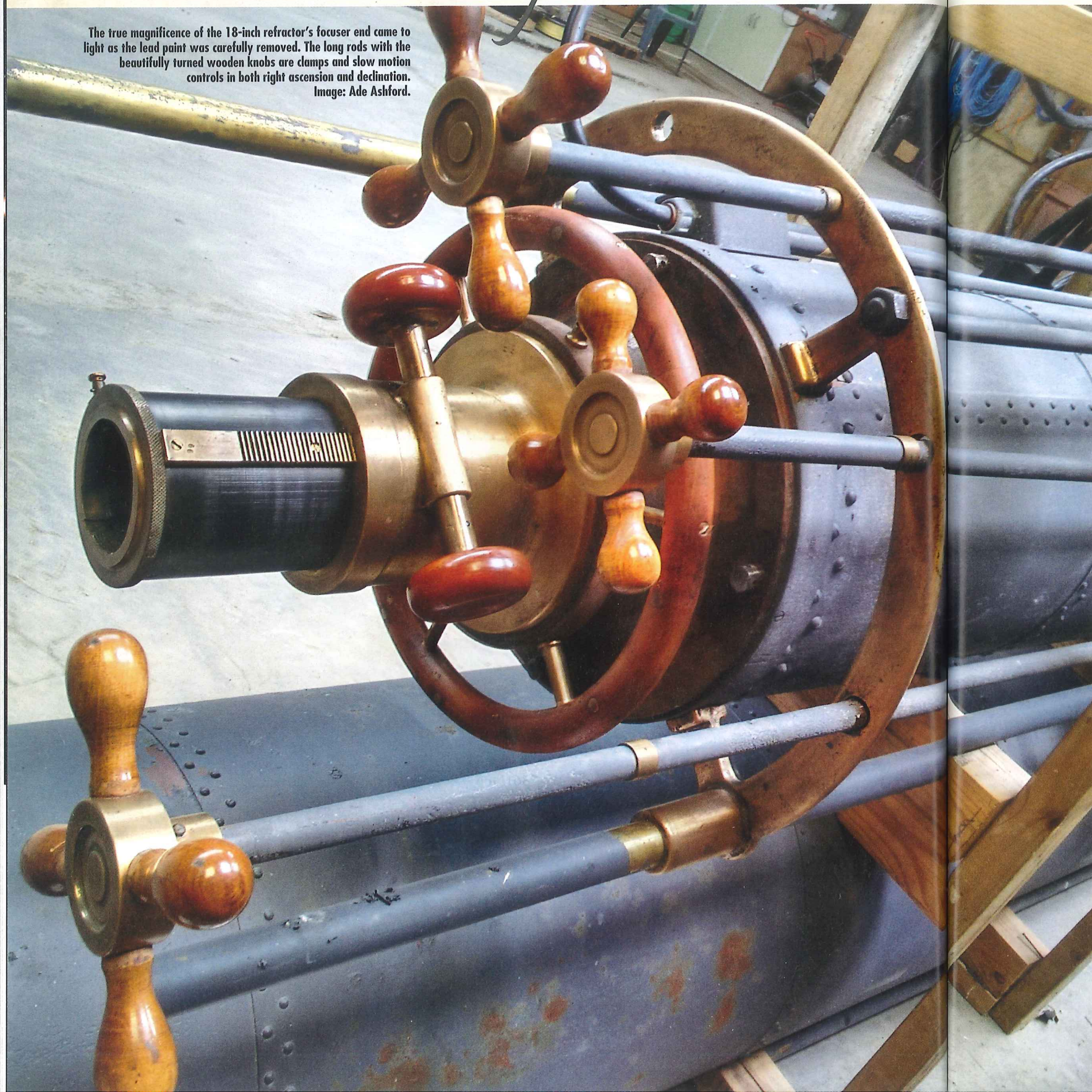


Restoring a lost leviathan

The true magnificence of the 18-inch refractor's focuser end came to light as the lead paint was carefully removed. The long rods with the beautifully turned wooden knobs are clamps and slow motion controls in both right ascension and declination. Image: Ade Ashford.



Far from its American birthplace, a pedigree 18-inch aperture refracting telescope with a chequered history is being nursed back to its former glory, the intended focus of a new astronomy centre in the heart of New Zealand's South Island, writes Ade Ashford.

Ask the proverbial man in the street to describe an astronomical telescope and they will almost invariably depict a long tube with a large lens at one end and an astronomer squinting into an eyepiece at the other. This is a somewhat curious stereotype as it doesn't correspond to the appearance of modern-day research instruments, but closely resembles the giant refracting telescopes that reached the pinnacle of their craft at the close of the nineteenth century. Such is the influence of these Victorian engineering marvels of glass and brass, iron and steel, that even after 125 years they still grip the public consciousness.

In the late 1800s, observatories around the world vied with one another to produce the largest lens-based instrument, culminating in the 40-inch (one-metre) aperture, 20-metre-long refractor of the Yerkes Observatory at Williams Bay, Wisconsin, USA, in 1897. Despite being briefly surpassed by the 49-inch Great Paris Exhibition Telescope of 1900 – a siderostat-fed $f/45.6$ behemoth that proved useless for scientific research – the Yerkes refractor remains the largest successful instrument of its type. The highly esteemed Massachusetts-based firm of Alvan Clark & Son made the lenses for the Yerkes 40-inch and the Lick Observatory 36-inch refractor that preceded it by a decade.

The Brashear legacy

At the age of nine, John A. Brashear (1840–1920) had his first view of the Moon and Saturn through the telescope of Joseph P. Wampler in Brownsville, Pennsylvania. The experience had a profound effect on the young Brashear, leaving him with a lifelong passion for astronomy and optics. Apprenticed to a machinist when aged 15, he eventually found work as a millwright in 1861. Too impoverished to buy his own telescope, Brashear resolved to make his own refractor. By 1880 he had mastered the art and science of glass-working and dedicated himself to the manufacture of telescopes and scientific equipment.

John Brashear gained a reputation as an optician and instrument maker of equal skill to Alvan Clark. He also made some grand and highly sought-after telescope objectives, the largest being the 30-inch lens of the Allegheny Observatory refractor in Pittsburgh, Pennsylvania. Brashear would later become the observatory's director and in due course his ashes and those of his wife, Phoebe, would be interred in a crypt below the 30-inch Keeler telescope there.

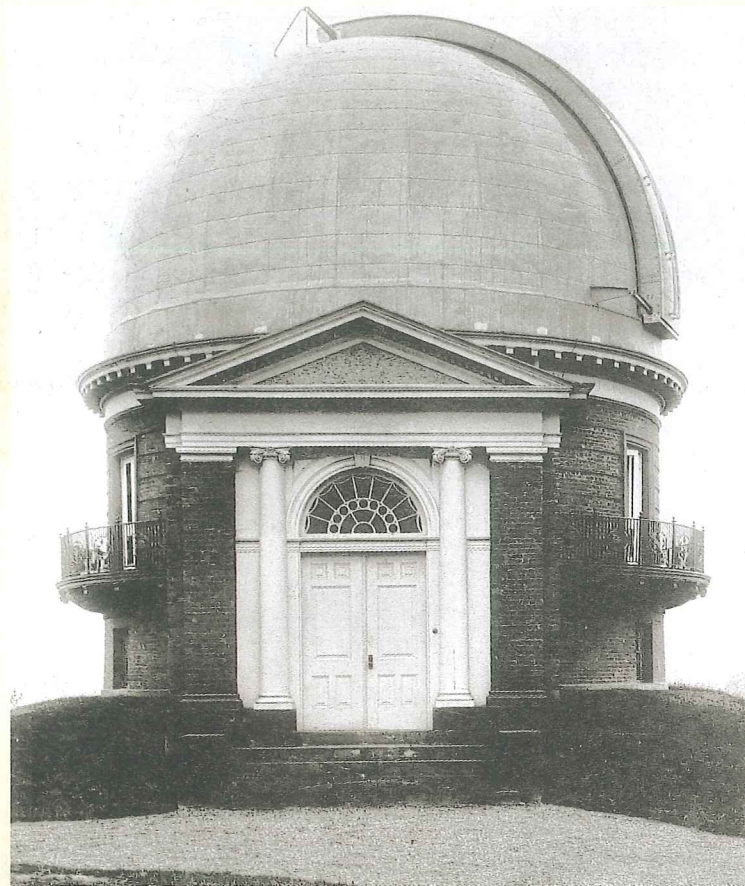
In the early 1890s, Brashear completed an 18-inch (0.45-metre) diameter, eight-metre focal length 'achromatic doublet' at his optical workshop in Pittsburgh. A doublet, more commonly known as an achromat, is two lenses of differing optical properties sandwiched together, the pair producing an image largely free of chromatic aberration – an image-degrading fault of single lenses that manifests itself as false prismatic colours around bright objects.

The 18-inch, $f/17.5$ visually-corrected doublet that Brashear had so painstakingly and exactly crafted proved to be of exceptional quality. Having been proudly displayed at the World's Columbian Exposition in Chicago in 1893, the lens was loaned from the University of Pennsylvania to wealthy Bostonian businessman, mathematician and astronomer Percival Lowell (1855–1916) to further his studies of the planet Mars. In the spring of 1894, Lowell installed the lens – by now in a telescope tube – in tandem with a 12-inch Clark refractor borrowed from Harvard in a temporary dome at the newly established Lowell Observatory in Flagstaff, Arizona.

Mars revealed

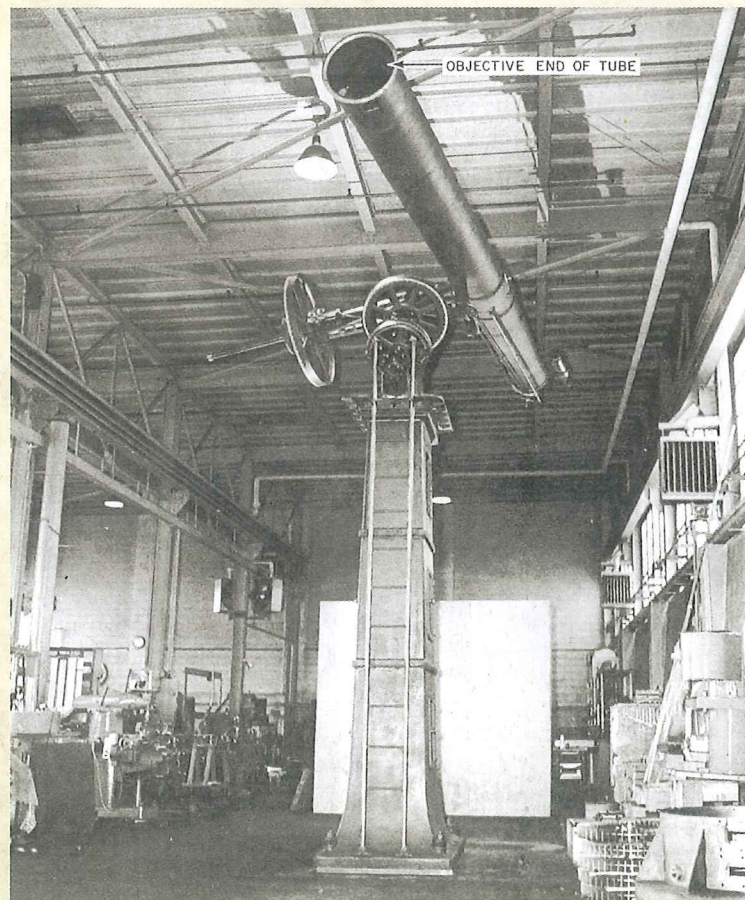
Lowell made extensive use of the 18-inch Brashear refractor for his early Martian studies starting on 1 June 1894, extending through the planet's favourable opposition of October 1894 and finishing on 3 April 1895. Although he would later become (in)famous for his sadly illusionary and discredited observations of a planet-wide network of artificial canals carrying melt-water from the poles to hypothetical inhabitants of the arid desert regions, Lowell did record other intriguing Martian phenomena that stand up to modern scrutiny.

An observation that is also a testament to the resolution and contrast of the 18-inch Brashear lens occurred during a twilight observation of Mars on 8 June 1894 at 6:17am local time in Flagstaff. Lowell wrote: "... as I was watching the planet, I saw suddenly two points like stars flash out in the midst of the polar cap. Dazzlingly bright upon the duller white background of the snow, these stars shone for a few moments and then slowly disappeared. The seeing at the time was very good." As he later acknowledged, these were "not the fabled signal-lights of Martian folk", but glints of sunlight reflected back to Earth from polar ice slopes turned by the planet's rotation to a serendipitous angle. At the time, Mars was 150 million kilometres from Earth and just 9.3 arcseconds in diameter.



The beautiful and classically inspired 10-metre dome, replete with Doric columns and portico, at the Flower Observatory in Pennsylvania. Image: University of Pennsylvania.

Prior to being shipped out to New Zealand to become a research telescope at the Mt John University Observatory, the Brashear telescope was fully refurbished and refitted for Southern Hemisphere operations at the Wilmot Fleming Engineering Company in Philadelphia. Image: Wilmot Fleming.

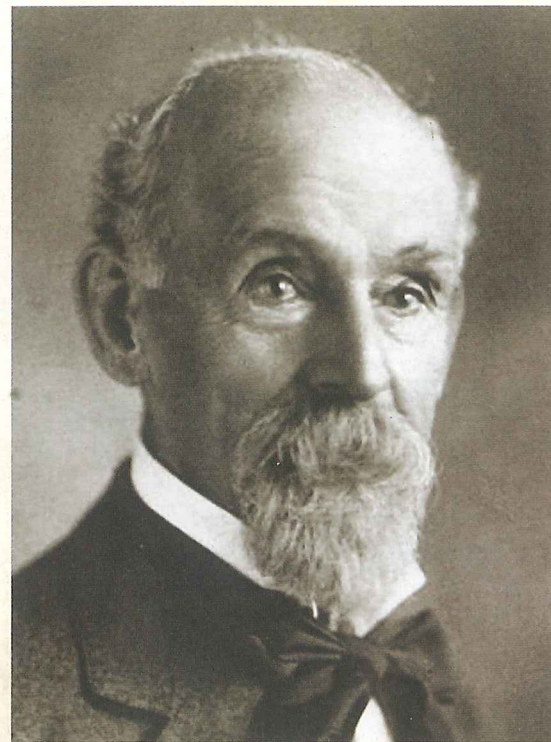


The Flower Observatory

After its safe return to Pennsylvania, the 18-inch Brashear lens was installed in a new tube on a German equatorial mount fabricated in 1896 by the illustrious Warner & Swasey Co. of Cleveland, Ohio – the same company that built the world’s largest 36-inch Lick and 40-inch Yerkes refractors. The 18-inch telescope was destined for the Flower Observatory, founded on what was Flower Farm in Upper Darby, on land bequeathed to the University of Pennsylvania by Mr Reese Wall Flower in 1875. The beautiful and classically-inspired ten-metre diameter dome, replete with Doric columns and portico, finally received the completed instrument in late 1896 and the observatory was formally opened on 12 May 1897, though the telescope was probably in use before that.

The scale of the 18-inch, f/17.5 refractor as built by Warner & Swasey is initially hard to grasp. The vast tube was nearly eight metres (26 feet) in length, pivoting about its midsection some five metres (16.7 feet) above the floor on a massive three-section cast iron pedestal. Overall, the instrument weighed 7.3 tonnes. For over half a century this telescope and the other instruments at the Flower Observatory site produced a wealth of valuable research data. The 18-inch was used chiefly for the measurement of visual binary stars and changes in luminosity of variable stars with a wedge photometer, but the planets were also scrutinised. In 1946 the first pulse-counting photoelectric photometer to be used on astronomical objects was fitted to the great refractor.

Walter Leight, a keen Mars observer and instrument maker at the Flower Observatory, held the Brashear behemoth in particularly high regard for planetary observations. He made a number of eyepieces for the 18-inch refractor and is documented as having used a 0.3-inch focal length ocular at powers of 972x to observe Saturn, stating somewhat tantalisingly that “We often saw things (like numerous sub-divisions in Saturn’s rings) we weren’t supposed to see and didn’t



The genial countenance of John A. Brashear, who ground and polished the lens pair of the 18-inch f/17.5 doublet in the early 1890s.

mention them.” Walter Haas, founder of the Association of Lunar and Planetary Observers (ALPO), is also on record as stating that the 18-inch gave him the best views of Saturn he’d had in any telescope.

Consigned to storage

Sadly, however, the productive nights of the Flower Observatory were numbered and it was closed in 1954. Its facilities were amalgamated with the superbly equipped private observatory of Gustavus W. Cook nearby, which had been willed to the University of Pennsylvania. The 18-inch Brashear refractor was dismantled and placed into storage since funds were unavailable to renovate it and construct a new building to house it – an unfortunate theme that runs through the instrument’s subsequent history, as we shall discover.

In 1962, the University of Pennsylvania sought to establish a Southern Hemisphere observing station and entered into partnership with the University of Canterbury at Christchurch in New Zealand. One of the fruits of this academic union was the Mt John University Observatory that was officially opened on 10 July 1965. The observatory is situated close to the 1,029-metre summit on the western shore of Lake Tekapo in the heart of the South Island. It was decreed that the 18-inch Brashear would be restored to working order and shipped to New Zealand for a use atop Mt John.

Destined for southern skies

Back in Pennsylvania, some mechanical parts of the 18-inch telescope had deteriorated in storage, or were simply lost. The instrument was completely refurbished and the corroded or missing parts remade by the Wilmot Fleming Engineering Company in Philadelphia. The mount received a dual-axis electric drive upgrade, replacing the elegant clockwork polar axis mechanism of the original, which was designed to track the opposite way in the Southern Hemisphere. Further adaptations included changing the angle of the German equatorial mount’s polar axis to suit the 44-degree southerly latitude of Mt John. On completion, the instrument was stripped down and meticulously packed for its long sea voyage.

The 18-inch refractor arrived in

In the early 1890s, Brashear completed an 18-inch diameter, eight-metre focal length ‘achromatic doublet’ of exceptional quality

New Zealand in October 1963 and was gingerly negotiated around the switchbacks of the single road to the summit of Mt John. However, funds for the construction of a suitable dome and auxiliary buildings to support the new telescope were not forthcoming, so the mighty telescope was destined to remain in its original shipping crates in a wooden storage shed for quite some time – until 1990, in fact. Considering the extremes of weather experienced on the mountain top, the instrument was found to be in remarkably good condition after nearly three decades of incarceration. Fortunately, the irreplaceable lens, along with eyepieces and other optical

accessories, had been safely stored at the university campus in Christchurch.

An uncertain future?

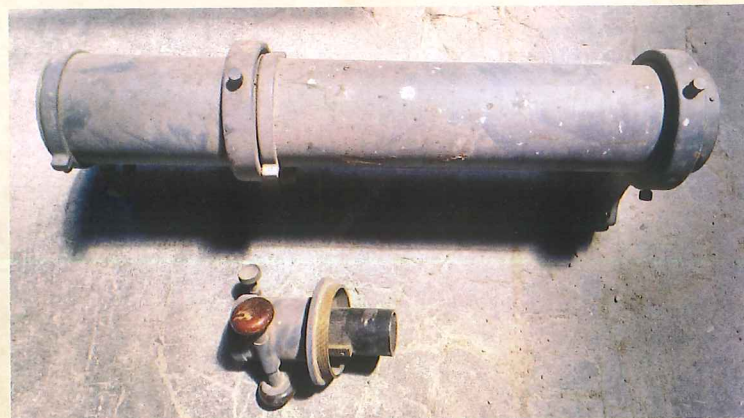
In 1990, with no likelihood of a dome being built, the University of Canterbury entered into an agreement with the Yaldhurst Museum of Transport and Science on the west side of Christchurch. Yaldhurst was to acquire possession (but not ownership) of the Brashear telescope if it could raise funds to provide a suitable building to display it as a working exhibit. Yet again, despite best intentions, raising the money to build a ten-metre-diameter, five-metre high wall surmounted by



Earth & Sky general manager Margaret Munro (left) with Elton Zhang inspecting the massive German equatorial mount of the 18-inch Brashear refractor, prior to its removal from the Yaldhurst Museum outbuilding. Image: Earth & Sky.

Earth & Sky director Graeme Murray (in green overalls), at the Yaldhurst Museum, near Christchurch, assists with the recovery of the 8-metre-long tube of the 18-inch Brashear telescope. Image: Earth & Sky.





In these before and after restoration pictures, we see the great Brashear refractor's finderscope, itself a respectable five-inch aperture refractor about a metre long. After the 1963 Wilmot Fleming refurbishment, the entire instrument was coated in battleship grey lead paint. As you can see, a wealth of beautifully turned brass work lies beneath. Image: Ade Ashford.

a five-metre radius rotating hemispherical dome proved impossible. An application for lottery funding was turned down in 1993 because the telescope lacked a New Zealand heritage.

For sometime it seemed that a rich US institution would eventually reclaim the 18-inch refractor, even though by this time the dissolved partnership of the Universities of Pennsylvania and Christchurch meant that the asset was now legally Kiwi. Indeed, the Californian Chabot Space and Science Center – already in possession of its ‘sister’ 20-inch Brashear refractor – expressed a strong interest in acquiring the instrument. A February 1996 deadline came and went for Yaldhurst Museum, but the University of Canterbury didn’t take the great refractor back into its possession. So time passed and the disassembled pieces of the great Warner & Swasey tube, mount and pedestal were consigned to an outbuilding for a further quarter century.

Revealing the lens

On a personal level, I first came across the 18-inch Brashear refractor’s story and tantalising photographs of this seemingly lost leviathan while working at the Mt John Observatory in 2008 and 2009. Having researched the great refractor’s history, I first met Professor John Hearnshaw, a long-time custodian of

the telescope’s optical components, at Canterbury’s Department of Physics and Astronomy in Christchurch on 18 March 2010. He let me examine further historical documentation (partly upon which this article is based) and kindly offered to let me view this well-travelled objective lens with such a rich provenance that still sat cocooned in its 47-year-old wooden shipping crate.

The palpable sense of excitement I felt at the prospect of seeing this historic optic is something that anyone who loves antique optical instruments will acknowledge. Once the long screws securing the lid of the box and the protective layers of wood wool and brown paper were removed, the doublet sat in a robust flanged cell with a huge threaded retaining ring keeping the two lens elements precisely registered. It is one thing holding a measuring tape and attempting to conjure a mental image of a lens 45cm in diameter, but nothing quite prepares you for the sight of a large refractor’s objective seen up close.

What amazed me was the lens’ condition. For what was then a 117-year-old doublet, the exterior of the convex crown glass was truly without a mark or blemish. It was as if John Brashear had just lifted his final, deft figuring touch from the objective. Nor could I see any tiny bubbles in either of the lens elements, something one can occasionally see in the glass discs of antique refractors. As in smaller air-spaced achromats, three thin foil tabs separated the 18-inch crown and flint glasses at 120 degree intervals around their circumference.

In stark contrast to the joy I felt at seeing the 18-inch Brashear lens, however, my first sight of the telescope’s mechanical parts at the Yaldhurst Museum elicited a sense of profound sadness. Stored in an old outbuilding, the exquisitely engineered Warner & Swasey German equatorial was partly covered by an old shredded canvas and a quarter century of pigeon guano from the rafters. The eight-metre-long tube, in two sections, lay on a damp gravel floor surrounded by rusting old cars. The massive, fluted lower section of the cast iron pedestal had merely been left outside to the elements for 25 years. It was pitiful that such a noble instrument that had advanced our knowledge of the cosmos should come to this.

A brighter future

Fortunately, the Brashear telescope has always had a tireless advocate in Professor Hearnshaw, so I was not alone in subsequently helping to exposing the plight of the 18-inch telescope and seeking ways to restore it. Help was also about to come from another quarter. Based in Tekapo township in the shadow of Mt John is the office of Earth & Sky Ltd, an astro-tourism venture that offers stargazing tours in the heart of New Zealand’s South Island Mackenzie District – a region blessed with an unusual microclimate that delivers a high proportion of clear, exceptionally dark nights. The International Dark sky Association recently declared the area an International Dark Sky Reserve.

Earth & Sky is about to embark on the construction of an ambitious astronomy centre on the southern shore of Lake Tekapo, the restored Brashear telescope forming the centrepiece of a working museum that will also feature a collection of displays about leading New Zealand astronomers and the history of Mt John. Earth & Sky’s general manager Margaret Munro agrees that the Brashear is an amazing and beautiful piece of 19th-century technology that must be recovered. “Having this sort of equipment in the Southern Hemisphere is

really rare”, she said in a recent interview. “Once it’s restored it will be a big drawcard for the region and will be an important part of the theme we are creating in Tekapo around the night’s sky.”

The mechanical parts of the Brashear telescope were finally removed from the Yaldhurst Museum on 18 September 2015 at the instigation of Earth & Sky and driven the 110 miles west to the spacious workshop of Mackenzie Electrical in the township of Fairlie, just 30 minutes drive east of Tekapo. Until such time as it goes on display, the Brashear has a temporary home here while it is returned to full working order. Further to consultation with Professor Hearnshaw and engineer Graeme Kershaw (an expert on Victorian scientific instruments), I was privileged to be the first to start restoration work on the 18-inch telescope in mid-November 2015.

Despite my first impression of the telescope’s cosmetic condition at the Yaldhurst Museum in 2010, the instrument had weathered the past five decades in New Zealand surprisingly well. Most of the rust on the two four-metre-long riveted cast iron tube sections was largely confined to the inner and outer surfaces. The liberal coating of battleship grey lead-based paint that the entire telescope and mount received during its initial restoration by Wilmot Fleming in the early 1960s had actually preserved much of the finely tooled detail. The removal of 52 years of accumulated dust and muck also did much to transform its appearance.

Initially concentrating on the telescope’s tube, I spent three months carefully exposing the non-ferrous parts using chemical paint-stripping methods and plastic tools so as not to damage the soft brass and bronze components beneath. Often feeling somewhat like an archaeologist, I was constantly surprised at the fine detail and exquisite Victorian workmanship that lay beneath the monochrome paint layer. The enormous rack-and-pinion focuser – still working as well as the day it was made – was turned from solid brass. What I had assumed to be a merely functional circular handrail proved to have been crafted from a deep red mahogany inlaid with brass. The telescope’s finder, itself a respectable five-inch aperture refracting telescope a metre long, also proved to be made of finely turned solid brass.

An imposing telescope

Once fully restored over the next couple of years, the 18-inch telescope’s eight-metre-long tube will be finished in gloss white, while the five-metre-high pedestal and German equatorial mount – which, incidentally, still swings effortlessly about its polar and declination axes – will most likely receive a royal blue finish. With the gleaming brass and bronze fittings, and long control rods with their turned wooden handles, the 18-inch Brashear refractor will be just as imposing to look at as undoubtedly it will to look through. The irony of the great Brashear telescope’s New

With gleaming brass and bronze fittings, and long control rods with turned wooden handles, the Brashear refractor will be just as imposing to look at as it will to look through



In a scene reminiscent of Christmas morning in the dreams of any antique telescope aficionado, Professor John Hearnshaw of the University of Canterbury in Christchurch, New Zealand, shows the author the 18-inch Brashear lens. Image: Ade Ashford.

Zealand story is that had it been erected on Mt John under the pristine MacKenzie Basin sky in the mid-1960s it would have been an anachronism as a research instrument. Even fifty years ago, such refractors had been largely superseded by reflecting or catadioptric (using both lenses and mirrors to form an image) telescopes of much larger aperture and more compact dimensions, equipped with electronic detectors of far greater sensitivity and objectivity than human eyes.

Yet research is not where the value of such a majestic Victorian telescope lies today. Wherever they are found at historic observatories around the world, great refractors often instil a greater sense of awe and fascination in the general public than modern instruments. This is not on account of the size of such telescopes – as contemporary reflectors are often far larger – but because a classic refractor looks like a telescope should, so it is far easier to relate to.

The great refractors of the late 1890s and early 1900s offer a unique view of the cosmos. The timeless, rugged surface of the Moon, or the subtle features and colours presented by an exquisitely detailed planet such as Jupiter or Saturn, are utterly unforgettable experiences when seen ‘live’ through a large refractor.

The 18-inch Brashear telescope is one of a half dozen giant refractors known to exist in the entire Southern Hemisphere and one of just two dating from the nineteenth century. When it is eventually turned skyward in Tekapo, towards objects that would never have risen in its original Pennsylvania home, I will be one of the first in the queue at the eyepiece – no doubt feeling the ghostly yet approving presence of Percival Lowell, Walters Leight and Haas and, of course, John Brashear.

Ade Ashford has an abiding interest in antique telescopes and their restoration, dividing his time between the UK and New Zealand’s South Island, where he continues restoration work on the Brashear telescope.