In Search of the *English Rose*, Robert Hooke's Lost Constellation

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Abstract

The *English Rose* was a small, circumpolar, telescopic 'constellation' apparently first identified by Robert Hooke circa 1677. The information outlining the location and spatial relationship between the stars that comprised the *English Rose* are, however, lost. Here we attempt to recreate what Hooke might have had in mind when he described the 'constellation'.

Introduction

Dr. Robert Hooke (1635 – 1703) F.R.S., was a thoroughly remarkable man[1]. History, however, has not served the memory of his extensive and innovative scientific career too kindly and, indeed, he is more often remembered in the modern era for his cantankerous (but arguably justified) 'run-ins' with such other luminaries as Newton, Hevelius, Huygens and Flamsteed. The topic of this essay, however, is concerned with an attempt to rediscover a lost remnant from amongst Hooke's astronomical works. Specifically, we have set out to recover some of Hooke's imaginative artistry and identify those stars that constitute the circumpolar constellation he defined and named the *English Rose.* "Discoverable only by a telescope", Hooke mentioned the *English Rose* in just one of his published works, where he described it as follows:

"Consisting of six Stars in the Rose itself, and several others in the Leaves and Branches, one of these is in the Center of the Rose, and five in the five green Leaves of the Knob:

This I have somewhere described about ten Years since, but have mislaid then at the present: the way of finding them I shew'd to Sir *Chr. Wren*, and some others of this Society at the time when my Instrument was fixed for that purpose."

The above quotation is from Hooke's *Discourse of Earthquakes and Subterraneous Eruptions*[2], read to the assembled Fellows of the Royal Society over several meetings starting February 9th, 1687. Hooke became well known, if not infamous, in his latter years for asserting prior authority over many supposedly new scientific discoveries and/or mechanical innovations[1]. While some of his priority claims can be readily established, in the case of the *English Rose* his original description, presumably dating from circa 1677, has not, apparently, survived to the modern era. The authour is not aware of any references being made to the *English Rose* by contemporaries of Hooke, and likewise, no celestial cartographer appears to have explicitly incorporated it into any sky map.

The "about ten years since" comment relating to his initial description of the *English Rose* suggests that Hooke first identified it sometime between 1674 and 1680. A survey of Royal Society meeting notices[3] and Hooke's personal diary[4] indicate that he was actively observing the heavens and building new astronomical instruments in the time interval of interest. For example, we find from the published extracts of his personal diary that between 1674 and 1680 Hooke was making observations of the Moon, the Sun, sunspots, the planets, comets, lunar occultations, and lunar eclipses. We also find Hooke working on the design and construction of various quadrants, multiple numbers of helioscopes, a selenoscope, a new observatory turret at Gresham College, and upon the construction of numerous telescopes. Amongst the various telescopes that Hooke tried at that time, we find reference to objectives with focal lengths of 7, 8, 12, 15, 20, 24, 30, 50, and 60 –feet[5]. Further, and again in the time interval of interest, Hooke published the first part of his *Animadversions* to Hevelius's *Machina Cœlestis*, and he delivered Cutlerian Lectures on topics relating to the motion of the Earth, the construction of helioscopes and the observational properties of comets[6]. And, all this astronomical work was being conducted in parallel with his many other experiments, investigations, and writings for

the Royal Society, as well as in conjunction with his civic duties as City Surveyor of London.

It would seem that there are no specific reasons to doubt Hooke at his word concerning the discovery the *English Rose* sometime circa 1677. Certainly Hooke was keenly observing the heavens at that time and he had numerous instruments with which to make his observations. We have not, however, been able to identify from his diary entries any specific time and experiment when Hooke might have discovered and/or described the *English Rose* to Society Fellows. In addition, it seems reasonably clear from his surviving works that Hooke made no great public advertisement of his 'new' constellation prior to 1687, and we note that he made no mention of the *English Rose* in his *Lectures concerning Navigation and Astronomy*[7] read in 1683.

Polar Drift, The True Meridian and Latitude

Hooke included a description of the *English Rose* in his a *Discourse of Earthquakes* by way of making it an aid to the location of the north celestial pole [NCP]. The relevance of identifying the pole position being that Hooke was describing in his *Discourse* the procedure known to all navigators since antiquity that the altitude of the visible celestial pole corresponds to the observer's latitude on Earth[8]. All that Hooke was encouraging at that time [1687] was that the meridian and latitude be measured with the greatest of possible accuracy. The reason why Hooke was advocating exacting precision, however, related to his belief that "the axis of its [the Earth's] rotation hath and doth continually by a flow of progression vary its position with respect to the parts of the Earth" [9]. While Hooke knew that any such changes must be very small, on a time scale of say years, he argued that they should, none the less, be measurable with 'modern' equipment. Just as precession can be measured by a shift in the position of the NCP against the background stars, so Hooke was suggesting that an addition motion might be present (and measurable) as a result of volcanically driven land mass shifting.

Hooke (rightly) believed that the accuracy required for his polar drift experiment could only be achieved through telescopic observations. His method suggested the use of a long focal length telescope to first determine the location of the NCP on the sky, and from the telescope he then proposed to mark out the meridian. To achieve this latter goal he suggested dropping two plumb lines from each end of the telescope tube or support, the line on the ground between the plumb bobs would then delineate the observer's meridian. In his reading[10] to the Royal Society on February 16th, 1687, Hooke suggested that "six, twelve, or fifteen foot" focal length telescopes might be used, although he later indicated (at the February 23rd meeting) that a "two-foot glass" was adequate. In a moment of grandeur Hooke also suggested that perhaps extremely long focal length objectives might be employed, the objective being "fix'd at the top of some Tower or Steeple, and the Sights and Eye-glass at the Ground"[9].

The Royal Society meeting notices for 1687 indicate that Hooke first broached the subject of a changing polar axis in a lecture delivered on January 19th, their raising the question "whether the earth's poles are fixed in the earth, or not?" He continued the debate on polar drift at the January 26th and February 9th meetings, and at the latter meeting outlined his telescopic method for determining the true meridian. Hooke introduced his method for finding the NCP via the *English Rose* at the February 23rd meeting, and we find that an experiment to substantiate the method was postponed at the March 9th meeting due to cloudy weather. The Fellows returned to the discussion of the Earth's shifting poles at the March 23rd meeting; it then being suggested that "the protrusion of mountains by subterraneous fire or otherwise may occasion some alteration of the poles of the earth, as well as the accession of new matter". At the April 6th meeting Hooke introduced a new method for the determination of latitude; in this case advocating the use of a planisphere constructed according to a gnomic projection. Hooke described additional methods for the determination of latitude at the April 13th, April 20th, April 27th and June 9th meetings. The method outlined at the April 27th meeting relied upon the placement of "the Pole Star [α Ursa Minoris], and two other stars not far distant from the pole [NCP]" into appropriate location circles engraved upon a glass plate positioned at the focal plane of a telescope. At the April 20th meeting Hooke also showed a "reflecting

telescope made to take in several degrees. This he proposed as a very proper instrument to discover the true pole-point among the telescopical fixed stars". Unfortunately no specifications for the telescope Hooke presented at the meeting were recorded. At the May 25th meeting of the Society, Hooke expanded his discussion on polar drift and raised a "suspicion of his, that the earth being made up of heterogeneous parts may have some inequality in the diurnal rotation from the different actions of the sun and moon". He further argued that any variations in the Earth's diurnal motion could be determined by measuring the crossing times of selected stars, all with the same declination, through a telescope's field of view, at various times during the same night. Hooke followed-up on the details of this latter 'thought experiment' by presenting lectures at the June 8th and June 22nd Society meetings on the topic of exact time measurement. While Hooke was prepared to raise the question of a non-uniformly rotating earth in 1687, we note that one of John Flamsteed's first research projects at the newly founded Greenwich Observatory was, in fact, to establish that the Earth did rotate uniformly[11]. Using pendulum clocks built by Thomas Tompion, Flamsteed made daily culmination measurements of the bright star Sirius, and concluded as early as 1680 that the Earth did, indeed, rotate at an even rate (to the accuracy measurable with the then available instruments).

The general trend in Hooke's discussions concerning latitude determination in 1687 is one of evolving practicality. The initial method introduced on February 23rd involved the use of a very long focal length telescope and the identification of stars in a faint, poorly advertised 'constellation'. A refined, more utilitarian method using a shorter focal length telescope ("1 foot, or 18 inches in length") to locate Polaris and several other bright stars was introduced at the April 27th meeting. Alternate methods based upon azimuth, altitude and zenith angle measurements of bright stars were introduced at Society meetings held in early April, May and June. While all of the methods for latitude and true meridian determination outlined by Hooke would have worked in principal, there is no indication that he actually set out to perform, in any systematic manner, the measurements required to test the polar drift hypothesis.

Identifying the *English Rose*

Finding patterns between the distributions of stars on the sky is an age-old human pre-occupation, and one that brings together both the visual acuity and the imagination of the observer[12]. We can not be certain which stars Hooke had in mind when he identified the *English Rose*, but there is no specific reason to suppose that we can not 'find' them again for ourselves.

From Hooke's description in his *Discourse of Earthquakes*, we know that the *English Rose* is only discernible through a telescope and that it is close to the NCP. The meeting notes to the Society gathering held on February 23rd, 1687 contain the additional information:

"[The] small telescopic constellation, called by him the *English Rose* (which he said, he had discovered just about the present pole-point, and wherein he formerly had marked the very point) …. This method having the advantage of being [able] to be put in practice at all times of the night, when clear, and these small stars to be seen with a two-foot glass."

We have, therefore, that the *English Rose* actually encompasses the NCP, or, at the very least, the NCP is located close to some part of its imagined figure. Further, we may assume that most, if not all, of the stars in the *English Rose* are fainter than an apparent magnitude of +6, the typical clear-sky, naked-eye visibility limit. Likewise, we also assume that the stars in the *English Rose* are not so faint that a telescope with a large light-grasp is required to reveal them. Hooke, indeed, suggests a modest "two-foot" focal length telescope is adequate to reveal the stars. This being said, the limiting magnitude of a telescope is determined by the size of its objective and not its focal length.

There are only a very few occasions in all of his written works when Hooke actually refers to the diameter of the objective being employed in his telescope. One such case relates to a 3 ½-inch diameter objective, used circa 1663, in a 36- foot focal length telescope to study[13] both the Pleiades star cluster and the Orion nebula. A second instance can be found in a letter[14] written by Hooke to Hevelius circa 1666. In this latter case, the

objective of a 60-foot telescope is described as being "a piece of glass between ¼ and ½ -inch thick, and between 5 or 6 inches over; it bears an aperture of about 3 inches, sometimes 4 or more." Hooke's observations on the Pleiades cluster were published in his famous *Micrographia*[13], and an inspection of the figure reproduced therein reveals that he was both a good observer and draftsman, and that his telescope could reveal stars down to an apparent visual magnitude of +10.5 (and possible to magnitude +11). Certainly, the theoretical limiting magnitude achievable with a 3 ½ -inch objective is of order magnitude +14, but it is highly unlikely that any of Hooke's objectives were close to being 'ideal'[15]. It is probably safe to assume that the stars constituting the *English Rose* are much brighter than apparent magnitude +10. Indeed, if we set a limiting magnitude of +8.5 for the stars in the *English Rose* then they should readily fall within the light-grasp of a telescope with a 1 to 1 ½ -inch (20 to 30-mm) diameter objective.

Figure 1 in here

Figure 1 shows those stars brighter than a limiting magnitude of +8.5 within 5 degrees of the NCP at the time Hooke was making his observations (epoch 1680)[16]. The brightest star in the field is Polaris (α Ursae Minoris) with an apparent magnitude of +2.1. The stars in the figure are shown with equal weight (i.e., the same sized positional dot is used in each case) in an attempt to enhance any figurative or spatial correlation. We have used the apparent magnitude as a secondary indicator (i.e., faint stars being less 'prominent' than bright ones to the eye) in our search. The group of stars that most clearly 'stand-out' to the authour's eye and which apparently 'fit' the description given by Hooke are joined by solid lines, loops and ellipses in the figure[17]. In this suggested configuration, the *English Rose* is apparently seen 'side-on', like a pressed flower, rather than from 'above' as in the heraldic depiction of the Tudor Rose. The stars in our suggested *English Rose* configuration fall in the magnitude range +7.8 to +6.3, and the 'constellation' stretches some 4 degrees across the sky. The NCP is located close to the 'bend' in what we suggest is the 'stem' of the *Rose*, and the stars that constitute the 'leaves and petals' are situated along what is now designated as the boundary between Ursa Minor and Camelopardalis. We also note that the stars SAO 1975, SAO 2012 and SAO 2010, the three brightest stars

in our evoked *English Rose* all have approximately the same angle of Right Ascension (RA ≈ 12 hr) and consequently they act as convenient guide stars which 'point' directly towards the NCP. As a consequence of precession the stars in our suggested *English Rose* are now no longer close to the NCP. Indeed, the star in the *English Rose* that we place closest to the NCP, star SAO 2010, is presently separated from the pole by 2.3 degrees on the sky, as opposed to a 0.5 degree separation in 1680. Polaris has experienced the exact reverse of this displacement; it presently being 0.7 degrees from the NCP, as opposed to 2.5 degrees in 1680.

Just as no clearly authenticated portrait of Hooke's likeness has survived to the modern era[18], so too has Hooke's original description of the *English Rose* been lost. We have here, however, sought to reconstruct the latter, and while we can not be certain that the stars as specified by Hooke have been identified, we present the construction shown in figure 1 as a possibility to what he might have had in mind.

Notes and references

1 See, for example, the recent books: S. Inwood, *The Man Who Knew Too Much* (Pan Books, London, 2002); and J. Bennett, M. Cooper, M. Hunter, and L. Jardine, *England's Leonardo: the life and work of Robert Hooke* (OUP, Oxford, 2003). See also, A. Chapman, 'England's Leonardo: Robert Hooke (1635-1703) and the art of experiment in restoration England'. *Proc. Royal. Inst. Gt. Brit*. **67**. 239-275 (1996).

2 R. Waller (Ed.), *The Posthumous Works of Robert Hooke*. (Johnson Reprint Corporation, New York, 1969). pp. 279 – 450.

3 R. T. Gunther, *Early Science in Oxford.* vol. VII. pp. 416 – 567 (Oxford, 1930).

4 H. W. Robinson and W. Adams (Eds.), *The Diary of Robert Hooke: 1672 – 1680* (Wykeham Publications, London. 1968).

5 We leave the focal lengths in their original units of feet; the conversion to meters, for those that will, being made through the multiplication by 0.3048. Hooke used

long focal length objectives, as did all his contemporaries, as a means of minimizing the image-degrading effects of chromatic aberration.

6 R. T. Gunther, *Early Science in Oxford.* vol. VIII. pp. 31 – 114 (Oxford, 1930).

7 Hooke outlines in this work a method by which an observer's meridian can be determined through the measurement of the extreme eastern and the extreme western positions of any circumpolar star. See note 2, pp. 505 – 506.

8 Hooke had been 'charged' by the Royal Society, in June of 1669, to find a method for determining the "true meridian", but in spite of additional 'reminders' in April and July of 1670, and in June of 1671, no practical method was apparently brought forward. The Royal Society meeting notices for April 14, 1670 do record, however, that Hooke "suggested a method for striking exact meridians by the North Star, and by observing the time of night" - see, R. T. Gunther, *Early Science in Oxford.* vol. VI. (Oxford, 1930). In 1670, the North Star (= Polaris = α Ursae Minoris) was some 2.5 degrees angular distance from the NCP, and the method that Hooke appears to be advocating would require the determination of its times of upper and/or lower culmination. It seems clear, then, that Hooke had not identified the stars in the *English Rose* by June of 1671, which is consistent with his comments referenced in note 2.

9 See note 2, pp. 353 – 362.

10 Editorial comment by Waller. See note 2, p. 360.

11 A. Chapman, *Dividing the Circle: The Development of Critical Angular Measurement in Astronomy 1500 – 1850* (Praxis Publishing Ltd., Chichester, 1990). p. 50.

12 There is typically only a slight or, at best, a passing similarity between the actual distribution of stars on the sky and the constellation figure that they are supposed to represent. Our assumption in this article, however, is that the stars that constituted Hooke's *English Rose* did have a distribution on the sky that would be generally 'recognizable' as a rose, or at least a flower-like motif.

13 R. T. Gunther, *Early Science in Oxford.* vol. XIII. pp. 241 – 246 (Oxford, 1938). Hooke began his observations of the Pleiades cluster in April of 1663 - see, R. T. Gunther, *Early Science in Oxford.* vol. VI. p. 128 (Oxford, 1930).

14 See note 8, pp. 279 – 281. The extract quoted is from an undated letter [but designated circa 1666] by Hooke to Hevelius. Hooke continues in his letter, "It [the 60-ft glass] discovers many things not visible through a very good 36 [foot] glass; such as the shadows of the satellites, and the veracity of Jupiter and Mars on their axes". Hooke further designed and presumably experimented with variable aperture attachments. An iris-like diaphragm, for example, was described at the July 27, 1681 meeting of the Royal Society: "Mr. Hooke showed his new-contrived aperture for long telescopes, which would open and close just like the pupil of a man's eye, leaving a round hole in the middle of the glass of any size desired; which was well approved of". See note 3, p. 577.

15 The theoretical limiting visual magnitude of a telescope with an objective of diameter D(mm) is: $m = 2.7 + 5 \log D$. See e.g., R. Gupta (Ed.), *Observer's Handbook of The Royal Astronomical Society of Canada* (University of Toronto Press, Toronto, 2004). R. Willach [The Development of Telescope Optics in the Middle Seventeenth Century, *Annals of Science*, **58**. 381- 398 (2001)] notes, however, that circa 1610 Galileo could detect stars down to magnitude +8.5 with an objective glass of 20mm diameter. Galileo was thus 'loosing' about one magnitude from the theoretical limiting magnitude of his telescope. This 'loss' was caused by the poor optical quality of the glass available to Galileo in his experiments. Since the quality of optical glass hardly improved during the entire run of the 17th century [see e.g., M. E. Rudd, R. Willach. K. Stauberman and D. H. Jaecks, A curious Example of a Fraunhofer-Dolland Connection, *Bulletin of the Scientific Instrument Society*, No. 79. 2 – 5 (2003)] a one to two magnitude loss from the theoretical limiting magnitude of any telescope being used by Hooke would not be surprising.

16 The figure has been constructed with the aid of the 'Redshift 2' planetarium program (Maris Multimedia, 1995). The program incorporates both proper motion

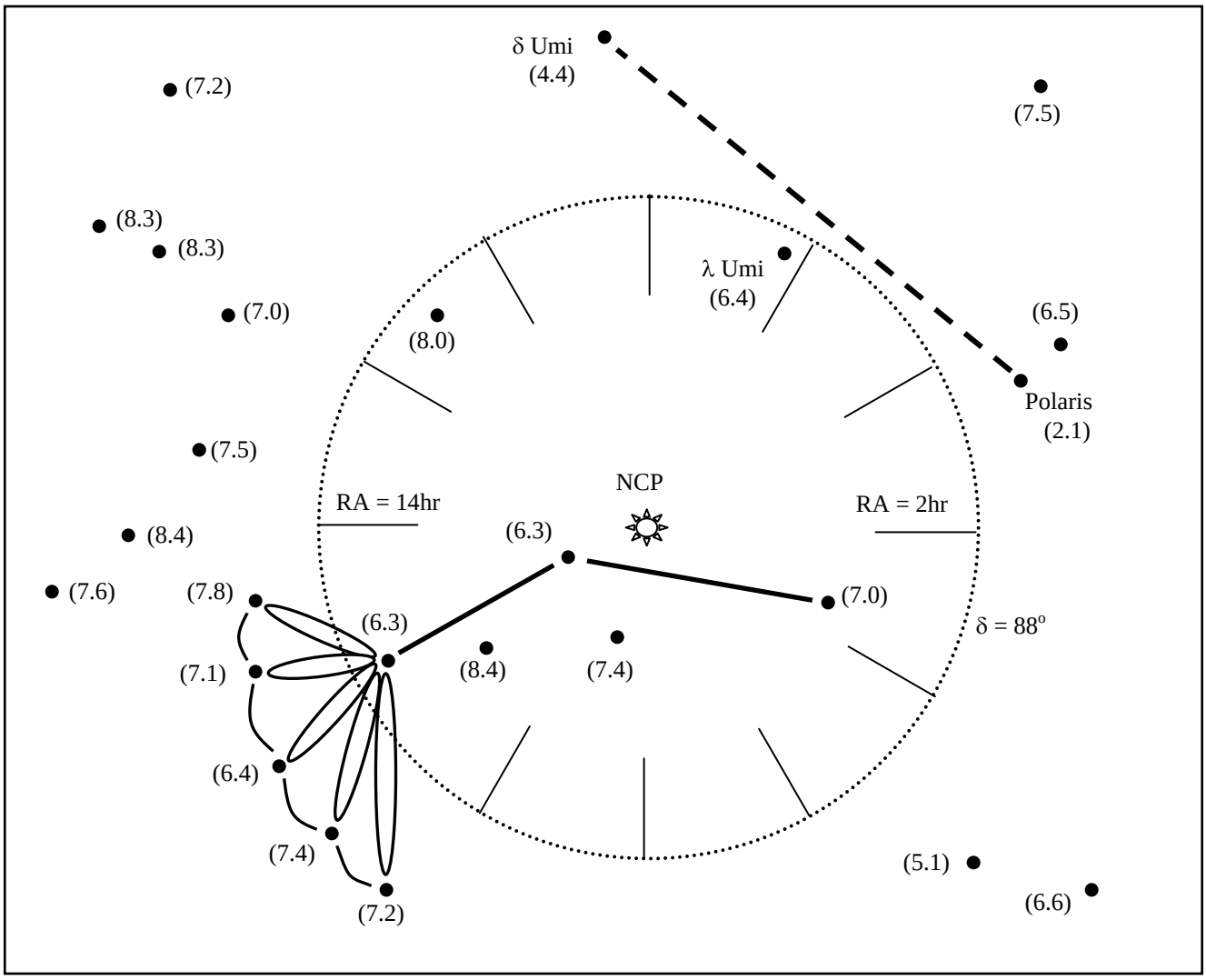
and precession adjustments to star locations in accordance to the prescribed viewing epoch.

17 The star designations in the Smithsonian Astrophysical Observatory Star Catalogue (SAO listings) are: SAO 2012 for the 'central knob', with the five leaves being SAO 2122, SAO 2057, SAO 1975, SAO 1902, and SAO 1834. The 'stem' is composed of the tree stars SAO 2012, SAO 2010, and SAO 1401.

18 A. Chapman, 'The astronomical works of Robert Hooke'. *The Observatory*. **123**. 241 - 245 (2003). A portrait propounded to be of Hooke has recently been found, however, and this may be viewed at the MacTutor History of Mathematics Archive, maintained by the University of St. Andrews. The internet URL is: www-history.mcs.st-andrews.ac.uk/history/PictDisplay/Hooke.html

Figure caption:

Figure 1. The spatial distribution of stars brighter than apparent magnitude +8.5 located within 3.5 degrees of the north celestial pole (epoch 1680). The north celestial pole (NCP) is at the center and the circle (dotted) has an angular radius of 2 degrees on the sky. The star positions are shown with 'dots' of equal weight (in order to enhance any spatial correlation) and their apparent visual magnitudes are given in the brackets. The dashed line in the upper right hand corner indicates the 'tail stars' of Ursa Minor. Our suggested grouping for the stars in the *English Rose* is shown by the solid lines (the stem), ellipses (the five leaves) and arcs (the rose petals).


δ Umi
(4.4)
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(6.4)
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Polaris
(2.1)
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NCP
RA = 14hr
RA = 2hr
(8.4)
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(7.0)
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