Nasmyth's Great Un-built Reflector

Kevin J. Kilburn
Past President, Manchester Astronomical Society

James Nasmyth (1808 to 1890), successful engineer and amateur astronomer, is best known for his development and use of his unique, 20-inch aperture, 'comfortable' telescope, which he used first in Patricroft, near Manchester, then in Penshurst, Kent. The main innovation in this modified Cassegrain telescope was that its fixed eyepiece, in a hollow altitude trunnion, offered the user greater productivity than conventional designs. Less well known is that in 1849 Nasmyth outlined plans for a 60-inch aperture telescope using the same principles. The speculum-metal mirror was to be mounted in a steel tube 5½ feet in diameter and 35 feet long, the whole mounted on a turntable. The telescope was never built; why?

By the mid 1840s, James Nasmyth (Figure 1) had become a very wealthy man. His engineering business in Patricroft, near Manchester, was doing well and he could afford time and money to pursue his passion, astronomy. His interests were the Moon, the Sun and the planets. As a teenager he had fashioned a 6-inch reflecting telescope and had shared his interest in astronomy with the engineer and inventor, Henry Maudslay[2], to whom he and his brother, George, had been apprentices and later assistants for 2 or 3 years, until 1831, when Maudslay died[3]. Shortly before this, Maudslay had been planning a 24-inch telescope for his private observatory at Norwood, west London.

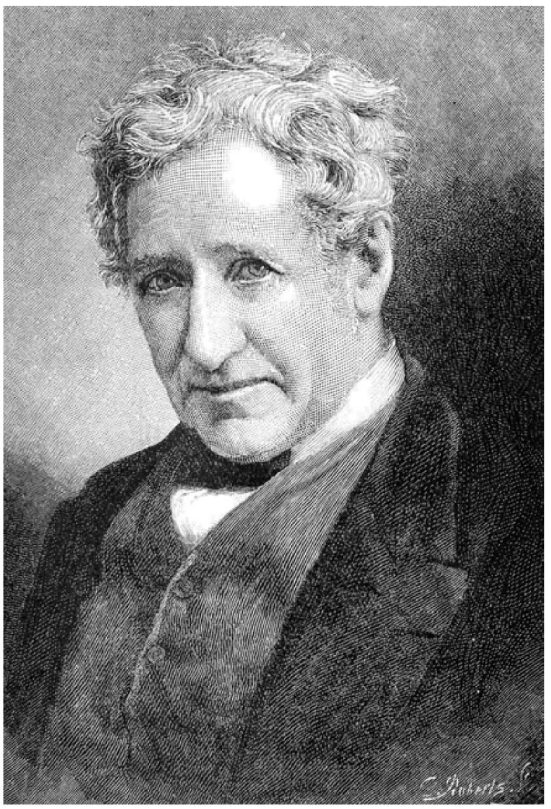

Figure 1

Portrait of Nasmyth

Image taken from Reference 1.

Nasmyth had set up at Fireside, the home in Patricroft that he and his wife occupied from 1843 to 1856, a small Newtonian reflector, fitted initially with an 8-inch diameter speculum and later with a 10-inch diameter speculum, mounted in a square wooden tube[4]. Anecdote, probably encouraged by Nasmyth himself, suggested that a boatman on the Bridgewater Canal, which ran past Fireside, seeing him in his nightshirt at the dead of night, carrying the telescope around the garden to avoid shrubs and trees blocking his view of the sky, claimed that a ghost carrying its coffin in its arms haunted this bend of the canal.

It was at Fireside, too, that Nasmyth subsequently erected his pioneering 20-inch aperture reflecting telescope on its novel Nasmythian mounting[5]. The instrument was still under development in 1848-49, but it had already convinced him that its method of mounting, a hand-wheel-propelled turntable and trunnion, on which the seated observer moved around with the telescope, was the future for visual observations of solar system objects.

Nasmyth's configuration is a modified Cassegrain system, in which light is reflected from the primary, concave mirror to a convex secondary mirror, before being reflected to a flat tertiary mirror angled to reflect it to an eyepiece in the hollow trunnion of the altitude bearing. This system not only causes field rotation, but is extremely wasteful of light. In the 1840s, each reflection from metal specula lost about 60% of the incident light. Speculum metal was an alloy of high-purity copper and tin. Even though arsenic was added to 'whiten' the alloy, it had poor reflectivity, and needed more-frequent repolishing, compared with front-silvered, glass mirrors that became readily available a decade or so later. This light loss was of little concern to Nasmyth. He was interested in the Moon, the Sun and the planets, and they provided light in relative abundance. He wanted resolution and high magnification, both of which could be provided by a Cassegrain telescope of large aperture and long focal length.

Also, before Foucault's test, which was introduced in late 1850s to fine-tune parabolic refl-

ecting surfaces of medium or short focal ratio, it was necessary to optimise optical performance by using spherically-figured primary mirrors of long focal length[6]. These mirrors needed long tubes, commensurate with their large diameters and high focal ratios. A folded Cassegrain system was a light-losing compromise, but one that Nasmyth could afford to adopt in order to build a shorter telescope that was more convenient to operate.[7] His experiments and experience with the 20-inch supported his claims.

In 1849, Nasmyth discussed these points with his long-standing friend, Sir David Brewster, then living at St Andrews[8]. This correspondence may have precipitated his next idea. In a diagram dated 12 May 1849 Nasmyth outlined a monster 5-foot diameter telescope, with a tube 35 feet long and with a focal length approaching 70 feet. Two days later, on 14 May 1849, he wrote to Professor James Forbes at the University of St Andrews describing his proposed instrument[9] (Figure 2).

In anticipation of Forbes's likely objection to the increased light loss from a 3-reflection system, Nasmyth pointed out that the light loss from the third reflection on a 5-foot telescope would still give equal image brightness to a telescope of 4ft 6inches aperture but of 'usual' layout. However, his main argument for the design was that:

> '… rendering such gigantic instruments comfortable to use will importantly serve science [and] there can be no doubt in as much as the observations with such a telescope as I propose to make will by the simple reason of comfort & ease of management yeald (sic) 100 observations while one on the hitherto cumbrous system would not yeald 10.'[10]

The Nasmythian tertiary reflector (Figure 3) lost a lot of light, but he reasoned that observing from a fixed seat at the trunnion-mounted eyepiece more than made up for that loss by providing a comfortable observing position that actually encouraged one-man operation and hence more frequent use. The telescopes of William and John Herschel, and the Earl of Rosse's 6-foot, 'Leviathan of Parsonstown', had complex mountings that needed several men to work them on behalf of the single observer. It should be remembered, however, that the Herschels and Rosse probed the skies for very faint objects, close double stars and nebulosities. For these observations they needed telescopes with maximum light grasp, which was achievable only by minimising the number of reflections. The Herschels used single-

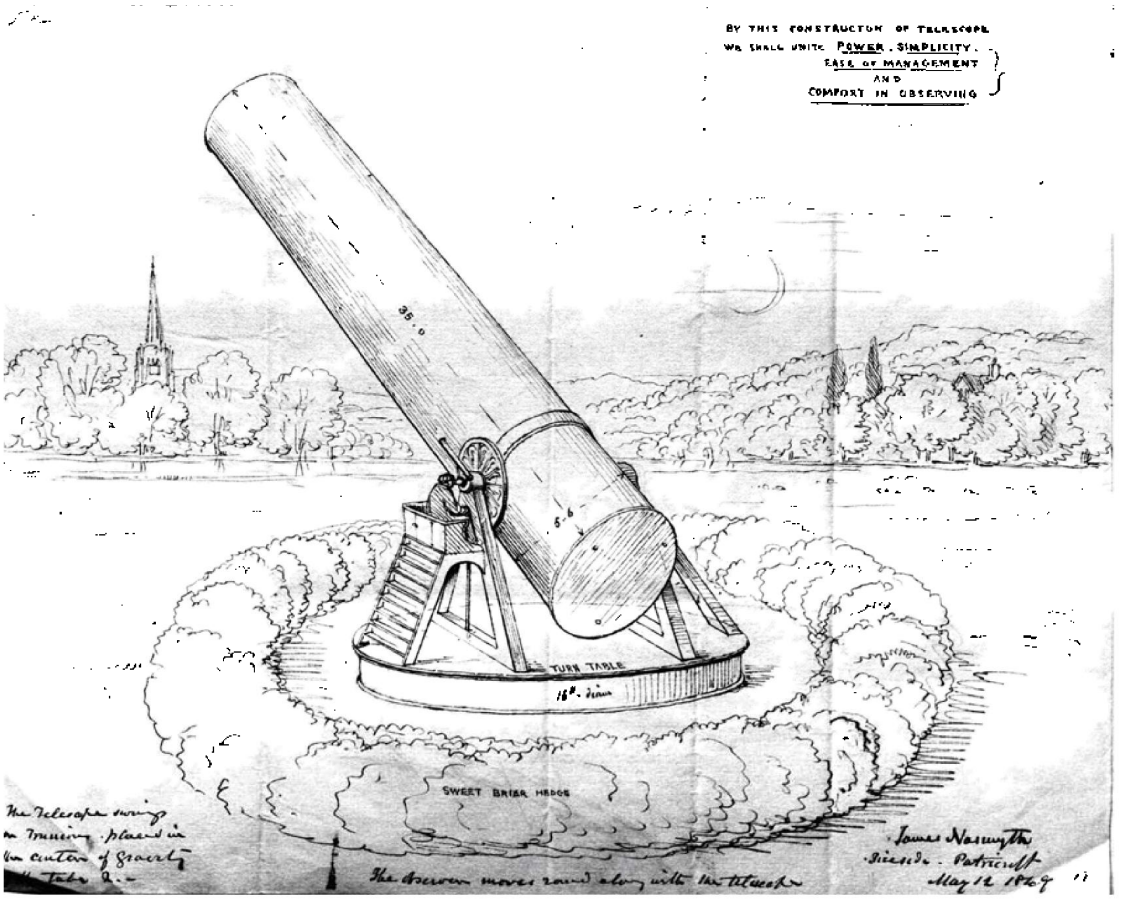

Figure 2

Nasmyth's sketch of his proposed 5-foot reflector

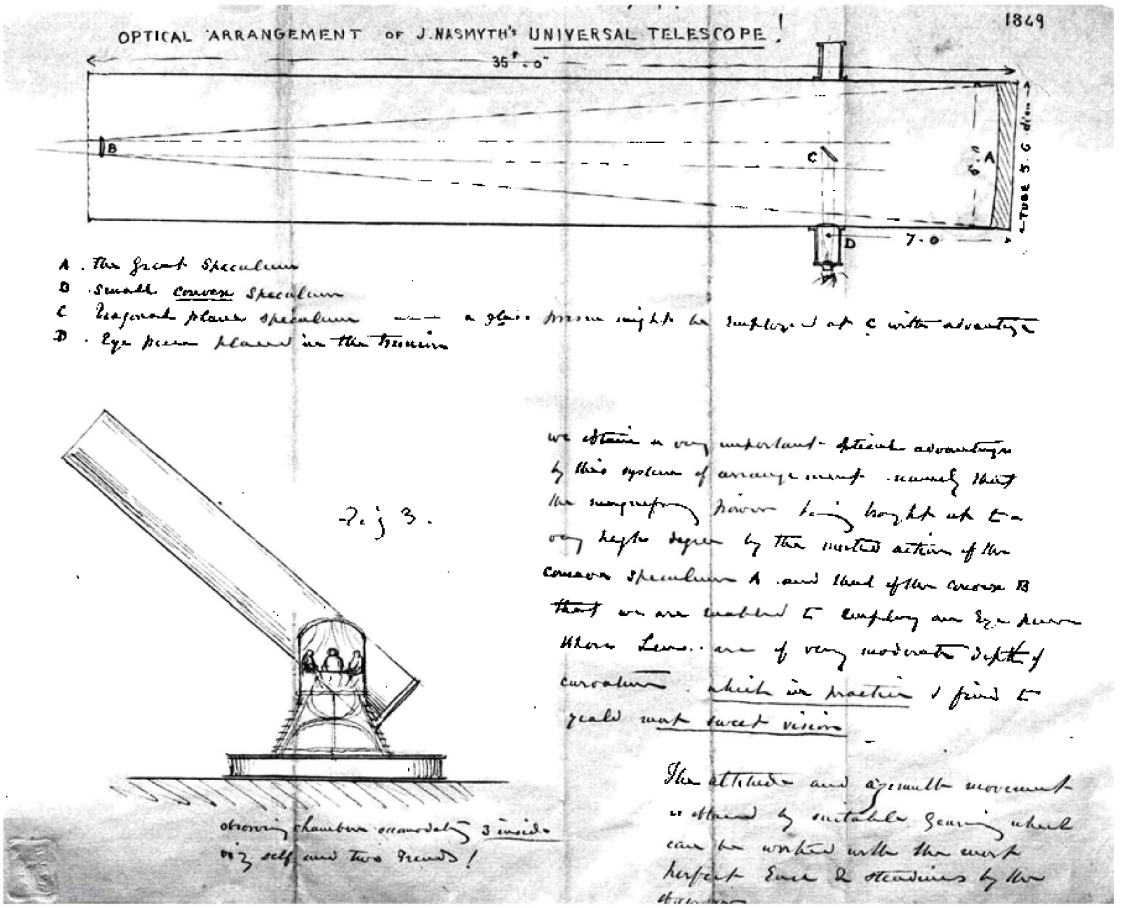

Figure 3

The optical layout of Nasmyth's proposed 5-foot reflector

Illustration taken from Reference 9.

reflection, front-view Herschelian telescopes; Rosse used the two-reflection, Newtonian design.

Nasmyth intended to manage the magnification of his 5-foot telescope not by using interchangeable eyepieces of short focal length, but by adjusting the separation of the primary and secondary mirrors, which he referred to as 'metals':

> 'I bring up the Power by the action of the concave & convex metals so that the greater part of the duty of magnifying power is accomplished by the metals themselves and not by the eye piece which in my case admits of the use of an eye piece of very moderate power whereby the light is not put to torture in having to be treated by lenses of such small diam. [sic] & deep curve […] there is a pleasantness of vision and a sharpness & comfort that so far as I can judge remarkably characterises the vision with my system of arrangement.'[11]

With a focal length of some 70 feet, the magnification of his proposed telescope would have been enormous using conventional eyepieces. The eyepiece optics therefore had to be matched to those of the primary optics and, like Rosse, he had to design his own. He illustrates his proposal in his letter to Forbes[12], and contrasts it to a conventional eyepiece (Figure 4). It is not clear if the device would have

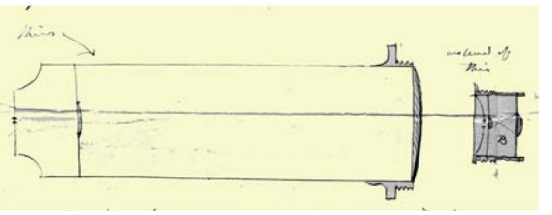

Figure 4

Nasmyth's design for eyepiece of his proposed 5-foot reflector

Note the contrast of the light path with that of the conventional eyepiece shown at the right of the sketch.

optimised the telescope, and if moving the secondary mirror with respect to the primary would have had a precisely-controlled affect on the gross magnification from an essentially fixed eyepiece. Nevertheless, had it ever been constructed, Nasmyth's 5-foot telescope would have been the second-largest telescope in the world at that time, second only to Lord Rosse's 6-foot telescope.

Nasmyth never did build the 5-foot telescope although he said:

> 'If £1000 will accomplish this I shall gladly devote that sum to the attainment of such an object.'[13]

It would have been a huge investment for the mid–19th century, but one that Nasmyth felt worthwhile. He would certainly have been able to afford the cost, and materials and skilled labour would have been available from his Bridgewater Foundry. But it never happened: why not?

The 20-inch telescope was certainly a success. In June 1851 Nasmyth wrote to Professor John Phillips of Oxford:[14].

> '… I have done a deal on the moon this year with my new comfortable 20in reflector which is a first rate tool for that special job or class of work it is really a vast comfort to be able to sit at ones ease on an easy chair and sweep the heavens without having to mount ladders. as the Picture Books used to say "See there it is"' [Figure 5]

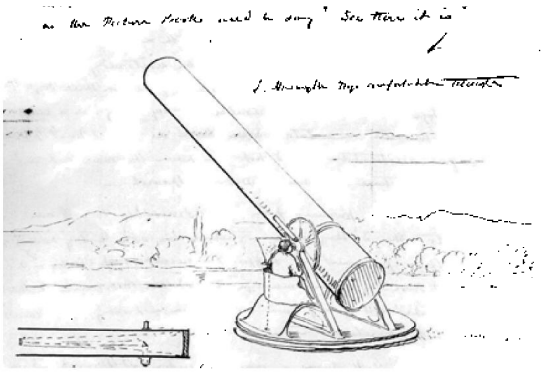

Figure 5
Nasmyth's 20-inch telescope sketched in his letter to Professor Phillips
Illustration taken from Reference 13,
reproduced by courtesy of University of Oxford Museum.

> 'The eye piece is placed in the hollow trunnion and the observer seated with his eye opposite to it and the entire instrument being mounted on 'a turn table' so which ever direction he points the telescope it makes no difference to him he is always in the right position to obtain this & employ a 3d reflecting surface by which a little light is lost and a vast amount of comfort and convenience gained.
>
> 'Excuse this palaver from yours most faithfully
>
> James Nasmyth'

The 20-inch telescope was more than adequate for observing the Moon, the Sun and the planets. A 5-foot telescope would have been better, but might have presented engineering problems that could have more than offset its much greater light grasp. A 16-foot railway turntable, modified to carry the proposed 35-foot telescope tube would, alone, have weighed several tons. Similar turntables were used in Nasmyth's foundry. They were easily capable of being operated by one or two men to swing 20-ton railway locomotives in the Bridgewater Foundry from tracks laid into the factory and then at right angles onto the siding that ran to the main line. But to manoeuvre a large telescope single-handed, with the delicacy needed to follow an astronomical body, might have proved too much, even for Nasmyth. However, his name is well remembered in the world of big telescope building; the stationary Nasmyth foci, using the configuration he invented, are widely used on giant, modern instruments to carry heavy, sensitive instruments such as spectroscopes.

Acknowledgements

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Notes and References

1 Nasmyth, J. *James Nasmyth, Engineer: An autobiography*. Ed. Smiles, Samuel. London: John Murray. 1883.
2 For a fuller account of Nasmyth's work on the development of the telescope, and of his observations of the Sun and Moon, see Chapman, A. *James Nasmyth: Astronomer of Fire*. In: *Yearbook of Astronomy, 1997*. Ed. Moore, Patrick. London: Macmillan. 1996. 143-167.
3 Ashbrook, J. *James Nasmyth's telescopes and observations.* In: *The Astronomical Scrapbook.* Cambridge, Massachusetts, USA: Sky Publishing Corporation. 1984.
4 King, H.C. *The History of the Telescope.* London: Charles Griffin & Company Limited. 1955. 217.
5 The 20-inch telescope is currently (2005) in storage at the National Museum of Science and Industry, London. It has not been on public display since 1988, although it can be viewed by obtaining prior permission. In 2002 it was proposed by the author that this instrument might form the focal point in a refurbished Air and Space gallery at the Museum of Science and Industry, Manchester (MSIM). Informal discussions with Dr Ian Griffin, Director of MSIM, suggest it possible that the Nasmyth telescope will be loaned to MSIM.
6 The Focal Ratio (f) of a telescope is the mirror focal length divided by its diameter. Most modern reflecting telescopes have a focal ratio in the range f4 to f8. Spherically-figured mirrors are typically f10 or greater.
7 This is analogous to use of configurations such as folded Maksutovs to produce portable telescopes today.
8 Nasmyth, J. Reference 1 above. 337.
9 Letter from Nasmyth to Forbes dated 14 May 1849. Papers of James David Forbes. msdep7, Incoming Correspondence 1849 number 25, Forbes Collection (1849/25 a & b), transcribed by Dr John A. Cantrell, with permission of the University of St Andrews Library.
10 From Reference 9 above.
11 From Reference 9 above.
12 Reference 9 above.
13 From Reference 9 above. On purely currency conversion basis, this sum would equate to about £50 000 today [Bank of England Contemporary Values of the Pound]. This figure ignores relative levels of affluence; a realistic equivalent would be considerably greater.
14 Letter from James Nasmyth to Professor John Phillips 2 June 1851. University of Oxford Museum Accession number 1851/3.