(4) The large stone at 204° showing the farthest south setting of the moon.
(5) The stone at 317° showing the furthest north rising of the moon.
(6) The line across the ring from the stone about 277° to the three stones in the "cell" at 97° showing the equinoctial sunrise. These stones also mark two of the 30° divisions of the circle.
(7) The line from the fallen stone at 322° to the small stone at 141° showing the midwinter rising Sun.


WSR
Moon at
lowest decl.
MWSS
150
160
170
180
190
200
210
220
230
240
250
260
AD
RG_SR
AN

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