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The conservation treatment of a refracting telescope on a universal equatorial mount c. 1741, signed *Hindley*, *YORK*

Timothy M. Hughes* and Matthew Read**

Henry Hindley (1701–1771), clockmaker, watchmaker and maker of scientific instruments, was born in Wigan and worked in York from 1731 until his death. Hindley was the maker of the world's first equatorially-mounted telescope, which can now be seen in Burton Constable Hall, East Yorkshire. The Hindley telescope is the subject of this article; the conservation ethos and methods described in the full report are relevant to the conservation of a wide range of historic dynamic objects, including clocks and watches. The communication of conservation processes is also, we believe, important to the wider understanding of time-finding and time-telling collections.

Introduction

Henry Hindley made clocks in Wigan, Lancashire, between 1726 and 1730. He moved to York in 1731 and, in his workshops in Petergate and then in Stonegate, he continued to make clocks. He also invented a fusee-cutting engine and a screw-cutting lathe, and made one of the first dividing engines for the construction of accurately-graduated arcs on scientific instruments. His universal equatorially-mounted telescope, the subject of this article, is thought to be the world's first. Hindley was a long-term friend of renowned civil engineer John Smeaton. Smeaton's second cousin, clockmaker John Holmes, was apprenticed to Hindley in 1743.

Examples of Hindley's domestic and public clocks can be found in the pages of this journal. Several remain in York, at York Castle Museum, York Minster, the Bar Convent and at Temple Newsam near Leeds.

The information in this article is based on a report of a conservation project carried out at West Dean College in 2013. The project was inspired by the research into the life and work of Henry Hindley conducted by Rodney J. Law,[1] a founding member of the Antiquarian Horological Society and a visiting lecturer on, and advisor for, the Antique Clock Restoration course at West Dean College for over twenty years from its founding in 1974.[2] The aim of the conservation project was threefold: firstly, to create a detailed record of a previously undocumented historic dynamic object, secondly to stabilise the instrument through a process of conservation cleaning, and thirdly, to provide a West Dean College student with access to a world-class object.

The instrument, inventory number BCF 56, belongs to the Burton Constable Foundation, and is now on permanent display at Burton Constable Hall , East Yorkshire.[3]

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Overall description

The instrument (Fig. 1) described in this article comprises a brass refracting telescope

*Timothy M. Hughes (tim@tmhughes.co.uk) is a clockmaker-conservator based at J E Allnutt & Son, Midhurst, West Sussex.

** Matthew Read (enquire@clockmaker-conservator.co.uk) is a clockmaker-conservator based in York.

1. See R. J. Law, 'Henry Hindley of York 1701–1771, Part 1', *Antiquarian Horology,* June 1971, 205–221, and 'Henry Hindley of York 1701–1771, Part II', *Antiquarian Horology,* September 1972, 682–699.

2. Michael Wright, 'Rodney Law (1925–2021)', *Antiquarian Horology,* December 2021, 462–464.

3. https://www.burtonconstable.com

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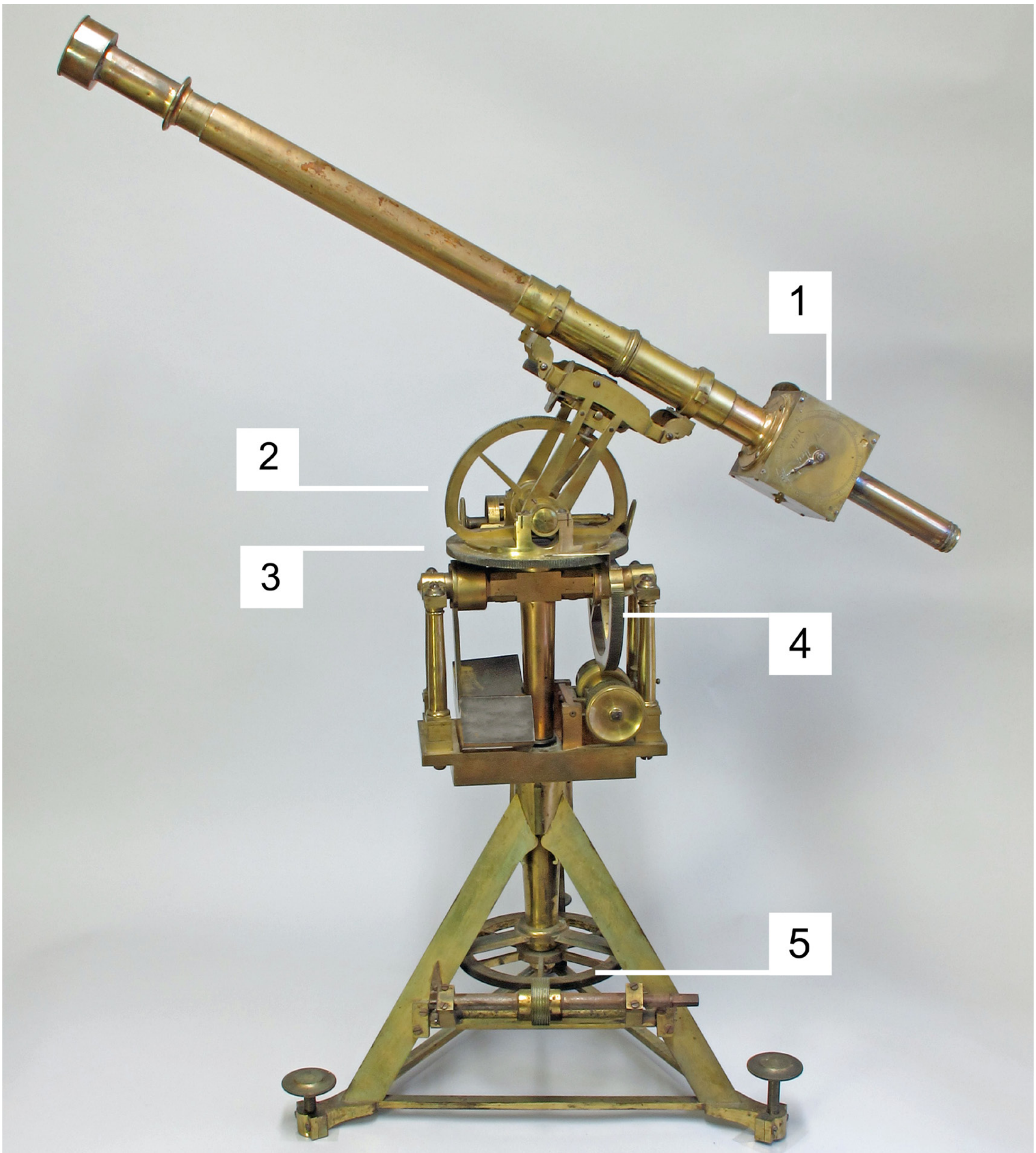

Fig. 1. The instrument photographed before treatment, October 2010.
1. micrometer box / 2. declination circle / 3. equatorial circle / 4. meridian circle / 5. setting circle.

with a micrometer box, which contains moveable wires that form a square reticle within the field of view. The telescope has a universal equatorial mount with a tripod base.

The instrument is of particular interest because of the use of worm gears of enveloping or globoidal form. In engineering this design of gear is widely referred to as the Hindley worm.[4] The worm gears are used to set the position of the telescope via four circles: the declination circle, the equatorial circle, the meridian circle and the setting circle.

The telescope is described by John Smeaton in a paper, read at the Royal Society on 17 November 1785, entitled 'Observations on the graduation of astronomical instruments,

4. Preliminary analytical metrology and CAD modelling of a worm gear and worm wheel was carried out by Charles Frodsham & Co. Ltd.

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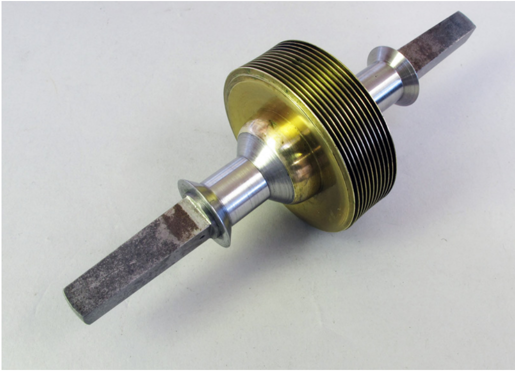

Fig. 2. An example of a worm gear – the meridian worm gear. Ref. F037.[5]

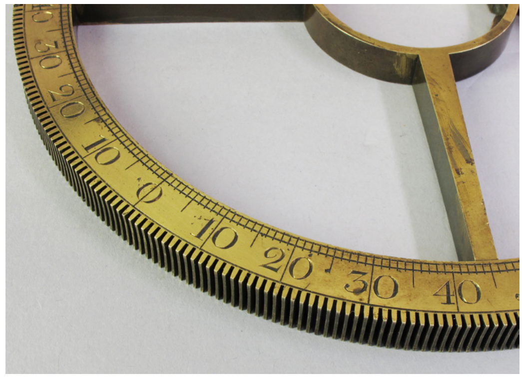

Fig. 3. An example of a worm wheel – the declination Circle. Ref. C030.

with an explanation of the method invented by the late Mr Henry Hindley of York, clockmaker, to divide circles into any given number of parts.' The transcription of the lecture describes the instrument as follows:

> This instrument was of the equatorial kind, the wheel parallel to the equator, the quadrant of latitude, and semi-circle of declination, being all furnished with screws containing fifteen threads each (see Figs 2 and 3), framed and moved in the same manner as that of the engine[6] […] and the telescope tube in its place, which was intended to be of the inverting refracting kind, and to be furnished with a micrometer.[7]

Mount

The mount comprises an upper, declination circle[8] over an equatorial circle above a meridian circle. The whole rotates about a vertical axis via a setting circle mounted between the tripod legs. The positioning of all four circles is via ground, worm wheels of enveloping hour-glass form, engaging with throated gears cut into the edges of the circles. All four worm gears are set in pivoted sprung frames that can be latched out of engagement for rapid setting. The flanks of the threads are tapered. Worm and worm wheel are pushed together in use by leaf springs, eliminating back-lash. The equatorial worm is fitted with a universal joint and square female socket, presumably for a hand wheel, crank or clock drive.[9]

Telescope

The 825mm-long, brass-bodied refracting telescope of 2' 7'' (78.74 cm) focal length, has a micrometer box towards the eyepiece end. The objective end has a dew shade and a push-fit dust cap. The eyepiece has a sliding dust cover.

Lenses

The telescope optics comprise four lenses. The objective lens is a doublet, 46mm in diameter. Focusing is achieved by turning a winding wheel on the micrometer box.

Micrometer box

The cuboid micrometer box (Fig. 4) is approximately 80mm square with two hand-operated knurled wheels; one wheel, set on one of the box edges, is for focusing the telescope. The other, the reticle setting wheel, is in the centre of a face of the box, opposite the engraved scale and signature. The setting wheel is for adjusting the four wire frames and is geared to a blued steel indicator hand, with a corresponding engraved graduated scale.

5. This number refers to the object part numbering regime applied during the conservation process.

6. Hindley's dividing engine.

7. The worm screws are not all of fifteen turns or 'threads', they are all single-start threads ranging from 10–15 turns. The quadrant of latitude is in fact a semi-circle.

8. Circle means both full circle, i.e. 360 degrees, in the case of equatorial and setting circles, and semi-circle, i.e. 180 degrees, in the case of declination and meridian circles.

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Fig. 4. The micrometer box, with the maker's signature.

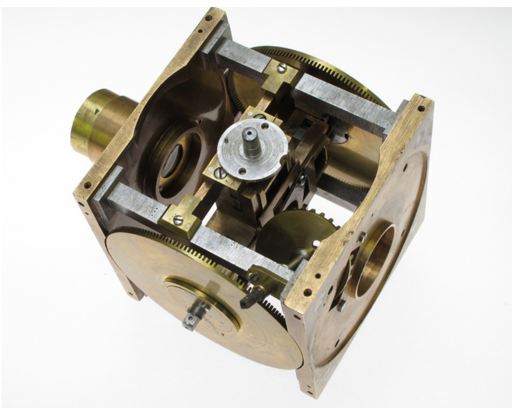

Fig. 5. The micrometer box, with the cover plates, and two of the contrate wheels removed.

The face of the box with the graduated scale is signed below the centre, *Hindley YORK*.

The scale of arc seconds is engraved up to 120 in increments of one, with every ten marked in Arabic numerals. This face of the box has a bevelled square aperture to one corner with a revolution counter having 13 stations. The engraved scale is graduated zero to 12, indexing one station for every revolution of the blued steel hand.

Within the box are four, 70mm diameter, intermeshing contrate wheels. Each wheel is mounted on a captive steel threaded arbor.

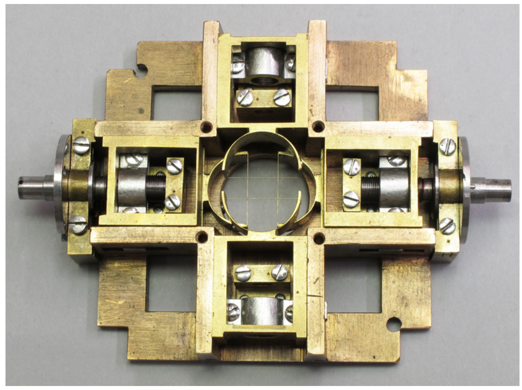

Fig. 6. Reticle wire frames. The contrate wheel arbors and wire frames have alternate left-hand and right-hand threads, due to the contrate wheels being intermeshed.

When the wheels are rotated via the external setting wheel, four brass wire frames move, reducing or enlarging the square reticle within the field of view. The frames are presently fitted with wires that are approximately one tenth of a millimetre thick and are for the purposes of measuring an object, or distance between objects, in the field of view (Figs 5 and 6). Stopwork, acting on one of the contrate wheels, ensures the travel of the wire frames is restricted at both ends of their range.

Telescope mount and frame

The telescope is mounted in an open brass frame, retained by two split clamps that allow the telescope to be rotated about its axis within the frame. The frame incorporates a pivoted spirit bubble mounted parallel with the telescope tube (Fig. 7).

The mounting frame, tube, bubble and worm gear, are mounted on a frame pivoting about the axis of the declination circle.

Declination circle

The 150mm (6") diameter circle[9] has 180 effective teeth and is engraved plus and minus 90 degrees from perpendicular to the equatorial plane. The corresponding worm gear is single start and of 10 turns. Rotation of the worm is indicated on an engraved circular scale, up to 60 arc minutes, in increments of

9. To keep the subject in the field of view, counteracting the rotation of the Earth in longer celestial observations.

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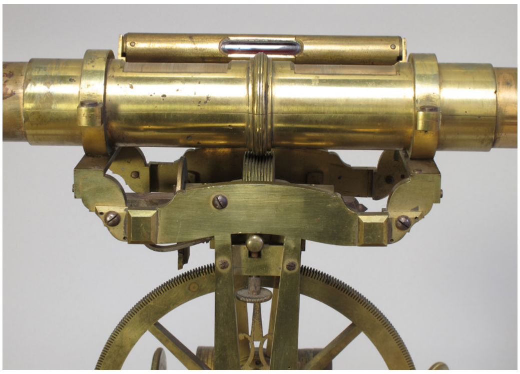

Fig. 7. Telescope tube within the frame clamps with spirit bubble.

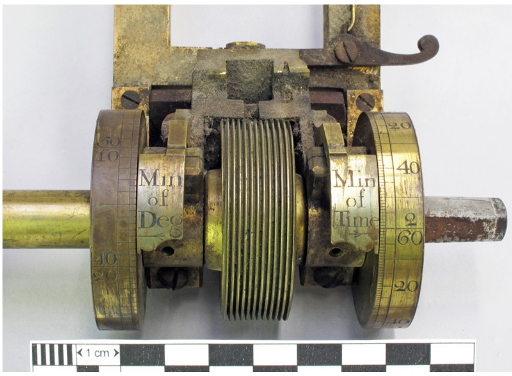

Fig. 8. Equatorial worm and scales.

30 arc seconds. The telescope mounting frame pivots about the axis of the declination circle. The setting worm is pivoted within the frame legs and sprung to engage with the wheel. It can be latched out of engagement for rapid setting. The position of the telescope mount, in relation to the declination circle, is indicated by a single pointer screwed to the pivoting element of the hub of the mount, indicating against the scale engraved on the face of the circle.

Equatorial circle

The declination circle mounting pads are screwed to the upper surface of the equatorial circle. The equatorial circle has 360 teeth and is engraved on its upper face with an outer track of 360 degrees reading clockwise and 360 degrees of arc reading counter-clockwise, with an inner track of hours of time. Hours are marked 1 to 12, twice, in Roman numerals.

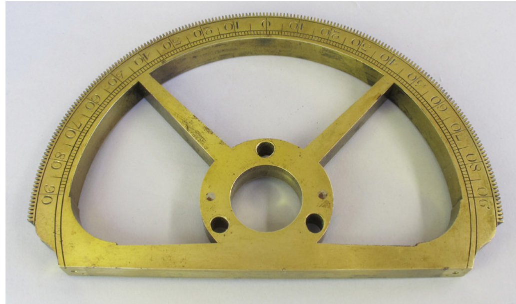

Fig. 9. Meridian circle.

Midday and midnight correspond with the 360-degree and 180-degree marks. Half hours have *fleur-de-lis* markers at the end of radial lines and quarter hours are marked by plain radial lines.

The equatorial worm is single start, twelve turns. It is embraced by two graduated micrometer scales; the left scale[10] (in Fig. 8) is engraved 'Min[utes] of Deg[rees]', up to 60 in minutes of arc. One full revolution of the worm advances the equatorial circle by one degree. The right scale[11] is engraved in Min[utes] of Time', 1–4 minutes, each minute sub-divided into 20 40 60 seconds of time. The equatorial worm axis is fitted with a knurled brass thumb wheel via a universal joint.

The equatorial circle is mounted on a steel spigot, which is 190mm in length and tapers from 25mm to 21mm diameter. The spigot rotates within a matching brass tapered tube, part of a cast brass frame supporting all of the above. Equatorial circle readings are taken from brass pointers mounted on the meridian circle frame.

Meridian circle and counterpoise

Fixed to the tapered socket that provides the bearing for the equatorial circle is the meridian circle (Fig. 9) and counterpoise. The meridian circle has 180 effective teeth and is engraved plus and minus 90 degrees from the axis of the equatorial circle, indicated by a brass pointer. The segment-shaped, brass-cased lead weight weighs approximately 3.62kg (Fig. 10).

The meridian circle and counterpoise pivots are mounted on four tapering brass

10. Proper right.

11. Proper left.

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Fig. 10. Brass-cased, lead-filled counterpoise.

Fig. 11. Setting circle worm and pivot blocks screwed to the tripod legs.

columns, which in turn are fixed to a brass chassis. To this chassis, the meridian worm screw is mounted. The single start worm has 12 turns and engraved with a scale reading up to 60 in increments of ten. The chassis rotates on a tapering brass spigot, to the lower end of which the setting circle is mounted. The spigot mount, a tapered brass tube, is screwed to the tripod frame.

The unengraved setting circle is rotated by a worm screw. The screw and its axis are mounted across two legs of the tripod (Fig. 11). The tripod has three adjustable screw feet used for levelling.

Treatment

The treatment of the object can be divided into the following three stages: (1) record the condition, including photography, notes and sketches; (2) treatment proposal, including options based on a contextual agreement; (3) treatment and reflections.

The context for the treatment proposal was the requirement to stabilise the object for Museum/Heritage display, including provision of a new vitrine. The act of cleaning the optics additionally allowed for preliminary field tests.

(1) Condition of the object as received

Completeness
Overall, the main body of the instrument was complete with no missing parts. It was not possible to discern whether all worm gear squares were fitted with individual knurled knobs for adjustment. The one square present was not pinned in place, so loss seemed likely, as did loss of a sidereal drive or crank.

Losses
There was significant loss to the lacquered finish of the brass work and, although the instrument appeared to have been cleaned/polished with metal polish, a good amount remained of what was believed to be original surface finish of the substrate.

Corrosion
Where loss had occurred to the lacquered finish, or where the lacquer had degraded and cracked, the brass work had tarnished to a multitude of hues ranging from pale gold to almost black. There was considerable finger printing to the telescope tube. Almost all of the exposed steel work showed light surface rusting. Many of the screw threads were corroded and semi-seized due to the presence of the remains of a cleaning/polishing agent.

Cleanliness
The instrument overall had a powdery and chalky white residue in almost all of the corners, engraving detail and screw threads, which was restricting the free movement of many components. The equatorial circle was 'locked' into position, likely due to corrosion and old lubricant. The instrument

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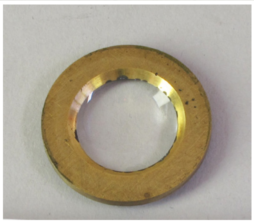

Fig. 12. The optic lenses to the telescope were contaminated with organic material including what appeared to be fungal growth and insect remains. This shows a lens before and after treatment.

Fig. 13. Cleaning the optics – Ceramics and Related Materials, West Dean College.

was superficially dusty and the optics were contaminated with organic material, including what appeared to be fungal growth and insect remains.

Broken parts
The pointer to the meridian circle had broken away from one side of its mount. One of the tripod adjustable feet was broken and was missing a portion of its threaded foot.

(2) Treatment proposal

- Completely disassemble the telescope and mount. Wash all metal components by hand brushing and rinsing in a proprietary spirit-based watch rinsing solution.
- Loose and surface corrosion to steel work to be removed using 0000 grade steel wool soaked in microcrystalline wax.
- Once washed, rinsed and dried, all components with the exception of the optics to be treated with microcrystalline wax.
- Bearings to be oiled as required using a proprietary synthetic lubricant.
- The cleaning of the optics to be carried out by a ceramics conservator.
- All components to be allocated numbers, measured, photographed and recorded.
- Repair the broken tripod levelling screw by letting in a new piece of brass and cutting a new thread to match existing.

(3) Description of the treatment

Cleaning
The instrument was dismantled in sections and cleaned as per the proposal.

Optics
The optics were cleaned by the West Dean College Ceramics Conservation Department (Figs 12 and 13) using a diluted solution of industrial methylated spirits. The objective lens, being a doublet (i.e. two lenses together in one rubbed-in mount) was not removed from its mount as this was thought to present a risk of damaging the lenses. Hence just the exterior of the two lenses was cleaned and as a result there is still light fogging between the two lenses.

Repairing the Meridian Circle pointer
The brass pointer to the Meridian Circle was repaired by filing a piece of cast brass to span the internal 90 degrees of the two broken pieces which was then glued into position using a proprietary epoxy resin.

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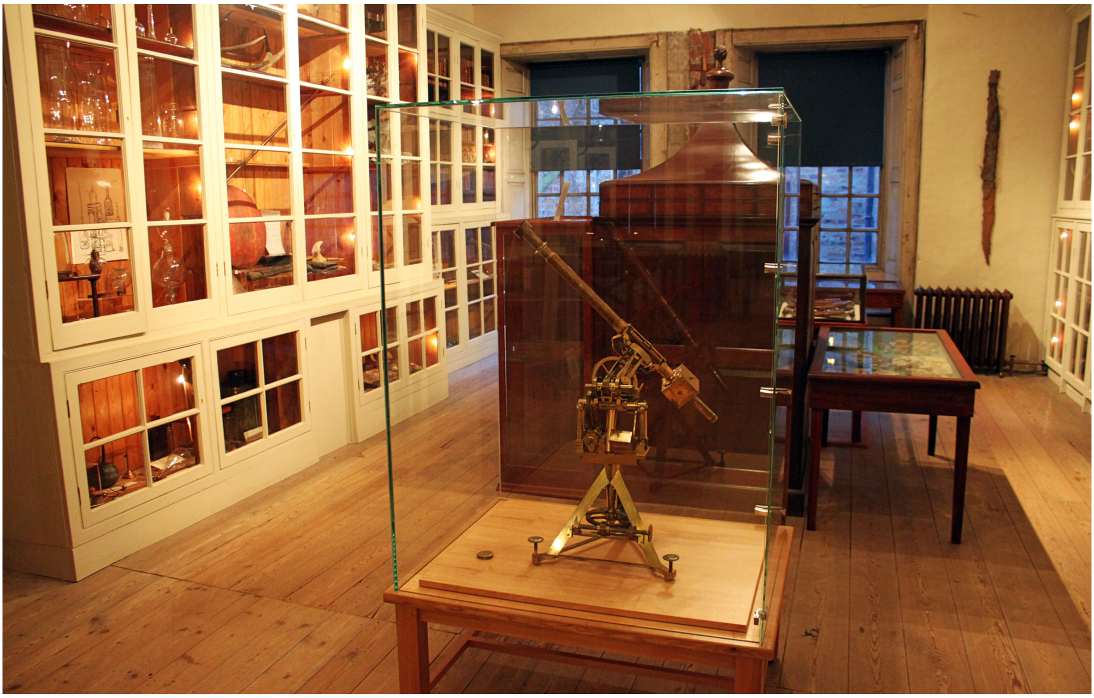

Fig. 14. The instrument in situ, Burton Constable Hall. Image courtesy of Burton Constable Hall.

Repairing the broken adjustable tripod foot
A thread cutter was made from 4mm silver steel and turned in the lathe with a graver to the same profile as the historical thread.

A section of 60mm nylon bar was turned to hold the foot by the remaining length of thread. The broken end was turned flat and a 6mm diameter hole was drilled 20mm into the end. A cast brass plug was turned to the thread major diameter of 10.3mm and secured with thread retaining fluid.

The work was mounted in the lathe and a nylon follower drove the lathe carriage from the existing thread, replicating the existing thread pitch on new material. The lathe was turned using the hand crank and the thread was cut in 10mm sections. The insert was parted to length and a foot was created with a graver.

The thread was then polished with a fine pumice powder soaked into the string with oil.

On completion of conservation survey and treatment, the instrument was returned to Burton Constable Hall where it is now displayed in its new vitrine (Fig. 14).

The full conservation report from which this article was taken is available at:
https://www.clockmaker-conservator.co.uk.[12]

Acknowledgements

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12. The project was carried out in 2013 by Tim Hughes, student, and Matthew Read, Programme Leader. The project followed the display of the instrument at Fairfax House, York, as part of their 2012 *Keeping Time* exhibition. All dimensions in this report are approximate.