

HOPEWELLIAN GEOMETRY AND ASTRONOMY AT HIGH BANK

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Introduction

In a previous paper we analysed the geometric structure and the possible astronomical significance of the circle–octagon earthworks near Newark, Ohio.¹ We demonstrated that the details of the structure and orientation of these earthworks can be plausibly interpreted in terms of two fundamental concepts: (1) a simple yet precise geometrical plan based on a single length of 321.3 m; (2) a structure and orientation which was designed to incorporate alignments to the rise and set points of the Moon at the lunar standstills. If these concepts were consciously applied by the builders in the construction of the earthworks, this would have significant implications for American archaeology. The only previous suggestions of prehistoric observations of lunar standstills in the New World involve the Anasazi culture at Fajada Butte² (A.D. 1000), Casa Grande³ (A.D. 1200–1500), and Zodiac Ridge⁴ (A.D. 1000–1500). The earthworks at Newark are believed to have been constructed by Native Americans associated with the Hopewell culture between A.D. 0 and A.D. 500.

If geometric Hopewellian earthworks were constructed in part to celebrate and record geometrical and astronomical regularities, then one would expect to see evidence for this astro-geometric tradition at sites other than Newark. The hypothesis of deliberate astronomical alignment must be put to the test by analysing other Hopewellian sites using the same principles which were apparently successful in interpreting the Newark site. Two criteria should be observed in choosing additional sites to test this hypothesis: (1) the site should be comparable in scale and precision to the Newark site, thus rendering it more likely that the chosen site might have been similar in function to the Newark site; (2) accurate and reliable survey data must be available for the main structural features of the site. At present these two criteria are satisfied by only one site: the circle–octagon combination known as the High Bank Works near Chillicothe, Ohio. Thus, the purpose of this paper is to show that the structure and orientation of the High Bank Works can be plausibly understood using astronomical and geometrical principles very similar to those invoked in our interpretation of the Newark earthworks.

Background

Altogether, more than one hundred Ohio sites involving large Hopewellian earthworks, many of them geometrically regular, were known by 1900. Only two of these works (Newark and High Bank) are known to contain large equilateral octagons. Each of these sites consists of a large circle joined by an avenue to a large equilateral octagon together with an adjacent array of avenues and smaller circles. A good impression of the structure and similarities of these two sites may be gained by comparing maps (Figures 1 and 2) published by Squier and Davis⁵ in 1847. A comparison of that portion of the two sites surrounding and including the circle–octagon combination shows that the

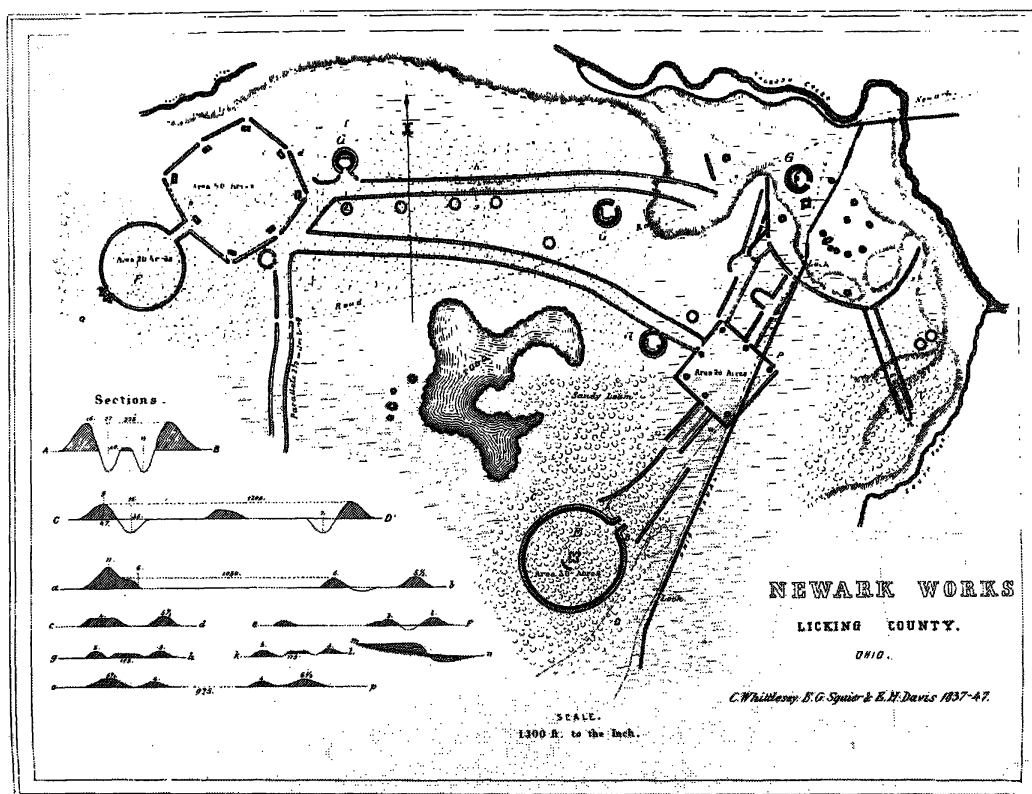


FIG. 1. This map, published by Squier and Davis in 1847, shows the Newark earthworks which have been analysed by the authors¹ and which bear a striking similarity to the High Bank Works.

sites are quite similar except for orientation. The circle-avenue axis at High Bank is rotated eastward by about 90° with respect to the corresponding axis at Newark. Nevertheless, the striking structural similarity between the two sites at least suggests that the motivation for their construction could have been similar. The distance between the two sites is approximately 113 km.

It is probable that the High Bank works were noticed by the first European settlers who began to farm the site on the Scioto River in 1796. Chillicothe itself, only five miles to the north, was founded in 1796, and became the capital of the Northwest Territory in 1800. Yet we know of no archaeological notice of the High Banks works, nor of any attempt to map them earlier than the work published by Squier and Davis in 1847. Year by year the site has become more difficult to map, as it has been under cultivation almost without interruption since the region was opened to European settlement.

The anthropologist Lewis Henry Morgan attempted to explain the character of the High Bank octagon as an Ohio "pueblo" constructed with *adobe* brick houses atop the walls, and adjoined to a "ceremonial" circle. None of the subsequent archaeology done at the site supports such a conjecture. As early as 1901 the Ohio archaeologist Gerard Fowke rejected this.⁶ He objected that the wall summits were too narrow to permit such use, and noted that the construction of the walls shows no evidence that they were intended to support

dwelling. Subsequent work at the site supports this conclusion, and what is presently known about Hopewell habitation sites in the period involved makes the suggestion altogether implausible.

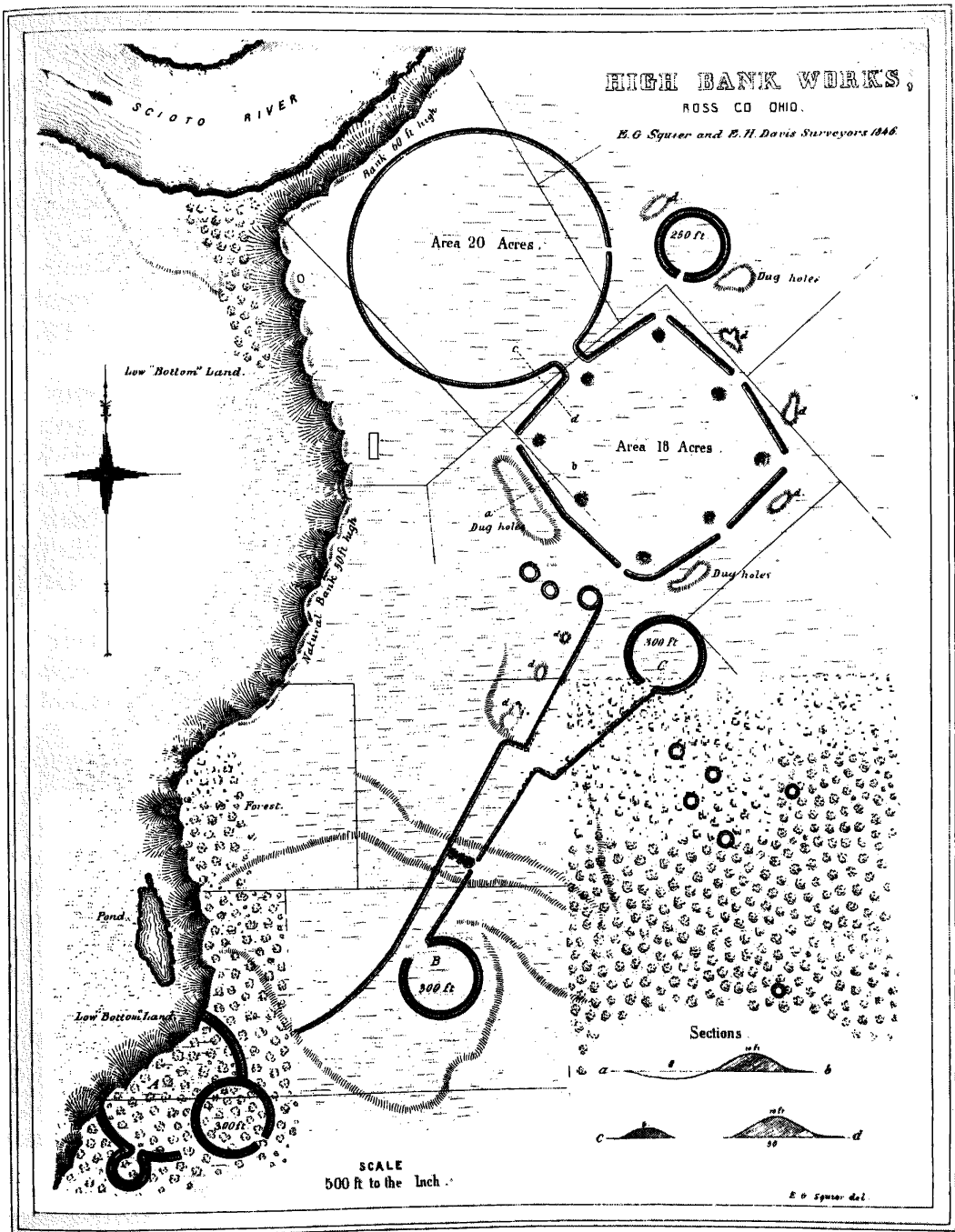


FIG. 2. This was the first map made of the High Bank Works taken from Squier and Davis.⁵ The mounds interior to the octagon and the earthworks exterior to the octagon-circle combination were obliterated by the time of the Middleton survey.¹⁰

In 1972 a team of archaeologists working under Oren Shane, now curator of anthropology at the Science Museum of the University of Minnesota, dug trenches through the walls of both the octagon and circle at High Bank. Their aim was to find material which could be carbon tested, as an aid in dating the structure. No datable material was in fact found. The walls were largely free of any artifacts, with the exception of a few archaic flakes and a portion of an archaic projectile point scattered among the fill in the wall.⁷

Nothing resulting from Shane's exploration of the works seems to bear directly upon our interpretation of the geometrical or astronomical features of the circle and octagon. Just inside the wall of the circle, and north of the intersection of the circle and the avenue, the trench dug by the excavating team cut across an apparent "pavement" of cobble-like stones, varying in size from 8 to 15cm in diameter. The "pavement" appears to be concentric with the circumference of the wall, and to be continuous for the 21m distance which was explored at 3m intervals. The portion of the "pavement" which was examined was from 10 to 15cm deep, and about 1.4m wide. At present it is not known whether the cobbles extend around the entire circle.

A further point, perhaps important for our arguments, is that no carbon was found on the site. No traces of any burning which was done to clear the "prairie island" site in the first place remain. Shane suggests that deliberate efforts were made to make the interior of the octagon and circle as clean and clear of debris as possible. As extensive clearing may have been necessary to establish the horizon sighting lines which we postulate, the fact that no carbon remains were found within the circle and octagon should be noted. In the absence of datable material from High Bank, it is impossible to assign a secure date to the structure. Similarities to the Newark works, and to datable Hopewellian works such as Cedar Bank and Ginther, suggest a relatively late date, perhaps closer to A.D. 400 than to the 250 we have proposed as an approximate date for Newark.⁸

The first prerequisite to any convincing study of the geometry or astronomy of the High Bank site is a complete and accurate survey. The circle-octagon combination can still be traced on the ground and is easily visible on aerial photographs⁹ (see Figure 3). However, nearly two centuries of continuous cultivation have certainly altered the profile and midline of the walls to some degree, and any current survey must be somewhat suspect as to the accuracy with which it reflects the orientation of the original structure. The only two published surveys of the site which include the octagon are those by Squier and Davis and by Thomas.¹⁰ It has been known since the Thomas report that the reliability and accuracy of the Squier and Davis maps are not sufficient for precise quantitative work. The survey of High Bank reported by Thomas was supervised by James Middleton in 1887. We have attempted to assess the accuracy of the Middleton survey in three ways: (1) a comparison of Middleton's results for the High Bank Circle with those obtained by Holmes¹¹ who surveyed the circle in 1892; (2) a comparison of Middleton's survey of Newark with our own survey of that site conducted in 1980; (3) a comparison of the Middleton survey data with a coarse survey of the High Bank site which we made using recent aerial photographs.

The Holmes and Middleton surveys determined that the High Bank Circle

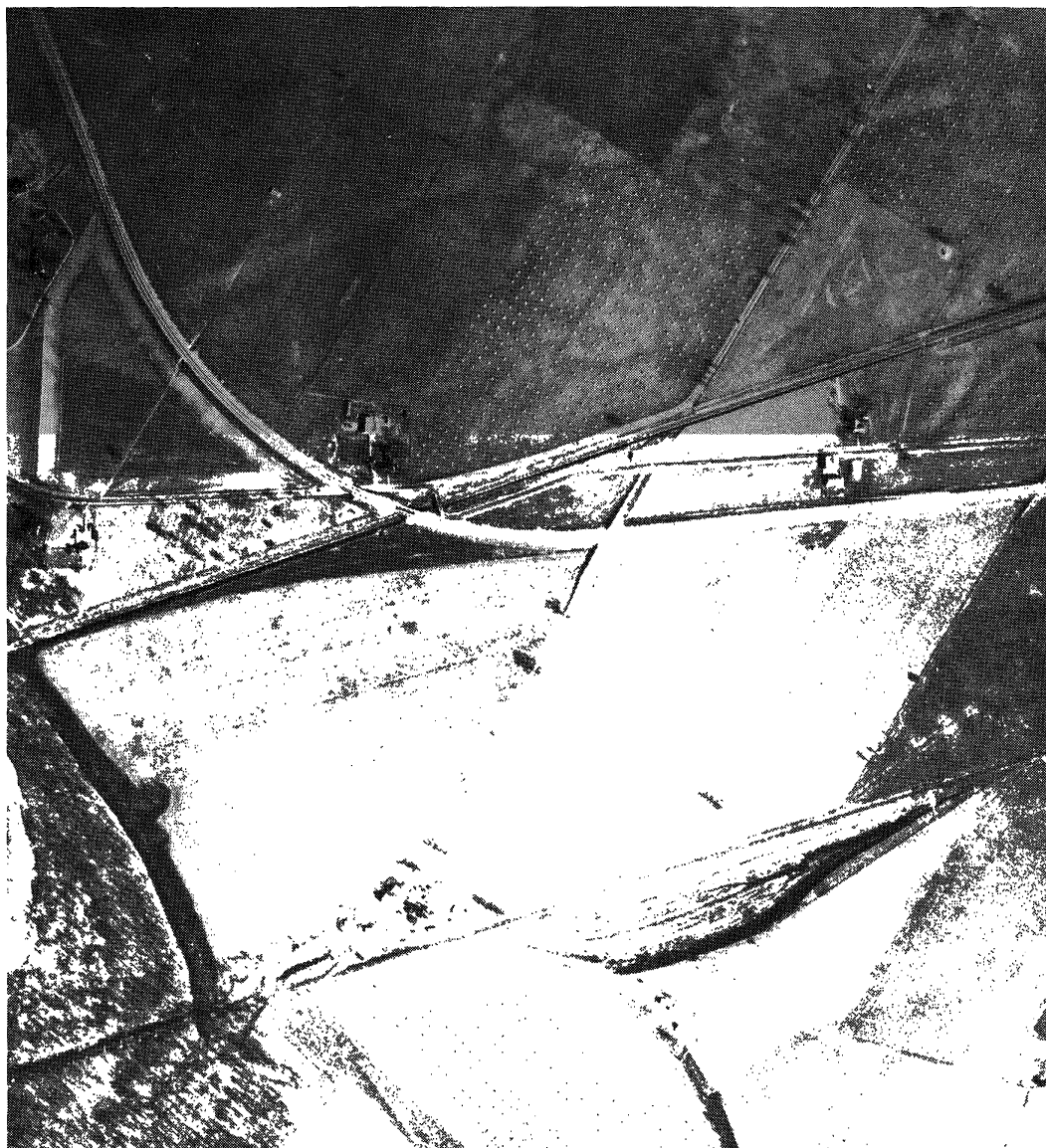


FIG. 3. The remnants of the High Bank Works are shown in this aerial photograph taken by Reeves⁹ in 1934.

was a close approximation to a true circle and their measurements of the diameter of this circle differ by only 1.5 m. Based on our experience in surveying earthworks, we estimate that each of these measurements has a probable uncertainty of 1 m; therefore, we conclude that the two measurements of the circle are consistent. A coarse check of the azimuths which the Middleton survey gives for High Bank was made utilizing aerial photographs taken in 1976 and supplied to us by the Ross County Engineer. This check verified the accuracy of the Middleton azimuths to within $\pm 1^\circ$. The best assessment of the probable accuracy of the High Bank survey is our analysis of Middleton's survey of the Newark site.¹² This analysis shows that the Middleton azimuths had a probable accuracy of $\pm 0^\circ.25$ and the measured distances were

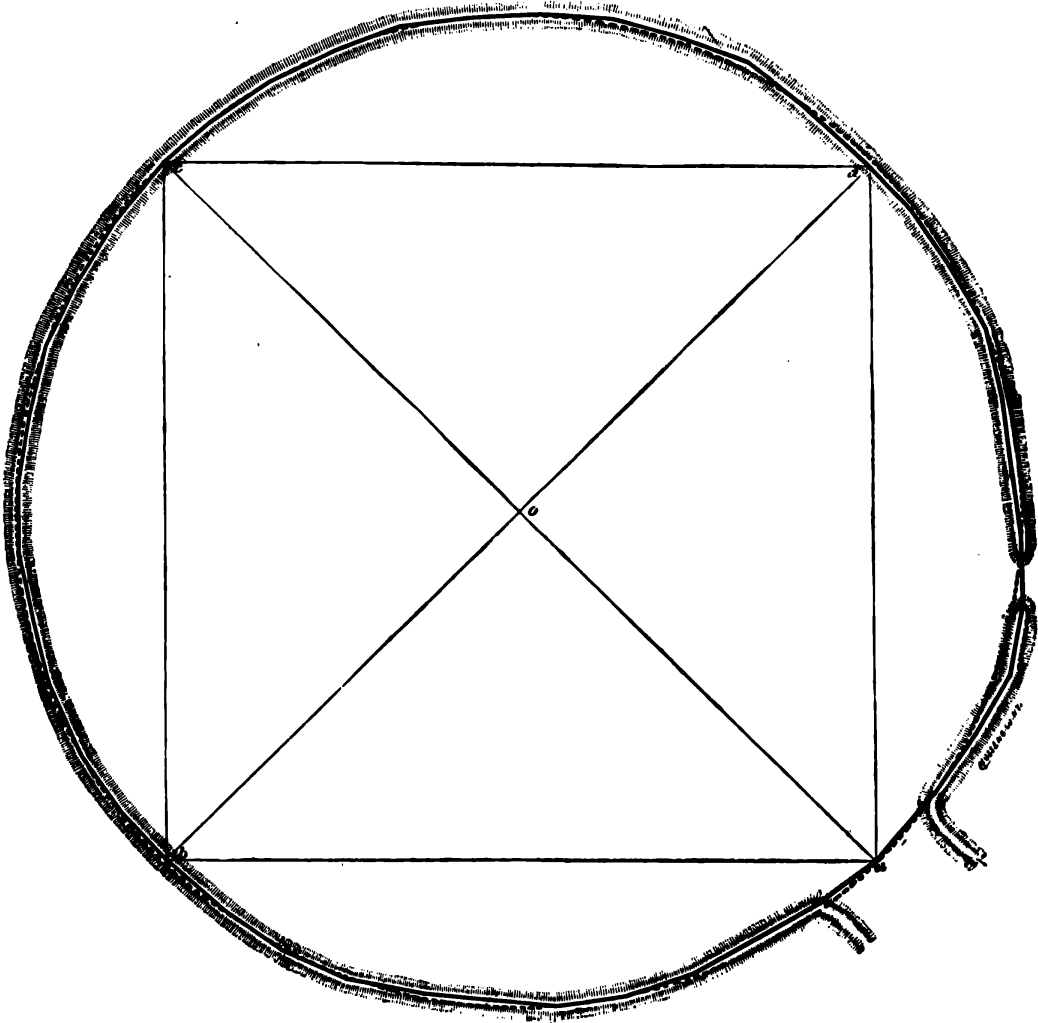


FIG. 4. This is a plan of the High Bank circle taken from the Middleton survey.¹⁰

TABLE 1. The Middleton survey data for the High Bank circle and octagon. The structural features are identified using notation defined in Figures 4 and 5.

Alignment	Azimuth	Distance
c-a (circle)	143°32'	321.9 m
1-2 (octagon)	60°03'	136.6
2-3	136°10'	136.9
3-4	149°43'	134.7
4-5	224°15'	136.9
5-6	240°43'	103.6
6-7	250°41'	19.8
7-8	273°15'	18.3
8-9	306°23'	43.9
9-10	317°03'	84.7
10-11	328°33'	127.1
11-1	43°27'	146.9
5-12	240°43'	143.3
12-10	317°03'	138.1

accurate to about 0.5 per cent. Since the High Bank survey was supervised by the same person and was undertaken for the same purpose, we believe it reasonable to assume that Middleton’s High Bank data have a comparable accuracy. It should also be noted that the Thomas report of the Middleton survey states that the walls of the circle and octagon were prominent at the time of the survey (1887) and were 0.6 m and 1.5 m in height respectively.

Geometry of High Bank

Maps of the High Bank circle and octagon based on the Middleton data appear in Figures 4 and 5. The survey data describing the octagon and circle appear in Table 1. The survey demonstrates that the circle conforms closely to a true circle with a diameter of 320.6 m. It is significant that this diameter is essentially

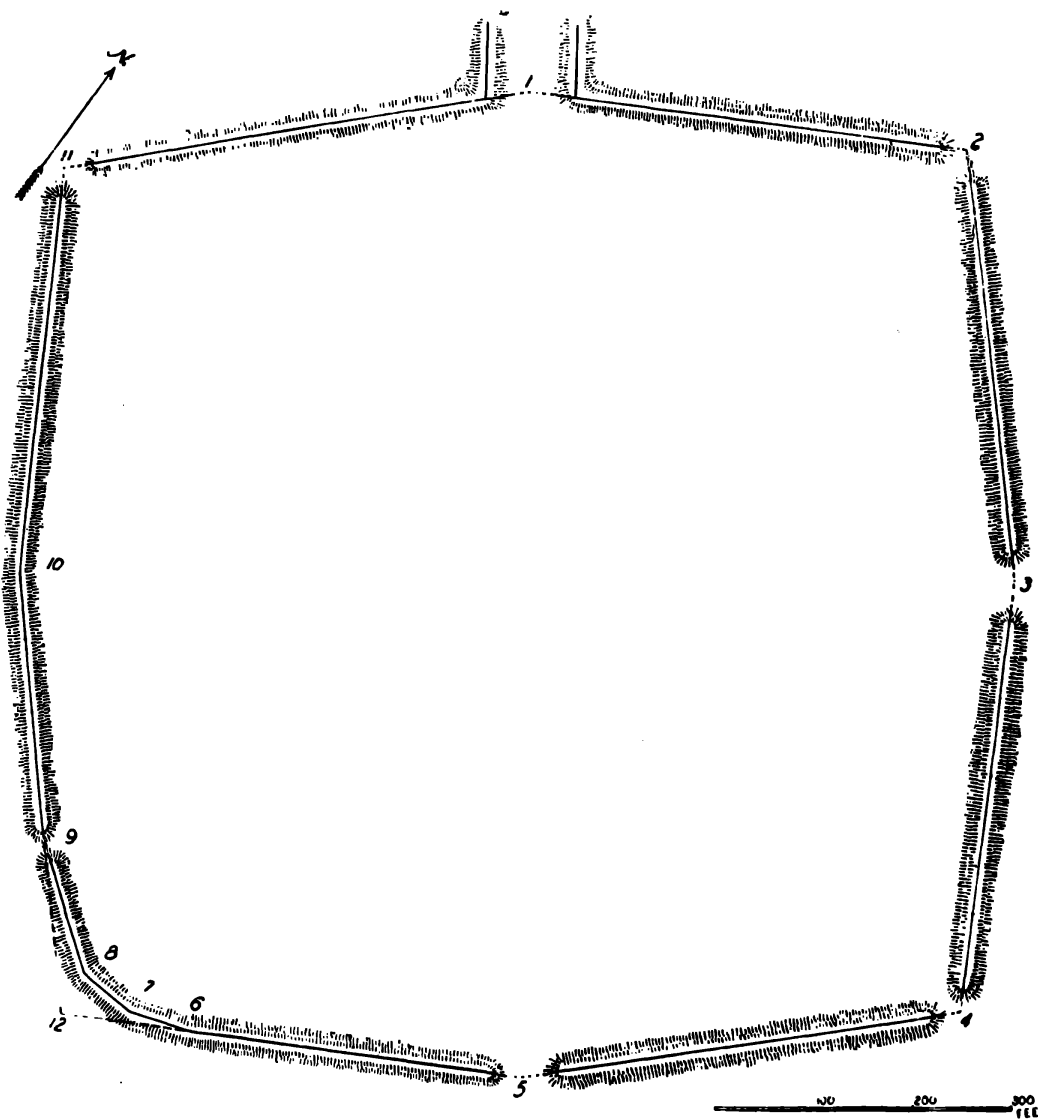


FIG. 5. This is a plan of the High Bank octagon taken from the Middleton survey.¹⁰

TABLE 2. Distances between octagon vertices defined in Figure 5. These were computed from the Middleton survey data and have a probable accuracy of ± 1 m.

Vertex pair	Distance
1-12	321.7 m
2-5	320.2
2-10	321.9
3-12	322.8
3-11	323.2
4-10	321.6
4-1	317.1
5-11	317.6

identical to the diameter of the corresponding circle at Newark (321.3 m), a fact first noted by Squier and Davis. Hereafter, the distance 320.6 m (the High Bank Diameter) will be denoted by the abbreviation HBD.

It has not been noted in previous analyses of this site that the scale of the octagon also appears to be based on the HBD. Consider the distances between octagon vertices shown in Table 2. The eight vertex-vertex distances shown there have a mean value of 320.8 m, which deviates only 0.1 per cent from 1 HBD. The pair of parallel walls (1-2) and (5-12) are separated by 1 HBD within an accuracy of 0.3 per cent; the pair (2-3) and (10-12) are separated by 1 HBD within 0.6 per cent; (3-4) and (10-11) are separated by 1 HBD within 0.6 per cent; walls (11-1) and (4-5) are separated by 1 HBD within 1 per cent. As a consequence the midpoint of each octagon wall lies very close to the circumference of a circle identical to the High Bank Circle and centred on the octagon (see Figure 6). It would seem probable that the scale of the octagon and the associated circle was consciously chosen to incorporate a common length (the HBD) in both figures. Another possible indication of the importance of the HBD in the relation between circle and octagon may be seen in the fact that the length of the circle-octagon axis (from a point on the circumference of the circle to vertex 5 of the octagon) is 650 m or 2 HBDS within 1.4 per cent.¹³ Significantly, a similar (although not identical) harmony of scale based on the same length is present in the structure of the Newark circle-octagon.

Finally, it should be noticed that the portions of the octagon on opposite sides of the circle-octagon axis differ dramatically in their precision. The half of the octagon east of the avenue axis has been laid out with great care. Three of the four sides have the same length within 0.3 m. The length of the fourth side is only 2 m shorter than the others. The western half of the octagon appears to have been laid out with far less care. There are dramatic differences in the length of the sides. Side (11-1) is 16% longer than side (10-11). The wall along side (10-12) is not straight, and the gap which one would expect to be at vertex 12 is located northward along this wall. These departures from symmetry can always be dismissed as due to poor workmanship or economy of effort (as was done by Thomas). However, when one considers the precision and the extravagant expenditure of energy in labour and planning evident in this and other earthworks, we believe it is more reasonable to assume that these deviations may well have been deliberate.

An equilateral octagon with four symmetry axes passing through its centre

has three degrees of freedom: (1) scale; (2) shape (determined by the choice of a single vertex angle); (3) orientation with respect to true north. A full understanding of the High Bank octagon must seek explanations for the choices of these degrees of freedom. We have seen that the scale of the octagon was probably chosen to conform to the scale of the associated circle. The shape and orientation of the octagon cannot be explained in terms of simple and obvious geometrical constructions. Perhaps the simplest way to construct an octagon with parallel sides separated by 1 HBD would be to circumscribe an octagon about a circle with a diameter of 1 HBD. Instead, the designers of the High Bank octagon have chosen a more subtle plan, one whose deviation from a square can scarcely be appreciated from the ground. We will show in the next section that the shape, orientation, and asymmetries of the octagon may have been designed to achieve astronomical alignments.

Astronomical Alignments

We have computed astronomical rise and set points for the High Bank location (latitude $39^{\circ}30'$) for A.D. 250 utilizing the astronomical tables prepared by Aveni.¹⁴ We have adopted the criterion of lower limb tangency to define the rise and set points of the Sun and the Moon. This criterion was chosen because it gave a consistently better fit to the most likely astronomical alignments.¹⁵ We have estimated the altitudes of the horizon using topographic maps. Experience in the field with this technique suggests a probable accuracy of

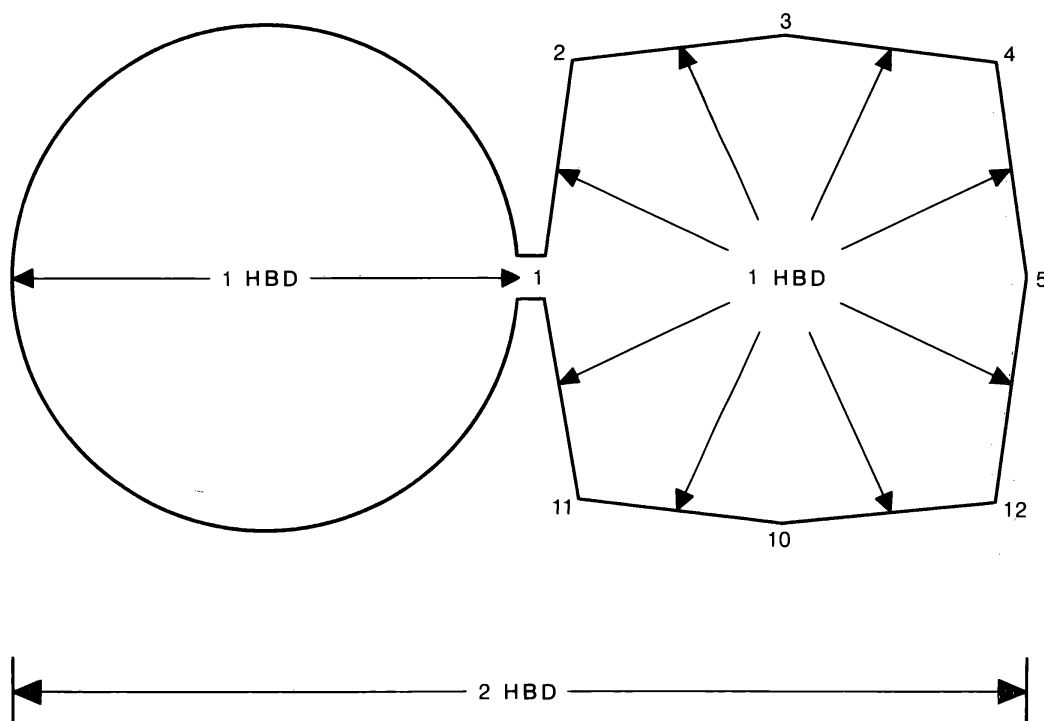


FIG. 6. This drawing shows the harmony of scale based on the HBD (320.6 m) which is present in the design of the circle-octagon combination at High Bank.

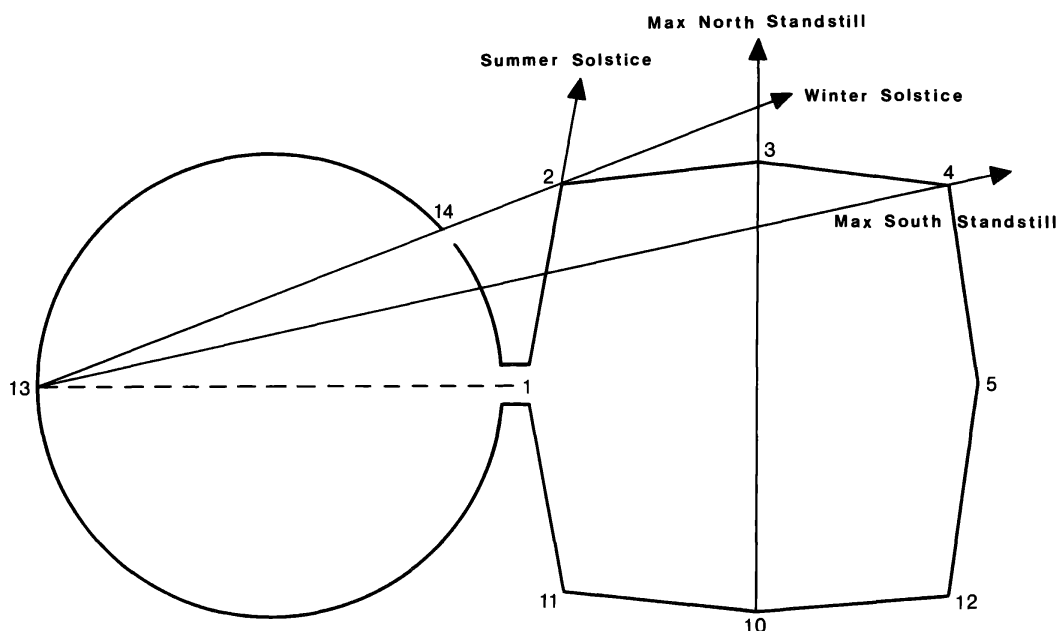


FIG. 7. This diagram shows the four alignments which mark the extreme north and south rise points of both the Sun and the Moon. If deliberate, these alignments would determine the main features of the shape and orientation of the structure.

$\pm 0^\circ.1$ for the computed altitudes. We have also assumed that any trees which might have been present at the time High Bank was constructed had been cleared to such a distance that they had a negligible effect on the altitude of the horizon. In the absence of any reliable evidence on this point, we believe that this is the simplest and most reasonable assumption to make.

When considering possible alignments of the High Bank structure to rise and set points on the horizon, the uncertainty of the date of High Bank makes it necessary to restrict our attention to the Sun, Moon, and planets. The motion of the Earth's axis significantly alters the rise and set points of stars over the time span of a few hundred years. The rise and set points of objects near the ecliptic are not affected significantly over this time scale. We have not uncovered any convincing evidence for alignment with the planets. However, we believe that it is likely that the two angular degrees of freedom associated with the shape and orientation of the octagon were chosen to achieve comparable alignments with the Sun and Moon.

If the structure of the High Bank octagon were astronomically determined, we would expect to find two accurate alignments corresponding to these degrees of freedom. The data and computations displayed in Table 3 show two alignments associated with the symmetrical eastern half of the octagon: (1) wall (1–2) is aligned with the summer solstice sunrise within $0^\circ.5$; (2) symmetry axis (10–3) is aligned within $0^\circ.1$ to the rising point of the Moon at the northern maximum standstill (see Figure 7). The likelihood of the lunar alignment being intentional is enhanced by recalling that the Newark octagon had a comparable symmetry axis (the avenue axis in that case) aligned within $0^\circ.3$ to the same

lunar event (defined by the same lower limb tangency criterion). If one assumes that the only two octagons constructed by the Hopewell were randomly oriented, the probability of their both having a comparable symmetry axis aligned within $0^{\circ}.3$ to the same lunar event is 1 in 700.¹⁶

One would not expect to see more than two alignments associated with the octagon unless: (1) there were an 'accidental' correspondence between the octagonal symmetry and the distribution of astronomical events along the horizon (as we found at Newark); (2) there were deviations from perfect octagonal symmetry in such a direction as to achieve additional alignments (as was also found at Newark). Consider the major deviations from symmetry to be found in the half of the octagon west of the avenue axis. We have noted that the wall (11–1) is 16 per cent longer than wall (10–11). This has the effect of displacing vertex 11 from its ideal position in such a way as to produce a lunar alignment between vertices 11 and 5. This line points to the southern extreme moonrise at the minimum standstill within $0^{\circ}.6$ (see Figure 8). If wall (11–1) had been the ideal length (136.6 m), the alignment 11–5 would have missed the lunar event by $2^{\circ}.4$.

Next we recall that there is no gap located at the position of the ideal vertex at position 12. Instead, the gap has been moved northward to position 9 in Figure 5. A line between points 4 and 9 aligns with the southern moonset at the minimum standstill within $1^{\circ}.1$ (see Figure 8). If the backsight were to be taken

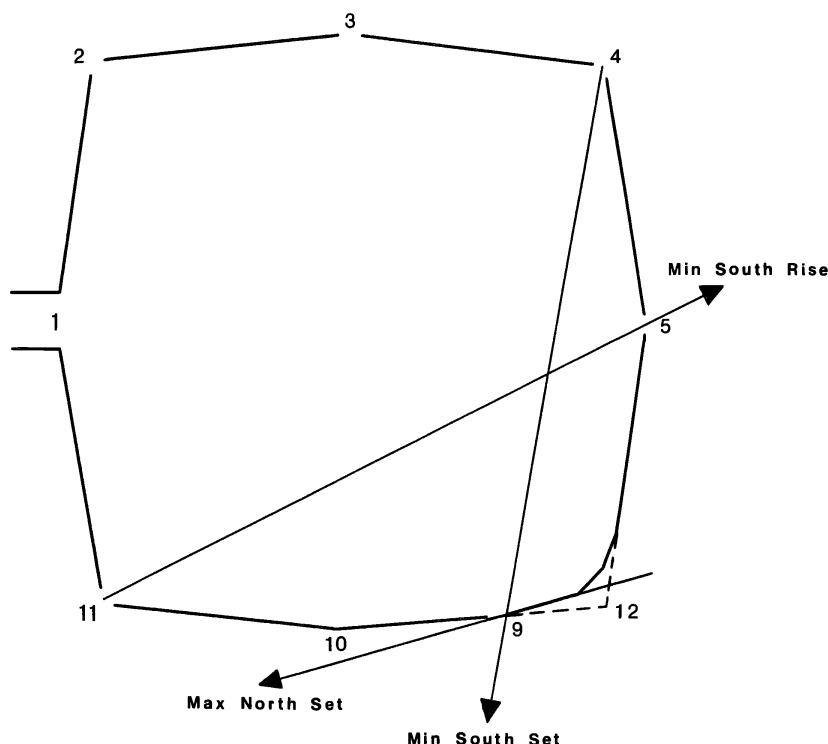


FIG. 8. This diagram shows the three astronomical alignments which account for asymmetries at vertex 11, at the gap at 9, and along the "ideal" wall 10–12.

from the east end of wall (4–5) rather than from the vertex, this alignment has an error of $0^{\circ}.7$. The latter choice of backsight actually seems equally plausible since the vertex would be difficult to identify accurately on the ground unless it were marked in some fashion. Thus, the displacement of the gap to position 9 produces an additional lunar alignment.

Finally, consider the wall trending southward from vertex 10. According to Table 1 and Figure 5 this wall deviates markedly from linearity after the gap at 9. According to the Middleton survey this wall is tolerably straight from position 9 for 43.9 m to position 8. This section of wall (8–9) points within $0^{\circ}.9$ to the northern moonset at the maximum standstill (see Figure 8). Thus, this deviation as well can be understood as an attempt to achieve yet another lunar alignment. Our conviction that these additional alignments should not be dismissed as chance comes in part from recalling a similar pattern of deviations from symmetry for the same purpose in the Newark octagon.

It should be noticed that the octagon design defines four lunar alignments: two rise points and the corresponding set points for the northern maximum and southern minimum standstills. For both standstills the rise points appear to be more accurately marked with the associated set alignments providing a less accurate check. These alignments would be sufficient to monitor the 18.6-year lunar cycle. The astronomical hypothesis also provides a plausible explanation for the builders' puzzling lack of concern for the accurate placement and construction of vertex 12. Vertex 12 is the only one of the eight vertices for which an inexact placement would not seriously degrade the astronomical function of the octagon. The other seven vertices together with the gap at 9 define four different alignments. An accurate placement of vertex 12 would have produced no additional astronomical information. Unlike the other vertices, vertex 12 is astronomically superfluous.

A crucial test of the alignment hypothesis is presented by the avenue axis (defined by the line 1–5 through the centre of the octagon). This axis must have been chosen carefully, and yet it points to no solar, lunar, or planetary event. If no convincing astronomical explanation exists for the direction of this axis, it would seriously weaken the alignment hypothesis. We believe that there is a plausible astronomical explanation for the avenue axis. This axis uniquely defines a point on the circumference of the circle (point 13 in Figure 7). If an observer stands on this point by sighting along the axis, he will be in position to observe the winter solstice sunrise over vertex 2 with an accuracy of $0^{\circ}.5$. Supporting evidence for the plausibility of this alignment comes from the position of the otherwise inexplicable gap in the circle near vertex 2. The winter solstice alignment passes through the left edge of this gap as it has been located by the Middleton survey (see Figure 7). This suggests that this gap was deliberately located to accentuate this alignment. Moreover, it should be noted that an observer standing on the axis–circle intersection would also see the southern extreme moonrise at the maximum standstill over vertex 4 to within $0^{\circ}.7$. The distance between the point 13 on the circle and the foresight (point 4) is 2 HBD within 0.5 per cent, further suggesting that vertex 4 may have been carefully placed with respect to point 13. Thus, this point on the circle serves as a common backsight for observing the extreme southern rising points of both the Sun and Moon (see Figure 7).

If the hypothesis of deliberate astronomical alignment is to be considered seriously, one must ask why the builders would choose to mark only some of the lunar and solar extrema and not others. It is of some interest, therefore, to note that the five additional lunar and solar extrema not mentioned thus far can indeed be observed using the High Bank structure. It must be admitted at the outset, however, that the plausibility of deliberate alignment in these cases rests entirely on the strength of the astronomical context established for the alignments which have been previously described. The width and length of the connecting avenue can be understood in terms of three additional alignments. A line from vertex 4 passing through the vertex (vertex 16 in Figure 9) formed by the wall (1-2) and the eastern wall of the avenue aligns with the summer solstice set point within $0^{\circ}.8$. A line from vertex 2 passing through the vertex (vertex 17 in Figure 9) formed by the wall (11-1) and the western wall of the avenue aligns with the winter solstice set point within $0^{\circ}.2$. If deliberate, these two alignments would explain the width of the avenue. A line from the centre of the avenue (where it leaves the circle) passing through vertex 2 aligns within $0^{\circ}.8$ to the northern extreme moonrise at the minimum standstill. If deliberate, this alignment would account for the length of the avenue. This alignment passes through the vertex formed by the circle and the eastern wall of the avenue (shown as vertex 15 in Figure 9), so that vertex 15 could also have been utilized as a backsight. Finally, by utilizing alignments formed between the ends of octagon walls two additional lunar alignments are found: the southern

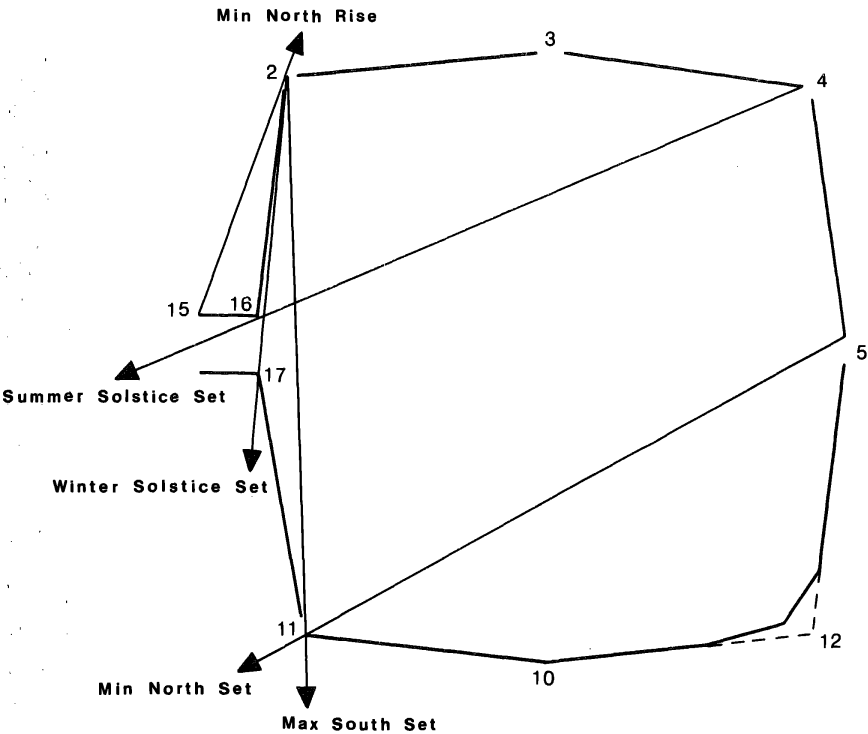


FIG. 9. This diagram shows five additional astronomical alignments which can be obtained in the High Bank structure. If deliberate, these alignments would explain the length and width of the avenue together with the widths of the gaps at several vertices.

TABLE 3. This table summarizes the astronomical alignments which we have found in the High Bank structure. The alignments are identified using notation defined in Figures 7, 8, and 9. The solar events are identified with the solstice designation; the remaining events refer to the lunar standstills. The notation W(10–11) is to be read as the western end of the octagon wall between vertices 10 and 11.

Alignment	Azimuth (Middleton survey)	Horizon altitude (computed)	Astronomical event	Azimuth (A.D. 250)	Error
10–3	53°·4	1°·13	Max. north rise	53°·4	0°
1–2	60°·1	1°·12	Summer solstice rise	59°·6	0°·5
13–2	122°·2	0°·65	Winter solstice rise	121°·7	0°·5
13–4	130°·7	0°·65	Max. south rise	130°·0	0°·7
11–5	116°·0	0°·55	Min. south rise	115°·4	0°·6
4–9	243°·3	0°·71	Min. south set	244°·4	1°·1
E(4–5)–9	243°·7	0°·71	Min. south set	244°·4	0°·7
W(4–5)–N(10–11)	294°·0	0°·55	Min. north set	293°·2	0°·8
2–N(10–11)	229°·5	1°·12	Max. south set	229°·4	0°·1
8–9	306°·4	0°·50	Max. north set	307°·3	0°·9
4–16	300°·1	0°·49	Summer solstice set	301°·0	0°·9
2–17	238°·5	0°·67	Winter solstice set	238°·3	0°·2
15–2	68°·3	1°·28	Min. north rise	67°·5	0°·8

extreme moonset at the maximum standstill and the northern extreme moonset at the minimum standstill (see Figure 9). Thus, as shown in Table 3, all twelve extreme rise and set points associated with the Sun and Moon are incorporated into the High Bank structure with a mean error of 0°·57.

Conclusions

In seeking to evaluate the evidence for deliberate astronomical alignment at High Bank one is confronted with a difficult and unresolved methodological question associated with all investigations in archaeoastronomy. How are we to distinguish between deliberate and accidental alignments? A statistical analysis of the expected frequency of astronomical alignments in randomly oriented and shaped octagons would be helpful here. Such a study would not solve the problem, however. Perhaps the only fact that would command wide agreement at the outset is that the Newark and High Bank octagons were certainly not constructed randomly. The question then becomes: what is the probability that an octagon constructed for a specific non-astronomical purpose would accidentally produce a host of astronomical alignments? Without some knowledge of the degrees of freedom consistent with the purpose of the structure, this question cannot be answered.

The astronomical alignments which we have summarized in Table 3 can be divided into three groups. The first group of four alignments (shown in Figure 7) seems to be the most fundamental and the most likely to have been deliberate for several reasons: (1) these alignments would determine the shape and orientation of the octagon together with the location of the connecting avenue and the gap in the northeastern part of the circle; (2) these four alignments all have a comparable purpose: the marking of the north and south extreme rise points of the Sun and Moon; (3) the alignment along the symmetry

axis 10–3 repeats an alignment found in the Newark octagon; (4) vertex 2 serves as a common foresight for both solstice rise points; (5) vertex 4 is 2 HBDS from point 13 suggesting that these two points may have been consciously associated by the builders. If this first group of alignments were deliberate, then one would plausibly expect the builders to design additional degrees of freedom associated with the vertex gaps to achieve yet additional alignments. Thus, the five alignments shown in Figure 9 might account for these features. Finally, one might reasonably expect the builders to incorporate minor deviations from symmetry into the structure to produce yet additional alignments. We have seen that the three alignments shown in Figure 8 can be understood in this fashion.

We believe that our analysis of the High Bank Works when combined with the even stronger evidence at Newark provides significant evidence that: (1) some Hopewellian earthworks were designed to reflect a geometrical harmony based on a fundamental length of 321 m; (2) some Hopewellian earthworks were deliberately aligned to the extreme rise and set points of the Sun and Moon. These hypotheses need to be tested at as many Hopewellian earthworks as possible. Unfortunately, most of the earthworks have been all but obliterated, and the other surveys in the Thomas report are only fragmentary. Nevertheless, it may be possible to survey additional sites with the required accuracy using ground and aerial surveys combined with excavation. Geometrically regular sites for which some accurate survey data exists would be prime candidates for such investigation. Several such sites are described in the Thomas report.¹⁷ Radiocarbon dates for these sites would also be extremely useful as it would allow the possibility of testing for stellar alignments as well. Excavations taking due note of post holes and other structures which could have been used for astronomical markers would also provide a valuable extension to these studies.

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