The Spread of Descriptive Geometry in Great Britain Between the XVIII and XIX Century

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Abstract

Between the Eighteenth and Nineteenth Centuries the diffusion of the Monge's Descriptive Geometry in Europe determines, with different times and outcomes in the various countries, a radical change in the field of representation. It modifies not only the approach to design but also, and substantially, professional education. In Britain, however, the new science, for both political and cultural reasons, officially arrives very late.
Its circulation among professionals, craftsmen and designers, though well attested before, sees it grafted onto a series of independent research experiences, also fueling the attempts by British theoreticians to define a universal system of graphic communication.
The present study, through a research review on the history of representation related to this era, and the collection of documentary sources, intends to offer a systematic reconstruction of the diffusion of Descriptive Geometry in Great Britain, contextualizing it in the socio-political climate of the time and intertwining new instances of the Monge's method with the original research conducted across the Channel in those years.

Keywords: Geometrical Drawing, England, porjections, Monge, Nicholson.

Introduction

At the end of the Eighteenth Century the definition of Monge's Descriptive Geometry system represented the beginning of a profound cultural revolution in the field of technical sciences. The new discipline, was able to bring together in an organic corpus the vast existing empirical production and delineated the traits of a Science of Representation, until then never existed, or, at least, never formalized in such a unitary way.
With the Monge's geometry a radical process of transformation of the education system also began; the training in the technical-engineering field found in the new scientific method of representation an indispensable study tool for young engineers, connecting theoretical and mathematical subjects with applicative ones, in an educational path that involved a multiplicity of disciplines often heterogeneous. France was certainly the fulcrum of this change, but the theoretical refinement of the Monge's method and its different fields of application attracted, in a few years from its public dissemination, the entire European scientific community.
In the various countries the impact of the new discipline on studies gradually initiated significant processes of change in the educational pathways, grafting onto existing models or interacting in various ways with them. If in Spain, Italy and Germany the Descriptive Geometry was quickly accepted and reacted in an osmotic manner with the scientific knowledge hitherto matured, in other countries it did not find the same success.

Political factors and social reasons of the delay in the diffusion of the Monge's method in England

In particular, in England the Monge's method is transposed with delay due to a combination of both political and cultural factors [Mason 1971; Lawrence 2003]. From the political point of view, as it has been noted, "The lack of interest shown upon the translation of the technique into English is partly due to its having been translated during the period between the Napoleonic wars, so the technique itself was regarded as the invention of one of the most prominent republican educationalists. The competition between the two nations–English and French–in matters not only of war but of prosperity and industry during the intervals of peace is an important element to be considered. The lack of a suitable translation and instruction into the technique by one of the 'original' students was another result of the wars in which the French and English were engaged in at the time" [Lawrence 2003, p. 1271].
Indeed, the political events following the Revolution, coinciding with the years of Descriptive Geometry spreading beyond the French borders, are characterized by a period of peace between the two nations–intervened after the 1802 Treaty of Amiens and ceased already in 1803–but this appeared to be linked to contingent needs rather than to the search for a cultural unity.
Actually, England was moved to peace, among other things, by the interest of re-establishing trade relations with France to exchange its industrial surpluses [Bignon 1840, p. 270]. Such relations, however, never took off because of the evident French protectionism aimed at limiting British economic hegemony. The political contrasts and industrial competition between the two states therefore remained essentially constant and this, independently of the war, did not facilitate the scientific diffusion of Monge's work on the Island. The continuous state of tension and competition also prevented that French scientists could transfer knowledge of the Method to Great Britain, contrary to what happened instead in the United States of America, both on a practical and theoretical level, thanks to Marc-Isambard Brunel, Claude Crozet and Simon Bernard [Cardone 2017, p. 150].
From a cultural point of view, the slow expansion of the Monge's science in the uses of professional practice and in British technical training seems to depend, instead, on some profound differences between two national identities, the French one, and the English one; the first oriented towards theory, the second towards practice. And it is not a mere cliché, even though it may appear in the words of Hyppolite Taine when, in his *Notes sur l'Angleterre*, he writes "*le Français demande à tout écrit et à toute chose la forme agréable; l'Anglais peut se contenter du fonds utile. Le Français aime les idées en elles-mêmes et pour elles-mêmes; l'Anglais les prend commes des instruments de menémotechnie ou de prévision. […] En général, le Français comprend au moyen de classifications et par des méthodes déductives, l'Anglais par induction, à force d'attention e de mémoire, grâce à la représentation lucide et persistante d'une quantité de faits individuels, par l'accumulation indéfinie des documents isolés et juxtaposés*" [Taine 1874, p. 326].
The contrast between theoretical and practical orientations, between deduction and induction, elements, those,

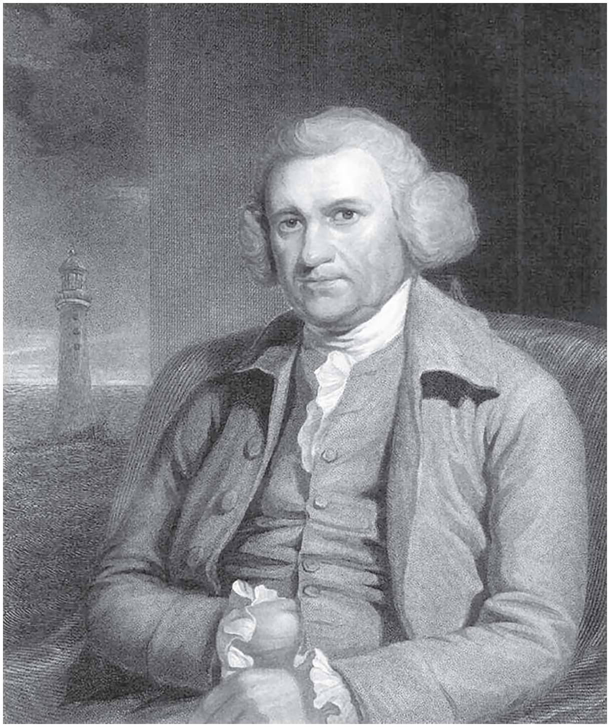


Fig. 1. John Smeaton (1724-1792). Engraving after a portrait by the painter Mather Brown, 1788 ca.

Fig. 2. Thomas Telford (1757-1834). George Patten, Portrait, 1829. Oil on canvas. Glasgow Museums. Image distributed under a CC BY-NC-ND licence.

which appear specific peculiarities of the two peoples, does not arise only from a rhetorical emphasis on two antithetic and historically competing traits. It finds precise evidence in the training models and in the approach to science and technology. And it is precisely the British education system of the time, perhaps, the main cause of the failure to disseminate a method that was sublimated in its theoretical aspects.
A first reflection can be made on the engineer's education in the Nineteenth Century in both countries. The French engineer was a state figure, hinged into hierarchical bodies such as the *École des Ponts et Chaussées* or the *Corp du Génie*. He was trained in specialized schools and was considered part of what could already be called a professional category [Picon 1992]. The British context was completely different. In Britain between the eighteenth and nineteenth centuries engineering was not yet a fully organized profession [Buchanan 1989] and engineers were still figures trained through a traditional craft apprenticeship, often as millwrights, mechanics, instrument makers or stonemasons. Among them, we can mention some of the most brilliant innovators of the century such as engineer John Smeaton (1724-1792), founder of the Society of Civil Engineers in 1771, who made his apprenticeship in London as a mathematical instrument maker (fig. 1); Thomas Telford (1757-1834), engineer and first president of the Institution of Civil Engineers, who formed itself as stonemason (fig. 2); or even George Stephenson (1781-1848), who, before discovering his genius in the construction of locomotives, worked as brakeman [1].
The opportunities for formal education or training were reduced and, in general, even men of science acquired their basic skills from apprenticeships or as self-taught, naturally endowed with ingenuity and entrepreneurial ability. Technical and scientific instruction, despite the great results achieved by the industry, was in a state of backwardness as well as the whole educational system [2]. More generally, the teaching of scientific-engineering disciplines, at least until the mid-Nineteenth Century, was only exceptionally provided in the ancient English universities or in public schools, however of a clerical type [3].
Many of the engineering pioneers or scientists who received scientific education in these areas studied in continental Europe schools, or, if in England, in the so-called 'dissenting academies'. These academies were run by the 'dissenting' or those who did not conform to the Church of England. Dissenting academies spread to England after 1662 as a result of the so-called 'Conformity legislation' that accentuated the differences between the Orthodox and non-Orthodox state schools.
They formed a significant part of England's educational systems from the mid-seventeenth to the nineteenth centuries [4]. In Britain the best education was the Scottish one, offered by the universities of Glasgow and Edinburgh who excelled in medicine, science and engineering much more than the less enlightened Oxford and Cambridge did [5].
Therefore, if in France, Monge's Geometry was a catalyst for the reform of engineering studies, centered on a system in some way ready to incorporate its enormous formative scope, in Great Britain not only did the discipline delay in spreading for political reasons, but when it arrived, it did not even find an educational and training-professional system prepared to welcome the disruptive novelty.

The new technical language, established thanks to the Monge method, allowed in fact to outline a new engineer figure; on the one hand offering a common repertoire, which allowed to control the details of the construction with extreme precision, without the need to acquire the manual crafts skills or to take an interest in the practical-realization aspects of the artefacts. On the other hand, the modalities of this form of drawing had important implications for the work organization and the design of artifacts, redefining in fact the role of the engineer in the production cycle. That is an increasingly clear separation between the designer-creator of a work, and its executor. As Joël Sakarovitch writes, the Descriptive Geometry "can also be viewed as a transition discipline that allowed a gentle evolution to take place: from the 'artist engineer' of the Old Regime, whose training was based on the art of drawing rather than scientific learning, to the 'learned engineer' of the 19th Century for whom mathematics–and algebra in particular–is going to become the main pillar of his training" [Sakarovitch 2005, p. 240].
It is clear that in Britain, where constructive practice still had an extraordinary educational force for professionals and where state intervention on training was marginal [Baynes 2009, p. 15], an extremely theoretical approach to the engineering discipline of drawing could not have found fertile ground [6]. However, it is certain that Monge's method, to some extent, came to be part of the cognitive baggage of the English technicians even if there was, at least until the mid-Nineteenth Century, a translation that perpetuated the systematic dissemination for technical instruction.

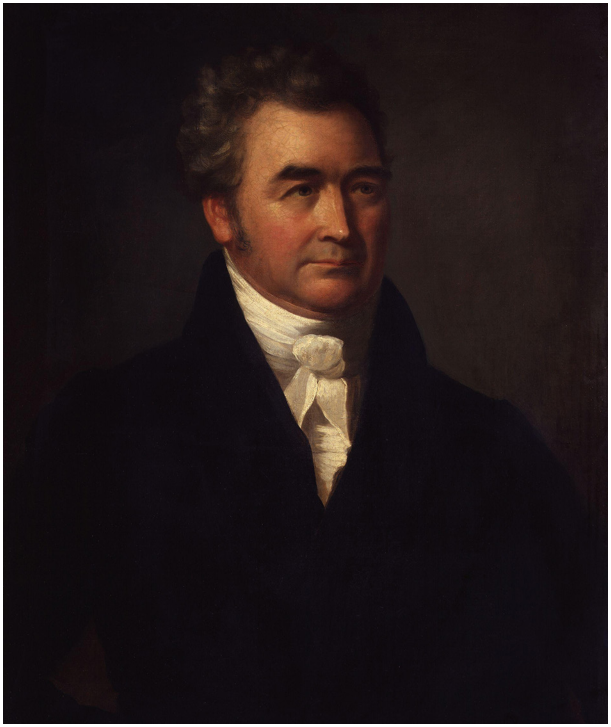


Fig. 3. Peter Nicholson (1765-1844). James Green, Portrait, 1816. Oil on canvas. National Portrait Gallery of London.

The diffusion of Descriptive Geometry: adaptations, translations and autonomous orientations

It seems certain that, as soon as the *Géométrie descriptive* saw print in France, the British War Office obtained a copy [7]. However, the office did nothing with it [Belofsky 1991, p. 35]. Regardless of this circumstance, likely since the subject was no longer subject to secrecy, certainly some copies of the method in French circulated among the experts of the field.
His entry into the professional knowledge has been traced back to some time before, linking him to the figure of Marc-Isambard Brunel. During his training, the Franco-British engineer had the opportunity to meet Monge, who was given to him as a tutor during a course in Rouen to became an official navy cadet. Known for his 'realist' ideas, he emigrated to the United States in 1793 where he became chief engineer of the city of New York, before moving to England in 1799 [8]. Concerning Brunel's activity, however, even though there may certainly be recognized a fundamental role in disseminating a new orientation in engineering design, it did not condense into theoretical writings of the Beaune's master work, as happened for Crozet in the United States of America. The first writings on the Monge's method, even if partial, are instead dated to 1812, by the Scottish architect, engineer and mathematician Peter Nicholson (1765-1844). His eclectic personality and his multi-faceted activity represent the typical characteristics of the teaching and architectural-engineering profession in Great Britain at the beginning of the Nineteenth Century, aimed at the essentiality of a theory always devoted to

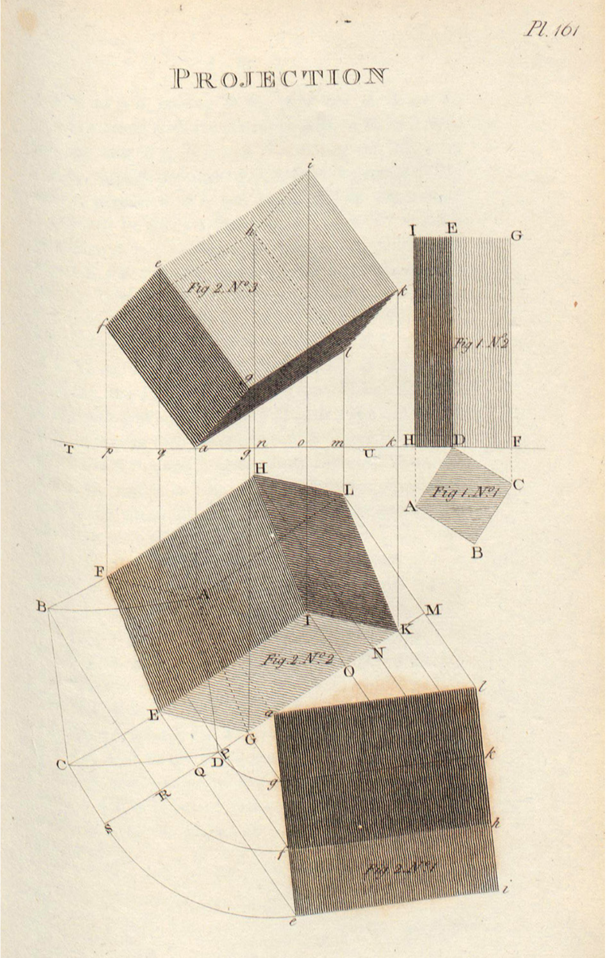


Fig. 4. Peter Nicholson. Ichnography and elevation of a rectangular parallelopipedon [Nicholson 1797, vol. II, Fig. 2].

the building practice (fig. 3). He was able to put together, with awareness and versatility, the scientific aspects of the geometrical drawing and the architectural and engineering practice, distinguishing himself for its works aimed at education and for its mathematical spirit that will characterize even a large part of its vast production.

In many of his treatises he inserts exemplary drawings derived from its professional practice in which there is always the worker's eye, activity that had characterized his early training.

In 1794 he attempted the orthographical projection of objects in any given position to the plane of projection and he succeeds in describing the "ichnography and the elevation" of a rectangular parallelopipedon [9]. The printed drawing (fig. 4) of the plates processed in those years appears in II vol. of the *Principles of Architecture* (fig. 5) published in 1797 [Nicholson 1797], but the work is republished with improvements in the year 1809.

The principles of the projection formed at that time for English draftsmen the British equivalent of Monge Descriptive Geometry. And Nicholson can be considered one of the main scientist on the subject at that time in England. He himself was claiming its autonomy from Monge asserting, strongly and with many arguments, that he did not knew the treatise of Monge until the year 1812, when the engraver Wilson Lowry would have lent him a copy [Nicholson 1828, pp. 44-54].

Although he often uses his personal projection method in different works intended for building operators, he produces a more rigorous dissertation at first in the *Architectural Dictionary* of the year 1812 s.v. '*Projection*' [10]–in which also inserts a large extract of the Descriptive Geometry of Monge s.v '*Descriptive Geometry*' translated by Mr. Aspin [Nicholson 1819a]–then in the *Ree's Cyclopaedia* of the 1814 [11]. That year he is called by Abraham Rees, as an expert in the subject, to write, for the vol. XXVIII, one of the most relevant articles (more than 15 columns s.v. '*Projection*'), to be followed by the related graphic plates in the IV vol. (plates) of the year 1820 [Nicholson 1820].

The Nicholson projections soon became the British system of representation [Grattan-Guinnes, Andersen 1994]. In its final version, it has collected some principles and nomenclatures of descriptive geometry, preserving, however, his original prerogatives [12]. This system indeed, closely linked to the practice of stereotomy and carpentry, had the advantage of being easy to remember and readily adaptable to the practical problems of architecture and engineering. A forerunner of the method 'direct' called by the Anglo-Saxons [Rowe, McFarland 1939], which determined, in English-speaking countries, an increasingly sparse production of theoretical texts of Descriptive Geometry in favor of those more properly called of 'technical drawing'; in these latter, theoretical assumptions are reduced for the benefit of

practical techniques for graphical visualization. The knowledge that Nicholson had of projection techniques used in the crafts of the stonemasons and joiners was unquestionably important in the definition of his method.
The personal research to develop a graphical method of valid use, not only for architects and engineers, but also for workmen, led him to constantly expand its studies on the subject. So he refined at first the orthographic projections in the treaty of the year 1827 *A Popular and Practical Treatise on Masonry and Stone-cutting* [Nicholson 1827]. Later he defined the system that he called "oblique parallel projection"; a projection system offering along with orthographic views also a three-dimensional image of the object.
Therefore, it is indisputable that in Britain, in those years, there was an independent research orientation that was not only supported by Nicholson, perhaps less known to historiography than scientists as William Farish, Joseph Jopling and Thomas Sopwith. Indeed, the attempt to define a universal system of graphic communication [Booker 1963] based on a clear geometric visualization had led many island theorists to try developing less abstract and easy to apply methods of representation [Docci, Migliari 1993; Càndito 2003] compared to that of Monge, which however did not remain without echoes.
Actually the parallel orthographic projection of Nicholson, having as reference a single plane of projection (fig. 6), can rightly be considered an axonometric representation that, before Farish and unlike the latter's work, starts from the true shape and size of the object to represent. Examples are the plate of the year 1794, and the plates accompanying the writings of the years 1812 and 1814. These are orthogonal axonometries (figs. 7, 8), which under certain conditions–such as an inclination of the plane of projection of 90 degrees with respect to the plane of the figure (original plane)–result as projections entirely comparable to those theorized by Monge. For example, when solids are represented in that condition, the axonometric projection of the base is reduced to a segment; in this way, the axonometric image of the volume is tantamount to an elevation (a second projection in Monge method), that it is moreover correlated with the true shape of the base.
So, when William Farish, scientist and professor of Chemistry and Natural Philosophy at the University of Cambridge, published in 1820 his study on isometric orthogonal axonometry, the science of representation in Great Britain seemed to have finally arrived at a new method, simpler, more effective and respectful of a peculiar identity.

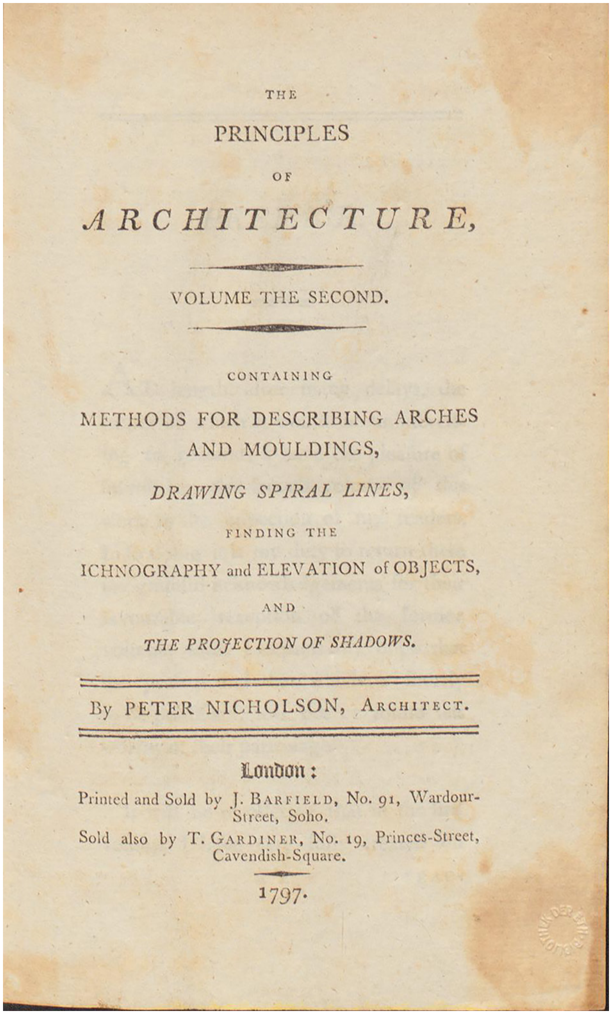

THE
PRINCIPLES
OF
ARCHITECTURE,
VOLUME THE SECOND.
CONTAINING
METHODS FOR DESCRIBING ARCHES
AND MOULDINGS,
DRAWING SPIRAL LINES,
FINDING THE
ICHNOGRAPHY and ELEVATION of OBJECTS,
AND
THE PROJECTION OF SHADOWS.
By PETER NICHOLSON, Architect.
London:
Printed and Sold by J. Barfield, No. 91, Wardour-Street, Soho.
Sold also by T. Gardiner, No. 19, Princes-Street, Cavendish-Square.
1797.

Fig. 5. Frontispiece of The Principles of Architecture, vol. II [Nicholson 1797].

Apart from the works of Nicholson and a reference to the topic of Descriptive Geometry, made by the Scottish scientist John Leslie [13], Monge's work in those years does not seem to have been fully accepted by the British

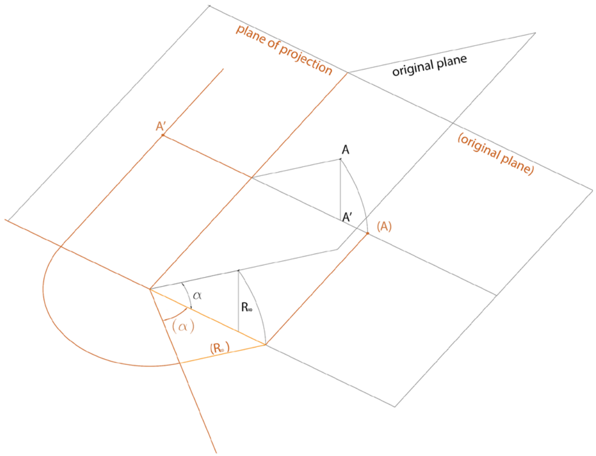


Fig. 6. Spatial scheme illustrating the method of projection used by Nicholson (graphic elaboration by the author).

scientific world. This is evidenced by the fact that various encyclopaedias of the time such as the *Encyclopædia Britannica* or the *Chamber's Cycopædia* do not hint at the subject neither under the heading '*Monge*' nor by presenting a specific note under the heading '*Geometry*'. On the other hand, in 1836, Mr. Thomas S. Davies [14], at that time one of the mathematical masters at the Royal Military Academy in Woolwich, wrote " several years ago a considerable extract was made from Monge's work in the Architectural Dictionary of Mr. Peter Nicholson. […] Mr. Nicholson afterwards commenced a work in numbers, bearing the title of Descriptive Geometry, but the commercial casualties of the period (1825) put a stop to the undertaking […] Nothing further on this branch of science has appeared in England" [Cunningham 1868, pp. 49, 50].
In 1837, again Nicholson published *A Treatise on Projection* in which the method of parallel oblique projections was anew presented, and in a more complete form [Nicholson 1837]. On the work of Nicholson, the engineer and geologist Thomas Sopwith in the preface to his own 1838 treatise on the isometric drawing will write: "This method possesses the advantages of being extremely simple in its principles and universal in its application; nor in the writings of either continental or English authors has any other general method been proposed" [Sopwith 1838, p. 66]. A method based on the clarity of perception in relation to the intuitive relationship between orthographic view and the spatial configuration represented.
Only in 1841 was published by the editor J. Parker the first text in English of Descriptive Geometry entitled *The Elements of Descriptive Geometry, chiefly designed for Students in Engineering*. It was an educational text written by the Reverend Thomas Grainger Hall [15], a professor of mathematics at the King's College in London, in support of the students of the course of Mr. Thomas Bradley [16], then lecturer of geometric design at the Department of Civil Engineering and Mining from the same College (figs. 9, 10). The writing, produced in close collaboration with Bradley himself, was, in fact, largely a translation from the French of the Lefébure de Fourcy treatise [17].
In 1849 the Lords Commissioners of the Admiralty [18] intrusted the publication of a *Treatise on Descriptive Geometry and its Applications to Shipbuilding* to the Reverend Joseph Woolley [19], for the Portsmouth Dockyard shipbuilding school. The treatise also had to be adapted to university students in civil engineering.
The treaty was published in 1850 [Woolley 1850]. It is interesting to note how the British scientific community began to become aware of the Monge's work importance and the delay with which it was received until the middle of the century by the British scholars. This is, in fact, what Woolley writes in the preface: "The properties of Descriptive Geometry have been thoroughly investigated by continental mathematicians: they have paid the greatest attention to the subject: by us it has not met with that regard it most deservedly merits; since it contains not only a course of geometrical reasoning of a most interesting character, but it also unfolds to us properties of the highest value to practical mathematicians. As this volume is designed not only for students who have the advantage of constant direction, but also for those who, deprived of tutorial aid, may yet be desirous of acquiring a knowledge of the principles of the science, it became necessary, in the introductory and elementary parts, to have an especial view to the latter class of students" [Woolley 1850, pp. III, IV].
It is also clear the commitment not only to design the work for university students use but, according to the British tradition, also for those who, without a tutorial aid, were desirous of acquiring a knowledge of the principles of the new science. The text still refers to two French works. This is the volume of A.F. Amadieu, *Notion*

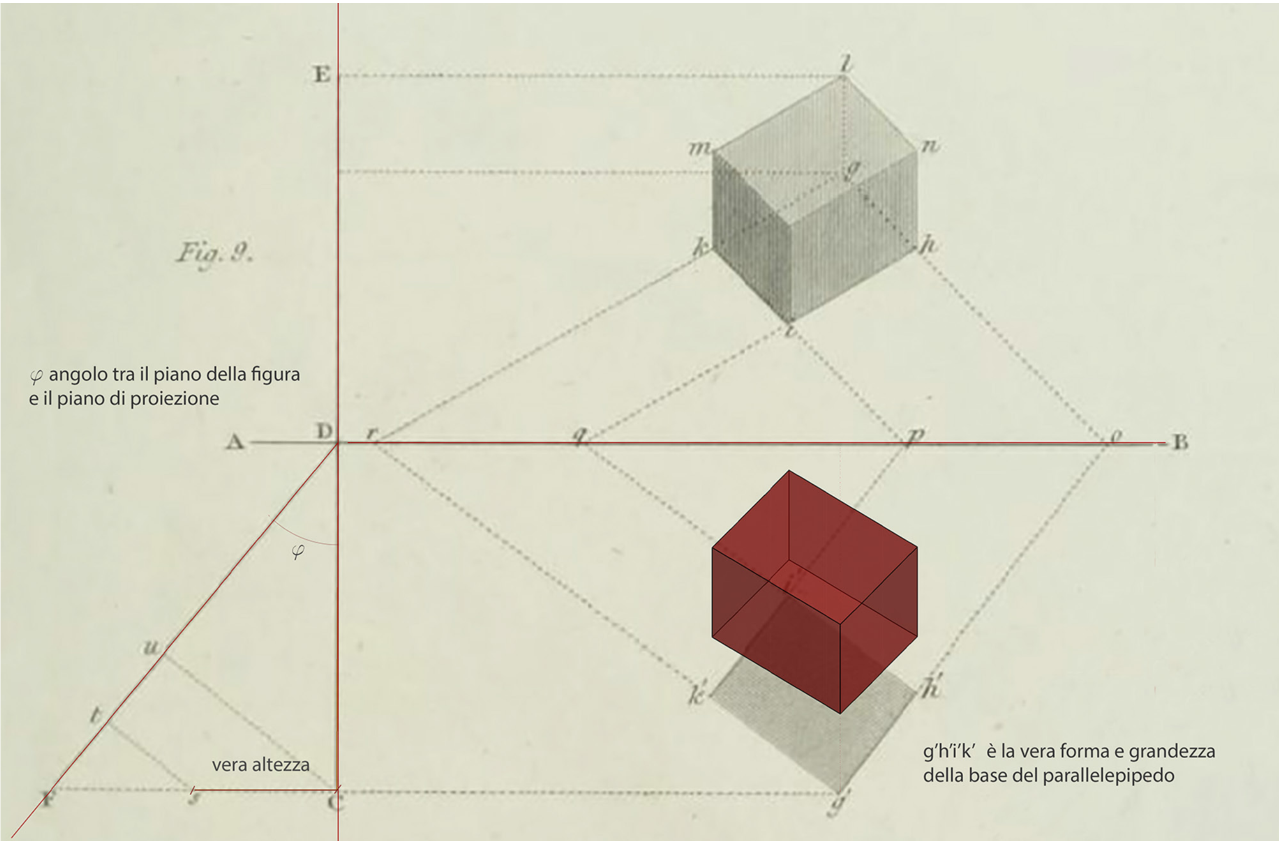


Fig. 7. Digital representation on the basis of a Nicholson drawing: projection of a solid object (graphic elaboration by the author).

élémentaires de géométrie descriptive éxigés pour l'admission aux diverses écoles du gouvernment published in Paris by Bachelier in 1838 and, again, the work of Lefébure de Fourcy, already mentioned, used in this case to treat the properties of the hyperboloids of revolution, the hyperbolic paraboloid, and the twisted surfaces in general, as well as the properties of the spherical epicycloid. At the end of the introduction to the two volumes the author still makes some considerations on the state of knowledge of the new science of representation in England: "The scarcity of works on this subject in the English language has encouraged the author to hope that much of the contents of the present volume will be new to the English student: that not only the Naval Architect and Engineer (who is especially interested in this branch of mathematics) will find it of use, but also students in the Universities, to whom the principles of the Geometry of Space are usually accessible only in an analytical form, will find this subject rendered much more distinct and clear when seen by the light which the more palpable methods of Descriptive Geometry enable us to throw upon it" [Woolley 1850, p. IV]. In Woolley's text, for the first

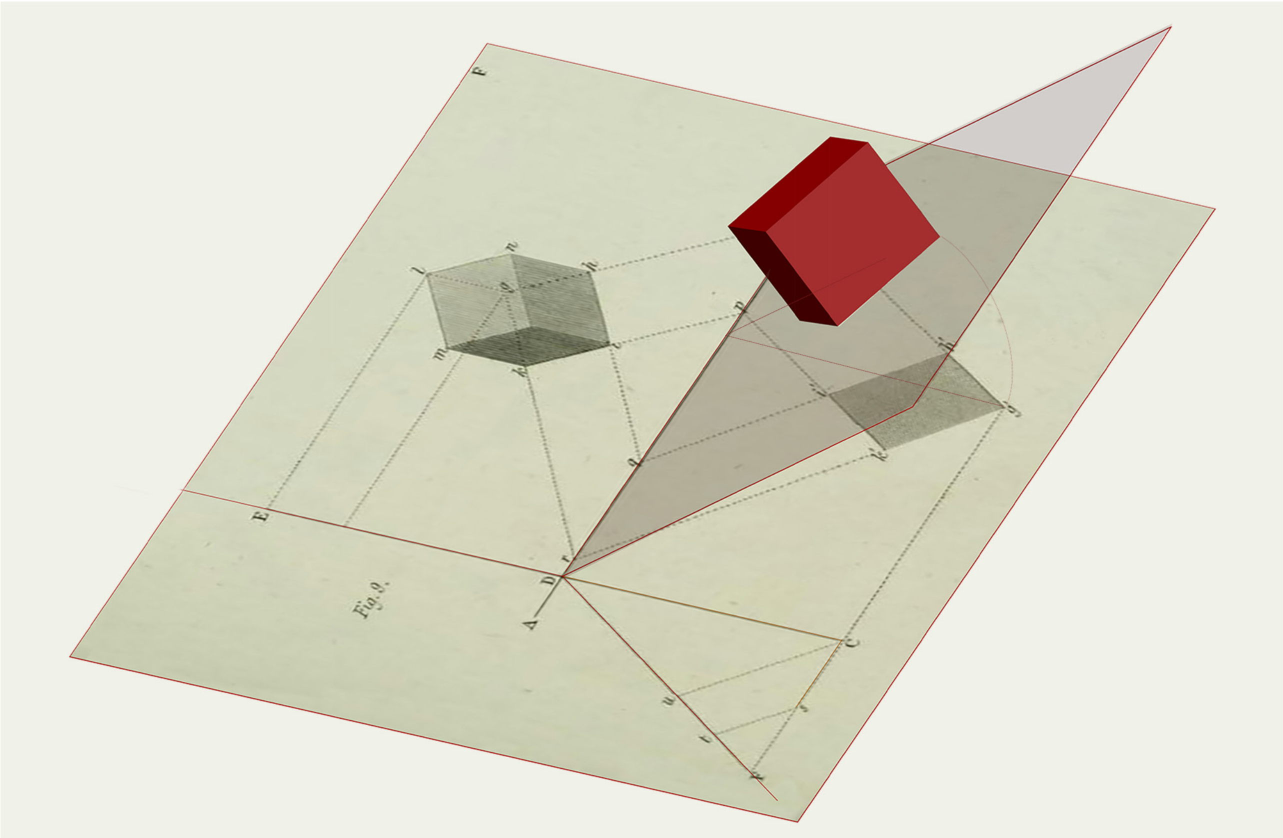
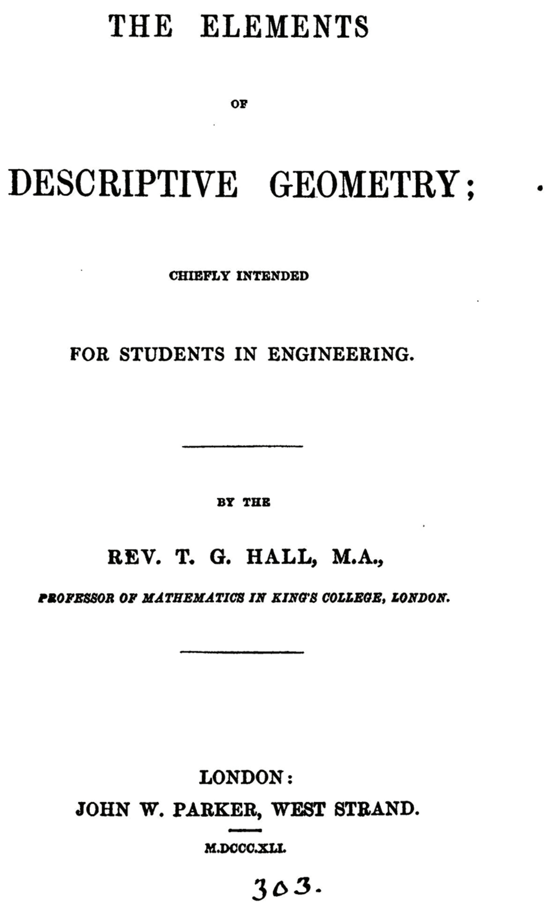


Fig. 8. Axonometric scheme; projection of a rectangular parallelopipedon (graphic elaboration by the author).

time the rabatment principle is clearly explained and the French term '*Rabattement*' is left unaltered. It is significant to note that in the 1860 *Encyclopædia Britannica* under the heading '*Shipbuilding*', in the part dedicated to the practice, the author of the article says that the principles for making constructive drawings are "very able treated by the Rev. Dr. Woolley, in a work entitled *Descriptive Geometry*. Before the publication of this work the efforts in this direction in this country had been chiefly made by practical men, each showing the mode of delineating the more difficult object in his own art" [Murray 1860, p. 184].

Conclusion

Immediately after the Universal Exposition, the English educational system was the object of a profound reflection; it was highlighted the weakness of a scientific approach that could have driven industrial development itself. In a tight period of time new university institutions arose. Between 1840 and 1860 in the architecture and engineering programs even in the most traditional schools, some teachings of descriptive geometry, projections and axonometric drawings appeared, hybridizing the national



THE ELEMENTS

OF

DESCRIPTIVE GEOMETRY;

CHIEFLY INTENDED

FOR STUDENTS IN ENGINEERING.

BY THE

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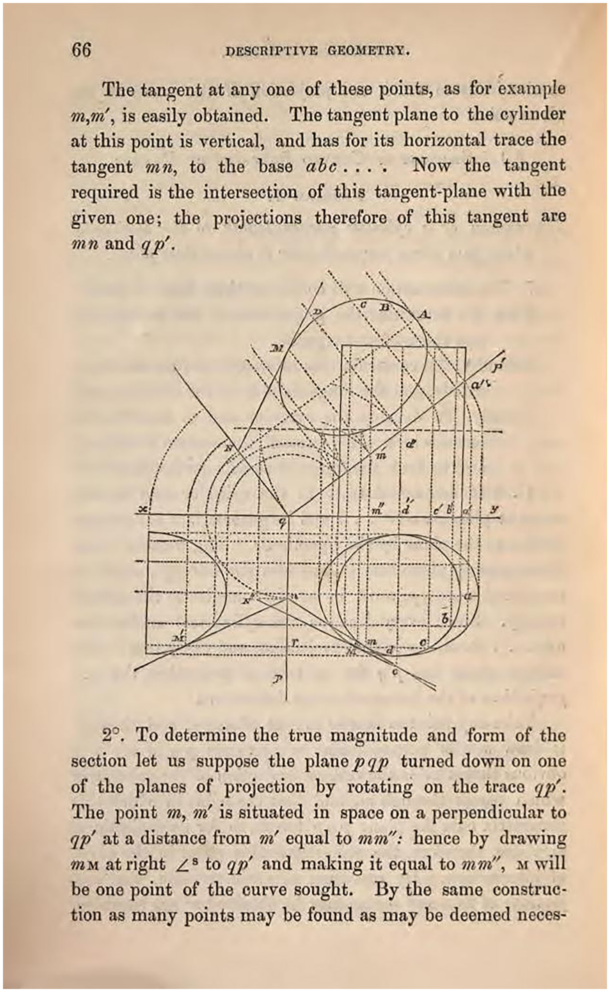

66 DESCRIPTIVE GEOMETRY.

The tangent at any one of these points, as for example *m,m'*, is easily obtained. The tangent plane to the cylinder at this point is vertical, and has for its horizontal trace the tangent *mn*, to the base *abc* .... Now the tangent required is the intersection of this tangent-plane with the given one; the projections therefore of this tangent are *mn* and *qp'*.

2°. To determine the true magnitude and form of the section let us suppose the plane *pqp* turned down on one of the planes of projection by rotating on the trace *qp'*. The point *m*, *m'* is situated in space on a perpendicular to *qp'* at a distance from *m'* equal to *mm''*: hence by drawing *m*M at right ∠s to *qp'* and making it equal to *mm''*, M will be one point of the curve sought. By the same construction as many points may be found as may be deemed neces-

Fig. 9. Frontispiece of The Elements of Descriptive Geometry [Hall 1841].

Fig. 10. Sections of curved surfaces by planes [Hall 1841, p. 66].

theories of Nicholson and Farish with the Monge's ones [Lawrence 2003, Cardone 2017].
In 1851 it was John Fry Heater [20] of the Royal Military Academy of Woolwich who still published a book on Descriptive Geometry. This time the text is composed of copious extracts of Monge's work. Although this represents a further step in the transfer of the original contents of the French engineer, the fact that it did not offer the whole work, but only extracts, was the object of criticism. In 1868 Cunningham wrote that, although the Monge's text itself, albeit with the posthumous additions of Brisson, is complex and perhaps not suitable as a textbook, Heater's book, certainly excellent, has damaged the cause of Descriptive Geometry in the Country. Indeed: "It has been a stumbling-block to many, who, regarding it as a complete elementary text book on the subject, have, after a brief inspection, laid it aside, and rashly pronounced that Descriptive Geometry was not sufficiently practical for their requirements" [Cunningham 1868, p. 52].
In any case, in the sixties of the Nineteenth Century the Descriptive Geometry is a matter required also in universities, so much so that in 1861 the Committee of Council on Education asked Mr. Bradley–at the time a professor at the Royal Military Academy and at the King's College in London–to prepare a complete course of Geometric Drawing ("Graphic Geometry"). The text written for the above course, divided into two parts, will be titled *Elements of Geometrical Drawing, or Practical Geometry, Plane and Solid, including both Orthographic and Perspective Projection* [Bradley 1861], and was considered, in those years, one of the most complete works both in practical and theoretical terms, also accompanied by splendid drawings [Cooke 1866, p. 136]. Bradley's book became a fundamental text for training and was used as a reference for qualifying certification exams periodically issued by the Royal Society of Arts [21].
We have to note that both Woolley and Bradley's text were produced on the initiative of the government, interested in those years to improve training within many special schools of the Army and Navy. With considerable delay, but with great awareness of its usefulness, the Descriptive Geometry, although taught in a different way than France, is now firmly part of the study programs, both in technical schools–for example the Royal School of Mines–both in the Universities, in particular in the schools of architecture, engineering and mechanics [Lawrence 2008].

Notes

[1] The list could also include other famous names as James Brindley (1716-1772) who was trained as millwright; James Hargreaves (1720-1778) who began his career as carpenter and hand loom weaver, as well as Samuel Crompton (1753-1827). See also Buchanan 1978.

[2] Babbage writes: "It cannot have escaped the attention of those, whose acquirements enable them to judge, and who have had opportunities of examining the state of science in other countries, that in England, particularly with respect to the more difficult and abstract sciences, we are much below other nations, not merely of equal rank, but below several even of inferior power. That a country, eminently distinguished for its mechanical and manufacturing ingenuity, should be indifferent to the progress of inquiries which form the highest departments of that knowledge on whose more elementary truths its wealth and rank depend, is a fact which is well deserving the attention of those who shall inquire into the causes that influence the progress of nations" [Babbage 1830, p. 1].

[3] Religion has significantly influenced the development of technical education in England. Indeed, all the phases of the English educational system have been subjected to religious dogmas and beliefs that have hindered the development of an effective national education system over many centuries.

[4] The Uniformity Act of 1660 established that: "Every schoolmaster keeping any public or private school and every person instructing or teaching any youth in any house or private family as a tutor or School master' should subscribe a declaration that would confirm to the liturgy as by law established and should also obtain a licence permitting him to teach from his respective archbishop, bishop or ordinary of the diocese" [Parker 1914, pp. 46, 47].
[5] Until the Oxford University Act of 1854, the University of Oxford requested an admission test of conformity to the Church of England. [Brock & Curthoys 1997, p. 220; Marsden & Smith 2005, pp. 251, 252].

[6] Booker in its text *A history of engineering drawing* claims that Monge's Descriptive Geometry slowly spreads to England "possibly because they were on too theoretical a level for the practical Englishman" [Booker 1963, p. 130].

[7] Several authors, including Lawrence (2003), Sakarovitch (2005) and Belofsky (1991), converge in dating the arrival of Monge's work in England. Both Lawrence and Sakarowitch refer to a translation of Monge's method in 1809. In particular, Lawrence writes: "*Géométrie Descriptive* was translated into Spanish in 1803, and into English in 1809, presumably for military

purposes, as there are no publications to be found in English libraries to suggest that the work was made public" [Lawrence 2003, p. 1270].

[8] Regarding Brunel's contribution to the arrival in Great Britain of Monge's Geometry, Cardone writes: "He […] left France when engineering studies had not yet been reformed and descriptive geometry was still covered by military secrecy; but he had to know the new discipline, set by Monge as early as the mid-sixties of the century, in Mézières. To prove it, the fact that the French gendarmerie searched him for a long time, just fearing that he was the depositary of some secrets of the master. And, even more, the noble title of which Brunel was awarded in Britain, precisely because he introduced the new discipline beyond the Channel and not, as was also believed, for the construction of the Thames Tunnel": Cardone 2017, p. 150. A careful biography of Brunel is in the recent book of Bagust 2006.

[9] Precisely, Nicholson writes: "In the year 1794 I first attempted the Orthographical Projection of objects in any given position to the plane of projection; and, by means of a profile; I succeeded in describing the ichno-graphy and elevation of a rectangular parallelepipedon: this was published in volume II of the 'Principles of Architecture'" [Nicholson 1828, p. 46].

[10] The *Architectural Dictonary* was published between 1812 and 1819. The edition consulted and reported in the bibliography was found online at the Universitätsbibliothek of the Berlin Technische Universität and is dated 1819.

[11] The vol. XXVIII of *Rees Ciclopædia* was published for the first time in 1814. However, the text quoted in the bibliography dates back to 1819. To avoid errors in dating, it is important to clarify that the encyclopedia was printed from January1802 to July 1820. After the conclusion of vol. XXXIX, the entire series was reprinted with the only date of 1819. Since this, however, posed a problem of priority of published scientific research, in the Philosophical Magazine of 1820 a list was published with the correct dating of all 85 parts of the 39 volumes: "We have been sorry to observe the date 1819 affixed to the title page of each of the 39 volumes, instead of the particular year, in which each volume was finished; because of the great number of discoveries and improvements in the useful Arts and Sciences, which have been for the first time submitted to the Public […] We trust therefore, that our Readers will approve our giving here, a list containing the Dates of Publication, of each of the 85 Parts of this extensive Work" [Tilloch 1820, p. 222].

[12] In the treatise *The School of Architecture and Engineering*, Nicholson, introducing to the projections, points out the difference between the Descriptive Geometry and the projection he treated: "Projection is an art which teaches the rules for representing (or drawing) upon one plane, any body or solid whatever, the position of one of them, and the position of one of them to the Plane of projection are known" [Nicholson 1828, p. 51].

[13] John Leslie (1766-1832) was a Scottish mathematician and physicist, professor of Mathematics and Natural Philosophy at the University of Edinburgh and a correspondent member of the Royal Institute of France. He refers to the Descriptive Geometry in the preface to the text *Geometrical analysis, and geometry of curve lines, being volume second of a course of mathematics, and designed as an introduction to the study of natural philosophy* of 1821: Leslie 1821, p. IX. Here, he advances the personal purpose of writing a book on Descriptive Geometry and Solid Theory. That Leslie was aware of the new discipline is probable. The part on the geometric analysis of 1811 Leslie's text [Leslie 1811], is translated into French by M. Comte, to be inserted in the text of M. Hachette of 1818, *Second Supplément de la Géométrie Descriptive*, published in Paris by Firmin Didot: [Hachette 1818, pp. IV, X].

[14] Thomas Stephens Davies (1794?-1851) was a British mathematician. In 1834 he was nominated among the mathematical masters of the Royal Military Academy in Woolwich.

[15] Thomas Grainger Hall (1803-1881), of a deeply religious family, first studied in the city of Wisbech and then at the Magdalene College of the University of Cambridge. He obtained his Bachelor's degree in 1824 and became a Master of Arts in 1827. In the same year he was ordained deacon and then received the priesthood in 1828. He taught mathematics at King's College in London from 1830 to 1869. From 1851 to 1861 he held the office of Dean of the Applied Sciences Department and from 1861 to 1862 he was Dean of the engineering section of Applied Sciences Department. He was the author of several writings of algebra, differential and integral calculus, and trigonometry. See Cambridge University Alumni, 1261-1900; Secretary's In-Correspondence, KA / IC / G31, King's College London Archives.

[16] Thomas Bradley (1797?-1869), was born in Westminster in London. On Bradley's date of birth there are still some uncertainties, since on some documents the date of birth is 1797, while the documentation held by King's College shows the date of his baptism on 28 April 1799 at St. Anne's Church Soho in London, and this leads the same historians of the College to date their birth in that year. In 1838 he was appointed superintendent of the Royal College of Practical Science and was appointed as a lecturer of Geometrical Drawing at King's College London. He became a professor in 1848. In 1855, while maintaining his position at the London University, he was also called to teach at the Royal Military Academy in Woolwich. Thomas Bradley was the first to give lessons on Descriptive Geometry during the sessions of 1839-1841 at the Department of Engineering at King's College. These lessons were also part of the architecture curriculum.

[17] Thus declares Hall himself in the preface: "The treatise on Descriptive Geometry, by Mr. Lefébure de Fourcy, has been selected, and the following pages are, for the most part, translated from it": Hall 1841, pp. V-VI. Louis Lefébure de Fourcy (1787-1869) was a French mathematician. He worked at the École polytechnique as deputy assistant and then assistant at the course of Descriptive Geometry by Charles François Antoine Leroy. Although this is a secondary figure [Cardone 2017, p. 157], his text of Descriptive Geometry, along with other mathematical writings, has long been considered a 'classic', as evidenced by the fact that in 1847 it was in its fifth edition [Havelange et al. 1986, p. 452].

[18] It was the Admiralty Office Council, one of the great British state offices that ran naval affairs.

[19] Joseph Woolley (1817-1889), was a naval architect. He trained at the University of Cambridge and for about 25 years served Admiralty as instructor of naval architecture and as inspector. Noteworthy was his contribution to shipbuilding education.

[20] John Fry Heater (1815-1886), naval architect.

[21] The Royal Society for the Encouragement of Arts, Manufactures and Commerce or simply called the Royal Society of Arts, became the first association to offer vocational qualifications at the national level. The qualification exams, established in 1852, were specifically aimed at the so-called working class, whose education began to be considered fundamental for the economic prosperity of the country. In 1863 it was possible to support the examination also in Geometric Drawing. Among the recommended texts were those of Bradley and Hall and "in consequence of the great deficiency of English works on Geometrical Drawing" also the French texts of Descriptive Geometry of Lacroix, Lefébure de Fourcy, Armengaud and Amouroux (for industrial drawing) and Bardin. See [Blake 1862].

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