The Megalithic Unit of Length

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SUMMARY

A large number of megalithic circle diameters is now available. The analysis shows that the unit suggested for the radius (2·72 ft) can be accepted without hesitation. It also shows that there is a marked increase in the accuracy with increasing circle diameter. The distances between stones in rows and alignments are also examined. Here again the same unit appears but it seems that in a significant number of cases the half unit was also used.

1. INTRODUCTION

IN an earlier paper (Thom, 1955) it was shown that in a statistically significant number of cases the diameters of stone circles were multiples of 5·44 ft. This might be called the megalithic fathom. The analysis was based on surveys of 52 circles and in the appendix supporting evidence from other sources was given. Since then many more surveys have been made. These include sites where there are two or sometimes three circles close together and from the surveys it is possible to obtain the distances between the circle centres. Thus, including these distances, there are now available 156 measurements. It is not proposed to include distances to outliers from the circle centres even although these distances are in a number of cases multiples of the fathom. The reason for excluding these data is that numerous ambiguous cases arise; for example, where an outlier is near two circles it may belong to either; also there are many stones which may or may not be true outliers. The diameter of a circle is unambiguous if at times uncertain in value and the same applies to the distance between circle centres.

TABLE 1

Circles in England and Wales

Site	*Lat.* ° ′	*Long.* ° ′	*D. (ft)*	*L. (ft)*	*Remarks*
D1/3 Nine Ladies	53 11	1 38	35·5		
D1/7 Barbrook	53 17	1 35	47·7		Type B
D1/8 Owler Bar	53 17	1 34	86·6		Type A
D1/9 Moscar Moor	53 23	1 41	54·2		Type A
D2/1 Mitchell's Fold	52 35	3 11	93·3		Type A
D2/2 Black Marsh	52 36	3 0	76·0		Type A
L1/1 Castle Rigg	54 36	3 6	107·8		Type A
					Resurveyed
L1/4 Burnmoor	54 25	3 17	70·0 ± 2 (omit)	122·5	
			49·7	150·7	Resurveyed
			54·6	339·3	
			52·0	419·0	
			104·5 ± 2 (omit)		Type A
L1/10 Seascale	54 24	3 29	88·9		Type D

TABLE 1 (*continued*)
Circles in England and Wales

Site	*Lat.* ° ′	*Long.* ° ′	*D.* (*ft*)	*L.* (*ft*)	*Remarks*
L1/13 Lacre (S)	54 13	3 18	49·7		
L5/1 Birkrigg Common	54 9	3 5	87·0 ± 2 (omit)		
			27·7		
S1/1 The Hurlers	50 31	4 27	107·6	204·0	
			136·8	215·9	
			113·7	419·1	
S1/2 Nine Stones	50 34	4 29	49·6		
S1/3 Duloo	50 24	4 29	38·6		Type A
S1/5 Treswigger	50 33	4 39	108·3		
S1/6 Leaze	50 34	4 38	81·5		
S1/7 Rough Tor	50 35	4 37	150·7		Type D
S1/8 Dinnever Hill	50 35	4 38	139·7		Type A
S1/10 Nine Maidens (Cambourne)	50 11	5 15	53·6		? Type A
S1/11 Nine Maidens (Ding Dong)	50 10	5 36	71·6		
S1/13 Boscawen-un	50 5	5 37	82·6		Type B
S1/14 Merry Maidens	50 4	5 35	77·8		
S1/16 Botallack	50 8	5 39	71·6		Type A
S2/1 Grey Wethers	50 38	3 56			
South Circle			108·5	128·3	
North Circle			104·5		
S5/2 The Sanctuary	51 25	1 50	129·7		
			64·8		
			46·8		
			34·3		
W6/1 Kerry Pole	52 28	3 14	86·9		Oval shaped
W8/3 Four Stones	52 14	3 6	17·2		
W9/2 Gors-fawr	51 56	4 43	73·2		
W9/4 Castell-Garw	51 54	4 42	43·7		
W11/2 Trecastle	51 58	3 42			
South-west Circle			43·7 24·3		Concentric
North-east Circle			76·3	144·2	
W11/3 Maen Mawr	51 52	3 40	59·8		
			? × 62·5		Egg shaped
W11/4 Usk River	51 55	3 43			
West Circle			65·0	365·8	
East Circle			68·2		
W13/1 Gray Hill	51 38	2 49	32·6		

Tables 1 and 2 give a list of these new sites with the lengths found at each, tabulated as *D* (diameter) and *L* (distance between centres). A few of the earlier surveys used in the 1955 paper had been made in unsatisfactory conditions of weather and lighting. This applies especially to the circles on Burnmoor (L1/4) where on a subsequent new survey extra stones were found by bayonet prodding. New values are also given in Tables 1 and 2 for the Loupin Stanes (G7/4), The Seven Brethren (G7/2) and Castle Rigg (L1/1) all of which were resurveyed. Otherwise the values in the earlier paper are to be taken with those now given with the proviso that all diameters are now omitted where the uncertainty was considered to be greater than ± 1·5 ft.

TABLE 2

Circles in Scotland

Site	*Lat.* ° ′	*Long.* ° ′	*D. (ft)*	*L. (ft)*	*Remarks*
B1/5 Upper Auchnagorth	57 36	2 16	45·0		
B1/6 Easter Aquorthies, Manar	57 17	2 27	64·0		
B1/8 Sheldon of Bourtie	57 19	2 18	108·4		
			53·5		Concentric
B1/9 South Ythsie	57 22	2 11	28·0		Type B
B1/10 Foutain Hill, Tarves	57 23	2 12	16·9		
B1/16 Westerton	57 16	2 29	49·0		
B1/18 Holywell or Ardlair	57 20	2 45	37·6		
B2/1 Tyre Bagger, Dyce	57 13	2 14	59·3		
B2/2 Sun Honey	57 8	2 28	83·2		
B2/4 Esslie Major	57 1	2 28	76·2		
			59·2		Concentric
			20·6		
B2/5 Esslie Minor	57 1	2 27	43·6		
B2/6 Garrol Wood	57 1	2 27	58·9		Type B
B2/7 Cullerlie	57 8	2 21	33·4		
B3/1 Aquorthies, Kingausie	57 3	2 10	75·1		
			49·7		Concentric
B3/3 Raedykes	57 0	2 16	57·1±	315·5	
B3/4 Raedykes (N)	57 0	2 16	32·5		
B4/1 Carnousie House	57 33	2 32	84·0	163·1	
			27±		
B4/2 Burreldales	57 35	2 32	21·3		
B4/4 Milltown	57 32	2 45	92·0		
B5/1 Urquhart	57 40	3 11	110		
B7/1 Clava	57 28	4 4			
Middle Tumulus			103·9	189·2	
South-west Tumulus			103·6	232·8	
North-east Tumulus			103·5	413·7	Egg shaped
B7/2 Miltown of Clava	57 28	4 5	59·1		
			22·0		Concentric
B7/5 Daviot	57 26	4 7	48·7		
B7/6 Castle Dalcross	57 31	4 2	39·2		
B7/10 Easter Delfour, Alvie	57 9	3 54	57·2		
			23·6		Concentric
B7/12 Aviemore	57 12	3 50	76·0		
			43·0		Concentric
B7/14 Belladrum	57 26	4 28	10·8		
B7/15 Mains of Gask	57 24	4 12	119·9		
			82·9		Concentric
B7/16 West Farr	57 22	4 12	113·2		Type A
			66·8		Concentric
B7/17 Farr (P.O.)	57 22	4 11	32·0		
G7/2 Seven Brethren	55 8	3 14	65·5		Type A Resurveyed
G7/3 Wamphray	55 15	3 21	38·0		
G7/4 Loupin Stanes	55 16	3 10	37·7		Type A
			44·0±	65·5	Resurveyed
G9/10 Borrowston Rig	55 46	2 42	136·0		Egg shaped
M8/1 Loch Creran	56 31	5 21	12·6		
P1/3 Killin	56 28	4 19	32·2		Type B

TABLE 2 (*continued*)
Circles in Scotland

Site	*Lat.* ° ′	*Long.* ° ′	*D.* (*ft*)	*L.* (*ft*)	*Remarks*
P1/4 Weem Carse	56 37	3 57	15·4		
P1/13 Monzie	56 24	3 49	16·4		
P1/14 Tullybeagles Lodge	56 31	3 36	23·0	54·0	
			31·4±		
P1/16 Meikle Findowie	56 32	3 41	27		? Type B
P2/1 Leys of Marlee	56 35	3 22	48·4		
P2/3 Blindwells	56 28	3 25	28		
P2/4 Courthill or Glenballoch	56 37	3 20	22·8		
P2/8 Shianbank	56 26	3 22	27·5	70·5	
			27·5		
P2/9 Guildtown	56 28	3 23	27·0		
P2/11 Scone	56 25	3 24	21·6		
P2/14 Spittal of Glenshee	56 49	3 27	12·7		

It has become apparent that the most reliable values are often to be obtained from the least known and least impressive sites. One reason is that these sites are often constructed from small stones so that the circle is more accurately delineated; but it also appears that many well-known impressive sites have been tampered with by well-meaning people who have re-erected the fallen stones. Unfortunately, often no record of the re-erection is to be found. It is known definitely that H1/1, S1/1, S2/1 and P1/3 have had stones re-erected and several other sites are in this respect suspect. A little-known circle of stones on a lonely moor is most likely to have escaped attentions of this kind and we can assume that where a stone, even a small stone, in such a circle has its major axis vertical it is in, or at least near, its original position.

2. ANALYSIS

Broadbent (1955) has given a method of assessing the probability of the reality of an *a priori* value of a quantum. In a later paper (Broadbent, 1956) he dealt with the case where the assumed value comes from the measurements themselves. It seems to the author that a sufficiently rigid proof lies in the fact that the measurements made *since* the publication of his earlier paper in themselves show a high significance value.

It may be of interest to look at the presentation of the results in Fig. 1. The circle diameters were arranged in order of magnitude and numbered so that they could be plotted consecutively. It is seen how the diameters progress in steps, tending to cluster round the integral fathoms.

About 55 per cent. of all circles have the diameter an even number of fathoms. In setting out a circle it is the radius rather than the diameter which has to be measured out on the ground, so that where the diameter is an odd number of fathoms, that is, in about 45 per cent. of all circles, the constructors used a half fathom. Thus for our present purpose it seems better to take as the unit a length of half a fathom (2·72 ft) and for convenience call it the megalithic yard.

With Broadbent's notation (Broadbent, 1955) put

$$y = 2r\delta + \epsilon$$

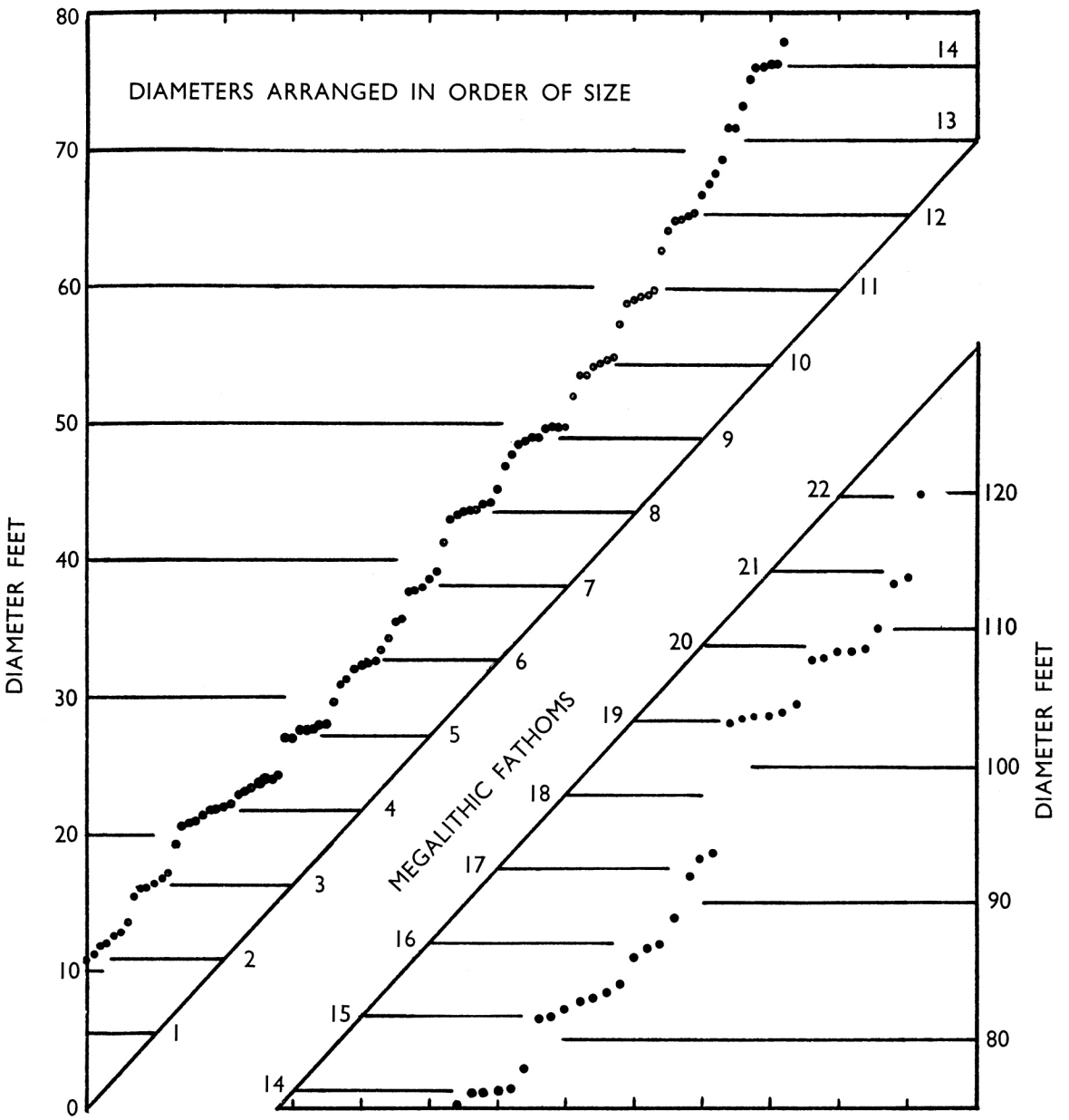

FIG. 1. Diameters of circles 10 to 120 ft.

where y is the radius or other length,

2δ is the quantum to be examined, e.g. the megalithic yard,

r is a positive integer,

and ϵ is the deviation of the measurement from the expected length.

Taking the quantum (2δ) to be 2·72 ft the value of ϵ was found for each radius. Fig. 2 shows the histogram for $|\epsilon|$ obtained by dividing the half range 1·36 into twelve equal parts. Fig. 3 shows the 18 measured distances between circles (L) treated in the same way. The overwhelming significance of the megalithic yard for the radius (i.e. the megalithic fathom for the diameter) becomes apparent, but it is interesting to see whether the large or the small circles contribute most to the agreement.

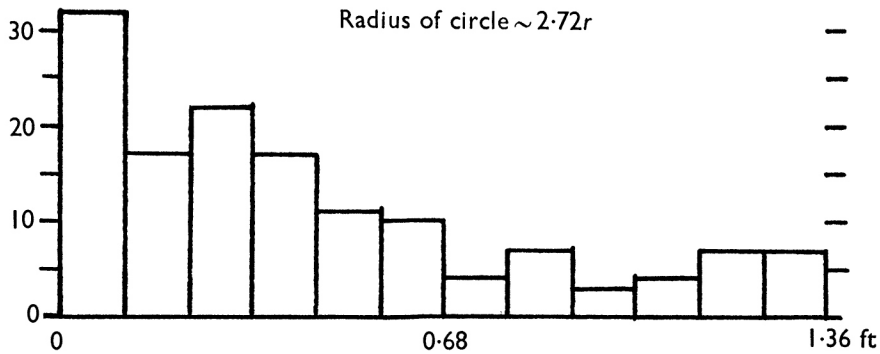

FIG. 2. Histogram of circle radii.

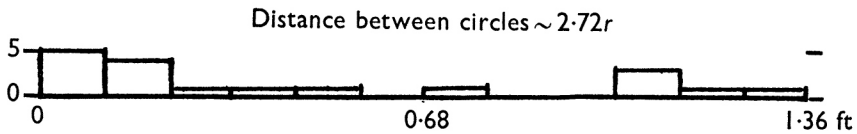

FIG. 3. Histogram of distances between circles.

No deterioration of the agreement with increasing size of circle is apparent in Fig. 1. To examine this matter in greater detail the total of 141 circles has been divided into three groups, small, medium and large, containing respectively 50, 50 and 41 circles. With Broadbent we have for the "lumped variance"

$$s^2 = \frac{1}{n}\Sigma\epsilon^2.$$

The results are given in Table 3.

TABLE 3

The effect of size of circle on the variance

Radius (feet)	*Number in group*	$\Sigma\epsilon^2$	s^2	s^2/δ^2	P
5–19	50	19·8	0·396	0·214	0·0005
19–38	50	17·3	0·345	0·187	0·0002
38–185	41	9·9	0·241	0·130	0·0001
all	141	46·9	0·333	0·180	<0·00001

P is estimated by extrapolation from Broadbent (1955, Table 3) as being the probability level.

If the circles were set out by, say, pacing the radius, the error would increase with size. Instead we see that the variance (s^2) decreases with increasing radius. This probably means that the large important circles were set out with much greater care; however, another explanation should be considered. Suppose that, for some reason some circles were set out with the diameter ($m+\frac{1}{2}$) fathoms (m an integer), i.e. with a radius ($m+\frac{1}{2}$) yards. Fig. 2 shows that in fact some 23 per cent. lie nearer the half yard than the yard. If a larger percentage of these half-yard circles lies in the lower group, then this would raise the variance in this group as calculated in Table 3. The actual percentages are, 28 per cent. in the lower, 22 per cent. in the middle, and 17 per cent. in the upper 41. Here we are in a dilemma; we do not know whether these percentages are due to the larger circles being more carefully set out or whether the apparent better setting out of the larger circles is due to these percentages representing a greater tendency towards the use of half yards for the smaller circles.

In fact there remains unsolved the problem of determining statistically the probability level at which we can accept the hump at the right of Fig. 2 as being real. If it were real and we could remove it, the variance from the integral megalithic yard would be lowered by some 60 per cent., leaving a standard deviation on the radii of the larger circles of less than 4 in. or about 1 in 350. This is almost comparable with ordinary chain survey accuracy and indicates that future surveys of circles ought to be made with a steel rather than a cotton tape. It is most impressive to superimpose the tracings of circles from opposite ends of the country when the diameters are obviously meant to be identical, e.g. G9/10 from Berwickshire and S1/1 from Cornwall. Both of these are egg-shaped circles, but the stones in the circular parts fit together on to what appears to be identically the same circle.

3. Distances Between Stones

The difficulty of knowing how to treat the subdivisions of the fathom or of the yard led the author to look to other megalithic measurements, if possible of shorter lengths. Without very much hope of finding anything useful the distances between stones (centre to centre) in rows were tried. All the alignments of which surveys were available were used and the distances between the centres of the stones measured. The definition of an alignment given in Thom (1961) was used to decide whether or not two stones standing close should be included. The alignments at Mid Clyth (N1/1 Thom, 1961) were all omitted as the distances there seem to depend on special considerations.

The measured distances are shown in Fig. 4 arranged in ascending order. It will be seen that up to about 12 ft there is definite indication that the megalithic yard was in use. Above this distance the indication fades out almost entirely.

The first hundred measurements lie between 2·3 and 15·6 ft. Comparing each with the megalithic yard we obtain for the deviations the histogram in Fig. 5. Since the histogram is nearly as high at the right end as at the left it appears that the half yard was almost as much used as the yard. The histogram for the half yard (range $\pm 0{\cdot}68$ ft) is shown in Fig. 6. Applying the "lumped variance" test (quantum 1·36 ft) we find

$$n = 100, \quad \Sigma\epsilon^2 = 12{\cdot}25, \quad \text{Variance } s^2 = 0{\cdot}122, \quad s^2/\delta^2 = 0{\cdot}264,$$

giving a probability level of 0·01. Again we are faced with the problem of the reality of the lump at the right-hand end of the figure.

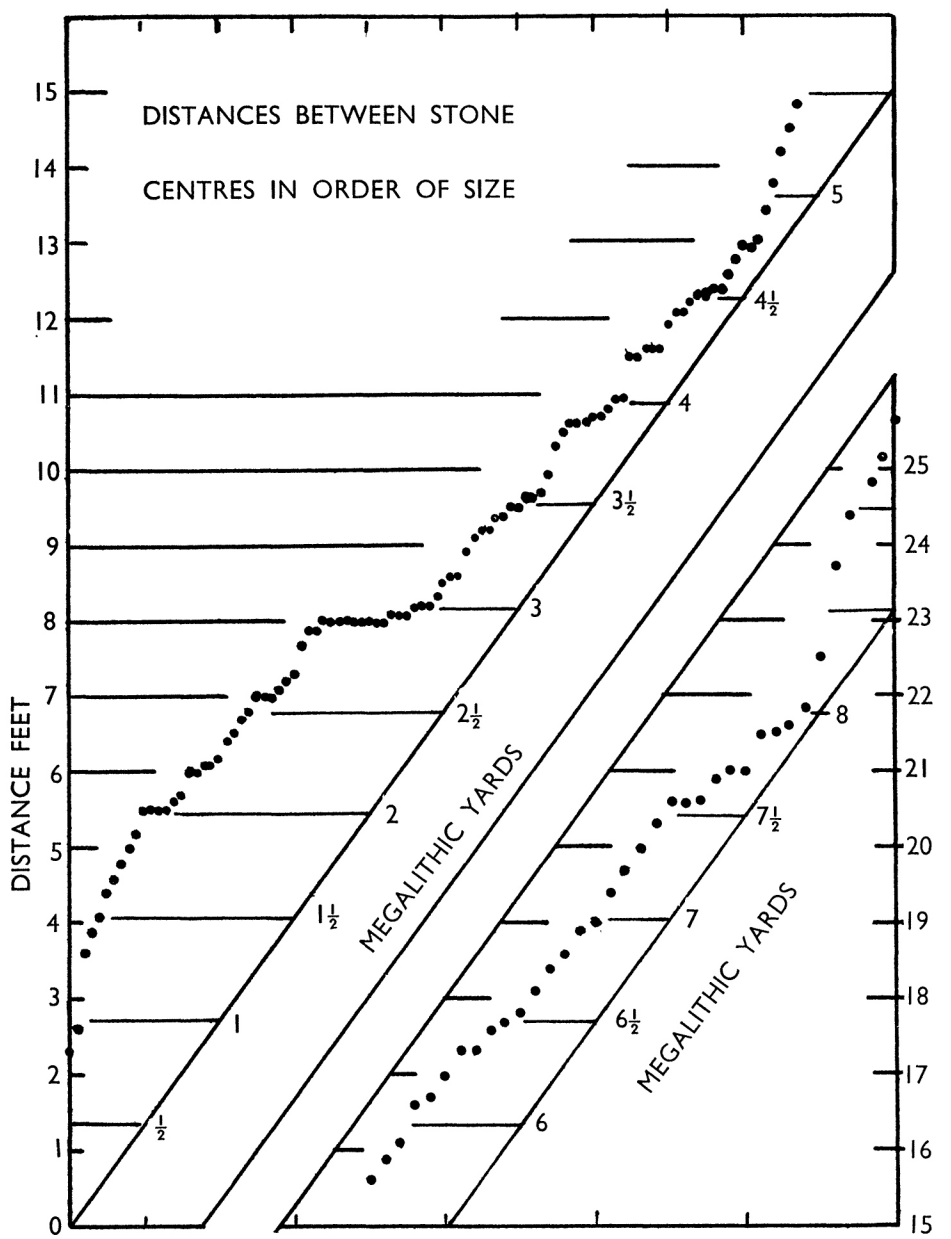

FIG. 4. Stone rows. Distances between stone centres 2 to 26 ft.

Care must be taken in analysing subdivisions of the assumed unit. Thus, suppose we are dealing with a distribution giving a very close grouping round each multiple of the quantum or unit; if we apply Broadbent's method to the half or quarter unit, or for that matter to any subdivision, we shall still obtain a high significance which in fact would be quite misleading.

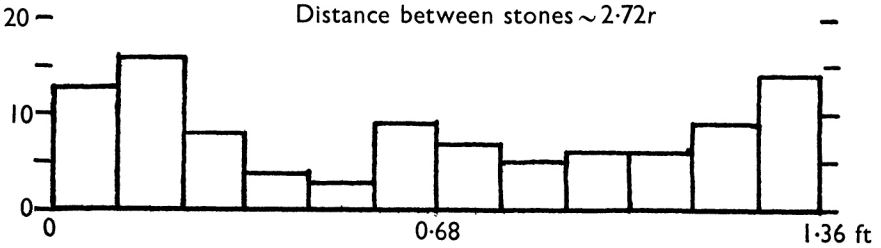

FIG. 5. Histogram of distances between stones in rows.

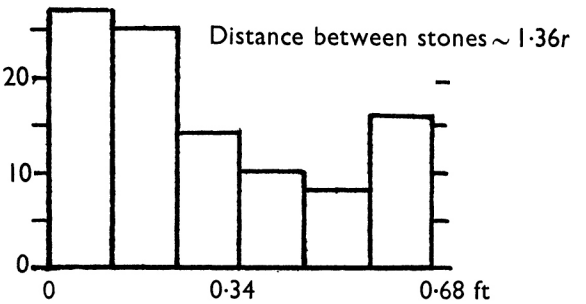

FIG. 6. Histogram of distances between stones in rows.

4. CONCLUSIONS

In conclusion we can say that from an examination of the radii of megalithic circles it is certain that the unit of 2·72 ft was used with the possibility that the yard was occasionally halved. From an examination of the distances between stones we see a high probability (0·01 level) for the use of the half yard (1·36 ft); the use of the quarter yard cannot be ruled out but no probability level can be attached.

It seems likely that the larger circles were set out with greater care and accuracy than the smaller.

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