

Welcome to UCC!

National Heritage Week 2020



<https://www.heritageweek.ie/>
@heritageweek

@UCC
#UCCheritage
@UCCBandE





Scientific Heritage of UCC

Looking at the Crawford Observatory

Margaret Lantry, Acting University Curator, Heritage Services, Buildings & Estates, UCC

July 2020

A TRADITION OF
INDEPENDENT
THINKING



UCC

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

175 Years
1845-2020

Why is the Crawford Observatory important to the heritage of science in Ireland?



Main Quadrangle, QCC, 1880-90. *Eblana Photograph Collection*, © National Library of Ireland: EB_0129

Most Grubb telescopes were bought by existing observatories but at Cork Howard Grubb designed the complete observatory, the telescope dome, the three major telescopes - an equatorial telescope, a transit telescope, and a siderostatic telescope - and ancillary equipment.

Today the observatory is unique in Ireland for the remarkable state of preservation of its instruments and the original condition of the building. It is the only observatory on a university campus in the country.

The equatorial telescope is the largest of the three. It fills the 15 foot wide dome and tracks the stars in the sky using an intricate and very accurate clockwork mechanism. This telescope was exhibited at the Paris International Exhibition in 1878 before installation at Cork, and it was awarded a Gold Medal.

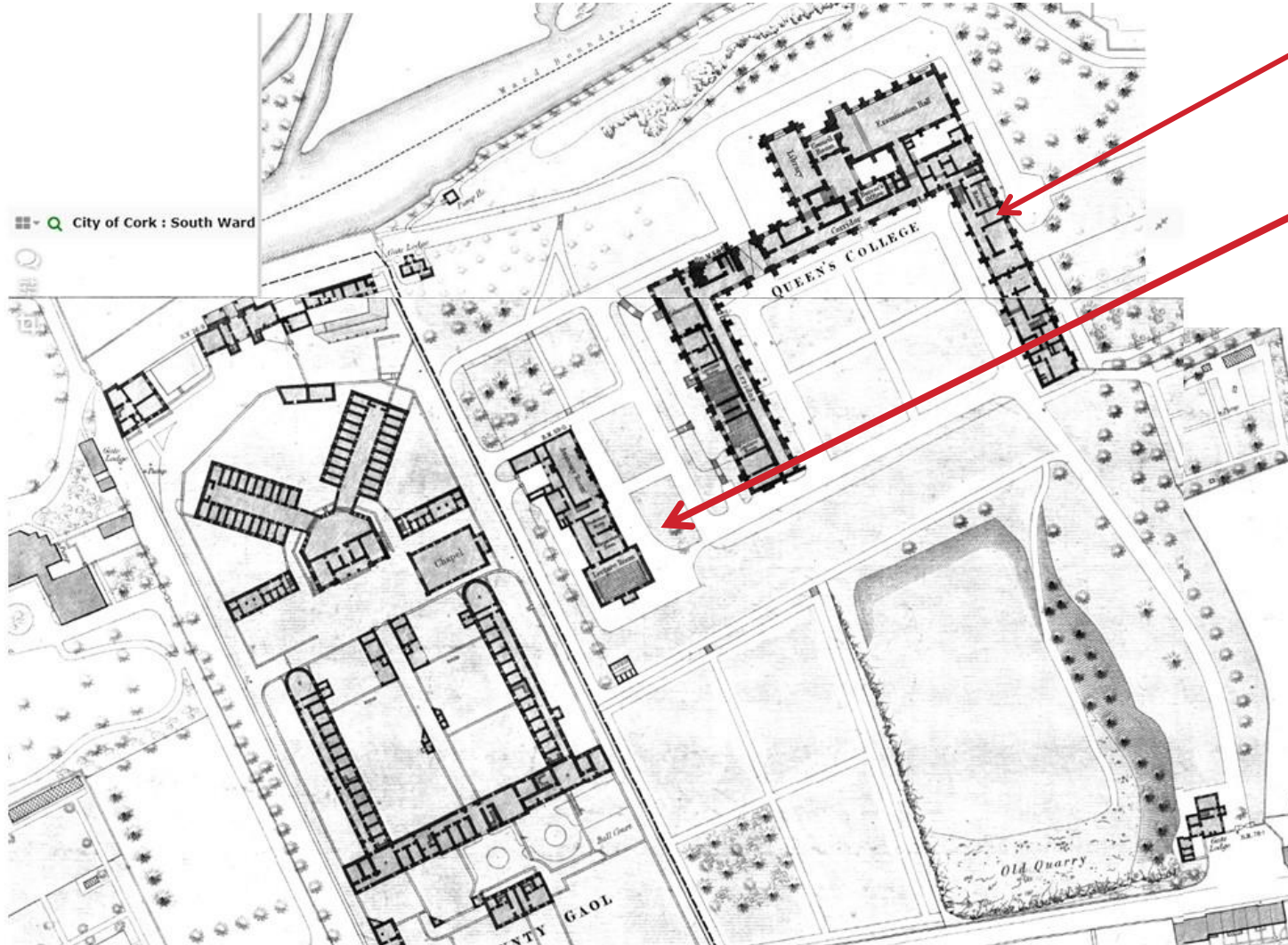
Queen's College Cork

- The Colleges Act was passed in 1845. This enabled Queen's Colleges to be opened at Belfast, Cork and Galway. In Cork the site was purchased in 1846.
- Queen's College Cork opened on 30th October 1849. The first lectures were delivered on 7th November.
- The buildings around the main quadrangle included:
 - Lecture rooms
 - Museums: Zoological, Geological, Physical & Mechanical, Art & Antiquity
 - Library

The early College

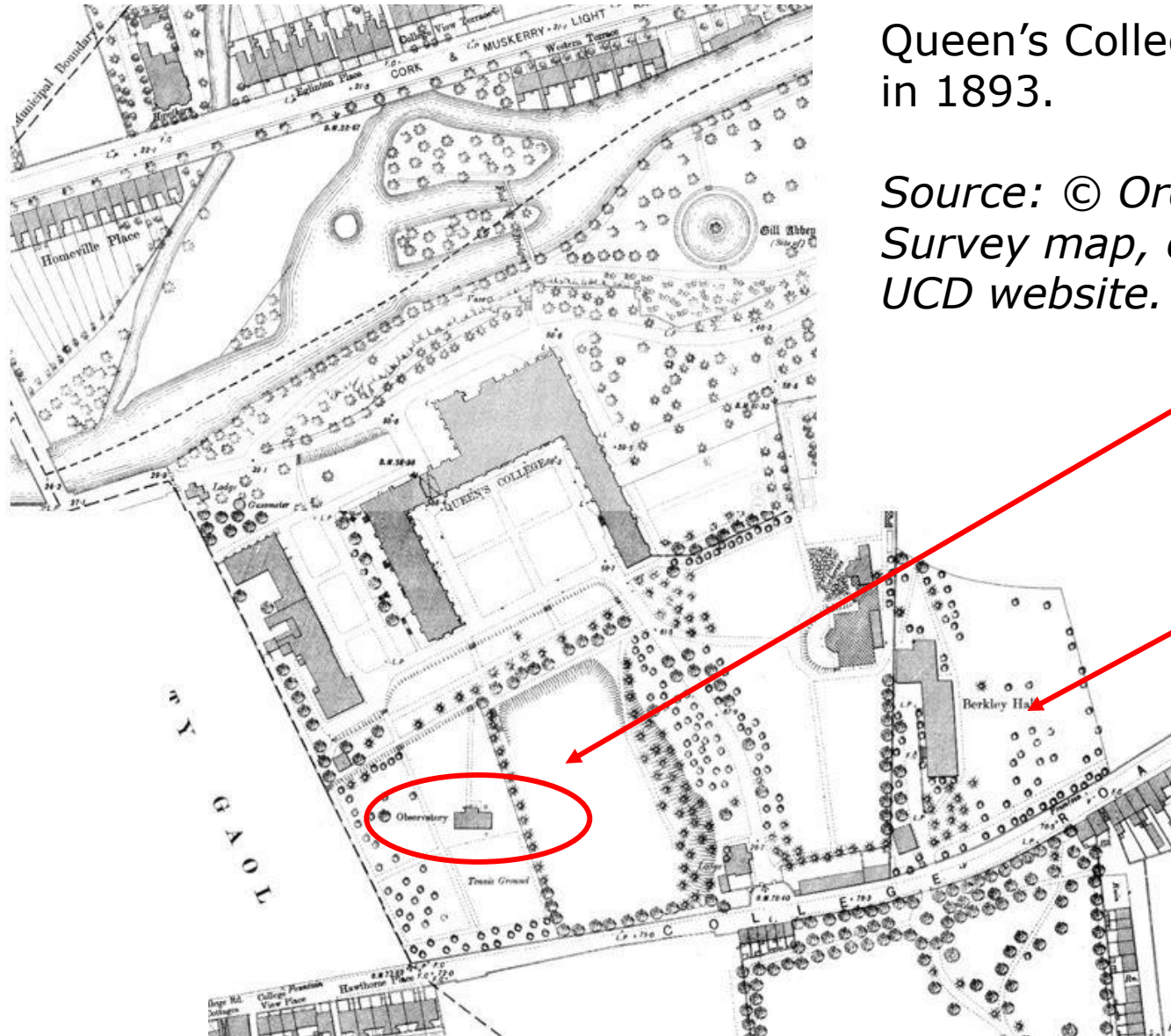
Queen's
College
Cork in
1869.

*Source: ©
Ordnance
Survey
map, online
at UCD
website.*



The Main Quadrangle was finished in 1849. The Clarendon Building, later known as the Medical Building and more recently as the Windle Building, now The Hub, was built between 1860 and 1880. There were two entrances to the campus: from the Gaol Walk on the north side, and from the Gaol Road (later renamed the College Road) on the southern side. These entrances are still in use today.

The College at the end of the 19th century



Queen's College Cork in 1893.

Source: © Ordnance Survey map, online at UCD website.

Fourteen years later the site hasn't changed very much in terms of new buildings.

The Crawford Observatory is at the SW corner of the campus.

There's also the buildings at the corner of what is now College Road and Donovan's Road – a hall of residence for students, called Berkeley Hall (later Honan Hostel), which opened in 1884.

UCC in the mid-twentieth century

Aerial view of University College Cork in about 1950.

Source: © *Independent archives.*



This is an aerial view of UCC taken about 1950.

The Restaurant building was opened in 1948.

The Crawford Observatory is now surrounded by buildings and the surrounding area is a built-up residential area.

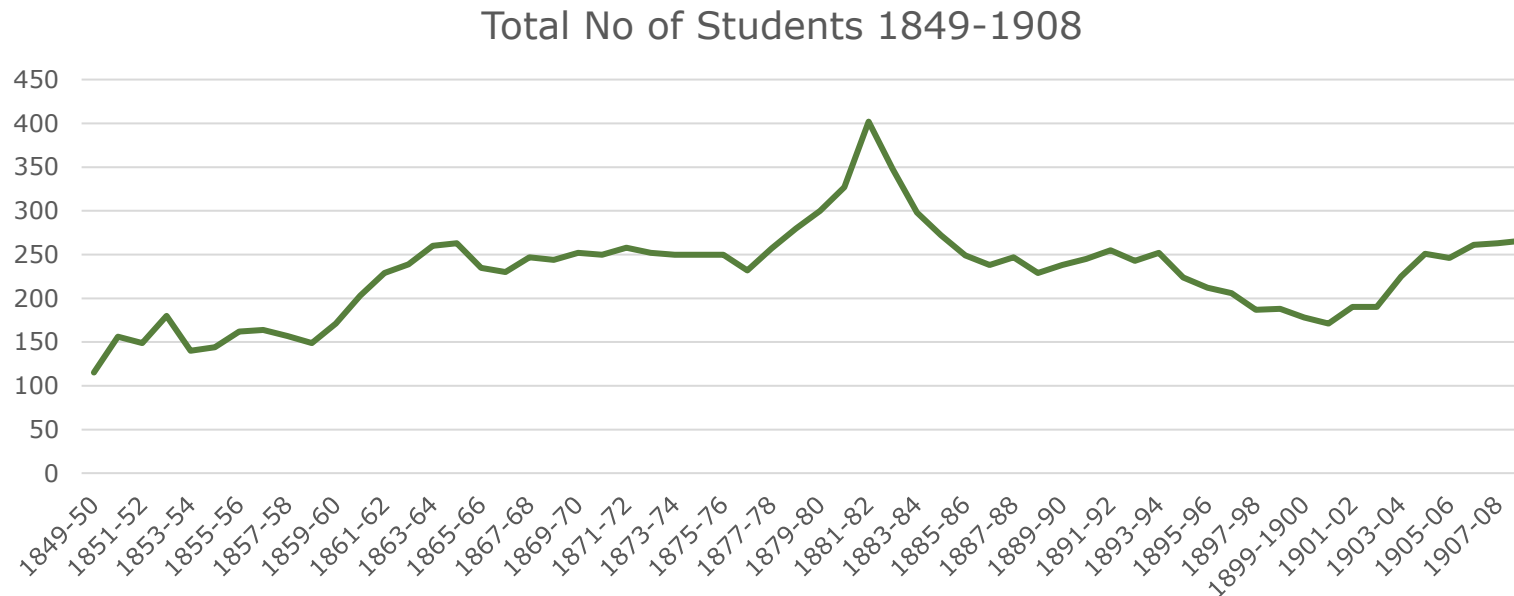
The present Civil Engineering building was opened in 1910. The County Gaol is still there; the site was transferred to UCC in 1958.

Science at Queen's College Cork

There were five Faculties in 1849:

1. Faculty of Arts – this included Divisions of Literature and Science
2. Faculty of Medicine
3. Faculty of Law
4. School of Engineering, Civil and Mechanical
5. School of Agriculture

**No of
Students
115**
**aged
between
14 and 27**



Science at QCC in 1849-1850

FIRST YEAR.

The Greek and Latin Languages.
The English Language. *One Term.
The Modern Languages.
Mathematics.

SECOND YEAR.

Logic. A course of one Term.
Chemistry.
Principles of Zoology and Botany.
The Higher Mathematics, or
The Greek and Latin Languages.

THIRD YEAR.

Natural Philosophy. = Zoology/Botany
History and English Literature.
Physical Geography.
Metaphysics,* or
Jurisprudence and Political Economy.*

Bachelor of Arts course over three years

Included Science and Humanities subjects.

The courses in **Civil Engineering** included the subjects of:
in 1st Year, Mathematics, General Physics, Chemistry,
Drawing, Surveying and Mapping;
2nd Year, Higher Mathematics, Practical Mechanics,
Mineralogy and Geology, Drawing and Civil Engineering,
including the Principles of Architecture.

Students in **Medicine** also had to study Natural Philosophy (Physics).

Natural Philosophy (Physics)

This subject was studied in the Faculty of Arts, Schools of Engineering and Agriculture. Courses on the curriculum for these degrees included:

- 'General principles of Statics and Dynamics, Hydraulics, Pneumatics, and Heat.'
- 'A course of Experimental Lectures on Mechanics, Hydraulics, and Pneumatics, with special reference to Farm Engineering.'
- 'A Course of Lectures on Heat, Electricity, and Meteorology.'

The subject 'Natural Philosophy' now covers the area called Physics.

The first Professor of Natural Philosophy was George Frederick Shaw, 1849-55. He was succeeded by John England, 1855-1894, who used the Crawford Observatory.

In 1908 the subject became 'Experimental Physics'.

Subjects provided in 1878-9

	No. of Lectures on each Subject.	Total No of Students attending the Classes in each subject.
Greek,	234	32
Latin,	213	29
English Language,	28	21
" Literature,	48	14
Modern History,	40	9
French,	189	98
Logic,	65	17
Metaphysics,	55	2
Political Economy,	32	6
Mathematics,	297	59
Natural Philosophy,	301	98
Chemistry, Theoretical,	83	82
" Practical,	89	54
Geology and Mineralogy,	30	1
Zoology and Botany,	62	60
English Law,	75	8
Jurisprudence and Civil Law,	48	7
Anatomy and Physiology,	136	86
" Practical,	148	159
Medicine,	58	25
Surgery,	63	35
Midwifery,	62	25
Materia Medica,	62	47
Medical Jurisprudence,	38	27
Engineering,	300	25

The five most popular subjects were (in order):

Practical Anatomy – 159
 Natural Philosophy (Physics) – 98
 French - 98
 Theoretical Chemistry - 82
 Anatomy & Physiology - 86

At the time that the idea of the Observatory came about, Astronomy was not a subject at Cork but was probably covered to some extent at least in Natural Philosophy.

William Kirby Sullivan, second President of QCC



Dr William Kirby Sullivan, born at Dripsey in 1822, died at Queen's College, Cork, on 12 May 1890. A Roman Catholic and sympathetic to the nationalist cause. President of QCC from 27/9/1873 to 1890.

Educated at CBS, Cork, and studied chemistry in Giessen, Germany.

Lectured at the Cork Mechanics' Institute, Cork
Private assistant to Sir Robert Kane at the Museum of Irish Industry, Dublin. Kane was the first President of QCC from 1849 to 1873.

In 1856 Sullivan was Professor of Chemistry at the Catholic University of Ireland, Dublin.

He published articles on chemistry, philosophy and was also a philologist and antiquarian.

A new President and new energy at Cork

Dr William Kirby Sullivan became President of Queen's College Cork in 1873 becoming the second person to hold that position. He was a native of County Cork, born in 1822; he died in office in 1890.

The first president of the College was Sir Robert Kane, who was a scientist. Sullivan, a chemist, had been Kane's deputy in the Museum of Irish Industry (later the College of Science) in Dublin.

Unfortunately Kane had not spent all his working hours in Cork but continued to run the College of Science in Dublin. With Sullivan in post and permanently located in Cork city, in 1873 he began to improve the facilities of the College for staff and students. This was the first big renewal since the opening of the College in 1849.

Sullivan was particularly interested in improving the Library, providing an Observatory and creating a Herbarium and plant houses.

During the 1870s there was a lot of interest in astronomy and meteorology. There were already observatories dotted around Ireland, for example, at Birr Castle, Co. Offaly, Markree Castle in Sligo, Armagh and Dunsink Observatories.

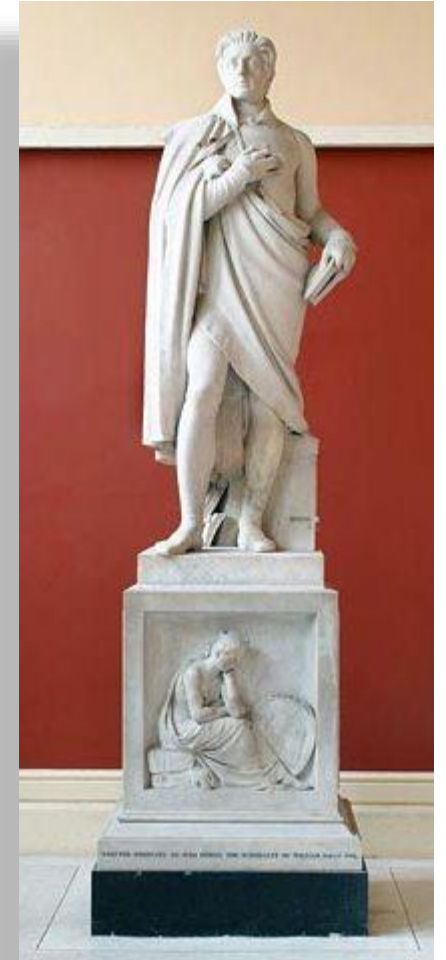
In order to carry out his projects, Sullivan needed funding. Fortunately, in Cork he became friendly with a local businessman, W. H. Crawford, who was very wealthy.

William Horatio Crawford (1812-1888)

- Brewer – Beamish & Crawford, South Main Street
- Bibliophile – had a large private library in his home at Lakelands, Mahon
- Horticulturist – was very interested in plant collecting
- Philanthropist – to Queen's College Cork; gave £20,000 to build extension to the Old Custom House: this became the Crawford Municipal Schools of Science, Art and Music and is now the Crawford Art Gallery; donated £18,300 to complete St Fin Barre's Cathedral



Araucaria araucana
(monkey puzzle tree) in former
Lakelands estate, South Ring
Road N40
Google maps



John Hogan,
William Crawford Jr, 1843
[father of W. H. Crawford]
Crawford Art Gallery

Crawford's munificence to Queen's College Cork

- Sullivan in his 1876-1877 President's Report wrote about the need for an observatory so that students could be taught the methods of Observation used in Astronomy, Magnetism and Meteorology. Apparently W. H. Crawford on reading this, gave a sum towards the purchase of astronomical instruments for a new observatory. He also part-funded the erection of the plant houses in the Botanic Garden [President's Report 1879]. This reflected his own interest in plant collecting.
- Crawford also made donations of
 - almost 1,600 books and journals to the College Library,
 - £2,750 towards the erection of plant houses in the new Botanic Garden (as well as plant specimens)
 - and making the new entrance and road (from Western Road);
 - £6,000 for building of Berkeley Hall (later known as the Honan Hostel);
 - and £2,000 to clear debts on this building.
- In 1878/9 Sullivan in his report announced that the Observatory building was underway.

The progress of the QCC Observatory

Considerable progress has also been made with the erection of the Observatory. The building is nearly completed, and the revolving dome erected, and we have received from the maker, Mr. Howard Grubb, the equatorial telescope, which he constructed specially for this College, and for which he was awarded a gold medal at the last Paris Exhibition, and several other instruments, among which I may mention a new siderostatic telescope and spectroscope. To complete the building, and furnish it with the necessary instruments, will cost about £2,500, towards which I have received the following donations :—

W. H. Crawford, Esq.,	.	.	.	£1,000
The Duke of Devonshire,	.	.	.	500
The Earl of Cork,	.	.	.	20
A. H. Smith Barry, .	.	.	.	10
The Marques of Lansdowne,	.	.	.	10
				<hr/>
				£1,540

A small tower, provided with a room for meteorological instruments, has also been built. Owing to want of funds it cannot be furnished at present. The fitting up of the building, and providing a complete set of self-registering meteorological instruments, would cost about £500.

President's Report, 1878-79



"Mr. Howard Grubb has nearly completed the Transit and other instruments which he has in hands for the Crawford Observatory. The necessary preparations have been made for mounting them during the autumn."

President's Report, 1882-83

"Mr. Howard Grubb has completed the fine transit instrument for the Crawford Observatory, upon the construction of which he has been for some time engaged. The Observatory will be in full working order this year."

President's Report, 1883-84

Funding the QCC Observatory

		Purchasing Power 2018	Labour Cost 2018
Estimated cost, 1878-79	£2,500	£238,300	£1,150,000
Actual expenditure, 1878-1892	£2,995	£285,500	£1,378,000
Balance, 1908	£149		
Overrun	About £640 (about 25%)	£61,020	£294,400

Using 1878 as baseline, comparative figures: <https://www.measuringworth.com/calculators/ukcompare/>

However ... more was added to the original design than originally planned: during the academic year of 1890-1 the equatorial telescope was modified so that photographs could be taken.

Donations towards the cost of the Observatory and instruments

Year	Amount	Donor
1878-79	1,000	WH Crawford
	500	Duke of Devonshire
	20	The Earl of Cork
	10	A. H. Smith Barry
	10	The Marquess of Lismore
1879-80	600	WH Crawford , 1st instalment of additional donation for completion of the Observatory
1884-85	430	WH Crawford , completion of the Transit Instrument
1885-86	114	WH Crawford , various fittings, etc., for the Crawford Observatory
1891-92	400	Representatives WH Crawford , for stellar photography
1892-93	6	Reps WH Crawford
TOTAL	£3,090	Total contribution by WH Crawford was £2,550; the equivalent of £243,100 Sterling or Euro 275,336 today

Source: President's Reports, Queen's College, Cork, 1878-1893

Building the Crawford Observatory

Architect: James Higgins Owen, Board of Public Works (since 1856)

Contractor: Edward Fitzgerald, Cork

Builder: Western Road gatehouse (1879) and Crawford Observatory (1879)

Other builders: D. O. Sullivan & Sons
J. Sisk

Painting etc.: J. O'Connell

Gasfitting: W. R. Harris

Covering dome: J. Perry & Sons, R. Perrott & Son, both in Cork

Superintending works: S. Hennessy

Instruments: Howard Grubb, Rathmines, Dublin, who also designed the optimum layout of the astronomical instruments within the building



'4 x 3' and EF monogram on downpipe.

© Margaret Lantry 25/06/2019

The new Crawford Observatory



Queen's College, Observatory, Cork City
Lawrence Photograph Collection, © National Library of
Ireland: L_CAB_02821



Hallway
© Margaret Lantry 9/9/2019

The Crawford Observatory in 1893



Queen's College Cork
in 1893.

*Source: © Ordnance
Survey map, online at
UCD website.*

The instruments in the Crawford Observatory



Sir Howard Grubb
(1844-1931)

Howard Grubb with his father Thomas were the premier maker of telescopes in Ireland and beyond.

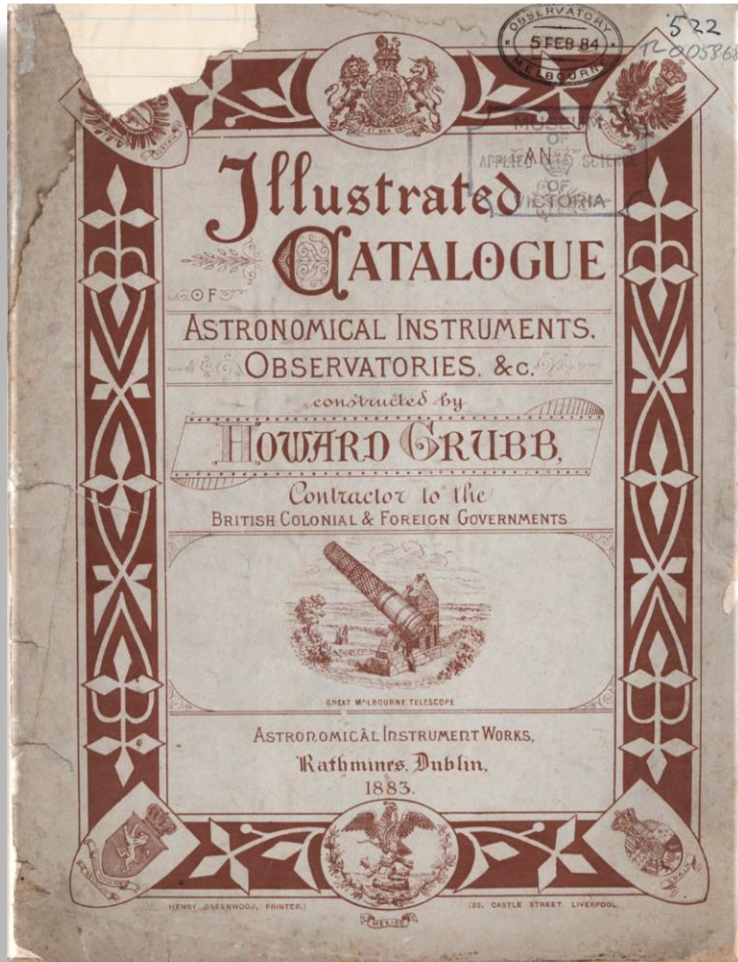
By getting Grubb to make the instruments for the Crawford Observatory, Queen's College Cork was aiming for the best quality. Howard Grubb produced telescopes and other instruments for observatories all over Europe and beyond.

He had studied Engineering as a young man and was always coming up with new ways to improve the instruments. At the time of the Crawford Observatory, his newest design was a clock drive for the telescope to ensure that it stayed in position, and during World War I he refined the design of the submarine periscope.

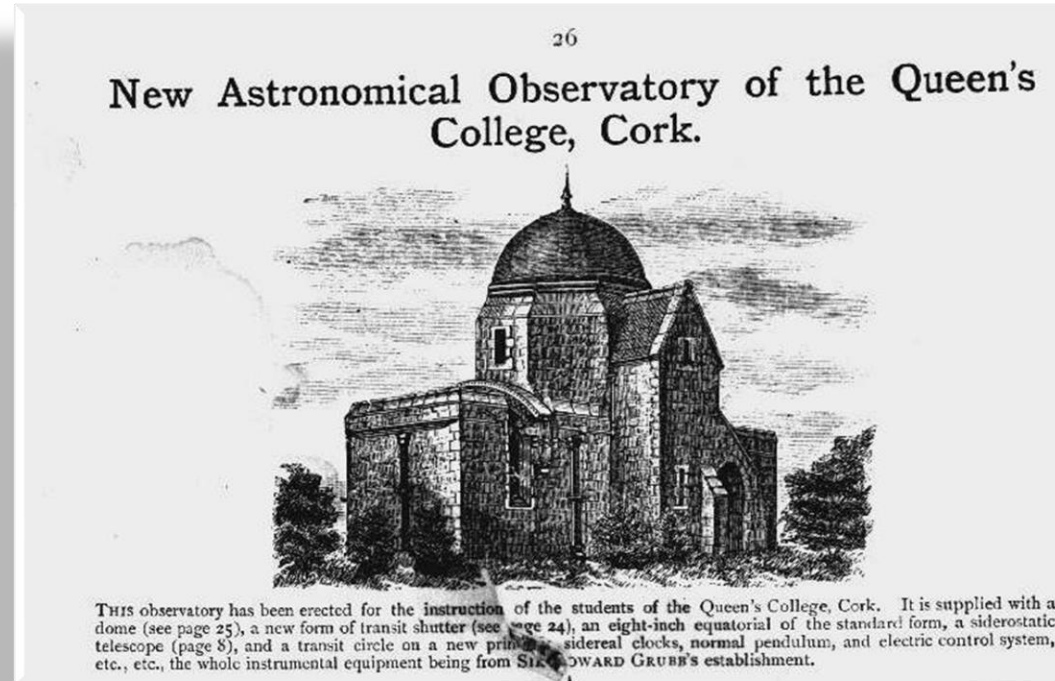
Grubb's firm produced many telescopes, such as, the 27-inch refractor for the Vienna Observatory (1878), the 10-inch refractor at Armagh Observatory (1882), the 24-inch refractor at Royal Observatory (Cape of Good Hope), and the 28-inch refractor at the Royal Observatory, Greenwich – the UK's largest refractor (1893) – and the 10-inch refractor at Coats Observatory, Paisley (1898). Also produced heliostat at Smithsonian Institution, Washington DC.

In 1887 the firm built seven normal astrographs for the 'Carte du Ciel' international photographic star catalogue project, 13-inch refracting telescopes all designed to produce uniform photographic plates.

Howard Grubb's Catalogues



Grubb's Catalogue (1883): used at Melbourne Observatory, where he installed a telescope



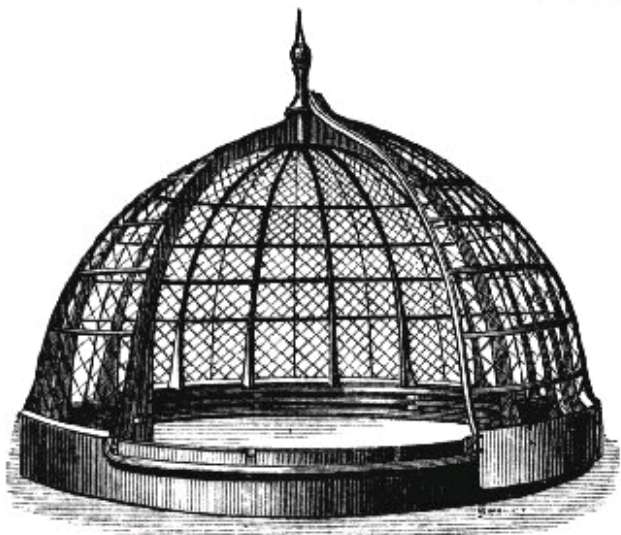
Grubb's Catalogue (1888): engraving showing the new observatory at Cork. In the text underneath, Grubb tells the reader about the instrument he installed: the dome; "a new form of transit shutter"; the 8-inch equatorial telescope of the standard form (there was also a deluxe version) and siderostatic telescope; as well as the transit circle, sidereal clocks, a pendulum and the electric control system. Everything was provided by Sir Howard Grubb – the complete observatory provider.

Buy an Observatory!

25

TYPE OF SMALL PRIVATE OBSERVATORY.

FRAMING OF 15-FEET ROOF.



15-foot Dome, ready for reception of canvas covering.

Approximate Prices of various Forms of Observatory Roofs.

	12	15	18	20	24	30	36	45
	£	£	£	£	£	£	£	£
Wooden Observatory, with sliding roof, covered with zinc	21	25	...	...	...	...	...	...
Iron frame, covered with wood sliding roof, covered with wood and zinc ...	25	35	...	...	...	...	...	...
Iron Drum Roof, covered with wood, revolving on simple rollers	50	80	120	...	...	...	...	...
Iron-framed Dome, as above, covered with wire and canvas, revolving on simple grooved rollers	65	100	150	200	...	...	...	...
Iron-framed Dome, as above, covered with wire work and canvas, revolving on "canted" rollers and planed wall-plate	90	120	180	240	330	500	...	...
Ditto ditto covered with papier maché ... ..	...	150	200	280	380	550	...	...
Ditto ditto covered with wood and copper ... ..	...	...	...	330	500	700	...	...
Ditto ditto covered with wood and copper, and revolving on best triple roller system... ..	...	...	...	420	600	860	...	...
Ditto ditto covered with iron plate ... ..	...	...	...	...	500	800	1200	2000

4

Grubb, *Catalogue* (1888)

From this catalogue, an astronomer could order wooden or iron frame domes over which canvas could be stretched in order to install an observatory at home.

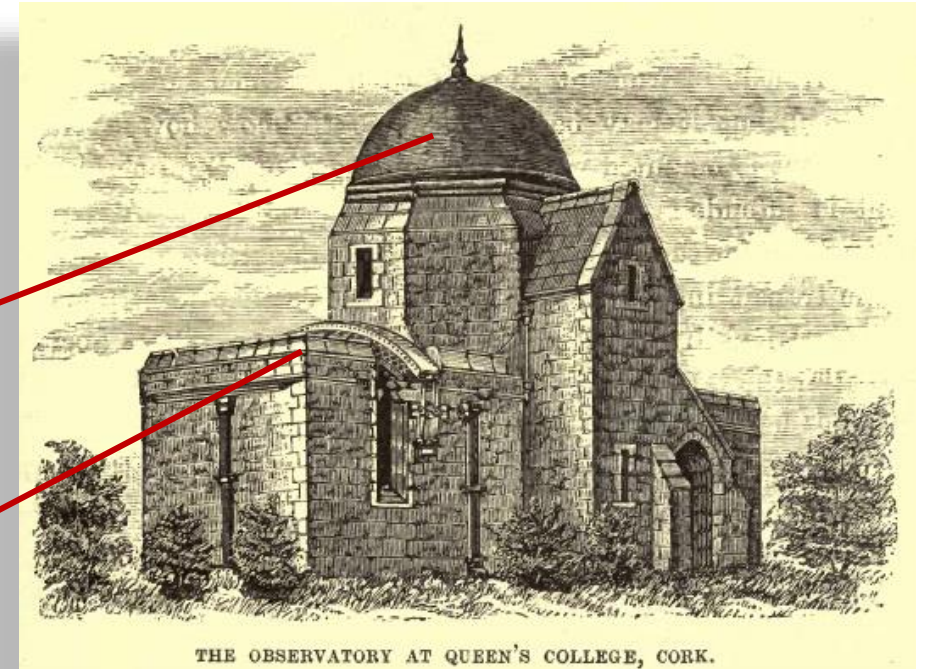
The instruments in the Crawford Observatory

"For large observatories Grubb has devised a form of balance shutter which swings, and is said to work well. It will be seen that the transit room of the Observatory at Queen's College, Cork, is fitted with such a shutter."

G. F. Chambers, *A Handbook of Descriptive and Practical Astronomy*, Vol. 2, 4th ed. (Clarendon Press 1890), p.203.

The rotating dome,
with opening
shutter

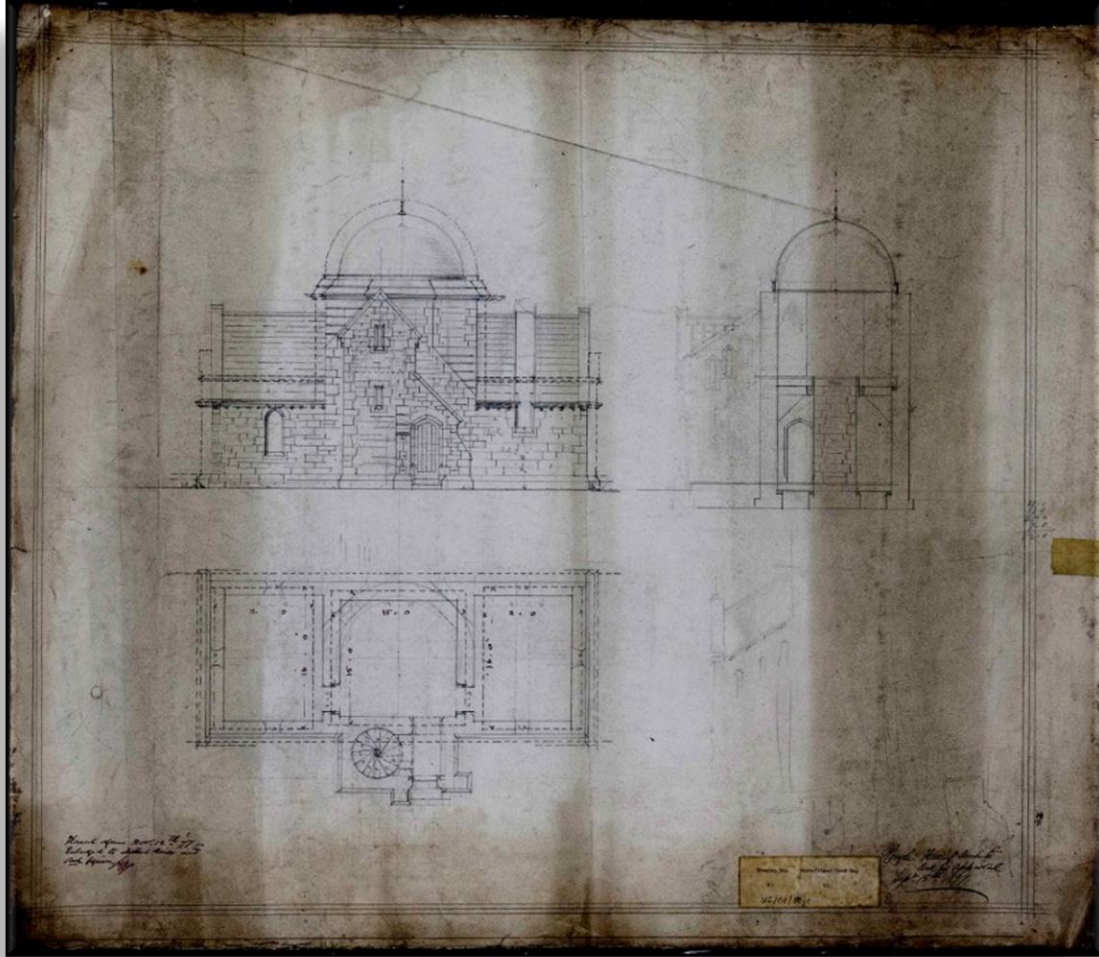
Transit room, with the
shutter



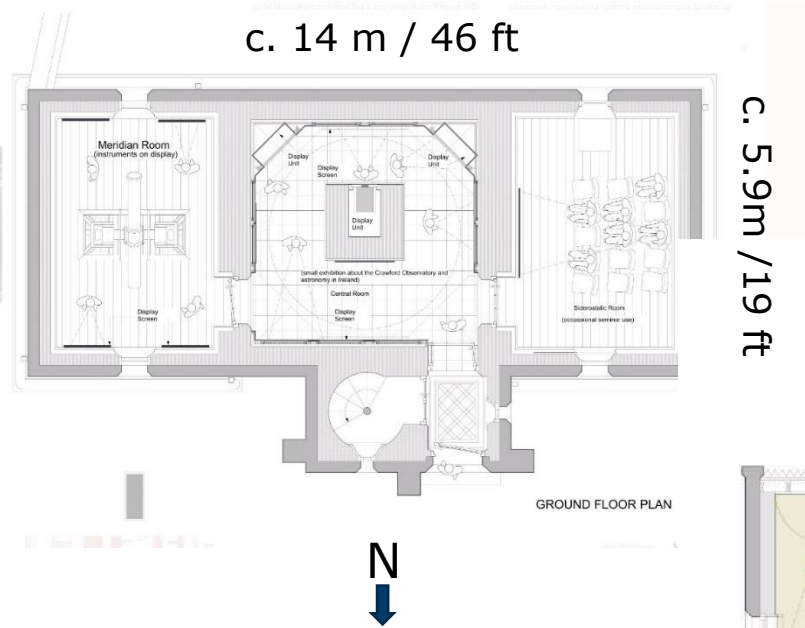
G. F. Chambers, Fig. 116.

Anyone reading this book would find out about the new technology available at Cork.

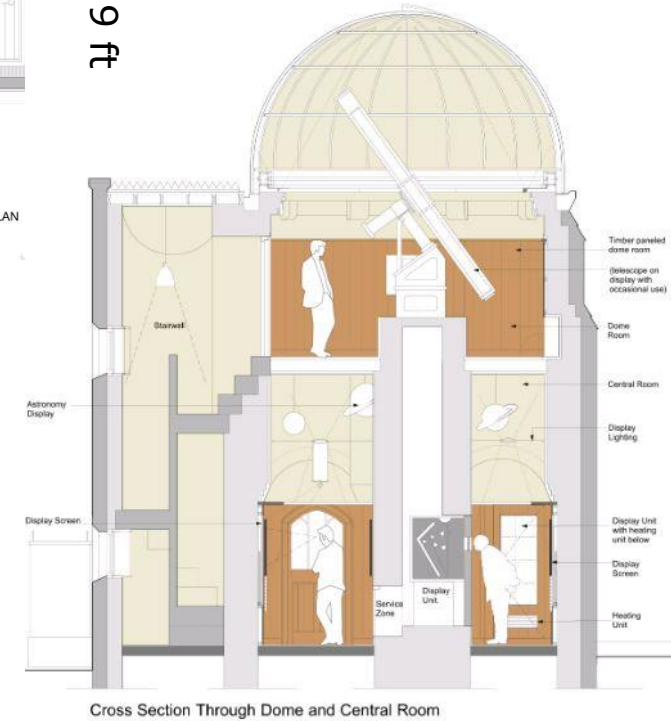
The Crawford Observatory interior



Plans, 1877. © UCC, University Archives
Online: <http://www.astronomytrail.ie/crawford/history/>



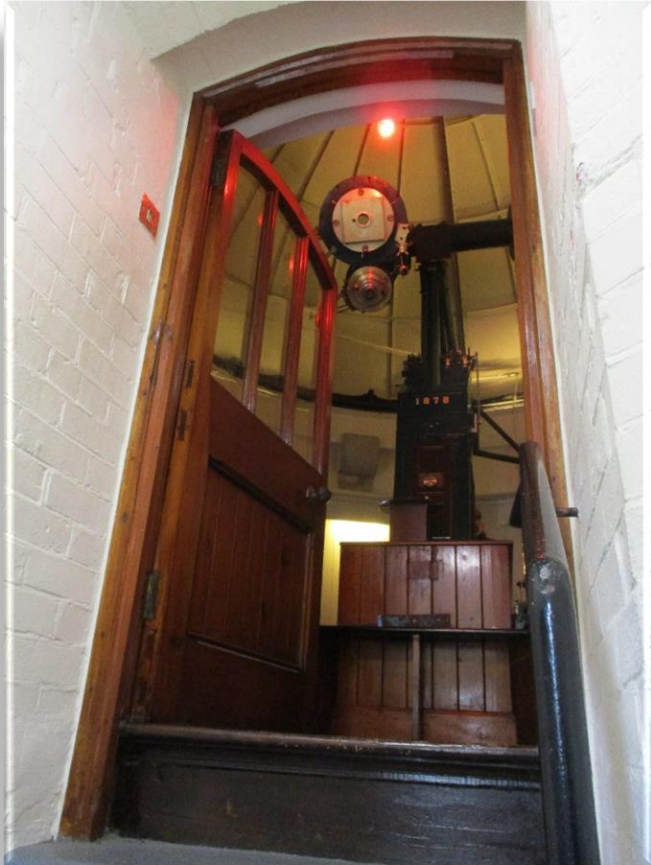
GROUND FLOOR PLAN



Cross Section Through Dome and Central Room

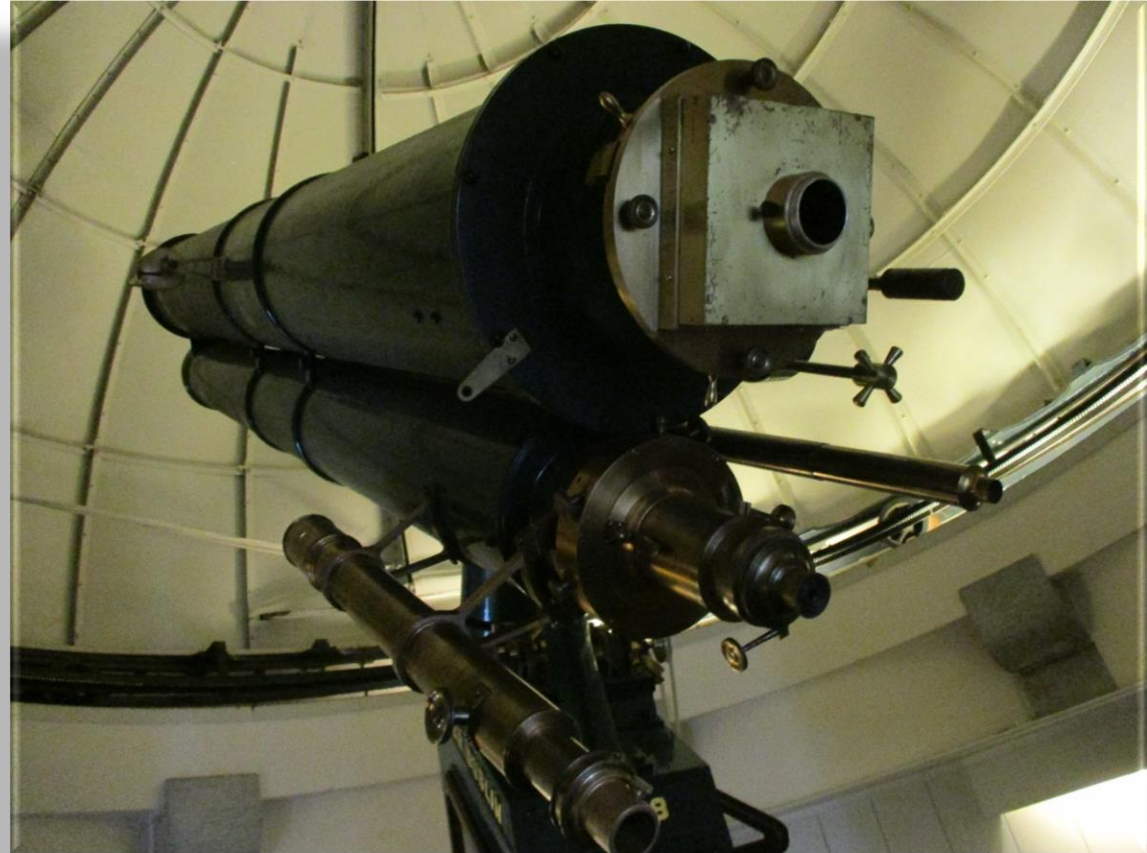
Images courtesy of © Howley
Hayes Architects, Dublin.

The Equatorial Telescope



© Margaret Lantry, 9/9/2019

Entrance at the top of the concrete spiral staircase to the equatorial telescope room with dome.



The equatorial telescope seen under the closed dome.

The Equatorial Telescope

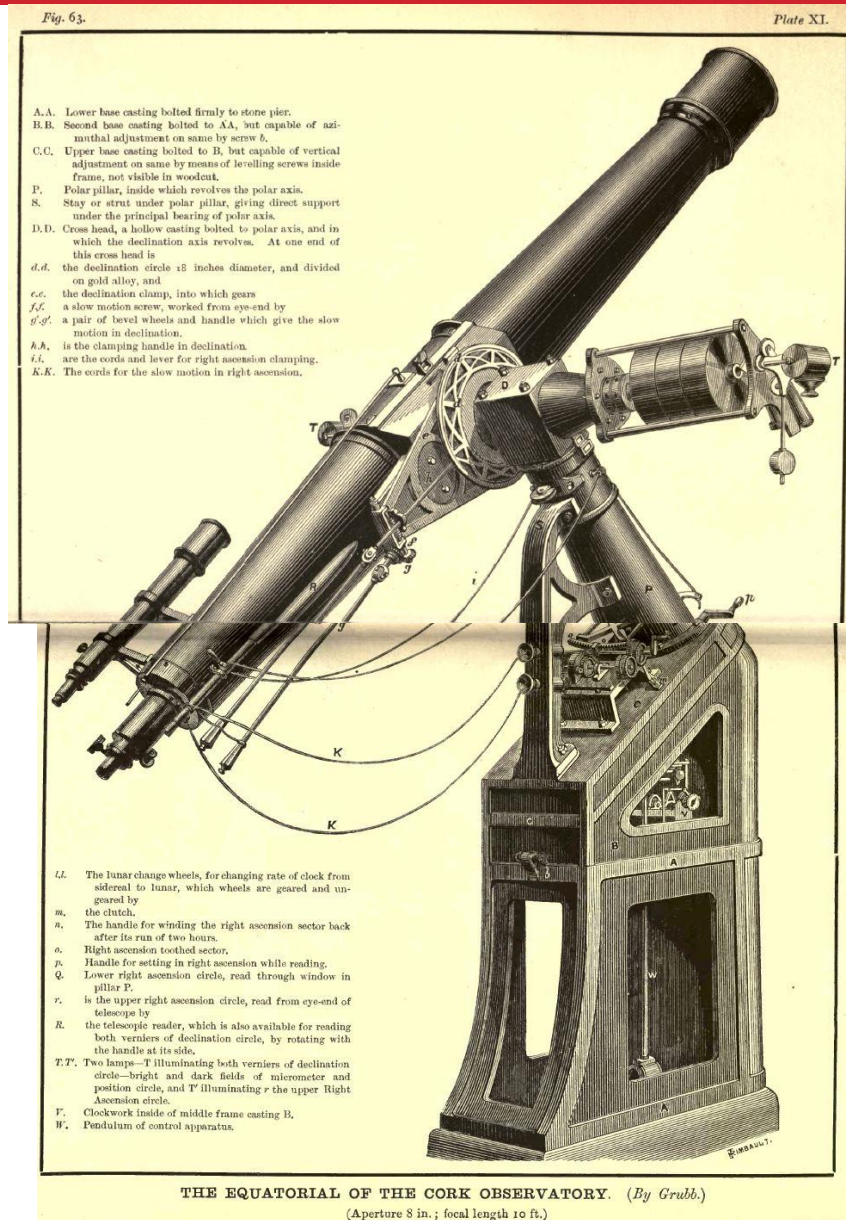
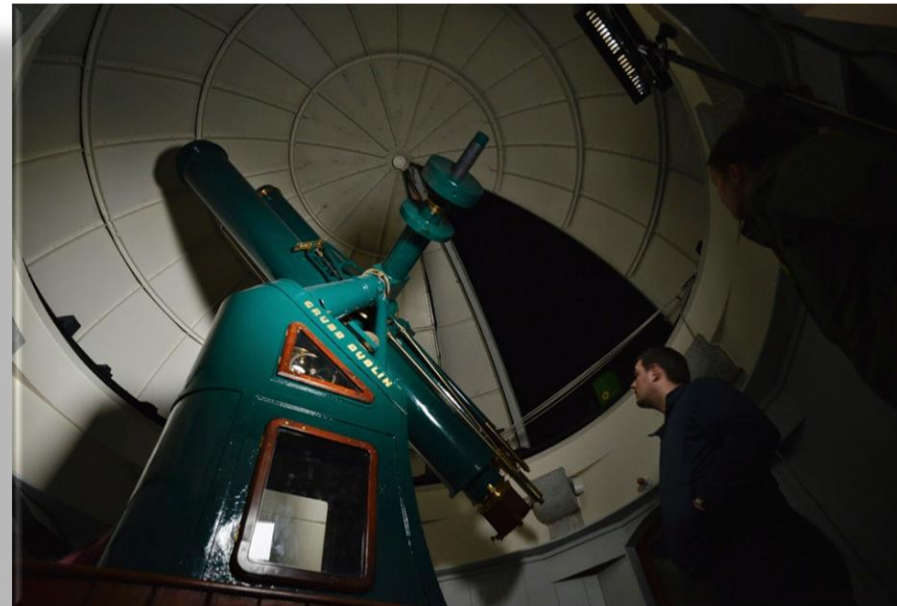


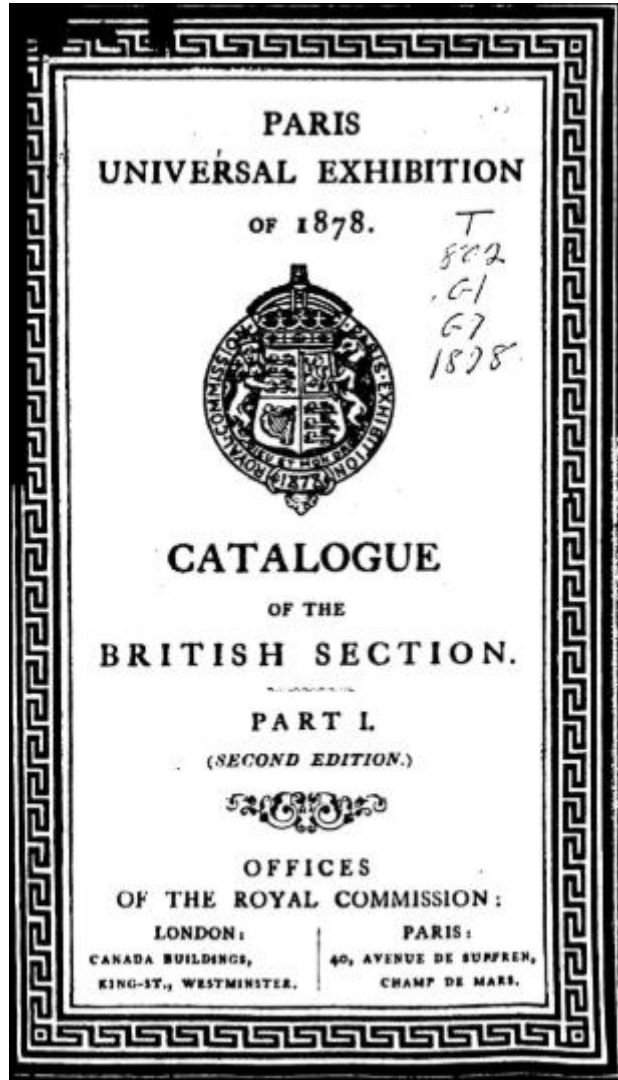
Plate XI. The Equatorial of the Cork Observatory. Aperture 8 inch, and focal length 10 feet.

G. F. Chambers, *A Handbook of Descriptive and Practical Astronomy*, Vol. 2, 4th ed. (Clarendon Press 1890).



Grubb's 8-inch and 15-inch Equatorial Telescope in the Observatory. This had a clock drive, which meant that once put into a position, it remained in place thus permitting photography.

The Equatorial Telescope wins Gold!



THE PARIS EXHIBITION.

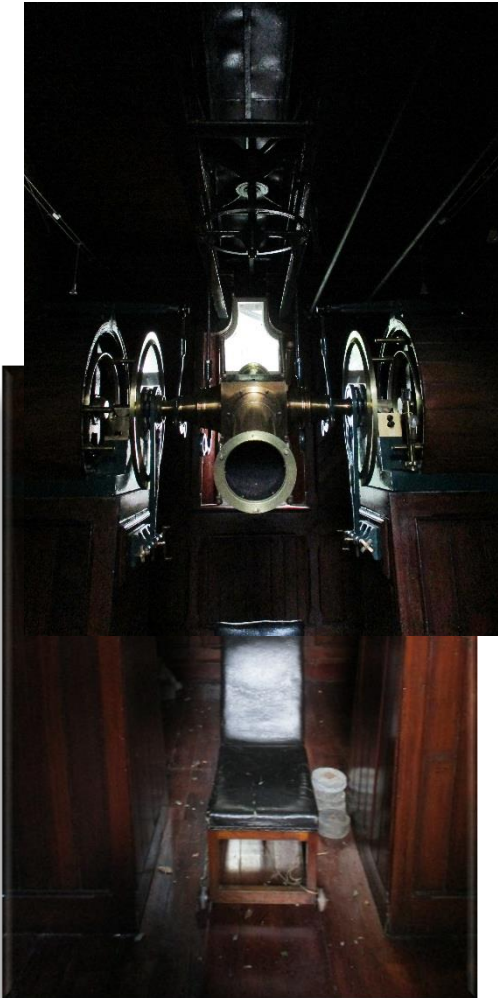
Mr Howard Grubb has been awarded a gold medal at the Paris Exhibition for the Equatorial Telescope he has exhibited. In this branch of industry at least Ireland is able to hold her own against all competitors. Twenty years ago all the world went to Germany for astronomical instruments, now Ireland sends her instruments even to Germany and Austria, close to what used to be the great centre of astronomical instrument manufacture, and now in this, the first Continental exhibition in which Mr Grubb has ever exhibited, his instrument has carried off the gold medal. It is a satisfaction also to see that Mr Grubb's instruments are beginning to be appreciated at home as well as abroad, this instrument having been, we understand, already purchased for the New Observatory of the Queen's College, Cork, for the acquisition of which the College are indebted to the munificence of a private citizen, Mr Crawford. We understand that all the other instruments for the Observatory have been ordered from Mr Grubb.

Cork Constitution – Thursday, 19 September 1878



Gold medal (example),
Exposition Universelle
Internationale de Paris, 1878

Transit Circle Telescope



Transit instruments are used for astronomy – that is measuring the position of the stars to a high degree of accuracy. This telescope points at the meridian – and so observes 'transits' across it. Transit telescopes were designed to map accurate positions of stars, necessary, for example, to test Newton's theory of gravitation, and to assist navigation at sea.

This telescope is housed in the single-storey east wing of the observatory. The telescope is pointed to the meridian, which is a circle of constant longitude passing through a given place on the earth's surface and the terrestrial poles. Thus the alignment of this instrument determined that of the entire building.

Grubb used an innovation in this telescope, which is that the scales are engraved on a delicate glass disc 30 inches wide and so can be read by light passed through the glass. This greatly increased the accuracy of measurements and this concept was then used in many astronomical and surveying instruments.

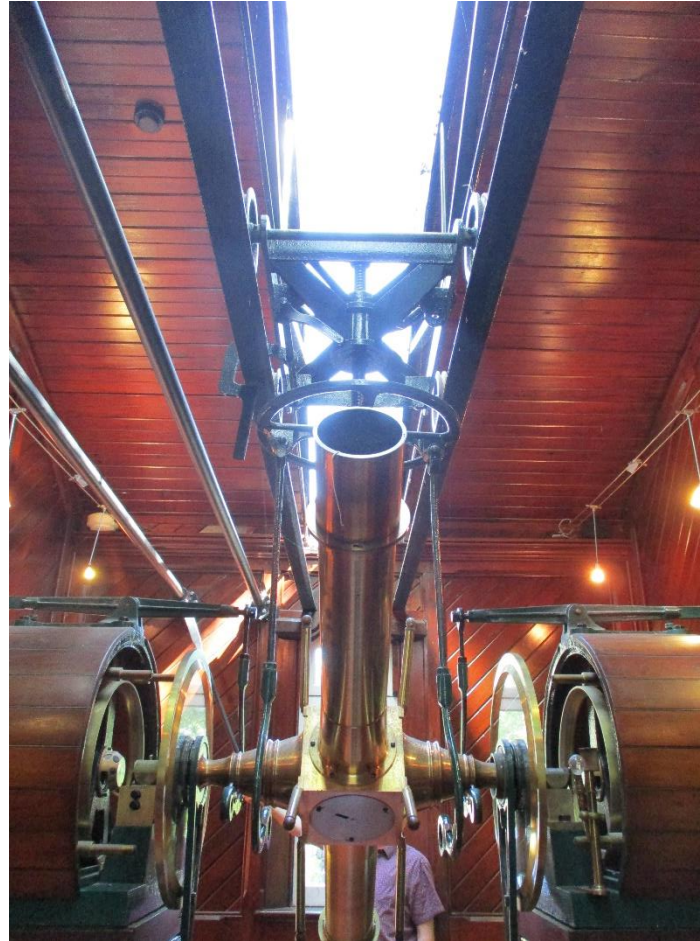
The observer's seat was also innovative. The chair, padded with horsehair, has an adjustable back and is on castors.

© Margaret Lantry,
composite photo, 9/9/2019



The piers outside on either side of this room on which telescopes can be rested. These were aligned with markings on distant buildings to ensure accurate positioning of the Transit Circle Telescope.

Transit Circle Telescope



© Margaret Lantry, 9/9/2019 and 21/7/2020

In the ceiling of this room is the mechanism which opens the shutter that allows the telescope to look at the night sky.



Section of roof that opens

Siderostatic Telescope



© Margaret Lantry, 9/9/2019

The siderostatic telescope works by counteracting the rotation of the Earth and this means it offers the observer a stationary image in a stationary eyepiece. This design originated in France in the 1830s.

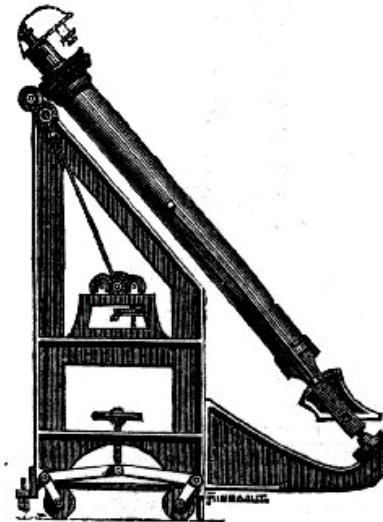
This kind of telescope was designed primarily to observe the Sun. It is located in a room at the western side of the Observatory. The Crawford Observatory version is one of the first of its type made by Howard Grubb. Its design is simple and elegant and an important link in the development of this type of instrument.

This telescope was used by Prof. John England to view the Transit of Venus on 6th December 1882 (see *Scientific Proceedings, Royal Dublin Society*).

8

Grubb, *Catalogue* (1888)

NEW FORM OF SIDEROSTATIC TELESCOPE.



Complete with four-inch Objective and corresponding plane mirror, clockwork, etc., etc., £90.

A most convenient form of instrument for star-gazing purposes. The Objective and Mirror (when in use) are outside the Observatory; the eyepiece inside. All the advantages of good definition due to working in open air are thus obtained, combined with the utmost degree of personal comfort to the observer himself, situated in the interior of the building. For full description of this instrument, see paper by Sir Howard Grubb in Proceedings Royal Dublin Society.

Seismograph

A Seismograph of a Milne Twin boom 1910 pattern, was installed in the Crawford Observatory in about 1911. It was probably located in the Siderostatic Room.

Latitude $51^{\circ} 88'$ Longitude $-8^{\circ} 47'$

This was used for readings between 1911 and 1919 (see *UCC Official Gazette*). It is not now present.

See: Lovell & Henni, 'Historical Seismological Observatories in the British Isles (pre-1970)' (British Geological Survey 1999)

<http://www.earthquakes.bgs.ac.uk/hazard/pdf/wl9913.pdf>

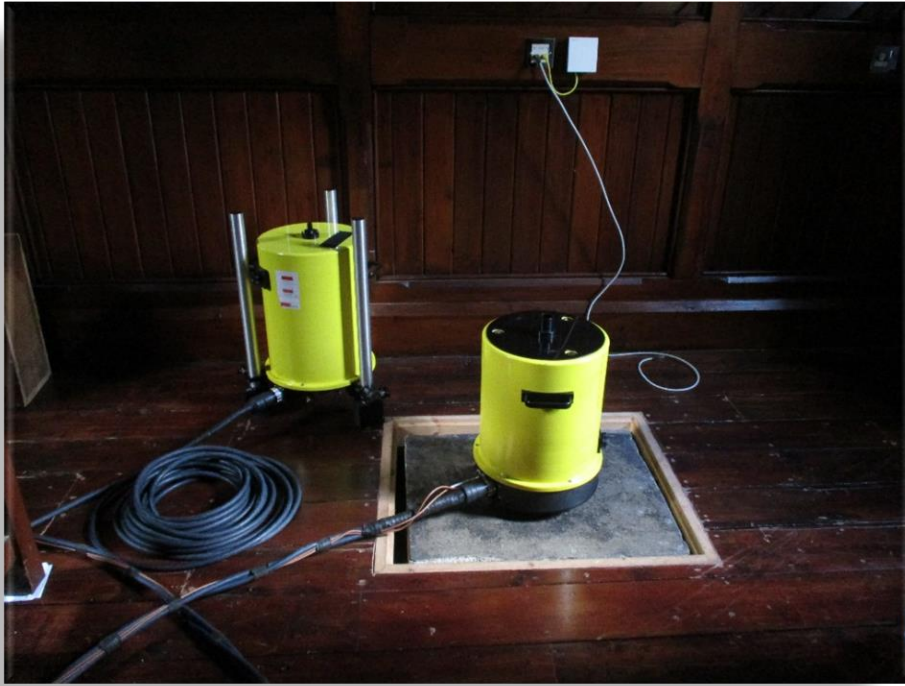


Milne Double Boom Seismograph, 1908.

Maker: R. W. Munro.

In the double boom seismograph, two horizontal pendula were carried at right angles to each other but with the booms running parallel, so the two traces could be recorded on the same roll of paper.

Recent use of the Crawford Observatory



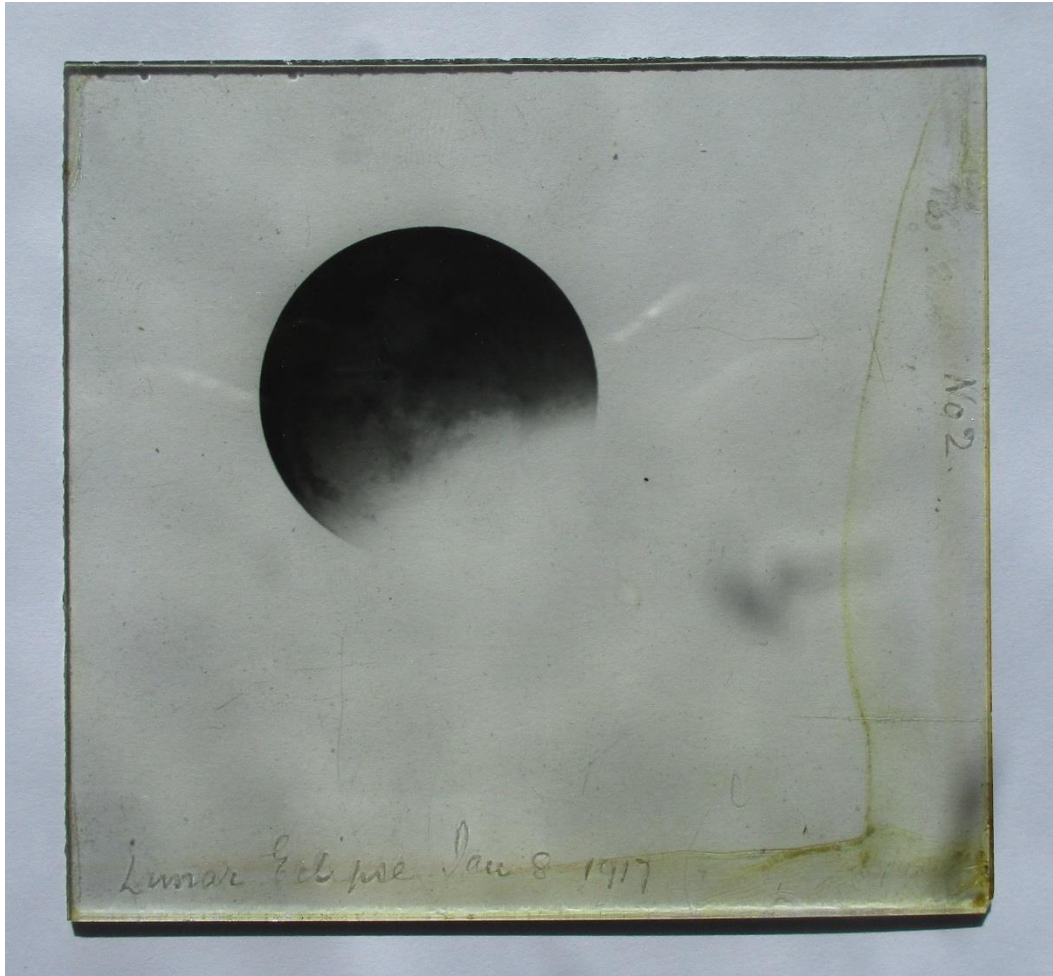
In the Siderostatic room is a particular spot that can be used to measure the force of the Earth's gravity. The Crawford Observatory is part of the the International Gravity Station Network (IGSN). Absolute measurements have been made from this location, fixed to the very stable foundations of the Observatory. This means that the measurements obtained at this point are extremely reliable.

The instrument used is a gravimeter. Once the bottom part of it reaches a particular temperature, then the upper part of the instrument is stacked on top and the readings can begin.

© Margaret Lantry, 9/9/2019

More information: <https://www.ucc.ie/en/physics/news/the-gravity-of-the-situation-in-the-crawford-observatory.html>

Possibly taken at the Crawford Observatory



Glass plate negatives taken during a lunar eclipse, 8th January 1917.
UCC Curatorial Collections, Heritage Services, Buildings & Estates, T0709.

Importance of the Crawford Observatory

Dr John Butler, Armagh Observatory, in his 1994 report wrote that Howard Grubb was proud of his achievements in Cork and detailed the many improvements he first introduced there in article published by The Royal Dublin Society. Amongst the innovations he mentioned were:

- A telescope mounting that allowed uninterrupted viewing of all objects south of the zenith and above the horizon.
- A new form of telescope drive controlled by electrical impulses from a pendulum clock.
- A telescope on the siderostatic principle which is one of the earliest of its type.
- A duplex micrometer (only one other existed).
- A transit circle that employed circular glass scales, probably the first such use of glass scales in an astronomical or surveying instrument (they are now ubiquitous).
- A novel shutter mechanism for the transit instrument superior to any used previously.

Two of the major instruments incorporated a variety of other labour-saving devices.

All in all, the Crawford Observatory is a monument to the ingenuity and craftsmanship of its builders and is of exceptional interest both for the history of the sciences in Ireland and for the technological achievements it incorporates.

https://web.archive.org/web/20050409030252fw_/http://astro.ucc.ie/obs/butler/index.html

A Tiny Gem – even a Star!



Images courtesy of © Howley Hayes Architects, Dublin.

This small building is one we should be proud to have in Ireland. It is on the Record of Protected Structures held by Cork City Council. Not only were the instruments designed and made by the Irish man Howard Grubb, the building was designed by him too. The equatorial telescope here won the Gold Medal at the Paris International Exhibition – a huge achievement for anyone at the time. Grubb also introduced other innovations in the other instruments at the observatory. This perfectly formed tiny gem is part of heritage of astronomy and Irish science.

To access the observatory, enquire at the UCC Visitors' Centre, Main Quadrangle

<https://www.ucc.ie/en/discover/visit/centre/>

More information about the telescopes and instruments at:

<http://www.astronomytrail.ie/crawford/history/>

Howley Hayes Architects, restoration in 2006:

<http://www.howleyhayes.ie/projects/crawford-observatory/>

Article by Ray, Callanan et al. 'Astronomy in Ireland' *The Messenger*:

<https://www.eso.org/sci/publications/messenger/archive/no.176-jun19/messenger-no176-3-7.pdf>

'The Irish role in Einstein's defining discovery'

<https://www.ucc.ie/en/news/the-irish-role-in-einsteins-defining-discovery.html>

'How Cork keeps Ireland's feet on the ground'

<https://www.rte.ie/brainstorm/2019/1114/1090866-how-cork-keeps-irelands-feet-on-the-ground/>

Further reading

About Queen's / University College Cork:

R. A. Baker, 'Rev. William Hincks (1794-1871) and the early development of Natural History at Queen's College (University College) Cork, *Irish Naturalists' Journal* (1999)

John A. Murphy, *The College* (Cork Univ Press 1995)

About W. H. Crawford:

Donal & Diarmuid Ó Drisceoil, *Beamish & Crawford: the history of an Irish brewery* (Collins Press 2015)

About Howard Grubb:

The Biographical Encyclopedia of Astronomers, Vol. 1 A-L (2007), p446

Grubb, *Catalogue* (1888): <https://www.sil.si.edu/DigitalCollections/trade-literature/scientific-instruments/files/51620/imagepages/image1.htm>

Helen Andrews, 'Grubb, Sir Howard', *Dictionary of Irish Biography*

List of instruments by Thomas and Howard Grubb: www.sao.ac.za/~isg/g.html

Royal Commission for the Paris Exhibition, *Official catalogue of the British section* (1878): <https://archive.org/details/officialcatalog00britgoog> (Grubb's telescopes, p.338)