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GEORGE SARTON CHAIR

of the

HISTORY OF SCIENCES

1994-1995

SARTON CHAIR LECTURES

INTRODUCTION

Michel Thiery

Today we install the ninth Laureate of the Sarton Memorial Chair of the History of Sciences, and this ceremony offers me the opportunity to recall the roots of the Chair and the man whose name it bears.

George Sarton, who was born in Ghent, spent the greater part of his life in the U.S.A. and was to gain international recognition as the spiritual father of a new discipline : History of Science. It had to be Science in the singular because his grand scheme was to correlate and integrate the origin and evolution of the sciences into those of yet other products of man's intellectual endeavours. In other words, what Sarton has done was to interweave the history of the sciences with that of the arts, of litterature, of religion, etc. To canvass History in such a broad perspective was no doubt innovative in the pre-World War I period.

The name given to the new discipline — Neo-Humanism — Sarton derived from the word "human" to acknowledge its main purpose : to investigate and assess how in the course of his long evolution Homo sapiens did apply his dearest possession — his intelligence and intellect — to positively change his environment, to create a "better" (Sarton was the optimist par excellence) world. History *of* Science is more than history *and* science; it is pure cultural history.

Those of you who are familiar with Sarton's work may question the validity of this proposition by observing that the father of Neo-Humanism himself violated the premises in his opus princeps, the several-volume "Introduction to the History of Science". Indeed, in this gigantic treatise the author analyzed the various sciences separately, be it in a chronologic order. However, for clearness' sake and paedagogic reasons he felt bound to do this. But in all his other works our masterintegrator did faithfully stick to his philosophy of scientific historiography.

Was Sarton a historian or was he a scientist ? This question has been asked over and over again, be it solely by professional historians. My elliptic answer to this question is that Sarton was a true scientist equipped with sufficient knowledge of history to avoid missteps in this discipline. Thanks to his rigorous scientific training he was in command of a summa of knowledge and experience which many a professional historian could envy.

Those who have approached Sarton — and I consider it a rare privilege to have had that chance — were impressed by the complexity of his personality. I have already mentioned his idealism, his Platonicism. But he was an artist as well, as acknowledged by the poems published during his student years, under a penname, as thought fitting. This litterary gift he transmitted to his daughter : Miss May Sarton is the internationally acclaimed poet and novellist who has published more than fifty books. Sarton was a dreamer, but at the same time a realist and a rigorist. Having started his studies at the Ghent Faculty of Philosophy and Philology, he shortly after resolutely (such was his character) switched to the Faculty of Sciences, because the lengthy and muddy discourses of the philosophers did not satisfy his mind. In 1911 he obtained the diploma of Doctor in Mathematics and Physics. The subject of his doctoral thesis was "The Principles of Newtonian Mechanics".

That very year was to become *the* turning point of his life : the scientist decided to devote his further life entirely to the study of the history of physics and mathematics. Shortly thereafter, however, the short subject list was enlarged to include the other sciences as well.

A gigantic task indeed for a young man in command of an exceptional intelligence and an unlimited stock of energy but without a fixed income. Sarton, who was an orphan and in the meanwhile had married the English graphic artist Mabel Elwes, decided to sell the patrician family home and auction his deceased father's sumptuous wine-cellar. With the money he retired to a modest country house at Wondelgem, a village at about 15 kilometer from his native Ghent. The next year was a unique one. It produced a twin birth : that of his daughter and of *Isis*, the first international journal devoted to the history of science. *Isis* is still published and has remained one of the leaders in the specialty.

His Wondelgem years were of short duration. Soon after the occupation of Belgium by the Germans Sarton quit his country. Via The Netherlands and England he reached the U.S.A.. For keeps. There he immediately started the search for the elusive post which had to be remunerated to keep the family alive and should also give him the freedom and leasure to pursue his work. Harvard University threw him the life-buoy by offering a scholarship. The strings were tiny his sole obligation consisting in a weekly lecture to the students on a topic of science history of his choice. Three years later — in 1919 — he was appointed Research Associate at the Carnegie Institution and offered in the prestigious Library of Harvard — the Widener Library — the spacious study where most of his articles and books were written. Widener was to remain Sarton's business address until his death. Quid pro quo : yearly implement and deliver a cycle of lectures on the History of Science, the field which in the meanwhile had become associated with his name. Finally, in 1936, Sarton was promoted Master and, shortly thereafter, made a Full Professor in the History of Science.

The demise of his sweet and faithful spouse — his aegis — in 1950 was a tragic ordeal which the helpless scholar would never overcome. He nevertheless went on with his life's task, but the old fire was extinguished. Professor emeritus Sarton died suddenly on March 22, 1956 of a heart attack. Quietly resignated he had anticipated the end as an entry in his diary, written a few days before his departure, attests : "To die suddenly is like taking the wrong bus, and that bus flies out of the road to the stars". The "stars" which had been the subject matter of his first scientific book. And to quote Proust : "Et mort, il continue à nous éclairer comme ces étoiles éteintes dont la lumière nous arrive encore".

Sarton lived to reap the harvest of his labours. When presented with the prestigious "History of Science Award", the guest speaker summed up his contribution in one sentence : "Dr. Sarton has established to a greater extent than anyone else, our present foundation of the knowledge and understanding of the history of science".

His native country did not wish to fall behind. Already in 1951 Sarton had been made a Honorary Member of the Royal Flemish Academy. The centenary of his birth was commemorated in 1984 with an international symposium and an exhibition of memorabilia. To continue the memory of its glorious pupil the University of Ghent created the interfacultary G. Sarton Memorial Chair of the History of Sciences. This time the plural had to be applied to enable the various faculties to participate in the initiative. An ad hoc Committee was appointed to yearly choose the Chairholder and a number of distinguished candidates to be honored with the Sarton Memorial Medal for distinguished services rendered to the study of the history of sciences. The lectures delivered by both the Laureate and the Medallists are printed annually in the series "Sartoniana".

The first scientist appointed to the Chair, in 1986, was Robert K. Merton, Emeritus Professor of Columbia State University, New York, father of "Sociology of Science" and a former pupil of George Sarton.

The Chairholder for this academic year is Professor Gerard L'Estrange Turner. His candidature was proposed by the Faculty of Applied Sciences and it is his collega proximus Prof. Willem Wieme who will pronounce the laudatio of the Laureate. As I do not wish to give the show away my presentation of Prof. Turner will be schematic. Turner is a physicist by profession who, besides other missions and functions, teaches "History of Scientific Instruments" at the Imperial College of the University of London and currently acts as Curator of the "Museum of the History of Science" of the University of Oxford. He is *the* authority of what I would like to call "The Golden Century of England", a fascinating period, i.a. on account of the intensive intellectual and cultural exchanges that took place between Turner's country and "our" United

Provinces. Although succinct, these data suffice to indicate that the Chairholder's contribution is in line with the Sartonian tradition and it is on account of his outstanding contribution to the history of physics and of physical instruments in particular that Prof. Turner was granted the Sarton Memorial Chair for the academic year 1994-1995.

LAUDATIO GERARD L'ESTRANGE TURNER

W. Wieme

Today we honor Prof. dr. Gerard L'Estrange Turner as the Laureate of the 1994-95 Sarton Memorial Chair. As our Chairman Professor Thiery just explained this Chair was created at our university to acknowledge important individual contributions to the history of sciences. I will endeavor to summarize the contributions of Professor Turner to this field.

Gerard Turner was born in 1926 and studied at the University of London where he obtained in 1949 a B.Sc. in physics and subsequently in 1959 a M.Sc. in crystallography. He started his professional career as a research physicist at the General Electric Research Laboratory. He went on to teach crystallography at Battersea College, then worked as a researcher at Philco Corporation in Philadelphia, USA. However, I suspect he always had a secret love affair with old instruments. Indeed, when in 1963 he was invited by the Curator of the Museum for the History of Science in Oxford to join their staff he did not hesitate. This unexpected twist became not only the start of a second career but a lifetime passion. His special attention went to the unrivaled collection of microscopes hidden behind the walls of this Museum. Only a few weeks ago some of our engineering students had the opportunity of glimpsing at that collection, being given a private tour by Professor Turner. They can certainly testify as to the importance of it.

The research carried out on the collection of optical instruments owned by the Museum established Gerard Turner as an authority in this field. For this research he was awarded a D.Sc. from the University of London.

Professor Turner has been studying historic instrument collections all over the world. He is especially appreciated by our Dutch neighbors and he visits them frequently. It may be worth mentioning that his first book was a catalogue of the late eighteenth-century Van Marum collection owned by the Teyler Museum in Haarlem. It may also be worth mentioning that several of his publications have been translated into Dutch, as for example : "Antieke Wetenschappelijke Instrumenten" and "Historische Microscopen" (Moussault's Uitgeverij, Bussum, 1981).

In 1988, having spent 25 years with the Museum in Oxford, Turner was appointed Visiting Professor in the History of Scientific Instruments at Imperial College, London. This appointment allowed him to devote still more of his time to research on historic instruments and to increase his already impressive list of publications which at the last count included 10 books and more than 100 papers. Recently, his special interest turned towards the sixteenth century, e.g. to instruments made during the reign of Elizabeth I and to Renaissance astrolabes. Today he will share with us some of his findings from that Elizabethian period, and tomorrow he will give a lecture about Mercator's astrolabes. Mercator died on December 2, 1594, to the day almost exactly 400 years ago. As you know 1994 has been proclaimed "Mercator Year" in commemoration of his 400th birth anniversary, and the interest of the general public in this important scientist has been revived. Although Mercator's parents were German, he was born and educated in Flanders and he learned the craft of scientific instrument making in Flanders. He was famous as an instrument maker even before he started making the maps and globes which would establish his name. It was thought that all of Mercator's instruments had been lost. I am particularly proud to remind you that it was Professor Turner who identified a number of the astrolabes which belong to the Istituto e Museo di Storia della Scienza in Florence as having been manufactured in Mercator's workshop. We all look forward to hear more about this in tomorrow's lecture.

Having given a short overview of Gerard Turner's career, I shall make no further attempt at summing up his many professional achievements. Let me just add that he has been the first Chairman of the Scientific Instrument Society, President of the Royal Microscopical Society and the British Society for the History of Science, and that last year he was awarded by the trustees of the National Maritime Museum at Greenwich the prestigeous Caird Medal.

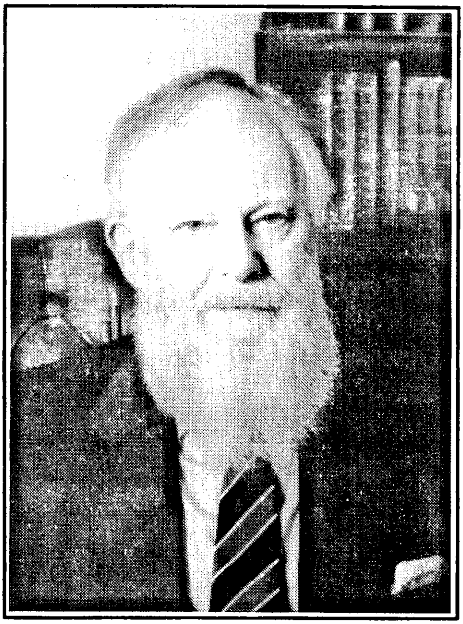
It takes many qualities to achieve recognition as an instrument historian : connoisseurship, technical insight, historical feeling, familiarity with instrument populations both in museums and in private hands are all necessary but do not by themselves result in great achievements. For this one needs unlimited passion. I think Gerard Turner's passion for scientific instruments has indeed brought him the worldwide recognition he deserves. When I recently telephoned him early on an Sunday morning and excused myself for disturbing him at such a moment he simply said "you don't disturb me at all, I'm always working on old instruments, it's my life".

This life is his, but he happily shares it with his charming wife Helen. She not only supports him, but actively encourages and assists him with his research.

Ladies and Gentlemen,

I think it is abundantly clear that Gerard Turner has indeed devoted a life's work to the history of scientific instruments. It was the proposal of the Faculty of Engineering of our university to acknowledge this with a Sarton Memorial Chair. Although in a faculty of engineering little time — too little time perhaps — can be devoted to the study of historic roots, instruments have undoubtedly always been central to scientific practice and consequently to engineering and engineering applications. I think you will agree that Professor Turner's research fits perfectly within the interests of the engineering community. On the other hand, Gerard Turner's passion and vision are in line with the vision of George Sarton as to the importance of the history of Science. Turner's investigations have been wide-ranging and his influence on other contemporary scholars in the field of the history of scientific instruments is unequaled. For all these reasons, the Sarton Committee has unanimously decided to award the Sarton Memorial Chair 1994-95 to Professor Gerard l'Estrange Turner.

It is with the greatest pleasure that I now invite my dear colleague to give his lecture about "The Instrument Makers of Elizabethan England".



THE INSTRUMENT MAKERS OF ELIZABETHAN ENGLAND

G.L'E. Turner

The need to measure land developed as soon as communities became settled. The Flemish "landmeeter" — a word that still means surveyor — was in existence as early as the twelfth century, for in 1190 this description was added to the name of a practitioner : Bernoldo Landmetra. In 1282, Johannes Landmetere is referred to as Geometricus and Agrimensor. During the first half of the sixteenth century the scene was being set for the development of surveying into a profession, requiring increasing skill and accuracy, and also the use of instruments devised to make angular measurements. Surveying was to become a science alongside, and to a certain extent as a result of, the development of deep-sea navigation and the growing military skills of fortification and siege associated with the use of artillery. The accurate determination of position, both at sea and on land, became of increasing economic importance as ships left the security of coastal waters, and as new tracts of unexplored territory were discovered. One of the major activities of a surveyor is levelling. Water running from high ground to sea level causes problems in flat coastal area as in the Low Countries and the English Fens. It was the surveyor's task to devise waterways, dikes, and locks to rescue land for agriculture and hence economic gain.

The disintegration of the medieval pattern of land tenure led to the establishment of a much higher proportion of individual ownership, and so to the need for more accurate definitions of boundaries. As a result of these needs the art of map-making grew rapidly in importance at a time when the necessary skills of engraving and printing were available, and most notably in the Low Countries. The engraver of copper-plate illustrations could also divide the circle on brass instruments for the use of the surveyor and the seaman. Another important requirement, both for instrument makers and for those who practised surveying and navigation, was mathematical knowledge. As with printing and engraving, mathematics, in particular in the practical applications, was developed on the Continent of Europe by such notable scholars as Martin Waldseemüller (1470-*c*.1518) in Lorraine, and Gemma Frisius (1508-1555) at Louvain. During the mid-sixteenth century, John Dee (1527-1608), a founder Fellow of Trinity College, Cambridge, spent three years studying in Paris, Brussels, and Louvain, and on his return home he pioneered the provision of textbooks and translations of Continental practice in English. At much the same time, in 1543, the highly influential work by Robert Recorde, *The Ground of Artes Teaching the Worke and practise of Arithmetike* was published, which, running through twenty-eight editions in the next 150 years, introduced pen reckoning and the use of arabic numerals to a wide public. Before the new, angular measuring techniques could be satisfactorily imported from the Continent, a prior requirement was a knowledge of arithmetic : arabic had to replace roman numerals. In the Exchequer Records arabic numerals were first used at the end of the sixteenth century, but roman did not disappear for another 60 years. Accounts were done by using ruled boards or cloths, and casting-counters : hence the phrase — to cast one's accounts. Recorde may be regarded as the founder of English mathematics, since his text-books opened the way for self-education for the new class of technicians. He was also the founder of the English school of mathematical practitioners, among whom were later numbered many of the great London instrument makers.

The English mechanician, Cyprian Lucar (fl.1564-1590), who was educated at Winchester College and New College, Oxford, published at London in 1590 his *Treatise named Lucar Solace*, where he illustrated the instruments in common use during the late sixteenth century. His selection is soon confirmed by John Norden in *The Surveyors Dialogue* of 1607. The illustration in Lucar's book shows a plane table with frame to hold the paper and an alidade or ruler, a chain, a square, and a pair of compasses. Rods and cords for direct measurement were in use throughout the century, but the chain, an obvious — though expensive — improvement on the cord because it was not subject to variation in length, was first referred to by Conrad von Ulm in a book he published at Strasbourg in 1579. The length of the chain was related to various local measures, and the Gresham Professor, Edmund Gunter proposed a decimal chain of 100 links in 1620. Also used for direct measurement of length, though not shown by Lucar, was the waywiser. A dial recorded the revolution of the wheels of a carriage, and soon a hand-propelled measuring wheel, also called a waywiser or a perambulator, came into use in the seventeenth century, and continues to be used today.

The plane table was the most ubiquitous of sixteenth-century surveying instruments, being practical and easy to use in the field. It is a board with paper held down on it, and an alidade or ruler with sights at each end. By aligning the sights with topographical features and marking the line of view by pencil along the side of the alidade, the plan is simply made. The plane table was, however, despised by those with mathematical knowledge. Thomas Digges, in the 1591 edition of his father's book, *Pantometra,* described it as "an Instrument onely for the ignorante and unlearned, that haue no knowledge of Noumbers". Throughout the sixteenth century mathematicians were working on versions of an instrument for surveying that eventually became the theodolite. The first man to design what was recognizably an altazimuth theodolite was Martin Waldseemüller, who produced in Lorraine not only world maps, but also detailed maps of his own area of the upper Rhine. In the 1512 edition of the *Margarita Philosophica* of Gregor Reisch, which is a philosophical and scientific compendium, was included a section on architecture and perspective by Waldseemüller that depicted an instrument called the 'Polimetrum', which contained the two essential devices for the simultaneous measurement of horizontal and vertical angles.

Leonard Digges (d.1571) of University College, Oxford, and his son, Thomas (d.1595) of Queens' College, Cambridge, were the authors of two influential texts on mathematical surveying, published in the second half of the sixteenth century. In the first of these, entitled *Tectonicon,* and published at London in 1556, Leonard described those for whom the book was intended as 'Surveyors, Landmeaters, Ioyners, Carpenters and Masons'. As well as providing tables to help those who used measuring cords, he recommends three instruments : the carpenter's ruler, the carpenter's square, and a version of the cross-staff. It was, however, in his posthumously published *A Geometrical Practice Named Pantometria* (1571), completed by his son, that Digges introduced instruments for the specialist surveyor. He described three instruments that could be combined to form what he called a 'topographicall instrument'. These were a vertical quadrant with shadow square that was intended to measure heights; a square with inscribed quadrant and alidade, mounted on a staff; and a circular plate divided into degrees with a centrally mounted alidade, to which Digges gave the name 'theodelitus'. The combination was, in effect, an altazimuth theodolite, while the 'theodolitus' by itself was the simple theodolite. An astrolabe could be used for measuring horizontal or vertical angles, and one can see that the theodolite, which combines together the means to make both measurements, can be said to derive from the astrolabe. And sixteenth-century astrolabes often incorporate a magnetic compass. Aaron Rathborne, in his book called *The Surveyor*, published in 1616, lists the following instruments : the plane table; the altazimuth theodolite; the circumferentor; the simple theodolite; and a chain. This list reflects the gradual acceptance during the course of the sixteenth century of versions of the more elaborate mathematical instruments that had at first been regarded as too complex by the working surveyor.

Much the same pattern of development is apparent with instrumentation for navigation at sea. While in coastal waters, the seaman relied on experience, a lead line, and a magnetic compass. Crossing the Atlantic was a completely different matter, for experience was very hardly gained, and instruments were an essential requirement when out of sight of land, birds, and other tell-tale features. He still needed the lead, log-line, and magnetic compass, but also a quadrant, a forestaff, a sand-glass, charts, and a good knowledge of the star map. Two books on navigational techniques from the end of the Elizabethan period deserve special mention. One is William Barlow's *The Navigators Supply* of 1597. Barlow (fl. 1564-1625) was a graduate of Balliol College, Oxford, churchman at Winchester and then chaplain to Prince Henry, son of James I. Although Barlow abhorred the sea, by knowing his mathematics, and talking with seamen, he learnt of what was needed and proceeded to invent instruments. He improved the magnetic compass, and invented or improved the variation compass, *Traveller's Jewel,* pantometer, the nautical hemisphere, and the traverse board. There was an advertisement on his title page, just above the engraving of the *Traveller's Jewel* which ran :

> If any man desire more ample instruction concerning the vse of these instruments, hee may repayre vnto Iohn Goodwin dwellinge in Bucklersburye teacher of the grownds of these artes. The instruments are made by Charles Whitwell, over agaynste Essex howse, maker of all sortes of mathematicall instruments, and the graver of these portraytures [that is to say, the engravings in the book].

David Waters, in his masterly history of navigation, has written of Edward Wright : "his book set the seal on the supremacy of the English in the theory and practice of the art of navigation at the end of the sixteenth century". Like Barlow, a Cambridge mathematician, Wright (1558-1615) was brought into the Queen's service as a result of the Armada, and travelled on naval ships to gain practical experience. The result was *Certaine Errors in Navigation, arising either of the ordinarie erroneous making or using of the sea Chart, Compasses, Crosse staffe, and Table of declination of the Sunne, and fixed Starres detected and corrected,* published in 1599. Here Wright provided a most thorough mathematical treatment of errors in measurements and in the practices of seamen.

Printers and copper-plate engravers were craftsmen from the Continent who were to influence English practice. Robert Recorde's *The Ground of Artes* was printed by Reynor Wolfe, who left his native Drenthe in the north of the Netherlands to settle in London in 1533. Even fifty years later it was difficult to find an English printer who could set up a mathematical work correctly. Throughout the sixteenth century the English were indebted to the Continent, and especially to Flanders, for the skills of printing, of engraving book illustrations, maps, and instruments, and for surveying techniques. All these activities are melded together in the work of Christopher Saxton (d.1596), who was obliged to farm out his engraving needs to several men to hasten the production of engraved maps. His *An Atlas of England and Wales*, published at London in 1579, contains 34 maps, 23 of them bearing the engraver's name. There are seven different signatures, four of them by Flemings, and three by Englishman. The English are : Augustine Ryther (4 maps), Francis Scatter (2), and Nicholas Reynolds (1). Ryther was to become a leading instrument maker. The migration of skilled men increased during mid-century when the grip of Spanish religious persecution was tightening on the Netherlands, finally to result in the Revolt which broke out in 1564.

The main materials used for making mathematical instruments were brass and wood, usually boxwood. Prior to the sixteenth century, brass that was needed for such uses as candlesticks, or memorials in churches, had been imported from the Continent, and was expensive. Now with the military threat from Catholic Europe and growing demand for brass and bronze, the Royal Charters for the Company of Mineral and Battery Works and the Company of Mines Royal for the production of brass and brass plate amongst other things, were granted in May 1568, thus allowing English manufacture for the first time. Humfrey Cole, of whom more will be said later, was closely involved in the setting up of the Mineral and Battery Works, which necessitated bringing in German craftsmen to train Englishmen in metal-working skills, and in prospecting for ores. Cole was engraver of dies for the Royal Mint, as well as the leading instrument-maker of the period.

Type of Instruments Made

Compendia & pocket dials	25
Surveying instruments	18
Horizontal dials	12
Drawing instruments	10
Astrolabes	9

Navigation instruments	7
Quadrants	7
Gunnery instruments	4
Nocturnals	4
Armillary spheres	2

The great influence on instrument design, map, chart and globe making came from Gemma Frisius and Gerard Mercator, and it was from this Louvain area that came the man who can be regarded as the first to establish the scientific instrument-making trade in England. Thomas Gemini (*c.*1510-1562) came from a village near Liège, and it is probable that he served his apprenticeship alongside Mercator. He moved to England, and at Blackfriars in London, he carried on the business of map-engraver and mathematical instrument-maker. He made his reputation with his plates for his own printing of the *Anatomy* of Vesalius, issued in 1545. This earned him an annuity of £10 from King Henry VIII. An astrolabe by him is in the Musées Royaux d'Art et d'Histoire, Brussels, bearing the arms of the Duke of Northumberland and of King Edward VI. It is dated 1552. In 1555, Gemini printed the *Prognostications* of Leonard Digges, and in the following year, Digges' *A Boke Named Tectonicon.* It was said there that the instruments could be obtained from Gemini. Another astrolabe was made for Queen Elizabeth I. This is dated 1559, is engraved with the queen's name and the royal arms, and is in the Museum of the History of Science, Oxford.

There is no doubt that Humfrey Cole (*c.*1530-1591) was London's foremost mathematical instrument maker of the sixteenth century. Cole was from the North of England, and was employed at the Royal Mint. He undertook to supply all the instruments described in the 1571 edition of Digges' *Pantometria.* Cole's masterpiece must surely be the large, two-foot diameter astrolabe, dated 1575, in the possession of the University of St Andrews, Scotland. This has several resemblances to the Gemini astrolabe made for Elizabeth I, both instruments having on the back a horizontal projection of the sphere derived from the planisphere of Gemma Frisius. Cole's production is both varied and extensive, judging by the twenty-six known instruments, and two engravings. It is clear, also, that he had an influence on subsequent makers, as would be expected. This is shown by comparing Cole's two theodolites with those by Ryther and James Kynvyn. One must also compare the pocket dials by Cole, Ryther, Kynvyn, Whitwell, and Elias Allen. Although Cole was free of the Goldsmiths' Company and not the Grocers' Company, Cole may be said to be the originator of that line of craftsmen. Kynvyn was a younger contemporary of Cole, and is mentioned with him by at least one customer. The Cambridge scholar, Gabriel Harvey (*c.*1550-1630), in a note on his copy of Blagrave's *The Mathematical Jewel,* wrote : "James Kynvyn of London, near Powles [St Paul's]. A fine workman & mie kinde frend : first commended vnto me bie M.Digges & M.Blagrave himself... He & old Humfrie Cole, mie mathematical mechanicians."

Instruments by Humfrey Cole

1568	HVMFRAY COOLE	compendium
1569*	Humfray Coolle	gunner's compasses
1569	Humfray Colle	compendium
1570*	*not signed*	6-in jointed rule
1571*	H. Cole	nocturnal
1574	Humfrey Cole	sundial, quadrant
1574	Humfray Colle	sundial, quadrant
1574	Humfrey Côle	12-in surveyor's rule
1574	Humfrey Côle	12-in surveyor's rule
1574	Humfrey Cole	astrolabe
1574	H. Cole	theodolite
1575	H. Cole	gunner's compasses
1575	Humfrey Côle	12-in surveyor's rule
1575	Humfrey Côle	12-in surveyor's rule
1575	H. Cole	sundial, poke
1575	Humfrey Cole	compendium
1575	Humfrey Cole	compendium
1575	Humfridus Côle	astrolabe
1579	H. Cole	sundial, horizontal
1579	Humfrey Côle	compendium

1579	Humfrey Côle	compendium
1582	H. Côle	plane-table alidade
1582	Humfrae Colle	sundial, horizontal
1582	Humphrey Cole	armillary
1586	H. Cole	theodolite
1590	Humfrey Cole	compendium

* = not dated. Note the variations in the way Cole spelled his name.

A key factor in the establishment of the instrument-making trade was the way in which it could become grafted on to the existing guild structure. The City of London Guilds were medieval and, by the 16th century, what are known as the Twelve Great Livery Companies had emerged as leaders. To learn a craft and to practise it meant that an apprenticeship had to be served, and the arrangement properly recorded and approved by a City Company. Practising a new craft, mathematical instrument makers had to find a company as best they might; one method was to join a father's company, whichever it might be, under the patrimony arrangement. New companies were formed, of course : the Spectacle-Makers in 1629, the Clockmakers in 1631. But the mathematical instrument-makers were captured to a great and surprising extent by one of the Twelve Great Livery Companies, the Grocers. Once a master-apprentice succession was established, the instrument makers remained in the Company, and so a school was built up. This has been fully explored by Joyce Brown in her book on *Mathematical Instrument Makers in the Grocers' Company* (1979).

By a most fortunate chance, a uniquely important group of twenty scientific instruments by the first London makers has been preserved in the Museo di Storia della Scienza in Florence. These were taken to Italy in 1606 by Sir Robert Dudley (1574-1649), the son of Queen Elizabeth's favourite, the Earl of Leicester. As a young man, he was sponsored at court by his father, and studied navigation with Abraham Kendall, who was pilot to Dudley's expedition of 1594-5 to the West Indies. The following year, he joined the Anglo-Dutch fleet, known as the Counter-Armada, that sacked the port of Cadiz, in which engagement he was knighted. After the death of Elizabeth, Dudley was involved in a lawsuit to prove himself the legitimate heir of Leicester. When this failed, he left England for good, and settled in Florence, at the court of the Medici. Already leaders in commerce, this powerful family were anxious to join the race to the New World, and were building up a fleet at the port of Leghorn (Livorno). The skills brought by Robert Dudley were therefore most welcome, and he earned high favour at the Medici court. His gifts as navigator and ship designer were embodied in his great, three-volume work, *Dell'Arcano del Mare*, published in 1646. This contains engravings and descriptions of a range of complex navigational instruments, as well as the first Atlas on the Mercator projection.

The Dudley instruments in Florence were made by Cole and Kynvyn, whose work has already been referred to, Augustus Ryther, and Charles Whitwell. Ryther was an engraver of distinction, and signed some of his maps "Augustinus Ryther Anglus" to distinguish himself from the Flemish engravers. His earliest signed work are the maps dated 1576, engraved for Christopher Saxton. A pack of playing cards is also attributed to him. In 1582, Ryther took as his apprentice for nine years Charles Whitwell (d.1611), who obtained his freedom of the Grocers' Company in 1590. Hood advertised on the title page of his book on the *Sector* that "the instrument is made by Charles Whitwell, dwelling without Temple Barre against St Clements Church". Whitwell engraved the illustrations for Hood's book, and did the same service for other authors. There are eight men among his known apprentices, the most famous being the incomparable Elias Allen (d.1655), who became free of the Grocers' Company in 1612 after serving for nine years. With Allen, the London trade in scientific instruments was well and truly established.

By 1600, the number of men trained as engravers had increased, and workshops had grown in number and size. Instruments became more complex and varied, with competition in producing new designs to catch attention and to compete with a rival. Earlier, craftsmen had worked in collaboration with the scholar-inventor; now they were to become capable of independent invention. Instruments for astronomy, time-telling, navigation, and surveying were created for economic reasons. There was, too, a market among wealthy men interested in scientific matters, and elaborately embellished instruments were provided for their delectation. But this group is more obviously catered for by the products of the leading Continental makers rather than the English, whose instruments are austerely functional.

Elizabethan Scientific Instrument Makers

Name	Dates working	Instruments known
Thomas Gemini	1540-62	7
V.C.	1554-57	2
Humfrey Cole	1568-91	26
Barthelmewe Newsum	1568-93	2
James Kynvyn	1570-1610	10
Augustine Ryther	1576-95	2
Charles Whitwell	1590-1611	29
Thomas Osbom	1590	1
T.H.	1596	1
Robert Beckit	1597	1
John Goodwin	1595-1610	3
William Senior	1600	1
R.G.	1600	2
T.W.	1602	1
Isaac Simmes	1610	3
Anonymous	16th C	9
	Total	*100*

Acknowledgements

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I am indebted especially to Professor Paolo Galluzzi, Director of the Istituto e Museo di Storia della Scienza, Florence, and his staff, for the opportunity to study the instruments taken to Florence by Sir Robert Dudley. I am also grateful to the directors and staff of several other museums for help in tracing and examining instruments of the Elizabethan period.

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THE DISCOVERY OF GERARD MERCATOR'S ASTROLABES

G.L'E. Turner

Introduction

Gerard Mercator was born on 5 March 1512 at Rupelmonde in Flanders, and died on 2 December 1594 at Duisburg in Germany. Therefore 1994 is being marked as the 400th anniversary of his death. From 1530, when he entered the University of Louvain, he studied philosophy and theology; however, on graduating he turned to astronomy and mathematics working under the guidance of Gemma Frisius. He determined to transform cartography, which was vital for the exploration of the world that followed the discoveries of Christopher Columbus. Mercator became a highly skilled engraver, cut copperplates of his italic scripts, engraved the gores for his first globe in 1536, and in 1537 published his first map. His revolutionary contribution to cartography, one of the great inventions of all time, was his world map of 1569 drawn using the cylindrical projection he devised. It is this map, meant for ships' navigators, that continues to be familiar to many people today. Mercator is famed, secondly, for the great collection of maps he designed, engraved, and published during the later part of his life. The entire collection was published by his son Rumold in the year after Gerard Mercator's death as the "Atlas : or Cosmographical Meditations on the Structure of the World". This was the first time that a collection of maps had been given the name Atlas.

No instruments made by Gerard Mercator were known to have survived until the present writer identified an astrolabe, early in 1992, in the Istituto e Museo di Storia della Scienza, Florence; it is unusual because it has a double-sided map plate.[1] This has a North polar projection on one side reaching to the Tropic of Capricorn, while the other side is a South polar projection to the Tropic of Capricorn only. The engraving characteristics found on this plate are markedly similar to some products of the Mercator workshop. Not only that, but a critical examination of the rest of the instrument showed that, apart from one latitude plate, the remainder is most likely to be in the hand of Gerard Mercator himself. The odd latitude plate, made for the latitude of Florence, is from the workshop of Giovan Battista Giusti. It can be shown that Giusti made the astrolabes commonly associated with Egnazio Danti (1536-1586), cosmographer to Duke Cosimo II of Florence.[2] Danti published his *Trattato dell'uso et della fabbrica dell'Astrolabio* at Florence in 1569, the same year that Cosimo (1519-1574) was created Grand Duke of Tuscany on 27 August by the Pope in Rome. It is likely, therefore, that the Florence Mercator astrolabe was bought for the occasion.

While the Florence instrument was being studied, two more astrolabes were identified as closely similar.[3] On the evidence supplied by examination of all three astrolabes, and by comparison with astrolabes and maps of contemporary craftsmen, only the Mercator workshop could have produced these instruments. The astrolabe in Augsburg is of exactly the same size at that in Florence, and the engraved information on the back is identical. The Brno astrolabe is slightly smaller, and it is signed with a monogram. This is located on the bottom edge below the hour symbol 12 on the limb, and reads 'GMR', standing for : Gerardus Mercator Rupelmundanus. Gerard Mercator was born at Rupelmonde, and referred to himself by this style on his productions from 1536.[4]

The astrolabes described

The astrolabes are made of brass, with the Florence example gilded. Associated with this are five original latitude plates, and a further one made in Florence in about 1570. A seventh plate is engraved with projections of the Earth from the North and South Poles. The other two astrolabes each have a single latitude plate. In all three of the astrolabes the mater can accept only one plate at a time.

Limb. The limbs on all three astrolabes are divided in degrees, marked, from the top, 90°-10° in each quadrant (zero degrees are not marked). Inside the degree scale is one for 24 hours, engraved 1-12 twice. The Brno limb has the degree scale inside the hour scale.

Mater. The mater of the Florence astrolabe is engraved with projections for the latitudes of 90° North and 0°. Also engraved are the (un)equal hours for latitude 0° (twenty-four hours) and the astrological houses (numbering twelve). The maters of the other two astrolabes have engraved on them a *quadratum nauticum,* or diagram of the wind directions. On the Augsburg instrument the sides are labelled *Longitudo minor; Longitudo maior; Latitudo meridiana; Latitudo ſeptentrionalis.* Superimposed are 32 radial lines each labelled in Dutch with the wind directions. The Brno mater is similar to Augsburg, but rotated through 180°; the winds are not named except for the cardinal points.

Back. The backs of both the Florence and Augsburg instruments are identical, with a shadow square in the lower semicircle, and in the upper left quadrant a diagram for conversions between equal and unequal hours (also called planetary or temporary hours) based on the times of sunrise and sunset; the right quadrant is blank. On the Brno astrolabe this quadrant is not blank, being filled with a diagram for measuring time in unequal hours based on the Sun's altitude; the left quadrant has its hour conversion diagram like the other two, but it is a mirror image and turned through 90°. In other respects it is the same as the others. Around the edges of all three are divided scales for degrees, the zodiac, and the calendar. The calendar is eccentric with respect to the zodiac.

Plates. The original plates with the Florence instrument are engraved for latitudes every 3° between 36° and 60°, and one has a tablet of horizons. These, and the latitude plates on the other two astrolabes, are each engraved with almucantars at 2° intervals, and azimuths at 5°. The sixth plate is made for the latitude of Florence, 43°, and it is not from the same workshop as the rest of the astrolabe. Because the instrument was to be used in Florence, a plate for 43° was made by a craftsman of the city, Giovan Battista Giusti.[5] The fabrication of this plate, although skilled, is not to the same very high standard as the rest. The maters of all three astrolabes can accommodate but one plate at a time, contrary to the usual practice. This makes for a better fit, and it may explain why the other two instruments have just the one plate with them; any others could have been lost over the centuries. The Brno plate has a projection for the latitude of 49°, unlike the others. This is backed by a projection for 51°, so giving a deliberate 2° difference; the others are at 3° intervals, normal for the climates and their extensions. Augsburg has one plate for 45°/48°, which matches one of the Florence plates. Brno does not match any in the Florence set, and, by inference, Augsburg. The 2° latitude range covers the region from Antwerp (modern value 51° 13') to Paris (48° 50').

A remarkable feature on the Florence plates is the burnishing of the gilding in alternate segments of the unequal hours and on some other parts. Such a decorative conceit has been remarked on only one other astrolabe (also Flemish), and means that the instrument came from a first-class workshop, and that it was probably made for a notable customer.

The Florence astrolabe's maps are engraved on a copper disc, the land mass and decorative elements are gilded, while the seas are left as copper. This has blackened through long contact with the atmosphere. One side is a North polar projection to the Tropic of Capricorn, while the other side is a South polar projection cut off at the Tropic of Capricorn. This side has more space for engravings of monsters and sailing ships. On both sides the outer rim is divided into degrees, marked every five from 5° to 360°. The prime meridian runs through the Azores, a few degrees West of the Canaries, and through the magnetic pole, *Polus Magnetis*, at longitude 180° and latitude c. 74°. The meridians and the parallels are engraved for every 10°. The longitude scale is on the outer rim, marked by punched numbers every five degrees from 5° to 360°. The latitude scale is along the prime meridian and is marked every ten degrees from 10° to 90°. Both sides of the plate show the polar circles, *Circulus Arcticus* and *Circulus Antarcticus*, the equator, *Circulus Aequinoctialis*, and the two tropics, *Tropicus Cancri* and *Tropicus Capricorni*.

Rete. The retes are in the 'tulip' strapwork pattern typical of the Flemish astrolabes of the sixteenth century. The Florence rete has some extra flourishes within the ecliptic circle, otherwise it is the same as Augsburg. Both have pointers for 50 stars; Brno has pointers for 48 stars.[6] The Brno rete is not identical to the other two; it bears a closer resemblance to the retes of Thomas Gemini, a Flemish engraver working in London from about 1540 to 1562.[7]

The retes on both the Florence and Augsburg astrolabes bear the names of the same 42 stars or groups of stars. The Brno instrument has 31 stars in common with those engraved on the Florence and Augsburg instruments with the same names. Of the remaining, 1 is not named, but is in the correct position for *Lanx septemtrionalis* (β Lib); 3 stars are common, but have different names; 1 has the same name, but refers to a different star (ι Cet). Additionally, the Brno rete has 5 stars that are completely lacking on the others. Also two stars are in the wrong position through simple errors in calculation, for example a Declination of -6° instead of +6°, and -7° instead of -17°.

Throne. The thrones on all three astrolabes are the same : they are formed by a bar attached to the limb and supported by two S-shaped brackets with elaborate decoration. The ring at the top swivels above a bracket that moves in a shackle left or right. The boss is foliate on the Florence instrument and plain on the others. The pendant attached to the ring has a grotesque face on either side. The face and brackets are cast from the same mould; the brackets seem to be stylized dolphins, a sea mammal whose form has had a perennial appeal in all manner of decoration. The dolphin is found as a support in architectural features such as the corbel or bracket.

Monogram. On the Brno astrolabe, the monogram 'GMR' has the G engraved in the typical manner of Gerard Mercator. The capital G is formed by cutting the semicircle first, followed by the vertical stroke, which leaves part of the circle protruding to the right below the vertical stroke. If this is an early piece, one of the first astrolabes made by Gerard, then it might well have contained errors that he was not proud of. Since it was usable to one who was aware of its faults, he put his initials on it in order to mark it as not for sale : purely personal to him.

When were the astrolabes made ?

Evidence from the Rete Pattern

As has been pointed out, the rete patterns of the Florence and Augsburg astrolabes are the same. The Brno rete, however, has a closer kinship with two astrolabe retes made by Thomas Gemini of London that are dated 1559.[8] Thomas Gemini (originally Lambert, Lambrit, or Lambrechts), was born in eastern Flanders at Lixhe (Lieze) in about 1510. He died in London in June 1562. He had migrated to Blackfriars, London, in around 1540, and set up as an engraver, printer, and instrument maker. Gemini is known chiefly for his edition of Vesalius' *Fabrica* that he published in London in 1545 with the title *Compendiosa totius anatomie delineatio*. For this he received a pension from King Henry VIII. In 1555, he published maps of Spain and of England, and in the same year published Leonard Digges's *Prognostication of Right Good Effect*. What is important about Thomas Gemini (the name he assumed in his London period) in the present context is the similarity between his style and that of Gerard Mercator. Gemini was a highly skilled engraver, and his calligraphy owes everything to that expounded and taught by Gerard Mercator.

Thomas and Gerard, being much the same age, may have trained together in the workshop of Gaspar van der Heyden, a goldsmith of Louvain, who produced in 1536, with the cooperation of Mercator, a globe for Gemma Frisius. Mercator acquired tools in 1540, and from then on worked at Louvain independently of Van der Heyden and Gemma Frisius. This is also about the time that Thomas Gemini is thought to have left Flanders for London. During the 1540s, Mercator is known to have made mathematical instruments, and the group of instruments made for the Holy Roman Emperor Charles V points to his high reputation and skill. It must be stressed that the style and quality of the work by Thomas Gemini is such that he could have learned it only at Louvain before his London period.

For Mercator, the decade began with his terrestrial globe (1541) and ended with his celestial globe (1551). During this period his calligraphy settled down into the style he kept through the rest of his life, which was spent in Duisburg from 1552. A careful scrutiny of the gores that form these two globes prompts the impression that the engraving on the Brno astrolabe resembles more the globe of 1541 than it does that of 1551.[9]

The Horary Quadrant

The back of the Brno astrolabe has two horary diagrams, the upper left is for conversion between equal and unequal hours, and the upper right (blank on Florence and Augsburg astrolabes) is for finding the time in unequal hours from the Sun's altitude. For equal hours the day/night period is divided into 24 equal hours. Unequal hours are formed by dividing the day and night periods each into 12 hours, which become equal to each other only at the equinoxes. Clocks keep equal hours, but many sundials, from Roman times into the seventeenth century, are constructed to read unequal hours. The diagram of unequal hours and its approximate readings, except at sunrise, noon, and sunset, is fully analyzed mathematically by Dr Archinard.[10] The horary quadrant that appears on the upper right of the Brno astrolabe occurs in the medieval period, and it is inherently inaccurate, getting much worse as the user moves to higher latitudes (e.g., above 30°). Mercator chose to leave a blank space on his masterpiece and its close kin, so the presence of the diagram on the Brno astrolabe points to an earlier period in Mercator's life.

The Astrolabes at Florence and Augsburg

There are several independent pieces of evidence that, taken together, focus a date for two of the astrolabes to quite a narrow span of years. The sheer controlled skill of the engraver's hand, and so many characteristic letter forms, point to Gerard Mercator's second period, which was at Duisburg. The style has settled down by the time of the celestial globe (1551), and found its great expression with the world map of 1569.

The map plate does not appear to be in the hand of Gerard, and a case has been put forward that this was engraved by the second son, Rumold.[11] He was born *c.*1546, and by 1565, at the beginning of his twenties, he would have been mature enough to produce the map plate. This is the period in the run-up to the publication of the world map, when Gerard would have needed additional help because of the volume of work. From the evidence of his own signed map of the world published in 1587, Rumold was highly skilled, and his hand seems to match that of the map plate's engraver.

The role of Egnazio Danti in Florence is almost certainly an important reason for the presence there of a Mercator astrolabe. He was appointed Cosmographer to Duke Cosimo II in 1562, and designed a globe and 29 wall maps between 1564 and 1575 for the *Guardaroba* in the Palazzo Vecchio. In 1569 he published a treatise on the astrolabe. Cosimo de'Medici came to power in 1537. With skill, luck, and force of arms he was created the first Grand Duke of Tuscany on 27 August 1569. He was now 50, and his Cosmographer, whose *Trattato* on the astrolabe had just been published with a dedication to Cosimo showing the six balls of the Medici over a globe of the Earth, was 33 years old. Clearly in great favour, Danti was, in 1571, granted permission to live in the Palazzo Vecchio. Unfortunately for Danti, Cosimo died on 21 April 1574, and was succeeded as Grand Duke by his son Francesco (1541-1587), who disliked Danti and summarily dismissed him on 28 September 1575.

Danti's presence in Florence between 1562 and 1575 introduced the court to cosmography, and one would expect to find here the reason for a copy of Mercator's world map to have been purchased at Antwerp on 1 November 1569 for delivery to Florence. Although the local craftsmen were reasonably competent, they were no match for the renowned cartographic and craft centre : Flanders. At the time of the crowning of the first Grand Duke of Tuscany in 1569, what would be more appropriate than to acquire from the world's finest astrolabe maker an example of his art ? After all, Gerard Mercator had made mathematical instruments for the Holy Roman Emperor himself, and Cosimo was rising in the courtly circles of Europe.

All things considered, the date of *circa* 1570 seems to fit this astrolabe of Gerard Mercator and his Duisburg workshop. The Augsburg astrolabe is the same size and has the same back as the Florence instrument, has the same star names, but differs in having a less elaborate rete and it is not gilded. Another common feature is in the sizes of the alidades and rules, and it is tempting to believe that these parts were made at the same time. The weight of evidence means that a date near 1570 is also reasonable for the Augsburg astrolabe.

The Astrolabe at Brno

It can be argued that the Brno astrolabe was made earlier than the others. In fact, it may have been the first, or one of the first, astrolabes made by Mercator in his Louvain workshop. The calligraphy is slightly different, suggestive of an earlier date. If one examines the style of the engraved letters and numbers on Mercator's globes of 1541 and 1551, one readily sees many small variations in the layout of the letters, and the decorative flourishes, which are more pronounced in the earlier globe and on the Brno astrolabe. The pattern of the Brno rete is closely similar to the retes cut by Thomas Gemini, who left Louvain for London in about 1540; the other two Mercator astrolabes have quite noticeable differences in the pattern. Then there is the choice of stars and star names on the rete, which has a number of layout mistakes in its construction. The unequal hour diagram in a quadrant left blank on the other two instruments is yet another pointer to an earlier date. It is not an accurate device, and if the unequal hour is required, then it is much better to take the reading on the astrolabe of the equal hour and then convert by means of the diagram engraved on the left-hand quadrant that is to be found on all three of Mercator's astrolabes.

The star positions on all three astrolabes can be shown to be according to the new theory of Copernicus published in 1543, and which reached Gemma Frisius in Louvain quite rapidly. This gives a lower limit of about 1545 for the Brno astrolabe.

There is yet another significant piece of evidence to show that the Brno astrolabe was made in Louvain and not in Duisburg, and this is in the size of the instrument. It is customary for globes and instruments to be made with dimensions in convenient units of the local standard measure. For example, globes can be 6, 9, 12, 15, 18, etc inches in diameter; reflecting telescopes have mirrors with a focal length of 1, 1½, 2, 3, 7, etc feet. Mercator's astrolabes are about one foot in diameter, while his most famous globes are 1½-foot in diameter. But which foot ? In the sixteenth century, Mechelen was the most influential city of the Low Countries, and its foot is equivalent to 278mm. Van der Heyden came from this city, and Mercator lived there after his university years at Louvain. Taking the standard of one Mechelen foot at 278mm, and one Rhineland foot at 315mm (as used at Duisburg), the following table can be constructed.

Standards of length used by Mercator		
Van der Heyden, Globe 1536	370mm	16 Mechelen inches
Van der Heyden, Globe 1537	370mm	16 ditto
Mercator, Globe 1541	420mm	18 ditto
Mercator, Globe 1551	420mm	18 ditto
Mercator, Astrolabe, Brno, *c.*1545	278mm	12 ditto
Mercator, Astrolabe, Augsburg, *c.*1570	317mm	12 Rhineland inches
Mercator, Astrolabe, Florence, c.1570	316mm	12 ditto

It is the calligraphy that points to a date during the 1540s for the

Brno astrolabe, and the standards of length strongly support this. If correct, then the Brno astrolabe was made in Mercator's Louvain workshop during the period 1545 to 1550, while the astrolabes now at Florence and Augsburg were made in the Duisburg workshop around 1570.

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Notes

1. This astrolabe is fully described in Gerard L'E. Turner and Elly Dekker, "An Astrolabe attributed to Gerard Mercator, *c.*1570", *Annals of Science*, 50 (1993), pp. 403-443. This paper will be referred to subsequently as Turner and Dekker. Instituto e Museo di Storia della Scienza, Florence, inventory no. 1098. International Checklist [hereafter IC] no. 490. Sharon L. Gibbs, Janice A. Henderson, and Derek de Solla Price, *A Computerized Checklist of Astrolabes* (New Haven, Conn. : Yale University Department of the History of Science, 1973).

2. Turner and Dekker, Section 3.

3. Städtische Kunstsammlungen, Augsburg, Germany, inv. no.3537 (IC 4609). Moravská Galerie, Brno, Czech Republic, inv. no. 24-385 (IC 4608). All the astrolabes are described in G.L'E. Turner, "The Three Astrolabes of Gerard Mercator", *Annals of*

Science, 51 (1994), pp. 329-353.

4. Gerard Kremer had Latinized his name to Mercator by the time he enrolled at the university of Louvain on 29 August 1530. See R.W. Karrow, Jr, *Mapmakers of the Sixteenth Century and their Maps* (Chicago, 1993), p. 276. Karrow provides a full listing of Mercator's cartographic output, starting with the terrestrial globe he engraved for Gemma Frisius *c.*1536, pp. 376-406.

5. See G.L'E. Turner, "The Florentine Workshop of Giovan Battista Giusti, 1556-*c.*1575", *Nuncius : Annali di Storia della Scienza*, 10, pt 1 (1995), in press.

6. The stars are listed in Turner and Dekker, pp. 438-439, and in Turner, "The Three Astrolabes", p. 344.

7. For Thomas Gemini, see C.D. O'Malley in *Dictionary of Scientific Biography*, v (New York, 1972), pp. 347-349.

8. Museum of the History of Science, Oxford, dated 1559, and dedicated to Queen Elizabeth of England, inv. no. 36.6 (IC 575); Instituto e Museo di Storia della Scienza, Florence, dated 155 [last numeral omitted], inv. no. 1093 (IC 489).

9. See the reproductions from originals in the Bibliothèque royale at Brussels, *Les Sphères terrestres & célestes de Gérard Mercator 1541 et 1551* (Brussels, 1968), Preface by A. de Smet.

10. Margarida Archinard, 'The Diagram of Unequal Hours', *Annals of Science*, 47 (1990), pp. 173-190. Professor J.D. North confirms the unsatisfactory nature of this diagram, see his *Stars, Minds and Fate : Essays in Ancient and Medieval Cosmology* (London and Ronceverte, West Virginia : Hambledon Press, 1989), pp. 221-2.

11. Turner and Dekker, p. 430, Section 6.2.

SARTON MEDAL LECTURES

LAUDATIO JAN GODDERIS

R. Rubens

The task of introducing Prof. Dr. J. Godderis as recipient of the Sarton Medal for the academical year 1994-95 is certainly not easy. On the one hand it is appropriate as a collega proximus to honour such an outstanding scholar in the history of medicine, on the other hand every introduction fails to mention all the endeavours and fields of medicine in which Dr. Godderis is active.

Jan Godderis was born in 1944. After his secondary school in which he first encountered his life-long love for the classical Greek language, he went to the University of Louvain where he graduated as M.D. in 1970. After a short period of general medical practice, he returned to his Alma mater for further training in neurology and psychiatry. In 1976 he obtained his specialist certificate in neuro-psychiatry. He remained after the completion of his training in Louvain and became physician in charge of the department of gerontopsychiatry at the University. Later on he was appointed professor and put in charge of the teaching in the graduate curriculum of the medical and paramedical students at the faculty of medicine in Louvain for psychiatry and gerontopsychiatry.

In 1989 he was furthermore charged with the course on the History of medicine at the University of Louvain.

In the same period he obtained his Ph.D. in Louvain on a thesis reflecting his interests in classical Greco-roman medecine (Bijdragen tot de geschiedenis van de begripsontwikkeling in de psychiatrie en de geneeskunde. Een reflectuur van bepaalde auteurs uit de Grieks-Romeinse medische philosophische traditie, KUL 1990).

Prof. Godderis is also very active in a multitude of committees and societies concerning the care of the older psychiatric patients. He is a well-known gerontological psychiatric physician. From his hand numerous (more than 120) papers and reports concerning his interests have been published in international and national journals and in books. The most famous of these covers new aspects of Galen's knowledge of psychiatry (Galenos van Pergamon over psychiatrische stoornissen).

Dr. Godderis' motto during his clinical, scientifical and historical career remains the basic principle and ethical dimension of the ἰᾱτρός in ancient Greece, so admired by him as a philhelennic person. It therefore is appropriate that I invite him now to lecture us about 'The Hippocratic asclepiad and his patient'.

THE HIPPOCRATIC ASKLEPIAD AND HIS PATIENT

SOME THOUGHTS ON THE PHYSICIAN–PATIENT RELATIONSHIP IN ANCIENT GREEK MEDICINE

Jan Godderis

ên gar parêi philanthrôpiê,
paresti kai philotechniê
(Hippocrates, *Paraggeliai*, L. 9.258)[1]
"Die Medizin beschäftigt den ganzen Menschen,
weil sie sich mit dem ganzen Menschen beschäftigt"
(Goethe, *Dichtung und Wahrheit*)

Every medical action takes place in the context of an encounter between two subjects, the physician and the patient. The content, form and further development of this subject–subject relationship is defined by unconscious desires as well as conscious intentions on the part of either participant at the moment of their meeting. This humane encounter can only achieve a satisfactory result if the physician reacts compassionately to the patient who seeks his aid and consciously puts his competence, authority and responsibility to work in the interest of that patient, and if the latter, from a complementary point of view (that is, accepting the physician's competence and authority and waiving his own responsibility), reaps the benefits of this attitude. The coincidence of these two intentional, evaluative, but at the same time dispositional approaches is the foundation of every medical act. In any meeting between physician and patient a number of important aspects can be pointed out which, by their mutual interaction, give that event a concrete expression. First and foremost there is a cognitive aspect, namely the making of a diagnosis (the recognition or determination of the nature and location of an illness or injury on the basis of the symptoms), and the formulation of a prognosis (the knowledge, prediction or expectation of the (further) course of the affliction). In addition, there is an operative and an affective aspect, i.e., respectively, the treatment applied, and the concrete emotional relationship between physician and patient, which to a large extent determines how the former attends to the latter. And finally there are the ethical-religious and the social aspects. On the ethical-religious level appear the underlying — and sometimes variable — questions of meaning and value systems particular to the individual environment of physician and patient. The social aspect has to do with the fact that both occupy a position in a given society (*societas*), in which human interaction is regulated by cultural norms. The physician–patient relationship — in ancient Greek medicine too — can only be fully understood when all aspects are given due credit. In the present paper all will accordingly be checked against the available data, insofar as these can be documented on the basis of the diversified (medical and non-medical) and sometimes contradictory evidence[2].

From wizard or purely empirical 'dêmiourgos' to 'technites': development of the cognitive and operative aspects of medicine

Before the period in which the Pythagoraean Alkmaion of Kroton (ca. 540 B.C.) and Hippocrates of Cos (460-377) appeared on the scene, medical science in ancient Greece was a combination of empiricism and magic. The military surgeons of the Iliad — *ab Homero principium!* — Machaon and Podaleirios, the sedentary or itinerant healers (*periodeutai*) and the root or herb-seekers (rhizotomists) of pre-Hippocratic medicine were more or less skillful empirical '*dêmiourgoi*' (literally: men who worked for the public good); other means of healing — among them incubation in the temples of Asklepios and magical incantations and cathartic rites — were a reflection of mantic–theurgic medical thinking, which predominated until the fifth century B.C.[3]

Hippocrates introduced a radically new 'technique' in which the physician approached the patient to aid him in the event of illness: the *technê iatrikê*, usually translated as the 'art of healing'. Here one must not forget that the traditional Greek notion of '*technê*' comprised not only the technical 'know-how' and, in connection with medicine, the concomitant 'artful' aspect of the discipline (the intuition in arriving at a diagnosis and formulating a prognosis; the experientially acquired acumen or intuitive determination in prescribing a therapy); it also implied 'knowledge' (*sophia*). The Greek concept of '*technê*', besides "artfully executed handicraft", "artifice" or "art", can also mean "knowledge" or "science" — the opposite of '*tychê*', "blind fate" or "what is decided by fate", which is synonymous with '*atechniê*', "absence of art". '*Technê*' means the knowledge or science how to act in accordance with "what" and "why". The 5th-century B.C. physician, unlike his predecessors, already acted with a measure of rationally acquired competence, which contained the basis of the true knowledge he carried in him in the inductive '*tribê meta logou*' ("the reasoned rubbing in"[4]). He acts in the scientific knowledge of "what" (*ti*) he does with the patient and "why" (*dia ti*) he does so. According to Alkmaion and Hippocrates a '*technitês*', a technical doctor or craftsman who knows his art, requires three forms of knowledge: he must know the disease he is dealing with (this presupposes that he is not only capable of a functional and dynamic interpretation of the pathological processes and clinical phenomena, but also knows something about the specific person afflicted by them, i.e. his patient); he must know what the healing action or remedy is (*ex hou*); and he must know why this treatment cures certain symptoms but not others. From this highly fertile natural-scientific approach (*physiologia*), constructed shortly before by the pre-Socratic philosophers (*physikoi*), there gradually developed the sciences of human '*physiologia*' and '*anatomê*' (the study of the actions, build and structure of all living organisms: i.e. physiology and anatomy in the modern sense of these words), of '*pharmakologia*' (i.e. the scientific knowledge of medicines, the so-called materia medica), of '*pathologia*' (i.e. the scientific study of the various forms of disease), and of the '*technê therapeutikê*' (i.e. the scientific doctrine as to which treatment is to be prescribed)[5]. Against the primitive empirical *dêmiourgoi*, wizards, exorcists and physician-priests, in the wake of the "the sage of Kos" the technical successors, so to speak, of Asklepios, the so-called Asklepiads[6], came to the fore of the contemporary medical scene, yet without wholly eliminating the former. After them medicine would always be understood as *technê iatrikê*, as it is called in several treatises in the Corpus

Hippocraticum[7].

In ancient Greece, however, the relationship between physician and patient, within the framework of the just described technical approach, and insofar as it can be defined by the evidence at hand, by no means showed a uniform character. A close reading of the available texts (not only the Hippocratic writings, but also the Platonic texts, in particular *Lysis*, *Symposion*, *Charmides*, *Gorgias*, *Politikos*, *Timaios* and *Nomoi*, in which medicine, the physician and the patient are repeatedly spoken of), leaves little doubt on this point. The relationship varied considerably according to the patient's status: free and prosperous citizen, free but poor citizen, or slave. With this restriction in mind, it would appear interesting to trace the concrete emotional relationship between the Hippocratic Asklepiad and his prosperous and cultivated patient.

"Philia" as key to the understanding of the physician–patient relationship: the affective aspect of medical practice

In the event the Asklepiad had to do with a prosperous and cultivated patient he was led not only by financial interests or pure scientific curiosity; he was apparently also 'moved' by a desire to give this patient the best possible technical assistance. The patient, in turn, consulted his doctor because he wanted to be cured. Although there is a difference in motive here, the Greeks — as Pedro Lain Entralgo[8], whose readings of the ancient texts I strongly endorse, has emphasized — perhaps had the acumen to render this in a single word: i.e. the comprehensive term *'philia'*, meaning 'love', 'affection', 'devotion', 'friendship'.

Hôste hygiainôn oudeis iatrôi philos dia tên hygieian: "so no one in health is friend to a doctor, on account of his health", *all' ho kamnôn (...) dia tên noson*: "but the sick man is (the doctor's friend) on account of his disease", thus Socrates in Plato's *Lysis* (217a), a treatise on friendship; *ên gar parêi philanthrôpiê, paresti kai philotechniê*: "for where there is love of man, there is also love of the art": thus a passage in the *Paraggeliai* (Precepts), a late text in the Corpus Hippocraticum (L 9.258)[9].

Besides a providing of technical assistance (the cognitive and operative aspect), the relationship between physician and patient in Greek antiquity was apparently based on *philia.*

What is the full significance of these two statements (the Platonic and the post-Hippocratic)? What did the notion of *philia* really mean to a Greek, whether a philosopher or a mere mortal?

The major philosophers of the Hellenic world — Sokrates, Plato, and also Aristotle — raised this notion to the very object of their philosophical reflection. For Sokrates (469-399) nothing was more important than *philia.* It is either a desire for something one does not possess, or, if one does possess it, a desire never to lose it again (*kai ou monon einai, alla kai aei einai* – *Symposion* 206a). In a conversation with Lysis and Menexenos, one day in the palaestra, he rather confidentially said: "There is a certain possession that I have desired from my childhood, as every one does in his own way (*tygchanô gar ek paidos epithymôn ktêmatos tou, hôsper allos allou*). One person wants to get possession of horses, another dogs, another money, and another distinctions: of these things I reck little, but for the possession of friends I have quite a passionate longing (*egô de pros men tauta praiôs echô, pros de tên tôn philôn ktêsin panu erôtikôs*), and I would rather obtain a good friend (*philon agathon*) than the best quail or cock in the world; yes, and rather, I swear, than any horse or dog. I believe, indeed, by the Dog, that rather than all Darius's gold I would choose to gain a dear comrade, far sooner than I would Darius himself, so fond I am of my comrades (*houtôs egô philetairos tis eimi*)" (Plato, *Lysis* 211e). Plato (430-347), in the wake of his mentor, was also to meditate on this topic, and his pupil Aristotle of Stageira (384-322) posited in the *Ethica Nicomacheia* that love or friendship was one of the most indispensable requirements of life: *eti d'anagkaiotaton eis ton bion* (1155a).

But what did love or friendship really mean to Sokrates or Plato, and how are we to look at the relationship between *philia* and the better-known notion of *erôs* (or passion)? There are passages in Plato, e.g. in the *Symposion*, but also in the *Phaidros*, in which the two concepts are clearly distinguished. Yet in other texts, for example in the *Nomoi*, he stresses their mutual interlocking: "Friendship is the name we give (*philon men pou kaloumen*) to the affection of like for like in point of goodness (*aretê*)". This must be taken to mean: with regard to a desire for beauty, for what is not deformed, for what is good; the perfection of the soul, man's highest aspiration to happiness (*eudaimonia*), "the good life" (*to eu dzên*) or "doing well" (*kai to eu prattein*)[10], without which life would not be worth living. But — Plato continues — "(friendship is) also (the name we give to the affection) of the needy for the rich, which is of the opposite kind; and when either of these feelings is intense we call it 'love' (*erôta eponomadzomen*)" (*Nomoi* 837b).

This essential connection between *philia* and *erôs*, in which mention is made of a love of other things (including other people), in which the *erôs* is seen as an intensified or extreme form, i.e. as a '*hyperbolê*' of *philia*[11], and in which the two are linked with "the longing for what is good", with "a pursuit from want towards fulfillment", enables us, according to Lain Entralgo, to understand the exposition with regard to friendship and its meaning for the relationship physician–patient as it is found in Plato's early dialogue *Lysis*. *Philia*, Plato states there, is based on a latent feeling of familiarity or relation (*to oikeion*) that binds a person to his friends; and this in turn is based on "*physis*", nature: "Then if you two are friends to each other, by some natural bond you belong to one another (*hymeis ara ei philoi eston allêlois, physei pêi oikeioi esth' hymin autois*). ... What belongs to us by nature has been shown to be something we needs must befriend (*to men dê physei oikeion anagkaion hêmin pephantai philein*)" (*Lysis* 221e–222a). According to Plato the need for *philia* can never be fulfilled by a single friend; in other words, it cannot be seen as an attitude towards the only beloved. Nor can it be fulfilled by all beloved together, for one can always make new friends. It must therefore be concluded that man does not love all other things (including other people) in view of himself, but in view of something else. Like the person who aspires to health (the patient) loves the physician because of what he desires, i.e. good health (*heneka hygieias*), so he likes good health itself because of something else, ... and thus he might continue, until he comes to the so-called *prôton philon*, literally the "first loved", the primary or ultimate object of love, for whose sake all other things (including men) can be said to be friends (*all' hêxei ep' ekeino ho esti prôton philon, hou heneka kai ta alla phamen panta phila einai*, 219d). The *prôton philon* is in itself desirable, because eternal happiness consists only in the possession of the "first loved". Another, e.g. the patient for the physician, is desirable only insofar as he enables one to achieve the *prôton philon* and therewith eternal bliss[12]. He is desirable not because of "who" (*tis*) he is, but because of "what" (*ti*) he is; to the extent that he is individually part of the just mentioned primary and fundamental reality, of the "first beloved", of something that belongs to the actual roots of human nature (*physis*) and therefore also to the nature of the universe, the original nature or "*archaia physis*", dealt with in the *Symposion* (193c).

Greek thought concerning love, and also the view of the Hippocratic Asklepiads — and perhaps of Hippocrates himself as well — of friendship, of the evaluative and dispositional attitude towards another (the patient), does not seem at that time to have gone any further. Even the notion of *philanthrôpia*, hardly found in the Hippocratic corpus[13], will, when used by the Stoics with whom it receives a more lofty philosophical–ethical connotation, still largely bear as underlying motif the perfection of nature (*hê teleiotês physeôs*). It remains 'love from need', born of a lack, driven by a desire for fulfillment, to make up for what is felt as a deficiency. Here we certainly do not yet hear the profound and richer significance of the New Testament notion of "*agapê*", which for that matter hardly appears in pre-Christian philosophical and medical literature, and which will cover a completely different meaning[14]. For *agapê* means 'love to give'[15], love of man, love of one's neighbour, without any ulterior motive or oblique glances at anything else. It is the love of another because of God, whereby God is not the end, the final object (*di ho ti*), but the beginning and its permanent foundation (*to hyph hou*)[16]. *Philanthrôpia* does not possess this more profound dimension; to the Greek (including the late Hellenistic Hippocratic Asklepiad) it still remained, like *philia*, pure *physiophilia* or love of universal nature, in its specific appearance of 'human nature'. In the view of some Greek philosophers and physicians the natural perfection of all things (including all men) worked together to bring about the perfection of the universe. The philosophically trained Hippocratic physician sensed it as his own duty to participate in this joint undertaking (*synagein*). *Philia* and/or *philanthrôpia* are the terms the Greeks of that time gave to this desire to cooperate. They of course also formed, as general underlying motifs of human relations, the basis of the physician–patient relationship.

How was *philia* concretely interpreted or applied in the context of the medical relationship in ancient Greece?

For the well-schooled physician the *'iatrified philia'*[17] or friendship for his patient boiled down to an appropriate mixture of *philanthrôpia* (friendship for man in the above-mentioned sense of the word) and *philotechnia* (love of one's art). In this context it must be explicited what an Asklepiad precisely understood by the notion of *technê* and by the term *philotechnia*. No one has given a clearer definition of the concept of *technê* than Aristotle. Unlike the empirical physician, the *empeiros* or *dêmiourgos*, for whom it sufficed to learn how to perform certain acts simply by repeating them, the 'modern' Greek *technitês* or technical doctor acted — as already said — in full awareness of 'what' (*ti*) he was doing and 'why' (*dia ti*). His actions, depending on the situation, were a *mimêsis* or emulation of what nature did of its own accord, or — and this was his most important trump — *poiêsis*, the conscious creation of something nature never produced but which followed the normal line of evolution. His *technê*, the *technê iatrikê* or art of medicine, thus consisted in helping nature in its tendency to heal, both imitatively and creatively. This art found its information in science (the *alêthês logos*, as formulated by Aristotle in his *Ethika Nikomacheia*) and of course relied on *physiologia*: the scientific understanding of nature itself. The physician's function was a 'creative' one in the sense that he might heal a patient who would never recover if left to himself; it was 'imitative' insofar as medicine remained faithful to nature and that the cure it effected in no way differed from the cures that came about in a natural way. *Philotechnia* or 'love of the art' therefore meant nothing more than the physician's love of the technical knowledge and skill that enabled him to boost a patient's natural inclination to get better or, in other words, remedy a dangerous change in the *physis* (nature). A technophile Asklepiad thus combined *philia, logos* and *erôs*: *philia* because he felt friendship for the patient and because he showed his love for the art of healing; *logos* because his skill was based on *physiologia* — does not Aristotle state in his *Metaphysics* that medicine is the *logos* of health? — and finally *erôs* because in the true heart of the *philotechnia* there was an especially strong impulse toward the perfection of nature or maintaining that perfect state: something that Plato undoubtedly means where he writes in his *Symposion* that the art of medicine "may be summarily described as a knowledge of the love-matters of the body in regard to repletion and evacution (*epistêmê tôn tou sômatos erôtikôn pros plêsmonên kai kenôsin*)" (186c)[18].

In other words, the *philia* of the Hippocratic physician for his patient, the result of a combination of *philanthrôpia* and *philotechnia*, was a love of the perfection of man as individualized in the body of the patient. It must be seen as a joyous and respectful love of all that is beautiful in nature (health or harmony) or that leads to beauty (the natural restorative powers of the organism). It is, since it complies with the line of nature's evolution, at the same time a resigned and respectful love for the dark and terrifying inevitability or inescapability imposed by nature upon incurable or fatal illness, in particular for the *anagkê physeôs* (the *fatalis vis et necessitas rerum futurarum*: "the power of Fate and the Necessity that governs future events", as Cicero has the Stoic philosopher say in his *De natura deorum* [I XV 39]).

In the friendship of the patient himself for the physician treating him, two distinct but strongly intertwined ingredients can, upon closer glance, be distinguished. On the one hand, there is his faith in medicine and consequently in doctors, and, on the other, in the individual physician caring for him and to whom he afterwards usually feels grateful. The patient's confidence in the art of healing appeared in the end to be founded on the religious and sacral prestige that the various 'Arts' or *technai* enjoyed in ancient Greece[19]. Even when this reverence later assumed a more rational character, Greek medicine lost but little of the prestige it drew from its *prôtoi heuretai* (first discoverers). On the other hand, the Greek's faith in the *technê* of the Hippocratic Asklepiad was of course not unlimited, but fundamentally tempered by his (in the final analysis religiously embedded) conviction that *anagkai*, inexorable powers, existed in nature. Certain illnesses were in his mind inevitably (*kat' anagkên*) fatal or incurable, and the phsyician's skill was no match for these unavoidable and inescapable powers (the so-called *atrepta kai anaphylakta*). But this was not the only reason of his limited faith. Feelings of dissatisfaction and disappointment concerning the attitudes and skills of physicians were more than once a matter of discussion in Periclean Athens, even among the most informed and most critical members of the population[20].

His technical prowess was nevertheless an important reason why the Hippocratic physician enjoyed the confidence and perhaps also the friendship of his patient, yet it was by no means the only one. His external appearance, decent and clean clothing, a discrete perfume, a dignified bearing, earnestness, gentleness, irreproachability and self-control, as we read in the somewhat later Hippocratic treatises *Peri iêtrou* (Physician) and *Peri euschêmosynês* (Decorum), could strongly stimulate the patient's confidence. By way of complement to Plato's statement "that the patient is the friend of the physician because of his disease" (*dia tên noson*), the Asklepiads therefore also assumed that the sick could entertain a feeling of *philia* for the doctor because of the physician himself (*dia tou iêtrou*).

Social aspects of the physician–patient relationship

On the social aspects of Greek medicine (besides the affective aspect another important facet of the physician–patient relationship) little information is provided, especially in the Hippocratic treatises. Plato, on the other hand, is a prime source here. In several texts, in particular in the *Charmides, Gorgias, Politeia, Politikos, Timaios, and Nomoi,* he paints a vivid picture of medical practice in the main city-states of Hellas. He shows that it conformed largely to the social structure of the polis or city(-state). Thus there was a considerable difference in the standard of medical treatment between the three main categories: slaves, prosperous free citizens, and poor freemen. Slaves, for instance, were not treated by real doctors (Asklepiads trained in the medical schools of Kos, Knidos, Cyrene or Sicilia), but by crude empiricists, who had picked up some rudimentary medical knowledge as slave of a practising physician. Verbal communication between healer and patient as well as the individualization of the treatment was reduced to a minimum[21]. Differences between the more prosperous and the poorer freemen are also pointed out by Plato.

This acute critic of contemporary medicine also shows an interest in two theoretical problems concerning medical care: in his view it should be regulated by just or good laws, and in each individual case applied from a correct appraisal of the effectiveness of the general rules of the *technai.* But how could medical skill be perfected when all patients were unequal or each case different from the other? And how could laws, which by definition possess a universal and binding character, be attuned to individual cases? Plato offered a solution for the difficult problem of the relationship between *nomos* (law) and *physis* (nature, but also behaviour) — a question the Sophists debated zealously and passionately — by treating separately the relationship between 'law' and 'art' on the one hand, and the possible perfection of their respective applications on the other. With regard to the art of healing he was convinced that perfection could only be attained by a rational individualization of the diagnosis and treatment of each patient, in other words by emulating the practice of the Athenian physicians (the true '*technitai*' of medical science) with regard to their free and prosperous patients. To this end, in his opinion, certain conditions had to be fulfilled: the patient should be well instructed in medical matters, in particular about how illnesses come about and how they can be halted or remedied; the patient had to be verbally persuadable if the physician was to win his confidence (*pistis*); and finally the doctor also had to devote sufficient attention to his biographical data. In the first condition, the instructing (*didaskein*) of the patient, Plato was followed by two important Hippocratic texts, namely the *Peri euschêmosynês* (Decorum) and the *Peri archaiês iêtrikês* (Ancient Medicine). "But if you miss being understood by laymen, and fail to put your hearers in this condition — so we read in the latter tractate — you will miss reality" (*ei de tis tôn idiôteôn gnômês apoteuxetai, kai mê diathêsei tous akouontas houtôs, tou eontos apoteuxetai*) (L. 1.572-574).

From both of these Hippocratic texts it appears that the combination of the physician's knowledge with the intelligent patient's accurate perception of what is happening to him, and of how his illness has developed, contributes significantly to a correct diagnosis and a successful therapy. For that matter, a measure of medical instruction was, according to Jaeger[22], part of the education or *paideia* of any cultivated citizen. The best way to win the confidence of such a patient and to individualize his treatment was, in Plato's view, without any doubt *hê peithô*, verbal persuasiveness. A good physician, says Plato, will prescribe his patient nothing before he has in some way persuaded him, in other words has obtained his consent (*kai ou proteron epetaxe prin an pêi xympeisêi – Nomoi* 720d). Instruction (*hê paideia*) and persuasion (*hê peithô*) are most effective when the doctor also has some biographical data on the patient and some information on the chronological evolution of his illness. This recommendation was in all probability put to practice by many Hippocratic physicians. One need only think of the importance attributed in the Corpus to the most suitable moment for medical intervention. It was not enough to do something, it also had to be done at the right moment. The Greeks called that moment *ho kairos*. The patient also had to be closely monitored, according to Plato, like a pedagogue follows the development of the child entrusted to him (*Politeia* 406a-b).

It is understandable that only wealthy, or the so-called 'best' (*hoi aristoi*), citizens could afford such a 'pedagogical therapy'. Only the rich, who could afford to abandon their daily duties, were indeed able to subject themselves completely to those who cared continuously for their health. To the free but poor(er) citizens, in other words the 'the masses' (*hoi polloi*), little care was actually devoted. They did not get the crude treatment of the slave, but were given a quick 'resolutive' treatment (for example with drastic vomitive and purgative agents)[23].

Although the cultivated Greek discussed the relationship between *nomos* and *physis* with considerable dialectical energy, and although Plato had issued clear directives concerning the perfection of medicine, such a differential approach of the patient appeared to fit in well with the average Greek's view of the social structure of his *polis*. It was important to the common good, in other words for the prosperity of the city(-state), and for that reason eminently defensible. Wholly conform with these views concerning *philia* and the ideal society in Plato's *Politeia* (Republic), according to which persons were appreciated only as long as they were of benefit for the common good and lost their value as objects of affection from the moment they ceased to be of use[24], some physicians would make little effort to aid hopeless and weakened patients, regardless of whether they belonged to *hoi aristoi* or *hoi polloi*. They held that no trouble need be taken to prolong a life of which little good remained: "when bodies were diseased inwardly and throughout, he (Asklepios) did not attempt by diet and by gradual evacuations and infusions to prolong a wretched existence (*kakon bion*) for the man and have him beget in all likelihood similar wretched offspring (*kai ekgona autôn, hôs to eikos, hetera toiauta phyteuein*) he did not think it worth while to treat him (*mê oiesthai dein therapeuein*), since such a fellow is of no use either to himself or to the state (*hôs oute hautôi oute polei lusitelê*)" (Plato, *Politeia* 407d-e).

Yet one may well ask whether the Asklepiads indeed systematically adopted this disposition towards hopeless or much weakened patients, who in the Platonic view were both corporal and mental 'wrecks' (*kakophyeis*). According to the author of the treatise *Peri technês* (The Art), many physicians in Antiquity preferred not to treat hopeless or hard-to-cure cases, but rather illnesses that abated spontaneously: "Some say that while physicians undertake cases which would cure themselves, they do not touch those where great help is necessary (*legontes hôs tauta men kai auta hyph' heautôn an exygiadzoito, ha egcheireousin iêsthai, ha d' epikouriês deitai, ouch' haptontai*)" (L. 6.12). Even so, there appear to have been differences between the *philia iêtrikê* concerning the above question among many Hippocratic physicians, and Plato's opinions concerning the ideal doctor. Some Hippocratic Asklepiads were undoubtedly driven by the bond of brotherly love (*philia*) they felt with their patient, primarily because he was a human being who shared the common filial relationship of all men with the *physis*. Plato's ideal physician, on the other hand, felt friendship for his patient only because he was a member of the community (*polis*) of man, in the service of which he played his part as fully as possible and where he achieved his highest dignity.

Ethical(–religious) aspects of the physician–patient relationship

The physician–patient relationship is played out not only between two subjects, but also within the context of behavioural patterns that reflect contemplation about meaning and values. The latter cannot only be subject to diachronic changes, but may also vary within a given synchronic temporal moment.

The ethic of the Hippocratic physician probably did not develop as secularly, autonomously and independently as we are generally made to believe[25], but was firmly embedded in religion. On the fringe of the ancient religious cults (Olympian, Dionysian, Orphic or Eleusinian) there developed, so to speak, an enlightened religion: 'naturalism', a religious and philosophical doctrine whose inner strength was strongly linked to the emphasis on the basal and indivisible character of the *physis*, omnipresent mother nature, of which Zeus, Dionysos, Orpheus and Demeter were merely popular personifications. Thales, Anaximenes, Anaximander, Pythagoras, Empedocles, and the other Pre-Socratics, the precursors whose ideas intellectually influenced the founders of the *technê iêtrikê*, were both *theologoi* and *physiologoi*. The Hippocratic Asklepiads apparently felt and thought in the same way as these great forerunners; in other words, their ethic was rooted in a well-defined explicitly religious feeling, which can be regarded as a compromise, floating between the adoration of the old cult and the more modern '*physiologia*'[26].

The first aspect is still clearly recognizable in the opening lines of the *Horkos* or Hippocratic Oath: "I swear by Apollo Physician, by Asclepius, by Health, by Panacea and by all the gods and goddesses, making them my witnesses (*Omnumi Apollôna iêtron, kai Asklêpion, kai Hygeian, kai Panakeian, kai theous pantas te kai pasas, historas poieumenos*)" (L. 4.628-629). The second, the great veneration of '*physiologia*', appears in such texts as *Peri hierês nousou* (The Sacred Disease), *Peri aerôn hydatôn topôn* (Airs, Waters, Places), *Peri diaitês* (Regimen), and the treatises *Nomos* (Law) and *prognôstikon* (Prognosis). Piety (*hê eusebeia*), which is extolled vigorously and repeatedly by the author of 'The Sacred Disease', is without doubt a combination of the traditional cult of the gods and the new 'physiological devotion' of the Pre-Socratics. It condemns the purification rites and magical rituals with which the superstition of the Ancients would vanquish epilepsy, and recommends instead a combination of religious ceremonial (such as smoke sacrifices, prayers of thanks and protection to the temple gods: *thyein te kai euchestai kai es ta hiera pherontas hiketeuein tous theous*, L. 6.362) with 'natural' therapeutic methods based on the divine nature of the *physis*.

Yet all this does not mean that the medical ethic was the same in structure and content throughout the Corpus. Even the most venerable document with regard to medical morals, the already mentioned *Horkos*, which dates primarily from the fourth century — and which contains the famous phrases *ou dôsô de oude pharmakon oudeni aitêtheis thanasimon, oude hyphêgêsomai xymbouliên toiênde*: "Neither will I administer a poison to anybody when asked to do so, nor will I suggest such a course", and *homoiôs de oude gynaiki pesson phthorion dôsô*: "Similarly I will not give to a woman a pessary to cause abortion" (L. 4.630-631) — was never accepted as inviolable dogma by all the physicians of Classical Antiquity[27].

Comparison of several Hippocratic treatises shows that there were indeed differences in concrete ethical attitude between the various schools and also between the periods in which the authors of these tractates are to be situated. Nevertheless, some scholars, like Lain Entralgo, have wondered whether they all did not have something in common: for they were all Greeks, *technitai* and *iatroi.* It indeed seems worthwhile to examine whether a common Greek factor can be found which is shared by all the writings of this impressive Corpus, Koan as well as Knidian texts, humoral as well as pneumatic works, those dating from Periclean as well as late Hellenistic times. The question may be asked: what were the most important recurrent ethical prescriptions of Hippocratic medicine within the plurality of co-existing and conflicting moral perspectives? (see n. 39 below).

According to Lain Entralgo[28] the 'iatrified philia' of the Asklepiads expressed itself *in ethicis* first and foremost in the transformation of the instinct to help, which is demonstrably active in human nature, into a technique, a skill; and secondly in an ethical reflection on the range of medical intervention and on the physician's attitude as to his remuneration for services rendered (a remuneration that seemed morally justified when he proved, through his professional conduct, that he had attained perfection in the practice of his Art).

As for the first aspect it must be emphasized that an instinct to help is indeed active in human nature. One of the basic principles of the Hippocratic medical ethic consisted in the acceptance, interpretation and technical execution of this natural instinct in order to aid the sick and to take action "for the benefit of the suffering" (*ep' ôpheleiêi kamnontôn*), as the Oath says (L 4.630-631). "There are some arts — thus writes the author of *Peri physôn* (Breaths) — which to those that possess them are painful, but to those that use them are helpful (*eisi tines tôn techneôn, hai toisi men kektêmenoisin eisin epiponoi, toisi de chreomenoisin onêistai...*), and medicine is one of these. For the medical man sees terrible sights (*ho men gar iêtros horêi te deina*), touches unpleasant things (*thigganei te aedeôn*), and the misfortunes of others bring a harvest of sorrows that are peculiarly his (*ep' allotriêisi te xymphorêisin ideas karpoutai lypas*); but the sick by means of the art rid themselves of the worst of evils, disease, pain, suffering and death (*hoi de noseontes apallassontai tôn megistôn kakôn dia tên technên, nousôn, ponôn, lypês, thanatou*)" (L. 6.90). The important principle that the physician must be kind to the patient, without bias (*hypopsia*), and the repeated statement in the *Paraggeliai* (Precepts) that the physician must treat his patient with devotion, not only in the interest of the latter's health (*heneken hygieiês*) but also of his own "good appearance" (*heneken euschêmosynês*) (L 9.258), are direct expressions of this moral attitude. According to Lain Entralgo, who differs somewhat of opinion here with Edelstein[29], this attitude was rooted in the *philanthrôpia* of the Greek physician, in his love of man for *what* he is (see above). A Hippocratic Asklepiad who adhered to this ethical norm would develop a love of his Art through his love of man, and express his love of man (his patient) through the love of his Art.

This noble task which some (religiously inspired?) Hippocratic physicians appear to have taken upon themselves sprang from a twofold source. In the first instance it was a practical, a 'technical' skill, already found among the Homeric physicians. But at the same time it was the application of the by then developed concepts of '*philia*' and '*technê*', with the result that medical *philia* always remained '*physiophilia*' (or love of nature)[30], while *technê* was the rational skill to do what nature permitted, to comply with its line of evolution. As *physis* was to them a 'deity', they were as a matter of course profoundly and spontaneously aware that they had to respect the limitations of their Art and thus refrain from therapeutic intervention when the *anagkê physeôs*, the inevitability imposed by inexorable nature, made that pointless. This religious or philosophical–ethical imperative is in any event manifestly present in a number of ancient texts, for instance in the definition of the *technê iatrikê* in the aforementioned treatise *Peri technês* (The Art): "In general terms, it is to do away with the sufferings of the sick, to lessen the violence of their diseases, *and to refuse to treat those who are overmastered by their diseases* (*kai to mê egcheireein toisi kekratêmenoisin hypo tôn nosêmatôn*), *realising that in such cases medicine is powerless* (*eidotas hoti tauta ou dynatai iêtrikê*)" (L. 6.4-6).

The question that arises here, of course, is whether this explicit order to refrain in such cases from therapeutic intervention was indeed generally obeyed by the Greek physicians of that time. The finding that this imperative fits in particularly well with the aim of this sophistically argued treatise, which is essentially to demonstrate that medicine is merely a '*technê*', may relativize the meaning it may have had for the less philosophically schooled, practising physician of that time. Nevertheless this imperative also appears elsewhere in the Corpus Hippocraticum, for instance in the *Aphorismoi* (Aphorisms): "It is better to give no treatment in cases of hidden cancer (*hokosoi kryptoi karkinoi ginontai, mê therapeuein beltion*); treatment causes speedy death (*therapeuomenoi gar appolyntai tacheôs*), but to omit treatment is to prolong life (*mê therapeuomenoi de, poulyn chronon diateleousin*)" (L. 4.572). In this attitude, for that matter, the basic Hippocratic rule from the first book on *Epidemiôn* (Epidemics) is clearly concretized: "As to diseases, make a habit of two things – to help, or at least to do no harm (*askeein, peri ta nousêmata, duo, ôpheleein, ê mê blaptein*)" (L. 2.634-637). The repetition and the explicit character of this imperative suggest that we may be dealing here with more than merely 'technical' advice, namely with a philosophical or religious-ethical commandment.

This is not all that suprising. The prevailing views of nature, man and the Art — and not in least the Platonic ideal of *kalokagathia* (complete physical and mental equilibrium in man, applying to all areas of life and therefore also to the physician–patient relationship) — probably led many Greek physicians to consider it their duty to refrain from treating incurable or fatally ill patients, or, more correctly, those patients that their ability to distinguish between inescapable disease (*nosos kat' anagkên*) and accidental ailment (*nosos kata tychên*) convinced them that they were incurably ill or condemned by an unyielding decision of divine nature. For that matter, this ethical attitude is in line with what Plato has Pausanias say about the granting of favours: "it is right to gratify good men (*tois men agathois kalon charidzesthai tôn anthrôpôn*), base to gratify the dissolute (*tois de akolastois aischron*)". It is reflected as well in the later application of the same rule to medicine by Eryximachos: "it is a disgrace to do aught but disappoint the bad and sickly parts, if one aims at being an adept (of the profession) (*tois de kakois kai nosôdesin aischron te kai dei acharistein, ei mellei tis technikos einai*)" (*Symposion* 186b-c). Finally, it formed the basis of Aristotle's advice to the physician to abandon those whose illness proved incurable: "he has altered, and if one cannot restore him, one gives him up (*alloiôthenta oun adynaton anasôsai aphistatai*)" (*Ethika Nikomacheia* 1165b).

If a sick person wanted to resume his place as a full-fledged member of the community, he therefore had to regain his health. If his condition was hopeless, his disease incurable, then the physician — in accordance with the Platonic view, but also in the spirit of the treatise *Peri technês* — would not take his case. Treatment of such an affliction would in this instance be pointless, since it would fall beyond the legitimate reach of medicine as *technê*, of the art whose aim it is to effect the restoration of a condition of corporal well-being (*eukrasia*) or health of spirit (*sôphrosynê*). The radical naturalism of Greek thought, and the resultant concepts of *philanthrôpia* and *physiophilia* could hardly be otherwise expressed. To take a different point of view would probably have amounted to *hybris*, a lack of humility vis-à-vis the unyielding divine character of the *physis*. The Hippocratic physician was, in the view of Lain Entralgo, the "friend of his patient" because he was, even more fundamentally, the "friend of nature"; and he was the "friend of his Art" insofar as nature permitted him to show his respect and awe as '*physiologos*'[31].

Nevertheless, the Greek saying "*Andros kakôs prassontos ekpodôn philoi* – When things go bad, one's friends disappear"[32] apparently does not always apply, and other views crop up which considerably weaken or even contradict the aforementioned imperative concerning the non-treatment of the incurably ill[33]. Numerous Hippocratic physicians indeed appear upon closer investigation to have started some kind of therapy on incurably sick patients. Or they had wholly different reasons than the author of *Peri technês* not to intervene in certain diseases, as is apparent from the treatises *Peri agmôn* (Fractures) and *Gynaikeiôn prôtôn* (Gynecology I).

In the former work, a Koan treatise, the author states with regard to a compound fracture of femur or humerus: "that one should especially avoid such cases if one has a respectable excuse (*malista de chrê ta toiauta diaphygein, hama ên tis kalên echêi tên apophygên*), for the favourable chances are few, and the risks many (*hai te gar elpides oligai, kai hoi kindynoi polloi*). Besides, if a man does not reduce the fracture, he will be thought unskilful (*kai mê emballôn atechnos an dokei einai*), while if he does reduce it he will bring the patient nearer to death than to recovery (*kai emballôn eggyterô an tou thanatou agagoi, ê tês sôtêriês*)" (L.3.540). A closer look here reveals a different approach than in the treatise *Peri technês*. The therapy is no longer dismissed because the hard-to-treat or incurable ailments are beyond medicine's potential to treat them, but because of a concern for the physician's social prestige! Refusal to treat without good excuse, an expectable poor result when treatment is instituted: both can damage a doctor's position or reputation. If he knows he cannot succeed and therefore cannot complete a successful therapy, he will, according to the author of the *Gynaikeiôn prôton*, in the event of a mola-pregnancy (*mylê*) in which the prognosis is in certain cases infaust, indeed "refrain as much as possible from treating this condition (*tautên malista men mê iêsthai*), but if he does attend to his patient, give warning (*eide mê, proeiponta iêsthai*)" (L. 8.150). No treatment (and/or in the event of therapy immediate communication of the poor prognosis: *proagoreuein*) will thus protect the physician against later reproach.

Although pride of place is given here to the doctor's social prestige and the deontological rule aims to protect him rather than the patient, the treatment of incurable disease still appears to have been frequently considered. In case of red discharge (*rhoos erythros*), which often takes a nasty turn resulting in a woman's death (*kai hôde apollyntai kata biên*) — thus the author of *Gynaikeiôn deuteron* (Book 2 of the above treatise) — the physician "will from the very onset of the red discharge state his prognosis (*prolegein oun dei archomenôn tôn rhoôn*) and prescribe this regimen (*diaitêin de tonde ton tropon*)" (L. 8.236): thus he can protect himself against later reproach while leaving open the possibility, without endangering his position, of ameliorating the patient's condition by applying the means at his disposal or at least of trying to diminish her suffering. Here we clearly find the physician turning to a patient suffering from an ailment with a bad or dangerous course.

This viewpoint, which contrasts somewhat with the aforementioned counsel not to treat such patients, and which is based on the assumption that the natural condition (*physis*) is not at all exemplary but in need of correction, is brought to the fore even more plainly by the author of the Koan treatise *Peri arthrôn* (On joints). Here the reduction of a compound tibiotarsal dislocation is, to be sure, absolutely refused ("do not reduce such a lesion" – *ta toiauta mê emballein*) — "as it risks killing the patient if the bones are maintained in the state of reduction (*sapheôs gar eidenai chrê, hoti apothaneitai, hôi an emblêthenta emmeinêi*), in which case he dies as a result of spasm (tetanus), and it even happens that leg and foot die off (*spasmos gar ho kteinôn estin, atar kai gaggrainousthai hikneetai tên knêmên kai ton poda*)"; nevertheless careful treatment of the wound is recommended, to keep the patient, who will of course be deformed and paralyzed, alive (*hoti anagkê ton anthrôpon chôlon aischrôs genesthai ... homôs de ... houtô men iêtreuomenoi sôdzontai*) (L. 4.268-274). Although a 'restitutio ad integrum' is not a real possibility, this author recommends some (albeit limited) therapeutic effort, in order to grant the patient a life with limited functioning[34].

This notion of "cure with limited perspectives of functions", for that matter, was not only applied in surgery (which often occupied itself with patients whose life was not in danger, but who could not be completely cured); it is also found in diverse 'internist' treatises of the Knidian school, for instance in the already mentioned *Gynaikeiôn prôton*, in which it is made clear that certain treatments of a serious ulceration of the uterus can lead to a cure, albeit that the woman will remain sterile (*tauta poieousa, hygiês ginetai, geneê de ouk eti*) (L. 8.134). In *Peri nousôn to deuteron* (Diseases II), too, and in the treatise *Peri tôn entos pathôn* (Internal affections), which are reckoned among the oldest writings of the Corpus Hippocraticum,[35] numerous instructions for treatment are found, even in cases where the illness takes a chronic course or becomes incurable. That the author of the last-mentioned work is well aware of the fact that many of such ailments are difficult to treat (*hautê hê nousos chalepê*) and require considerable care (*kai therapêiês deomenê pollês*) is apparent from the recurrent stereotype concluding formula: "without this, the disease is not willing to leave off, but clings to many patients until they die (*ei de mê, ouk ethelei eklipein ton kamnonta, kai hôs ta polla en toisi polloisi xynapothnêskei*)" (L. 7.178-180). The therapy in such cases is directed towards a good adaptation of the life style (*diaitia*) and towards the relief of the symptoms, especially the pain. The aim is to give the patient as much comfort as possible, regardless of the incurable nature of his disease, and this is clearly underscored by the following statement, which concludes several chapters in which therapeutic indications are given for chronic ailments: *houtô gar an rhêista diagoi, hê de nousos chalepê*: "for with this regimen he will fare most easily; the disease is severe" (L. 7.182).

From a number of works in the Corpus Hippocraticum — especially the just mentioned Knidian texts — it appears that incurable illnesses are not by definition placed beyond the therapeutic reach of medical science. The discussion concerning the question whether or not the physician should turn his back on an incurable patient was not (or hardly) waged in these works. It makes one wonder if the recommendation of therapeutic abstinence only appeared in the more theoretical treatises, such as the already mentioned *Peri technês*[36], which offer reflections on the essence of medicine as a *technê*. But even practical writings, such as the Koan *Peri arthrôn*[37], deal explicitly with the therapeutic range of the Art, whereby the author explicitly states that untreatable conditions — such as a backwards and non-reducible femur dislocation, resulting in a permanent shortening of the leg — are not beyond the scope of medicine (*exô iêtrikês*) (*sic*). "The investigation of these matters too belongs to the same science (*tês gar autês gnômês kai tauta xynienai*); it is impossible to separate them from one another. In curable cases we must contrive ways to prevent their becoming incurable (*dei men gar es ta akesta mêchanaasthai, hokôs mê anêkesta estai*), studying the best means for hindering their advance to incurability (*xynienta hokê an* *malista kôlutea es to anêkeston elthein*); while one must study incurable cases so as to avoid doing harm by useless efforts (*dei de ta anêkesta xynienai, hôs mê matên lymainêtai*)" (L. 4.252). Here the physician — so much is clear — is expressly obliged to familiarize himself with incurable diseases, so that he will be able to arrest their development or alleviate their effect on the patient. The author of Diseases I, *Peri nousôn to prôton*[38], is even more explicit on this matter: "Correct is (*orthôs*) to treat the diseases that can be treated (*kai therapeuonta ta men anysta ektherapeuein*), but to recognize the ones that cannot be, and to know why they cannot be (*ta de mê anysta eidenai, dioti ouk anysta*) by treating patients with the former, to give them the benefit of treatment as far as it is possible (*kai therapeuonta tous ta toiauta echontas ôpheleein apo tês therapeiês es to anyston*)" (L. 6.150-152).

A comparative reading of Platonic as well as theoretical and practical Hippocratic texts makes it clear that in Greek antiquity the question 'whether or not one was to bother with patients suffering from an incurable disease' did not always receive the same answer. In other words, there was by no means a consensus '*in ethicis*'[39]. Still, it must not be forgotten that not every Hippocratic physician will have assumed the aforementioned Platonic or Aristotelian position, which in certain cases came to therapeutic abstinence or even outright turning away. Caring for hopeless cases apparently belonged, in many circumstances as we have seen, to the classic duties of the Greek physician. The Christianization of the Roman Empire wrought an enormous change in both the theory and practice of human relations. The Greek philanthropic ideal, which was still to experience several possible interpretations but received — certainly in the later Hellenistic period — an increasingly ethical definition[40], was to be replaced by wholly new terms, not in the least the *caritas hominum*, the 'love of one's neighbour' (a notion complementary to the Greek *erôs* and *philia*), and by the distinction between 'the natural good' (*bonum commune*) and 'the good of the soul' (*bonum animae*). The *caritas* or *agapê*, a term scarcely found in pre-Christian Greek philosophical and medico-philosophical literature (cf. supra), will boil down to the free and active movement of the soul towards another and his needs, towards another 'me' (*allos egô*), whether that be a 'true' friend (an *alêthês philos* in the Platonic and Aristotelian sense of the term) or just a poor, pitiable fellow man (*kakos philos*). And this *agapê* becomes truly Christian at the moment when this outpouring of love towards another is seen as taking place 'within God', when God is not its *causa finalis*, but its *causa efficiens*[41]. In this new, humanely enriching view of things, *caritas* by definition no longer has any 'natural' limits, i.e. defined by the *physis*, nor any social limits (set by the *polis*). This applies also to the *caritas* of the physician, who will give his care without any restraint to the so-called 'personae miserabiles', the incurable and the dying; something the Greek physician, as we have seen, did not consider an evident duty.

Notes

1. L = Littré: LITTRÉ, E., *Œuvres complètes d'Hippocrate*, 10 vol. (Paris 1839-1861). The translations of Greek passages have mostly been borrowed from the *Loeb Classical Library*.

2. It is evident that some interpretative modesty is frequently in order here. The available evidence is extremely fragmentary. Much is to be conjectured. Furthermore, in some attempts to state conclusions one must be continually aware of the danger of unhistorical retro-projection of present-day concepts or of views that underwent a very gradual development.

3. Mantics = art of prediction; theurgics = magical action by which spirits are exorcized.

4. See ALLBUTT, T.C., *The Historical Relations of Medicine and Surgery* (London 1905), p. 6-13.

5. See TEMKIN, O., *Griechische Medizin als Wissenschaft und Handwerk*, in: Antike Medizin (H. Flashar, Hrsgb.), Wege der Forschung CCXXI (Darmstadt 1971); KOELBING, H.M., *Arzt und Patient in der antiken Welt* (Zurich 1977), p. 96-97, and HEINI-

MANN, F., *Die geistigen Voraussetzungen der hippokratischen Medizin*, in: Fundamente moderner Medizin, Documenta Geigy (Basel 1964), p. 2 ff.

6. The honorary title 'Asklepiad', by which Greek physicians were sometimes addressed, eventually, and certainly by the 5th or 4th century, referred no longer to a deity (Asklepios) or to a formal religious sect, but to a family or guild of physicians, who handed down their medical knowledge from father to son or from mentor to pupil. See ACKERKNECHT, E., *A Short History of Medicine* (New York 1955), p. 44, and KUDLIEN, F., *Der Beginn des medizinischen Denkens bei den Griechen von Homer bis Hippokrates* (Zürich 1967), p. 19-22.

7. See KUDLIEN, F., *o.c.* (I. "Arzt und Kranker"; II. "Die Heilkunde", and III. "Grundformen des Krankheitsbegriffes und der Therapie").

8. LAIN ENTRALGO, P., *Doctor and Patient* (London 1969), p. 17.

9. On the late dating of the *Paraggeliai* see e.g. FLEISCHER, V., *Untersuchungen zu den pseudohippokratischen Schriften Paraggeliai, Peri iêtrou, und Peri euschêmosynês.* Neue Deutsche Forschungen, Abt. Klass. Philologie, 1939. For the concrete interpretation of this passage, as well as for the several explications already proposed the reader is referred to FLEISCHER, *o.c.*, p. 38 and esp. to EDELSTEIN, L., *The Professional Ethics of the Greek Physician* (p. 320-321) in: Ancient Medicine. Selected Papers of Ludwig Edelstein (Baltimore 1967).

10. Aristotle, *Ethika Nikomacheia* 1095a19.

11. See also Aristotle, *Ethika Nikomacheia* 1158a, 1172a.

12. BRÜMMER, V., *Liefde van God en mens* (Kampen 1993), p. 115.

13. The notion of *philanthrôpiê*, for that matter, appears only once in the Hippocratic texts, viz. in the late Hellenistic treatise *Paraggeliai* (L. 9.258), in a context leaving some uncertainty as to the significance to be attached to it: see GOUREVITCH, D., *Le triangle hippocratique dans le monde gréco-romain* (Paris 1984), p. 282 and EDELSTEIN, *o.c.*

14. To accept that the word *philanthropia* would already contain the germ of an, if not Christian, then at least truly humanistic ethic would, as Edelstein has rightly emphasized, boil down to an "unhistorical projection of later concepts into an age entirely ignorant of them" (*o.c.*, p. 322). For the evolution of the notion of *philanthropia* see LORENZ, S., *De progressu notionis philanthrôpias*, diss. Leipzig 1914, and HEINEMAN, s.v. "Humanismus", *Realencyclopädie der classischen Altertumswissenschaft*, Supplementband 5, 1931, col. 298. As for the philosophical, Peripathetic and Stoic interpretation of the term *philanthropia* as 'friendliness', 'friendly disposition', see esp. EDELSTEIN, *o.c.*, p. 329 n. 19 and 330 n. 20.

15. NYGREN, A., *Eros and Agape* (London 1982), p. 210-212.

16. BRÜMMER, *o.c.*, p. 137.

17. LAIN ENTRALGO, *o.c.*, p. 21.

18. LAIN ENTRALGO, *o.c.*, p. 23.

19. The Greek's mythopoeic mentality interpreted the origin of the Arts as something that was stolen from the gods (cf. the Prometheus-myth) or, in the concrete case of medicine, as the outcome of the beneficial and divine learning given by the centaur Cheiron to Asklepios, the son of Apollo.

20. Not only Aristophanes in his second *Ploutos* spoke ironically of the Asklepiads; Socrates too complained about the doctors of

Athens, who showed an insufficient understanding of the part played by the soul in the genesis of disease ("and this was the reason why most maladies evaded the physicians of Greece – that they neglected *the whole* [*tou holou*], on which they ought to spend their pains, for if this were out of order it was impossible for *the part* [*to meros*] to be in order" – *Charmides* 156e).

21. "The slaves are usually doctored by slaves, who either run round the town or wait in their surgeries; and not one of these doctors either gives or receives any account of the several ailments of the various domestics (*kai oute tina logon hekastou peri nosêmatos hekastou tôn oiketôn oudeis tôn toioutôn iatrôn didôsin oud' apodechetai*), but prescribes for each what he deems right from experience, just as though he had exact knowledge, and with the assurance of an autocrat (*prostaxas d' autoi ta doxanta ex empeirias hôs akribôs eidôs, kathaper tyrannos*); then up he jumps and off he rushes to another sick domestic" (*Nomoi* 720).

22. JAEGER, W., *Paideia: the Ideals of Greek Culture* (New York 1944).

23. See MAGNER, L.N., *A History of Medicine* (New York 1992), p. 70.

24. BRÜMMER, *o.c.*, p. 116.

25. See e.g. SCHOTSMANS, P., *En de mens schiep de mens* (Kapellen 1992), p. 32.

26. LAIN ENTRALGO, *o.c.*, p. 44.

27. For that matter, it is not known how the Hippocratic Oath came about, nor who (first) pronounced it. According to Edelstein we have to do with a Pythagorean manifesto and not with an absolute standard of medical behaviour: EDELSTEIN, *The Hippocratic Oath. Text, Translation and Interpretation*. Suppl. Bull. Hist. Med. no.

1, Baltimore 1943. Indeed the Oath only assumed canonical significance in the Middle Ages and in Modern Times, whereby it was attributed to Hippocrates and the erroneous assumption prevailed that the 'father of medicine' demanded that all his pupils respect this canon.

28. LAIN ENTRALGO, *o.c.*, p. 45-52.

29. "His view of the Greek physician's *philanthropia* (...) is at variance with Ludwig Edelstein's. Edelstein makes a distinction between the kindliness of the physician–craftsman and the *humanitas* of the later Stoic or the religiously inspired physicians", PELLEGRINO, E.D., and D.C. THOMASMA, *A Philosophical Basis of Medical Practice* (New York 1981), p. 198.

30. LAIN ENTRALGO, *o.c.*, p. 48.

31. LAIN ENTRALGO, *o.c.*, p. 49.

32. Aristides, *Oratio Panathenaica*, cf. Euripides, *Medea* 561; *Hercules Furiens* 559 and *Phoenissae* 403; Zenobius, *Proverbia* 1,90.

33. See e.g. WITTERN, R., *Die Unterlassung ärztlicher Hilfeleistung in der griechischen Medizin der klassischen Zeit*, Münch. med. Wschr. 121, p. 731-734, 1979, and EDELSTEIN, L., *The Hippocratic Physician* (p. 87-110) and *The Professional Ethics of the Greek Physician* (p. 391-419) in: Ancient Medicine (Baltimore 1967).

34. See also KUDLIEN, F., *Der alte Makel der chronische Krankheit*, esp. p. 117 ff., in: Der Beginn der medizinischen Denkens bei den Griechen (Zürich 1967).

35. JOUANNA, J., *Pour une archéologie de l'école de Cnide* (Paris 1974).

36. This treatise dates from the last quarter of the 5th century; see (also for the purpose of the work) JOUANNA, J., *Hippocrate*. Tome V 1ère partie: *Des Vents. De l'Art* (Paris 1988).

37. This treatise must probably be dated about 400 B.C. On its place in the Corpus Hippocraticum, see DEICHGRÄBER, K., *Die Epidemien und das Corpus Hippocraticum. Voruntersuchungen zu einer Geschichte der koischen Aerzteschule* (Berlin 1971), p. 88-89.

38. This treatise dates from the last third of the 5th century; see WITTERN, R., *Die hippocratische Schrift De morbis I. Ausgabe, Uebersetzung und Erläuterungen.* Altertumswiss. Texte und Studien 3 (Hildesheim 1974).

39. There was no well-defined, universally accepted ethic in Antiquity in which the principles of collegiality, the inviolability of life (including that of the unborn fruit), professional secrecy and chastity in contact with the patient and his household, as prescribed in the Hippocratic Oath (*ius iurandum*), were rigourously followed. In this context it should not be overlooked that one of the catalytic factors in the development of Greek medical ethics, according to Edelstein at least, was of a mainly practical nature: an ethical code made it possible to distinguish the Hippocratic physicians from the quacks against whom they were pit. For many their ethical code may simply have had the same function as the incitement to practice formulating a prognosis. It served as proof for the patient and his family that the physician was to be reckoned to a different class of doctors than the unschooled impostors or swindlers who took advantage of the gullibility of many a patient. Perhaps it all boiled down to "an ethic of outward achievement rather than of inner intention": see EDELSTEIN, L., *Ancient Medicine* (Baltimore 1967), and GOUREVITCH, D.: "Qu'en était-il donc réellement de la déontologie hippocratique? Ses règles déontologiques ne sont pas la marque d'une 'belle âme' éthérée, mais représentent plutôt des chapitres d'une morale en action, destinés à protéger le médecin plus encore que

le malade, à défendre la profession contre ses détracteurs" (*Hippocrate au cours des siècles*, p. 70, in: Hippocrate de Cos. De l'art médical (Paris 1994)). See also AYACHE, L.: "Analysée en termes aristotéliciens, l'éthique hippocratique relève de la *phronêsis*: de la prudence, c'est-à-dire d'un savoir-faire tenant compte des opportunités dans un monde changeant, plutôt que de l'impératif moral. Le médecin n'est pas soumis à une loi qui s'imposerait catégoriquement et limiterait le pouvoir de la technique; au contraire, c'est la médecine elle-même qui règle le comportement du practicien en fonction de l'opportunité et des intérêts de la communauté médicale" (*Hippocrate* (Paris 1992)), and PELLEGRINO, E.D. & D.C. THOMASMA: "The Hippocratic books are moral in the sense that they espouse a set of strongly held beliefs about what is right and wrong in the physician's conduct. They are not really ethical in any formal sense of the term; that is, they do not give a systematic justification of philosophical principles for the relationships and obligations they enjoin. The moral precepts themselves are not problematic but simply stated as true. What genuine ethics there is — in the sense of justification of beliefs — is only implicit. No dialectic or analysis of contrary opinions is offered — except possibly between books, but not within them" (*A Philosophical Basis of Medical Practice. Toward a Philosophy and Ethic of the Healing Professions*, p. 201 (New York 1981)).

40. See e.g. GOUREVITCH, D., *o.c.*, p. 255-288 "Les legs de la déontologie hippocratique et les idées nouvelles".

41. BRÜMMER, *o.c.*, p. 137.

LAUDATIO HENDRIK DEELSTRA

R. Dams

Hendrik Deelstra graduated as a chemist from the University of Ghent in July 1959. He obtained his Aggregation for Teaching in High School in 1961. He became Philosophical Doctor in Chemistry at the same University in October 1963 with a Ph.D. thesis on 'Complexes of Lanthanides by Cation Exchange with α-hydroxycarboxylates'. This scientific work was performed at the Laboratory of Analytical Chemistry (Director : Prof. Dr. J. Hoste). Very soon the young doctor left for Africa, where he started a fruitfull teaching career at the Universities of Kinshasha and Kisangani, Zaïre (1964-1967) and at the University of Bujumbura, Burundi (1968-1972). Often in very difficult circumstances, he has enthusiastically taught Principles of Inorganic Chemistry and Advanced Analytical Chemistry at these Universities in the framework of the Belgian Organisation for the Cooperation with Developing Countries. Later on, when he had returned to his home country, his interest in the education in developing countries continued. Up to now he is still involved in organizing cooperation with the University Education in Middle-African countries.

In Belgium his teaching career continued at the Universitaire Instelling Antwerpen. At the Department of Pharmaceutical Sciences he first became Associate Professor and, since 1979, Full Professor, teaching several branches of Analytical Chemistry and Bromatology. At the University of Antwerp he is very much appreciated by his students and his research group performs internationally recognized work in the field of atomic spectroscopic analysis and bromatology.

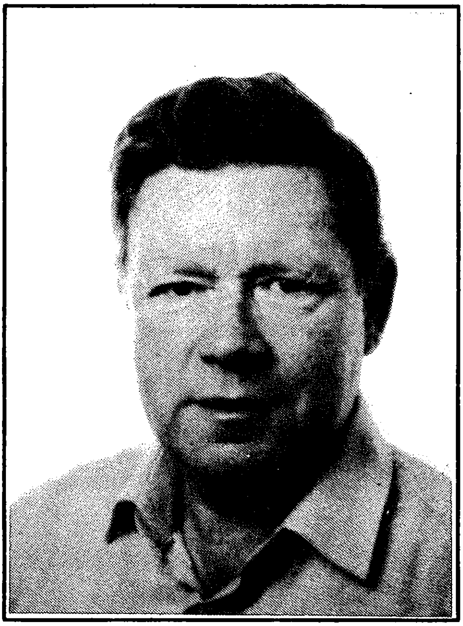
Very soon his interest in History and Philosophy of Science showed up and since 1973 he teaches "History of Chemistry" as an optional course. More recently he has also been charged with compulsory courses on "Studium Generale in connection with Philosophy of Science" and on "History of Science and Technology". In addition he co-organized a large number of national and international symposia, colloquia, conferences and exhibitions on subjects such as "The Evolution of Scientific Thinking", "History of Sciences", "Exact Sciences around Christoffel Plantijn", "Scientific and Industrial Patrimony", "Conservation Management of our Paper-Patrimony", "From Mercator to Frimout", etc. At these occasions and on many other symposia and conferences in Belgium and abroad he was an invited or plenary lecturer and often acted as chairman. Deelstra frequently addresses societies of young chemists, service clubs, high school teachers, and even the general public on subjects linked to the history of science, the career of famous scientists, the story of scientific discoveries, etc.

His list of publications on these subjects is impressive, including 10 chapters in books, 40 articles in scientific journals and monographs. He was co-editor of the proceedings of four symposia.

Deelstra's interest in science and history is also illustrated by his memberships and his participation in international committees. In the "Working Party on the History of Chemistry" of the Federation of European Chemical Societies (FECS) he not only represents his country but since 1993 he is the chairman of this international body. He is also member of the programme of the European Science Foundation : "The Evolution of Chemistry in Europe 1789-1939".

Especially during the last decade Prof. Deelstra has made efforts to increase interest for the history and philosophy of science in Belgium. For example within the Royal Flemish Union of Chemistry (KVCV) he established a section on "History of Chemistry". Since 1990 he also chairs this section, which recently organized some interesting scientific manifestations. He is member of still other national commissions and committees for the History of Sciences, linked to the Royal Academies, the Royal Library, the Royal Academies for Overseas Sciences, the Royal Antwerp Pharmacists Union, etc.

In Belgium Professor Hendrik Deelstra is without any doubt one of the pioneers in the history and philosophy of sciences, especially of chemistry. He was and still is extremely active in arising the interest in this matter of both scientists and the general public. To this aim he wrote a great number of papers and monographies, lectured at many occasions on a variety of subjects connected with the development of Science in Europe and in Belgium, and recently has been very active in organizing scientific meetings and in establishing scientific societies on history and philosophy of science. We are grateful for his efforts to remind us of our important scientific past.



LA PROFESSIONNALISATION DE LA CHIMIE EN BELGIQUE

H. Deelstra

Introduction

La "professionnalisation" dans le domaine scientifique, et plus spécifiquement en chimie, diffère de ce qui se passe dans les autres professions (métiers, commerce et autres professions pratiques ou libres)(1). La différence se situe dans le lien existant entre les professions et les occupations. Alors que la relation entre les occupations et les activités des infirmières, par exemple, est relativement facile à décrire, les chimistes eux peuvent exercer un grand nombre d'activités totalement différentes (2).

On a constaté une évolution dans presque chaque profession : au départ il existe une communauté relativement homogène, dont les membres partagent l'identité, les valeurs, la définition du rôle et de l'intérêt; cela change vers un amalgame imprécis de segments poursuivant des objectifs divers de différentes manières et tenu ensemble par un nom commun, comme cela peut être démontré par l'évolution de la profession médicale.

Les sociologues utilisent différentes caractéristiques pour définir une profession (3). Dans cette étude, nous avons utilisé les critères suivants comme indicateurs de l'institutionnalisation de la chimie comme profession.

1) La création de la première chaire de chimie, l'évolution dans l'enseignement de cette discipline et finalement la législation ou la légitimation de la chimie par la création des grades

académiques spécifiques.
2) L'évolution des activités exercées et le contenu du travail.
3) La création des association professionnelles et leurs activités.

Le but de cet article est d'essayer d'identifier et de décrire ces trois indicateurs pour la Belgique comme une contribution à l'historique du développement de la profession de chimie en Belgique.

L'Enseignement en chimie et les grades académiques en Belgique

1. L'enseignement de la chimie avant 1830

Selon les sociologues, un des meilleurs indicateurs du début du professionnalisme ou mieux "l'institutionnalisation" d'une profession pourrait être la création d'une chaire dans cette discipline (4). Il y a encore peu de connaissance sur les origines de l'enseignement de la chimie en Europe, mais il y a peu de doutes que la chimie était largement discutée et même enseignée avant qu'une chaire spécifique ne soit créée (5).

La reconnaissance académique de la chimie est venue de sa valeur pratique pour la profession médicale. Johan HARTMANN (1568-1631) devint en 1609 le premier professeur de chimie à Marburg et l'Université de Louvain nomma Adrien REGNAULT (1651-1695) comme premier professeur de chimie en chaire indépendante le 7 juillet 1685.

La chimie était considerée comme un sujet auxiliaire dans le programme d'études médicales directement en rapport avec la préparation des médicaments. Jusqu'en 1817, l'étude de la chimie en Belgique étant toujours une partie de l'enseignement médical, la chimie elle-même était dispensée par des professeurs de médecine ou des pharmaciens. Seulement les derniers titulaires de chimie à l'ancienne université de Louvain et surtout Ch. VAN BOCHAUTE (1732-1793) semblent avoir envisagé la chimie comme une science de manière plus large que comme "servante de la médecine" (6).

Après la suppression de la vieille université de Louvain en 1797, les Pays-Bas méridionaux restaient sans aucune institution d'enseignement universitaire. Le développement de l'enseignement supérieur en Belgique, en particulier celui de la chimie a commencé durant la période de l'unification avec la Hollande en 1815. La situation désastreuse sur le plan de l'enseignement supérieur s'acheva par un décret royal de Willem I le 25 juillet 1816 "sur l'organisation de l'enseignement supérieur dans les provinces méridionales". Trois universités d'Etat furent créées respectivement à Louvain, à Liège et à Gand. Leur organisation était copiée sur celle des trois universités du Nord, de Leiden, d'Utrecht et de Groningen, réorganisées un an auparavant. Le roi Willem I créa dans chaque université une faculté de mathématiques et de sciences naturelles, séparée de la faculté de médecine.

Dans ces nouvelles facultés on enseignait les mathématiques, la physique, la chimie, la botanique et la zoologie. Le décret déclarait que les étudiants de médecine devaient obligatoirement passer les examens de candidature en mathématiques et sciences naturelles avant de commencer leurs études de médecine dans la faculté de médecine. La grande majorité des étudiants dans les candidatures de mathématiques et de sciences naturelles se destinaient à la médecine. Ils étaient obligés de suivre un cours sur "les principes de chimie générale". Très peu d'étudiants de cette faculté souhaitaient faire ici un doctorat, essentiellement parce que les perspectives professionnelles étaient limitées. Ces quelques étudiants devaient suivre au cours de leur doctorat un cours de "chimie appliquée".

Quoiqu'il en soit, l'enseignement de la chimie en Belgique pendant la période hollandaise fut insignifiant. A Gand, un ancien professeur de mathématiques d'Allemagne, J.C.F. HAUFF (1766-1846) fut nommé professeur de physique et de chimie, bien qu'il s'intéressait bien plus aux pratiques médiçales. A Liège J.Ch. DELVAUX de Fenffe (1782-1863) fut nommé pour enseigner la chimie, la physique et la métallurgie. Etant plus intéressé en physique, il avait peu de temps pour la chimie. J.B. VAN MONS (1765-1842), incontestablement le plus célèbre chimiste, fut nommé à Louvain. En 1789 VAN MONS était l'un des premiers disciples de la théorie de Lavoisier et il avait une profonde connaissance de la recherche en chimie de son temps. Après sa nomination à Louvain en 1816, J.B. VAN MONS fut le seul professeur de chimie en Belgique à créer un laboratoire de chimie. P.J. HENSMANS (1802-1862) devint son assistant.

Une des multiples initiatives du roi Willem I fut la promulgation d'un décret le 13 mai 1825, instaurant l'enseignement de la chimie technologique à la faculté de mathématiques et de sciences naturelles. Ce cours n'était pas destiné à la formation générale des étudiants en chimie, mais au grand public. Cette initiative originale eut uniquement du succès à Gand. C.A. BERGSMA (1798-1859) fut nommé specialement par le roi pour enseigner "la chimie appliquée à l'Ecole des Arts et Métiers" (School van Kunsten en Ambachten) nouvellement créée. La ville de Gand offrit les possibilités de création d'un excellent laboratoire equipé (7).

2. L'évolution de l'enseignement de chimie et des grades académiques après 1830

L'indépendance de la Belgique fut suivie d'une période très instable. Les facultés de sciences de l'université de Gand et de Louvain furent fermées par le gouvernement provisoire en octobre 1830. Mais cette mesure fut suivie immédiatement par la création des facultées libres de sciences. En effet ces facultés étaient indispensables pour la formation des étudiants dans la faculté de médicine. Le premier professeur de chimie à Gand fut E. JACQUEMIJNS (1806-1874), mais pour des raisons politiques, il fut remplacé par D.J.B. MARESKA (1803-1855), anciennement préparateur de C.A. BERGSMA à l'Ecole des Arts et Métiers (8). A Louvain, l'enseignement de la chimie était dispensé par J.B. VAN MONS et P.J. HENSMANS. A Liège J.Ch. DELVAUX fut maintenu comme professeur. Trois étudiants bien connus suivaient pendant cette période les cours de VAN MONS, à savoir, L.G. DE KONINCK (1807-1887), J.S. STAS (1813-1891) et L. MELSENS (1814-1866).

En 1834, une université Catholique fut créée à Malines; à Bruxelles une autre fut créée par des libre-penseurs. Il y avait donc cinq universités. Cette période confuse de transition (1830-1835) se termina par la promulgation de la première loi organique sur l'enseignement supérieur (loi de THEUX) effective le 27 décembre 1835. Cette loi, tant attendue, reconnut deux universités de l'Etat : à Gand et à Liège et deux universités libres : une université catholiqùe à Louvain (transférée de Malines à Louvain) et une université libre, non catholique à Bruxelles. En 1836 une école vétérinaire fût fondée et en 1838 une académie militaire. Un événement probablement très important dans le professionnalisme des chimistes fut la création en 1835 des instituts polytechniques dans les deux universités d'Etat. Ces instituts polytechniques, bien que faisant partie des facultés des sciences, étaient principalement inspirés par l'école polytechnique française fondée en 1794.

Le développement de l'enseignement supérieur en Belgique en général, et donc aussi l'enseignement de la chimie, fut entravé depuis 1835 par les rivalités et la méfiance entre les différentes universités. Trois thèmes étaient continuellement en discussion : (a) l'autorité ayant la qualité d'accorder les grades académiques; (b) les critères d'admission à l'université; et (c) le continu des programmes d'études (9).

Comme compromis, dans le but de garantir l'équivalence des diplômes et de respecter la liberté constitutionnelle de l'enseignement, il fut décidé que tous les examens universitaires seraient organisés par "un jury central" résidant annuellement à Bruxelles. Les membres du jury seraient désignés par le sénat, le parlement et le gouvernement. La loi du 15 juillet 1949 (loi ROGIER) modifia la composition de jury. Il serait composé en moitié par des professeurs des universités d'Etat, en moitié par des professeurs des universités libres (dénommé jury mixte). Malgré les bonnes intentions, ce système d'examen fut un échec pour le développement des sciences dans les différentes universités. Le système d'un jury unique fut aboli par la loi du 20 mai 1876 (loi DELCOUR). A partir de ce moment, chaque université pouvait délivrer ses propres diplômes, qui devaient être homologués par une commission du gouvernement.

Le deuxième point de discorde entre universités était en les critères d'admission pour les étudiants de première année. Différents systèmes furent successivement adoptés : admission libre (27.12.1835); examens d'admission (15.07.1848); admission libre (14.03.1855), certificat d'études secondaires (01.05.1857); deux conditions : un certificat d'études secondaires et un examen d'admission (27.05.1861); admission libre (20.05.1876) et finalement un certificat homologué d'études secondaires en 1890 (10).

La promulgation de deux lois en 1890 et 1891 (respectivement loi DEVOLDER et loi de BURLET), furent d'une grande importance pour le développement des sciences, et particulièrement la chimie, parce que ces lois créaient six grades académiques à la faculté des sciences, dont un grade de docteur en sciences chimiques. La présentation d'une thèse sur un travail original en chimie expérimentale et sa défense devant un jury était nécessaire avant l'octroi du diplôme de docteur en sciences chimiques. La loi du 21 mai 1929 (loi VAUTHIER) fut enfin de nouveau une stimulation pour l'enseignement et la recherche en chimie, puisque l'étudiant se préparant pour une carrière en chimie pouvait choisir dès les candidatures l'orientation de la chimie. Cette même loi organisait dans les écoles spéciales des études pour un grade académique nouveau, celle des ingénieurs chimistes.

L'évolution de l'enseignement de chimie dans les quatre universités peut être mieux comprise par le rappel des plus importants professeurs et de leurs enseignements dans chaque université.

A Gand D.J.B. MARESKA était responsable de tout l'enseignement de chimie. En 1842 il était assisté par un autodidacte, F.M.L. DONNY (1822-1896). La mort soudaine de MARESKA en 1858 fut une occasion pour le gouvernement de demander à J.S. STAS de lui succéder. L'éminent chimiste belge, très connu pour ses déterminations méticuleuses des poids atomiques, ne pouvait se résoudre à quitter Bruxelles, où il avait été nommé en 1840 professeur de chimie à l'académie militaire, parce qu'il avait consacré plusieurs années à travailler dans son laboratoire privé, monté et équipé à ses frais. STAS, qui était directeur de l'académie belge des sciences, persuada le gouvernement de chercher un chimiste étranger pour pouvoir à la vacance à Gand, parce qu'aux yeux de STAS, le seul chimiste valable, L. MELSENS, professeur à l'école vétérinaire depuis 1846, était en mauvaise santé. STAS persuada le gouvernement d'inviter A. KEKULE (1829-1896) à accepter les cours de chimie générale (11). F. DONNY, soutenu fortement par J.B. DUMAS (1800-1884) fut désigné pour le cours de chimie appliquée. La présence de A. KEKULE à Gand fut extrêmement important pour le développement de la chimie en Belgique, car avec l'influence de STAS, le premier véritable laboratoire d'enseignement et de recherche en chimie fut crée à l'université de Gand en 1862 (12). Ce qui était vraiment exceptionnel en ce temps, à tel point que STAS déclarait dans une lettre à J. LIEBIG (1803-1873) en 1859 que "en vingt cinq ans, le gouvernement belge n'a pas fait pour l'enseignement de la chimie autant que ce qu'il fait maintenant pour Kékulé seul" (11). Après neuf ans à Gand, l'université de Bonn offrit à Kékulé la chaire vacante après le départ de A.W. von HOFFMANN (1818-1892) pour Berlin. T. SWARTS (1839-1911), assistant de Kékulé, lui succèda en 1867. Avec DONNY il était responsable du plus grand enseignement de chimie pour le restant du 19ième siècle. De nouveaux cours de chimie furent instaurés pour les futurs pharmaciens : en 1876 un cours de chimie analytique et en 1886 un cours de chimie alimentaire. Enfin, un cours sur la chimie physique fut instauré comme cours à option en 1895.

En 1837, J.Ch. DELVAUX quitta l'université de Liège et fut succédé par un chimiste plein de promesse, L.G. DE KONINCK. Par manque de subvention à l'installation d'un laboratoire il orienta ses recherches vers les études paléontologiques qui le rendirent célèbre. Cependant son enseignement de chimie restait à jour. En 1865 déjà, il introduisit dans son cours de chimie organique la théorie des types de A. LAURENT (1807-1853) et Ch. GERHARDT (1816-1856). La chimie appliquée était enseignée par J.T.P. CHANDELON (1814-1885). En 1877 W. SPRING (1848-1911) succéda à DE KONINCK. Ingénieur de formation il fut le premier professeur belge de chimie physique, nouvelle discipline à l'époque. En 1876, L.L. DE KONINCK (1844-1921), fils de L.G. DE KONINCK, devint le professeur d'un nouveau cours officiel de chimie analytique et en 1883, on nomma A. JORISSEN (1853-1920), professeur de chimie alimentaire.

M. MARTENS (1797-1863) fut le premier professeur de chimie à l'université de Louvain. Son enseignement était purement théorique et il était plutôt conservateur. L. HENRY (1834-1915) lui succéda en 1863; il poussa les autorités académiques de l'université à porter plus d'attention à la formation pratique de chimie des étudiants. Il demanda et obtint des facilités pour créer un grade spécifique de docteur en sciences chimiques. En 1875, donc bien avant le 10 avril 1890, date officielle d'instauration de ce grade, deux étudiants d'Henry obtiennent ce grade officieux de l'université de Louvain (13). HENRY peut aussi être compté parmi les pionniers de la chimie organique. Il devint célèbre par ses travaux de synthèse et pour ses recherches poussées sur la volatilité des composés organiques qu'il a dénommé la "solidarité fonctionnelle", qui peut être considéré comme la base de la corrélation moderne de relation structure-activité (14). Grâce à son l'influence, l'enseignement de la chimie devint plus diversifié à Louvain à la fin du 19ième siècle.

Le premier professeur de chimie à l'université Libre de Bruxelles fut G.E. GUILLERY (1791-1861). En 1840 il était assisté par C.J. KOENE. Ce dernier donnait sa démission en 1858 et fut replacé par J.B. FRANCQUI (1835-1871). J.B. FRANCQUI, recteur de 1861 à 1869, stimulait beaucoup la réorganisation de l'école de pharmacie, créée en 1842. En 1864 un cours nouveau de chimie alimentaire est introduit avec comme titulaire J.B. DEPAIRE (1824-1919). Le professeur le mieux connu fut P. DE WILDE (1835-1916) nommé en 1871 après le décès de FRANCQUI. P. DE WILDE recruta A. REYCHLER (1854-1938), un excellent chimiste qui se consacra à la recherche physico-chimique. P. DE WILDE et A. REYCHLER publièrent ensemble plusieurs études importantes sur la chimie appliquée.

A l'école militaire, le célèbre J.S. STAS fut désigné en 1840 comme professeur de chimie; il termina son enseignement en 1865 quand une affection du larynx l'empêcha de continuer à donner ces cours. Le deuxième professeur de chimie à l'école militaire, qui jouit d'un grand prestige fut L. CRISMER (1858-1944) qui fut nommé en 1893. A l'école vétérinaire, créée en 1836, il existaient des cours de sciences jusqu'en 1890. Le professeur de chimie le mieux connu est sans aucun doute L. MELSENS, qui fut nommé en 1846 et qui resta titulaire jusqu'à sa mort en 1886.

Chimiste par occupation

Au cours du 19ième siècle, des chimistes propres n'étaient formés que très rarement dans les universités belges, essentiellement parce que les perspectives professionnelles étaient limitées. Les universités avaient seulement besoin de quelques chimistes pour les quelques chaires.

Seuls quelques bons étudiants avaient l'occasion d'aller dans un pays étranger, principalement la France ou l'Allemagne pour faire de la recherche afin d'être préparé pour un professorat dans une université Belge ou un institut d'enseignement supérieur. Quelques exemples : L.G. DE KONINCK, le premier professeur de chimie à l'université de Liège avait fait des séjours à Paris et à Giessen de 1834 à 1835, où il avait eu des contacts avec J.B. DUMAS (Paris) et J. LIEBIG (Giessen). Son successeur W. SPRING cependant avait l'occasion de faire de la recherche à Bonn de 1871 à 1875 chez A. KEKULE et R. CLAUSIUS. J. STAS et L. MELSENS étaient de 1837 à 1840 chez DUMAS à Paris, tandisque MELSENS continuait ses recherches chez J. LIEBIG jusqu'en 1844. L. HENRY, le premier professeur de chimie à Louvain avait étudié la chimie de 1856 chez H. WILL, le successeur de J. LIEBIG à Giessen. Le premier professeur d'une chaire de chimie formé au pays fut T. SWARTS à Gand qui avait eu la chance d'être initié en chimie chez A. KEKULE de 1858 à 1867. Comme déjà cité plus haut, L. HENRY fut le premier d'introduire un grade spécifique de docteur en sciences chimiques. En 1875, deux étudiants de doctorat, G. BRUYLANTS et U. WAREG-MASSALKI, obtinrent ce grade (14).

Les médecins, pharmaciens, ingénieurs et vétérinaires apprenaient la chimie au cours de leur formation, certains d'entre eux s'orientant vers une profession où ils avaient besoin de la chimie. On a encore très peu de connaissance en ce qui concerne la "professionalisation" de ces diplômés dans des occupations où la chimie était nécessaire. On peut citer l'exemple de Charles MAURICE, formé à l'institut polytechnique ou aux écoles spéciales de Gand, qui en 1866 fondait à Charleroi la première industrie d'engrais phosphatés sur le continent.

Il est clair cependant que pendant le 19ième siècle la "professionalisation" de chimie avait aussi lieu en dehors des universités. Un exemple est celui de Ernest SOLVAY (1838-1921), qui a été un autodidacte et qui installa en 1865 à Couillet une nouvelle industrie pour la préparation de la soude ou des carbonates de sodium (15).

L'industrialisation chimique en Belgique et le travail des chimistes dans ces industries est encore un domaine intéressant pour la recherche.

La creation et les activites de l'association professionnelle

En 1887, 23 chimistes fondèrent "l"Association Belge des Chimistes" à Bruxelles. L'article 2 des statuts de l'Association exprimait l'objectif commun des membres fondateurs : "l'étude des questions chimiques et techniques et la défense de l'intérêt professionnel commun ...". Les membres fondateurs avaient clairement l'idée de créer une société pour la chimie appliquée.

La figure 1 montre l'évolution des membres de l'Association pendant la première décennie (1887-1897). On constate une augmentation importante durant les quatre premières années, ce qui est dû à la création de trois sections. Les fondateurs se groupaient presqu'entièrement dans la section sucrière. Le 20 mars 1889 il fut décidé d'organiser une section des denrées alimentaires et d'hygiène publique, le 7 août 1889 une section de la chimie agricole et le 23 avril 1890 une section des industries de fermentation et des industries connexes. Après la constitution de cette dernière section l'Association comptait le 30 avril 1890 292 membres (effectifs et honoraires, ce qui veut dire : chimistes et industriels).

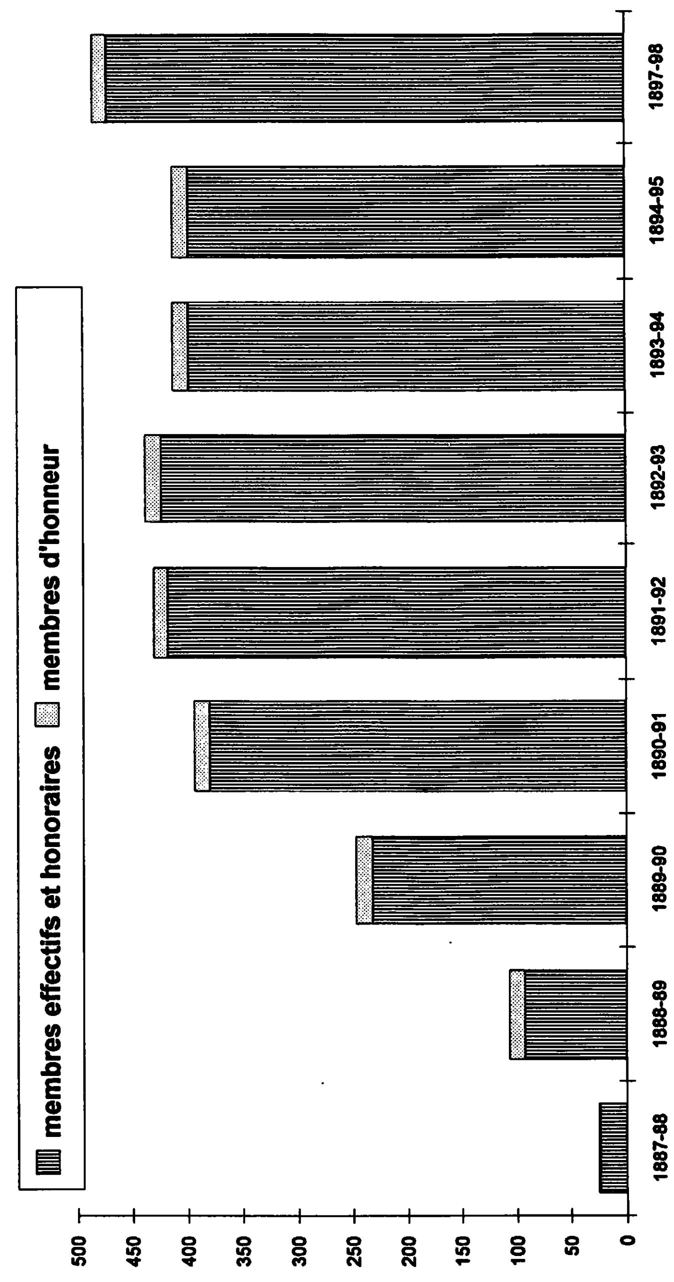


Figure 1

La figure 2 donne la répartition des membres sur les quatre sections pendant cette première décennie après la création de l'Association.

En plus de la création des sections il fut décidé de nommer des membres d'honneur : le premier fut l'éminent chimiste J.S. STAS. Le conseil d'administration proposait d'inscrire le nom de M. STAS en tête du tableau des membres d'honneur de l'Association, parce qu'il était "l'incarnation de l'exactitude et de la méthode dans la recherche analytique". Un bulletin de l'Association était prévu en 1890; il débuta en 1892.

Sept ans seulement après la fondation de l'Association Belge des Chimistes, (maintenant un siècle passé) les chimistes belges organisaient à Bruxelles et Anvers du 4 ou 11 août 1894 le Premier Congrès International de Chimie Appliquée. La préparation de ce congrès, actuellement considérée par l'IUPAC comme son premier congrès, a certainement énormément contribuée à la "professionalisation" de la chimie en Belgique. La préparation de ce congrès, initialement prévu pour 1892, a eu lieu en 1894, parce que l'exposition universelle était organisée cette année à Anvers. Le président de l'Association M.Ed. HANUISE proposait de restreindre le congrès aux matières agricoles et sucrières, mais les autres membres du comité central s'opposaient radicalement à cet idée. Finalement, chaque section préparait l'organisation du congrès, entre autres par la préparation d'un certain nombre de questions à soumettre au congrès (16). Le congrès fut ouvert le 4 août 1894 au Palais des Académies à Bruxelles par M.L. DE BRUYN, Ministre et Président d'Honneur du Congrès. Dans son discours d'ouverture le ministre insista sur le problème qui dominait toutes les questions du programme du congrès, c'est-à-dire la question "de l'unification des méthodes d'analyses dont la solution a été vainement poursuivie jusque là, parce que l'état de la science ne permettait pas encore d'atteindre cet idéal, mais surtout parce qu'on avait pas encore trouvé l'occasion de s'entendre". Le nombre des adhésions reçues pour le congrès s'élèvait à 397 personnes (voir tableau I), qui se répartissaient sur les quatre sections (voir Tableau II).

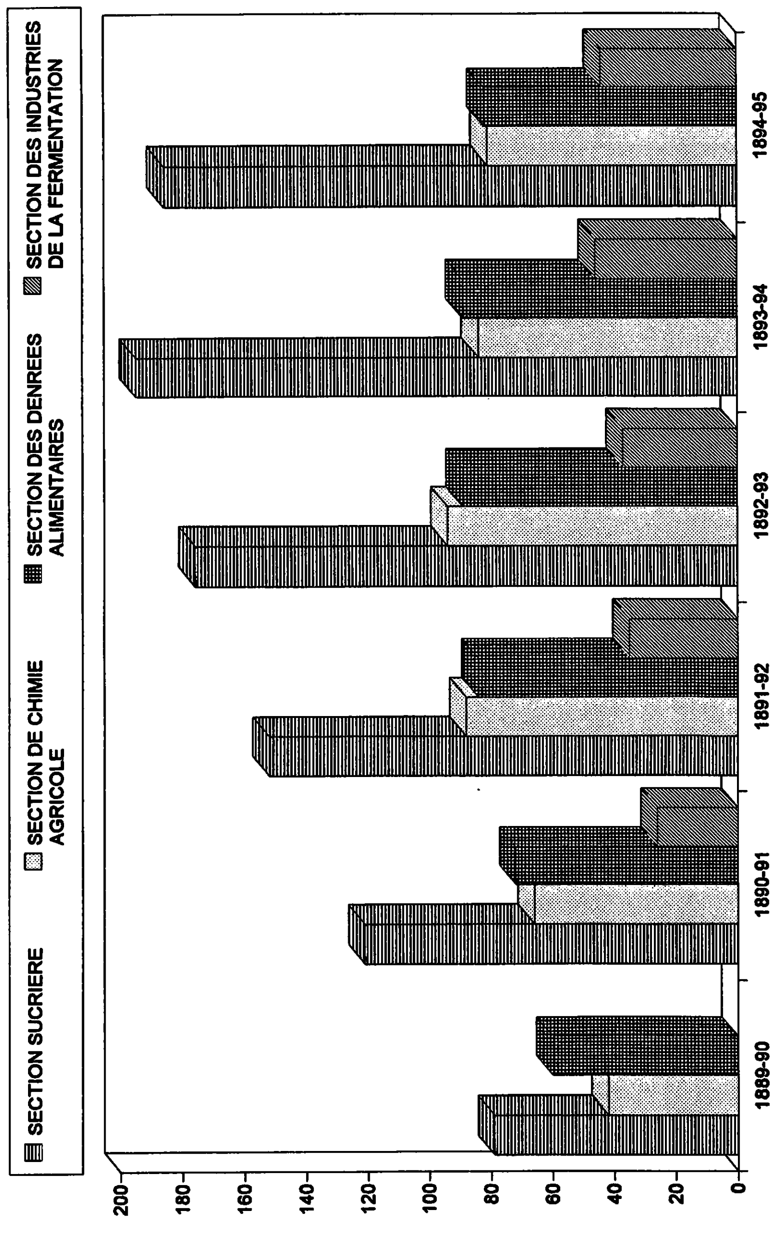


Figure 2

Belgique	205	Bulgarie	2
France	78	Etats-Unis	8
Pays-Bas	16	République Argentine	3
Allemagne	17	Brésil	1
Autriche-Hongrie	11	Canada	1
Angleterre	11	Bolivie	1
Russie	11	Guyane Anglaise	1
Italie	10	Porto-Rico	1
Espagne	3	Egypte	1
Roumanie	2	Ile Maurice	2
Portugal	2	Chine	2
Suisse	2	Japon	1
Suède	2	Java	1
Luxembourg	2		
	2		
A reporter	372	Total	397

Tableau I : Adhésions reçues pour le congrès

Section sucrière	150
Section de chimie agricole	64
Section des denrées alimentaires et d'hygiène	83
Section de chimie biologique	78
Non classés	22
	Total 397

Tableau II : Répartition des participants sur les sections

Il faut encore insister sur le rapport remarquable, au nom du comité central de l'Association Belge, qui fut donné par M.H. VAN LAER, avec comme intitulé "Des mesures destinées à faciliter aux chimistes et techniciens l'accès rapide de toutes les publications qui les intéressent". Le compte-rendu, publié par F. SACHS en 1894 chez l'imprimerie G. DEPREZ (530 p.) donne une bonne idée des travaux (première partie, 230 p.) et des rapports (deuxième partie, 300 p.) du congrès (17).

La plupart des professeurs de chimie des université belges devinrent membres de l'Association après ce congrès. Leur présence provoqua une situation critique. Certains membres fondateurs de l'Association craignaient que l'objectif de l'Association serait modifié des aspects pratiques de la chimie vers une chimie plus académique. En 1904 l'Association adopta un nouveau nom : "Société Chimique de Belgique". Entretemps l'Association avait abandonné les sections concernant des disciplines, mais avait créé des sections régionales, dans huit villes du pays.

Conclusion

L'institutionalisation de la chimie en Belgique à été étudiée à l'aide de trois critères spécifiques. Cette étude traite surtout l'émergence de la "professionalisation" de chimie en Belgique pendant le 19ième siècle. On peut citer plusieurs critiques :

- on est parti du point de vue que le chimiste devrait avoir une formation universitaire; ceci fut peut-être vrai pour le 19ième siècle, mais n'est certainement plus exact plus tard;
- pendant le 19ième siècle il n'y avait en Belgique (avant 1890) pas de diplômés avec un grade académique en chimie; les chimistes pendant cette période furent donc d'autres diplômés, comme les pharmaciens, les ingénieurs civil ou agricoles, etc., mais aussi des chimistes autodidactes, donc des personnes ayant appris la pratique de la chimie pendant leur travail;
- enfin, cette étude n'a pas encore fait de distinction entre les chimistes propres et les chimistes technologues.

Il est donc clair que notre étude sur la professionalisation de chimie en

Belgique présente encore bien des imperfections. Ceci signifie en tout cas un défi pour la continuation de la recherche.

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LAUDATIO STUART BENNETT

A. Van Cauwenberghe

Prof. Stuart Bennett obtained a Diploma in Applied Mathematics in 1964 and a Ph.D. degree in 1970, both at Sheffield University in England. In 1972 he became lecturer in the Department of Control Engineering. Since 1989 he is full professor at the same department at Sheffield University.

In 1982 he was visiting Research Fellow at the Department of the History of Science and Technology at the National Museum of American History, Smithsonian Institution in Washington D.C. and in 1988-1989 he enjoyed a sabbatical leave as Senior Research Fellow at the same institution.

Prof. Bennett is a specialist in computer control : real-time and interactive computing including management information systems and computer control in the process industries. As such he (co-)authored 4 books and wrote more than 30 papers.

He also got interested in an early stage in the history of control engineering, particularly measurement and control instrumentation. He wrote two books on this subject, one describing the historical development from 1800 to 1930, the other one from 1930 to 1955. He is the author of the section "History of Control" in the well-known "Encyclopedia of Systems and Control" (Editor M.G. Singh, Pergamon Press, 1987). He authored 13 papers on the same subject.

His current activities embrace :
- strategic planning and operations control for complex mixed-mode systems;
- instruments and the heat treatment of steel : a comparative study; and
- technology, organization and people.

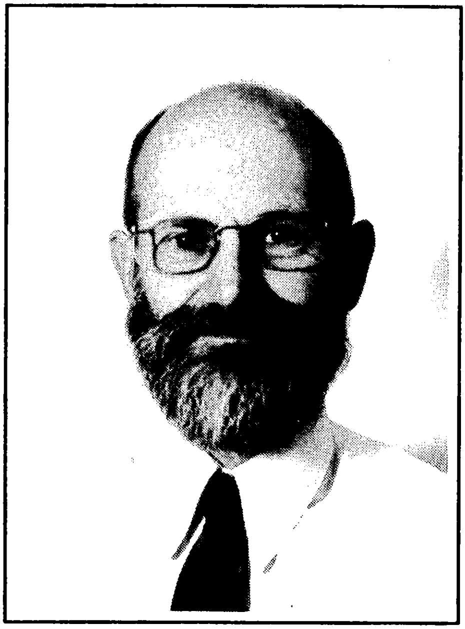
His present duties include teaching as well as administration. His teaching relates to computer control, software engineering and real-time system design. He is member of the University's Teaching Quality Assessment group, a member of Court, Council and Senate of the University of Sheffield and of the Finance Committee of his university.

During his stay at the Smithsonian Institution he took part in the organization of two exhibits : "Workers and Managers" (1989-1990) and "The Information Age" (1990).

Prof. Bennett is also a member of IFAC's (International Federation of Automatic Control) Technical Committee on the "Social effects of automation" as well as of the History Committee of the IEEE (Institute of Electrical and Electronic Engineers) Control System Society. He is also a trustee of the Kelham Island Industrial Museum.

From this we rightly conclude that Prof. Bennett is a brillant engineer, a man of science and technology, a scholar with wide and interdisciplinary interests. As a young professor, working in a country where the industrial revolution started, he got interested and became proficient in the history of the technological evolution in control engineering, a discipline that greatly influenced the shaping of our modern industrialized society.

The Sarton Committee is happy that he accepted to deliver a G. Sarton Memorial Lecture to-day in Ghent, one of the very first towns where the industrial revolution took roots, in the "terra firma" of the European continent.



THE ONE BEST WAY : INSTRUMENTS FOR MEASUREMENT AND CONTROL

Stuart Bennett

When I first began to write about the history of control engineering — as a Research Assistant preparing material for the inaugural lecture of my Professor — much of the engineering history I read was written by engineers, for engineers, and like most of the more general history of technology, it was internalist in approach. It was an account of inventions and of the struggles and eventual triumph of inventors; there was also the assumption that technical progress followed from scientific discovery. There were some dissenting voices : Lewis Mumford, in a series of books, took a broader view; as did the physicist J.D. Bernal who, in writing from a Marxist perspective, attempted to relate scientific and technical change to economic and social conditions.[1] It was refreshing to read Bernal arguing that the scientific discoveries of the 19th century owed much to the mechanicians and practical men of the 18th century.

Over the past 25 years the genre has been transformed : the history of technology has been incorporated into the mainstream of economic, social and labour history. Economic historians such as David Landes and Nathan Rosenberg have explored deeply industrial change and the complex relationships between technology and economic and legal structures. Alfred D. Chandler Jr. in his book *The Visible Hand* drew attention to the important changes in the organisation of industrial companies which occurred during the latter part of the 19th century and the early part of this century; in particular to the development of a managerial bureaucracy with its need for measurement, and calculations of performance and efficiency.[2] Thomas P. Hughes has shown that technical change needs to be viewed as part of the development of socio-technical systems.[3] The work of the labour process historians, and in particular Harry Braverman and David Noble, has focused attention on the issue of who is in charge, managers or workers.[4] More recently both sociologists and historians have argued that technology is a social construct and that technological change cannot be understood outside its social context.[5]

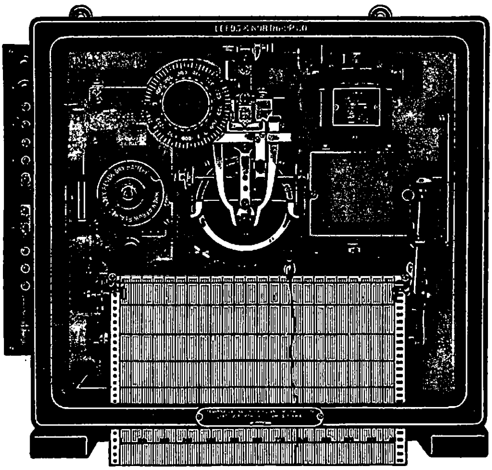
There is also a growing interest in studying the history of smaller scale enterprises and networks of independent producers.[6] As well as in the history of the enabling technologies such as the telegraph and telephone. My particular interest is in an enabling technology — measuring, recording and controlling instruments — and their introduction into industry.[7] The scientific triumphs of the nineteenth century physicists combined with changes in business structures together produced a thirst for quantification and standards. This in turn led to the movement of measuring instruments — indicators, recorders and eventually automatic controllers — from the scientific laboratory to the factory; and also to extensive changes in the record keeping within businesses.[8]

I am going to tell the story of one instrument : the Leeds & Northrup recorder which was designed and developed by Morris E Leeds between 1908 and 1912. Morris E Leeds was born, in 1869, into a Quaker family. He developed a fascination for nature, became an expert botanist and ornithologist, tried his hand at teaching but eventually decided on a career in business. Through family connections he joined the James W Queen Company of Philadelphia, then the largest American instrument firm; during 1892-93 he studied at the University of Berlin and took the opportunity to visit the leading European instrument makers. He continued to work for the Queen company until 1899 when he left to form his own company - the Morris E Leeds Company. In 1903 he took as a partner the physicist Edwin Northrup and the company was renamed as the Leeds & Northrup Company.

The Leeds recorder (see figure 1) is designed to produce on paper a record of small changes in electromotive force (emf) produced by a measurement sensor, for example, from a thermocouple or from the

LEEDS & NORTHRUP COMPANY

PRICE LIST



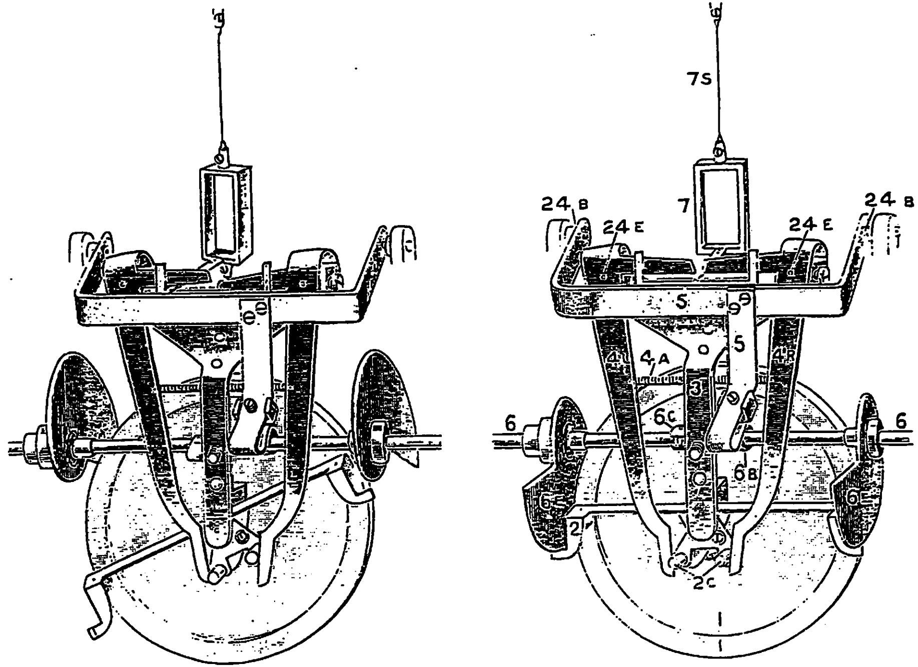
No. 8571-h Potentiometer Recording Controller with front setting device

POTENTIOMETER RECORDING CONTROLLERS

Fig. 1 : Leeds & Northrup Recorder (reproduced from Leeds & Northrup Catalogue No. 84 1920).

imbalance in a Wheatsone bridge circuit. The emf is converted into a mechanical movement by the use of a galvanometer and this movement is recorded over a period of time as a trace on paper. The technical problems are (i) how to get a visible mark on the paper without disturbing the galvanometer movement and hence distorting the measurement; and (ii) how to get a record on a rectangular grid rather than a curved grid - the galvanometer arm swings in an arc. The essence of the device is a servomechanism, that is a position following system which both amplifies the movement of the galvanometer arm and also follows its movement precisely. To do this, Morris Leeds designed a system in which, periodically (typically at 1 minute intervals), the galvanometer needle was clamped and then mechanical feelers were used to sense its position. The principle is illustrated in figure 2. The spring loaded feelers are pressed against the needle, the larger the deflection of the needle from

CONSTRUCTION AND OPERATION OF THE RECORDER MECHANISM



MECHANISM UNBALANCED
Fig. 1.

MECHANISM BALANCED
Fig. 2.

Fig. 2 : Detail of the recorder balancing mechanism (reproduced from Leeds & Northrup Catalogue No. 85 1914).

the null position, indicated by the centre of the feeler arms, the greater the tilt in the follow-up mechanism. When the needle is unclamped the cam (6E on figure 2) corrects the tilt and in so doing moves a pen across the recording paper. The first recorders used clockwork drives for the chart and the follow-up mechanism, however, by the time the recorder was released for general sale the clockwork drives had been replaced by single electric motor whose speed was controlled by a mechanical governor.

Neither the periodic clamping of the needle, nor the use of a follow-up servomechanisms were new; both were use in the Callendar recorder (see figure 3) being sold by the Cambridge Scientific Instrument Company (it was marketed by the Taylor Instrument Companies in the USA). The Callendar recorder used electrical contacts and on-off control for the follow-up mechanism : a key feature of the Leeds recorder was that the follow-up movement was made proportional to the error. Furthermore the Leeds instrument was designed for industrial use rather than scientific use and was made robust.

Recorders were sold to the Packard Motor Company, who had approached the Leeds & Northrup Company in 1909 for advice and assistance with overcoming the problem of the lack of trained heat treaters, and to the Midvale Steel Company where they were used in the heat treatment room. A Leeds & Northrup employee, William J Wrighton, when visiting the works noticed that the traces obtained clearly showed the recalescence point of the carbon steel being treated (see figure 4). The recalescence point, also referred to as the critical point, is the point at which a phase change takes place in carbon steels. Investigations by Henry Clifton Sorby and others during the 1880s on the effects of heating and quenching of carbon steels, that is steels containing between 0.6 % and 1.4 % carbon, had shown that the hardness, and hence the ability of steel to retain a sharp edge, was dependent on the grain structure and crystalline form of the ferrous-carbon mixture. Heating and cooling changed the grain structure, for example, rapid cooling (quenching) preserved the grain structure that had been formed at the high temperature.

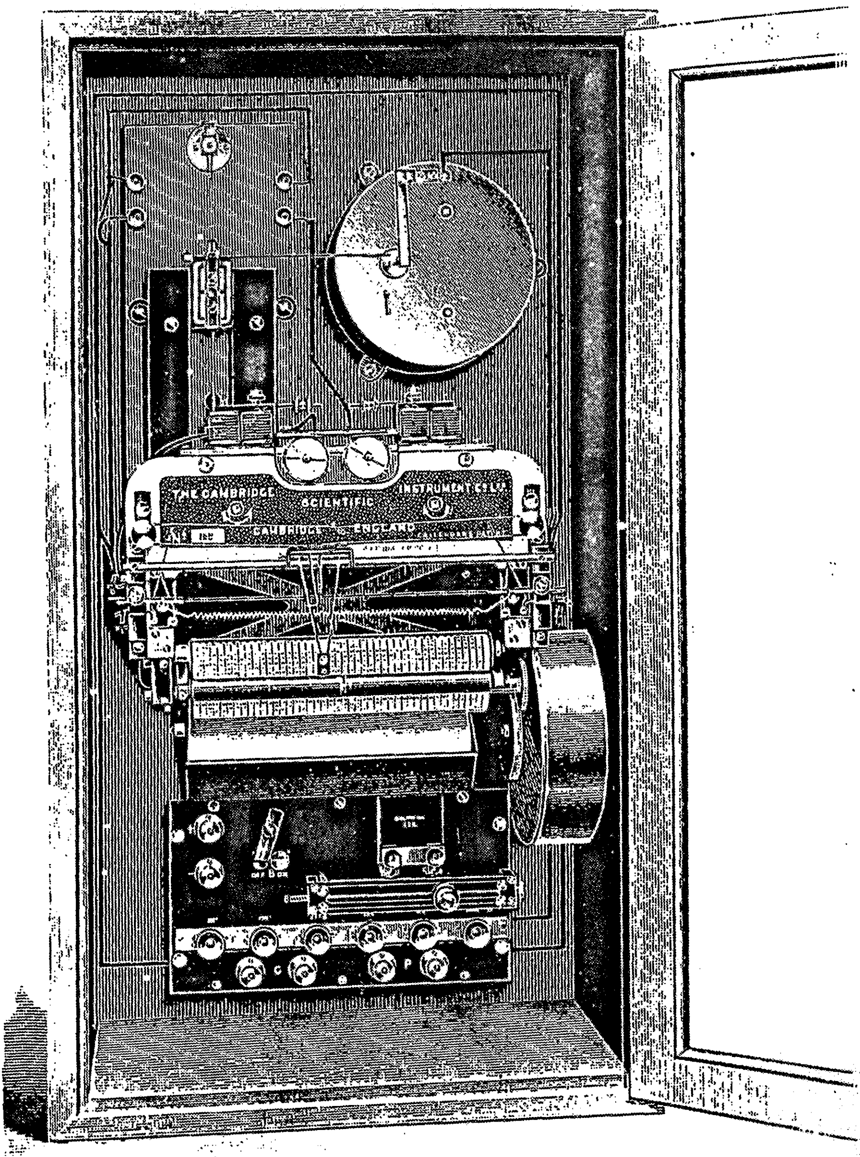


Fig. 3 : Callendar Recorder (reproduced from the Cambridge Scientific Instrument Company Catalogue 1906).

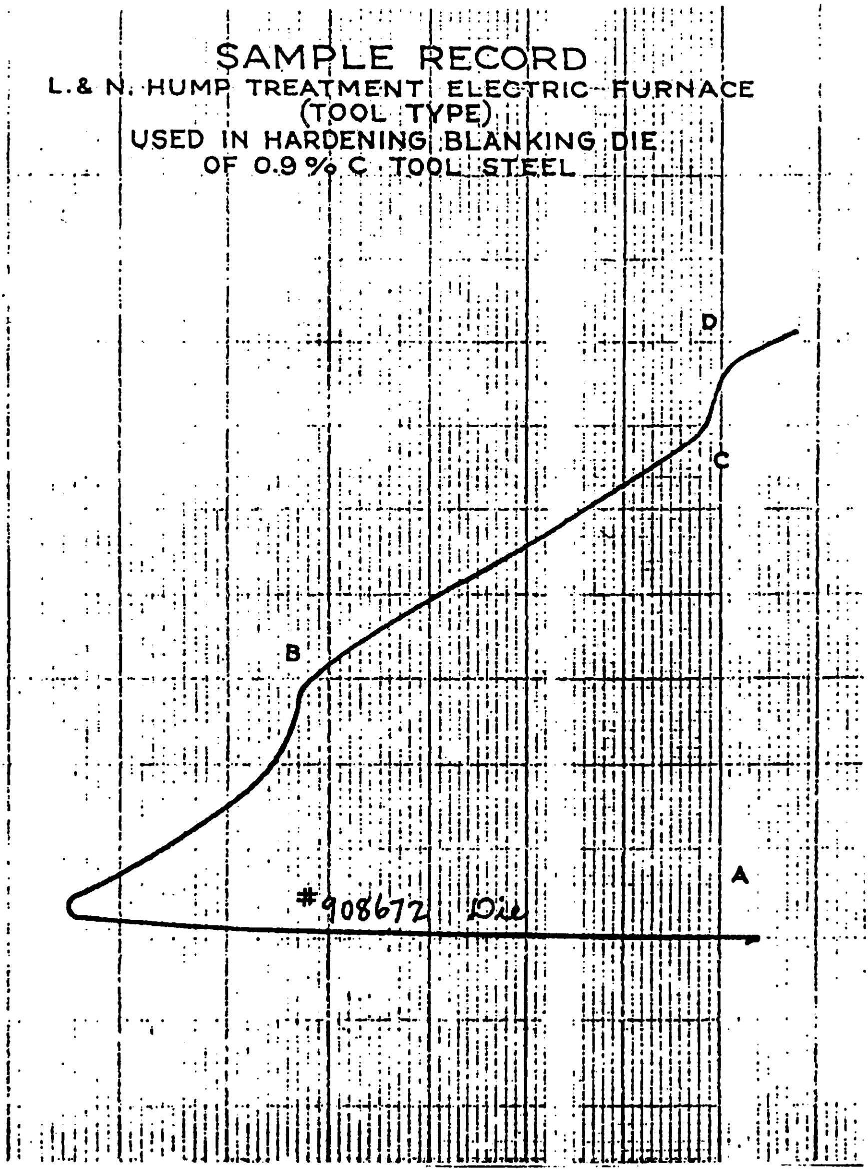


Fig. 4 : Recalescence Curves (reproduced from Leeds & Northrup Catalogue No. 84 1920).

In the hardening of components such as gears, and in the preparation of steel for the edge tools, the steel has to be heated to just above the critical temperature. Unfortunately this temperature varies with the composition of the steel and hence the furnace temperature, in the absence of accurate knowledge of the composition, was not an adequate guide. During the phase change heat is absorbed and hence the temperature does not rise so that by observing the rate of rise of temperature the critical point can be determined without knowledge of the composition.[9] This is what Wrighton had noticed. He filed a patent application, in 1915, for a method of heat treatment in "which the temperature...need not be known or determined". The patent was assigned to the Leeds & Northrup Company and was granted on June 20, 1916.[10] The method was promoted as the "Hump" method of heat treatment and the company began to manufacture electric furnaces for heat treating steel components. The furnaces were equipped with the Leeds recorder and also could be fitted automatic temperature control systems (the purpose of these was to prevent overheating and hence "burning" of the steel).

The Leeds recorder was sold in large numbers, for not only were the fitted to the furnaces manufactured by Leeds & Northrup but also to furnaces sold by other manufacturers (any company fitting a Leeds recorder was granted a right to use the hump method without payment of a royalty). The mechanical recorder was eventually superseded in 1931 by an electronic version, the "Micromax".

This is the story as told in the official company history *Precision, People and Progress*, written by William Vogel and published in 1949.[11] It is a traditional story of invention and discovery, of technological progress and of the transfer of scientific knowledge to industry. The Leeds recorder can be seen as a simple straightforward technical improvement of the Callendar recorder. A similar account is found in P. H. Syndenham's book *Measuring Instruments : tools of knowledge and control.*[12]

But this story leaves many unanswered questions. Why did the Packard Motor Company approach a *scientific instrument* maker for help with an industrial problem ? Why was the recorder built in two forms : the multi-point recorder and the single point curve tracing recorder ? Why did a scientific instrument manufacturer change to become a major industrial instrument manufacturer (and furnace manufacturer) ?. Surely not on the basis of a chance discovery ? Vogel tells us that Morris Leeds did not do anything without considerable thought and thorough preparation. Why did companies buy expensive recorders (in 1912 a simple indicator was sold for around $30, a Leeds recorder cost between $250 and $430) ? Why did some firms install recorders on the shop floor where they could be seen and used by workers, while others installed them in the superintendent's office and in central control rooms ?

Let me tell the story in another way. When Edwin Northrup joined the Morris E Leeds Company in 1903 there was already considerable interest in pyrometers for measuring the high temperatures found in metal production and working applications. Journals such as *American Machinist*, a publication intended for skilled artisans and small factory owners, and the *Engineering Magazine*, whose intended readership was managers and supervisors, carried articles in 1900 and 1901 on the industrial use of pyrometers. They also carried reports of experiments on heat treatment being carried out by Frederick Winslow Taylor and Maunsel White at the Bethlehem Steel Company in which accurate temperature measurements were being made by using a pyrometer. Taylor's famous paper on the "Art of cutting metals" was published in 1906, and the 1906 catalogue of the Cambridge Scientific Instrument Company carried illustrations of the use of pyrometers for heat treating. In 1907 the William H Bristol Company announced its base metal thermocouple together with a chart recorder and these were widely advertised and reported in trade papers. According to Bristol's 1907 catalogue, Bristol Electric Pyrometers (see figure 5) were already in use in over 300 companies including 14 Automobile Manufacturers (one of which was the Packard Motor company). In 1909 the American Gas Furnace Company was selling a furnace with automatic temperature control and in 1910 the Hoskins Manufacturing Company of Detroit was offering a "Recalescent outfit", which comprised a small electric furnace and a temperature indicator.

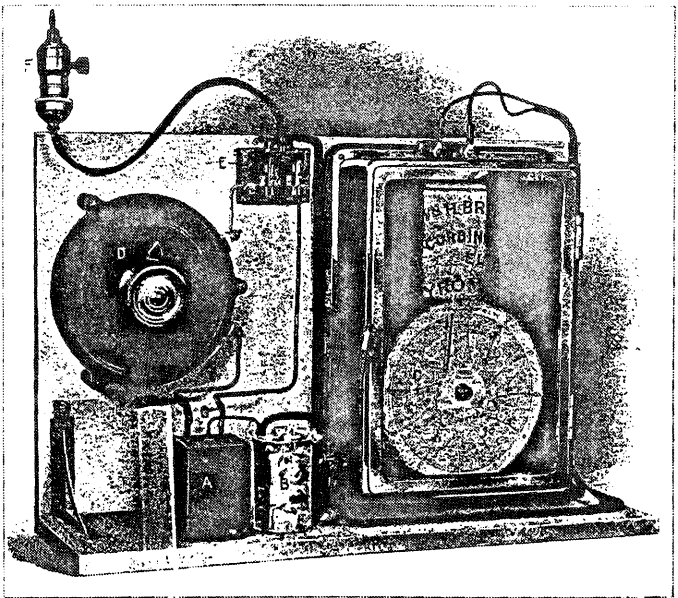


Fig. 5 : Bristol Company Electric Furnace and Recording Pyrometer (reproduced from the *Engineering Magazine*, 1909).

Judging by a paper published in 1908 in the *Transactions of the American Institute of Chemical Engineers* Edwin Northrup was clearly aware of the industrial use of electric resistance pyrometers, and he had a detailed understanding of problems associated with their introduction into an industrial environment. He observed that a pyrometer system can easily provide "a workman at the furnace, and a superintendent in the office" with simultaneous readings of temperature. He refers to the availability of a recorder, which from his description would appear to be the Callendar recorder, and he emphasises the importance of such devices in obtaining "unbiased evidence".[13]

The content of this paper suggests reasons why the Packard Motor company might have asked Leeds & Northrup for assistance. However, firms such as the William H Bristol Company, the Hoskins Manufacturing Company, Edward Brown, and Taylor Instruments all had experience in this area and had developed appropriate instruments so there is still some mystery as to why Leeds & Northrup were asked to help. There is one possible connection, Frederick Taylor was friendly with F.F. Beall of the Packard Motor Company and, given that around 1909 Morris Leeds seems to have also become involved with work at the Midvale Steel Company, there may be some connection. Taylor's approach to the question of shop management — in his 1903 paper he argued that "all possible brain work should be removed from the shop"; that management should determine, by careful observation and recording, followed by scientific analysis, the "one best way" of carrying out a task; and that artisans should obey management's orders — was likely to have appealed to Morris Leeds. As would the comments of James M Dodge who, in 1906, described the Taylor system as "simply an honest, intelligent effort to arrive at the absolute control in every department, to let tabulated and unimpeachable fact take place of individual opinion"[14] Leeds, although he believed in looking after the welfare of his workers, was anti-union, and believed that it was the duty of the workers to obey managers.[15]

The system installed at the premises of the Packard Motor Company reflected this view of the relationship between management and workers (see figure 6). A small electric test furnace, equipped with a curve tracing recorder, was used to determine the critical temperature. The main furnaces were fitted with thermocouples and the signals from these were recorded on multi-point Leeds recorders placed in a separate room. The supervisor in the control room set the desired furnace temperature and each furnace was equipped with a set of lights and a temperature error indicator which showed the difference between the set temperature and the measured temperature. The furnace operator did not have any indication to the actual temperature.[16]

This system is similar to that used by the Standard Tool Company of Cleveland, Ohio which was described by E F Lake in an article in *American Machinist* of 1908. The heat treatment furnaces were housed in a special building with window apertures designed to maintain constant ambient light conditions and hence assist the operator in estimating the temperature of the components being treated by observing their colour.

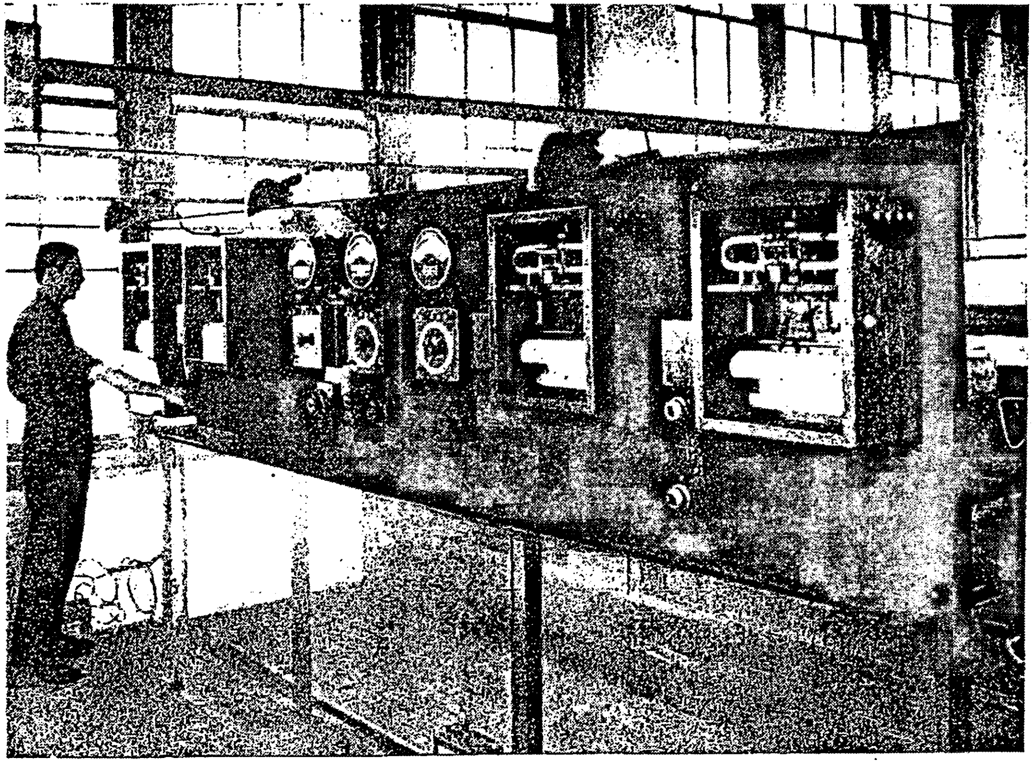


Fig. 6 : Leeds & Northrup Heat Treatment Control System - Packard Motor Company (reproduced from *Factory*, 1915).

However, the operator did not judge temperature by colour alone; each furnace was equipped with a thermocouple and a supervisor in a central control room periodically read the temperature of the furnace, if the temperature corresponded to that on the job sheet then no action was taken, if the temperature was too high or too low this was signalled to the operator by a temperature indicator attached to the furnace. This system was devised to "aid the operators in their work", for as Lake explained "intelligent judgement of the operators cannot be ignored" and they made the final decision that the treatment was complete.[17]

The earliest published reports of the Packard system that I have been able to find are those which appeared 1915. However, in the Leeds & Northrup Company records there is a reference, in the Experimental Committee minutes dated 25 March 1912, to project X-79 "Experimental Recalescence Recorder" and to recalescence curves obtained for samples of steel for Packard. On 18 November 1912 this file is reported as closed and the comment is made that the recorder is now a practical device for determining critical points. At a further meeting at the end of November 1912, project X-230 "Recalescence furnace of a type to be marketed" was reported as being completed. This was a laboratory scale furnace which was installed at the Packard Motor Company and was used for determining the temperature at which different components reached the critical point.[18]

There is no reference to the Packard system in the 1914 recorder catalogue, the illustrations are of installations at the Midvale Steel works : perhaps the Packard Company did not want any publicity. This catalogue is interesting in that it draws attention to the recorders being placed were workmen can see them. The publication of Frederick Taylor's views in book form in 1911 and the congressional hearings on "The Taylor and other systems of shop management" held during 1912 had fuelled the debate about "shop management" and, in particular, who was to exercise control on the shop floor - the artisan or the manager. Measuring instruments were one source of contention - should artisans on the shop floor be provided with instruments to help them perform their job better or should the managers and superintendents use the instruments ? Many saw in the recorder a means of control "because mechanical recorders eliminate the personal equation, they give an important measure of control." Both because it provided information for managers but also because "one of the most valuable features of such devices is the moral effect on the workmen".[19] Advertisements and catalogue descriptions were not always so blatant as this but they still go over the message. By 1914 there began to be references, in advertisements, to scientific management "modern methods of scientific management have settled beyond all question that he use of Recording Instruments is indispensable in order to secure the highest efficiency and economy of results" ran one such advert from the Bristol Company in 1914.[20]

The minutes of the meeting of the Experimental Committee for November 1912 report a decision to commence project X-270 "Develop an electric furnace for hardening and annealing", this project went well at first and in June of 1914 it was reported as being complete with the design being turned over to the engineering department to prepare for production. One of the first furnaces built was used by Leeds & Northrup themselves and another one seems to have been supplied to the Midvale Steel Company. The furnaces did not work as expected and in a paper given at a meeting of the American Society for Testing Materials in June 1915 Leeds reported on experiments carried out by Radclyffe Furness and A H Miller of Midvale Steel and William Wrighton of Leeds & Northrup. They found wide temperature variations in the oven, problems of different rates of heating with different sized specimens and observed the large quantity of heat absorbed during transformation.[21] It is presumably as a result of this work that Wrighton filed the patent application for the Hump method.

During the period between 1915 and 1920 the Leeds & Northrup Company changed from being a scientific instrument manufacturer and supplier to become industrial instrument manufacture. It was also during this period that the influence of Morris Leeds declined; a crucial point in this change was the formation, in 1918, of Executive Committee comprising Leeds, C Reed Cary the sales director, C S Redding, Chief Engineer and I. B. Smith who was responsible for development. Morris

Leeds remained as President of the company and chaired the Executive Committee but from 1920 onwards he devoted most of his energy and time to personnel matters.

During 1918 and 1919 the Executive Committee devoted a lot of time to developing a strategy for the Company. They were aware of the company's dependence on the recorder, (just how dependent did not become clear until the end of 1919 when they reviewed the performance over the eight years and discovered that 50% of the total income had come from recorder sales and that the profits from the recorder — around $48,000 — were greater than the total net profits for the period of $42,000).

The recorder was an excellent product and was superior to all its rivals. As long as they could convince a customer of the need for a recorder they could sell it at a premium price and make a good profit on the sale. But how could they convince a customer to expend $250 to $400 on a recorder instead of $30 to $40 on a simple indicator, or $75 on a Hoskins Manufacturing Company recorder ? The Hump patent offered a means of persuading customers to buy a recorder but it added significantly to the cost of a furnace — typical furnace prices were between $430 and $1010 depending on size. They were also aware from reports from their sales staff that the Hump patent was going to be difficult to defend against infringements. How could they detect and prove that a user, who installed another company' s recorder on a heat treatment furnace, was using the Hump method ? They also had to make a decision about the electric furnace development; they had already made a significant investment in the furnace but there were still major problems to be overcome. Sometime during 1918 they decided to continue with this product. This decision was to have far reaching consequences, it took almost 10 years and an expenditure of $100,000 to get a satisfactory electric furnace, and during the down turn in the business cycle, which occurred in 1921, the committed expenditure on the furnace almost bankrupted the Company.

Having made the decision the Executive committee, in January

1919, considered a report from I. B. Smith on a strategy for selling the heat treatment furnaces. He proposed directing sales effort at managers but noted that if they adopted this approach "then we have opposed to us a class that is as a rule not intelligent, but prejudiced and very jealous of anyone or anything lessening their importance in the eye of management".[22]

The outcome of this change in strategy can be seen in 1920 catalogue for the Hump method in which it is claimed that "all heat-treating operations can be brought under the complete and certain control of one man, who is guided by the unequivocal indications of instruments." This was a significant change, for the whole essence of the hump method was to aid the operator. The 1923 edition of the catalogue put the position even more clearly :

> "By installing temperature measuring instruments of the indicating type a physical effect of temperature is substituted for the workman's guess, but quality is still dependent upon the care and accuracy with which he adjusts valves, etc. The next step is to put in an autographic recorder to keep a record of the results of his efforts and to guide him in applying his manipulative skill. It is manifest that each of these steps makes possible the employment of less trained or lower grade labor in obtaining a given result, but the next step, the use of automatic temperature control, eliminates labor almost entirely, in so far a continuous regulation is concerned."

The support for fully automatic control given at the end of this paragraph is a reflection of the declining influence of Morris Leeds. The 1918 catalogue had argued that for accurate temperature control a curve drawing recorder need to "be used by the man who operates the furnace" for in "furnace control, the direction in which the temperature is changing is a factor of equal importance with the temperature at any instant." Leeds had for many years opposed attaching automatic control units to the recorder because he argued that the then available technology — on-off control — could not provide adequate control and that a human operator would provide more precise control of temperature.

What do the stories of the Leeds recorder tell us ? It seems to me that the recorder was developed to meet a management desire for records rather than to meet a specific technical need, the Callendar recorder or even manual recording of results would have provided the information necessary to set the temperature of the furnace. The recorder was part of a system of heat treatment, which was itself part of a manufacturing system. The technology adopted was determined by the chosen system of manufacturing.

Turning to the Hump method : although the evidence is not entirely clear, I think that prior to the experiments carried out in 1915 at the Midvale Steel Company Leeds & Northrup had viewed the curve drawing recorder as a "scientific instrument for use in the testing laboratory, so that although they must have observed the recalescent points in the heating curve many times they had not connected these with the production process". The tests at Midvale were being carried out on a Leeds & Northrup furnace intended for production use and when the temperature records showed the recalescent break point Wrighton realised that the curve drawing recorder could be used for production purposes.

By 1919 the Leeds & Northrup Company faced a difficult choice : Taylorism and the Scientific Management movement insisted that there was "one best way" but the company had two heat treatment systems which, in scientific management terms, were diametrically opposed. One, setting the furnace to a precise, predetermined temperature gave the management direct control, all an operator had to do was obey (experience during the 1920s showed that is was not as simply as this but that is another story). The other, the Hump method called on the operator to exercise judgement : for when batches were heated in a production furnace the critical point was not as clearly delineated as in a laboratory test of a single specimen. There was, of course, a strong financial pressure for Leeds & Northrup to favour the latter approach for it would increase the sales of the highly profitable recorder.

Illustrations given in the catalogues produced by Leeds & Northrup show that their customers made various choices : some adopted the Hump method and put a recorder alongside each furnace, others continued with multi-point recorders and a central control room, and yet others adapted the Hump method for use with a central control room and signalling systems. There was no consensus on the "one best way". The proponents of Scientific Management will of course argue that examining the detail of each application will show one best way — it is difficult to deploy historical evidence to dispute such a claim, we cannot interview the people involved and the written accounts are open to many interpretations. However, turning to our own times, we find in a recent book by Robert J Thomas some parallels. Thomas, a professor of organization theory at MIT and a member of the Leaders in Manufacturing program, made a detailed study of technical change that occurred during the 1980s in four different manufacturing sectors. He argues that form which technological change takes depends on the power structures within the organisation. The group holding the "power" to make the decision will rationalise its decision using any convenient argument : technological necessity, strategic choice, employment stability, but the outcome is determined when the particular group wins the power to make the decision.[23]

Technology does not dictate how it should be used, or if it should be used at all, we as a society, through the moral values we hold and the political decisions we take, choose. There is not one best, technologically determined, way.

Acknowledgements

Thanks to the generous support of the Hagley Museum & Library, Wilmington, Delaware and to a travel grant from the Royal Society of London I was able to consult the Leeds & Northrup papers held in the archives of the Hagley Library.

Notes

1. Lewis Mumford, *Technics and Civilization,* Routledge & Kegan Paul, London, 1934; J. D. Bernal. *Science in History, Watts & co. 1954.*

2. David S. Landes, *The Unbound Prometheus,* (Cambridge University Press), 1969, Nathan Rosenberg, Perspectives on Technology, Cambridge : Cambridge University Press, 1976, Alfred D Chandler, Jr., *The Visible Hand : The Managerial Revolution in American Business.* (Cambridge, MA: Belknap Press, 1977).

3. Thomas P. Hughes, *Networks of Power : Electrification in Western Society 1880-1930,* (Baltimore, MD: Johns Hopkins Press, 1983).

4. Harry Braverman, *Labour and Monoply Capital : the degradation of work in the twentieth century,* New York, 1974; David Noble, *America by Design,* New York: A.A. Knopf, 1977 and *Forces of Production : A Social History of Industrial Automation,* New York : Alfred A Knopf, 1984.

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6. See for example Philip Scranton, "Manufacturing Diversity : Production Systems, Markets, and an American consumer Society, 1870-1930", *Technology & Culture,* 35(3) (1994) : 476-505.

7. See for example, Stuart Bennett, A history of Control Engineering : 1930-1955, Peter Peregrinus, 1993, "The development of process control instruments 1900-1940", *Transactions of the Newcomen Society,* 63 (1992) : 133-164, and "'The Industrial

Instrument - Master of Industry, Servant of Management' : Automatic Control in the Process Industries, 1900-1940" *Technology & Culture,* 32(1) (1991) : 69-81.

8. The professions were not immune from these changes, for example, .see Deborah J Coon, "Standardizing the subject : experimental psychologists, introspections, and the quest for a technoscientific ideal", *Technology & Culture,* 34(3) (1993) : 757-783. For a discussion of the systematisation of businesses see JoAnne Yates, *Control through Communication : the rise of system in American management.* (Baltimore : Johns Hopkins, 1989).

9. This was first noticed by F. Osmond, in 1887, who observed that as steel cooled the rate of cooling was slowed down at certain points and that these breaks were associated with phase changes in the steel. He also found similar breaks when steel was heated.

10. US Patent 1, 188, 128, June 20 1916.

11. William P Vogel, Jr., *Precision, People and Progress,* (Philadelphia, 1949).

12. P.H. Sydenham, *Measuring Instruments : tools of knowledge and control,* (Stevenage, Peter Peregrinus, 1979).

13. Edwin F Northrup, "Modern electrical resistance pyrometry", *Trans. American Institute of Chemical Engineers,* 1 (1908) : 116-129.

14. James M dodge, "A history of the introduction of a system of shop management", *Transactions of the American Society of Mechanical Engineers,* 27 (1905-6) : 724.

15. See D. M. Nelson, "Precision, People & Progress, The business Career of Morris E Leeds 1869-1952, *Leeds & Northrup Journal,*

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16. The accounts of the Packard installation given in *Automobile*, **32** (March 11, 1915) : 460-1 and in *American Machinist*, **42(10)** (March 11, 1915) : 413-7 disagree on the location of the control panel.

17. E.F. Lake, "A new design for hardening rooms", *American Machinist*, **31(2**, (1908) : 327-331.

18. All references to the Leeds & Northrup Experimental Committee and Executive Committee are to the Company Records held as AC 1110 in the Archives Section Hagley Museum and Library, Wilmington, Delaware.

19. "Automatic Assistant Managers", *Factory*, **XIV** (4) (April 1904) : 290.

20. This was one of series which appeared in the *Engineering Magazine* during 1914.

21. Morris E Leeds, "Some neglected phenomena in the heat treatment of steel", *Proc. 18th Annual meeting of the American Society for Testing Materials*, **XV** (June 1915) : 6-22.

22. I.B. Smith, Meeting of executive committee, Jan 30, 1919, Leeds & Northrup, Executive Committee vol. 1, AC1110 Reel 1, Hagley Museum and Library.

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THE HISTORY OF MEDICINE VERSUS THE HISTORY OF ART

George Sarton[*]

In remembrance of Fielding H. Garrison

I appreciate the honor of having been invited to deliver this lecture, and I welcome the opportunity of paying homage to the memory of an old friend, who was a distinguished historian and did perhaps more than anybody else to promote the cultivation of the history of medicine in our country. There is no medical or reference library, however small, without a copy of one of the editions of his *Introduction to the History of Medicine*[1] and many American doctors have derived their knowledge of the subject almost exclusively from it. They were fortunate in having such a good source of information, for Garrison's Introduction is, all considered, the best one volume account of the medical past, especially the more recent past which concerns more immediately our contemporaries.

Herman Boerhaave

The subject of my lecture was selected on two grounds. Firstly, it enabled me to reassess the views formulated in the essay introducing

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Isis (1912); and secondly, it was a means of showing the humanity of Garrison's history. In spite of the lack of space, for the evocation of the whole medical past in less than a thousand pages is somewhat of an adventure, Garrison always managed to add the human touch without which history remains hopelessly dull. He thus illustrated his own sensitiveness to the essential if elusive values without which our life has no savor and hardly deserves to be recorded.

He was especially sensitive to music, witness his many references to it. These references were of necessity very brief, but I shall expand two of them in order to bring forth their rich implications.

I have the reputation of being a hard worker and among the physicians listening to me to-day there are perhaps many who work as hard as I do, or harder still, yet as compared with the famous Dutch physician, Herman Boerhaave, we are but self-indulging weaklings. According to his early biographer, William Burton,[2]

> The mornings and evenings he devoted to study, the intermediate part of the day to domestic and public affairs. He used to rise during summer at four in the morning, and at five in the winter, even in his later years; ten was his usual bed time. In severest winters he had neither fire nor stove in his study, where he passed the three or four first hours of the morning : his application to study was greater in the last ten years of his life, than in any space of equal duration from the year 1700. When business was over, he took the exercise of riding or walking, and when weary revived himself with music his most delightful entertainment; being not only a good performer on several instruments, particularly the lute, which he accompanied also with his voice, but a good theorist likewise in the science, having read the ancient and best modern authors on the subject, as appears by the lectures he gave on sound and hearing; and during the winter he had once a week a concert at his own house, to which by turns were invited some select acquaintance of both sexes, and likewise patients of distinction from other countries.

His teaching should presumably be understood as a part of those "domestic and public affairs" which occupied the intermediate part of his day. Perhaps he thought, as many scholars do, that teaching was not real work but rather an interruption of it. And yet he taught a lot, not only clinical medicine and ophthalmology (in 1708, he gave the first special course on that subject), but also physics, chemistry and botany ! In those days, famous professors did not occupy a chair but a whole settee.

Boerhaave's musical interest must have been deep, for he devoted a special section to it in his autobiography. That section (XXII) is very brief (seven words), but that is of a piece with the rest. Boerhaave was too busy a man down to his last day to indulge in reminiscences. Here it is

> XXII. Fessus testudinis concentu solabatur lassitudinem. Musices amantissimus.

How eloquent those few words ! Since I have read them and pondered upon them, Boerhaave is more alive to me than he was before, and I can almost see him with his 'testudo' (not a tortoise that, but a lute) relaxing his mind when his duty was done.

Billroth and Brahms

The other story concerns Billroth, whom you probably know better than I do. Theodor Billroth (1829-94) was one of the greatest surgeons of his time; the pioneer of visceral surgery.[8] Whatever be his greatness or his shortcomings as a surgeon, we shall love him better if we realize that he was a life-long friend of Johannes Brahms (1833-97). Brahms and he became very intimate in Zürich, and when Billroth was called to Vienna, Brahms, being a bachelor and without position, followed him there. Though they spent much of their time together and often travelled together, they exchanged a great many letters, of which 331 are preserved.[4] These letters deal chiefly with musical matters, most of Brahms' works being friendly discussed. The surgeon's villa in Alsergrund (a suburb of Vienna) became a musical center. Indeed, he enjoyed the *jus primae noctis* over Brahms' new creations, and the friends of both masters were given opportunities of hearing for the first time some of the masterpieces of chamber music. Did they appreciate their privilege ? Probably not, but we are interested here primarily in the relationship between the composer and the doctor, — a relationship which is, I believe, unique in its intensity.[5] Billroth was a good amateur, a clever pianist and a capable viola player much in demand for quartets[6] (bless the gentle violists for we need them). Under the combined influence of his scientific studies and of Brahms' conversations, Billroth devoted more and more thought to the psycho-physiological basis of music and gathered a number of notes on the subject which were edited after his death under the title *"Wer ist musikalisch ?"*[7] by no less a person than Eduard Hanslick (1825-1904). Who remembers Hanslick to-day ? Yet he was the leading critic of the German world, pontificating for a third of a century in the *Neue freie Presse*, defending with painful iteration the canons of "musical beauty" and of the "significant form" (*beseelte Form*). He was a member of the *Brahmsgemeinde* (Brahms clique) and was the champion of the Schumanns, of Brahms, of Dvořák against the *Musik der Zukunft*.[8] If Liszt and Wagner irritated him so much what would he have thought, I wonder, of the musical anarchists of our own days, of the 'jazz' and 'swing,' of all the music which seems to be written for the spinal chord rather than for the brain ? At that time the arch offender was Wagner, and I sometimes ask myself whether Hanslick was not right in his distrust of the Wagnerian witchery ? Historians discussing our times a few centuries hence will be able to discern more clearly than we can the spiritual origins of the present chaos. They will probably recognize Wagner and Nietzsche as the leaders in the movement to pull Germany back to the Nibelungen level.

Personalities are more important than achievements

There is considerably more to be said about medicine and music, but these two examples must suffice. It is more pleasant to talk about that, I think, than to write, for the talking would be less deliberate and we could digress more capriciously, and perhaps stop talking to listen to music. For what is the good of talking about music ? Let us listen. Take the *Third piano quartet in C minor* (op. 60). When Brahms sent the finished work to Billroth in 1874 he wrote "I am showing you the quartet purely as a curiosity ! An illustration as it were, to the last chapter of the man in a blue swallow tail and yellow waistcoat ..." Or take the two *Rhapsodies for piano*, dedicated to Frau Elisabeth von Herzogenberg (op.

19, c. 1878). Listen and remember Billroth's comment "In these two pieces there lingers more of the titanic young Brahms than in the last works of his maturity." Without the music itself, either present or remembered, these words are meaningless, and there is no point of quoting more.

To return to the history of medicine, I am afraid that many physicians think of it too much in terms of a list of discoveries and achievements. In fact, such lists have been compiled in such dry and impersonal manner that the names of physicians associated with each "item" might almost be replaced by an *x*, *y*, or *z*. Such lists are useful, but they are to the history of medicine hardly more than a skeleton to a living body. The skeleton is indispensable to be sure, but very insufficient.

A mere list of discoveries is a falsification of the history of medicine, even from the purely scientific point of view, for such a list exaggerates the discontinuities in medical progress. A deeper study of almost any discovery reveals that what we call the discovery is only the final clinching of an argument developed by many men throughout a long period of time. However, such a list is a far greater falsification from the broad human point of view.

The history of science, and in particular the history of medicine, we could not repeat it too often, is not simply an account of discoveries. Its purpose is to explain the development of the scientific spirit, the history of man's reactions to truth, the history of the gradual revelation of truth, the history of the gradual liberation of our minds from darkness and prejudice. Discoveries are evanescent, for they are soon replaced by better ones. The historian must try not only to describe these evanescent discoveries but to find in science, that which is timeless. When he does that he comes very close to the historian of art. To put it in other words, a man's name may be immortalized by his discoveries. Perhaps there was nothing else in him deserving of remembrance ? He may have been a poor sort of man, a man whose mind was as sharp and narrow as a knife... ? Or else the historian betrayed him ? In so far as a scientist is also an artist, his personality can survive, otherwise not. It is the historian's main duty to revive the personalities, rather than to enumerate their scientific excrescences. Discoveries are important, personalities infinitely more so.

The history of art as a means of explaining traditions

The materials investigated by historians of art often are of great value to historians of medicine, because artistic traditions are likely to be more tangible than purely scientific ones. This is especially true of ancient and mediaeval times, during which the diffusion of knowledge was necessarily difficult and erratic. Beautiful monuments had on the whole a better chance of survival than others, and their language is easier to understand, even today. Dr. Sigerist has given remarkable examples of the mutual aid of the history of medicine and the history of art in his lecture "The historical aspect of art and medicine."[8] Remember his pictorial history of the plague, and his account of the transformation of Apollo into St. Sebastian, both being saviors or intercessors in times of pestilence.

Such examples might easily be multiplied and a balanced explanation of them would enrich, as well as fortify, our traditions. I have adumbrated some of them in the first volume of *Isis* (p. 21-25) — e.g., apropos of the history of cultivated plants — and in my *Introduction*, e.g., indicating the importance of the pilgrimage roads, such as the Way of St. James (to Santiago de Compostela), and of the dispersion of Romanesque and Gothic architecture.

Much as they are needed for the following up of Western traditions, they are needed considerably more for the understanding of Eastern ones. Indeed, Western traditions are supported by literary witnesses in Greek, Latin or vernaculars which offer no special difficulties; while the Eastern literatures are generally closed to all but a few orientalists, and the latter's knowledge is almost always restricted to a single group of languages. Now consider this case. In the beginning of the fourteenth century, a most remarkable culture was developed in Tabrīz under the patronage of the Mongol rulers of Persia. The spiritual leader was Rashīd al-dīn, physician, theologian and one of the outstanding historians of the Middle Ages. He wrote chiefly in Persian, but had a deep knowledge of Arabic and was acquainted (directly or through secretaries) with documents written in Hebrew, Uighūr, Mongolian and Chinese. A scientific edition of his works requires a good knowledge of all of those languages.[9] This you will admit is a big order. Happily the cosmopolitanism of that age and place can be perceived almost immediately by any person sensitive to artistic values and knowing sufficiently the pecularities of Asiatic arts. Indeed, under the patronage of the same Rashīd al-dīn, there blossomed in Tabrīz a school of miniaturists whose works reveal immediately the same Chinese influences which can be only detected in the text by that *rara avis*, an Orientalist as familiar with Chinese as with Persian and Arabic. Indeed Chinese traits are just as obvious in those fourteenth century miniatures,[10] as they were to become four centuries later in the ubiquitous "chinoiseries" which delighted our Rococo ancestors.

Alexander von Humboldt

The view that we need art for the understanding of science and *vice versa* is by no means a new one, but it is so often forgotten or obscured by good scientists and by good historians that it is necessary to give it from time to time new strength and new life, and to treat it, as if it were a novelty, the most important novelty of our own time. Among the best exponents of it in the last century, was a man who was also one of the pioneers of our own studies. Do you guess whom I mean ? I will help you. He should not be difficult to find, for he was a hundred years ago the most famous man in the world. He is not so famous now, for the wheel of fortune never stops turning even after one's death. He is a bit forgotten and when our schoolboys are asked to name the most prominent men no one would think of chosing him. After having received a scientific preparation which was as elaborate as it was diversified, and having crowned it with a literary initiation in the Weimar circle (Goethe, so critical of others never wavered in his admiration of him), he spent five years exploring South America, then thirty more discussing and publishing the results of his observations. At the age of fifty-eight he delivered in Berlin a series of lectures which were but the sketch of the grand fresco of which he began the publication eighteen years later and to which he devoted the remainder of his life.

That man is — need I name him — Alexander von Humboldt, and the work of his old age to which I referred, is the *Cosmos*. The first two volumes appeared in 1845 and 1847 (when he was 76 and 78), vols. 3 and 4 between 1850 and 1858; he died in 1859 at the age of 90, and volume 5 appeared three years later. We need consider only the first two volumes. The first contains an elaborate description and explanation of the physical world, and the second is a history of science. Thus Humboldt was a pioneer in geographical synthesis, and also in historical synthesis. He was a founder of the new geography and also of the new history. The first innovation was rapidly understood and was developed in many countries; the second was comparatively neglected. Geography and history are two necessary bases of a man's education; even as some knowledge of geography removes his provincialism with regard to space, that is, teaches him that things are not necessarily better in his own village, in his own metropolis or in his own country than elsewhere, even so a knowledge of history is the only way of removing his provincialism with regard to time, that is, of making him realize that things are not necessarily better in his days than in earlier or may be in later ones. Neither geography nor history were new in Humboldt's days, but he increased considerably the scope and the implications of both. For example, he showed that history should be focussed upon the history of science, and also upon the history of arts and letters, but the most remarkable of all was his realization of the polarity of arts and sciences. After having described nature in volume one of the *Cosmos*, he devoted the second volume to a new description of nature as reflected in the human mind, by the imagination (that is art) or by the reasoning power (that is science). In this respect, he was breaking ground so new that the vast majority of scientists and scholars of to-day have not yet grasped what he was trying to do.

The project was so ambitious that realization fell far short of it, but we could not blame him for that. Pioneers are beginners; they cannot be expected to complete their task; it is not *their* business to complete it. Some day the substance of that volume two will have to be worked out again and rewritten, but it will take a man of unusual learning, artistry and wisdom to do it well. As I see it now the great story which cries to be told is that of the rhythm of the mutual interrelations between science, art and religion. The story is very difficult to tell, because it is not a story of progress like the history of science, but of vacillations and vicissitudes, of harmony followed with chaos, and beauty mixed with horrors. It would be the story of man's sensitiveness to the fundamental problems and the main values of life.

All honor to Alexander von Humboldt for having shown the way, and the more so that we are so slow in following it, and that our scientists, so intelligent in some respects, are so stupid in others, and our artists, so clever, yet so blind. Beauty is there for all to see, and truth, and virtue, but how few realize that they are but different aspects of the same mystery ?

Science versus art

The mention of the mystery brings us close to the heart of our subject, for it is there on its threshold that art and knowledge and faith meet and kneel together. This will appear more clearly when we have examined how far art and science diverge in the ordinary routine of life. After having completed that examination, briefly as we must, we shall retrace our steps and peep once more in the sanctuary.

The outstanding difference between art and science is that the latter is progressive while the former is not. Scientific activities are the only ones which are cumulative and progressive. Thus reading the history of science gives us the exhilarating feeling of climbing a mountain; we may go downward sometime for a short run, or we may turn around its slopes, but the general direction is upward, and the top of the mountain is lost in the clouds. Every scientist is enabled to start off from the highest level reached by his predecessors, and if he have it in him, to go higher still. The history of art, on the contrary, is like a glacial landscape, a plain wherein many hills are unevenly scattered. You may climb one of those hills and reach the summit, — but then you cannot continue without going down to the level land; then up again, and so on. Up and down like a drunken pendulum.

When I began my ascension of the topless mountain, I used to gloat on that. Progress, here it was indeed and nowhere else. Unfortunately, there is the devil to pay for it. Because of the progressive nature of science, its achievements are evanescent. Each one is bound to be superseded, sooner or later, by a better one and then it loses its practical value and becomes like a neglected tool in a museum showcase. On the other hand, because of its very unprogressiveness the works of art are eternally young. It is very difficult to read an old scientific treatise, for in order to understand it properly, one must know equally well the old science and the new, and everything before and between. It is painful to read Newton, but the plays of Shakespeare are as timely and pleasurable today as they ever were. "A thing of beauty is a joy forever." The following remarks made by Picasso in 1923 throw a curious light on this. Said he,

> To me there is no past or future in art. If a work of art cannot live always in the present it must not be considered at all. The art of the Greeks, of the Egyptians, of the great painters who lived in other times, is not an art of the past; perhaps it is more alive today than it ever was. Art does not evolve by itself, the ideas of people change and with them their mode of expression. When I hear people speak of the evolution of an artist, it seems to me that they are considering him standing between two mirrors that face each other and reproduce his image an infinite number of times, and that they contemplate the successive images of one mirror as his past, and the images of the other mirror as his future, while his real image is taken as his present. They do not consider that they all are the same images in different planes.[11]

Science is progressive and therefore ephemeral; art is non-progressive and eternal. A deeper contrast could not be imagined.

In the field of science, the methods are supremely important. A history of science is to a large extent a history of the instruments, material or immaterial, created by a succession of men to solve their several problems. Each instrument or each method is, as it were, a crystallization of human genius. Look at the cockpit of an airplane, and ask yourself what was the origin and development of each one of its tools; it is an endless story of patient accumulation and adjustment. On the contrary, in art the results matter more than the methods. I am not interested in knowing how a symphony was produced, how a fresco was painted, how a dish was cooked. The beauty of the symphony and the painting satisfy me, as well as the tastiness of the food and I do not ask for the recipe.

The scientist strives to be more and more objective and accurate; the artist lets himself go and his accuracy is untangible. The scientist says : "If you can measure the thing, you are beginning to know something about it, if not ...," but the artist answers, "What about beauty and love ?"

Science is essentially international, or perhaps we should say supernational. Men of science of all times and places coöperate together; they cannot help coöperating, even if they don't particularly wish to do so, because their task is essentially the same. They are ascending the same mountain, and even when their trails diverge they are aiming at the same goal. Art is tribal, national. To be sure, it may transcend local pecularities and reach the bedrock of human nature. Yet when we speak of Spanish painting or Russian music we evoke fundamental differences, which may be difficult to analyze, not to say measure, but are as tangible as the air we breathe. Sometime ago I had to write a study on Borodin, who was a distinguished chemist as well as one of the leading Russian composers. In order to reconstruct his background, I had to investigate the contemporary state of *international* chemistry and of *Russian* music.

The scientific procedure is essentially analytic; the artistic one synthetic, intuitive. Scientific discoveries are the result of long evolutions, artistic achievements of short involutions. This applies not only to the creation of scientific or artistic works, but also to their interpretation. We cannot penetrate the thought of Faraday or Poincaré without a sustained effort, but a Greek statue reveals to us immediately the best of Greece, and a Gothic cathedral illuminates the Middle Age. Science is the field of arduous and unremitting work, and how beautiful the flowers in it if we have earned them with honest travail of limbs or spirit ! Art is the paradise of immediate intuitions.

Medicine, art and religion

All of which is very true, but it is not the whole truth, and I knew it all the time. Let us look together now at the other side of the picture.

In science as in art, there is always a fundamental need of selection. Just as an artist cannot paint every landscape, or a lover love every woman, just so the scientist cannot investigate every problem. None of them has a ghost of a chance, unless he restricts his goal. The immense success of science is due largely to the selection of problems, one at a time, the simplest and easiest first, and so on. Genius in science as well as in art is essentially the ability to select properly.

Then there *is* technical progress in art. The history of music, like the history of science, can be written partly in terms of instruments. The modern symphony is as much an instrumental triumph as the transatlantic flights. Scientific knowledge is not simply rational, a good part of it is manual and intuitive. What a gulf between the born diagnostician and the physician who has learning enough but lacks insight ? There is uncanny wisdom in the hands of a surgeon as well as in those of a pianist.

Science and art have both their collectivist aspects, as well as their individualist ones. The former are seen at their best in religious art and in social medicine, and that rapprochement is suggestive. For what is religious art, but the highest form of social art ? and what else is social medicine but the finest realization of the second commandment "Thou shalt love thy neighbour as thyself." ? Neither religious art nor social medicine can succeed unless they be sustained by a living faith.

Science, every science and of course medicine above all, is an art as soon as it is applied. It becomes part and parcel of a man's religion, as soon as he is thoroughly conscious of his own insignificance and of his solidarity with the rest of the universe. We cannot understand the history of medicine, unless we see in it not only discoveries and scientific achievements, but also personal defeats and victories, the timeless fruits of men's love and faith. On the other hand, as Canon Streeter has remarked :[12] "Science is the great cleanser of the human spirit, it makes impossible any religion but the highest." The well-tempered historian of medicine will keep this in mind always, and think of men's art and religion, as well as of their learning. He will try to see the whole of their personalities and thus give to his own work its greatest value for other men. Science is the reason, art, the joy, religion, the harmony of life. None is complete without the others. We cannot hope to understand the mystery of life unless we be prepared to consider it from these three angles, and this means first of all that we must drop our scientific conceit, and second, that we must never, never, subordinate humanities to technicalities.

Notes

1. First edition, Philadelphia, Saunders 1913. Reprinted 1914. Second edition 1917. Third edition 1921. Reprinted 1924. Fourth edition 1929. Spanish translation, Madrid 1921/2.

2. Dr. William Burton of Yarmouth : An Account of the Life and Writings of Herman Boerhaave (vii + 226 p., London, 1743). I have consulted the second edition 1746, having exactly the same number of pages (see pp. 62, 212). Boerhaave died in 1738 at the age of 70, and Dr. Burton's biography of him, appearing five years after his death may be considered a contemporary biography.

3. According to Harvey Cushing in his *Life of Osler* (vol. 1, 114, 1925), Billroth had failed to appreciate as late as 1874 the relation of bacteria to suppuration. But that is another story.

4. Billroth und Brahms im Briefwechsel (Berlin, 1935), edited by Billroth's son-in-law, Otto Gottlieb-Billroth, who added an elaborate double biography.

5. The *Biographisches Lexikon der hervorragenden Ärzte*, newly edited by Franz Hübotter, devotes naturally a long article to Billroth (vol. 1, 541-42, Vienna 1929), but there is no mention of Brahms. Garrison's account of Billroth is necessarily much briefer, yet he finds space for Brahms. There is your medical humanist !

6. Walter Niemann : *Life of Brahms* (*passim*, New York, 1937).

7. First edition, Berlin 1895; I have used the third edition, 1898. The book is disappointing. Its most original feature is its subdivision in a musical way, the chapters being entitled : 1. Marcia, 2. Allegro serioso ma non troppo, etc.

8. Hanslick's main work *Vom musikalisch-Schönen* (Leipzig, 1854) was often reprinted and it was translated into French, Italian, English and Russian. He published many other books and there are a good many writings concerning him, pro and contra. His enemies treated him as roughly as he treated them. According to Stewart Deas : *In defense of Hanslick* (London, 1940), one of them said "Hanslick was, in fact, the most colossal ignoramus and charlatan that has ever succeeded in imposing himself on an editor as a musical critic." I can imagine that Hanslick's dogmatism and pedantism were sometimes unbearable, but it does not follow that he was never right.

9. *Bull. Inst. Hist. Med.*, vol. 4, 271-97, 1936.

10. See the partial edition by Edouard Blochet (Gibb Memorial Series, 2 vols., Leyden, 1910-11).

11. E. Blochet : Musulman painthlg, XIIth-XVIIth century (London, 1929), pl. LI, LIX, LX, LXI.

12. *Picasso, forty years of his art,* 2nd ed., edited by Alfred H. Barr, jr., issued by Museum of Modern Art (New York, 1939, p.11).

13. *Reality* (p. 272, London, 1926).