

## Megalithic Units of Length.

John R. Hoyle.

Around the nineteen seventies, Alexander Thom proposed his belief that the Neolithic man used a unit of length of 2.72 feet in the building of stone rings and that this unit was used throughout the British Isles. He called this unit the Megalithic Yard and he supported his belief with a large amount of evidence. He claimed that this unit was so accurate that there must have been a centre where exact copies of this length were produced and then these were distributed to other parts of the British Isles. This belief did not go down well with many archaeologists as many of them regarded the ring builders as rather crude technicians who had difficulty building rings that were circular. Thom's ideas were, understandably, not helped by the statistical equations that supported his theories, as these were complex and very difficult to follow. As the concept of the megalithic Yard was not accepted, it also became impossible to accept the ideas which stemmed from it, such as the idea that some non-circular rings had shapes whose arcs were centred on the corners of Pythagorean triangles, that is, triangles which have a perfect right angle and whose sides are whole numbers. The simplest example being a triangle with sides of 3, 4 and 5 units. Without the ability to measure accurately, it would have been impossible to set out the designs for these rings in any meaningful way. The result was that Thom's ideas were rejected by most archaeologists and it became almost impossible to have any research on these topics published.

My approach to the problem of the Megalithic Yard was that if it existed then there should be possible to demonstrate it by a much easier method that could be understood by any reasonable person. The method that I adopted was to produce a score that indicated how well a particular unit fitted a group of rings. If the diameters of the rings were close to multiples of the unit, then the score would be close to one. If the diameters were about half way between multiples of the unit, the score would be close to minus one. A difference between the diameter and the nearest whole unit of one quarter of the unit would score zero. Other errors would have intermediate scores and the scores for the group would then be added. The higher the score the better the unit fitted the group of rings. There are several ways that the scores could be calculated. The steps in the method I chose are:

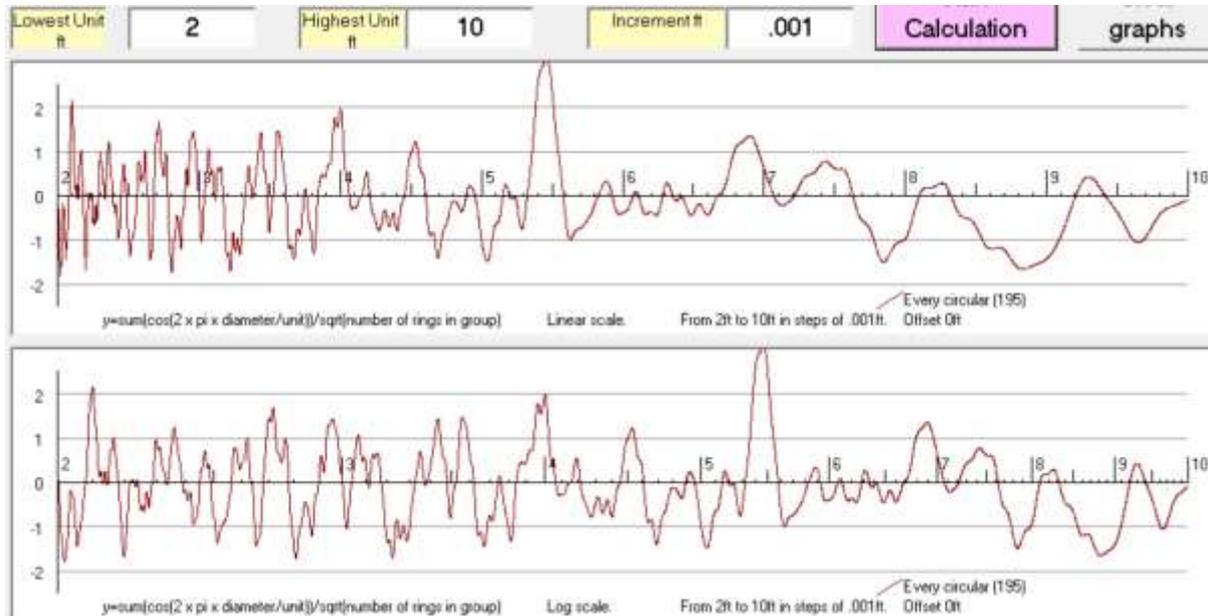
Divide the ring diameter by the length of the unit.

Multiply the result by  $2 \times \text{Pi}$ . (or 360 if working in degrees).

Find the Cosine of the resulting angle.

If the same process were to be carried out with a different possible unit, then the unit which produced the higher total score would be the length which better fitted that group of rings. Using a computer I repeated the process with hundreds, or even thousands, of possible units which were very close to each other and drew graphs of the resulting totals. The result was a wavy line in which the highest peaks indicated units that fitted the diameters best. There is no guarantee that the highest peak was an actual unit, as a wavy line will result from a set of diameters chosen completely at random, but if one peak is appreciably higher than the others it may indicate the use of that unit. Below is the graph of the output for all the rings in all the groups listed by Thom in *Megalithic Sites in Britain*. The lowest unit chosen is 2 feet, the highest is 10 feet and all the units in between differ by only one one-thousandth of a foot. The top graph has a linear scale, whilst the lower graph has a logarithmic scale in order to space out the peaks for the smaller diameters. The vertical scale has

been reduced by dividing the totals by the square root of the number of rings in the group. This makes it possible to better compare groups with different numbers of rings. One peak stands out and that is for 5.44 feet, which is 2 megalithic yards.

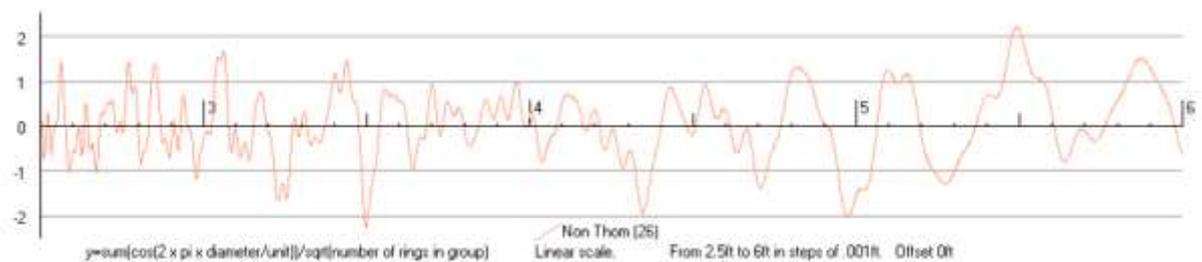


**Graphs for all 195 circular rings. Range from 2 feet to 10 feet in steps of .001ft.**

**Subsets of the above ring group.**

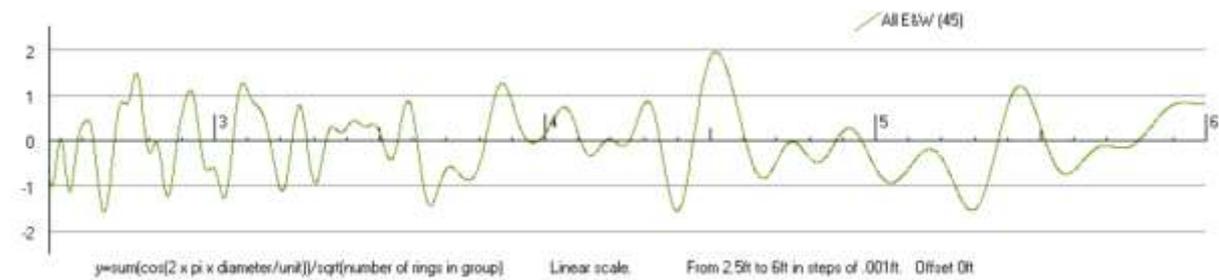
The following graphs cover the range 2.5 ft. to 6ft. in steps of .001ft. as this smaller range allows the details to be seen more easily. Only the linear scale graph is shown, as the crowding of the peaks at the shorter diameters is not too serious. The object is to trace which groups of ring are responsible for the peak at 5.44 ft. and perhaps show where the unit was most used. If the size of the ring is loosely correlated with its age, then it may be possible to determine if the use of the unit changed over time. The subgroups of rings have fewer rings in them and the indications of units are not as compelling as the above.

**Group of 26 rings that were not surveyed by Thom.**



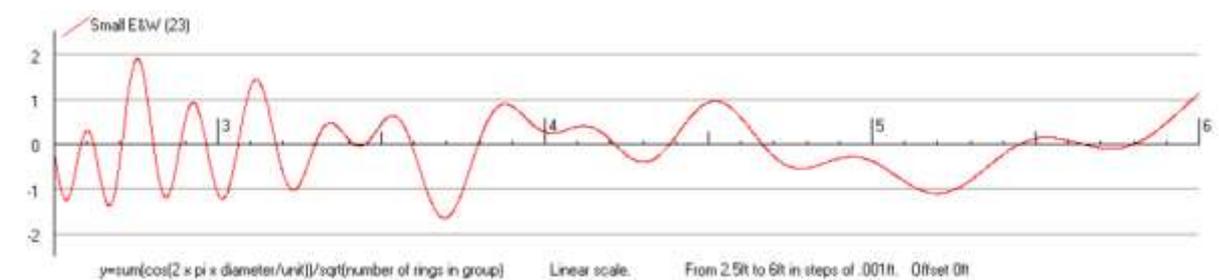
The highest peak is still close to 5.44ft. indicating that results from other researchers tend to support Thom's Megalithic Yard.

**Group of 45 English and Welsh rings surveyed by Thom.**



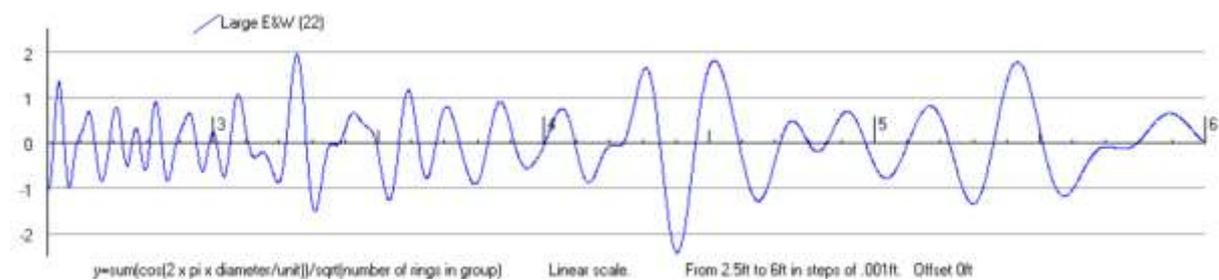
There is a peak at 5.44ft. indicating support for the Megalithic Yard, but the highest peak is a little over 4.5 ft. and so far I have not found any other evidence to show that this was a unit.

**Group of 23 small (under 50 ft. diam.) English and Welsh rings surveyed by Thom**



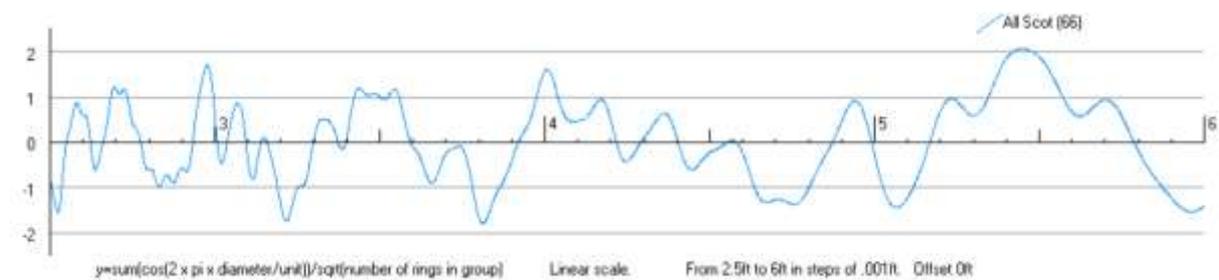
The highest peak is close to 2.75 ft. close to the Megalithic Yard of 2.72ft. This indicates the use of the half yard in the radius of the ring.

**Group of 22 large English and Welsh rings surveyed by Thom.**



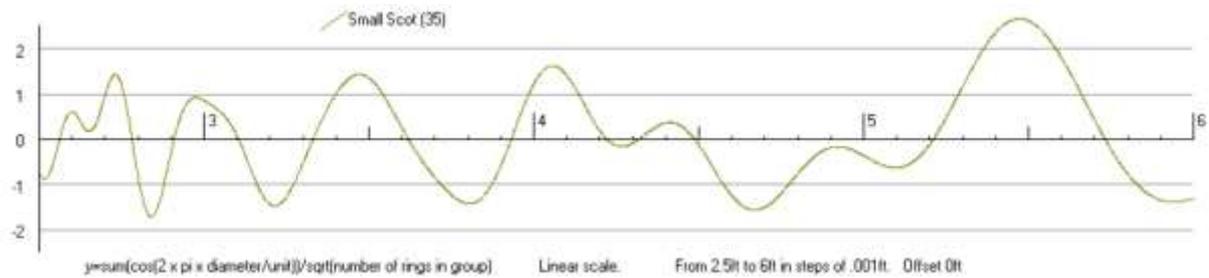
Some support given for the Megalithic yard. The 5.44 ft. peak is amongst the highest peaks. This demonstrates that spurious peaks can occur by accident, especially amongst smaller samples.

**Scottish rings. Group of 66 Surveyed by Thom.**



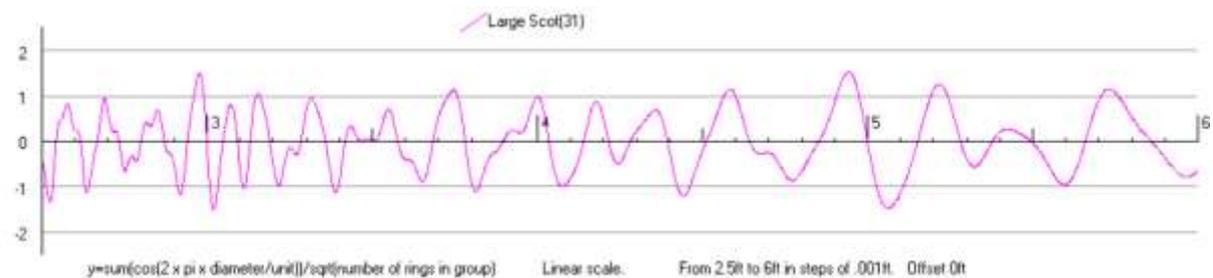
The highest peak is around 5.44 ft. or 2 megalithic Yards.

**Group of 35 small Scottish rings surveyed by Thom.**



The highest peak is close to 5.44ft. or 2 Megalithic Yards. A peak with a value well over 2 is a good indication of the use of that length as a unit.

**Group of 31 large Scottish rings surveyed by Thom.**



There is no indication here of the use of the megalithic yard. The two highest peaks are at 2.97ft. and 4.95 ft. These are very close to our own yard and multiples of five modern feet, being only one percent shorter. Each peak by itself would not be particularly significant, but together they deserve to be considered as possible units.

The small Scottish rings show very strong evidence for the use of the Megalithic Yard, but the large Scottish rings show none at all. If Burl was correct in his belief that large rings tend to be older than small rings, then this implies that, in Scotland, the Megalithic Yard must have been introduced only after most of the large rings had been completed and the unit perhaps displaced a previously used unit. I have called this possible unit “the Old Yard” and is 2.95 ft.

The next step was to examine individual rings to see if they were likely to have used a particular unit. One problem here is that it is often difficult to obtain accurate dimensions of such circles. Thom quoted the dimensions of the rings that he surveyed to the nearest tenth of a foot, and quoted the probable errors, so that it is clear how reliable the dimensions are. Burl in *The Stone Circles of the British Isles* and *Rings of Stone* converted all diameters into metres in an effort to make things consistent. The problem here is that it is clear that some of the original dimensions were given to the nearest foot, or even to the nearest five feet, where the dimensions had been obtained by pacing, and then quoted to the nearest tenth of a metre, giving a false impression of the accuracy. In the following examples I have used Thom’s quoted dimensions unless otherwise stated.

### The ring of Brogar (Brodgar).

This magnificent ring has been very carefully surveyed by Thom, who gave its diameter as 340.7 +/- 0.44 feet and that it had 60 stones which were evenly spaced. He found that the diameter was 125 megalithic Yards or 50 Megalithic rods (1 Rod equals 2.5 Megalithic Yards). As the following table shows I think the Old Yard is a much better fit as the perimeter comes out to be 360 Old yards and the distance between the stones is 6 Old yards.

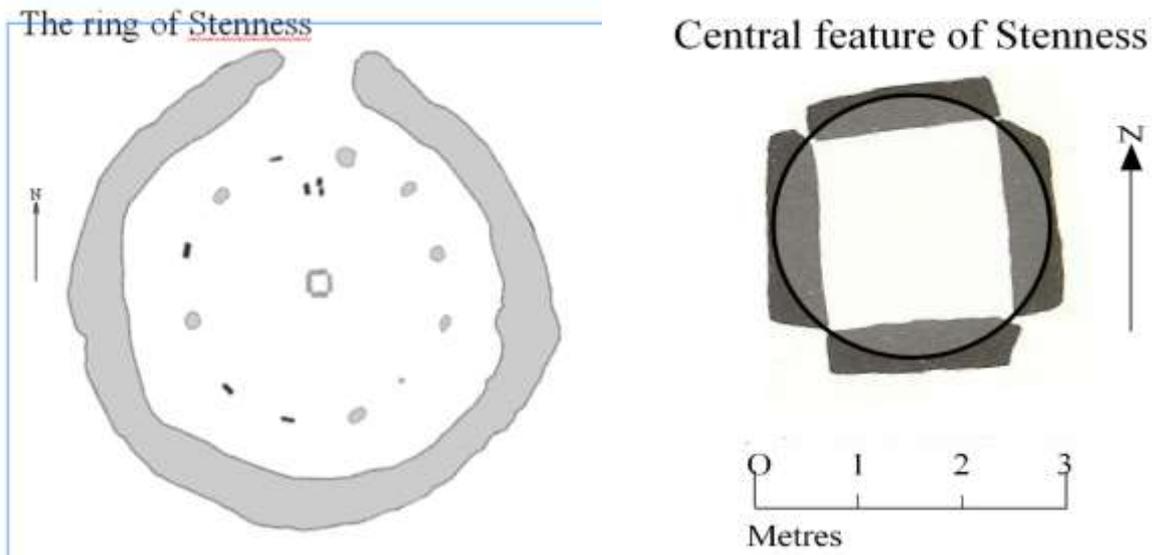
Brogar (Brodgar)	Diameter	Perimeter	Inter-stone distance
Feet	340.7	1070.34	17.84
Megalithic yards (2.72 ft.)	125.25	393.51	6.56
<b>Old yards (2.97 ft.)</b>	<b>114.71</b>	<b>360.37</b>	<b>6.01</b>
Five foot unit (4.95 ft.)	68.82	216.23	3.60

### The ring of Stenness

The ring of Stenness in Orkney is a very old ring which may have been built before 3000 B.C. Wikipedia states that the diameter is about 32metres (105ft.) laid out in an ellipse, though the plans that are available appear to show it as circular. Burl states that it is circular and has a diameter of 31.1 metres. This is 102.03 feet and in all probability derived from an original figure of 102 feet. I have used the latter dimensions. Originally the ring had twelve stones that were equally spaced.

Stenness	Diameter	Perimeter	Inter-stone distance
Feet	102	320.44	26.70
Megalithic yards	37.5	117.80	9.82
<b>Old yards</b>	<b>34.34</b>	<b>107.89</b>	<b>8.99</b>
Five foot unit	20.52	64.47	5.37

If the diameter of 102 feet is correct then the perimeter in Old yards would be 108 and the inter-stone distances exactly 9 Old yards.



In the centre of the ring there is a setting of four stones. this is shown enlarged on the right. The circle in the above diagram has a diameter of exactly three old yards. Alexander Thom believed that as the Megalithic Yard retained its accuracy from one end of Britain to the other for perhaps a thousand years, there must have been a standard unit of length and copies of this length must have been periodically distributed. Otherwise the length of the unit would have drifted and it would vary from place to place and from time to time.

As the Old yard was in use over wide areas and for a considerable time, the same argument also applies. It seems possible that the unusual feature in the centre of the Ring of Stenness could be such a standard unit of length. It now seems that the remains found closeby at the Ness of Brodgar was at the heart of ringbuilding over much of Britain, but lost its influence about 2450B.C. and after the extensive building remains had been covered up, it was abandoned. The centre for ring building then moved south, perhaps to the Stonehenge area. This date corresponded to the abandonment of the Old Yard of 2.97 feet and its complete replacement with the Megalithic Yard. If the centre of the Stenness ring was the place where the sacred unit of length was kept safe by being set in stone, it may be helpful to uncover it again and closely examine the stones for possible traces of the Old Yard. Why a particular length was of such importance is not known, but for four large stones to be placed at the centre of possibly the first stone ring to be built in Britain and for those stones to encompass a ring of exactly 3 Old Yards, the unit must have been very important.

Other examples of Scottish rings for wqhich the Old yard or Five Foot unit is suitable. This is not a comprehensive list, but is simply intended to illustrate what is available.

<b>Sunhoney (11 stones)</b>	Diameter	Perimeter	Inter-stone distance
Feet	83.0	260.75	23.70
Megalithic yards	30.51	95.86	8.71
<b>Old yards</b>	<b>27.95</b>	<b>87.80</b>	<b>7.98</b>
Five foot unit	16.77	52.68	4.79

The Old yard unit is the only unit that satisfies both the perimeter and the inter-stone distance.

<b>Midmar Church</b>	Diameter	Perimeter	Inter-stone distance
Feet	56.8	320.44	Stones not
Megalithic yards	20.88	65.60	evenly
Old yards	19.12	60.08	distributed
Five foot unit	11.47	36.04	

In this ring the perimeter is a multiple of both the Old yard and the Five Foot units.

<b>Tarland</b>	Diameter	Perimeter	Inter-stone distance
Feet	74.1	232.79	Stones not
Megalithic yards	27.24	85.58	evenly
Old yards	24.95	78.38	distributed
Five foot unit	14.97	47.03	

In this ring both the diameter and perimeter are satisfied by the five Foot Unit, but not by any other unit.

Avebury and Stonehenge.

The ring at Avebury is by far the largest in Britain, being about 360 m. in diameter, or nearly 400 yards. The perimeter is about 1120 metres or nearly three quarters of a mile and the ditch is about that length. Silbury Hill, which is part of the surrounding complex, is the largest man made mound in Europe and its flat top is large enough to allow the main ring of Stonehenge to sit on it. Some of the stones of the ring are of exceptional size and it was clearly built to impress.

Stonehenge is of much smaller size and the stones, though very large, are not as big as the larger ones at Avebury. However the stones have been shaped, placed close together and capped by lintels to form the closed ring that makes Stonehenge unique. Due to the close spacing, the lintels and the shaping of the stones, the ring has achieved a compactness which makes it stand out from other rings.

Both rings required an enormous amount of effort and were constructed over a long period during the third millennium B.C., so that the periods of construction overlapped each other. The strange thing was that they were barely twenty miles apart. No single group of people would have embarked on two such huge projects which were so close together. Each ring must have strained the resources of a large and powerful tribe. Avebury impresses by its huge size and the complexity of its design, but in concept it does not differ from other large rings. Stonehenge introduces new

ideas, new ways of construction and probably new ways of making observations. It is in a sense “modern”, whilst Avebury represents the old. The most likely conclusion is that there was a power struggle going on between two groups, each trying to impress, or intimidate the other.

It is quite clear from Thom’s very accurate survey and plan of Stonehenge that the outer sarson circle was set out using the megalithic yard and the only indication of the Old Yard was in the dimensions of the 56 Aubrey Holes.

<b>Aubrey Holes</b>	Diameter	Perimeter	Inter-hole distance	Distance to 3 <sup>rd</sup> hole
Feet	283.6	890.95	15.91	47.51
Megalithic yards	104.26	327.54	5.85	17.47
<b>Old yards</b>	<b>95.49</b>	<b>299.99</b>	<b>5.36</b>	<b>15.996</b>

Newham believed that the distance between each third hole was an important distance which he called The Lunar Measure. This was because stepping round the ring of holes in threes would keep track of the lunar cycle of 18.6 years. That is the interval between successive extremes of the declination, or Major standstill.

If the bluestones at Stonehenge were taken from the Preseli area and an advance party from there had prepared the holes for their insertion at Stonehenge, then it is likely that they would have used the Old Yard as a measure, as there is evidence that this unit was used in West Wales. This idea has been supported by my recent determination of the geometry of two rings in West Central Wales, which did use the Old Yard and is described in “Recent Surveys”. The probable reason for the holes never having been used to hold the bluestones is that the builders of Stonehenge used the Megalithic Yard. (Can you imagine the French using feet and inches to build a monument in France?)

According to Burl, Avebury did not remain in use for very long after its completion and it seems that the Stonehenge people succeeded in overcoming the resistance of their northerly neighbours and then went on to dominate the whole of Britain ending in the Orkney Isles.

There are three rings that have almost identical diameters of about 113.5 ft.. These are Farr West (113.2ft.), Elva Plain (113.4 ft.) and the middle sized and the northern ring of The Hurlers (113.7 ft.). This makes themj one third the size of The Ring of Brodgar, which has a 360 Old Yards perimeter.

Units in Old Yards	Diameter	Perimeter
Farr West	38.11	119.72
Elva Plain	38.18	119.94
Hurlers north	38.28	120.27

The units used in all three are Old Yards.

The other two rings of the Hurlers have the following dimensions:

Units in Megalithic Yards	Diameter	Perimeter
Hurlers centre	50.74	159.39
Hurlers south	39.71	124.74

From the above it can be seen that in the Hurlers, the North ring satisfies the Old yard in the perimeter, whilst the other two rings satisfy the Megalithic Yard. My conclusion is that the Northern ring was built first and the other two built after the Megalithic yard took over.

It has been argued, based on genetic evidence that, after the ice age, Britain was settled by two groups of people, one group coming by sea from the region of Spain and occupying the west and north of Britain, whilst the other group moved from South East Europe and migrated into South East England. The attitudes of these two groups towards each other when they met up could range from co-operation to suspicion and even hostility. The distribution of these populations corresponds, as far as it is possible to tell, with the two units.

## The design and geometry of Avebury.

I have stated that the geometry proposed by Thom for the great ring at Avebury was not satisfactory and that my proposed design, based on the Old Yard was more compelling and fitted in with other designs much better. In the light of this I am giving an account of the design below. The design was guided by the design of Type I egg type rings and the line of approximate symmetry through the ring, which runs from approximately west northwest to east southeast. The design has a complexity that mirrors the size of the ring. The units used in its design are the Old Yards and the Five Old Five Foot unit.

There are four diagrams to illustrate the design. The first is the complete design, but by itself it looks very complex and is difficult to follow. The other three show how the different triangles and centres of the arcs are related and illustrate the basic ideas behind the design.

Thom listed the co-ordinates of each stone, so it is possible to determine the accuracy of the design and how well the stones fit the perimeter. For this construction the sum of the root mean square errors for the stones is 172.81. For Thom's design it was 192.88 and he had to put stone 98 on a different arc or the total would have been appreciably more. This design then fits the stones rather better than Thom's design and I feel it is more satisfying. The length which best fits the construction is 2.958 ft. which is 0.40% less than 2.97ft. or about one seventh of an inch (0.36cm).

To correspond with the actual ring the design has to be rotated 19.33 degrees clockwise. ( Further details can be found in *Megalithic Matters* by John R. Hoyle, pages 73 to 91.)

In the triangle XEJ, where X is at the centre of the ring, E is at the western end of one axis and J is at the northern end of the other, the angle EXJ is exactly a right angle as the triangle XEJ is Pythagorean, having sides of **195**, **216** and **291**. Finding such a large Pythagorean triangle was quite an achievement and it must have been useful in setting out the design on the ground, as it ensured that the axes were exactly at right angles to each other.

Another feature, or co-incidence, is the fact that the sum of the lengths of the five sides that surround the two large shaded triangles in diagram 2, less the sum of the five lengths that surround

the small shaded triangles again in diagram 2, has a value of **1196 Old Yards** (The Shortest side in each group is only used once). The perimeter of the ring is **1195.206**. The difference is less than 1 Old Yard.

Put as equations:

$$\mathbf{DW + WV + VZ + ZD + DV - (DC + DR + RP + PD + RD) = 1196.000}$$

$$\mathbf{Perimeter = 1195.206}$$

Is this accidental or was it intended?

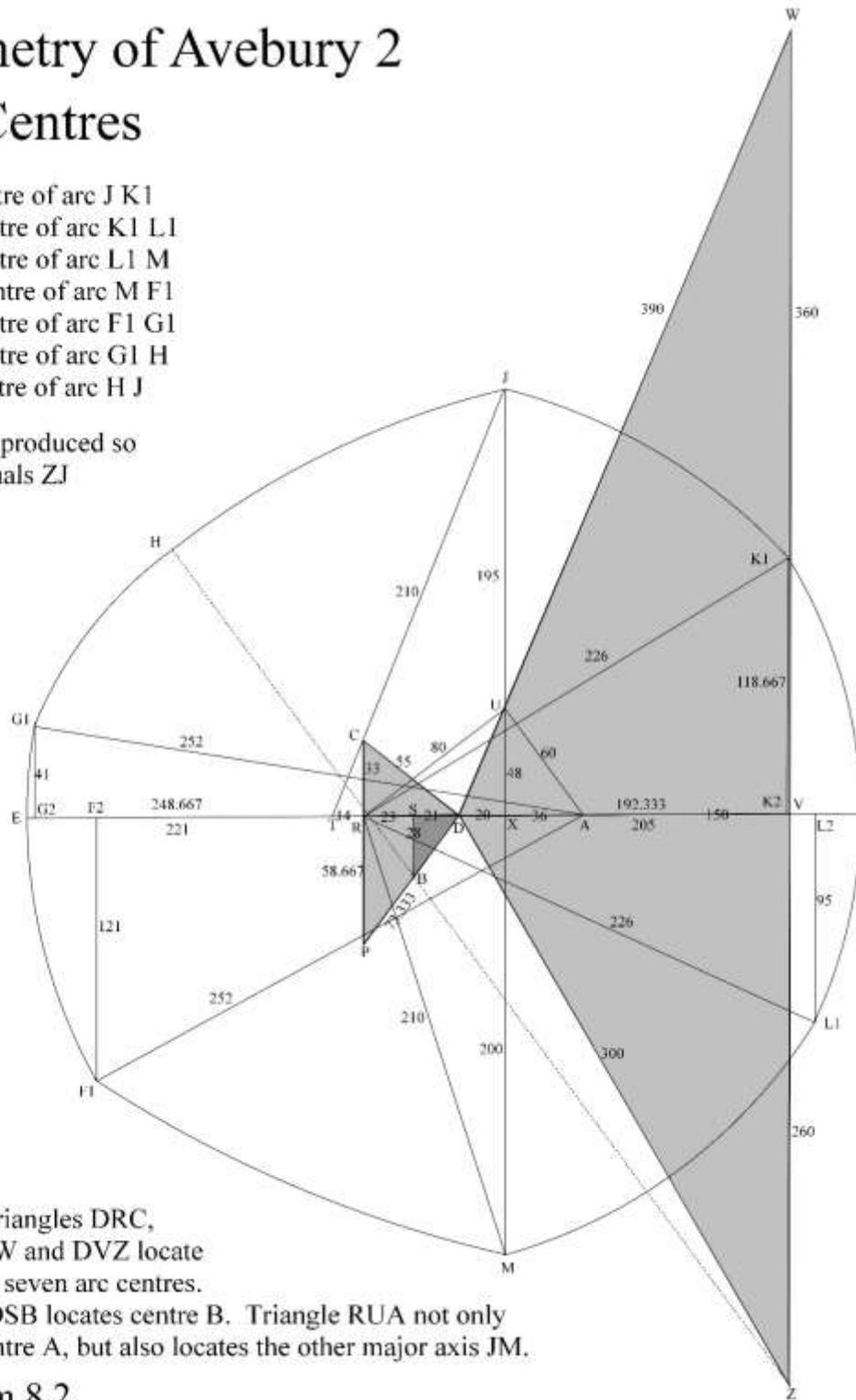


# Geometry of Avebury 2

## Arc Centres

P is the centre of arc J K I  
 R is the centre of arc K I L I  
 C is the centre of arc L I M  
 W is the centre of arc M F I  
 A is the centre of arc F I G I  
 B is the centre of arc G I H  
 Z is the centre of arc H J

H is on ZB produced so that ZH equals ZJ



The four triangles DRC, DRP, DVW and DVZ locate five of the seven arc centres. Triangle DSB locates centre B. Triangle RUA not only locates centre A, but also locates the other major axis JM.

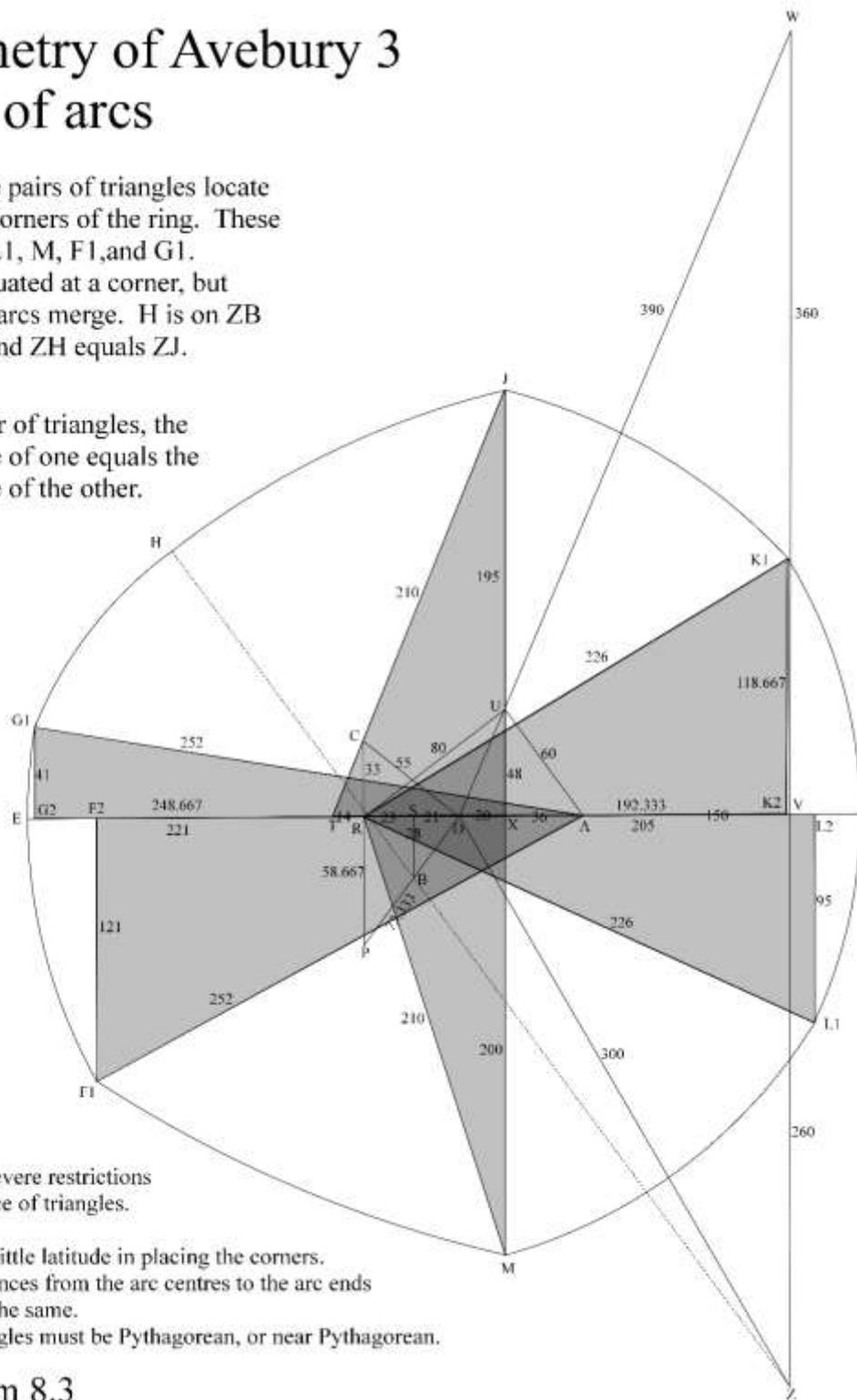
Diagram 8.2

# Geometry of Avebury 3

## Ends of arcs

These three pairs of triangles locate all the six corners of the ring. These are J, K1, L1, M, F1, and G1. H is not situated at a corner, but where two arcs merge. H is on ZB produced and ZH equals ZJ.

In each pair of triangles, the hypotenuse of one equals the hypotenuse of the other.



There are severe restrictions on the choice of triangles.

1. There is little latitude in placing the corners.
2. The distances from the arc centres to the arc ends must be the same.
3. The triangles must be Pythagorean, or near Pythagorean.

Diagram 8.3

