The Larger Units of Length of Megalithic Man

By A. THOM

Emeritus Fellow, Brasenose College, Oxford

IN a previous paper (Thom, 1962) I discussed the megalithic unit of length and showed that there is an overwhelming probability that such a unit existed and that its value was 2·72 ft (the Megalithic Yard) or a multiple or sub-multiple thereof. I specifically excluded from the data the stone rows of Caithness for the reason that these need a different type of analysis. It is the object of this paper to examine the longer distances set out by megalithic man and to look at the units used in the Caithness rows.

A number of sites have two, three or more circles and careful surveys give the distances between these circles with, in most cases, an accuracy of the same order as that obtained for the diameters. Table 1 gives particulars of all the multiple circles I

TABLE 1

Distances (L) between circles expressed in units of 2·72 ft

Site		*L* (MY)	*Site*		*L* (MY)
S1/1	Hurlers	75·0	W11/2	Trecastle	53·0
		79·4	W11/4	Usk River	134·5
		154·1	P1/14	Tullybeagles	19·9
S2/1	Grey Wethers	47·2	P2/8	Shianbank	25·9
L1/4	Burnmoor	45·0	B7/1	Clava	69·6
		55·4			85·6
		124·7			152·0
		154·0	B4/1	Carnoussie House	60·0
		560·1	B3/3	Raedykes	116·0
		490·7	B1/26	Loanhead, Daviot	24·0
		476·0	B1/27	Sands of Forvie	48·8 ±
		455·5			52·9
		465·7			89·3 ±
		555·6	G7/4	Loupin Stanes	24·1
S3/1	Stanton Drew	140·3	N2/3	Lairg	44·0
		262·5			
		388·1			

The location of most of the above sites will be found in previous papers. The distances actually measured were the distances between theodolite stations. These were then reduced to the distances between the centres as found by the methods described in an earlier paper.

have surveyed. There are five circles on Burnmoor in Cumberland and so ten distances. It is evident that all ten distances can hardly be multiples of the unit. The same remark applies to the four sites with three circles if the orientation of the lines depended on other considerations. So some consideration should be given to this restriction in examining the results of the analysis. The distances are given in terms of the megalithic yard. We are, I think, entitled to look for multiples of the yard and it becomes apparent that many of the distances have been set out in 5-yard intervals.

The data do not preclude the use of $2\frac{1}{2}$ yards, an idea which receives some further support from the peripheries of ellipses and eggs. However, our immediate object is to examine the 5-yard unit.

Broadbent has given methods for examining a set of measurements where a quantum is suspected to exist. In his first paper (Broadbent, 1955) he discusses the case where there is an *a priori* expectation that a common measure exists, and in his second he gives a tentative criterion for the rejection of a quantum hypothesis when the quantum comes from an examination of the data themselves.

Let the lengths be specified by y and let the successive assumed modes be designated r_0, r_1, r_2, etc. where r is the number of the mode from the assumed origin. Let N be the total number of measurements. We assume that any observation is given by

$$y = \beta + 2r\delta + \varepsilon$$

where the quantum is 2δ and the residual is ε.

In the present case $\beta = 0$ and with $2\delta = 5$ we obtain ε for each length and so s^2 from

$$s^2 = (1/N)\Sigma\varepsilon^2$$

s found to be 1·31.

Broadbent's criterion for accepting a quantum is

$$\sqrt{(N)}\left(\frac{1}{3} - \frac{s^2}{\delta^2}\right) > 1.$$

This is not satisfied (at 0·7), but in view of the difficulties mentioned above and the fact that we have, in a sense, an *a priori* reason for looking for a quantum of 5 MY this is hardly a reason for discarding the hypothesis. Rather let us look at the probability level with an *a priori* hypothesis. With $s^2/\delta^2 = 0{\cdot}21$ we enter Table 3 of Broadbent's first paper and find a probability level of 0·01. Thus it would seem that megalithic man did intentionally use multiples of 5 MY in setting out longer distances.

The Caithness Stone Rows

In Thom (1961a) I have given a brief description of the site at Mid Clyth (Fig. 1). A semi-graphical method showed that the lines in the main sector, which may be called lines of "longitude", radiate from a centre on the north/south line of symmetry 356 ± 3 ft from the base of the figure at A. In view of what has gone before this has been assumed to be 130 MY. Drawing in lines of "latitude" shows that these are best spaced at about 7·73 ft which seems to be also the spacing of the lines of longitude along the base.

There are not enough reliable lines of longitude to make it worth while to deal statistically with the spacing in longitude, but there seems to be enough material in the spacing in latitude to make out a case for a quantum. It is proposed to confine this examination to the main sector and to exclude the annex to the west. The annex which, judging by some remaining stones, existed to the east is destroyed. Further, it is arbitrarily proposed to exclude the stones along the top and bottom borders—a decision taken before the analysis started.

In the figure, which was originally to a scale of 1/120, an attempt was made graphically to make $\beta = 0$ and 2δ has been assumed to be 7·73 ft. The immediate objects are two: (i) to find if in fact a quantum exists, and (ii) to find the value of the quantum which best fits the measurements.

The survey was made with a full gale blowing and this made handling of the measuring tape difficult. As a result the tape stretch increased from about 0·45 per cent to over 0·6 per cent during the survey, but correction for this can be made at the end. Values of ε were found from the data given in Table 2. s^2 was then found from

$$s^2 = (1/N)\Sigma\varepsilon^2$$

to be 2·68 ft and so $s^2/\delta^2 = 0{\cdot}179$.

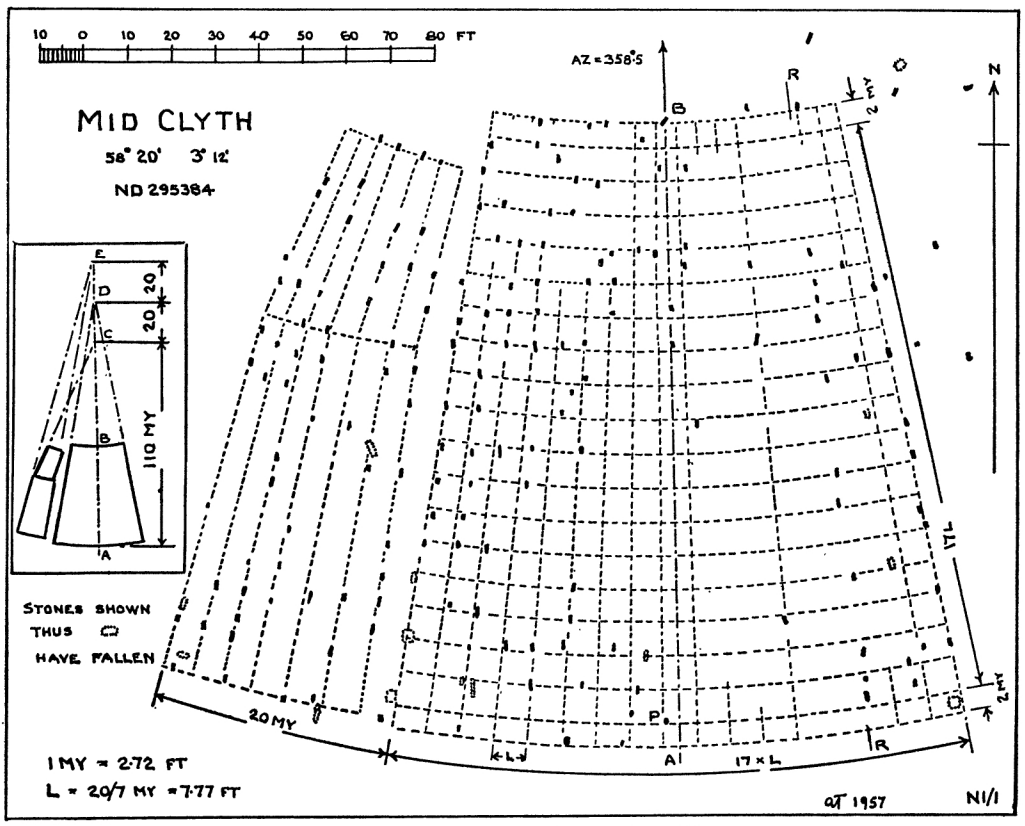

FIG. 1. Stone Rows near Mid Clyth, Caithness.

This is completely outside the range of Broadbent's Table 3 (Broadbent, 1955) which only extends to a probability level of 0·001, but a graphical extrapolation (by logs) shows a value of about 10^{-5}. Since the value of 7·73 ft comes from the data being used we ought to use Broadbent's second paper. We find

$$\sqrt{(N)}\left(\frac{1}{3}-\frac{s^2}{\delta^2}\right) = 1{\cdot}62.$$

Broadbent suggests acceptance if this is greater than unity. Thus there is no doubt about the existence of the quantum.

We now use Broadbent's formula to determine the best values of β and 2δ. Call these b and $2d$. I have shown previously (Thom, 1962) that there is no deterioration

in the precision of measurement with increasing circle diameter. Assuming that stone rows were set out in the same way, the formulae appropriate to a constant σ for all values of r will be used.

These are

$$b = (\Sigma r^2 \Sigma y - \Sigma r \Sigma ry)/\Delta,$$

$$2d = (N\Sigma ry - \Sigma r \Sigma y)/\Delta,$$

where $$\Delta = N\Sigma r^2 - (\Sigma r)^2$$

and the summations extend over all values.

TABLE 2

Mid Clyth. Scaled position of stones in "latitude" from P (Fig. 1). r is the mode to which the stone has been assigned

r	y ft	r	y ft	r	y ft	r	y ft	r	y ft	r	y ft
0	0·5	2	14·8	6	44·2	9	67·8	12	89·0	14	105·0
	1·2		14·8		44·4		68·6		91·2		107·2
	1·9		15·8		46·6		69·5		92·1		107·2
	2·1		15·9				69·6		93·0		108·1
	2·8		16·1	7	51·9		70·2		93·0		108·6
			17·0		52·1				93·1		108·7
1	6·0		17·1		53·1	10	74·6		93·8		108·7
	6·7				53·4		74·9		94·4		108·8
	7·0	3	21·0		54·5		76·0		96·6		
	7·2		23·1				77·4			15	115·2
	7·4		23·1	8	59·0		78·2	13	98·0		116·0
	7·9		23·1		59·8		78·2		98·0		116·2
	8·2		24·1		60·0		78·4		99·6		116·8
	10·4				60·8				99·6		
	10·4	4	29·1		61·5	11	83·5		100·6	16	122·8
	11·5		29·4		61·6		84·8		101·0		123·6
			30·5		62·0		84·9		102·6		123·8
			30·8		65·6		85·6		103·5		126·3
							85·8		104·0		126·6
		5	37·6				86·6				
			37·8				86·6			17	128·1
			37·9				86·6				130·0
			42·4								130·9
											133·0

Substituting the values from Table 1 in these formulae yields

$\Sigma y = 7265{\cdot}6$, $\Sigma ry = 84214{\cdot}8$, $\Sigma r = 940$, $\Sigma r^2 = 10906$, $N = 110$.

From these

$$2d = 7{\cdot}701 \text{ ft}, \qquad b = 0{\cdot}24 \text{ ft}.$$

To allow for the tape stretch already mentioned multiply by 1·0055 so that finally it appears that a quantum of 7·743 ft was used. Knowing how particular megalithic man was about using integral values, it seems possible that at Mid Clyth he divided

20 MY into seven parts obtaining 7·77 ft. This hypothesis seems preferable to the assumption that at Mid Clyth he was using an entirely independent unit.

THE WATTENAN SITE (Fig. 2)

This site is more ruinous than that at Mid Clyth and at first glance it did not seem that anything could be obtained from it, but by analogy with Mid Clyth a system of

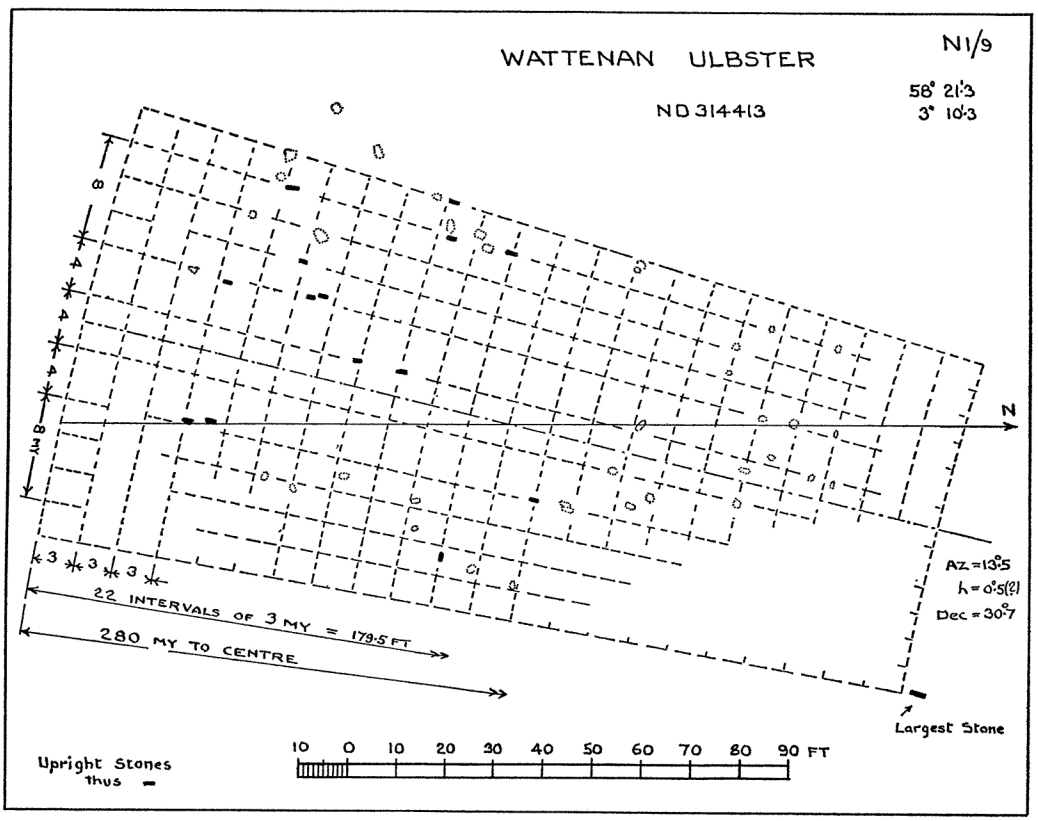

FIG. 2. Stone Rows on Hilltop near Ulbster, Caithness.

radiating lines was fitted. At the site during the survey it seemed likely that the south end had perished so I did not hesitate to extend the grid a short distance when the spacing became multiples of the megalithic yard. It then appeared that the distance to the centre might again be a multiple of 10 MY. Lines of "latitude" were drawn in, spaced 3 MY, and it seemed that there might possibly be a quantum of this amount. Thus, as at Mid Clyth, the argument is based on latitude only. The reader must judge for himself how much extra support is to be derived from longitude.

Treating the material as for Mid Clyth and taking all the 49 stones inside the sector (many of which have fallen), we find

$$2d = 8{\cdot}06 \pm 0{\cdot}05 \text{ ft}, \qquad b = +0{\cdot}03 \text{ ft}.$$

Retaining a quantum of 3 MY (8·16 ft) and retaining all 49 stones the residuals were found and so $s^2/d^2 = 0{\cdot}197$. For this value Table 3 (Broadbent, 1955) shows a probability value of 0·001. Assuming that there is no justification for an *a priori* quantum of 3 MY, we find

$$\sqrt{(N)}\left(\frac{1}{3}-\frac{s^2}{d^2}\right) = 0{\cdot}96.$$

This falls on the upper edge of the band in Fig. 6 (Broadbent, 1956) and so presumably allows acceptance at about the 1 per cent level. The tape stretch was small so no further correction is necessary. In view of the ruinous condition of the site it is considered that 8·06 ft is as near 3 MY as we can expect.

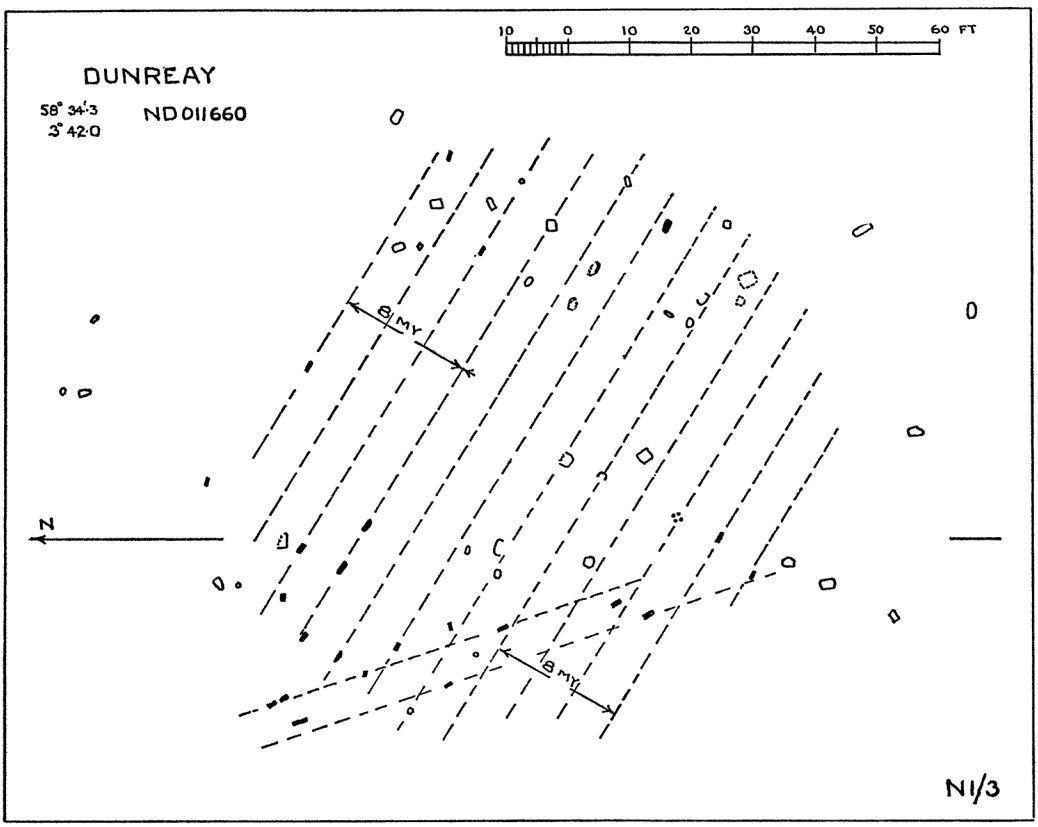

FIG. 3. Stone Rows in hollow near Dunreay, Caithness.

In Fig. 2 I have shown a set of longitude lines spaced at the assumed base in multiples of the yard, and it is seen that I suggest a spacing of 8/3 at the side panels. I have been asked if there is ever any sign of the yard being divided into 3 "feet". This is the first indication I found of such a sub-division and it will be admitted that it is not, in itself, convincing, but looking at the next site, Dunreay (Fig. 3), it appears possible that parallel lines spaced 8 "feet" apart were used. The position is complicated since it seems likely that a secondary set of lines crossed the western edge of

the figure. To attempt an analysis with the data in Fig. 3 would be futile, but the ground at the site is of such a nature that excavation would almost certainly reveal more stones. This is probably true of other sites, for example that near The Grey Cairns of Camster (ND 261439) where my survey shows so little that I do not include it. It is doubtful, however, if much more will be found at Mid Clyth or Wattenan. But these sites ought to be re-surveyed in a really precise manner. In view of the values I have been getting from megalithic sites, I am convinced that the accuracy of the builders' standard of length was such that surveys made with a fabric tape are not sufficient. A metal band and high-class surveying technique should be used even if the conditions of the site do not seem to warrant it. The position of the individual stones may have changed due to ground movement, growing trees long since gone, etc., but the overall figure obtained by careful statistical analysis is a very different thing and must be freed from systematic error produced by the survey. Extensive surveys of the kind required are beyond the capacity of a single individual.

REFERENCES

BROADBENT, S. R. (1955), "Quantum hypothesis", *Biometrika*, **42**, 45–57.

—— (1956), "Examination of a quantum hypothesis based on a single set of data", *Biometrika*, **43**, 32–44.

THOM, A, (1961a), "The geometry of Megalithic man", *Math. Gazette*, **45**, 83–92.

—— (1961b), "The egg-shaped standing stone rings of Britain", *Archives internationales d'Histoire des Sciences*, **14**, 56–57, 291–303.

—— (1962), "The Megalithic unit of length", *J. R. statist. Soc.* A, **125**, 243–251.