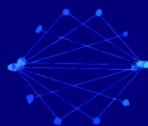


The objects called “penannular” and “annular brooches” appear to be what they are described as being, namely “brooches”. They have a decorative appearance, are round in shape and have a pin that may be used to attach them to clothing. Many are quite large for a brooch and heavy and the pins are longer than one might expect to be useful for attaching them but apart from these seemingly minor details they are accepted as having been used as decorative brooches and the larger more elaborate brooches considered as examples of valuable decorative high-status “bling”. There is though on closer inspection a detail that is interesting which might explain the primary purpose of the brooches as something other than decorative items namely the upper surfaces of the brooches which are decorated with raised features that create discreet channels in which the long needle can sit snugly across the top of the brooch. The raised decorative features or stops are constructed from amber or glass beads and the cast metal of the ring itself. When the alignments of the long needle are examined as it sits in the different channels, it appears that the bearing of alignments creates a similar radial pattern to that observed with the Neolithic Stone circles with alignments between the stones and the viewing positions on the perimeter of the circle. When the penannular brooch is aligned so that the gap in the ring faces due East the channels on the brooch surface allow the needle to align with the Sun on the horizon at sunrise. The extreme North-East and South-East channels in this orientation allow the needle to align with the rising Sun on the days of the Summer and Winter solstices respectively. The other channels between these extreme positions appear to align with the rising Sun on days when important bright stars appear due South in the sky at Civil Twilight. When the gap in the penannular brooch is aligned due West, a similar pattern of needle alignments is seen but this time with the setting Sun on the horizon. In other words, the brooches seem to be a portable development of the stone circle, and the Nebra Sky Disc, a calendrical sighting device for telling the time of the year which allowed special festival days to be determined when the Sun on the horizon aligns with the brooches long needle when it sits in the discreet channels provided on the brooch’s surface. It seems likely that the calendrical brooches were carried around by pinning them to cloth in the manner of a brooch but that their primary purpose was that of a calendar following the movement of the Sun along the horizon with the passing seasons and being able to indicate special festival days dedicated to stellar deities on the days when the star associated with that deity appeared due South in the sky at Civil Twilight.



Annular and Penannular Rings – Brooches or Portable Stone Circles?



It is a little frustrating that having described the incredible astronomical abilities and measurement technology of the Picts from five thousand years ago that the only instruments or tools relating to those abilities that have been found or survive as artefacts from prehistoric times are the stone geodesic spheres and the comb objects which are in any case hardly obvious as measurement tools. There are no artefacts that could be considered as a quadrant, nor a Z-rod compound pendulum, nor a clay ball maker all we have are images carved in stone that we have interpreted as representing those astronomical tools. There are stone circles, cairns, brochs and pyramids which all appear to support the proposed pendulum-based measurement system and the existence of a sophisticated pre-historic calendrical and astronomical technology but little in the way of metal artefacts as evidence of this. Perhaps it is not surprising that artefacts some 2000-5000 years old would not survive the ravages of time particularly in the Scottish climate. However there is another concern, given that the Picts were using stone circles as calendrical monuments from around 3000BC and that the Gregorian Calendar and Christian festivals were not fully accepted in Scotland until over 3500 years later it seems likely that the old stellar festivals would have continued to have been celebrated for over three and a half millennia and that in the absence of a written, date-based calendar the people would have needed some way of determining when the festival days were imminent. If we assume that stone circles had ceased to be used by the time of the Pictish Class I stones, due to precession causing the stone-Sun alignments to no longer occur on the days of the festival stellar alignments due South, we are left to wonder how the people determined when to celebrate their festivals. If the Picts continued to celebrate the same festival days indicated by the alignment of the constellation deities right up until the carving of the Class II Pictish symbol stones, as suggested by the

continuing use of the same stellar symbols on these later stones, there is a gap in the artefacts for a monument or tool which could have fulfilled this calendrical function.

There is no evidence for the development of a different type of circle though perhaps if the later circles consisted of wooden posts then they may have decomposed and disappeared without obvious trace. On the other hand, perhaps a smaller more convenient instrument was developed in line with the usual pattern of human invention and endeavour where objects which fulfil a specific function tend to be developed into smaller and smaller objects as people invent ingenious ways to make more compact and convenient portable tools.

It might be expected that such an instrument, if it existed, from this more recent time would have had a better chance of surviving as an artefact into the present era. The question resulting from this train of thought is, if such an artefact had survived into the present era what was it and how could it have escaped being identified as a calendrical tool? It seems improbable that there is a class of artefact dating from before and around the time of Christianity in Scotland whose true purpose has been forgotten and that nobody has even suspected its true purpose.

As with the case of the Stone-Age geodesic spheres all we have to do is to look again in the museums for artefacts whose description is in some way unsatisfactory in fully explaining their design. Such a class of object exists and there are many examples on display in the National Museum of Scotland, in fact there are scores of these precious silver objects on show in different display cases dotted around the early history section of the museum in Edinburgh. Given our tendency to identify objects by their similarity of appearance to objects that we know about, it is perhaps not surprising that an object that shares a similarity of form to a brooch is identified as such. Although we understand sundials and how they were used to tell the time before the invention of mechanical clocks and watches, it is not known how the date could have been measured using a device before the advent of the paper calendar. The identification of ancient ornate rings fitted with long pins therefore as being merely decorative objects is therefore unsurprising. Although these objects were worn pinned to clothing, this does not prove that they were exclusively used for decoration or fastening of material, perhaps wearing the devices as "brooches" was just a means of carrying a device that had a useful purpose in indicating the time of year in the same way that a watch worn around the wrist today is more than a decorative bangle.

Cloak Fasteners

The Pictish and Celtic brooches are currently believed to be cloak fasteners. Our acquaintance with current pin brooches tells us that these ancient artefacts are just an ancient version of a long line of clothes fastening and decorative objects based on the similarity of design, their ornate decoration and the presence of a pin. Examining the ancient brooches more closely, we find there are two different brooch-types which though sharing many of the same design features, differ in one critical aspect with respect to their proposed function as clothes fasteners, namely the penannular brooches as used in Pictland have a gap in their ring and could have been used to fasten material as the pin could be made to pass in and out again of the cloth material before passing the end of the pin upwards through the gap in the ring and then rotating the ring through 90 degrees to secure the brooch to the cloth. The other type of brooch however is annular, in other words the brooch consists of an unbroken circular ring so that the pin cannot be fixed in the same way as it cannot pass through the ring to fix the cloth to the brooch. Whilst it is possible that some other way may have been used to fix the pin, such as pulling the cloth up through the central hole in the brooch and then piercing the cloth, it is difficult to understand why a device meant to fasten material would be designed in such an inefficient way and we might logically ask whether the fact that the penannular brooches could have been used to fasten cloaks was incidental to their purpose, perhaps a useful feature that allowed the owner to carry the brooch but that the brooch itself served some other more important use.

The first clues as to the brooches true function comes in the form of the elaborate decorations on the brooches. Both annular and penannular types of brooches have been found in Scotland, the penannular form representing the Pictish brooch and the annular brooch from the lands occupied by the Scots in the South West of Scotland.



Figure 1 The Rogart Penannular Pictish Brooch

The Rogart brooch from Inverness shire and the Hunterston brooch from Ayrshire represent good examples of the penannular and annular brooch types. The first thing that strikes you about some of these "brooches" is their surprisingly large size: the Rogart brooch for instance has a diameter of 12cm. The design features of the Rogart brooch include a square formation of birds' heads at either end of the ring around a dot and circle and a triple-disc-type arrangement of two birds' heads either side of another circle and dot pattern at the central section of the brooch. The three large circles with central dots themselves form a triangular formation. These patterns may represent more than ornamentation and we have seen how the Pictish symbols of the Square, Triple disc and Triangular arrangement of Circles represented the Square of Pegasus, the constellation of Sagittarius and/or the Saturn Nebula and the star formation known as the Summer Triangle.



Figure 2 The Hunterston Annular Brooch

The Hunterston Brooch found in the 1830's in Ayrshire, Scotland has a diameter of 12.2cm and is intricately fashioned from silver gilt, decorated with filigree gold and amber beads. The end of the needle has broken off and several amber beads are missing, but the filigree gold inlays are complete. On the reverse side, the Ogham script scratched into

the silver ring is believed to have been done by its Viking owner perhaps two centuries after it had originally been crafted.



Figure 3 Reverse side of the Hunterston Brooch showing filigree gold panels and the later Viking Runic Inscription

The Hunterston brooch has four decorative clues as to its true purpose in its design; two heads resembling the Pictish Kelpie symbol protrude from either side of the ring and is also replicated in several of the filigree gold panels; complete with their water spouts, whilst at the head of the pin there appears to be a Triple disc pattern again similar to the Pictish symbol representing Sagittarius or perhaps more importantly, the Saturn Nebula as it is positioned above the head of and therefore acts as a marker for the festival of the Great Cat-head God, Capricorn. The brooch is decorated with amber beads in the Pictish tradition, suggesting a trading link with the Baltic countries, from where the fossilised tree resin originate. The positioning of these beads is interesting in that the head of the pin is decorated with a triangular arrangement of amber beads and the main body of the brooch itself is decorated with a square arrangement of beads. Perhaps once more these patterns reflect the stars of the Summer Triangle and the constellation of Pegasus.



Figure 4 Rogart Brooch

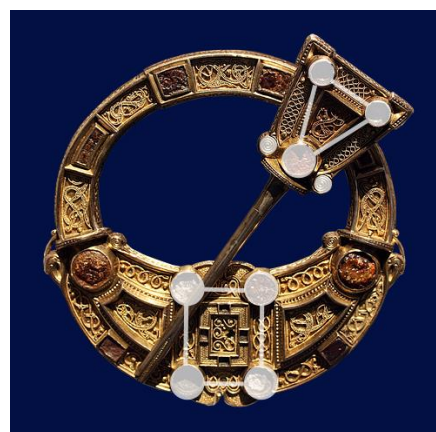


Figure 5 Hunterston Brooch

In these two brooches we see the common representation of the Summer Triangle and Winter Triangle representing the two triads of brilliant stars formed by Deneb, Vega and Altair and Betelgeuse, Sirius and Procyon respectively. The constellation of Pegasus is

represented by the square and the constellation of Sagittarius and the Saturn Nebula represented by the Pictish Triple disc symbol.

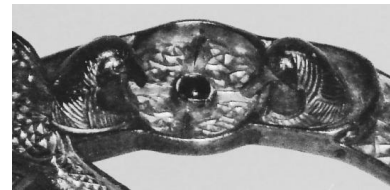
Meanwhile on the Hunterston brooch, the additional constellation of Monoceros is represented by the Pictish Kelpie.



Detail from Hunterston



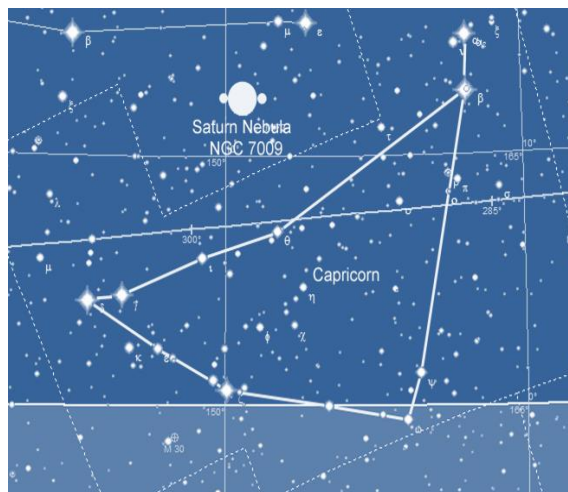
Pictish Triple Disc Symbol



Detail from Rogart Brooch



Saturn Nebula NGC7009



Saturn Nebula above the Cathead Constellation of Capricorn

Figure 6 Saturn Nebula and its possible depiction on Pictish Stone as the Triple Disc (which also represents the constellation of Sagittarius) and on brooches and its position relative to the constellation of Capricorn

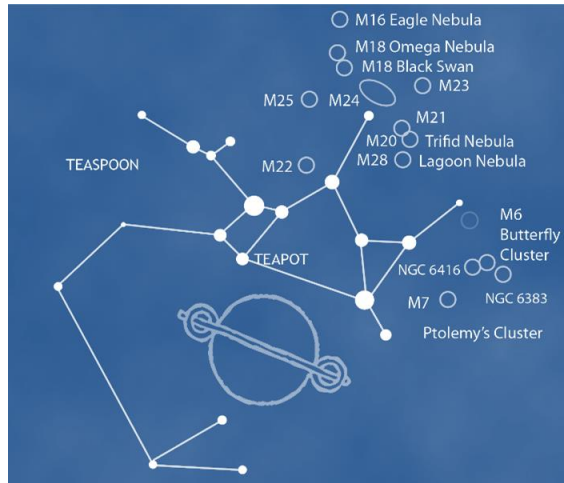


Fig 7(i) The Pictish Triple Disc Symbol representing the Constellation of Sagittarius (“The Teapot”)

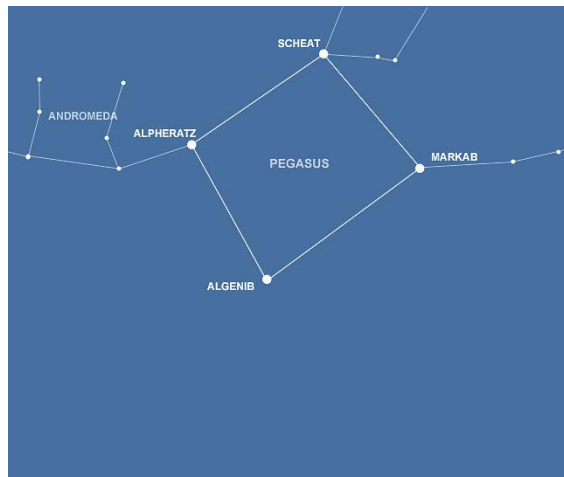


Fig 7(ii) The Square of Pegasus

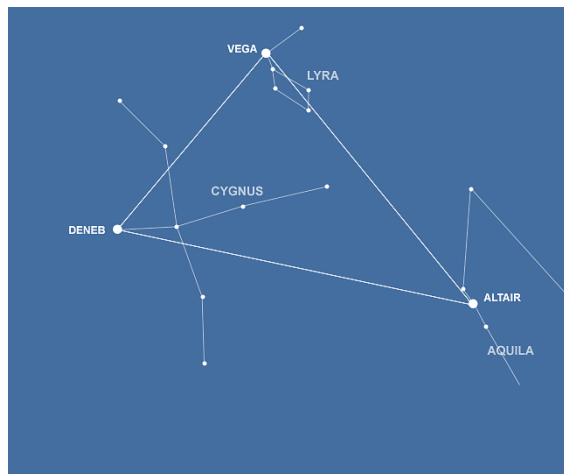


Fig 7(iii) The Summer Triangle of Deneb, Vega and Altair in the constellations of Cygnus, Lyra and Aquila

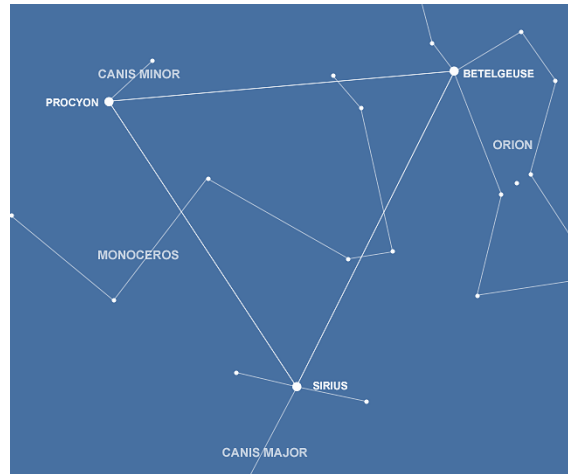
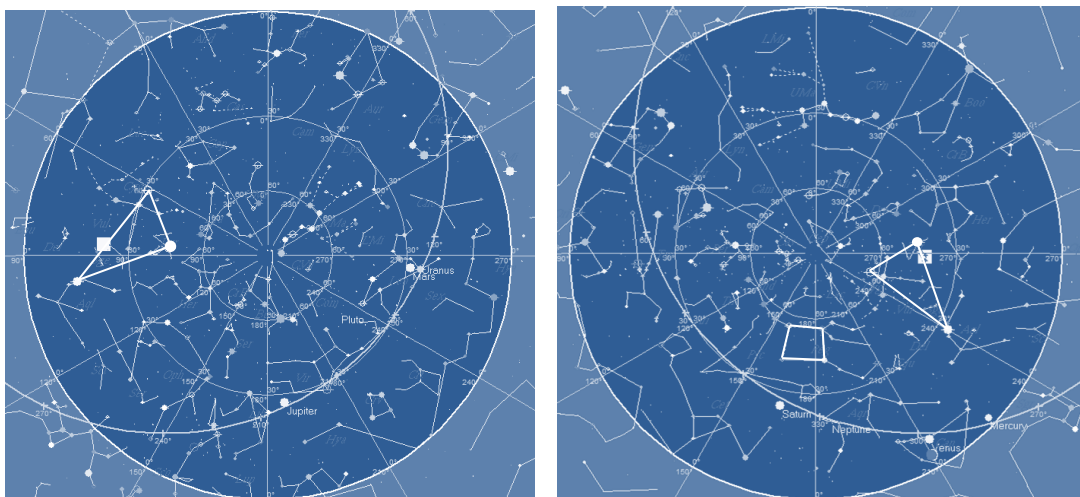


Fig 7(iv) The Winter Triangle of Betelgeuse, Sirius and Procyon in the constellations of Orion, Canis Major and Minor

These large and elaborate annular and penannular brooches are believed to date to around 700-800AD, the date is based on the inexact method of comparing their decorative style with the illuminated gospels of Lindisfarne written in the seventh century and the book of Kells generally believed to be written by monks on the island of Iona in Scotland around 800AD and taken to Kells in Ireland for safe keeping following the arrival of the Vikings. However, we cannot place too much reliance on this dating method as we have already seen the fallibility of this type of artistic associative dating with respect to the dating of the Class I Pictish symbol stones which were found to be nearly 2000 years older than expected from the style of decoration.

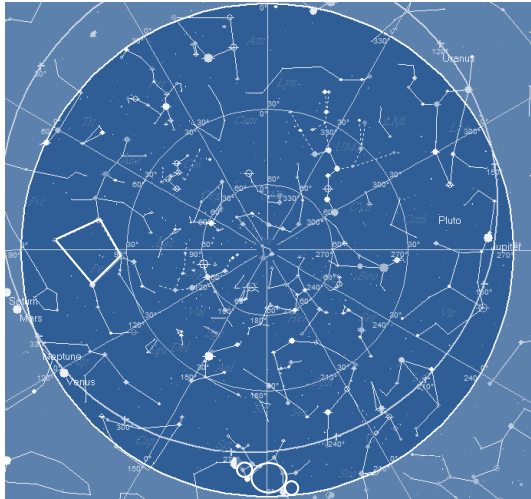
Night skies for known solar festivals 700AD Winter Solstice, Spring Equinox, Summer Solstice and Autumn Equinox.



Dawn (Summer Triangle East)

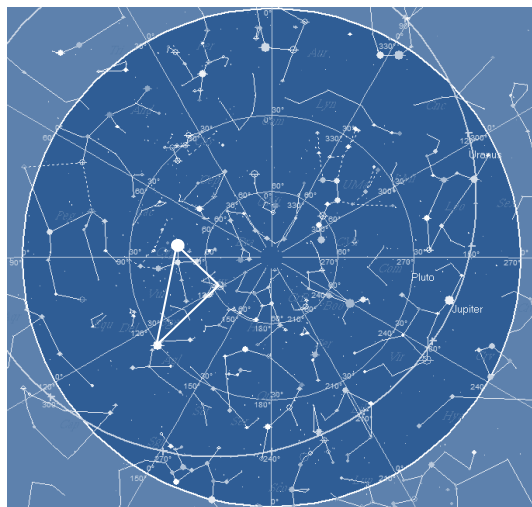
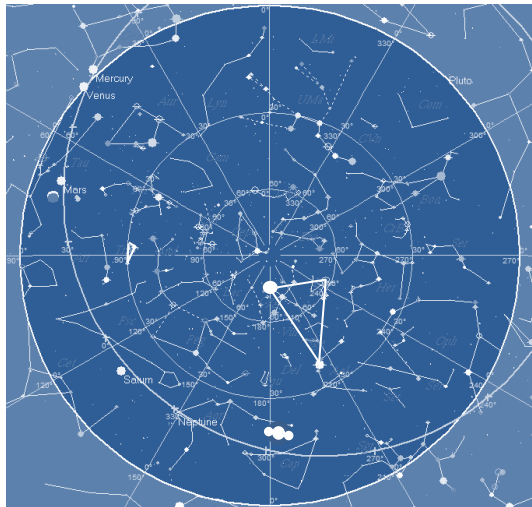
Dusk (Summer Triangle West, Pegasus South)

Figure 8(i) Winter Solstice Hunterston December 17th 700AD



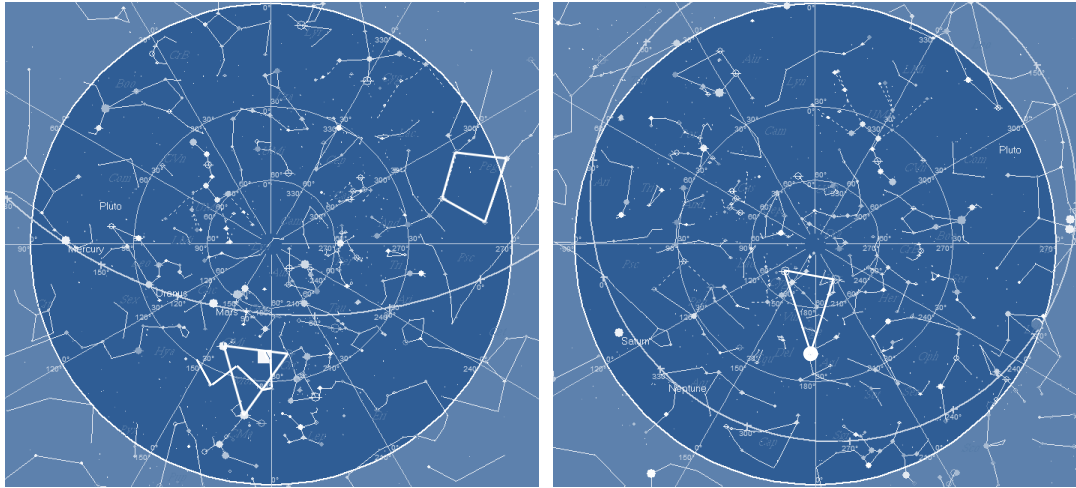
Dawn (Square of Pegasus East, Sagittarius South) Dusk (Winter Triangle and Monoceros South)

Figure 8(ii) Spring Equinox Hunterston March 17th 700AD



Dawn (Summer Triangle, Deneb and the Saturn Nebula South) Dusk (Summer Triangle East)

Figure 8(iii) Summer Solstice Hunterston June 18th 700A



Dawn (Winter Triangle and Monoceros South)

Dusk (Summer Triangle, Altair South)

Figure 8(iv) Autumn Equinox Hunterston September 19th 700AD

The constellations and deep space objects that are due South at Dusk on the festivals appear to be those represented by the triangular, square, triple circle and “W” patterns decorating the brooch. Looking at the night skies on the solar festivals of the Equinoxes and Solstices we observe the following important stellar alignments;

Festival	Alignments at Dawn (Start of Civil Twilight)	Alignments at Dusk (End of Civil Twilight)
Winter Solstice	Vega and M27 Due East	Pegasus South Vega West
Spring Equinox	Sagittarius South Pegasus East Draco head directly overhead	Monoceros South Nine Maidens (Mel 111) East Procyon South
Summer Solstice	Capricorn and Saturn Nebula South Cygnus South M33 East	Deneb East Nine Maidens(Mel111) West
Autumn Equinox	Monoceros NGC2237 South M33 West Betelgeuse South	Altair South

Table 1

The symbols decorating the brooches appear to be important stellar markers for the days of the Equinoxes and Solstices. The Summer Triangle stars indicate both the Winter and Summer Solstices and the Autumn Equinox whilst the Winter Triangle and Monoceros

mark both the Spring and Autumn Equinoxes. Pegasus can be used to mark the Winter Solstice and the Spring Equinox and the Pictish Triple Disc symbol represents both Sagittarius and the Saturn Nebula and are markers for the Spring Equinox and the Summer Solstice respectively. It can be seen that the choice of the Triangle, the Square, the Triple Disc and the Kelpie together account for all the deep space and stellar markers of the solar festivals at dawn and dusk. Even the Pinwheel Galaxy M33 aligned due West at dawn at the Autumn equinox is associated with a triangle in the form of the constellation Triangulum.

Stellar Festivals

If the recumbent stone circles indicated solar alignments for the days when Vega, Deneb and Altair, otherwise known as the Summer Triangle, were due South in the sky along with other festivals including the celebration of the male god Orion(Betelgeuse) and female goddess Virgo (Spica) then we might consider that these festival days may still have been important to the Picts some three thousand years later up until the late acceptance of Christianity in Scotland and a date-based Gregorian calendar and the subsequent gradual movement away from Pagan stellar deity worship. Indeed, the Pictish brooches may represent a solar alignment device, not a sundial which indicates the hour using the daily movement of the Sun across the sky, but an instrument that indicates the day of the year by measuring the alignment of the changing position of the Sun along the horizon at sunrise and sunset in the same way as the stone circles. There is no known instrument from pre-historic times that has so far been identified as a calendrical sundial but there are many penannular brooches and torcs that may have served this purpose allowing people to determine festival days and follow the annual cycle of the Sun, a sort of portable pocket stone circle where the amber and glass beads represent the marker stones and the long needle, fitting between these bead "stops" in discreet fixed position, acting as a sighting pointer aligned with the Sun on the horizon on these festival days at sunrise and sunset. It is also interesting to consider the possibility that the Sky Disc from Nebra in Germany may also have served a similar calendrical purpose (see Part 7).

The Sun's bearing at sunrise and sunset on the festival days can be determined for the festival days that may have been important to the people at this time. The proposal is that in addition to the solar festival days of the Equinoxes and Solstices, stellar festival days were indicated by solar alignments when bright stars in the constellations of Capricorn, Pegasus, Sagittarius, Monoceros, Cygnus, Lyra, Aquila, Orion, Canis Major and Canis Minor were cardinally aligned at civil twilight, additional stellar festival days were also celebrated on days when bright stars were aligned due South at Civil Twilight either at dawn or at dusk. This calendar of festival days forming a Wheel of the Year is proposed as it had originally been used in Neolithic times as demonstrated by the stone circle alignments and later continued to be used as demonstrated by the Pictish Symbol Stones

and the constellations and deep space objects carved on these stones as Class I Pictish symbols.

Looking at the decoration of the Tara Brooch there are other clues as to deep space objects that may have been important markers of stellar festival days. There is a silver braided cord that connected one side of the brooch to the other perhaps providing a means of hanging the brooch around a person's neck, an idea consistent with the suggestion that the pin on an annular brooch would be unsuitable for fastening the brooch to cloth). On closer inspection the silver woven braid has the head of a snake at its end and there are two other snake heads on the ring itself that allow the silver braid to be connected to the brooch. The snake may be a representation of "the Great Serpent" constellation, otherwise known as Hydra. Perhaps Alphard, the brightest star in Hydra was aligned due South at Civil Twilight on one of the festival days. Another object is possibly indicated by the decoration of the gold circle pinned into the centre of the bottom, amber bead which has been carefully punched with seven tiny circles arranged as a hexagon around a central eighth circle. The pattern of circles is reminiscent of the way in which the Pleiades in the constellation of Taurus were portrayed as usually a cluster of seven or sometimes six visible stars. The alignment of the Pleiades due South in the sky at Civil twilight could have indicated another stellar festival.

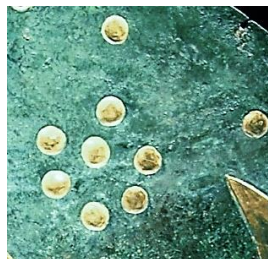


Figure 9 The Pleiades or Seven Sisters in Taurus as represented on the Nebra Disc (Note possible additional dots that could represent a further two stars in MEL 111 the Nine Maiden in Coma Berenices)

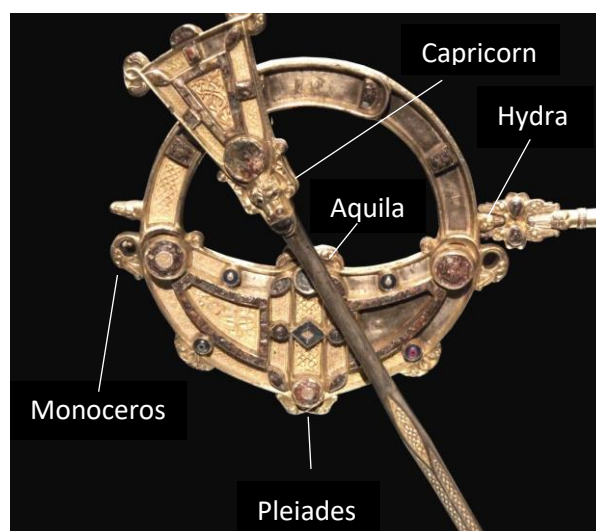


Figure 10

The annular ring described as the "Tara brooch" found in Ireland shares many similarities with the Hunterston brooch in that the protrusions at either side of the ring share the appearance of the Pictish Kelpie but despite the fact that the water spout here is absent, the association with the constellation of Monoceros can be seen as the head and neck of the Kelpie continues as a raised arching body around the amber bead ending with a circular decorated circle at the tail. This "Double U" shape follows the pattern of stars in the constellation of Monoceros and the decorated circle at the "Tail" may represent the Rosette Nebula (NGC 2237) in Monoceros.



Figure 11 Monoceros as portrayed on the Tara Brooch

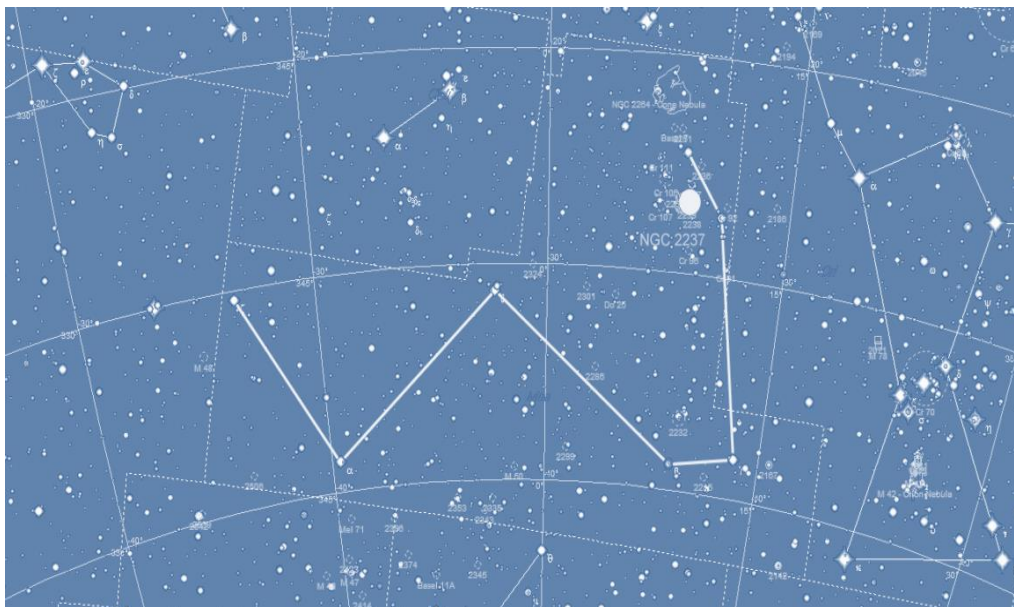


Figure 12 Constellation of Monoceros "The Unicorn" with the Rosette Nebula (NGC2237) indicated

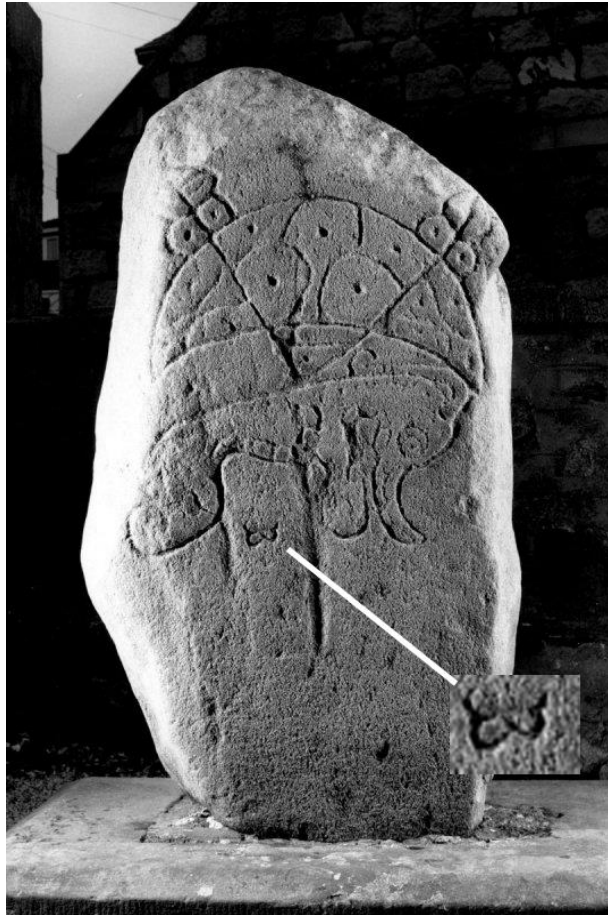


Figure 13 Pictish Class I stone from Kintore showing Kelpie and possible shorthand symbol



Figure 14 Golden Kelpie from Staffordshire hoard

A gold horse-headed artefact 1.6 inches in length is part of the Staffordshire hoard which was discovered by metal detectorist Terry Herbert in 2009. The identification of the animal is in some doubt but the similarity with the "W" shape of the constellation of Monoceros and the Pictish symbol of the Kelpie may suggest that this zoomorphic design also represents a stellar Water Horse reinforced perhaps by the appearance of what looks

like a tail or fin on the W-shaped horse. The massive hoard is associated with the Anglo-Saxons which might suggest that the association of the Kelpie with Monoceros was widespread across the different peoples inhabiting Northern Europe at this time, the hoard however was found on what might be described as a frontier zone on the border between Mercia and Wales and there exists the other possibility that the hoard including the golden kelpie was part of the spoils of battle.

The importance of the Saturn Nebula is again evident on the Tara brooch with the triple disc pattern decorating the head of the 10 inch long needle but this time the constellation of Capricorn itself may also be depicted as a Cathead or alternatively the decoration could be interpreted as a cow's head with a solar disc between the horns in the Egyptian style, representing Hathor and the star Spica.



Figure 15 Detail from Tara Brooch suggested as representing Capricorn with the Saturn Nebula above

The Tara brooch also confirms the importance of the constellations of Aquila and Cygnus in that we have a pair of Eagle heads and a pair of Goose heads on the inner and outer edges of the widest part of the brooch, supporting the idea that Altair in Aquila and Deneb in Cygnus were markers and perhaps the stellar embodiments of two important festivals.

As far as other possible additional important festivals are concerned, there are two more festivals that can be interpreted from the decorative features of the Tara brooch. The first festival is that of the Great Serpent Hydra which takes the form of two snakeheads positioned on either side of the ring above the Kelpie heads. One of the snake's heads is joined by a clasp to another snake which has a body formed as a silver woven cord. Although the silver cord has snapped at some time in its history, at one time it may have connected with both sides of the brooch allowing it to be suspended around the neck. The association of the snake design with Hydra gains support from the position of the snake heads on the ring which align with the bearing of the Sun on the horizon at sunrise and sunset on the day when Alphard, the brightest star in Hydra, is due South in the night sky at dusk.

The missing eighth sabat festival is perhaps indicated on the gold pin at the centre of the lower central amber bead which is decorated with tiny circles representing the star group in Taurus M45 known as the Seven Sisters or Pleiades but in this case represented by seven circles around a central eighth circle. When the date for the Pleiades appearing due South in the sky at dusk is calculated we find that the date corresponds with the missing spoke we saw on the wheel of the year graph.



Figure 16 Tara Brooch Amber bead decorated gold centre has eight small dots possibly representing the Pleiades

Festival	Date (700AD)	Sunrise	Sunset	Bearing (Sunrise)	Bearing (Sunset)
Winter Solstice	Dec 17th	09.06	15.30	137 5'56"	222 54'0"
Orion/Betelgeuse	Feb 26 th	07.15	19.45	103 23'53"	256 55'24"
Spring Equinox	Mar 17 th	06.19	18.32	88 41'8"	271 41'26"
Hydra/Alphard	Apr 1 st	05.36	19.05	77 39'29"	282 45'0"
Virgo/Spica	May 8 th	03.59	20.25	52 51'11"	307 32'47"
Summer Solstice	Jun 18 th	03.08	21.23	38 49'35"	321 10'40"
Lyra/Vega	Jul 31 st	04.10	20.30	53 14'59"	306 20'53"
Autumn Equinox	Sep 19 th	06.02	18.16	88 12'30"	271 24'36"
Aquila/Altair	Sep 21 st	06.06	18.10	89 42'39"	269 54'49"
Cygnus/Deneb	Nov 9th	08.01	16.04	124 10'27"	235 37'40"
Pleiades	Feb 3rd	08.13	16.54	119 15'31"	240 58'35"

Table 2 Dates and bearings of the sun on the proposed festival days. Bearing of the Sun on the horizon at sunrise and sunset on the proposed festival days for Rogart in Sutherland.

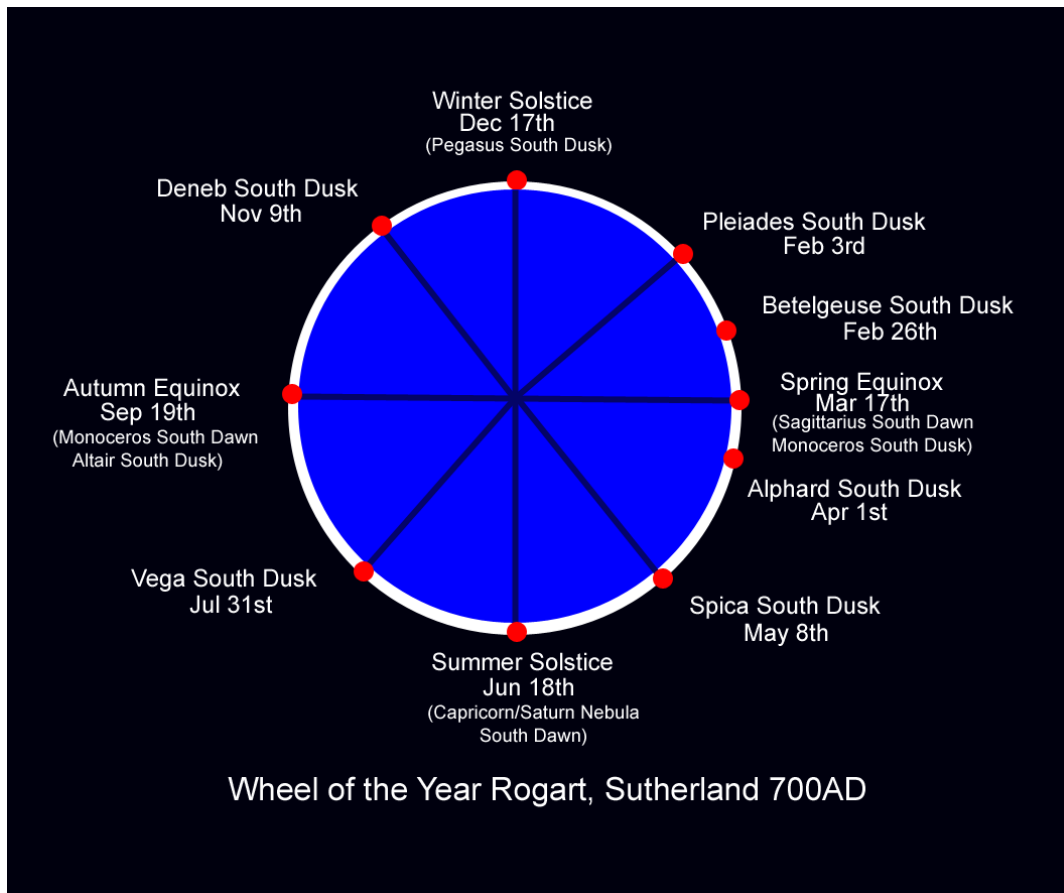


Figure 17 The wheel of the year calendar with festivals marked on perimeter for Rogart 700AD

The pattern of division made by the proposed stellar festivals is very close to the ideal of eight equal sabats with two additional festival days celebrating Orion and the other the Great Serpent Hydra.

The next step is to plot the Sun's bearing at sunrise and sunset on these festival days and see whether they match possible alignments of the needle on the Pictish brooches.

When the brooches are examined it can be seen that although essentially flat in nature the surface of the brooch is punctuated by raised amber or glass beads and metal ridges and that the needle can fit into discreet channels formed by these raised features. It is difficult to explore the possible alignments without having the actual brooch artefact available to test and given the precious nature of these brooches it is very difficult to access these objects for handling and testing.

As a first exploration the Hunterston brooch can be examined to try and determine whether the proposed solar alignments bear any relationship with the pattern of alignments of the needle and the amber beads.

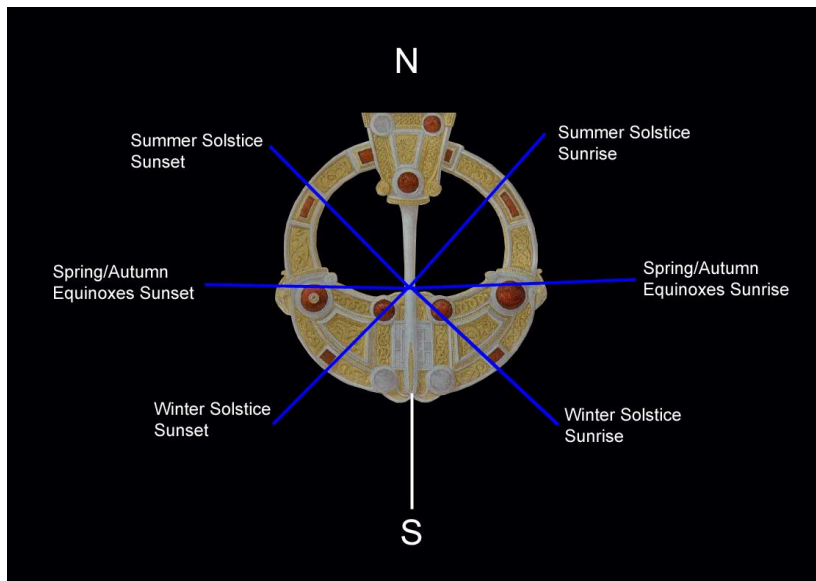


Figure 18 Attempt to align surface features on the brooch with the Solstices and Equinoxes

When the Sun's bearings at sunrise and sunset are overlaid on the brooch, we see that there is an interesting match between the positions of the amber beads for the days of the Solstices and the Equinoxes. However the needle can only traverse half the perimeter of the brooch and so in order to align with the Sun on the horizon when it is positioned North of the East-West axis (during the periods between the Equinoxes and the Summer Solstice), the needle needs to be made to swing around the brooch and point "outward" from the brooch. This seems like an impractical method of alignment and when we remember that the recumbent stone circles used two discreet viewing positions at either side of the circle, one for sunrise alignment and the other for sunsets, we can imagine that the brooch could have been used in a similar fashion. Rotating the ring through 90 degrees we can orientate the ring so that the widest part of the brooch faces either due East or due West and then the needle can be aligned with the Sun on the Horizon for all times of the year for sunrise when the brooch is orientated East and for all sunset positions when the brooch points West. In this way the decorated wide part of brooch can have the needle sitting across it with the needle aligned between the various beads.

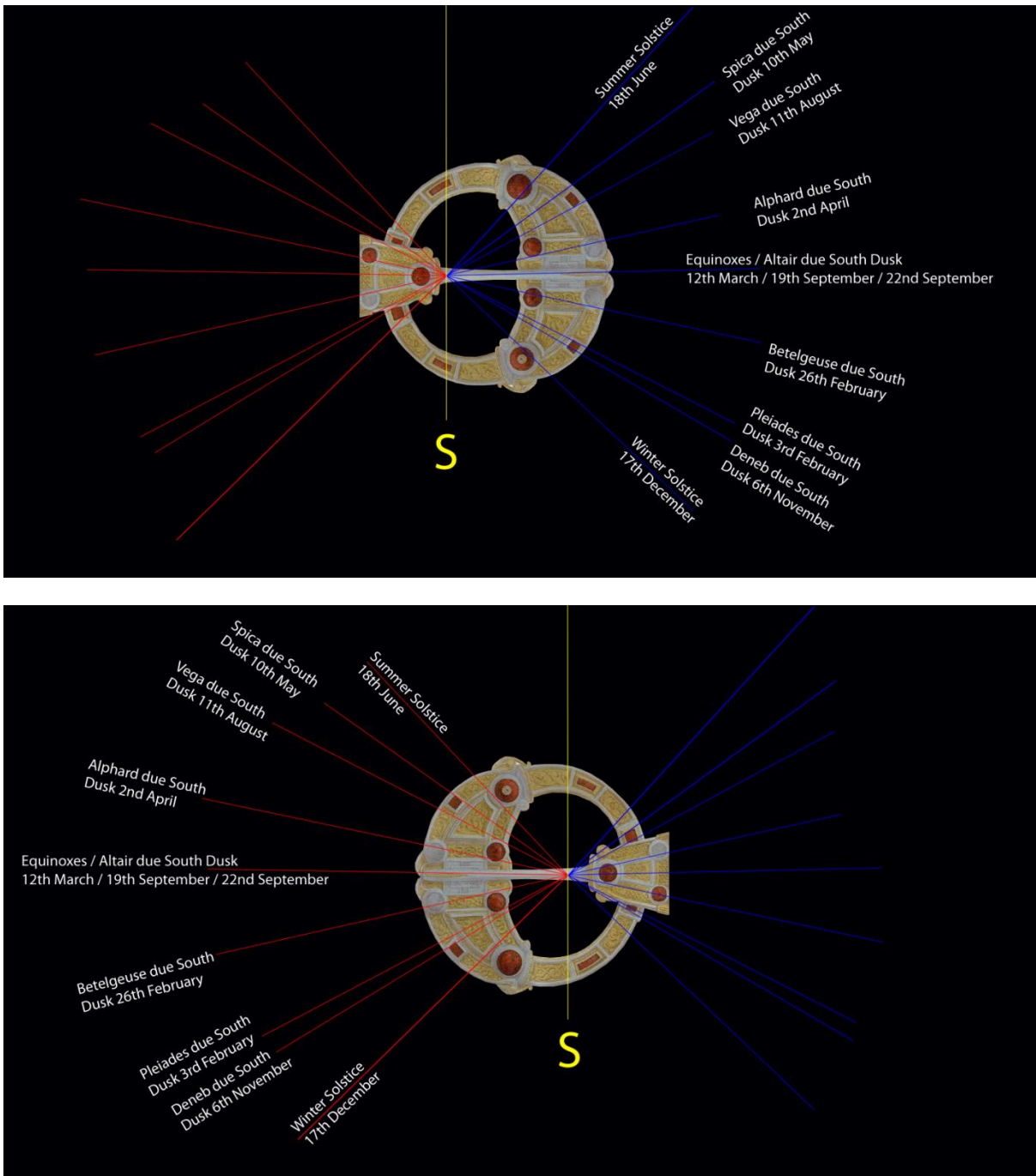


Figure 19 Bearings of Sun-on-the-horizon on proposed festival days overlaid on the Hunterston brooch at sunset (Red) and sunrise(Blue).

The loop behind the head of the needle connecting the pin to the ring does not fit tightly on the ring but rather has a considerable degree of lateral angular movement at each head position. The four rectangular amber beads on the thin runner section of the brooch may however act as stops for the needle's head whilst the gaps between the amber beads on the wide section of the ring fix the alignment of the needles point. The alignments of the Sun at the Solstices may be marked by the two large amber beads marking the North-

South axis alignment of the brooch when the needle head is fixed hard against the two outer rectangular amber beads and the Equinoxes marked by the near East-West gap between the four small round beads marking the rectangle when the head of the needle is fixed in the gap between the two central rectangular amber beads. Other festival day alignments appear to be consistent with respect to the needle alignments possible between the various beads but it is difficult to know whether the positions of the needle head would correspond to similar fixed positions on the ring without testing the actual brooch.

The next objective is to consider where each brooch was made and used, as the brooch would be expected to be location ndin particular latitude-dependent as the position of the Sun on the horizon changes as a function of latitude especially at the Winter and Summer Solstices that describe the most extreme Northern and Southern positions of the Sun on the horizon as the Sun rises and sets on these days. The further North the latitude, the greater the range of bearings the Sun has on the horizon because the Sun rises and sets further North in the Summer and further South in the Winter with increasing latitude.

The latitude can be seen to have a significant effect on the position of the Sun on the horizon. The range of solar bearings shown for the Solstices and Equinoxes are those for latitudes of Shetland (St Ninian's Isle 60° N), Inverness (Rogart 58° N), Glasgow 55°50' N and Dublin 53°20' N.

Location	Summer Solstice Sunrise Bearing	Summer Solstice Sunset Bearing	Winter Solstice Sunrise Bearing	Winter Solstice Sunset Bearing
St Ninians Isle Shetland	34 17'39"	325 42'45"	140 52'46"	219 6'57"
Rogart Inverness	38 49'35"	321 10' 40"	137 5'56"	222 54'0"
Hunterston Ayrshire	42 55'2"	317 5'6"	133 36'27"	226 23'33"
Dublin Ireland	46 21'37"	313 38'42"	130 37'26"	229 22'19"

Table 3 Bearings of the Sun on the horizon at the solstices from Shetland to Dublin.

There is a difference of up to 12 degrees between the bearings of the Sun on the horizon at the times of the Solstices for the range of latitudes covered by Dublin to Shetland.

It would be useful to have a large variety of Pictish brooches from the same location which could be compared and tested to see how easily their designs accommodate the proposed alignments of the Sun on the festival days and also establish perhaps a consistent pattern of movement of the needle moving from one festival to the next for

the whole year. Fortunately, there is such a collection in the National Museum of Scotland in Edinburgh from the Shetland Islands.

St Ninian's Hoard



Figure 20 St Ninian's Isle connected to the Shetland mainland by a sand bank.

In 1958, on St Ninian's Isle, an isthmus connected to the Shetland mainland by a sand bank or tombolo, a hoard of 8th century silver was discovered by a schoolboy in the chapel grounds under a stone slab in a wooden box. The treasure included many complete silver penannular brooches. The beauty of this hoard is that there are many different designs and sizes of brooch in the collection but each shares a similar penannular form. The most common decorative features on the brooches are the square form designs at the terminals of the penannular ring and the pattern of design at the ring's central section comprising a circle accompanied on either side by two small semi-circular patterns. We have suggested that these designs represent the constellation of Pegasus and the Saturn Nebula located in Capricorn and we have seen how these deep space objects are aligned due South at dusk on important festival days. Looking at some of the other brooches there also appear to be a significant number that have a triangular form of design at their terminals representing the star formations known as the Summer Triangle and the Winter Triangle. One brooch is unusual in that it has two dragon heads at its ends perhaps representing the Great Serpent Hydra or perhaps the Kelpie representing Monoceros which is due South in the sky at the equinoxes.

When the bearings for sunrise and sunset for the latitude of St Ninian's Isle for the year 700AD are overlaid on the brooches we find that a reasonable match can be made between the brooches features and the solar bearings on the proposed festival days.

FESTIVALS	ALIGNMENT	DATE (700AD) St Ninian's Isle
1. WINTER SOLSTICE	Pegasus	December 17th
2. SEVEN SISTERS	Pleiades	February 5th
3. ORION	Betelgeuse	February 26th
4. SPRING EQUINOX	Monoceros	March 17th
5. HYDRA	Alphard	April 1st
6. VIRGO	Spica	May 5th
7. SUMMER SOLSTICE	Capricorn/Saturn Nebula	June 18th
8. LYRA	Vega	July 3rd
9. AUTUMN EQUINOX	Altair	September 20th
10. CYGNUS	Deneb	November 11th

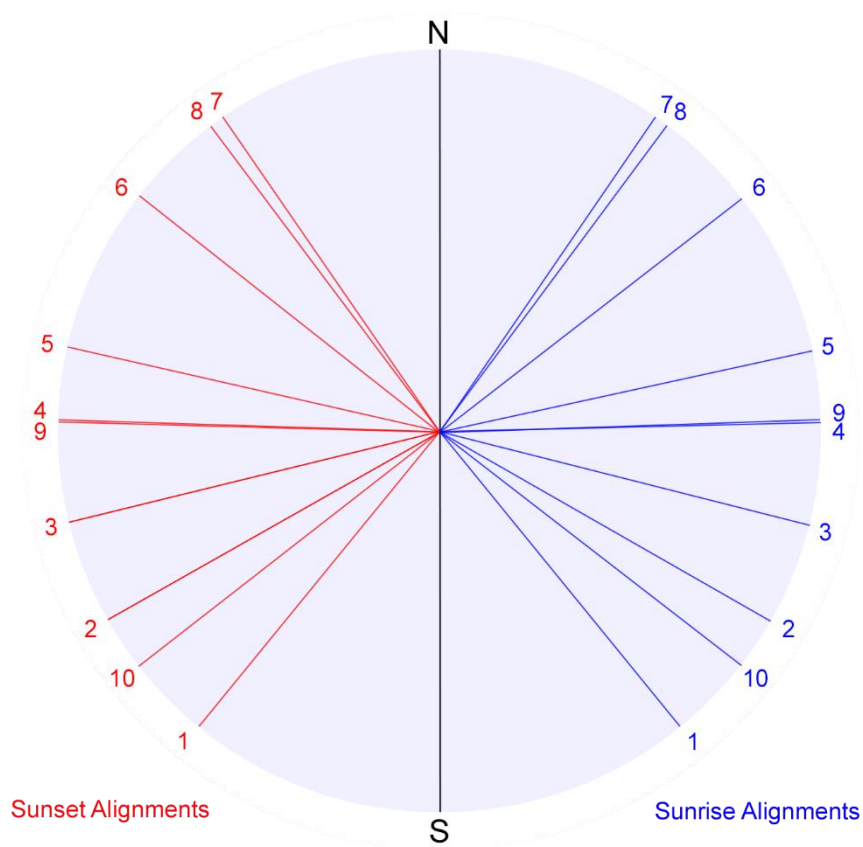


Figure 21 Alignments with the Sun on the Horizon on the proposed festival days 1-10 St Ninian's Isle, Shetland 700AD

A sample of nine penannular brooches from the St Ninian's Isle hoard was examined.

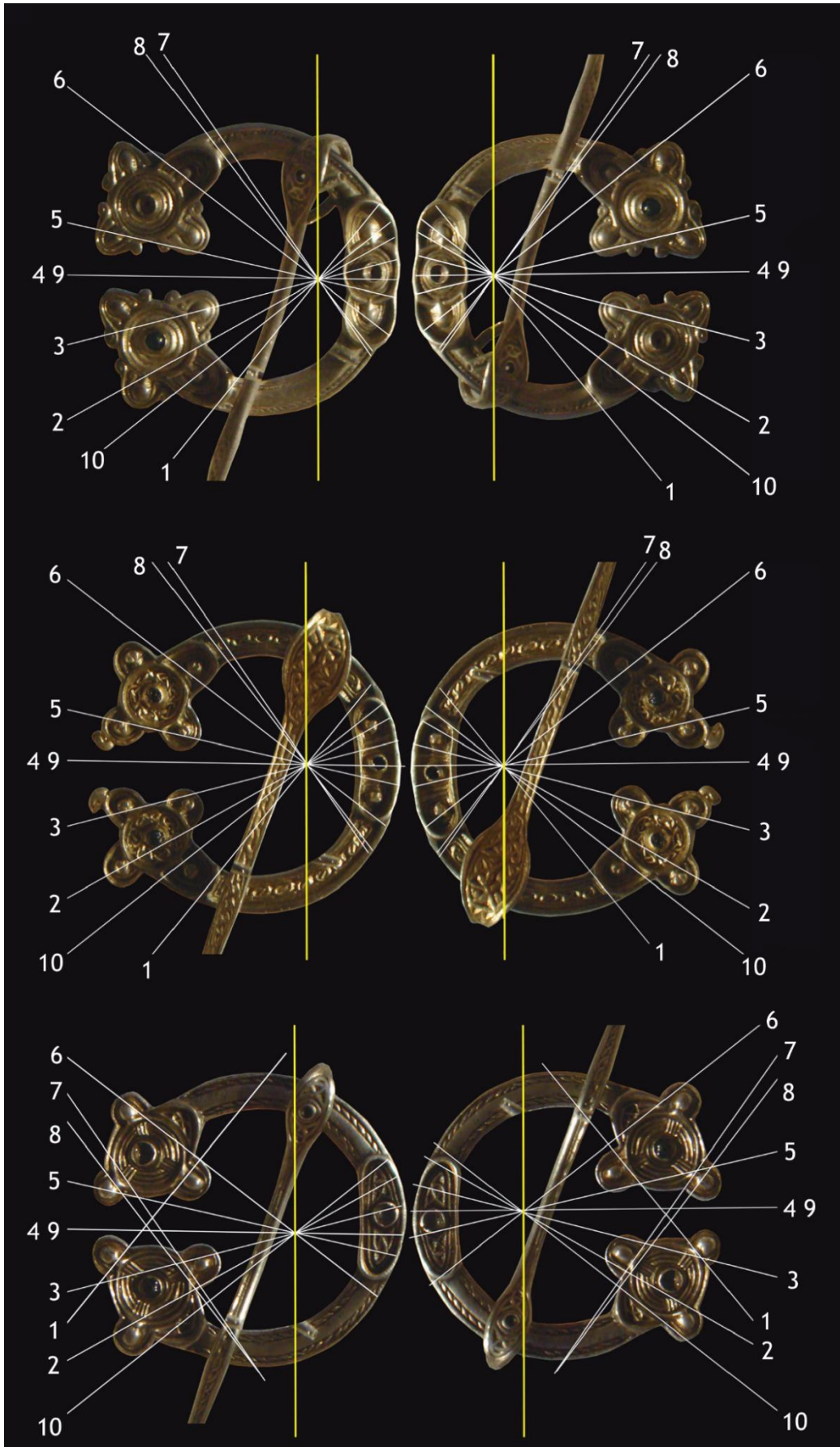


Figure 22 (i) Three Pictish penannular brooches from the St Ninian Hoard

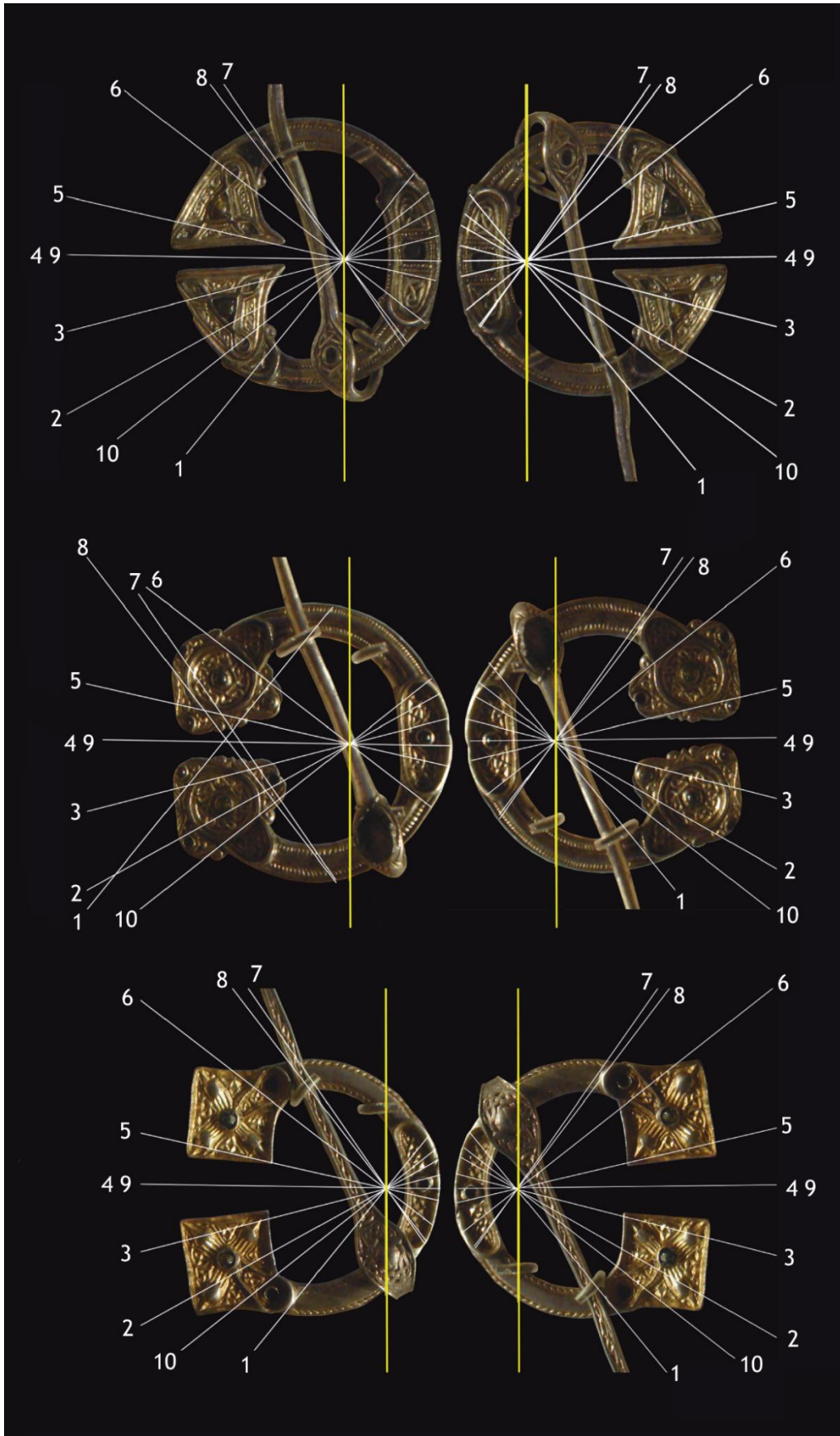


Figure 22(ii) A further three Pictish brooches from the St Ninian Hoard

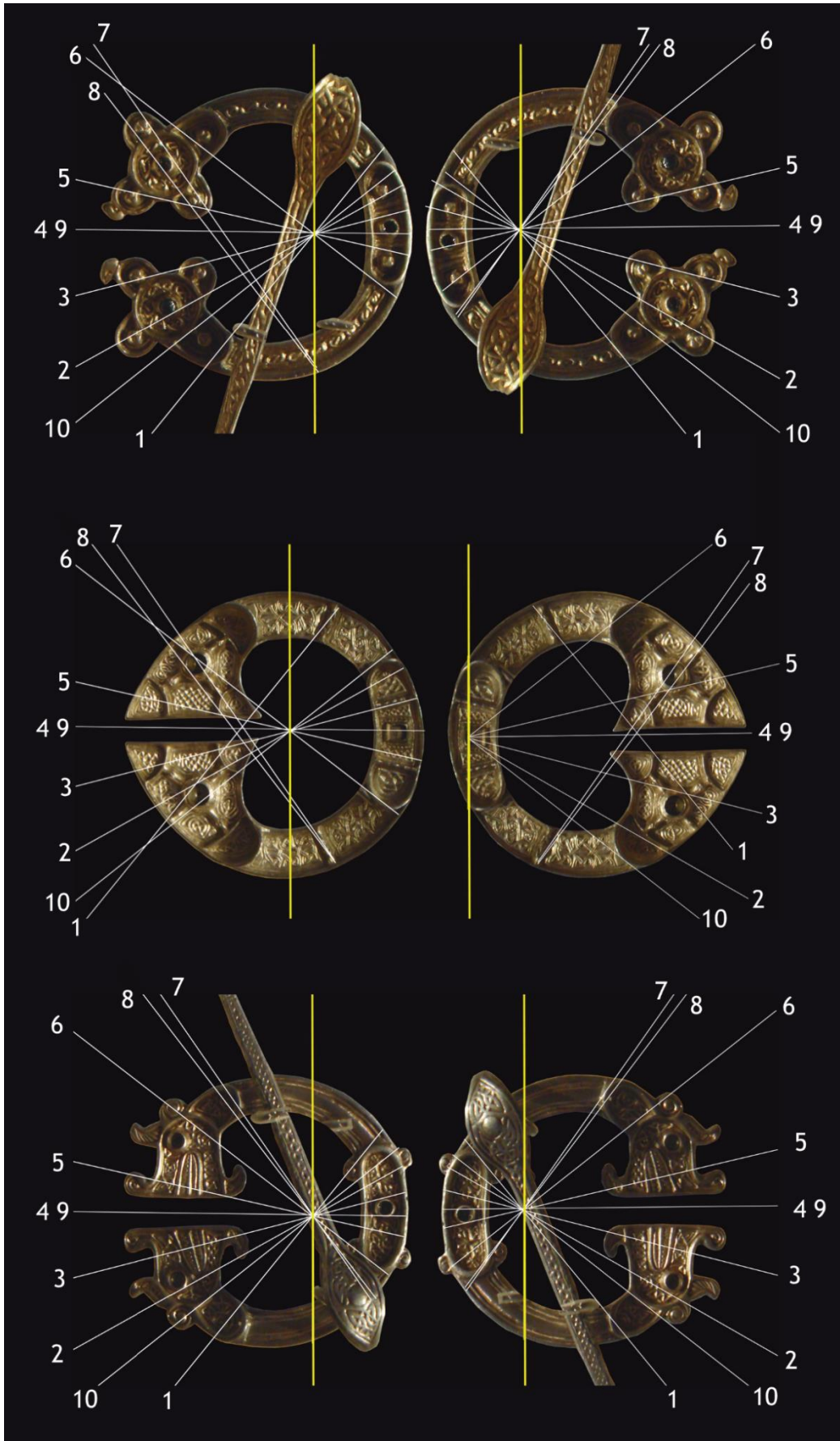


Figure 22(iii) Three more Pictish penannular brooches from St Ninians Hoard

When the rose of festival sunrise and sunset bearings is overlaid on the brooches the alignment lines seem to make a generally consistent pattern with the lines fanning out between raised features on each of the brooches. The needle could therefore be used to sit between these same features and be used to mark the same festival days. Seven of the nine brooches follow this pattern but for two of the brooches a more natural fit for the alignment of the winter and summer solstices is obtained by either using the gaps between the terminal features or grooved lines on the brooch which may indicate needle alignments in the case of the largest brooch found.

Although the alignments between raised features on the brooch appear to be reasonably consistent with the festival day bearings of the Sun on the horizon there is a difficulty in being able to ascertain to what extent the actual needle would fall naturally and accurately into these positions particularly with respect to the sliding head of the needle which may fit into discreet positions especially butting up against the central raised sections of the brooch whose pattern we have associated with the Triple Disc.

The Tara Brooch

The Tara brooch is named after the Hill of Tara considered as the seat of the High Kings of Ireland but the brooch has no connection with either and was reportedly found in August 1850 on the beach at Bettystown, near Laytown, County Meath, about thirty miles north of Dublin. A woman claimed to have found the brooch in a box buried in the sand, though some believe she claimed this in order to avoid a legal claim by the landowner where it was actually found. It was sold to a dealer and then to the Dublin jeweller George Waterhouse who renamed it the "Tara Brooch" to make it more romantically appealing and help promote sales of his existing line of Celtic revival jewellery.

The brooch is estimated to have been made around 700 AD and is composed of silver-gilt like the Hunterston brooch, embellished with intricate gold filigree decorated panels and amber and blue glass beads. When it was first found, only one panel of decoration was missing, but several more have now disappeared, apparently before 1872, when it entered the collection of the Royal Irish Academy who later transferred their collection of antiquities to the new National Museum in Dublin where it is now displayed.

The brooch today is regarded as a national treasure and access to the brooch is very restricted, however an opportunity arose as a one-off museum quality replica of the brooch was made in 1990 by Goldsmith jeweller Erwin Springbrunn was put up for sale recently and acquired by the author in order to test its proposed function as a calendrical dial and explore the actual needle alignments possible on the replica brooch with particular regard to the positioning of the head of the needle.

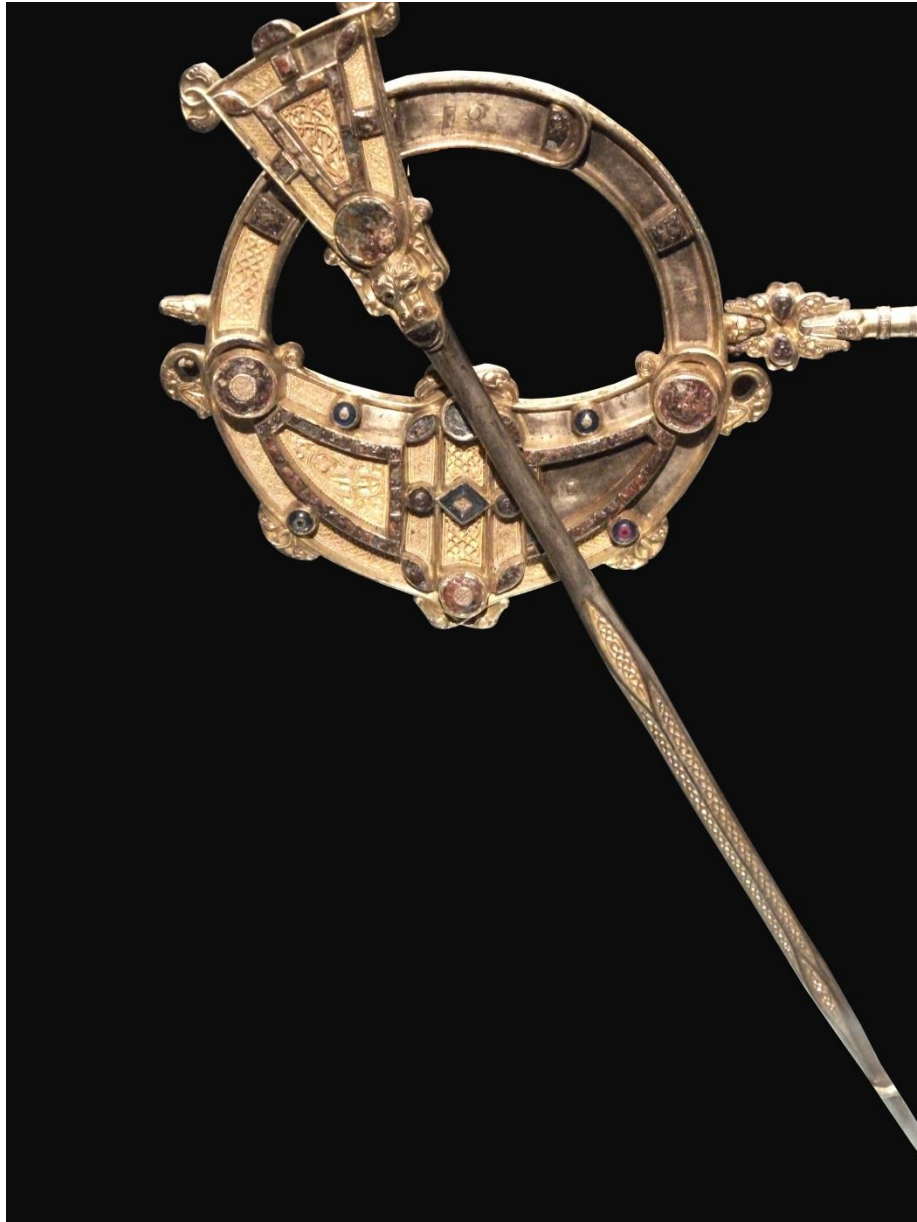


Figure 23 The "Tara" Brooch

The replica brooch was tested to see whether the proposed solar alignments matched the positions in which the ten-inch long needle naturally fitted between the amber glass beads and metal stops decorating the brooch.

When you experiment with the detailed replica, moving the needle around the ring you discover that the needle is loose and that there is too much lateral give for the needle to simply move around the brooch as a diameter with the needle always aligning with the centre of curvature of the circular brooch. However there are four amber filled metal stops positioned on the "track" of the brooch, two rectangular and two semi-circular and as the back of the triangular head of the pin has a ridge around it, at certain positions,

the needle is fixed by these amber "stops" and the angle of the needle can then be easily fixed by allowing the middle section of the needle to rest in the discreet channels provided by the blue glass and amber beads. It is apparent that there are only a limited number of "permitted" positions where the needle can sit firmly fixed.



Figure 24 Replica of Tara Brooch by Erwin Springbrunn 1990 showing the position of alignment of the needle at sunrise on the Summer Solstice.

The positions of the rising and setting Sun, particularly on the days of the winter solstice and summer solstice are related to the latitude and by matching the angles found on the brooch with the solar bearings found at different latitudes we can perhaps determine the likely location of manufacture or intended use for the brooch. Surprisingly, the best match for the Tara brooch replica was found for a latitude similar to that for the Hunterston brooch around 56 degrees North suggesting the possibility that the Tara brooch may have originally been made and used not in Ireland but in South West Scotland and taken to Ireland but further tests with the original would confirm this potentially contentious point. The Tara brooch and Hunterston brooch do share a strong similarity of design and extremely high level of craftsmanship and perhaps it is not unreasonable to consider that both could have been made in the same workshop in the South West of Scotland or perhaps the Northern most part of Ireland, areas inhabited by a culturally similar group of Gaels whilst the distinctive Pictish brooches with their penannular form

and Square terminal patterns of decoration and alignment were made and used further North in the lands of the Picts.

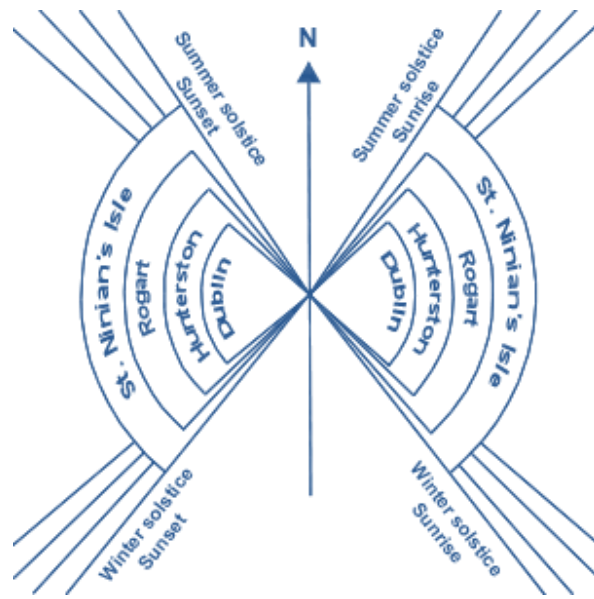
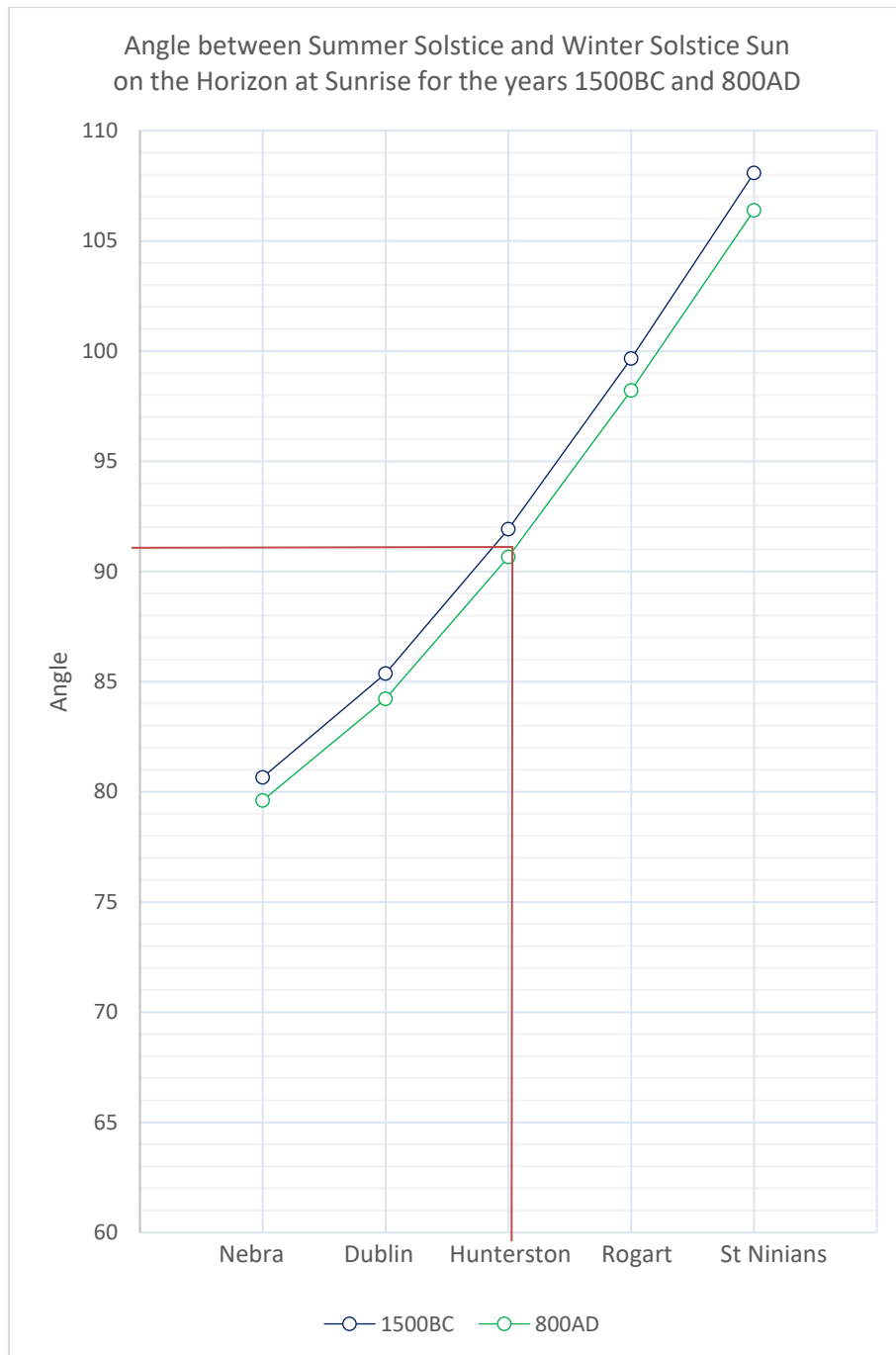


Figure 25 Angle between alignments of the needle between the proposed "Solstice glass beads" decorated with central gold Sun patterns. The positions shown representing the alignment of the Sun at sunrise at the Summer Solstice (needle pointing North-East) and the Winter Solstice (needle pointing South-East). The angle between the two extreme positions was measured as approximately 91 degrees.

Location	Latitude	Longitude
Nebra, Germany	51° 17' 1"N	11° 31' 7"W
Dublin, Eire	53° 19' 59"N	6° 14' 56"W
Hunterston, Scotland	55° 43' 24"N	4° 53' 54"W
Rogart, Scotland	58° 0' 0"N	4° 8' 0"W
St Ninians Isle, Shetland	59° 58' 20"N	1° 20' 53"E

Table 3 Latitude and longitude of places associated with Annular and penannular brooches and skydisc.



Graph 1 shows the arc angle between the Sun's positions on the horizon at the Winter and Summer Solstices. The red line corresponds to the Solstice Angle for the Tara Brooch.

For brooches to work accurately they needed to be made for a particular latitude so it is likely that brooches found in a particular location, assuming they were used as calendars, were likely to have been made by local craftsmen. Again, present day national boundaries are not helpful as they do not properly represent the cultural fluidity between peoples inhabiting the prehistoric lands that we today have labelled as countries. Scotland had perhaps three general cultural groups inhabiting its lands around the 8th Century: the Picts, the Northumbrians and the Gaels and whilst Pictland may have covered the vast

majority of the lands we today call Scotland and represented a distinctive cultural area bounded by the sea on its Eastern, Western and Northern fringes, the South and South West of Scotland were inhabited by peoples who were culturally the same as people living in present day Northern England and Northern Ireland respectively. Furthermore, there were likely to have been common pre-Christian beliefs in the star gods and the seasonal calendar amongst all three groups and different cultural groups came up with their own designs of brooch at various times perhaps aided by the mixing of people through trade or through displacement of people by invaders. It is important to realise that the use of these brooches both annular and penannular was widespread throughout the British Isles and Northern Europe and whilst we have been examining the most highly decorated, high status examples, simpler, smaller everyday examples may have been used from much earlier times by the general population. There are many penannular brooches from more recent times that share the same general form of the older devices but are too simple to have had the capability of being used as accurate calendrical devices, so perhaps these examples are just cloak pins that were decorated in the old-style.

There is one final parameter that needs to be considered, namely the orientation of the brooch. Whilst we have said that the brooch dials needed to be orientated relative to the North-South axis we might consider how this could be accurately achieved. There are two possibilities, firstly if the Picts had a compass, they could use this for alignment purposes but if this was the case, they would have needed to take into account the difference between Magnetic North, which is 3 degrees from true North. In the likely event that the brooches were aligned relative to true North and South we need to consider how this could have been simply achieved at that time without the aid of a compass. One such method is to use the brooch itself and follow the apparent movement of the Sun. By laying the brooch flat on the ground and raising the needle to point vertically upwards the shadow of the needle can be marked on the ground and a circle drawn that the shadow just touches the perimeter of this circle. If the first mark is made some time before midday the shadow will get progressively shorter as the azimuth of the Sun reaches its maximum at mid-day and then increase in length until once again the tip of the needle's shadow touches the opposite side of the circle marked on the ground. The line connecting these points runs East-West whilst due South is perpendicular to it or can be calculated as the line that bisects the angle between the two points on the circle through the origin.

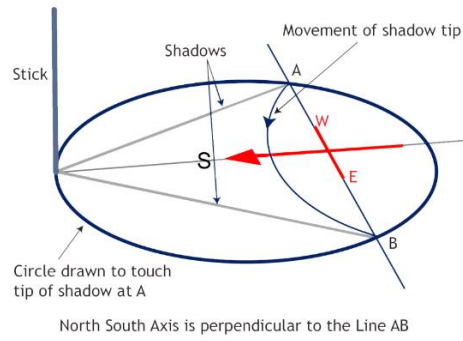


Figure 24 Method of determining due South using the Sun and the shadow of a vertical stick

The alignments of the needle between the glass and amber beads on the festival days, obtained using the replica Tara brooch is shown below.

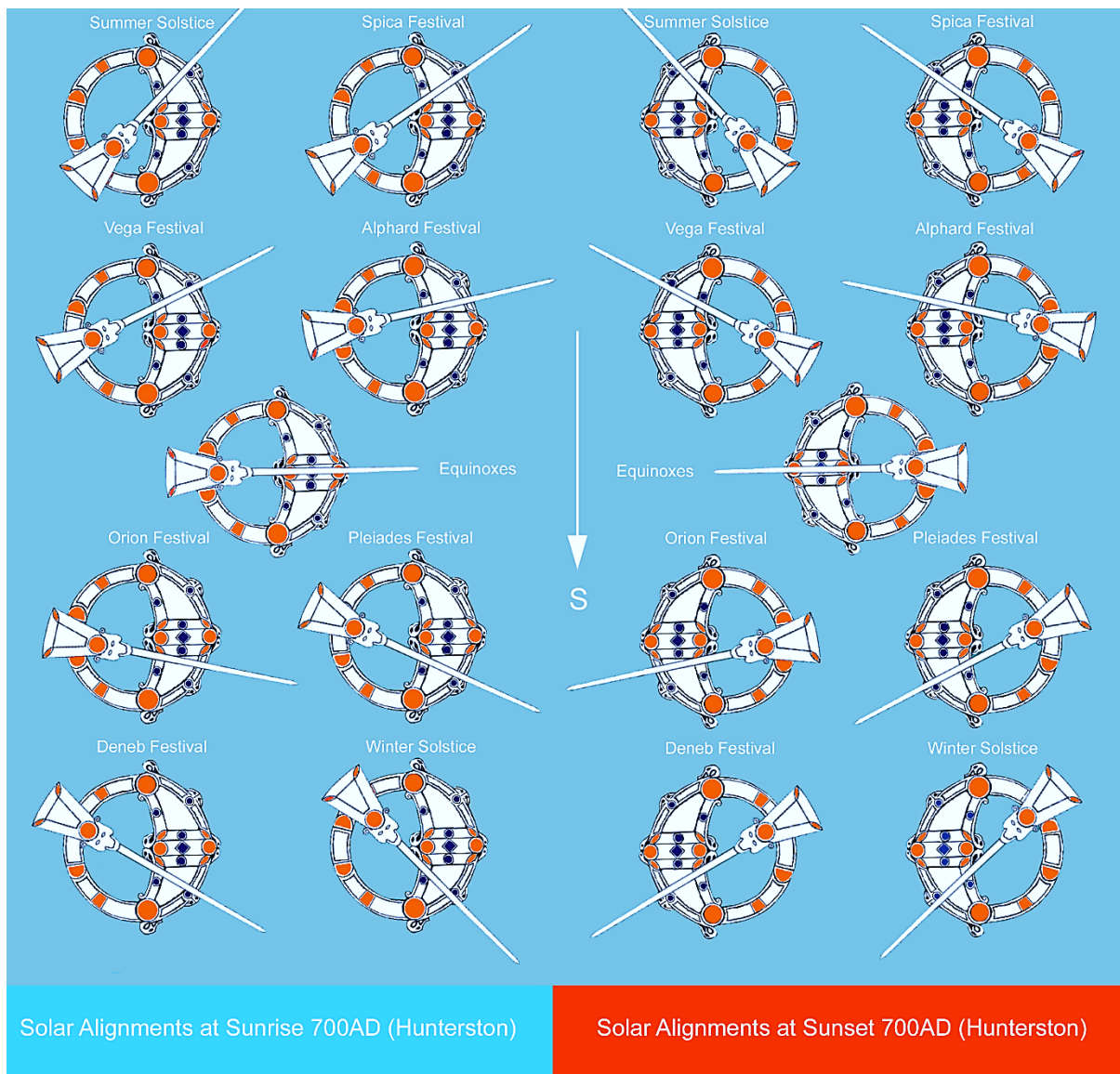


Figure 25 shows pin alignments of the Tara Brooch with the Sun on the horizon at sunrise and sunset on the festival days. The pin sits in discreet channels on the Brooch's surface formed by amber and glass beads.

The alignments obtained with the replica brooch are consistent with the bearings calculated for the proposed festivals for the latitude of Hunterston. The proposal that the so-called "brooches" were much more than cloak fasteners; their primary function being as calendrical dials, is supported by the alignments found on the brooch and the matching of these alignments with solar alignments on the days of stellar alignments due South at Civil Twilight on the festival days. In this respect the calendrical dials can be considered as portable stone circles.

Further analysis of the needle alignments of annular brooches found in Ireland and Southern Scotland would make an interesting study along with a comparison of the designs of the brooches including Anglo-Saxon, Viking and other forms of "brooch" which can now be re-examined in the context of their possible function as calendrical instruments rather than simple brooches. Furthermore, working backwards from the alignments possible on each type of brooch may allow us to determine which festival days were important to the different groups of people inhabiting different lands.



Figure 26 Bronze Viking brooch (10-12th Century) found in the Baltic Islands

The later Viking brooches dating to the 10th-12th Century share some of the design features of the Pictish brooches and some are decorated with four circle and dot symbols in a square arrangement at their terminals, reflecting the pattern of stars in Pegasus. The small Viking brooch shown was found in the Baltic Islands, where interestingly much of the amber used on the earlier Celtic brooches may have originated.

The use of Calendrical "brooches" continued for several centuries after the earliest Pictish and Celtic brooches and there are many examples of less elaborately decorated much smaller annular and penannular bronze brooches which may have fulfilled a similar calendrical function. However, if the date of 700-800 AD is correct then this paints an interesting picture of the continued use of the Pagan stellar-alignment based calendar into the first century of the Christian era which may reflect a gradual transition between the old and the new belief system. It seems likely, given the syncretisation of the old Pagan winter festival as Christmas, that the other popular Pagan festivals were also adopted by the church and maybe these festivals were rebranded as days dedicated to the new Messiah and characters and stories from the bible. We can speculate that even

the constellations which aligned due South on these days which had originally been associated with the Pagan deities may have been reidentified as biblical characters for instance Pegasus, the "White Horse" may have come to be associated with Jesus, Orion with Andrew, Virgo with Mary and Cygnus with the crucifix. These "Holy days" associated with the Messiah, Mary and Saints, soon became fixed dates on the Gregorian calendar and gradually the dates of celebration became distanced from the days when the stellar alignments occurred. Over the centuries any association between the days on which festivals were held and the alignment of bright stars was lost due to the precession of the equinoxes and the steady drift between the fixed date of celebration and the alignment of the star originally identifying the festival day. The use of the "brooch" as a calendar therefore became redundant and forgotten and whilst brooches may still have been made, their function may have been relegated to that of simple cloak fasteners just as the comb pi calculator became just another example of a comb.

Conclusions

We are very familiar with the idea of a sundial and its use to tell the time of day by the position of a shadow cast by an angled-gnomon aligned due South on the hour-calibrated dial as the Sun rises in the East and travelling at 15 degrees per hour eventually sets in the West. The idea that a dial could have been used to tell the time of year has not been considered probably because the passing year has become entrenched in our psyche as a date-based calendar. But this is a fairly recent development and we might ask how the passing year, the cycle of seasons and the marking of festival days was followed. A calendar based on the position of the Sun on the horizon makes sense because it is easily achieved as the Sun rises in the East and sets in the West and the position of sunrise and sunset varies as a function of the day of the year. The extreme positions of sunrise and sunset in the North occur at the summer solstice whilst the extreme southerly positions of sunrise and sunset occur at the winter solstice. The Neolithic stone circles used this principle of alignment of the Sun on the horizon with the stones positioned around the perimeter of the stone circle to mark special festival days. With precession of the equinoxes, the alignments of the Sun with the stones were lost. In time, man developed this idea and made more convenient portable devices that could fulfil the same function as the stone circles when he made what we describe as penannular and annular brooches which used a long needle to align with the rising and setting Sun on festival days indicated by channels created on the surface of the brooch by raised beads of amber, glass or metal that allowed the needle to align with the Sun on the horizon on special festival days.

Perhaps these Sundial brooches were attached to clothing as a means of carrying them around or indeed used to pin the cloth together to form a shawl or cloak, but their primary function was as a calendrical tool.