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Astronomical alinements in Britain, Egypt and Peru

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[Plates 23 and 24]

Photogrammetric air surveys have been made of Stonehenge, the Great Temple of Amon-Re, Karnak, and the desert lines near Nasca, Peru. The latter designs have been correlated in time with pottery of type Nasca 3 and 4. New astronomical alinements have been found for the trilithons and station stones at Stonehenge. The Amon-Re temple alined precisely, within the limits of present-day measurements, with the rising of the Sun at midwinter at the time of rebuilding of the structure by Tuthmosis III. No significant astronomical alinements were found for the desert lines. The possible significance of the British and Egyptian alinements are discussed together with the implications of the negative result in Peru. Some comments are made concerning the precision of the megalithic yard, and the geometries and stellar alinements of prehistoric British structures.

1. Introduction

(*a*) *Prehistory and astro-archaeology*

If prehistory is defined to cover that period in various localities before the use of written records, then – neglecting those contemporary cultures that, although non-literate, can be studied by verbal communication – the problem of reconstructing the past becomes exceedingly difficult. As Childe (1947) and Daniel (1962) asked: 'How far was it legitimate to infer non-material facts about prehistoric man from the material remains that survive'? Those non-material facts are the perishable qualities of a culture – ideas and ideals, philosophy and religion, knowledge and awareness of the environment. Here we are forced to make guesses, as Daniel puts it; nevertheless, we must make intelligent guesses, while guarding against the dangers of excessive speculation. In the worst extreme, the inherent vagueness of prehistory has been taken advantage of to defend a particular scheme or theory beyond warrantable logic – the hyperdiffusionist theory of a 'heliolithic' race, the theory of unilinear cultural evolution, and the reading of prognostications from the physical dimensions of the Great Pyramid. Yet despite such episodes, which lie so heavily in the academic literature, it is precisely those non-material questions relating to the thought processes of ancient man that are of interest to the modern scholar. Indeed, it is the direction of research indicated by the title of this discussion meeting.

Clark (1970) suggests that, by combining various disciplines within prehistoric studies, we should be able to reconstruct some assessment of the levels of perception and self-awareness, the behaviour patterns, and perhaps the ideology of early man. In reconstructing man's perception of the environment formed by the sky – the observation and marking of the movements of Sun, Moon, and stars – Hoyle (1966*a*) considers it an essential preliminary to ask 'How would *we* do it?' Of course, in this approach, one recognizes the enormous gap in time and culture, the so-called cognitive gulf, where the only common denominator is the calculable movement of the celestial bodies, and perhaps some parallels of response within the human brain.

To a large extent, astro-archaeology relies on material facts – the alinement of menhirs, post-holes, and other prehistoric structures with objects visible in the sky. These alinements, when verified by accurate survey and calculated to the given archaeological epoch, are material facts, as durable as arrowheads, burins, and burials. The alinements are artefacts in their own right, to be considered and assessed with other information in the study of a particular culture. There is no preconceived scheme or theory to be proved in astro-archaeology. Acceptance and evaluation are a matter for researchers in their various areas of expertise. However, acceptance of the alinements *per se* has a tacit but important corollary: the culture in question had knowledge of and an interest in the movement of astronomical objects as a function of time. It is beside the point to argue about the description of this knowledge. We are conditioned by our own vocabulary when we tend to describe the ancient endeavours as 'scientific', though for some prehistorians, as Daniel (1962) points out, the latter word is synonymous with 'modern'. Yet an equally valid description might well be 'magical understanding' (Schwartz 1965). The critical matter lies within the corollary that follows from acceptance of the alinements.

The author (1968) has suggested criteria to be applied in establishing the validity of alinements:

(i) *Construction dates should not be determined from astronomical alinements.*
(ii) *Alinements should be restricted to man-made markers.*
(iii) *Alinements should be postulated only for a homogeneous group of markers.*
(iv) *All related celestial positions should be included in the analysis.*
(v) *All possible alinements at a site must be considered.*

These standards are difficult to apply rigorously in all cases; nevertheless, they provide desirable prerequisites for credibility. The reasons for the choice of these criteria are given at length in the original publication. Early work had been made suspect by lack of attention to these points. Lockyer (1901), in his paper 'An attempt to ascertain the date of the original construction of Stonehenge from its orientation' was at odds with criterion (i). In his suppositions he set himself a series of traps. *If* (so the argument goes) the builders observed the Sun when it was 2′ above the horizon, and *if* they built the avenue to aline with this direction at the solstice, and *if* the engineering accuracy was at the limit of the resolving power of the human eye, then the construction date was 1680 B.C. ± 200 years. Each of these suppositions can be legitimately doubted, and the construction date can now be determined by unambiguous methods. In later work, Lockyer (1906) mixed tumulus and menhir, castle and ditch (see (iii)), used natural features such as hills (see (ii)), and tended to constrain the findings to a particular scheme (see (iv), (v)). His foray into egyptology (Lockyer 1894) collapsed almost entirely on the basis of ignoring criterion (i). Only a small part of Lockyer's work was valid, and archaeological opinion was prudent in rejecting this part with the whole. Earlier work on Maeshowe by Spence (1894) and on Stonehenge by Stukeley (1740), Smith (1771), and others, lacks the precision of survey and detail of computation and falls into the category of speculation.

There are number systems preserved in rings of holes and stones, in rows of objects, and in the notational markings in cave and mobiliary art. These again are material facts and are of significance in astro-archaeology when the numbers correlate with the natural periods of the Moon, seasons and eclipses. Acceptance of the correlation implies long-term observation and assessment by prehistoric man. At the lowest level, acceptance of the numbers has an important corollary: There was a number system, an understanding of numerical values, before the invention of writing.

Stonehenge presented the first comprehensive pattern of astronomical alinements and correlation of number sets with astronomical periods to be discovered (Hawkins 1963). These alinements have been accepted with varying degrees of reservation by Daniel (1964), Newham

(1964), Hoyle (1966*b*), Atkinson (1967), Newall (1967), Thom (1967*a*), and Clark (1970). The perception of astronomical periodicities by the builders of Stonehenge has been accepted by Hoyle, and the significance of the existence of numbers at the site by Daniel (1965).

(*b*) *Sun and Moon extrema on the horizon*

The pattern of alinements at Stonehenge consisted of the solstice extremes of the Sun (four positions) and the high and low positions of the Moon on either side of the solstice lines (eight), as shown schematically in figure 1. There was also evidence for east–west lines corresponding to equinoctial positions. The pattern would, of course, be modified by irregularities in the altitude of the skyline and vary with latitude. The observational phenomena have been fully described elsewhere (Hawkins 1965*a*). Briefly, the Sun appears to move from one arm of the pattern to another in a period of 6 months, whereas the Moon 'swings' in half a month. In addition, the swing of the moon is modulated by the regression of the nodes (direction of intersection of the plane of the Moon's orbit with that of the Earth) so that any particular phase (the full Moon nearest in time to the winter solstice, say) returns approximately to an extreme position after 18.61 years has elapsed. The seasonal Moon returns to an extreme more precisely after three cycles of almost exactly 56 years.

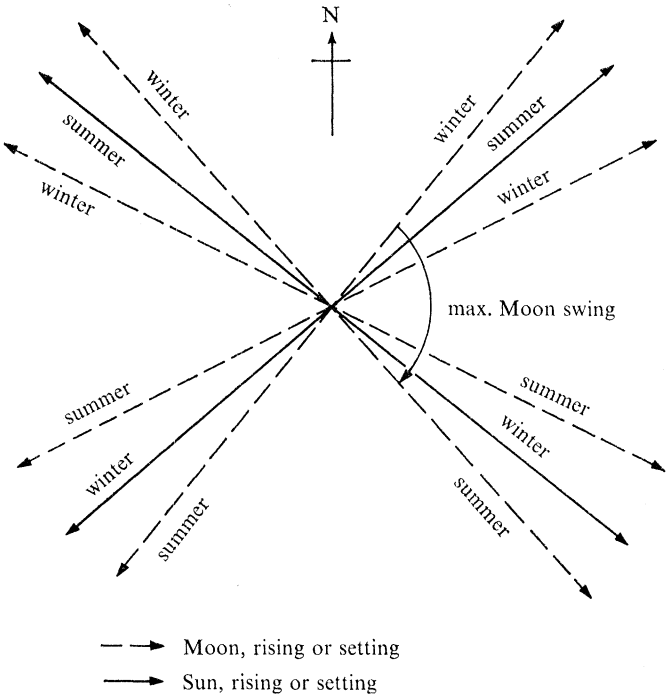

FIGURE 1. The four azimuthal extrema of the Sun at the solstices, and the eight extrema of the Moon.

In passing, it must be said that this pattern of directions was found in the analysis of the structure. It was not a sought-after, preconceived scheme. Also the pattern was not laid out at the site from a common centre, as shown in figure 1. This is a representation more compatible with present-day thinking. Rather, the lines were offset, and, as will be demonstrated later in this paper, very few or perhaps none of the lines originated at the geometrical centre. This peculiarity, if we might call it such, together with the disregard of the conventional north–south meridian, may have tended unduly to delay the discovery of the underlying astronomical basis. Granting that the builders observed, noted, and set the stones and archways to point to natural phenomena, an astronomer comes across a further enigma, a humanistic one – the extrema have no urgent, practical value. The periodicities are, to be sure, connected with eclipses, ocean tides, and the calendric passage of time, but none of these factors would seem to justify materialistically the enormous amount of effort. The reasons seem to be creations of the prehistoric mind. It is sufficient to note that the Sun and Moon are the brightest luminaries, exhibit the greatest movement with respect to the stellar background, and, uniquely for the Moon, show an apparent change of shape from night to night. What meaning was placed on these extrema in prehistory, particularly the Moon extrema, is difficult to imagine in our modern context.

Alinements to Sun and Moon extrema have found at Callanish (Hawkins 1965*b*), at other British megalithic sites (Thom 1967*b*), at Chichen Itza (Morley 1956), and in France (Thom & Thom 1971). Alinements to the Sun only, at solstice and equinox, primarily for calendric purposes, have been found at several sites in Central America, including Uaxactun (Morley 1956) and Monte Alto.

(*c*) *Singular astronomical directions*

It is more difficult to establish credibility for an isolated alinement than for a pattern. To the author's knowledge, the literature contains only one plausible case – the Plataforma Adosada on the western side of the pyramid of the Sun at Teotihuacan, Mexico. The platform is skewed by 6° from the direction of the base of the pyramid and points to azimuth 290.95° east of north (Marquina 1951). This is the direction of the setting Sun when the declination is +19.7°, numerically equal to the latitude of the site. On this day, the Sun passes through the zenith and can be said to have crossed the 'tropic of Teotihuacan'.

(*d*) *Calendric points*

In a general sense, the solar extrema within the pattern of §1 *b* above can be said to be calendric because the year is divided into two, albeit unequal, parts. But unless we accept the offset theory of Hoyle (1966*b*), or the hill and rim-flash techniques of Thom (1967*b*), these solstice dates cannot be observed to the precision of a day. Spence (1894) suggested a year divided into quarters and marked by solar azimuths; Lockyer (1906) extended this megalithic calendar to eighths with prehistoric solar alinements in Britain, and Thom (1967*b*), to sixteenths. Heliacal rising of certain stars, although calendric, is not within the present consideration, because the phenomenon is not alined with the horizon.

(*e*) *Star alinements*

A star rises at the same point on the horizon each night of the year. There is a slow drift in azimuth with a pattern of extrema somewhat similar to that shown in figure 1 and with a period of 26000 years. This drift would become detectable to unaided vision after about 20 years, and a man-made alinement would thereafter become inoperative.

In the author's opinion, the rising of a star is an uninspiring phenomenon. Even the brightest star in the sky, Sirius, can be seen only on less than 10% of the occasions when rising over a sea horizon (personal observations, Costa del Sol, Spain, 1966) and even then it is a faint object, scintillating into invisibility. Nor can the horizon be seen on a dark, moonless night; and when the Moon is up, visibility of the star is impaired. If star alinements exist, one would expect them to be toward stars brighter than magnitude zero at sites with elevated skylines.

Lockyer (1894, 1906) found star alinements for British megalithic monuments and for most Egyptian temples. His work was unsound as judged by criteria (i) to (v), and his attitude toward archaeological facts was pretentious. It is doubtful if any part of this early work is valid. Dow (1967) has suggested an alinement of the streets of Teotihuacan with Sirius, the Pleiades, and certain northern stars. Thom (1967*b*) reported megalithic alinements with 13 stars ranging in brightness down to magnitude +2.† In Lockyer's and Thom's work, construction dates were assumed.

(*f*) *Planets*

Owing to the inclination of the orbit to the plane of the ecliptic, a planet takes up positions similar to those of the Moon, shown in figure 1, but the azimuthal swing and the periodicity are different for each planet. At the time of writing, no prehistoric planetary alinements have been found.

2. Stonehenge, a new survey

The alinements at Stonehenge are to Sun and Moon extrema (§ 1*b*), as shown in figure 1, with the apparent exception of the omission of summer moonset lines, and with the possible addition of equinox lines. The original set (Hawkins 1963), derived from small-scale plans, was criticized by Atkinson (1966) and Hoyle (1966*a*) as showing misalinements greater than might be expected from the megalithic builders. Hoyle considered the misalinements to be deliberate offsets made to aid in observations of the extrema. At least part of the error was inherent in the charts themselves, in the reading of the charts, and in the determination of skyline altitudes from contour maps. A photogrammetric air survey was carried out, horizons were measured, and the alinements were redetermined (Hawkins 1971). Not all the lines could be checked, because some of the original data were derived from holes excavated in the past and returfed. The error was quoted in terms of the angular distance of the object above or below the skyline in the direction of the alinement, the azimuthal error being approximately a factor of 1.5 greater. In general, the new values showed greater accuracy with the root-mean-square error decreasing marginally from 1.1 to 0.9 %. In particular, the trilithon alinement to midsummer sunset (23 to 24 seen through 59 to 60)‡ increased in accuracy from an error of 3.2 to 1.7, midsummer moonrise (8 to 9 seen through 53 to 54) from 1.5 to 0.2, and the extreme moonrise (9 to 10 seen through 53 to 54) from 2.0 to 0.5. The error in the diagonal 91 to 93 remained excessively high (3.6) and was therefore deleted from the set. It would now appear that for station stone 91 to mark a moonrise extreme, some viewing line other than that through the centre of the monument would have to be postulated. Also, the extremely large error for midwinter moonset, declination +18.7°, if it were to be marked by sarcen 20–21 as seen through trilithon 57–58, was confirmed, the error in the original determination being +5.1° and that in the new, +4.7°. In fact, the error is such that the Moon would set within but to the extreme right of the slot. One is not sure whether to identify this as a misalinement accepted by the builders, or a building error. To correct the 'error', the builders would have had to distort the symmetry of the architecture, because the observation lines corresponding to figure 1 are not exactly symmetrical. During the second analysis, it was noticed that station stone 93 was just visible through the archways, and in exactly the correct position, as estimated from the plan, to act as a marker for the Moon. This prompted a new analysis of the trilithons taken as a group standing separate in the absence of the sarcen circle. The results are given in table 1.

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† There are 45 stars brighter than magnitude +2.

‡ The numbers follow the key of the Department of the Environment.

TABLE 1

point	seen from	azimuth	object	declination	error
93	57–58	299.3°	winter Moon	+18.8°	−0.1
91	51–52	118.3	summer Moon	−18.8	−2.9
53–54	57–58	140.7	summer Moon	−29.1	−1.1
57–58	53–54	320.7	winter Moon	+29.1	−1.1
51–52	59–60	138.7	summer Moon	−29.1	−2.2
59–60	51–52	318.7	winter Moon	+29.1	−0.1
55–56	heel	231.4	winter Sun	−23.9	−1.4
heel	55–56	51.4	summer Sun	+23.9	+0.5
H	51–52	142.8	summer Moon	−29.1	−0.1
H	53–54	130.4	winter Sun	−23.9	−0.4

It can be seen that alinements existed *ca.* 1800 B.C. between the trilithons and the outer stones, and between the trilithons themselves. Archaeological evidence (Stone 1924; Atkinson 1960) indicates that the trilithons were erected before the time of the sarcen circle that surrounds them. The astronomical finding therefore raises the question of whether the five trilithons had a period of observational use in the early stages of Stonehenge III, standing as an independently designed structure. Related is the question of whether the construction of Stonehenge III was according to a single, integrated plan or followed a series of developments akin to second thoughts.

Before accepting these alinements as intentional, one must note the excessive error in 91 as seen from 51 to 52. This line can be ignored without affecting the possible validity of the remainder of the table. After the Stonehenge alinements had been published, hole H was seriously questioned as to whether it was a man-made feature (Atkinson 1967), but the point has appeared again with significance in the computer output. (Could there be a corresponding point, H′, in the undug western sector?) Arguing on the positive side for acceptance of table 1, it should be noted that (i) all extrema of the pattern are marked (±18.8°, ±23.9° and ±29.1°) either at rising or at setting or at both; (ii) the accuracy of the previously suggested Moon diagonal in the station stone rectangle has been considerably increased because the trilithons are to the north and south of this line (indeed, there may have been some type of central structure at the time of the rectangle whereby the observing points were offset from the geometrical centre); (iii) trilithon 57 to 58 appears from the stereo plan (Hawkins 1971) to be rotated noticeably in the counterclockwise direction when compared with its corresponding partner 53 to 54, and this rotation places it squarely to face 93, the accurate far-sight to the Moon. These items are, of course, no more than conjectures and are offered for consideration within the total archaeological study. Table 1 has been included for completeness of data, and the astro-archaeological hypothesis does not stand or fall on its acceptance.

3. LINES IN THE NASCA DESERT

In the dry foothills of the Andes, many areas have been found – from the Cantogrande valley near Lima to the pampas of Jumana and Colorada near Nasca – where huge geometrical and figurative markings are inscribed on the desert pavement. The areas were formed by the erosion of thick alluvial fans, leaving a natural pavement of irregular pebbles, reddish in colour and blackened on top by desert varnish. When the pebbles are lifted or scraped away, the light yellow subsoil is exposed. A typical high-altitude photograph is shown in figure 2, plate 23. The ancient lines have been described as a gigantic astronomical calendar by Kosok (1949) and Reiche (1949, 1968), with features pointing to the solstice Sun, the Moon extrema, and stars.

Two areas were chosen for study by the procedures established for Stonehenge and other sites (Hawkins 1968). One was near the Ingenio valley, long. 75° 08′ W, lat. 14° 42′ S; the other, near Nasca, 74° 59′ W, 14° 49′ S. The results were negative on all counts – the lines did not show significant alinement with Sun and Moon extrema, stars, planets, or any currently unidentifiable astronomical object of fixed declination.

In an attempt to derive an archaeological date, a search for pottery shards was made in a traverse 2 km in length and 5 m in width. The most frequent occurrence was of styles 3 and 4 in early Nasca ware,† which corresponds to dates between 100 B.C. and A.D. 100 (Rowe & Menzel 1967). Although it is likely that the lines are contemporary with this pottery (since the fragments are scattered over the surface and whole pots have been found on mounds within the lines), it strictly indicates no more than that the lines predate the pottery. The analysis was therefore performed for the first centuries A.D. and B.C. and for a few previous millennia.

To summarize: All linear features in the area were measured (criterion (v)), and these were tested for Sun and Moon extrema and for all stars brighter than magnitude + 2 (criterion (iv)). Reiche, on the other hand, computed for only a few selected lines. A total of 30 overlapping, high-resolution air photographs were taken and a photogrammetric plan was drawn to the scale of 1:2000. Altogether, 93 linear features were measured, and since each could be viewed along two directions, this gave a total of 186 azimuths for consideration. Some of the lines extended beyond the edge of the charts to a distance of several kilometres.

Allowing an error of up to 1° in declination, we would expect about one direction in 10 to correspond, purely by chance, with one of the 10 Sun or Moon extrema or equinox positions, as given in § 1*b* above. Actually, 39 of the alinements matched the Sun or Moon positions. A closer inspection of the computer output showed that only a few of the 39 correlations were made with significantly differentiated lines. Thus, the hypothesis of a Sun–Moon pattern fails to account for the majority of the lines, even if we agree to reserve our judgement on the few that appear to fit. In the latter category, it is pertinent to note that the large rectangle, perhaps the most prominent feature in the area studied (figure 2), points to the winter Moon extreme at declination 18.5°. However, there are no matching rectangles for any of the other seven extrema taken up by the Moon in its 18.6-year cycle.

Alinements were computed for the 45 stars brighter than magnitude + 2 and the Pleiades cluster (an asterism of interest in Pre-Columbian cultures). Each star changed approximately 0.36° in declination during the course of a century. Because of the circumpolar areas in the sky, the declination for a line is limited to a range of 150°, between ± 75°. Thus, we would expect by chance approximately $(46 \times 0.36)/150$ stars per century along a given direction, or 0.11. In actuality, there were on the average 0.09 stars per line per century over the period 5000 B.C. to A.D. 1900, thus confirming the probability estimate. For the period of archaeological interest, 100 B.C. to A.D. 100, the averages were 0.05 and 0.06 stars per line per century, values again indicative of zero correlation.

To test for alinement with currently unidentified objects of fixed declination (such as the centre of a prehistoric constellation, nova, or planetary configuration), we adopted the follow-

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† Sometimes the word is spelled 'Nazca', following an older rendering of the name of the nearby town. The modern spelling on maps and on location is 'Nasca'.

ing procedure. The lines at the Ingenio site were divided into two groups (east and west of the Panamerican Highway, which is the dark, oblique line in figure 2). We computed the number of duplicate declinations in the sets. This would show whether a particular astronomical object had been used to fix the direction of certain of the lines in both groups. We expected 27 coincidences on the basis of chance; 33 were found. This was an insignificant excess. Similarly, there was no evidence of duplication between the Ingenio site and Nasca farther south.

Thus, the line complex could not be accounted for by astronomical alinements to the stars, Sun, Moon, or planets. This somewhat unfruitful exercise in astro-archaeology tends to negate the lurking feeling that alinements might perhaps be found with any ancient structure. Astronomically speaking, the lines in the Nasca desert are random. Speculations as to their purpose have been given elsewhere (Reiche 1968; Hawkins 1969, 1973).

4. The temple of Amon-Re at Karnak

The majority of Egyptian temples are river-oriented – that is, they face the Nile whether they are on the east or on the west bank. Furthermore, Posenor (1965) has cited evidence to show that the river was regarded as a fundamental direction, as a general north–south meridian. It would therefore seem superfluous to examine these river temples for astronomical alinement. However, in the case of the temple of Amon-Re, Barguet, in his definitive work (1962), concluded on the basis of architecture and inscriptions that the structure had a cosmic or astronomical significance. On the same evidence, he inferred that the temple pointed not toward but away from the river, to the desert to the southeast. It is therefore of interest to compute the declination of this particular axis.

A preliminary measurement was obtained from the air-survey charts of the Franco-Egyptian Centre at Luxor, as well as from German maps of the terrain made in World War II. There was a major rebuilding of the temple, particularly the Hall of Festivals, by Tuthmosis III. Hayes (1961) gives the reign of this pharaoh as established by various authorities, from which one can estimate the date of rebuilding to be *ca.* 1480 B.C. At that epoch, the obliquity of the ecliptic was 23.87°. Calculations show that the declination of the Sun, with disk tangent to the skyline and centred on the axis, was $-23.9°$, with an estimated error of 0.2° arising primarily from the reading of the maps. Thus, with a concordant declination, the temple pointed to the sunrise at the time of the winter solstice. For Amon-Re, this alinement was precise to within the limits of measurement ($\pm 0.2°$); the accuracy might be found to be further improved if ground surveys were taken. Because of the slow change in obliquity, the pointing to the midwinter sunrise would be an observable phenomenon for many centuries before and after the assigned epoch. The alinement is a property of the structure – a material fact. Whether it was an intention of the builders so to mark the southern extreme of yearly sunrises is difficult to establish. One cannot readily turn to criterion (v), because, as has been pointed out, the temples of the Nile seem to aline, in the first instance, perpendicular to the river. Nor can we expect the evidence of support to be clearly shown in the hieroglyphics, because the inscriptions are rich in metaphors, allusions, and ambiguities; nor do the writings describe the pharaonic knowledge of what we call physical science with exactitude. The calendar system and the method of reckoning time, for example (Neugebauer & Parker 1960; Parker 1950), were deduced from fragmentary data, not from a definitive text.

Barguet (1962) describes a small temple on the roof of the Hall of Festivals at the northeast

FIGURE 2. Ancient markings in the desert near the Ingenio valley, Peru. The large rectangle is approximately 800 m in length. The oblique, dark line is the Panamerican Highway.

(*Facing p.* 164

Figure 3. Position of the exterior stairway leading to the High Room of the Sun on the roof of the Hall of Festivals, in the Great Temple of Amon-Re.

Figure 4. Lower portion of window in southeast wall of roof temple dedicated to Re-Horakhty. This window was probably used for observations of the midwinter sunrise. The distant mud-brick wall was built several centuries after the temple.

corner. This was approached by an exterior stairway, now removed, the position of which is shown in figure 3, plate 24. Over the stairway was an inscription that Barguet attributes to Tuthmosis III. On the interior walls the temple was dedicated to Re-Horakhty – that aspect of the sun god when on the horizon – and there is a mural depicting adoration of Re-Horakhty† with the figures directed toward the east. This roof temple is parallel to the Hall over which it is built and, therefore, parallel to the axial direction of the Great Temple. There is the sill of a window (figure 4, plate 24) in the southeastern wall of the roof temple through which the winter sunrise could be observed. The distant temenos wall that blocks the view of the skyline was built later, probably in the reign of Nectanebo I (Habachi 1970). If, as Barguet states, the roof temple was open to the sky, the purpose of the window clearly was not for interior illumination, and therefore an observational function is feasible. Barguet draws attention to an inscription in the Hall of Festivals, referring to the initiation of a priest, Hor, under Takelot II. This text is somewhat obscure because of the poetic style, but Barguet takes it to refer to this small roof temple: '. . . one climbs to the (Aha), lonesome place of the majestic soul, high room of the ram (or spirit) which traverses the sky: one there opens the doors of the horizon of the primordial god of the two countries, to see the mystery of Horus shining'. Barguet reads 'Aha' as 'place of combat', and although this can be taken as an illusion to the legendary site of warfare between Upper and Lower Egypt, he argues for a more literal reading – that place where Re-Horakhty overcomes the enemies, that place where the sun god is reborn, the position of the sunrise. The astronomical result, shown by the preliminary measurements of this paper, supports the literal interpretation. The sunrise is marked out by the narrow slot of the axis. In addition, the sun god might be regarded as having overcome more serious obstacles than the powers of darkness – the solstice on the ecliptic, the low point of winter.

With regard to river orientation, it is interesting to note that the Nile makes its greatest meander away from the north–south meridian at Thebes. This stretch of approximately 50 km is the only one between Aswan and Cairo where a temple can be oriented precisely toward the midwinter sunrise and yet remain roughly perpendicular to the Nile. Other river-oriented temples in this stretch might therefore show solar alinement. Amon-Re, on the east bank, points astronomically away from the river. The Colossi of Memnon, on the west bank, face toward the river and, on the basis of available maps, again show an alinement to the rising Sun at midwinter.

L. Habachi (personal communication) has suggested that solar orientation might be found, not with the axes of major temples placed near the river, but with subsidiary chapels associated with these temples. In this regard, the side chapel at Abu Simbel is of interest. As at Karnak, it was dedicated to Re-Horakhty and may originally have been built open to the sky. From a preliminary study of archaeological plans, it appears to have been oriented toward the Sun, rising tangent on the horizon, at midwinter. The directions at Abu Simbel required the side chapel to be skewed through an angle of about 15° to the axis of the main temple and to the perpendicular to the Nile.

5. COMMENTS

The works described in the previous sections relate to separate cultural lenses and must be considered separately. If there is a common denominator in man's construction of sky alinements, it can only be construed as evidence for parallel development within the cultures.

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† Edwards (1972) attributes the introduction of this deity to Amenophis III.

Although there were a scattering of astronomical lines in the Peruvian analysis, the major portion of the desert pattern seems not to be so alined. The alinement at Karnak is for a single temple and must therefore be regarded as a tentative result, although it is the most important temple complex in Egypt and there seems to be internal evidence for the astronomical significance of the temple in the hieroglyphics. The new alinements, found at Stonehenge, based on the trilithons and perimeter stones, may not be important in themselves, but become significant when added to the number of alinements found previously for the site.

If we concede a similarity in the critical faculties of modern and prehistoric man, it is not surprising to find evidence for a knowledge of astronomical alinements and periodicities. The work required no more than watching for and marking a natural event – counting, remembering, and/or recording. As Stahlman said (Stahlman & Gingerich 1963): 'Celestial phenomena – ranging from stellar risings and configurations, to novae, comets, and solar, lunar, and planetary risings and positions – seem always to have appealed to the human psyche as at once incontestable and, in a sense, unique events. Time is measured in and by the heavens. Man has always sought to reduce celestial uniqueness to repetitive patterns and thus to "understand" them, but he has also learned that the patterns are never quite complete.' Stahlman was writing primarily within a historic context, but it is not unreasonable to extrapolate this statement, a short way at least, into prehistory. Hoyle transposed his own mind into prehistoric Britain with the question 'How would *we* do it?' He concluded that 'an excellent procedure for "us" to follow would be to build a structure of the pattern of Stonehenge, particularly Stonehenge I'.

On the other hand, it *is* surprising (Hawkes 1967) if one equates intellect with the arts and a certain style of graceful living, and if one expects an understanding of numbers to come with or after the invention of a written script.

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