Autumn, 1999

WITH assistance from the PRISM fund, the Museum has recently purchased a rare item of printed ephemera: an ink impression on paper from a copperplate engraved in London in 1653 by Henry Sutton. The print is an unused and uncut compass card intended for the centre of a circumferentor or surveying compass.

The print first attracted attention simply as a rare survival of an unused pull from a plate by a well-known engraver, but closer examination reveals that it may provide evidence of Sutton developing his design and even of the general evolution of the circumferentor in the seventeenth century.

Early in the century, the circumferentor, as described, for example, by Arthur Hopton in his *Topographicall Glasse* of 1611, had a rectangular wooden base with a central hole for a compass card, magnetic needle and glass, and sights positioned on either side. Later instruments had circular compass boxes, and the sights were carried by fixed arms extending from the north and south points of the card.

The earliest dated circumferentor is in the Museum's collection and is of this latter type. It is signed on the compass scale 'W. R. Dublin. fe.' and dated 1667; apart from prehistoric monuments with astronomical alignments, it is also the earliest known Irish scientific instrument.

There are general similarities between the designs of compass card as illustrated by Hopton in 1611, and as executed by Sutton in 1653 and by 'W. R.' in 1667. All three, for example, incorporate a sundial within the degree scale. However, there are also important differences of detail.

Henry Sutton was perhaps the most talented and original mathematical instrument maker in London in the middle of the seventeenth century. A number of paper instruments by him survive. The Museum has two horary quadrants by him made from printed sheets applied to oak boards: both quadrants are dated 1658 but the sheets on all four sides are different. Also in the Museum is an undated magnetic azimuth dial whose printed scales are different from the newly acquired print, as well as a print made directly from an astrolabe by Sutton of 1659 (also in the collection) and a surveying compass with a printed card dated 1661.

Sutton had close connections with early Fellows of the Royal Society. When he died in the plague of 1665, Robert Moray wrote to Henry Oldenburg, 'wee all here are much troubled with the loss of poor Thomson & Sutton.' Curiously, the Museum also has a brass quadrant signed '1669. Hen: Sutton fecit.'
The newly acquired compass card has a number of concentric circular scales. The outermost is a scale of degrees. On the inside it is numbered from 0 to 360 and on the outside in quadrants from 0 to 90 both east and west of north, and east and west of south. The four cardinal directions are also marked in the quadrants, in a manner that became standard for the circumferentor, but which has sometimes puzzled the casual viewer, since 'E[ast]' and 'W[est]' are transposed. The reason for this arrangement is that as the scale is turned with the fixed sights towards, say, the east, the magnetic needle remains in the meridian and so registers the angle from north on the scale running anticlockwise, which is marked 'E' to assist the surveyor in correctly noting the angle as a number of degrees east from north.

A second scale, within the degree scale, is unnumbered: an indication, perhaps, that this is an unfinished plate or a provisional design. Were we to think of this scale in terms of conventional degrees, the final subdivision would be to an incongruous 11/2 degrees. There is however a way to make better sense of it.

While the division of the circle into 360 degrees has long been standard, surveyors have in the past used alternative divisions. Early mining dials, which fall into the general family of circumferentors, typically divided the horizontal circle into 24 hours. Other kinds of 'degree' might also be employed. The only scale on Hopton's card is numbered to 120, for example. In Aaron Rathborne's description of the circumferentor in *The Surveyor*, 1616, he says that the card is 'diuided in the limbe into 120. equall parts or degrees.'
Sutton may therefore have been improving on the 120 degree circle by providing a more finely divided scale to 12, 24, 120 and 240 parts. But by leaving the latter unnumbered, he also leaves this ambiguity unresolved.

The instrument Sutton places in the middle of the print requires still more thought. It is a magnetic azimuth sundial, which makes use of the horizontal plane of the scale, the motion of the vertical sights around the horizon and the stationary magnetic needle.

A set of concentric circles is crossed by solid curved lines for the hours and dotted lines for the half hours. The numbers of the hours are set at both ends of the hour lines and are either Roman or Arabic numerals, the styles of numeral being separated by two curved dotted lines representing the horizon.

To use the dial as part of a complete circumferentor, the southern sighting arm is aligned with the azimuth of the sun (the sun's position in the horizon) with the help of the shadow cast by the southern sight. A circle is selected according to the place of the sun in its annual path through the zodiac, and the position where this circle cuts the magnetic needle gives the time, as indicated by the curved hour lines. The northern half of the needle and the corresponding Roman numerals are used for the summer months, the southern half and the Arabic numerals for winter. Zodiacal symbols are distributed on either side of the horizon lines, indicating which concentric circle is to be selected, the symbols being placed on the summer or winter sides of the lines as appropriate. Circles are included also for the middle of each sign, these being indicated by added flecks in the engraving.

Within the sundial is a circular zodiacal calendar, giving the sun's position in the zodiac to two degrees (30 degrees for each sign) for every second day of the year. This is used to convert from the date to the sun's zodiacal position and so to select the appropriate circle. The calendar has the 10th March as the Spring equinox, as appropriate to the Julian calendar then still in use in England.

This calendar scale is not present in the earlier design of Hopton, where the date of the sun's entry into each sign is simply printed alongside the zodiacal symbol that indicates the corresponding circle. Rathborne also has in mind an arrangement of this type for, although he rather glosses over the detail, he mentions a dial 'according to the Azimuths of the Sunne, wherein the houres are numbred, and the months named, seruing very aptly to shew the time of the day.' Sutton's inclusion of a calendar scale, however, has produced another incongruous feature of the design: the zodiacal position is now found to two degrees, but the circles are drawn at intervals of 15 degrees.

Within the calendar is the signature: 'Henry Sutton Londini fecit * 1653 *', and finally a small compass rose. One of the most interesting features of the print is that there is a more precise date beyond the outer circle, where the paper would normally be cut away to fit the scale into the instrument. 'August 16.1653.' presumably was the day on which Sutton finished engraving the plate, and this small and more personal detail, which would usually be lost, seems to bring us closer to the man, his bench, and his life in the workshop.

The print takes us closer to Sutton in other ways as well. It is not clear whether pulls from this plate were ever fitted to instruments: there is evidence that it was incomplete and not entirely satisfactory, and by only the following year Sutton had made significant revisions. A trade card preserved in the Science Museum, London, includes a modified version of the circumferentor design alongside an engraving of a protractor with degree and linear scales – the two instruments formed the basic tools of a surveyor. The inscription at the centre of the dial reads 'Henricus Sutton Londini fecit 1654.'
In the modified design, the outermost scale has been rearranged so that both sets of numbers relate more immediately to their shared degree divisions. The unnumbered 'degree' scale of the earlier instrument has been removed completely. The central compass rose is unchanged and the general arrangement of dial and signature is similar, but there are important differences in the details.

The most significant change made to the dial is that Sutton no longer uses the zodiacal position of the sun to select from among the concentric circles. Instead he adopts the solar declination – the sun's angle above or below the equator, which is subject to an equivalent cycle of annual change. The central circles of the calendar now relate the date, again indicated for every two days, to the solar declination in degrees between 0 and 231/2. Sutton can now provide a circle for every two degrees of declination (numbered every 10 degrees), which with interpolation is accommodated much better to the calendar scale.

No doubt the use of this unfamiliar dial was difficult to convey to customers and in the modified design Sutton has added a prominent sun symbol to the south side of the dial as a reminder to point it towards the sun. The brief instructions on the trade card begin: 'Place ye Sun on ye Card toward the Sun in ye Firmament …'. The instrument by W. R. also uses the solar declination in this way and includes a symbol for the sun; a very similar printed card in a compass at the National Maritime Museum is signed by Walter Hayes of London and dated 1664.

While the record may be incomplete, the presently-known compass cards suggest that in the years 1653-4 Sutton introduced and then modified the calendar scale and also removed the traditional 120-degree scale in favour of 360 degrees.

A final, more speculative, suggestion relates to the Latinization of Sutton's signature: perhaps it occurred, or was suggested, to him, that since he described the instrument as 'fecit Londini', he ought to style himself 'Henricus'.

It is rare at such an early date to be able to observe an instrument maker developing a design over a relatively short period. The adjacent dates of these two versions and the reading of the new acquisition as an unfinished and flawed design that was quickly improved offer us glimpses of Henry Sutton thinking. J. A. B.