Kelvin · James Watt · 1901

JAMES WATT

AN ORATION DELIVERED IN THE UNIVERSITY OF GLASGOW ON THE COMMEMORATION OF ITS NINTH JUBILEE

BY THE

RIGHT HON. LORD KELVIN, G.C.V.O.

GLASGOW
JAMES MACLEHOSE AND SONS
61 ST. VINCENT STREET
1901

JAMES WATT,

Born Greenock, Jan. 19th, 1736; died Heathfield, Staffordshire, 19th Aug., 1819.

THE name of James Watt is famous throughout the whole world, in every part of which his great work has conferred benefits on mankind in continually increasing volume up to the present day.

It is fitting that the University of Glasgow, in this celebration of its ninth jubilee, should recollect with pride the privilege it happily exercised a hundred and forty-five years ago of lending a helping hand, and extending the beneficent solace of personal friendly intercourse of professors of mathematics, philosophy, and classical literature, and giving a workshop within its walls, to a young man of no university education, struggling to commence earning a livelihood as a mathematical-instrument-maker, in whom they discovered something of the genius, destined for such great things in future.

James Watt's paternal grandfather, Thomas Watt, was the son of an Aberdeenshire farmer, who died in battle in one of the wars of Montrose early in the seventeenth century. As a poor orphan, he was rescued from destitution by benevolent relatives of whom no records are known. He settled in Carsedyke as a teacher of navigation, or "Professor of the Mathematicks," as he was styled on his tombstone.

Carsedyke, on the site of the present Port-Glasgow, was a borough of barony under a charter of Charles II. (1669), a mile or two from Greenock, to which a charter had been granted by Charles I. thirty-four years earlier (1635). The

two boroughs, one hundred years after Thomas Watt's settlement in Carsedyke, had together a population reckoned at 4100. But as early as 1700 they possessed between them four ships and two barques, besides probably a somewhat large fleet of open or half-decked fishing-boats, then a nursery of excellent seamen soon to be employed in the rapidly growing over-sea trade of Glasgow, Port-Glasgow, and Greenock. It is difficult to imagine how Thomas Watt could have supported himself on a professorship of mathematics in the latter part of the seventeenth century, or even in teaching mathematical navigation; and it seems probable that he may have taken active part in the creation of the four ships and two barques, furnished with which Clyde navigation entered on the eighteenth century. However this may have been, he certainly was a public-spirited man, working for the good of his fellow-citizens as elder of the parish and presbytery, and chief magistrate of the borough of Greenock, anxiously caring for the minds and morals of the little community, and applying his capacity for scientific engineering "to repairing the church, widening the bridge, and "trying by mathematical standards the weights and measures "used in the borough."[1] He died at the good old age of ninety-five (or ninety-two according to another reckoning judged less probable by Muirhead) leaving two sons, John and James, who both inherited from him mathematical and engineering capacity. The elder practised as a surveyor in Glasgow, and died in 1737 at the age of fifty, leaving behind him a survey-chart, made in 1734, of the Clyde River and Frith from Rutherglen above Glasgow, to Loch Ryan and the coast of Ireland, and including the islands of Islay, Colonsay, and part of Mull; which was engraved and published twenty-five years later (1759) by his brother James assisted by *his* two sons, James and John. Of these the younger brother, John, died on board one of his father's ships on a voyage to America two years later. The elder brother,

[1] This and all other statements distinguished by quotation marks are from Muirhead's Life of James Watt except when some other origin is indicated.

James, was *the* James Watt; and was twenty-four years old, occupied in his workshop in the University of Glasgow, when he assisted his father and brother and uncle in the production of the now celebrated chart.

James Watt's father was an energetic, practical man. After serving an apprenticeship to a shipbuilder in Carsedyke, he settled at Greenock at the age of thirty, and lived a busy life of work as a shipwright; a ship-chandler supplying vessels with nautical apparatus, stores, and instruments; a builder; and a merchant. For upwards of twenty years he was a member of the Town Council of Greenock, and, during great part of that time, its Treasurer; a magistrate; and always a zealous and enlightened promoter of the improvements of the town of which he was an inhabitant. Above all, it is recorded by one who knew him well, that "he "was an intelligent, upright, and benevolent man."

About 1729 he married Agnes Muirhead, "a fine-looking "woman, with pleasing, graceful manners, a cultivated mind, "an excellent understanding, and an equal cheerful temper ". . . descended from an old Scottish family of Muirheads "settled in the shire of Clydesdale time immemorial, and "certainly before the reign of David the First of Scotland, "anno 1120." Six children were born, of whom the three eldest died in early childhood. The fourth was the great James Watt, and the fifth was his brother John, who died in 1762.

James Watt was very delicate as a child and unable to take much part in the healthy sports and school work of other boys of his age, and early, like many other men of genius, manifested a very contemplative disposition. "His "parents were indulgent, yet judicious in their kindness; and "their child was docile, grateful, and affectionate. From an "early age he was remarkable for manly spirit, a retentive "memory, and strict adherence to truth; he might be wilful "or wayward, but never was insincere. He received from his "mother his first lessons in reading, his father taught him "writing and arithmetic. Owing to variable health, his "attendance on public classes at Greenock was irregular; his

"parents were proud of his talents; and encouraged him to "prosecute his studies at home. His father gave him a small "set of carpenter's tools, and one of James' favourite amuse- "ments was to take his little toys to pieces, reconstruct them, "and invent new playthings."

From a paper entitled "Memoranda of the early years of "Mr. Watt, by his cousin, Mrs. Marion Campbell," his biographer, Mr. Muirhead, quotes the following interesting statement, "That his powers of imagination and composi- "tion were early displayed, appears from the following "incident. He was not fourteen when his mother brought "him to Glasgow to visit a friend; his brother John "accompanied them; on Mrs. Watt's return to Glasgow "some weeks after, her friend said, 'You must take your "'son James home; I cannot stand the state of excitement "'he keeps me in; I am worn out with want of sleep; "'every evening before ten o'clock, our usual hour of retiring "'to rest, he contrives to engage me in conversation, then "'begins some striking tale, and, whether humorous or "'pathetic, the interest is so overpowering, that all the family "'listen to him with breathless attention; hour after hour "'strikes unheeded; in vain his brother John scolds him and "'pulls him by the arm, Come to bed, James; you are invent- "'ing story after story to keep us up with you till after "'midnight, because you love company, and your severe fits of "'toothache prevent your sleeping at an earlier hour.'

"Sitting one evening with his aunt, Mrs. Muirhead, at the "tea-table, she said: 'James Watt, I never saw such an idle boy; "'take a book or employ yourself usefully; for the last hour "'you have not spoken one word, but taken off the lid of that "'kettle and put it on again, holding now a cup and now "'a silver spoon over the steam, watching how it rises from "'the spout, and catching and connecting the drops of hot "'water. Are you not ashamed of spending your time in this "'way?'

"It appears that when thus blamed for idleness, his active "mind was employed in investigating the properties of steam; "he was then fifteen; and once in conversation he informed

"me that before he was that age he had read twice with "great attention 'S'Gravesande's *Elements of Natural* "*Philosophy*,' adding that it was the first book on that "subject put into his hands and that he still thought it one "of the best. When health permitted, his young ardent "mind was constantly occupied, not with one but many "pursuits. Every new acquisition in science, languages, or "general literature, seemed made without an effort. While "under his father's roof, he went on with various chemical "experiments, repeating them again and again until satisfied "of their accuracy from his own observations. He had made "for himself a small electrical machine, and sometimes startled "his young friends by giving them sudden shocks from it."

After the age of thirteen he was often in Glasgow with his uncle, Mr. Muirhead, taking opportunity to learn something of anatomy and chemistry. While at home with his parents he attained to considerable proficiency in Latin, and learned something of Greek, at the grammar school of Greenock; but he studied mathematics with much greater zest under Mr. John Marr, a relative of his family. He also got great benefit in seeing his father's business affairs, and so making the acquaintance of optical instruments of various kinds for astronomy and navigation, and learning the highly scientific and interesting mechanics of sailing ships. He had a small forge set up for his own use, at which he worked in making and repairing instruments of all kinds. Thus while his delicate health prevented him from being an athlete with other boys of his age, he early became a skilled mechanic; and a skilled mechanic he remained, taking pleasure in the exercise of his handicraft, to the very end of his life.

In June, 1754, Watt came to live in Glasgow under care of relations of his mother; and was introduced by one of them, Prof. Geo. Muirhead, to Prof. James Moore (his colleague in the editorship of the magnificent Glasgow edition of Homer in four folio volumes) and to Adam Smith, Robert Simson, and other professors in the University, whose friendship he enjoyed as long as they lived. Looking forward to earning his livelihood as a mathematical-

instrument-maker, Watt was advised by the professor of natural philosophy, Dr. Dick, to go to London for better instruction in the art than he could get in Glasgow. Accordingly, on the 7th June, 1755, young Watt rode out of Glasgow in charge of his old mathematical master, John Marr, who was going south to act as naval instructor on board the *Hampton Court*, a seventy-gun ship then lying at anchor in the Thames. They travelled by Coldstream, Newcastle, Durham, York, Doncaster, Newark, and Biggleswade, the whole way to London on horseback in twelve days, on two of which not more than a Sabbath day's journey was performed.

Touching letters to young Watt's father from himself and Mr. Marr showed the great difficulty they had to find in London a competent instrument-maker who would consent to give the required instruction, and the great anxiety of the son to avoid being a burden on his father, whose means had been seriously straitened through want of prosperity of his Greenock business. However, with the assistance of Mr. Marr and the good offices of Dr. Dick, an arrangement was at last happily concluded with a very good man, John Morgan, mathematical-instrument-maker in Finch Lane, Cornhill,—young Watt to receive a year's instruction in instrument-making, for which he was in return to pay twenty guineas and give his labour for the year. In Muirhead's book we have an interesting account of the young pupil's work and life during the year. He lodged under the roof of his master, but had to find his own food, which cost him eight shillings a week, "lower than that he could not "reduce it." To diminish the expense to his father, he earned some money on his own account by rising early and gaining something by work done before the shop-time. At night he was, as he wrote to his father, "thankful enough "to go to bed with his body wearied and his hand shaking "from ten hours' hard work." "We work to nine o'clock "every night, except Saturdays."

In his letters he regrets the charge his living must be to his father, and says he is striving all he can to improve

himself that he may be sooner able to assist him and to assure his own maintenance.

Of young Watt's time in London Muirhead tells us, "An "unexpected danger at that time hung over his destiny, "which might have cut short, at least for a season, his "projects of further improvement in natural science and "postponed *sine die* his return to Glasgow College, with all its "interesting consequences. This sword of Damocles was the "chance of being impressed for the navy. He writes in the "spring of 1756 that he avoids 'a very hot press just now "'by seldom going out.' And on a later day he adds 'they "'now press anybody they can get, landsmen as well as "'seamen, except it be in the liberties of the city, where they "'are obliged to carry them before my Lord Mayor first, and "'unless one be either a 'prentice or a creditable tradesman, "'there is scarce any getting off again. And if I was carried "'before my Lord Mayor, I durst not avow that I wrought in "'the city, it being against their laws for any unfreeman to "'work, even as a journeyman, within the Liberties.'"

Our country is happier and freer now than it was a hundred and fifty years ago. Volunteer sailors and soldiers compete enthusiastically for the honour of fighting their country's battles. Every employer is free by law to give work as he pleases; and every worker, old or young, is free by law to take work where he can find it.

Watt might probably have got good work in London after his year of pupilage had he decided to try for it. But the hard struggle had told upon his health. With violent rheumatic pain and "weariness all over his body" he found himself compelled to seek the benefit he expected to derive from the "ride homeward" and from his native air. So at the end of August, 1756, he took leave of London and of Mr. Morgan, who, dying in 1758, was not destined to witness the future success of his pupil. But before leaving Watt made a small investment of twenty guineas in "half "a hundred additional tools" and the materials necessary for "a great many more that he knew he must make "himself."

Soon after his arrival in Glasgow, an occasion for good employment of that little stock-in-trade came to him through the good offices of his friend the Professor of Natural Philosophy, Dr. Dick, who asked him to assist in unpacking a valuable collection of astronomical instruments just arrived from Jamaica. These instruments had been constructed at great cost by the best makers in London for their late proprietor, Mr. Alex. Macfarlane, a merchant and amateur astronomer, long resident in Jamaica, who died in 1755, having bequeathed the contents of his observatory to the University in which he had received his education. I doubt whether any of you here present may remember the old Macfarlane Observatory in the upper eastern part of the college green of the old Glasgow College in High Street. I remember it well, and remember being taught to take transits of the sun and stars about 1838 or 1839 on Alex. Macfarlane's own old transit instrument by my father's colleague, Dr. Nicol, afterwards my own colleague, and the father of my late colleague, Prof. John Nicol. That transit instrument and, I believe, other instruments from Mr. Macfarlane's old observatory in Jamaica are still doing good work for the University of Glasgow in its present observatory on Dowanhill. A minute of a University meeting held on the 26th October, 1756, regarding them is interesting—the Professor of Greek and the Professor of Natural Philosophy appointed as a deputation to call on the youthful mechanic James Watt! "Several of the instruments from Jamaica having "suffered by the sea-air, especially those of iron, Mr. Watt, "who is well skilled in what relates to the cleaning and pre- "serving of them, being accidentally in town, Mr. Moor and "Mr. Dick are appointed to desire him to stay some time in "town to clean them, and put them in the best order for "preserving them from being spoiled." A record of a few weeks later tells us that "a precept was signed to pay "James Watt five pounds sterling for cleaning and refitting "the instruments lately come from Jamaica." This was probably the first money he earned since the termination of his pupilage.

He was then within a few weeks of twenty-one, and wished to commence as soon as possible the regular exercise of the trade for which he had been preparing. But he was not allowed by city and trade rules to work as an instrument-maker in the City of Glasgow, because he was neither the son of a burgess, nor married to the daughter of a burgess, nor a passed apprentice to any trade. He was forbidden to set up even a humble workshop with himself as solitary tenant within the limits of the borough. The University is now happily within the borough of Glasgow. Happily it was not in the borough in 1757, and it was able to give James Watt protection from tyrannical usages outside its bounds. By midsummer of that year he received permission to occupy an apartment and open a shop within the precincts of the College, and to use the designation of "Mathematical-instrument-maker to the University." In the autumn of the same year the foundation-stone of an astronomical observatory, to receive the collection of the Jamaica instruments which he had refitted and set up, and to be called the Macfarlane Observatory, was laid. Probably the completion of that undertaking gave some of the earliest employment to Watt in his University workshop.

In work for outside the University he seems early to have made some progress, as we may judge from the following interesting letter to his father of date 15th September, 1758: "As I have now had a year's trial here, 'I am able to form a judgment of what may be made of this "business, and find that unless it be the Hadley's instru-"ments, there is little to be got by it, as at most other jobs I "am obliged to do the most of them myself; and as it is "impossible for one person to be expert at everything, they "very often cost me more time than they should do. How-"ever, if there could be a ready sale procured for Hadley's "quadrants, I could do very well, as I and one lad can finish "three in a week easily; and selling them at 28s. 6d., which "is vastly below what they were ever sold at before, I have "40s. clear on the three. So it will be absolutely necessary "that I take a trip to Liverpool to look for customers, and

"hope that upon the profits of what I shall be able to sell "there, I can go to London in the spring, when I make no "doubt of selling more than I can get made; all which I "want your advice on. And if that does not succeed I must "fall into some other way of business, as this will not do in "its present situation." The sale, however, of the profitable Hadley's quadrants in Glasgow appears to have increased so much as to have rendered the proposed speculative trading voyage to Liverpool unnecessary.

A year later, it is interesting to find an advertisement (dated October 22, 1759) of an engraved map of the Frith of Clyde "to be sold by James Watt at his shop "in the College of Glasgow." This was the final outcome of the survey made two years before he was born by his uncle, John Watt, of which I have already told you.

While still continuing to make mathematical and nautical instruments in his University workship, we find him also making organs, guitars, flutes, and violins, and making or repairing harps, guitars, mandolines, viol-de-gambas, and double-basses, in 1761 and 1762. Of this excursion from mere mathematical-instrument-making Robison, then a post-graduate theological student (afterwards successor of Black as Lecturer on Chemistry) in the University of Glasgow, wrote, "We imagined that Mr. Watt could do anything; "and, though we all knew that he did not know one musical "note from another, he was asked if he could build this organ "(an organ wanted for a Masonic Lodge in Glasgow). He "said 'Yes,' but he began by building a very small one for "his friend, Dr. Black, which is now in my possession. In "doing this a thousand things occurred to him which no "organ-builder ever dreamed of—nice indicators of the "strength of the blast, regulators of it, etc. He then began "to study the philosophical theory of music. Fortunately for "me, no book was at hand but the most refined of all, and "the only one that can be said to contain any theory at all— "Smith's *Harmonics*. Before Mr. Watt had half-finished "this organ, he and I were completely masters of that most "refined and beautiful theory of the beats of imperfect con-

"sonances. He found that by these beats it would be "possible for him, totally ignorant of music, to tune this "organ according to any system of temperament; and he did "so, to the delight and astonishment of our best performers."

While thus interestedly occupied in the fascinating study of musical instruments, Watt entered on his life-long work on steam-power. In a note by himself appended to Professor Robison's dissertation on steam-engines, he says, "My attention was first directed in the year 1759 to the "subject of steam-engines, by the late Dr. Robison, then a "student in the University of Glasgow, and nearly of my "own age. He at that time threw out an idea of applying "the power of the steam-engine to the moving of wheel-"carriages, and to other purposes, but the scheme was not "matured, and was soon abandoned on his going abroad.

"About the year 1761, or 1762, I tried some experi-"ments on the force of steam in a Papin's digester, and "formed a species of steam-engine by fixing upon it a syringe, "one-third of an inch diameter, with a solid piston, and "furnished also with a cock to admit the steam from the "digester, or shut it off at pleasure, as well as to open a "communication from the inside of the syringe to the open "air, by which the steam contained in the syringe might "escape. When the communication between the digester "and syringe was opened, the steam entered the syringe, and "by its action on the piston raised a considerable weight "(15 lbs.) with which it was loaded," which shows that he had steam at 170 lbs. per square inch to deal with. "When this was raised as high as was thought proper, the "communication with the digester was shut, and communi-"cation with the atmosphere opened, the steam then made "its escape, and the weight descended. The operations were "repeated, and, though in this experiment the cock was "turned by hand, it was easy to see how it could be done by "the machine itself, and to make it work with perfect "regularity. But I soon relinquished the idea of constructing "an engine upon this principle, from being sensible it would "be liable to some of the objections against Savery's engine,

" viz., the danger of bursting the boiler, and the difficulty of " making the joints tight, and also that a great part of the " power of the steam would be lost, because no vacuum was " formed to assist the descent of the piston. I described this " engine in the fourth article of the specification of my " patent of 1769, and again in the specification of another " patent in the year 1784, together with a mode of applying " it to the moving of wheel-carriages."

Precisely that single-acting, high-pressure, syringe-engine, made and experimented on by James Watt one hundred and forty years ago in his Glasgow College workshop, now in 1901, with the addition of a surface-condenser cooled by air to receive the waste-steam, and a pump to return the water thence to the boiler, constitutes the common road motor, which, in the opinion of many good judges, is the most successful of all the different motors which have been made and tried within the last few years. Without a condenser, Watt's high-pressure, single-acting engine of 1761 only needs the cylinder-cover with piston-rod passing steam-tight through it (as introduced by Watt himself in subsequent developments), and the valves proper for admitting steam on both sides of the piston and for working expansively, to make it the very engine which, during the whole of the past century, has done practically all the steam work of the world, and is doing it still, except on the sea or lakes or rivers, where there is plenty of condensing water. Even the double and triple and quadruple expansion engines, by which the highest modern economy for power and steam engines has been obtained, are splendid mechanical developments of the principle of expansion, discovered and published by Watt, and used, though to a comparatively limited extent, in his own engines. One thing James Watt did not know—the thermodynamic value of high temperature without high pressure. This was absolutely unknown, and nothing towards it was thought of by engineers or philosophers, till it was discovered by Sadi Carnot and published in his " Puissance Motrice du Feu " in 1824. Thus James Watt did not see merit in

superheated steam. Its use, introduced thirty years ago by John Elder, and only largely coming into practice within these last two or three years, gives the finishing touch of Science to obtain the highest economy in the modern steam engine.

With all the essential ideas of the finally successful engine in his mind, a long and arduous struggle to realise them for practical usefulness lay before Watt. He soon relinquished the idea of constructing a high-pressure, non-condensing engine, and, by being employed to repair a model of Newcomen's engine a year or two later, he was brought back to steam power as developed in Newcomen's engine, which essentially involved condensation. Having been for fifty-three years official guardian of the model with which Watt's practical work on the steam-engine thus commenced, I may be pardoned for asking your sympathy in recalling some trivial details of its history. In the records of the University of Glasgow we find two minutes, with six years interval:

"University meeting, 25th June, 1760. Mr. Anderson "is allowed to lay out a sum not exceeding two pounds "sterling to recover the steam-engine from Mr. Sisson, instru-"ment-maker at London."

"University meeting, 10th June, 1766. An account "was given in by James Watt for repairing and altering "the steam-engine with copper pipes and cisterns, amounting "to £5 11s. The said machine being the property of the "College, and having been in such a situation that it did "not answer the end for which it was made, the Principal "is appointed to grant a precept for payment of the said "account, which is to be stated upon the fund for buying "instruments to the College."

Sisson was a highly-skilled maker of astronomical instruments in London. The great French astronomer, Delambre, tells us that he made a mural quadrant for the Greenwich Observatory, and another for the private observatory of the King of England, and adds the remark: "Thus Sisson "maintained the honour and the pre-eminence of England."

Sisson soutint à cet égard l'honneur *et la pre-eminence* de l'Angleterre.[1] Yet it seems that he did not succeed in making the Newcomen model work.

Mr. John Anderson was my official great-great-grandfather as Professor of Natural Philosophy in the University of Glasgow, having been appointed to the Chair on the death, in 1759, of Watt's appreciative and devoted friend, Dr. Dick, and having been himself for five years previously Professor of Hebrew in the University. He occupied the Chair for thirty-nine years; and unhappily, somewhat out of temper with the College or University in the later years of his encumbency, made a will founding a rival institution, to be called Anderson's University, with a condition that in it not a lecturer, nor teacher, nor a porter, not even an instrument-maker, was to be employed who had worked for the old University. I don't believe this condition of Anderson's will was ever fulfilled. The Andersonian Institution has, from its foundation to the present day, worked in perfect harmony with the University—perhaps even more perfect harmony than if it had been founded as an officially incorporated College of the University.

Watt has told us that it was in the winter of 1763-4 that he was engaged repairing the model, and we see that his account for the work done was not given in till the 10th June, 1766; so we may fairly conclude that he had it in hand for more than two years, and made a great many experiments with it. In the course of these experiments he noticed with surprise the large quantity of water required to condense the steam—five or six times as much as the water primarily evaporated. In conference with Joseph Black, lecturer on chemistry in Glasgow College, it was found that this was a splendid and previously unthought-of example of the doctrine of latent heat, then fresh from Black's original discovery of it. With very primitive and imperfect instrumental appliances, Watt measured the amount of the latent heat of condensation of steam at different temperatures and pressures, and found

[1] Delambre, *Histoire de l'Astronomie au dixhuitième Siècle*, p. 237, 1827.

for its variations a roughly approximate law. When, eighty-one years later, a student under Regnault in his laboratory in the College of France, I used to hear him speaking of "la loi de Watt," and telling us that it was the nearest approach to the truth which he found among the results of previous experimenters, I felt some pride in thinking that the experiments on which it was founded had been made in Glasgow College.

In working on the Newcomen model, Watt found that it essentially involved great waste of heat by performing the condensation in the cylinder by the injection of cold water, which not only cooled the steam but the whole metal of the cylinder. To remedy this fault, he invented the separate condenser, and established the principle of working with the cylinder always hot and dry. Thus during the five years from 1761-6 Watt had worked out all the principles and invented all that was essential in the details for realising them in the most perfect steam-engines of the present day.

In 1763 Watt ceased to live in his College rooms, and took a small house in the town; and in 1764 he married a cousin of his own, Margaret Miller, who for nine years did everything possible to support him and to brighten his life through the severe trials which were before him in his great work, rendered harder by continued ill-health. Of this time of his life we find an interesting statement in Miss Campbell's Memoranda: "Even his powerful mind sank occasionally "into misanthropic gloom, from the pressure of long-continued "nervous headaches and repeated disappointments in his hopes "of success in life. Mrs. Watt, from her sweetness of temper "and lively, cheerful disposition, had power to win him from "every wayward fancy—to rouse and animate him to active "exertions. She drew out all his gentle virtues, his native "benevolence, and warm affections."

I wish I could tell you of his early trials and failures to realise the steam-engine for practical purposes with the co-operation and assistance of his enthusiastic friend, Dr. Roebuck, the founder of the Carron Ironworks. In 1770, deeply depressed by hope deferred and almost constant bad health,

he writes: "I am resolved, unless those things I have "brought to some perfection reward me for the time and "money I have lost on them, if I can resist it, to invent no "more. Indeed, I am not near so capable as I was once. I "find that I am not the same person I was four years ago, "when I invented the fire-engine, and foresaw, even before I "made a model, almost every circumstance that has since "occurred. I was at that time spurred on by the alluring "hope of placing myself above want, without being obliged "to have much dealing with mankind, to whom I have always "been a dupe. The necessary experience in great was "wanting; in acquiring it I have met with many dis-"appointments. I must have sunk under the burthen of "them if I had not been supported by the friendship of "Dr. Roebuck. I have now brought the engine near a con-"clusion, yet I am not in idea nearer that rest I wished for "than I was four years ago. However, I am resolved to do "all I can to carry on this business, and if that does not "thrive with me, I will lay aside the burthen I cannot "carry."

With a family of three children the necessity to earn money gradually led him, as his biographer Muirhead tells us, "more frequently to forsake the solitary vigils of his "workshop in the city for the active labours of his profession "of a civil engineer. 'Somehow or other,' as he modestly "expresses it—or, as we cannot doubt, from his ability and "integrity having now become well known—the magistrates "of Glasgow had for two or three years past employed him in "various engineering works of importance." In 1767 he was employed, in conjunction with Mr. Robert Mackell, to make a survey for a small canal intended to unite the rivers Forth and Clyde, by a line known as the Loch Lomond passage. He attended Parliament on the part of the subscribers to this scheme, and it appears from some of his letters to Mrs. Watt that he was not much enamoured of the public life of which he thus obtained a glimpse; "close confined "attending this confounded Committee of Parliament," he says, "I think I shall not long to have anything to do with

" the House of Commons again : I never saw so many wrong-
" headed people on all sides gathered together."

It seems that on his journey from London on that occasion he made the acquaintance of Dr. Erasmus Darwin (grandfather of *the* Charles Darwin), who writes to him from Lichfield, in August, 1767 : " Now, my dear new friend, I " first hope you are well and less hypochondriacal, and that " Mrs. Watt and your child are well. The plan of your steam " improvements I have religiously kept secret, but begin myself " to see some difficulties in your execution which did not strike " me when you were here. I have got another and another " new hobby-horse since I saw you. I wish the Lord would " send you to pass a week with me, and Mrs. Watt along with " you—a week, a month, a year. You promised to send me " an instrument to draw landscapes with. If you ever move " your place of residence for any long time from Glasgow, " pray acquaint me.—Adieu. Your friend, E. Darwin." The dear new friend did leave Glasgow seven years later to live in Darwin's neighbourhood, and formed with him " the Lunar " Society," an association of kindred spirits all devoted to the pursuit of natural knowledge and filled with mutual esteem and affection—Erasmus Darwin, Watt, Boulton Dr. Small, Wedgwood, Day (author of the delightful *Sandford and Merton* of our childhood), Dr. Withering, Keir, Galton, Edgeworth, and Dr. Priestley. The Lunar Society dined together every month at two o'clock on the day of full moon, in order to have the benefit of its light in returning to their homes at night ! Our scientific and friendly symposiums, alas ! are shorter in these degenerate days.

In 1769 he made a survey and estimate for a navigable canal from the collieries at Monkland in Lanarkshire to the City of Glasgow, which, as Muirhead tells us, " was carried " out under his own directions and superintendence, to the " great advantage of the public as well as of the parties " to the undertaking." His civil engineering work came to a melancholy close in 1773 while he was engaged in a survey of the Caledonian Canal. In the autumn of that year he was suddenly summoned home by the intelligence of the

dangerous illness of his wife, but arrived too late. She had died after having given birth to a still-born child. They had had four children, of whom two died in infancy, one daughter, who married in Glasgow but died early, and a son, James Watt, of Aston Hall, who long survived his father, and died unmarried in 1848.

The death of his first wife in Glasgow was the turning point in Watt's life. For thirty-eight years, except the one year of trade apprenticeship in London, his home had been in Scotland. During seventeen happy years in the University and City of Glasgow, chequered with much of painfully anxious care, he had laid a secure foundation for future ease and prosperity. He had emerged from the feeble and unstable health of his early life. He had taken in 1769 his first patent for engines realising steam-power, for which a twenty-five years' extension from 1775 was afterwards granted by Act of Parliament. He had entered into partnership with Mr. Boulton. He had in April, 1773, removed to Soho, Birmingham, his first practical steam-engine from Kinneil, a highland glen near Carron with sufficient water supply for condensation, where, after primary trials, it had been lying useless for some years perishing from long exposure to the weather. In terms of his partnership with Boulton he was to make his home in the neighbourhood of Soho, but this was not done before the death of his wife. A few months later he left Scotland, and thenceforward to the end of his life his home was in England.

I wish we had an hour to devote in imagination to James Watt in England for the remaining forty-five years of a beautiful and hard-working and useful and happy life. All I can say just now is—read of it in Muirhead, and in Arago's Éloge of Watt.

Greenock and the University and City of Glasgow never lost James Watt though he ceased to live among them in 1774. The University conferred the honorary degree of LL.D. upon him in 1806. In 1808 he founded the Watt prize in Glasgow College by a letter to Dr. Wm. Taylor, the

Principal of the University, in which he said: "Entertaining "a due sense of the many favours conferred upon me by the "University of Glasgow, I wish to leave them some memorial "of my gratitude, and, at the same time, to excite a spirit of "inquiry and exertion among the students of Natural Philo- "sophy and Chemistry attending the College, which appears "to me the more useful, as the very existence of Britain, as a "nation, seems to me in great measure to depend upon her "exertions in science and in the arts." In 1816 he made a donation to the town of Greenock for the purchase of scientific books, stating as his intention "to form the "beginning of a scientific library for the instruction of the "youth of Greenock, in the hope of prompting others to add "to it, and of rendering his townsmen as eminent for their "knowledge as they are for their spirit of enterprise."

Watt became

Fellow of the Royal Society of Edinburgh in	1784.
Fellow of the Royal Society of London in -	1785.
Member of the "Société Batave" in - -	1787.
Correspondent of the French Academy of Sciences in - - - - -	1808.
One of the eight "Associés Étrangers" of the French Academy of Sciences in - -	1814.

I do not know if any University in the world ever had a tradesman's workshop and saleshop within its walls even for the making and selling of mathematical instruments prior to 1757. But whether the University of Glasgow is or is not unique in its beneficent infraction of usage in this respect, I believe it is certainly unique in being the first British University, perhaps the first University in the world, to have an engineering school and professorship of engineering (commenced under Prof. Lewis Gordon about 1843).

Glasgow was, I believe, certainly the first University to have a chemical teaching laboratory for students, started by its first professor of chemistry, Thomas Thomson, some time between 1818 and 1830. Glasgow was, I believe, also certainly the first University to have a physical laboratory for the exercise and instruction of students in experimental

work, which grew up with very imperfect appliances between 1846 and 1856. Pioneer though it was in those three departments, it has been outstripped within the last ten or fifteen years by other Universities and Colleges in the elaborate buildings and instruments now needed to work them effectively for the increase of knowledge by experimental research and the practical instruction of students. But there is no lagging to-day in the resolution to improve to the utmost in affairs of practical importance; and we almost see attainment of the further aspiration to excel over all others in the James Watt Engineering Laboratory of the University of Glasgow, to be ready for work before the expected meeting of the Engineering Congress next September.

And now, through the magnificently generous kindness of Mr. Andrew Carnegie to the people among whom he has made for himself a summer home in the land of his birth, all the four Scottish Universities can look forward to a largely increased power of benefiting the world by scientific research, and by extending their teaching to young people chosen from every class of society as likely to be made better, and happier, and more useful to our country by University Education.

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