The origins and construction of the Isaac Newton Telescope, Herstmonceux, 1944–1967

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The 98-inch Isaac Newton Telescope was the largest telescope ever to be sited in the British Isles, but it was moved to La Palma in the Canary Islands after only twelve years at the Royal Greenwich Observatory, Herstmonceux, Sussex where observing conditions were not good enough for such a large instrument to be effective. This paper examines why the telescope took twenty-one years to build and why it came to be erected at Herstmonceux.

Introduction

In 1946, two proposals were made for large reflecting telescopes, both of which, when built, would have apertures of over 90 inches (2.28m). In February of that year Harry Plaskett, in his Presidential Address to the Royal Astronomical Society, made a case for a new large telescope to be located in the British Isles, for the use of British astronomers – what eventually became the Isaac Newton Telescope (INT).[1] Seven months later, Lyman Spitzer Jr. in the United States wrote a secret report on the 'Astronomical Advantages of an Extra-Terrestrial Observatory', in which he outlined the benefits of a telescope in Earth orbit, above the blurring effects of the Earth's atmosphere.[2] This was the original idea for what became the Hubble Space Telescope, which, despite it being found to have a flawed mirror soon after its launch in 1990, went on to become an outstandingly successful research instrument. The Isaac Newton Telescope, too, has been a great success since its removal to La Palma in the Canary Islands in 1979. But the telescope's twelve years before 1979 at its original site at Herstmonceux in southern England have long since entered the folklore of modern astronomy as an expensive failure.

The planning and construction of the INT took twenty-one years and cost nearly a million pounds, and, notwithstanding the dramatic discovery with this instrument in 1971 by Murdin & Webster of a possible black hole[3] – the first observational discovery of such an object, long predicted by theory – its output of scientific results at Herstmonceux proved to be a dismal disappointment. A 1983 study found that between 1969 and 1978, the INT produced just one-sixth of the number of papers written using two equivalent-sized telescopes abroad.[4] Moreover, by the late 1960s, the advent of cheap air travel meant that astronomers could observe at much better sites than anywhere in the UK, so by the time the telescope was completed it was not as useful as it might have been in an earlier era. The telescope's removal to La Palma meant partly rebuilding it, with a new dome and a new mirror. Just seven years later, it was decided to remove the entire RGO from Herstmonceux to Cambridge, leaving the derelict INT dome, which still adorns the Sussex landscape to this day, as a symbol of this astronomical blunder (Figure 1).

Figure 1. The empty Isaac Newton Telescope dome at Herstmonceux. Photograph by the author.

This paper aims to show that the history of how the INT was conceived, planned and built is essentially a narrative of bureaucracy and high politics, as revealed in the minutes of meetings and correspondence between an elite group of scientists and senior civil servants.

In his popular 1936 book, *The Realm of the Nebulae*, American astronomer Edwin Hubble wrote: 'The conquest of the Realm of the Nebulae is an achievement of great telescopes.'[5] Increasing the aperture of a telescope enables the astronomer to detect fainter objects and to resolve smaller and more distant objects. The increasing importance of stellar and extragalactic astronomy in the twentieth century – symbolised by Hubble's discovery that some of the 'nebulae' were external galaxies and then that those galaxies were rapidly receding from the Earth – led to an increasing demand for large telescopes. The INT was much the largest optical telescope ever built in the British Isles on its completion in 1967, and its disappointing performance at Herstmonceux compares starkly with the success of large telescopes elsewhere, especially in the United States. The failure of the INT must also be seen in the context of the remarkable success of radio astronomy in the two decades after the Second World War, within the United Kingdom as well as in other parts of the world. The 250-foot radio telescope at Jodrell Bank, which became an icon of British post-war scientific achievement after its well-publicised tracking of the first Soviet satellite *Sputnik I* in 1957, was completed in about

Figure 2. Rain clouds loom over Herstmonceux Castle, home of the Royal Greenwich Observatory from 1948 to 1990, symbolising the difficulty of doing optical astronomy in the British climate. *Photograph by the author.*

one-third of the time that it took to build the INT, despite enormous cost overruns and an enquiry by the Public Accounts Committee which threatened to halt the project and send its chief scientist, Bernard Lovell, to prison.[6]

To a modern reader, living in an era of giant telescopes located at remote mountain sites and in space, two questions clamour to be asked about the history of the INT. First, why did it take so long to build, especially when compared with, for example, the 100-inch Mount Wilson telescope, which was built in only ten years? Secondly, why was it built in the British Isles, a notoriously poor location for optical astronomy? In particular, why was it built at Herstmonceux? Modern observatories are usually located on remote mountaintops, where skies are dark, clear and stable. Mountain observatories were by no means unprecedented when plans to build the INT were first announced in 1946. As far back as 1856, Astronomer Royal for Scotland Charles Piazzi Smyth took a telescope to Tenerife (ironically, in the same group of islands as La Palma, where the INT was relocated), where his observations showed far more detail than could be seen from Edinburgh, thanks to the steadiness of the mountain air. Smyth passionately believed that most astronomical observatories even then were in the wrong place.[7] Since the end of the nineteenth century, American observatories had shown a trend to move to remote, high-altitude sites in the west of the United States.

Even a long-established British observatory, the Radcliffe Observatory at Oxford, had been moved to South Africa by observatory director Harold Knox–Shaw, frustrated by the poor observing conditions in Oxford. Knox–Shaw may have moved the observatory at the suggestion of Frank Dyson, Astronomer Royal until 1933.[8] Indeed, in a 1931 letter to Knox–Shaw, Dyson wrote that when the industrialist Johnstone Yapp offered to present the Royal Observatory with £15,000 for what would eventually become the 36-inch Yapp reflector, the money would be better spent by the Radcliffe Observatory, 'as they wanted to erect a large telescope in S. Africa where it would be more useful than in England.'[9] It is all the more surprising then, that Dyson's successor, Harold Spencer Jones, acquiesced in a decision to site a 98-inch telescope near the south coast of England and, as we shall see, remained firmly opposed to locating the INT overseas.

The Royal Observatory's traditional role was to provide accurate tables and other services to the Royal Navy and merchant marine, and also to provide a timekeeping service to the nation. Most of the astronomical work done was strictly positional, centred around timing the meridian passage of stars. The only astrophysical work carried out at Greenwich before the late nineteenth century was that which had a direct practical value, such as monitoring solar activity and the Earth's magnetic field, which were believed to affect the climate and navigation. Basic research – defined as research 'to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view'[10] – was not seen as part of the observatory's role.

From the 1880s onwards, under Astronomer Royal William Christie, the observatory branched out into areas of astronomy unconnected with navigation, notably participation in the *Carte du Ciel*, an international collaborative project to map the sky photographically. Work of this type, which was continued under Christie's successors, Frank Dyson and Harold Spencer Jones, demanded larger telescopes and also darker and clearer skies than were available in east London. In June 1945, the decision was taken to move the Royal Observatory from Greenwich to Herstmonceux Castle in Sussex (Figure 2).[11] Moving the observatory was a long and complex process, and was not completed until 1957. Thus the completion and construction of the INT must be seen in the context of a national observatory that was in the process of diversifying and also being moved to a new site. Although the observatory's role was changing, until 1965 its parent body was the Admiralty. Only in April 1965, with the reorganisation of science funding following the report of Sir Burke Trend, was responsibility for the telescope and its parent observatory transferred to the Science Research Council. The SRC began operations just two years before the INT was completed, long after all the important decisions relating to its design and construction had been taken, and so the INT belongs firmly in the Admiralty era of the Royal Observatory's history.

The origins and early history of the INT have hitherto been ignored by science historians. Even the best-known history of the Royal Observatory, published in 1975 to coincide with the observatory's tercentenary, devotes just two paragraphs to it.[12] Conversely, accounts written by astronomers lack the historian's critical approach. An article by Smith & Dudley, written on the eve of the re-opening of the INT on La Palma, falls into the trap of seeing history as progress

towards a present happy state of affairs, praising the construction of the new observatory on La Palma as British astronomy finally getting it right, as opposed to the bad old days of Herstmonceux.[13] Similarly, Sir Fred Hoyle, writing with the benefit of hindsight, criticised the INT in terms of how he thought it should have been built.[14] The complex story of the origins and construction of the INT is best tackled chronologically, and this approach will be used here, with a view to tackling the two questions posed above: why did the telescope take so long to build, and why was it sited at Herstmonceux?

Plaskett's telescope, 1944–1947

The concept of a large telescope in the British Isles for the use of all British astronomers owes its origins to Harry Plaskett (Figure 3), Savilian Professor of Astronomy at Oxford since 1932 and President of the Royal Astronomical Society from 1945 to 1947. Harry Plaskett was the son of Canadian astronomer John Plaskett (1865–1941), who designed and built the 72-inch reflector for the Dominion Astrophysical Observatory at Victoria, British Columbia, the second largest telescope on Earth on its completion in 1918. Harry Plaskett had spent the early part of his career as a research astronomer at Victoria, where his father was Director, and so may be said to have been born into the world of big telescopes.[15] In 1944, the Royal Society set up a committee to review the needs of post-war astronomy, consisting of Plaskett, Harold Spencer Jones (Astronomer Royal), and Arthur Milne and Henry Plummer, both of Oxford University. The committee met for the first time on 1945 July 27, and its report noted 'a complete lack of equipment of large light-gathering power'. While it acknowledged that the British climate 'does not justify the erection of instruments of the largest size', it believed that 'a reflector of 60-inch aperture at a selected site in the south of England could be effectively used for special observations which are not possible with the largest existing telescopes in this country'.[16]

Figure 3. Harry Hemley Plaskett, Savilian Professor of Astronomy at Oxford 1932–1960 and President of the Royal Astronomical Society, 1945–1947. *Photograph courtesy Royal Astronomical Society.*

After the committee had been formed, but four months before it met for the first time, Plaskett had written to the Astronomer Royal, saying that 'for some time now I have been vaguely alarmed about the state of observational astronomy in England...' Differentiating between the long-term, routine programmes of the sort traditionally undertaken at Greenwich and what he called 'experimental observation', meaning astrophysics, he went on: 'In our prime, when we had Airy at Greenwich and Lockyer and Huggins free-lancing outside, both kinds of observational astronomy flourished, but since, while the Royal Observatory has more than maintained its pre-eminence, the lead in experimental observation has left England'. Although he did not specifically mention a large telescope, he stated that re-equipping Britain's observatories was the first requirement for 'a true and lasting revival of experimental observation in this country'.[17] Plaskett by this time most probably knew that he was a member of the proposed committee, and in writing to Spencer Jones he may have been trying to sound out his opinions and, if possible, obtain his backing for his views, thus forming a steering group on the committee.

In a sense, Spencer Jones (Figure 4) was the last Astronomer Royal of the old school, in that he was primarily concerned with positional astronomy and timekeeping. His best-known scientific work was leading the worldwide attempt in 1930–'31 to refine the Astronomical Unit (the Earth–Sun distance) using positional measurements of the near-Earth asteroid Eros, and his 1939 paper which proved that the Earth's rotation was not uniform and so was not a reliable timekeeper.[18] But in his reply to Plaskett, Spencer Jones expressed his hope 'that there will be more opportunity in the future for experimental observation', although he believed that 'the Royal Observatory must necessarily be largely concerned with long range programmes, which can not be undertaken by university observatories'. In the same letter, Spencer Jones, positional astronomer that he was, expressed his wish for a Schmidt telescope, a wish that would be a recurrent feature of his correspondence for the rest of his tenure as Astronomer Royal.[19]

Plaskett expressed his own views in much greater detail in his address as President of the RAS on 1946 February 8. In this speech he emphasised the need for a large telescope to be erected in Britain and not 'in some more or less remote part of the Commonwealth where better conditions for observation prevail', which he believed to be 'fundamentally wrong', on the grounds that the proximity of observers and theoreticians was essential to the advancement of astronomy. He based this claim on a very selective reading of the history of astronomy, citing only certain developments in stellar spectroscopy, which he admitted was his own speciality.[20] A similar misrepresentation of history is visible in his claim that cloudy weather and poor 'seeing' – that is, unsteady star images due to atmospheric turbulence – were not arguments against building large telescopes in Britain. Plaskett claimed that 'the very fact that Herschel, Lord Rosse and Common successively and successfully used apertures of 48, 72 and 60 inches indeed suggests that the seeing here must be at least comparable with that prevailing in other places where large instruments are used',[21] but did not mention that little use was made of any of these three telescopes, precisely because the seeing was usually too poor for their

large apertures to be used to their full effect. Similarly, his claim that a lack of clear nights did not prevent Herschel, Huggins and Lockyer from making fundamental observational discoveries glossed over the fact that these three astronomers worked with relatively small telescopes, and at a time when no-one had done their kind of work before. Nor did he mention that the individuals he cited were all amateur astronomers, 'the risk takers' who pioneered early astrophysics,[22] whereas he was arguing for a State-funded astrophysical telescope.

Arguing that the British climate demanded an efficient, wide-angle telescope which could photograph large areas of sky with a short exposure, Plaskett made the case for 'an f/4 Schmidt telescope with an aperture of 49–74 inches', the telescope being convertible to enable slit spectroscopy when the sky was too moonlit for direct photography.[23] The telescope would be located at a 'central university observatory', where astronomers from any university in Britain could use it. Plaskett concluded his address by suggesting that an application should be made to the Royal Society Government Grant Committee for £100,000 to build the telescope, and he further suggested that the RAS hold a special meeting to discuss his proposals.[24]

The importance of this address cannot be overstated, as in it Plaskett publicly laid down several principles that would remain central to the telescope project, at least during its first ten years: that the new telescope could and must be erected in Britain; that Britain's climate demanded a telescope which could make efficient use of precious clear periods; that it had to be a dual-purpose instrument, of a type never attempted before; and that it should be at a central location where it could be used by all British astronomers.

It was decided to locate the new telescope at Herstmonceux very soon after Plaskett's 1946 speech. On 1946 March 8, the RAS formed a committee to consider whether the proposal for a large telescope in Britain was advisable, and if so, how to get the approval of the Society as a whole and how to go about applying for funding.[25] This 'telescope committee' held its first meeting on April 30 – importantly, with Plaskett in the chair. It recommended that the RAS make an application for funding to the Council of the Royal Society, which would then approach the Treasury.[26] It was also agreed at this meeting to name the instrument after Sir Isaac Newton, inventor of the reflecting telescope.[27]

At the tercentenary of Newton's birth in January 1943 (December 1942 reckoning from the Old Style calendar), it had been agreed to defer any major celebrations until after the Second World War was over. The full celebration was now planned for July 1946, and the RAS committee decided, apparently at the suggestion of Sydney Chapman and William McCrea,[28] to name the telescope and its building the 'Newton Memorial Observatory'.[29] The committee held a second meeting on May 10, by which time both Chapman and Spencer Jones had raised the project at a meeting of the Newton Tercentenary Committee, of which they were members. They reported that the Tercentenary Committee strongly supported the telescope being associated with the Tercentenary. They also said that the Secretaries of the Royal Society had suggested that it might be possible to obtain government approval for funding in time for an announcement to be made at the July celebrations, and that an application should be made to the Council of the Royal Society in time for its meeting on May 16, just six days later. Plaskett read out the proposed application, which he had already drafted, and this was approved by the meeting.[30] The application, the final form of which was dated May 14, called for: 'a sum of the order of £100,000 to build a reflecting telescope of at least 72 inches aperture, together with its dome, for observational astronomy in the United Kingdom'.[31] Herstmonceux was chosen as a site on the grounds that observing conditions there were thought to be as good as anywhere in Britain, and also because building the telescope there would allow it to share facilities such as a library and workshop with the rest of the Royal Observatory, thus saving on costs.[32]

The application was presented to the RAS Council, which held its meeting on May 10, later on the same day as the second telescope committee meeting. As Nautical Almanac Office Superintendent Donald Sadler noted shortly afterwards, 'the Council, with no prior information of the nature of the report and of necessity with little opportunity of discussing this important matter in detail, accepted the recommendations of the [telescope] Committee without hesitation and unanimously approved that an application be sent in the form proposed'.[33] The application was duly sent to the Royal Society in time for its Council meeting of May 16. By this time, the RAS discussion meeting proposed by Plaskett in his February address had already been arranged for June 14. Although Plaskett had advertised it as a discussion meeting, it in fact consisted of several presentations on the telescope by various senior astronomers and optical designers. Relatively little time was left for questions and comments from the floor, and no vote was taken, so Fellows merely listened to a decision that had already been taken.[34] Thus it appears that the proposal for the telescope was rushed through to the Royal Society before a democratic decision on its merits could be taken by the Fellows of Britain's premier astronomical society.

On June 1, a second meeting of the Royal Society Committee on Post-War Needs in Astronomy, of which Plaskett was still a member, 'took into consideration' the RAS application. The meeting resolved to recommend to the Council of the Royal Society 'that the minimum needs of British astronomy were, in order of priority', a large reflector 'of at least 72" aperture and preferably 100"' (this is the first reference to a 100-inch telescope), and two Schmidt telescopes – one for the southern hemisphere and another to be located in Britain.[35] On June 26, Sir Alfred Egerton, Secretary of the Royal Society, submitted a proposal for an 'Isaac Newton Observatory' to the Treasury by writing to Stuart Milner–Barry, who had joined the Treasury after a distinguished wartime career at Bletchley Park and was enthusiastic about science, although his academic background was in the Classics.

Egerton stated that the Council of the Royal Society hoped that the Treasury might agree to the project in principle 'so that some announcement may be made by the President [of the Royal Society] at the time of the Newton Tercentenary Commemoration on 15–19 July 1946'. His letter repeated the proposals of the Committee on Post-War Needs in As-

tronomy for a large reflector, preferably of 100 inches' aperture, to be built at Herstmonceux, and two Schmidt telescopes, one of them to be in the southern hemisphere.[36] Milner–Barry quickly passed the proposal to Sir Alan Barlow, Second Secretary to the Treasury, saying that 'the project is a proper one for support by the Government' and recommending that Treasury approval be given in time for an announcement 'with the requisite éclat' at the Tercentenary celebrations.[37] In a later letter, however, Milner–Barry said that 'it might be better to confine the announcement to the 100" telescope and to leave over the question of the Schmidt telescopes', on the grounds that the Schmidt at Herstmonceux had the lowest priority of the three proposed instruments, and that, for some reason, it might be difficult to fund another Schmidt in the southern hemisphere.[38] This was the beginning of the end of the idea of a separate Schmidt telescope at Herstmonceux, something which would have major consequences for the development of the project.

Figure 4. Sir Harold Spencer Jones, Astronomer Royal, 1933–1955. *Photograph courtesy Royal Astronomical Society.*

Barlow also acted quickly. He was Chairman of a committee set up by Clement Attlee's Labour government in December 1945 to assess a perceived shortage of scientists, and the committee's report saw science as central to the future of Britain 'if we are to maintain our position in the world and restore and improve our standard of living...'[39] Milner–Barry's proposal 'that the Government should provide a monster telescope'[40] would thus have immediately appealed to Barlow as a national prestige project. On July 8, he sent a proposal for the new telescope to the Chancellor of the Exchequer, Hugh Dalton. Once again, Plaskett's argument that the cloudy British skies demanded a large telescope was invoked, and Barlow claimed 'that the extra cost of the 100" lens [*sic*] ... is worth while if we are to try and recover our former pre-eminence in astronomy'.[41] Barlow further suggested that Dalton authorise the President of the Royal Society to announce at the Newton Tercentenary that the government 'are prepared to provide a new 100" telescope'.[42]

The Chancellor quickly agreed to fund the project: Barlow's letter to him bears a handwritten note saying 'I agree', signed 'H.D.' (Hugh Dalton) and dated 8 July.[43] On July 15, at the opening ceremony of the Newton Tercentenary, Royal Society President Sir Robert Robinson announced the decision to provide funds for the new telescope, and that the observatory was to be known as the Isaac Newton Observatory.[44] Thus the enthusiasm of the government and two top civil servants for a national scientific project, to be announced at a major international scientific event, meant that government approval for a 100-inch telescope to be located in Britain was announced to the world within little more than a fortnight of the proposal being received from the Royal Society, and little more than five months after Plaskett's original proposal to the RAS in February 1946.

It was agreed that half the costs of building the telescope, plus the entire maintenance costs once it was built, would be borne by the Admiralty, and that the other half of the construction costs would be paid directly by the Treasury, although the Admiralty was not keen on funding the project, because it saw the Royal Observatory 'rather as an old man of the sea, who has been saddled anachronistically on the Admiralty',[45] and thought that the proposed telescope 'would apparently be of only incidental value to the Navy'.[46] To design the telescope and direct its scientific work, the Royal Society appointed a Board of Management, consisting of the Astronomer Royal as Chairman, the Astronomer Royal for Scotland (William Greaves until 1955; Hermann Brück from 1957), the directors of the Oxford and Cambridge University Observatories (Harry Plaskett and Roderick Redman respectively), and four representatives each from the Royal Society and the Royal Astronomical Society. Notable nominees from the Royal Society in the Board's first four years included Lord Cherwell (formerly Frederick Lindemann, best known as Winston Churchill's scientific adviser) and the physicist Patrick Blackett. Among the representatives of the RAS was Sir John Carroll, who was also Deputy Controller (Research and Development) at the Admiralty, and so was effectively a representative of the Admiralty on the Board.[47] In addition, for most of the meetings held while Spencer Jones was Astronomer Royal, his Chief Assistant Robert Atkinson was a co-opted member of the Board. As we shall see, this meant that the Astronomer Royal had someone at his side at meetings who could be guaranteed to back up his views.

The Duplex design, 1947–1954

Although a majority had initially been opposed to Plaskett's suggestion of a dual-purpose instrument,[48] the Treasury's decision to fund just a single giant telescope led to the idea being revived. The decision to build a combination telescope was taken in 1947, and envisaged an instrument with a 100-inch main mirror and a Schmidt corrector plate of the same size, the latter being removable so as to allow the telescope to be used as a Cassegrain with a suitable secondary mirror. At the December 1947 Board meeting, Blackett reminded members that the original plan had been for two telescopes – a 100-inch and a smaller Schmidt – and expressed 'his doubts about a single, dual-purpose telescope'. But Spencer Jones pointed out that the Treasury had only approved funds for a 100-inch telescope, and Lord Cherwell 'thought the present moment impolitic to press for a second instrument ... the proposal would eventually have to go to the Treasury and it would be difficult to justify a second application for funds so soon after the approval for the 100-inch telescope'. The

minutes merely record that 'after considerable discussion this view was accepted by the Board'.[49] Because asking for a separate Schmidt was now judged to be 'impolitic', the Board was now committed to a dual-purpose instrument, even though a 100-inch telescope of this type had never been attempted before.

Making the glass disc (or 'blank') for the 100-inch mirror was no simple matter, because the large volume of glass involved had to be as free as possible from impurities and air bubbles, in order to give a good optical surface, and after the molten glass was poured the disc had to be carefully 'annealed' – that is, cooled under controlled conditions. At the inaugural meeting of the Board of Management on 1947 July 23, it was agreed to enter negotiations with the Pilkington glass-making firm of St Helens, Lancashire, the only British company judged capable of making the 100-inch disc.[50] But a contract was never placed with Pilkington, because in the early summer of 1948, Spencer Jones received news that the University of Michigan wanted to sell off cheaply a 98-inch mirror blank, together with a blank for a secondary mirror and the central plug for the Cassegrain hole in the main mirror. He received the news from Albert Uttley of the Telecommunications Research Establishment at Great Malvern, who was on an official visit to the United States.[51] The disc had originally been cast by the Corning Glass Company of New York in 1935 for a proposed University of Michigan telescope, but the telescope was never built, due to funding problems caused by the Great Depression. The disc had lain unused ever since, and in 1947 had been handed back to the telescope's original sponsors, the McGregor Fund. Further correspondence led to the McGregor Fund presenting the disc as 'an outright gift' to the RGO in February 1949,[52] and the glass duly arrived in Britain by ship on August 8 of that year.

It was agreed that the contract for grinding the mirror to the required curve should be placed with Grubb Parsons, the well-known engineering firm which had made large telescopes for several observatories across the British Empire and beyond.[53] However, soon after the disc was delivered to the firm's Newcastle works in April 1950, managing director George Sisson reported that both of its surfaces contained cracks,[54] and by the end of 1950 it was clear that there were some serious problems: the worst flaws in the glass appeared to be 'certain ropey cords of glassy material differing in constitution from the main mass of the disc'.[55] Some of these 'cords' had cracks around them, caused by their different expansion properties from the surrounding glass.[56] The cracks became worse as grinding proceeded, which meant that grinding was a long process, and not until August 1954 was the mirror finally ground to a spherical curve, the type of surface required by the dual-purpose telescope design.[57]

The enormous corrector plate proved to be even more difficult to make than the mirror. No Schmidt corrector plate of anything like this size had ever been attempted before; the largest Schmidt then in operation was the 48-inch at Mount Palomar. A large Schmidt corrector plate is extremely difficult to make, because not only has it to be shaped to a special curve, but it also has to be of the finest optical quality, ideally as good as the lens in a refractor. In March 1950, it was reported that the German optical firm Schott & Genossen could make a disc of a special optical glass which was able to transmit ultra-violet light, something that no other large Schmidt telescope was then capable of doing.[58] Schott later quoted a price of £4,000 for a 96-inch disc, but said that they could not eliminate all striations.[59] However, it was agreed at the March 1951 Board meeting that the disc should be ordered from Schott, subject to a 38-inch disc made by the same firm currently under order by St Andrews University proving satisfactory.[60] Nothing happened, however, until the next Board meeting in February 1954, when Erwin Finlay–Freundlich of St Andrews reported that he was 'fully satisfied' with his Schott disc, and it was agreed that the Admiralty should be requested to place a contract with the German firm.[61] It was also agreed to buy a disc of plate glass from Pilkington, apparently so that Grubb Parsons could experiment with figuring this to the required curve before working on the expensive German glass.[62]

A second major problem with the dual-purpose instrument was that it required extremely accurate alignment of the mirrors, and it was feared that the telescope tube would sag under its own weight more than the alignment tolerance allowed. At the December 1947 meeting it was agreed that the well-known aircraft designer Barnes Wallis should be consulted on this issue.[63] In his reply, Wallis confirmed that the rigidity required to keep the mirrors in alignment was not possible with currently available materials and methods, but suggested a method for stiffening the tube that involved pumping hot and cold liquids into hollow tube members.[64] Despite Spencer Jones 'having a distaste for such complications on a telescope',[65] it was agreed at the next Board meeting that Wallis's report should be published, 'to stimulate interest in the problem' and that Spencer Jones should 'enquire about a grant towards the cost of some experimental work'.[66] The minutes show no sense of urgency about the problem – a characteristic of the Board meetings that followed. A mechanical design committee was set up to look into the engineering aspects of the telescope. This was not formally appointed until March 1950,[67] and the next Board meeting was not held until more than a year later. At this latter meeting, there was still great interest in Wallis's proposals, and it was decided to arrange a visit to view some tests being undertaken by Wallis at Weybridge.[68] There was an even longer delay – almost three years – before the Board met again, when Spencer Jones announced that Wallis had now radically altered his design, which now involved placing the telescope in the open air! It was decided at this meeting that Wallis's proposals would be 'discussed later'.[69] Not surprisingly, they were not followed up.

The astronomers rebel, 1954–1955

It is not clear why there were such lengthy delays between Board meetings in the early 1950s, especially between 1951 and 1954. It is true that, as McCrea has pointed out, Spencer

Jones had many other priorities at this time – not least moving the Royal Observatory and its staff from Greenwich and setting up a completely new set of buildings at Herstmonceux.[70] But the fact remains that, as Chairman of the Board, he failed to take the initiative to move the project along when difficulties were encountered. An example of this can be seen in his response to concerns expressed by Plaskett, Carroll and Redman, when the Board met in February 1954, over the length of time the project was taking. Spencer Jones was defensive: he 'agreed with Sir John Carroll and Professor Redman that there was urgency, but with a major project like this it had seemed to him only right that any new ideas should be considered and given due weight, and that we should not necessarily be tied to a conventional design.'[71]

In October 1954, there came news that, due to budgetary cutbacks, the Treasury was unable to fund further design work on the telescope for the present, effectively stalling the project. This triggered more general consternation. In late October, some nine members of the Board sent a joint letter to Spencer Jones, requesting an immediate meeting of the Board, to include a statement by the Astronomer Royal on the current status of the project and 'discussion and proposals for some effective procedure to get the scheme out of its present stagnation'.[72] A meeting was duly held on November 17, at which Plaskett and Redman expressed their worries at what the delays were doing to the reputation of British astronomy.[73] Redman suggested setting up a small Executive Committee to speed up progress, and this was appointed the next month, to consist of Redman (Chairman), Plaskett and Atkinson.[74] Over the following months these three met and corresponded regularly. Their exchanges reveal the first serious doubts since 1947 about the wisdom of building a dual-purpose telescope. The most serious problems with the present design were the practicalities of making the giant corrector plate and the difficulty of aligning the mirrors accurately in the long tube. Greaves, for example, said that the difficulties involved with a combination instrument meant that it 'might easily be a somewhat ridiculous failure'.[75]

Around this time, serious opposition was expressed to locating the telescope in Britain – though not by Board members. Redman wrote to Atkinson quoting a letter from Andrew Thackeray, Knox–Shaw's successor at the Radcliffe Observatory in South Africa: 'It seems to me that a large modern telescope in the south is at least 5 times as valuable as its equivalent in the north. Further, with the Lick 120-inch going into action, the Isaac Newton in U.K. will be years too late quite apart from the handicaps of the British climate. With travel becoming increasingly easy and subsidised, there can be little objection to questions of distance. If the Isaac Newton really does materialise in U.K. I am sure that the next generation will deplore the short-sightedness of the preference over more favoured sites in the south.'[76]

More dramatic was a letter from Richard Woolley, who was due to succeed Spencer Jones as Astronomer Royal, and therefore take over leadership of the telescope project, at the end of 1955:

'Of course I think that without any question whatsoever the English 100-inch should be in the Southern Hemisphere where it could be guaranteed to do work of the highest significance...'[77]

It could be argued that both these dissenters were biased in favour of a southern hemisphere telescope, as they had spent much of their careers at southern hemisphere observatories. But by the time he wrote his letter, Woolley had accepted the position of Astronomer Royal, which entailed being based at Herstmonceux, so he would not have been advocating a southern hemisphere telescope in anticipation of having it for himself.

The Executive Committee presented two reports to the next Board meeting, held on 1955 July 8. The main report identified 'a number of serious difficulties' with the duplex design, including the corrector plate and the alignment problem, although did not see these difficulties as insurmountable, and left it to the Board to decide whether or not to go ahead with a dual-purpose instrument. There was also a minority report by Redman, who was adamant that the telescope should be a classical Cassegrain.[78] Members of the Board split into two camps: Redman, Greaves and McCrea wanted a single-purpose instrument, while most others, including Spencer Jones, clung to the duplex design. Spencer Jones claimed that a dual-purpose telescope would be 'a challenge to British design and originality'.[79] It was decided at this meeting that the Executive Committee should work on the assumption that a dual-purpose telescope would be built, but pending the approval of Woolley, who would attend an informal meeting of Board members to be held at the IAU General Assembly in Dublin that summer. Spencer Jones announced that Woolley's views on the project had been received, presumably referring to his letter to Redman of May 16. Spencer Jones claimed that Woolley 'had not objected to a duplex instrument',[80] but Woolley had actually written in his letter to Redman that 'I sympathise with your worries about the wisdom of making a 'duplex' telescope out of the English 100-inch'.[81]

Spencer Jones may have been deliberately misreporting Woolley's letter, in order to strengthen his own case for a dual-purpose telescope. In any case, he did correctly report Woolley's opinion on the telescope's location. 'But', Spencer Jones went on, 'this was not possible. The telescope had been approved for the benefit of British astronomy, in commemoration of the tercentenary of the birth of Sir Isaac Newton...' The Board agreed unanimously that the telescope should be built in Britain.[82] Spencer Jones stated this position bluntly when he replied to Woolley, three days later:

'The Board is unanimous that there can be no question of the siting of the Isaac Newton Telescope outside this country. The funds have been provided specifically as a commemoration of the tercentenary of the birth of Newton; the telescope was asked for on the ground that astronomers at observatories in the United Kingdom could not participate in any programmes of observation for which a large aperture is essential, as there is no telescope in the country with an aperture exceeding 36 inches.'[83]

So Spencer Jones, to the end of his time as Astronomer Royal, was insistent that the Isaac Newton Telescope should be a dual-purpose instrument, and that it must be built in Britain.

Woolley and the Treasury, 1956–1959

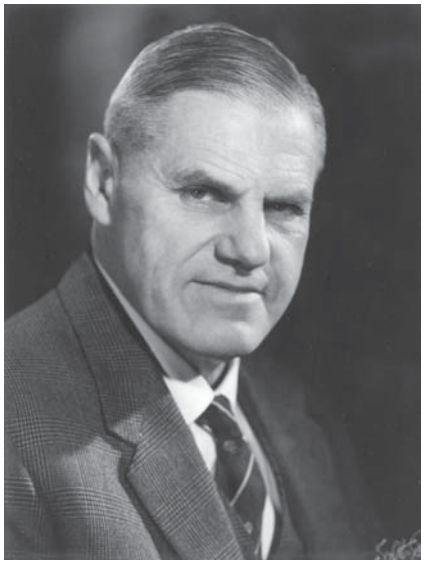

Figure 5. Sir Richard van der Riet Woolley, Astronomer Royal, 1956–1971. *Photograph courtesy Royal Astronomical Society.*

Richard Woolley (Figure 5) succeeded Spencer Jones as Astronomer Royal on 1956 January 1. Since 1939, he had been Director of the Commonwealth Observatory, later known as Mount Stromlo Observatory, near Canberra in Australia. His astronomical interests were in solar and stellar astrophysics, and while at Mount Stromlo he had co-authored an important paper on the solar chromosphere. He had also overseen the construction of a 74-inch Cassegrain reflector, which was built by Grubb Parsons, the firm which was to build the INT.[84] Thus whereas Spencer Jones and all the Astronomers Royal before him had primarily been positional astronomers, Woolley was an astrophysicist through and through – an astrophysicist, moreover, with experience of building and using large telescopes.

Woolley turned his attention to the INT soon after taking up his post. After attending the Dublin meeting, he stated that he 'could not take responsibility for the Duplex instrument'. He believed that a conventional Cassegrain was well suited to the astrophysical research that he wanted to do, and had serious doubts that a Schmidt telescope would be useful, citing the case of the 48-inch Schmidt at Mount Palomar, which was expected to be idle when it had completed its photographic survey of the northern sky.[85] At a meeting of the full Board on 1956 March 5, Woolley announced his decision to abandon the duplex instrument. The list of Board members present at this meeting is notable in that Blackett, who in 1947 had advocated building separate Schmidt and Cassegrain telescopes rather than a combination instrument, was still on the Board, whereas Cherwell, who had opposed building a separate Schmidt in 1947, had by now left. Barnes Wallis was among the apologies for absence. Spencer Jones was still on the Board, but he was no longer Chairman and said little. So the Board's membership was now more weighted towards those supporting a single-purpose instrument. Plaskett and Atkinson changed their tune. Plaskett now agreed that it might be difficult to find programmes of work for a Schmidt, and said that a conventional instrument 'would be easier and quicker to construct. He gave way over the Schmidt and was prepared to support the Chairman'. Atkinson, who at the previous Board meeting had declared his support for a duplex instrument, now said that it was 'unrealistic to plan for a telescope which was not considered practicable by the Astronomer Royal', and seconded the proposal to abandon the duplex telescope.[86]

This might be expected of the RGO's Chief Assistant, who had a personal interest in keeping on good terms with his boss. Plaskett's change of heart might not be as surprising as it first appears either, because the Astronomer Royal, regardless of who occupied that post, was then British astronomy's most prestigious figure, and *all* British astronomers had an interest in keeping on good terms with him, something recalled by Sir Bernard Lovell many years later: 'These were the days in the United Kingdom when no major project in astronomy stood the slightest chance of success without the backing of the Astronomer Royal.'[87] Woolley's proposal to build a Cassegrain telescope was carried unanimously. The meeting appointed a new Executive Committee, consisting of Woolley, Blackett, Plaskett and Redman, and authorised it to draw up a detailed specification for the telescope and submit it to the Admiralty.[88] Following several meetings, the Executive Committee agreed on a specification for the design of the telescope the following November,[89] and this was duly sent to the Admiralty.

The contract was delayed by more than two years due to the state of the British economy, which was seriously weakened in the months after the Suez conflict of 1956. In February 1957, Woolley reported that, even though the project was at 'such a stage that a contract could be placed tomorrow if the money was there', a contract for the INT could not be placed in the near future, because government economies had caused the telescope to be put on hold.[90] In July of that year, the Admiralty agreed to provide their share of the cost, but the Treasury now wanted to know 'why there is a continued need for the I.N.T. now that the Jodrell Bank Radio Telescope is in operation'.[91] Woolley tactfully explained that 'radio telescopes are completely different from ordinary telescopes', and that the latter complemented the former.[92] This is another example of scientific illiteracy at the Treasury, already encountered when they mistook the INT mirror for a lens. In fairness to the Treasury, Jodrell Bank was being investigated by the Public Accounts Committee at exactly the same time in 1957, due to the £260,000 cost overrun this project had incurred.[93] Thus the Treasury, already strapped for funds in the aftermath of Suez, was highly likely to take a dim view of having to fund a second, expensive astronomical instrument.

That same month, the economy took a turn for the worse, and the ensuing inflationary crisis culminated in the resignation of the Chancellor, Peter Thorneycroft, in January 1958. On January 28, the Royal Society was told that 'it has been decided that in present circumstances the work on the Isaac Newton telescope must be postponed.'[94] The INT remained at a standstill for another year; only in January 1959 was it announced that construction of the telescope was to proceed and that funds for it had been included in the estimates for 1959–1960.[95] Grubb Parsons sent a formal tender for building the telescope to the Admiralty on 16 April of that year,[96] and on December 4 a contract was placed with Grubb Parsons to build the telescope and deliver it to Herstmonceux.[97]

An astronomers' conspiracy, 1960

In 1960 there was a second rebellion over the INT. This time it came from Cambridge and challenged the fundamental wisdom of the whole project. On April 28, Harry Hinsley, a historian and fellow of St John's College, Cambridge, wrote to Norman ('Ned') Denning, Director of Naval Intelligence at the Admiralty. Denning had been in charge of the Admiralty's Operational Intelligence Centre during the Second World War, tracking the movements of enemy ships. Hinsley had played a leading role in signals intelligence at Bletchley Park and would have known Denning well; moreover, the work of Bletchley Park was still a total secret, and so he had access to channels of communication at the Admiralty that would have been denied to others. In his letter to his former wartime colleague he said that:

'Some concern is being expressed among the astronomers in Cambridge about the project, ...to build the Isaac Newton 98" telescope at Herstmonceux. Apparently the decision to build this large telescope at this place was taken more than ten years ago and doubts have increased ever since the decision was taken as to whether it will be worth building it at all and also as to whether, if it is to be built, it would not be very wise to base it somewhere else.'[98]

Hinsley also noted that the mirror was 'of questionable quality' and that 'the number of nights on which the telescope would be at all usable in its intended location would be about one in ten'. He asked if the matter could be 'raised unofficially'.[99] In addition to the secret wartime link between a historian and a career naval officer, we can see here the traditional link between the fellows of a Cambridge college, where academics of different disciplines gathered each night at high table. Among the other fellows of St John's were Fred Hoyle, Plumian Professor of Astronomy and Experimental Philosophy since 1958, and Ray Lyttleton, another theoretical astronomer. Both Hoyle and Lyttleton were on the INT Board of Management at this time. They were good friends and had collaborated on papers in the past. Moreover, Hoyle had long resented the power and generous funding of the RGO, whose record of scientific productivity he considered abysmal; in particular, he felt that the astrophysics it was now trying to do was best done by the universities.[100] It seems fair to suppose that Hoyle and Lyttleton, seeing that a contract had been placed to build the INT at Herstmonceux, asked Hinsley to use his influence with the Admiralty to have the decision reversed before construction of the observatory commenced.

Hinsley's letter was forwarded to the Hydrographer, who passed it to Woolley. The Astronomer Royal's reply was predictably indignant. On Hinsley's claim that the telescope would only be usable on one night in ten, he wrote that '60% of the nights of the calendar year 1959 were put to use in securing astronomical observations at Herstmonceux',[101] though he made no mention of the quality of the seeing on those nights, nor of how long on each night the sky remained clear. Woolley read out Hinsley's letter at a Board meeting on June 10, and hoped that the views it expressed 'would all be refuted strongly by the Board'. The minutes record that Hoyle 'asked if it were known who were the Cambridge astronomers alleged to hold these views. He thought the matter should be followed up and forced into the open'. This suggests that Hoyle wanted to use the letter as a pretext for raising the entire issue of the INT and its location with the Board – as well he might, if he had acted in collusion with Hinsley. But the Board followed Woolley's wish; even Blackett 'considered the letter unofficial and impertinent', and his motion that it be ignored was carried.[102]

Meanwhile, a separate initiative had been undertaken by Lyttleton. Around the same time as Hinsley was writing to Denning, Lyttleton wrote to Enoch Powell, an old school contemporary of Lyttleton's, who was now Conservative MP for Wolverhampton South-West and a former Financial Secretary. Powell – whose career was to end suddenly in 1968 with a controversial speech on Commonwealth immigration – was then one of the brightest young stars in British politics, with the potential to achieve great things. According to a letter to Woolley from the financial section of the Admiralty headed 'PERSONAL AND CONFIDENTIAL', Lyttleton's letter had started off a chain of inter-departmental correspondence. This had gone as far as the Minister for Science, Lord Hailsham, who was now demanding a response. Lyttleton's letter, apparently, criticised the decision to place the telescope in the 'Sussex marshes' (in Lyttleton's words), and referred to recent discussions of the Advisory Council on Scientific Policy on the possibility of developing astronomy in the southern hemisphere, clearly implying that the INT would be better located south of the equator. The Admiralty's letter continued: 'I think it would be unwise to under-estimate the significance of the criticisms now levelled since, clearly, the Treasury are showing a close interest'.[103] Lyttleton had succeeded in taking the matter to the highest levels of government. Woolley replied:

'Despite the possibilities of observing abroad which are available to the astronomers of most nations, there are difficulties of an administrative and personal character associated with observing overseas, and British observers have argued consistently that unless there is a large telescope actually in England the majority of British astronomers will not become sufficiently familiar with the use of large telescopes to make effective contributions to practical astronomy on the large scale...'[104]

In an official reply to Roger Quirk, Hailsham's deputy at the Ministry of Science, J. M. Mackay of Admiralty Finance stated that with regard to the location of the INT, 'I think we are dealing with a storm in a scientific teacup, a small minority still trying to lobby their views against the majority of scientific opinion'. Mackay noted that a meeting of the Advisory Council on Scientific Policy held on March 30 had 'expressed no dissent' at a paper claiming that the INT would greatly improve observational facilities for astronomers, but had then gone on to discuss possible schemes for a southern hemisphere observatory. 'The inference is obvious' – that is, that a minority wanted the INT to go to this proposed southern observatory instead of Herstmonceux. Mackay said that he did not know whether this started off further activity by the 'anti Herstmonceux lobby', but could only say that a letter

Figure 6. The Equatorial Group telescope domes, made of unpainted copper and now a leprous green due to verdigris. *Photograph by the author.*

was sent to the Admiralty on April 28 by a member of St John's College, Cambridge, though he did not name Hinsley.[105]

Nothing further on this episode is recorded in the RGO files, and this was the last attempt to change the location of the telescope (although the minutes of a Board meeting held in July 1962 note that criticisms of the design and location of the telescope had been communicated to the RAS Council).[106] Woolley had certainly changed his tune in this regard since his 1955 letter to Spencer Jones, perhaps because a majority of the Board were firmly in favour of building it in Britain, and he might have considered that the Treasury would not favour building it overseas without the Board's full support. But Woolley may also have had an ulterior motive. In their official history of the Anglo-Australian Telescope, Gascoigne, Proust & Robins note that as early as 1953 Woolley, while he was still Director of Mount Stromlo Observatory, was suggesting that a large telescope should be built in Australia as a joint project between Commonwealth countries – what eventually became the 150-inch Anglo-Australian Telescope.[107] Already in 1959, the Royal Society had approached its Australian counterpart, the Australian Academy of Science, with a formal proposal for this project.[108] Woolley may have considered that building the INT in the southern hemisphere would remove any justification for his project to build an even larger telescope in Australia, and now that his big southern telescope idea looked as if it might become a reality, there was no longer any need to put the INT there. Also, it would have been easy to make the INT a part of the European Southern Observatory then being formed by member states of the fledgling European Economic Community. Around the time of the 1960 'conspiracy', the British government was considering whether or not to join this joint European observatory initiative, but Woolley was not in favour of it, preferring instead to maintain Commonwealth ties.[109]

We have already noted the Admiralty's 'inference' that a minority of astronomers wanted the INT to go to one of the proposed southern observatories; like Woolley, the Admiralty wanted to avoid the INT becoming a part of one of these observatories, though perhaps for different reasons than Woolley. They may have wanted to avoid the expenditure of building the 98-inch telescope overseas, or they might have been keeping their options open until they knew whether the British government wanted to take part in a Commonwealth or a European observatory. This, as well as Woolley's stout defence of the decision to site the INT in England and the ACSP's wholehearted support, must have been a major factor in the Admiralty's dismissal of the incident as 'a storm in a scientific teacup'. Moreover, in making the connection between this incident and Hinsley's letter, Mackay at the Admiralty clearly saw through this Cambridge conspiracy to move the telescope to the southern hemisphere. The attempt by Hoyle and Lyttleton to persuade the highest levels of government to review the INT's location never became politically significant.

The battle for the dome

Construction of the telescope proceeded apace in the early 1960s. Most of the mechanical parts were complete by early 1964, and the mirror was finally ground to an excellent parabolic shape in April 1966, sixteen years after its arrival at the Grubb Parsons works.[110] However, one more battle between science and government caused further delay. In June 1961, the Board agreed that the exterior of the dome housing the telescope should be made of copper, painted white with titanium oxide 'for its thermal and durable properties'.[111] Observatory domes are usually painted white, because this colour reflects away most of the daytime heat. A darker colour would absorb heat, causing the interior of the dome to warm up during the day, and the resulting convection when the dome is opened up in the cool night air would have a disastrous effect on the telescopic image. Yet this was precisely what happened when the domes for the RGO's smaller telescopes, known as the Equatorial Group (Figure 6), were erected at Herstmonceux. Concerns of local people about the observatory's potential effect on the landscape led to

the Equatorial Group domes being made of unpainted copper, the idea being that they would gradually turn green with verdigris and so blend in with the Sussex countryside. But unpainted copper absorbs enormous quantities of solar heat. RGO astronomer Roy Wallis recalls how in one of these domes: 'I found that the telescope's temperature, very high when we opened the dome in the evening, only would have reached the ambient about two hours after dawn!'[112]

At the April 1962 Board meeting, it was announced that the Admiralty's consulting architect, Brian O'Rorke, the same architect who had designed the Equatorial Group buildings, now wanted to make the INT dome of unpainted copper as well, with the lower section of the building painted white, thus making a two-tone, green and white structure. The Admiralty had simply ignored the decision made at the previous Board meeting. The response of the Board was furious. Redman 'thought it ridiculous that scientific requirements should be subordinated to personal aesthetic considerations'. Two representatives of the Admiralty were then let into the meeting, and they displayed a drawing of their proposed green copper dome. One of the Admiralty men said that he saw no reason why the astronomers should not have a white-painted dome, 'although personally he would be sorry if it were not to be of unpainted copper'. He suggested aluminium alloy cladding instead of copper if a white surface was required. The Board then unanimously resolved 'that both dome and drum cladding shall be of copper, or of an aluminium alloy known for its corrosion-resistant properties, painted white with titanium oxide; and that any attempt to maintain a two-tone scheme shall be abandoned'.[113] No more was heard from the Admiralty. This time, the astronomers realised their previous mistake and successfully stood their ground against the Admiralty. Again, scientific considerations were not important to the government. They were more concerned about how their prestige project should look to the outside world.

Construction of the INT building finally began in October 1964, after a further slight delay in starting building work caused by a decision to merge the Navy Works Department with the Ministry of Public Building and Works.[114] The telescope (Figure 7) and building were completed in August 1967 and officially opened by H. M. The Queen the following December.

Conclusion

To return to the first of the two questions posed in the Introduction, we can see that the lengthy gestation period of the INT was due to an unfortunate combination of factors. One was the 1947 decision to build a dual-purpose telescope, interchangeable between the Schmidt and Cassegrain designs. No duplex telescope of this size had ever been attempted before, and it proved to be an unrealistic proposition. Why was the duplex design decided on, and why was it adhered to for so long? The second report of the Royal Society Committee on Post-War Needs in Astronomy, and the application for funding for the proposed Isaac Newton Observatory, had both recommended a Schmidt telescope as well as a large conventional reflector. The Schmidt was a very new design, invented only in 1930, and astronomers were beguiled by the possibilities offered by its ability to take photographs showing sharp star images over a very wide field and with unprecedentedly short exposures, thus providing what Osterbrock has called 'mass-production data for astronomy' – information on a huge amount of stars and nebulae all on one plate.[115] When the Treasury decided to fund just one large telescope, astronomers sought to incorporate the Schmidt design into it, even if it meant designing a combination telescope that had never been tried before.

The hiatus in activity between 1951 and 1954 may have owed much to the return to power in 1951 of the Conservatives under Churchill, which entailed a sharp rise in defence spending and a decline in the proportion of science funding devoted to civilian science, a trend accelerated by the Korean War as well as the Cold War. Of the total government spending on research, some 80% was devoted to defence in 1955–'56, and the proportion was still 74% in 1958–'59.[116] But although the wider political context undoubtedly held up the progress of the INT in the early 1950s, there is no evidence that Spencer Jones tried to hurry the government along. It is clear that Spencer Jones was not a good choice of leader for the project. As we have already noted, he was preoccupied with moving the rest of the Royal Observatory to Herstmonceux. But just as importantly, as a lifelong positional astronomer, Spencer Jones had no experience of, and probably not much interest in, large telescopes. Remarks by him at Board meetings such as that 'with a major project like this it had seemed to him only right that any new ideas should be considered and given due weight'[117] and that a duplex telescope would be 'a challenge to British design and originality',[118] strongly suggest that he saw the telescope as a technological challenge rather than a research tool. Even after the 1954 rebellion of the astronomers, had it not been for the retirement of Spencer Jones at the end of 1955, the project might well have ground to a halt again, particularly in view of the renewed financial constraints following the Suez crisis. By contrast, Woolley, an astrophysicist, knew what he wanted and sought the fastest way of obtaining the telescope that he needed.

As we have seen, Harry Plaskett was the main influence on the initial decision to build the INT at Herstmonceux, and before it could be properly debated, his proposal was rushed through to the Treasury in time for an announcement to be made at the Isaac Newton Tercentenary. There was therefore a commitment to building the telescope at the Royal Observatory's new home before the project was even started. But even if an open discussion had been allowed to take place, there was no obvious choice of overseas location for the INT in 1946. Canada and South Africa already had large telescopes, at Victoria and Pretoria respectively. Australia was too far away in 1946; to travel there by sea took weeks, and the journey by air was complex and risky. As for repeating the experiment of Piazzi Smyth by building the tel-

escope on the Canary Islands, it was politically out of the question. A country that had just defeated fascist regimes in Germany and Italy was hardly going to build a telescope on territory ruled by General Franco. In fact, from the viewpoint of 1946, Plaskett cannot be entirely blamed for thinking that observational and theoretical astronomers had to be physically close to each other in order for the science to advance. Astronomers went to the outposts of the Commonwealth to take up appointments lasting for years, not to obtain a few weeks or months of telescope time for the university research projects that Plaskett had in mind. Astronomers of Plaskett's generation, brought up in the age of the steamship, saw travel to remote observatories in terms of taking up lengthy appointments. The INT's Board of Management was dominated by scientists of this generation, and remained so for most of the telescope's gestation period, so that as late as 1955, its members overwhelmingly rejected the suggestion by Woolley that the telescope should be built in the southern hemisphere.

Woolley himself eventually came out in favour of a British-based telescope, and echoed the older astronomers' aversion to remote observatories when he claimed in 1960 that 'there are difficulties of an administrative and personal character associated with observing overseas'[119] – though the possibility of an Anglo-Australian telescope may well have been a factor in his thinking. The 'conspiracy' in 1960 was staged by two astronomers of a younger generation, Fred Hoyle and Ray Lyttleton, who had come to maturity in an era when air transport was becoming easier and cheaper, and so did not see travelling to overseas telescopes in the same way as the generation of Plaskett and Spencer Jones. But

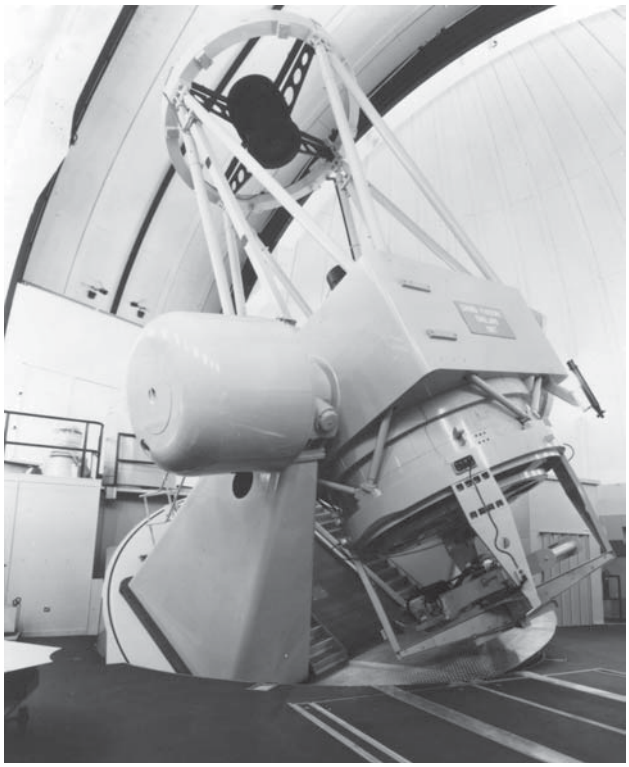

Figure 7. The completed 98-inch Isaac Newton Telescope. *Photograph courtesy Royal Astronomical Society.*

although the rebels succeeded in taking their case to the highest levels of government, the Board was still dominated by the older generation.

Both the Treasury and the Admiralty saw the INT project very differently to the astronomers. As we have seen, Treasury mandarins such as Barlow and Milner–Barry supported the INT because of its national prestige value, not because it was useful to astronomers. National prestige was also behind the Admiralty's insistence on a two-toned, green-and-white observatory building, which would look attractive and blend in with the landscape, regardless of the fact that such a building would render the telescope useless. Scientific illiteracy amongst Treasury personnel was a factor in the delays in the telescope's construction, although so too were the major financial difficulties of the mid-1950s, exacerbated by the financial troubles of Jodrell Bank.

The twenty-one-year story of the origins and construction of the Isaac Newton Telescope can be summarised as a combination of conflicts between political and scientific priorities, bad management, and sheer geography, or astronomers' response to geography. Government funding priorities seriously delayed the project during the 1950s. Even within the realm of civilian science, the interest of governments, Labour as well as Conservative, was in the national prestige that could be achieved through a big project like the INT, not scientific utility. For its first nine years, the project was managed by an observatory director who had many other responsibilities, and to whom large telescopes were not a priority; in any case, Spencer Jones's view of the project as a technological challenge rather than a research instrument fitted in well with the prestige-driven agenda of his superiors in Whitehall. It is fair to say that astronomers, rather than government, were responsible for siting the INT at Herstmonceux.[120] Had the idea of a large telescope for British astronomers not arisen until the 1960s, when a new generation of astronomers had come onto the scene, the balance of opinion in the astronomical community would have been far more in favour of locating it overseas. Indeed, while some critics have claimed that the telescope 'came ten years too late',[121] it could be said that the idea of the telescope came twenty years too early.

Acknowledgments

I would like to thank Peter Hingley, Librarian of the Royal Astronomical Society, for the use of RAS photographs; Professor Simon Schaffer of the Dept of History and Philosophy of Science, University of Cambridge, for reading through and commenting on a draft of this paper; and Dr Adam Perkins of the Manuscripts Dept of Cambridge University Library for his help with the Royal Greenwich Observatory Archives. This paper is based on the author's Cambridge University MPhil thesis submitted in 2008, and the examiners' comments on the thesis are acknowledged.

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References

The abbreviation 'RGO' in the references below refers to the Royal Greenwich Observatory Archives at Cambridge University Library, UK. RGO 9: Papers of Harold Spencer Jones. RGO 10: Papers of Sir Richard Woolley. RGO 37: Papers of Roderick Redman. The number after the stroke (/) indicates a folder number in the relevant astronomer's papers. 'TNA' refers to The National Archives, Kew, UK; T218/228 refers to a file held in the Treasury records at The National Archives, on the 'development and installation of the Isaac Newton 98-inch telescope'.

1 H. H. Plaskett, 'Address Delivered by the President, Professor H. H. Plaskett, on Astronomical Telescopes', *MNRAS*, **cvi** (1946), 80–94.
2 R. W. Smith, *The Space Telescope: A study of NASA, science, technology and politics* (Cambridge University Press, 1989), 30
3 P. Murdin & B. L. Webster, 'Optical Identification of Cygnus X-1', *Nature*, 233 (September 10 1971), 110; B. L. Webster & P. Murdin, 'Cygnus X-1 – a Spectroscopic Binary with a Heavy Companion?', *Nature*, 235 (January 7 1972), 37–38
4 John Irvine & Ben R. Martin, 'Assessing Basic Research: The Case of the Isaac Newton Telescope', *Social Studies of Science*, **13** (1983), 49–86, p. 74
5 Quoted in Michael J. Crowe, *Modern Theories of the Universe from Herschel to Hubble* (Dover Publications, 1994), 356
6 Sir Bernard Lovell gives his own account of the building of the 250-foot telescope in B. Lovell, *The Story of Jodrell Bank* (Oxford University Press, 1968). See also B. Lovell, *Astronomer by chance* (OUP, 1992) and J. Agar, *Science and Spectacle: The Work of Jodrell Bank in Post-war British Culture* (Gordon & Breach, 1998)
7 H. A. Brück & M. T. Brück, *The Peripatetic Astronomer: The Life of Charles Piazzi Smyth* (Adam Hilger, 1988), 48
8 A. D. Thackeray, *The Radcliffe Observatory, 1772–1972* (London: Radcliffe Trust, 1972), 18
9 M. Wilson, *Ninth Astronomer Royal. The Life of Frank Watson Dyson* (Cambridge: W. Heffer & Sons Ltd, 1951), 244. The episode is also referred to in Thackeray, *op.cit.* (ref. 8), 19.
10 T. Wilkie, *British Science and Politics since 1945* (Blackwell, 1991), 131
11 W. H. McCrea, *The Royal Greenwich Observatory* (HMSO, 1975), 48
12 A. J. Meadows, *Greenwich Observatory. The Royal Observatory at Greenwich and Herstmonceux 1675–1975. Vol.2: Recent History (1836–1975)* (Taylor & Francis, 1975), 24
13 F. Graham Smith and J. Dudley, 'The Isaac Newton Telescope', *J.Hist.Astron.*, **13** (1982), 1–18
14 Fred Hoyle, *Home is Where the Wind Blows: Chapters from a Cosmologist's Life* (California: University Science Books, 1994), 315
15 The history of Plaskett Senior's 72-inch reflector, and its influence on later large telescope designs, is described in Richard A. Jarrell, 'J. S. Plaskett and the Modern Large Reflecting Telescope', *J.Hist.Astron.*, **xxx** (1999), 359–90.
16 'Report of Royal Society Committee on Post-War Needs in Astronomy', 1945 July 27, RGO 9/129
17 Plaskett to Spencer Jones, 1945 March 13, RGO 9/129
18 McCrea, *op.cit.* (ref. 11), 37. See also K. Snedegar, 'Spencer Jones, Harold', in T. Hockey *et al.* (eds.), *Biographical Encyclopedia of Astronomers* (Springer, 2007), 1075–76, p. 1076.
19 Spencer Jones to Plaskett, 1945 March 19, RGO 9/129
20 Plaskett, *op.cit.* (ref. 1), 81
21 Plaskett, *op.cit.* (ref. 1), 85
22 J. Lankford, 'Amateurs and Astrophysics: A Neglected Aspect in the Development of a Scientific Speciality', *Social Studies of Science*, 11 (1981), 275–303, p. 275
23 Plaskett, *op.cit.* (ref. 1), 90–91
24 Plaskett, *op.cit.* (ref. 1), 93–94
25 D. H. Sadler, 'The Isaac Newton Observatory', *The Observatory*, No. 835 (1946), 380–383, p. 380.
26 Minutes of meeting of Committee on 'Newton Memorial Observatory', 1946 April 30, RGO 9/129
27 *ibid*.
28 Sadler, *op.cit.* (ref. 25), 380
29 *op.cit.* (ref. 26)
30 Minutes of meeting of 'Isaac Newton Observatory' Committee, 1946 May 10, RGO 9/129
31 Anon., 'The Isaac Newton Observatory: Memoranda addressed to the President and Council of the Royal Society', *MNRAS*, **107** (1947), 11–19, p. 11
32 *ibid*., 14
33 Sadler, *op.cit.* (ref. 25), 381
34 RAS Additional Ordinary Meeting, 1946 June 14, *The Observatory*, No. 833, 308–317
35 Minutes of second meeting of RS Post-War Needs in Astronomy Committee, 1946 June 1, RGO 9/129
36 Egerton to Milner–Barry, 1946 June 26, TNA: T218/228
37 Milner–Barry to Barlow, 1946 June 28, TNA: T218/228
38 Milner–Barry to Barlow, 1946 July 8, TNA: T218/228
39 Quoted in Wilkie, *op.cit.* (ref. 10), 47
40 Milner–Barry to Barlow, *op.cit.* (ref. 37)
41 Barlow to Dalton, 1946 July 8, TNA: T218/228
42 *ibid*.
43 *ibid*.
44 Egerton to Barlow, 1946 July 15, TNA: T218/228
45 Milner–Barry to Barlow, *op.cit.* (ref.38)
46 Coxwell (Admiralty) to Blunt (Treasury), 1946 Aug 9, TNA: T218/228
47 INT Board Minutes, 1947 July 23, RGO 37/712
48 *op.cit.* (ref. 26).
49 INT Board Minutes, 1947 Dec 12, RGO 10/643
50 *op.cit.* (ref.47)
51 Uttley to Spencer Jones, 1948 May 24, RGO 9/129
52 Judge Henry Hulbert (President of the McGregor Fund) to Spencer Jones, 1949 Feb 25, RGO 9/129
53 INT Board Minutes, 1950 March 10, RGO 10/643
54 Sisson to Spencer Jones, 1950 April 18, RGO 9/126
55 E. H. Linfoot to Spencer Jones, 1950 Dec 30, RGO 9/126
56 *ibid*.
57 Sisson to Spencer Jones, 1954 Aug 9, RGO 9/126
58 *op.cit.* (ref.53)
59 Quotation received from Schott & Genossen, 1955 Jan 23, RGO 9/126
60 INT Board Minutes, 1951 March 30, RGO 10/643
61 INT Board Minutes, 1954 Feb 26, RGO 10/643
62 INT Board Minutes, 1954 Dec 15, RGO 10/643
63 *op.cit.* (ref. 49)
64 Wallis to Spencer Jones, 1948 Feb 2, RGO 9/126
65 Spencer Jones to C. R. Burch, 1948 Feb 10, RGO 9/126
66 INT Board Minutes, 1948 May 11, RGO 10/643.
67 INT Board Minutes, 1950 March 10, RGO 10/643.
68 *op.cit.* (ref.60)
69 *op.cit.* (ref.61)
70 McCrea, *op.cit.* (ref. 11), 42
71 *op.cit.* (ref.61)
72 Joint letter to Spencer Jones, undated but stamped received 1954 Oct 26, RGO 9/126
73 INT Board Minutes, 1954 Nov 17, RGO 10/643
74 *op.cit.* (ref.62)
75 Greaves to Redman, 1955 Feb 8 (copy), RGO 9/126
76 Quoted in Redman to Atkinson, 1955 Feb 22, RGO 9/126
77 Woolley to Redman, 1955 May 16, RGO 9/126
78 Draft report of INT Executive Committee; undated, but accompanying letter from Redman dated 1955 March 1, RGO 9/126
79 INT Board Minutes, 1955 July 8, RGO 10/643
80 *ibid*.
81 Woolley to Redman, *op.cit.* (ref.77).
82 *op.cit.* (ref.79).
83 Spencer Jones to Woolley, 1955 July 11, RGO 9/129
84 D. Lynden–Bell, 'Obituary: Professor Sir Richard Woolley, OBE, ScD, FRS, 1906–'86', *Q. J. RAS*, **28** (1987), 546–551: 547
85 Woolley to Blackett, 1956 Feb 24, RGO 10/596
86 INT Board Minutes, 1956 March 5, RGO 10/643
87 Lovell, *Astronomer by chance* (ref.6), 199
88 *op.cit.* (ref. 86)
89 Report of meeting of INT Executive Committee (plus H. G. Barker, Secretary of the RGO and George Sisson of Grubb Parsons), 1956 Nov 16, RGO 9/130
90 Woolley to Hermann Bondi, 1957 Feb 14, RGO 9/130
91 Hydrographer to Woolley, 1957 July 4, RGO 9/130
92 Woolley to Hydrographer, 1957 July 9, RGO 9/130
93 Lovell, *The Story of Jodrell Bank* (ref. 6), 148–153; Lovell, *Astronomer by chance* (ref. 6), 251–254
94 Fraser (Treasury) to Brown (Royal Society), 1958 Jan 28, RGO 9/130
95 Fraser (Treasury) to Hodge (Royal Society), 1959 Jan 3, RGO 9/130
96 Sisson to Woolley, 1959 April 16, RGO 9/130
97 L. W. Smith (for Director of Navy Contracts) to Grubb Parsons, 1959 Dec 4, RGO 10/541

98 Hinsley to Denning, 1960 April 28, RGO 10/555
99 *ibid*.
100 Jane Gregory, *Fred Hoyle's Universe* (OUP, 2005), 233–'38. See also Fred Hoyle, *op.cit.* (ref.14), 362
101 Woolley to Hydrographer, 1960 May 30, RGO 10/555
102 INT Board Minutes, 1960 June 10, RGO 10/643
103 E.S. Roberts (General Finance Branch I, Admiralty) to Woolley, 1960 June 29, RGO 10/555
104 Woolley to Roberts (General Finance Branch I, Admiralty), 1960 July 6, RGO 10/555
105 Mackay (Admiralty) to Quirk (Ministry of Science), 1960 July 14, RGO 10/555
106 INT Board Minutes, 1962 July 9, RGO 10/643
107 S. C. B. Gascoigne, K. M. Proust & M. O. Robins, *The Creation of the Anglo-Australian Observatory* (CUP, 1990), 29
108 *ibid*., 30
109 A. Blaauw, *ESO's Early History* (ESO, Germany, 1991), 10. See also Gregory, *op.cit.* (ref.100), 220, and F. K. Edmondson, *AURA and its US National Observatories* (CUP, 1997), 204.
110 Sisson to Woolley, 1966 April 20, RGO 10/542
111 INT Board Minutes, 1961 June 9, RGO 10/643
112 Quoted in Anthony Wilson *(ed.), Astronomers at Herstmonceux in their own words* (Herstmonceux: Science Projects Publishing, 1999), 9–10
113 INT Board Minutes, 1962 April 25, RGO 10/643
114 Minutes of INT Technical Sub-Committee, 1963 March 8, RGO 10/640
115 Donald E. Osterbrock, 'Getting the picture: Wide-field astronomical photography from Barnard to the achromatic Schmidt, 1888–1992', *J.Hist.Astron.*, 25 (1994), 1–14:1
116 N. J. Vig, *Science and Technology in British Politics* (Pergamon Press, 1968), 19
117 INT Board Minutes, 1954 Feb 26, RGO 10/643
118 INT Board Minutes, 1955 July 8, RGO 10/643
119 Woolley to Roberts (Admiralty), 1960 July 6, RGO 10/555
120 This would seem to bear out a claim to this effect made by Irvine & Martin (ref.4), 83
121 George Wilkins, quoted in Wilson *(ed.)*, *op.cit.* (ref.112), 63.

Received 2009 April 13; accepted 2009 September 02