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Physics in Perspective

The Physical Tourist

Physics in Glasgow: A Heritage Tour

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I trace the history of the physical and applied sciences, and particularly physics, in Glasgow. Among the notable individuals I discuss are Joseph Black (1728–1799), James Watt (1736–1819), William John Macquorn Rankine (1820–1872), William Thomson, Lord Kelvin (1824–1907), John Kerr (1824–1907), Frederick Soddy (1877–1956), John Logie Baird (1888–1946), and Ian Donald (1910–1987), as well as physics-related businesses. The locations, centering on the city center and University of Glasgow, include sites both recognizable today and transformed from past usage, as well as museums and archives related to the history and interpretation of physics.

Key words: Glasgow; University of Glasgow; Joseph Black; James Watt; William John Macquorn Rankine; William Thomson; Lord Kelvin; Frederick Soddy; physics teaching laboratories; physics apparatus; Barr & Stroud; Kelvin & Hughes; Ian Donald; medical ultrasound; John Logie Baird.

Introduction

On the face of it, a guide for the physical tourist is straightforward: For a given region, describe the sites of events or individuals having significance for physics. But the more closely we examine the task the fuzzier it becomes, particularly in an ancient urban environment like Glasgow. Physics cannot readily be stretched backward in time; calling the activities of Francis Bacon (1561–1626), Isaac Newton (1642–1726), or even James Clerk Maxwell (1831–1879) merely "physics" misrepresents their activities unfairly, so much so that most Scottish universities adopted the name *physics* for their departments only within the last generation. And confining the task to an urban region that has expanded through the centuries places further strictures on how we are to identify the activities of different periods in the past. The visible remnants of that past may also be sparse and unrepresentative.

Nevertheless, Glasgow has attributes that make the aim feasible. It was one of a handful of centers in the British Isles for the teaching and research in the subject

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known as Natural Philosophy for over four centuries. The contents and methods of that subject evolved, but the location remained unusually well defined: The city's first university was the principal source of influential concepts and novel measurements, significant instruments, inventions, and applications. This tour for the physical tourist consequently centers on the university district within a diameter of about 2.5 miles (4 kilometers) encompassing Glasgow's city center and West End.

Glasgow

It could be argued that physics in Glasgow was built upon antecedents in prehistory. The modern subject there is based on earlier and more wide-ranging investigations in *natural philosophy*, which until recently has been the favored term at Scottish universities. And natural philosophy itself developed long after the original inhabitants had studied and recorded the natural phenomena of their world. Evidence for a small fishing village on the banks of the River Clyde dates back nearly two thousand years. But long before even this period, Neolithic peoples on the Orkney islands off northern Scotland aligned some of their stone buildings to track celestial events. Stone circles and standing stones are still to be found scattered around the country, with the best example of henges, aligned stones and a Neolithic settlement near Glasgow being Cairnpapple Hill, about 25 miles east of the city.*

Construction of Glasgow's cathedral – the acquisition of which has long been the technical definition of a British "city" – began in 1238, and in 1492 it became the seat of an Archbishop, making it an important medieval ecclesiastical center. The town was nevertheless small, having a population of scarcely two thousand. During the Reformation some seven decades later, the departure of the city's last Roman Catholic archbishop altered civic administration and raised the influence of local craftsmen and merchants.

Foreign trade increased through the sixteenth and seventeenth centuries, making Glasgow second only to Edinburgh as an important Scottish burgh. In the late eighteenth century, however, work carried out to flush silt and deepen the shallow River Clyde allowed access from the heart of the city to the west coast and the Atlantic Ocean, which provided the impetus for substantial urban growth. Shipbuilding became a major industry, and foreign trade with America and the West Indies increased substantially.

Glasgow industrialized rapidly during the following century, beginning with a range of manufacturing industries and, by the mid-Victorian period, the heavy industries of shipbuilding, locomotives, and engineering. During this time the city grew meteorically, from a population of some 77,000 inhabitants in 1801 to 784,000 a century later. Yet there was a broad industrial downturn after the First World War, and Glasgow was classed as one of the most severely depressed regions in the United Kingdom during the interwar period. The gradual renovation of housing and industries after the Second

* For the benefit of the modern physical tourist having access to a GPS device for navigation, this hard-to-find location is at 55º55'40"N, 3º37'40"W. The site is open April–September, and there is a small admission charge.

World War transformed the city. The shipbuilding heritage on the banks of the Clyde is scarcely visible today. The clearances of stone tenements (the most typical architectural style during the city's Victorian expansion) and dispersal of the population around the region altered the environment immeasurably.[1] Perhaps most surprisingly in this changing environment of religious and commercial life, the natural sciences were sustained and nurtured.

The Natural Sciences in Glasgow

Some two to four millennia after local Neolithic observations of the night sky, academic explanations and investigations of natural phenomena became situated in the first universities in Scotland. The University of Glasgow was founded in 1451 by a Papal Bull, making it the second oldest university in Scotland and fourth oldest in the United Kingdom as a whole (after Oxford, Cambridge, and St. Andrews).

More recently, Strathclyde University and Glasgow Caledonian University have contributed to higher education in the city.* Strathclyde was founded in 1796 as Anderson's Institution, at the bequest of John Anderson, Professor of Natural Philosophy at Glasgow University. Becoming the principal component of the Glasgow and West of Scotland Technical College in 1887, Anderson's College was granted university status and its present name in 1964. The institution had included a Department of Natural Philosophy from its origin in 1796, and subsequently focused on science and engineering. Since 2001, some departments of the two universities have merged as part of a strategic alliance, and inter-university research projects are increasingly common.

The center of mass for research and teaching from the eighteenth to the late twentieth century was thus the University of Glasgow. Originally an adjunct of the city's cathedral, the University was founded as an ecclesiastical institution, teaching the *artes liberales* throughout the medieval period and long remaining a major institution for training the clergy.** Natural Philosophy, which included mathematics and astronomy, was first taught there as a distinct subject in 1577, with a single *regent* responsible for taking each year's cohort of students through their entire degree course. The curriculum was reorganized in 1727, when separate Chairs of Natural Philosophy, Moral Philosophy, and Logic were instituted – allocating this early version of physics as one-third of every university student's studies. Only in 1893 did the university found a Faculty of Science as such, but philosophy remained a major component of all Glasgow students' studies well into the twentieth century.[2]

Beginning with the growing specialization of teaching and research during the eighteenth century and the growing Scottish Enlightenment and the Industrial Revolution that followed, the University of Glasgow attracted several of the influential figures of the western world as artisans, teachers, and researchers. These included philosopher and economist Adam Smith, engineer James Watt, scientists Joseph Black, William

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* The city's third university, Glasgow Caledonian, was founded in 1993 as a merger of Glasgow Polytechnic and Queen's College. While incorporating a school of Engineering Science and Design, it has not been involved in physics *per se*.

** Taught as a modern interdisciplinary *liberal arts* curriculum at its Crichton campus today.

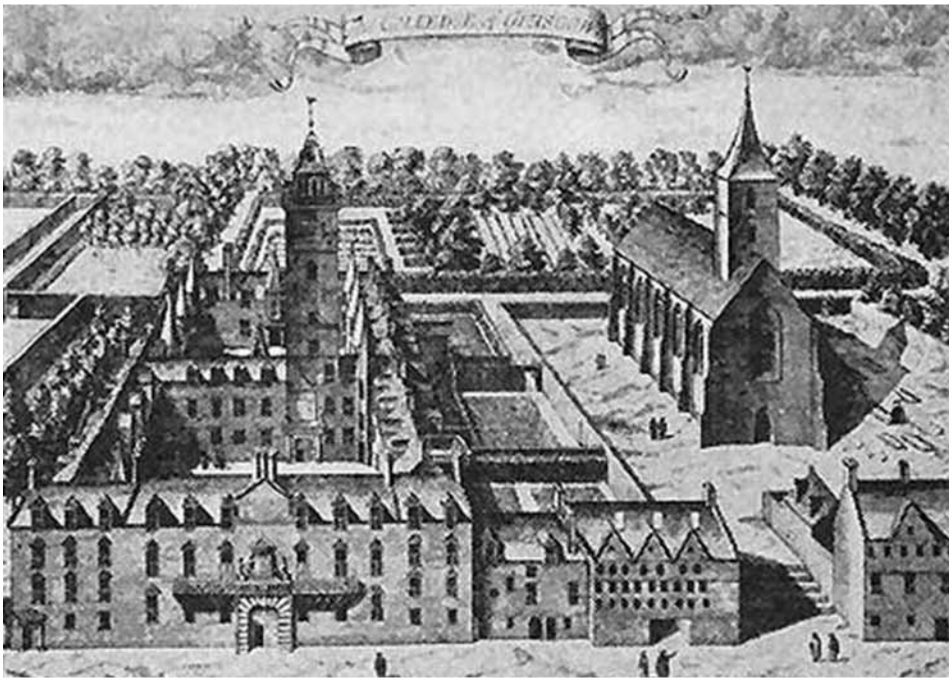

Fig. 1. The Old College of the University of Glasgow, where Joseph Black (1728–1799), James Watt (1736–1819), William McQuorn Rankine (1820–1872), and William Thomson (1824–1907) worked. *Source*: John Slezer, Theatrum Scottiae (London: John Leake, 1693).

Macquorn Rankine, William Thomson (Lord Kelvin), and Frederick Soddy. Natural philosophers at the University also played a significant role in commerce, contributing to the foundation of some of the city's technical firms.

Given the long history of the University and the steadily expanding city, it is not surprising that remaining physical traces are often scanty today. After over four centuries in the High Street area of the city (figure 1), the University moved in 1870 to the Gilmorehill district in the West End.* Most of the evidence for these activities today lies in University archives, museums, and place names.

Joseph Black

Often pigeonholed in science textbooks today as a physicist or chemist, Joseph Black (1728–1799) was in fact a polymath who had studied arts at the University of Glasgow

* The original site of the university is at 55°51'30"N, 4°14'30"W, postcode G1 1PP; the present university site is at 55°52'20"N, 4°17'20"W, postcode G12 8QQ, some two miles (3 kilometers) west-northwest. A map of the university district and central Glasgow areas discussed in this paper can be found at <http://www.glasgowguide.co.uk/maps-full.html>.

Fig. 2. Joseph Black (1728–1799) lecturing at the University of Glasgow in 1787, cartoon by John Kay (1742–1826). *Credit*: © University of Glasgow. Licensor www.scran.ac.uk.

from 1744 and then took up medicine, acquiring the subject while serving as a laboratory assistant in chemistry for William Cullen (1710–1790). He became Professor of Anatomy and Botany and lecturer in chemistry in 1756 when Cullen took up an appointment at Edinburgh (figure 2). Black began studies of latent heat and techniques of calorimetry, and developed the concepts of heat capacity and specific heat. Extending quantitative measurements to heat, he was able to make fundamental advances. Black determined the latent heat of ice experimentally in 1761, and the latent heat of formation of steam the following year. The experimental seed for these ideas in thermodynamics was the steam engine, and his accomplice was James Watt. Black's influence is commemorated by the eponymous Chemistry building at the University of Glasgow, where a plaque is mounted on the wall facing University Place (north).

James Watt

James Watt (1736–1819), appointed mathematical instrument maker at the University of Glasgow at the age of 20, met Joseph Black who was then studying the thermodynamics of steam. Requested to repair a demonstration Newcomen steam engine, Watt introduced several improvements during the 1760s, notably a separate condensing chamber. According to local tradition, Watt conceived the idea of a condensing vessel – and hence the key to the efficient and economical power generation that accelerated the industrial revolution – while walking through Glasgow Green in 1765, where an inscribed stone today marks the putative spot.*

That Newcomen demonstration engine is now displayed in the Hunterian Museum of the University of Glasgow, the oldest public museum in Scotland. Watt had, in fact, designed the heating system for the first Hunterian Museum, demolished in the 1870s. A white marble statue of Watt is located in the museum's front hall, and the Mechanical and Aerospace Departments of the modern university are housed in the building named after him. The ubiquitous term *watt* has been a unit of electrical power since its adoption by the Second Congress of the British Association in 1889.

James Watt was significant in civic terms as well. He helped supervise the flushing of silt from nineteen miles of the River Clyde in the early 1770s, opening up the city to deep-sea vessels and thus to commerce and manufacturing. A large bronze statue of Watt is to be found in George Square in the city center.

William John Macquorn Rankine

Besides Black and Watt, another important contributor to the developing science of thermodynamics was William J. Macquorn Rankine (1820–1872). Attending secondary school in Glasgow and University in Edinburgh, he was later apprenticed to the surveyor of a railway commission, where he became interested in civil-engineering problems. During the 1840s Rankine moved from engineering problems to science when he began experimental and theoretical studies of heat and birefringence. In 1855 he was appointed Professor of Civil Engineering and Mechanics at the University of Glasgow, a position he held until his death (this Chair, first created in 1840, was the first in this subject in Britain). By the time Rankine joined the University, he had formulated an account of dynamics according to a science of energetics, based on energy and its transformation.[3] He devised a thermodynamic temperature scale defining absolute zero in 1859. Rankine's various researches contributed to the important engineering arts of his day – notably steam power, naval engineering, and soil mechanics – and to contemporary theories of energy and atomic theory. The Rankine building of the University of Glasgow, which houses the Departments of Civil and Electrical Engineering, commemorates his influence in the university and beyond.**

William Thomson, Lord Kelvin

By far the best-known physicist at the University of Glasgow, however, was William Thomson (1824–1907). Born in Belfast, Thomson came to Glasgow as a child when his

* Located south of Nelson's Column in Glasgow Green, Greendyke Street, at 55°51'7"N, 4°14'27"W, some 2.5 miles (4 kilometers) from the present University as the crow flies.

** Its location is at 55º51'40"N, 4º15'00"W.

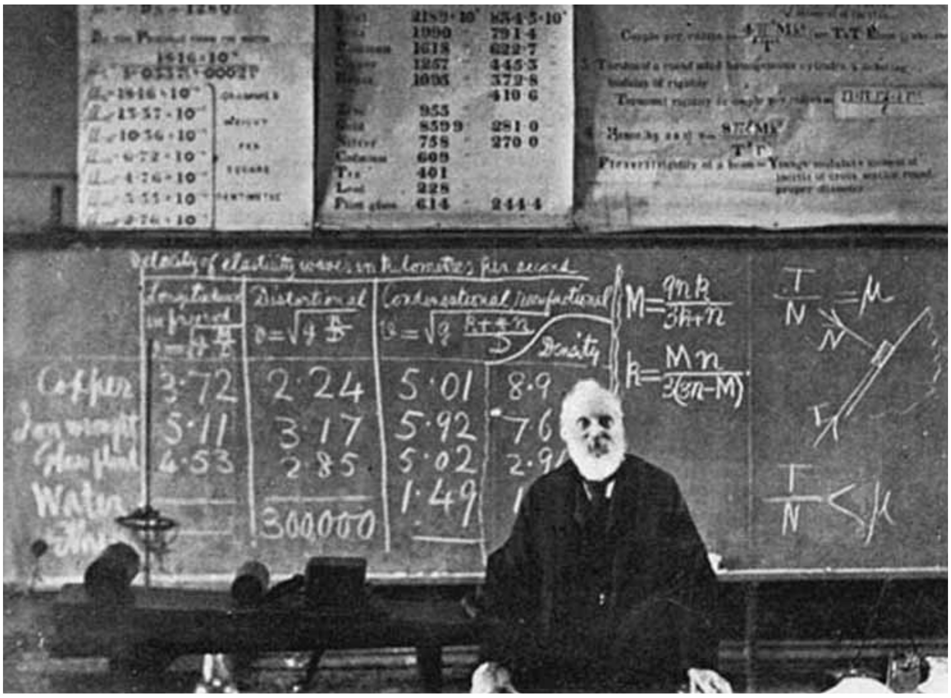

Fig. 3. The final lecture of Lord Kelvin (1824–1907) at Glasgow, 1899. *Credit*: © National Museums of Scotland. Licensor www.scran.ac.uk.

father took up the Chair of Mathematics at the University, and after careful grooming for the role at Cambridge and Paris, spent his own career there. Gaining the Chair in Natural Philosophy in 1846, he taught and researched at the University of Glasgow for the following 53 years (figure 3).

In 1846, Thomson established the first physical science laboratory in a British university for teaching and research purposes. A junior colleague who assisted in this expansion was John Kerr (1824–1907). Kerr had earned a degree in Divinity from the University and became a good friend of Thomson. Kerr became a lecturer in natural philosophy at the nearby Free Church Training College in 1857, and eighteen years later discovered the eponymous *Kerr Effect* there, in which an electric field causes an isotropic substance to behave like a uniaxial crystal and become doubly refracting. He also demonstrated the related *magneto-optic effect* for magnetic fields. Kerr too was a proponent of the metric system, a system of units that still has not been adopted for popular use in Britain.

Thomson, during his tenure at Glasgow, transformed natural philosophy from a single-person department to one taught by a system of professors and lecturers. These innovations were taken up at other institutions and became widespread in the teaching of physics by the end of the nineteenth century.

The economic environment at the time played a role in this. With some parallels to his contemporary, Rankine, Thomson was continuously involved in both high science and the practical engineering arts. Through both his Presbyterianism and scientific career, Thomson had a lifelong interest in efficiency and avoidance of waste, concerns that directed his research and commercial interests.[4] During the late 1850s Thomson was scientific advisor and a company director for the transatlantic telegraph cable between Ireland and Newfoundland. The project improved understanding of the electrical principles of bandwidth in cables, and Thomson invented the mirror galvanometer, a particularly sensitive instrument for the measurement of electrical current that benefited telegraphic communication. He also invented, patented, and commercialized designs for a marine compass and instruments for the measurement of tides and gauging sea depth.

The site of the researches of Black, Watt, Rankine, and Kelvin, known by the late Victorian period as the Old College, had been erected in the middle of the seventeenth century, but was increasingly constrained by encroaching factories and railway works by the late nineteenth century. The site became the railway terminus and goods yard when the University of Glasgow moved from the city center to the west end in 1870.* There Thomson spent the following twenty-nine years.

William Thomson, under his adopted title Lord Kelvin, appears to be commemorated copiously in and around the University, but in fact his name celebrates the University district more than the reverse. Created Baron Kelvin in 1892 for his achievements in physics, Thomson adopted the name Kelvin after the city's second major river, which flows past the University campus. The modern name for the absolute scale of temperature – itself adopted as the SI unit *degrees Kelvin* (°K) by international convention in 1954, and simply as *kelvin* (K) in 1967 – can thus be traced to this river at the foot of the University. More obvious than the river itself is Kelvingrove, the name given in the 1780s to a twenty-four-acre estate bordering the University and the river, and still today one of the more appealing urban spaces to be found in Britain. Thus the district and the man resonate: Kelvingrove Park, facing the University at Kelvinside across the Kelvin river, includes a major civic Art Gallery and Museum, and a statue of Lord Kelvin in nearby grounds (figure 4). But note that although the nearby Kelvinway bridge (1914) crossing the river incorporates a sculptural group with a figure resembling Kelvin, it represents in fact Leonardo da Vinci (1452–1519) as the embodiment of Philosophy and Inspiration.

Kelvin is remembered more tangibly at the nearby Hunterian Museum, a steep climb up the hill on the university campus, which includes a permanent exhibit (Lord Kelvin: Revolutionary Scientist).** This significant display includes teaching apparatus and memorabilia of Kelvin's time at the University. Elsewhere on the campus is one of the longest laboratory experiments ever undertaken: pitch 'flowing' imperceptibly but

* Today the area is a combination of railway land, parking lots, flats, and undeveloped areas east of the High Street, just south of the train station. The extensive university lands were bounded roughly by Drygate Street, The Gallowgate, Barrack Street, and the High Street.

** Across University Avenue is the Hunterian Art Gallery, which includes significant art works by James McNeill Whistler (1834–1903) and reconstructed interiors from the home of Glasgow architect and designer Charles Rennie Macintosh (1868–1928).

Fig. 4. Kelvin memorial, near the River Kelvin, with the University of Glasgow in the background. Photograph by the author.

inexorably down a mahogany slide to suggest the qualitative behavior of glaciers, still in progress some 120 years after Kelvin began it (figure 5).* Incidentally, Lord Kelvin – like most British physicists of his time, inspired by mechanical models – also conceived the luminiferous aether to have characteristics like those of pitch, namely, having prodigious rigidity to conduct the vibrations of light, while yielding gradually to imposed forces.[5] A portrait of Kelvin hangs in the stairway of the central tower of the Gilbert Scott building, in which the Hunterian Museum is to be found. The University's Department of Natural Philosophy was renamed the Department of Physics in

* This is catalogued as item 105646, "artificial glacier," 1887, in the Hunterian Museum collection, and is on display in the Physics Common Room (Room 470) of the Kelvin Building.

Fig. 5. Kelvin's artificial-glacier experiment with pitch on a plane. *Credit*: © Hunterian Museum and Art Gallery, University of Glasgow.

1986 when it merged with the Department of Astronomy, and occupies the Kelvin Building, but as a combination of structures built in 1905 and 1952 this postdates Kelvin himself.

Frederick Soddy

Just as the units *watt* and *kelvin* have a local connection, at the beginning of the twentieth century Glasgow was the source of another physics neologism. Frederick Soddy (1877–1956), an English chemist known to many physicists, was lecturer in Physical Chemistry and Radioactivity at the University during 1904–1914, after having worked with Ernest Rutherford (1871–1937) at McGill University in Montreal and with William Ramsay (1852–1916) at University College London. During his decade at Glasgow he conceived the "displacement law" for the transmutation of elements by alpha-particle emission, and his further research led him to infer the existence of isotopes, coining the term *isotope* itself in 1913 at his father-in-law's home, No. 11 University Gardens (now home to the University's Humanities Advanced Technology and

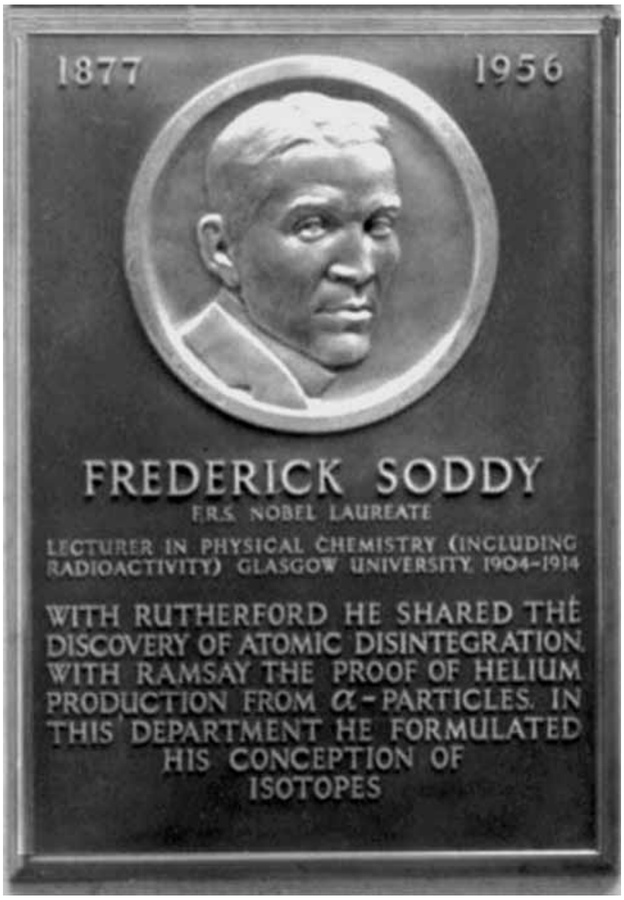

Fig 6. Commemorative plaque to Frederick Soddy (1877–1956), James Black Building, Uinversity of Glasgow. *Credit*: © University of Glasgow. Licensor www.scran.ac.uk.

Information Institute). A plaque on the wall there, and another in the Chemistry Building, commemorates Soddy (figure 6). These researches ultimately earned him the Nobel Prize in Chemistry for 1921 "for his contributions to our knowledge of the chemistry of radioactive substances, and his investigations into the origin and nature of isotopes." Intriguingly, Glasgow was a kind of intellectual terminus for Soddy: After leaving for the University of Aberdeen, he did no further research in radioactivity.

Entrepreneurship in Physics

As a city nourished by the Industrial Revolution, it is not surprising that university research was closely allied with industry. From the time of James Watt in the late eighteenth century, Glasgow research findings were being applied for commercial profit.

These activities grew principally from the design of scientific instruments for research and industrial purposes. The rising importance of instrumentation and quantification during the eighteenth and nineteenth centuries were changing trends in the practice of physics and engineering that can be traced directly to Glasgow and its innovators.

As mentioned above, William Thomson had industrial connections throughout his academic career. James White (1824–1884), a philosophical instrument maker who set up shop in 1850, worked closely with Thomson to build electrical balances and electrometers to his designs, and later outfitted the University laboratories after the move to the new campus in 1870. He subsequently worked with Thomson to produce compasses and sounding apparatus. When Thomson (now Lord Kelvin) gave up his university chair in 1899, he became Director of Kelvin & James White Ltd, which operated at 16–20 Cambridge Street in Glasgow. Following a series of mergers the firm has continued to the present day as Kelvin & Hughes. The company had a further intersection with the University and physics during the 1950s. Having developed ultrasound flaw detectors for welded joints after the Second World War, the firm contributed to the development of the first practical applications of medical ultrasound in association with Professor Ian Donald, MD (1910–1987).[6] Donald and his colleagues at the Department of Midwifery at the University pioneered the technique for obstetric and gynecological diagnoses.*

A larger and equally long-lived firm was Barr & Stroud. Archibald Barr (1855–1931), Professor of Civil Engineering and Mechanics at the University from 1891, collaborated with William Stroud (1860–1938) when both were professors at the University of Leeds to design optical rangefinders and other instruments for the British military. Their initial workshop was at 250 Byres Road, just west of the University, although they employed over 100 workers by 1904 at a purpose-built factory in Anniesland, Glasgow (figure 7). By 1913 both had resigned their chairs at their respective universities to become full-time company directors supporting war production.** During the First World War, the firm designed and produced torpedo depth recorders, periscopes, dome sights for aircraft, and more sophisticated rangefinders.[7] After the war the firm's products diversified to include binoculars and aerial photography equipment. The company survived a century, to 1988.

Repositories and Interpretative Sites

Today the material culture of those investigators and their times can be found in local repositories. The Glasgow University archives (13 Thurso Street, G11 6PE, just off the

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* A collection of historically significant equipment maintained by the British Medical Ultrasound Society is displayed at the Queen Mother's Hospital, about a half mile (1 kilometer) southwest of the University; see <http://www.bmus.org/BMUS/history_of_ultrasound.htm#bhc>.

** Barr was not the first Glasgow professor to contribute to military activities: John Anderson (1726–1796), a strong-willed Professor of Natural Philosophy who influenced College politics and the teaching of science in Scotland, had been an ardent supporter of the French Revolution and in 1791 presented his design for a new six-pound gun to the new French constitutional assembly as the "gift of Science to Liberty."

Fig. 7. Optical worker at Barr & Stroud during the First World War. *Credit*: Glasgow University Archives Service.

University campus) hold the papers of Lord Kelvin's businesses. Among the wider projects significant to historians of physics is its contribution to the Navigational Aids for the History of Science, Technology and the Environment (NAHSTE). This project has generated a catalog of history-of-science records at Glasgow, Edinburgh, and Heriot-Watt Universities, all of which are within 50 miles (80 kilometers) of each other.* The Special Collections Department of the University of Glasgow Library (Hillhead Street, G12 8QE) holds some 2.6 linear meters of Lord Kelvin's letters and papers, as well as papers of William Rankine and Joseph Black. The Hunterian Museum (Gilbert Scott

* For details see <http://www.nahste.ac.uk>.

Fig. 8. Glasgow Science Centre. *Credit*: Greater Glasgow and Clyde Valley Tourist Board.

Building, University Avenue, G12 8QQ, above the University of Glasgow Visitors' Centre) has, as mentioned, fascinating exhibits and a wealth of stored artifacts and apparatus, particularly demonstration equipment for physics laboratories. The Department of Physics and Astronomy (Kelvin Building, G12 8QQ) houses four cases of Kelvin's equipment (including the pitch glacier) in its Common Room, a bright and airy attic conversion on the top floor. After traipsing down corridors and climbing the slopes around the University and Kelvinside, visitors can find refreshment in the cafés and interesting shops on nearby Byres Road, just west of the campus.

If the views of historical artifacts, buildings, and locations adapted to new purposes do not sustain interest, there is an alternative. A modern view of the subject – and one particularly amenable for physical tourists with children in tow – is provided at the Glasgow Science Centre (50 Pacific Quay, Glasgow G51 1EA).* This gleaming glass and metal building beside the River Clyde (figure 8) includes fascinating interactive physics and engineering exhibits, including a modern working example of the 30-line mechanical television invented by local boy John Logie Baird (1888–1946).** Perhaps this is not physics – or even history of physics – in its purest form, but it can certainly produce enthusiasm for these subjects among the next generation.

Acknowledgement

I thank Roger H. Stuewer for suggesting this topic.

* It is located at 55º51'29"N, 4º17'35"W, about one mile (1.6 kilometers) by foot due south of the university, but following a circuitous maze of streets and a choice of two footbridges across the Clyde.

** Baird, a visionary inventor but ultimately unsuccessful entrepreneur, had attended the University of Glasgow and the West of Scotland Technical College before the First World War and during the 1920s developed his television schemes in England.

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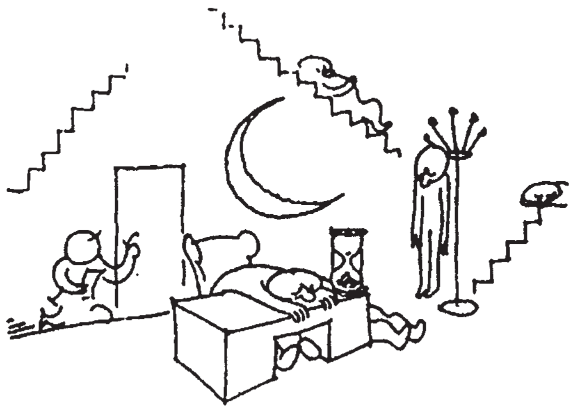

THE BOAST

It is the boast
of modern man
to do at most
the least he can.

Piet Hein