ON GARDENERS, DUKES AND MATHEMATICAL INSTRUMENTS[1]

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Introduction

My interest in the life and works of Edmund Stone (1695?-1768) began while conducting a study of Thomas Simpson's (1710-1761) works on fluxions, namely *A New Treatise of Fluxions* (1737) and *The Doctrine and Application of Fluxions* (1750) (Blanco, 2014). To understand the differences between both works, it was necessary to trace the mathematical influence of other authors on Simpson. Among these, I examined Stone's *Method of Fluxions both Direct and Inverse* (1730). Allegedly, this was the first book on fluxions that Simpson read. The "direct" part was a translation of the *Analyse des infiniment petits* (L'Hospital, 1696), while the "inverse" part was largely based on Cotes's *Harmonia Mensurarum* (1722). But, in addition to his *Method of Fluxions*, Stone published a large amount of mathematical works. Being the self-educated son of a duke's gardener, Stone's mathematical contributions were unusual, to say the least.

One of his earliest works soon caught my attention, *The Construction and Principal Uses of Mathematical Instruments*, published in 1723. It was one of the earliest general manuals on mathematical instruments in English, if not the first. It was essentially a translation from the French version of Nicolas Bion's *Traité de la construction et des principaux usages des instrumens de mathématique*, first published in 1709. However, this book was not just a bare translation. As the title of the book indicated, Stone annexed a number of instruments that had been omitted by Bion, in particular, those that

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were invented or improved by the English. After examining Stone's work and its production, this paper analyses Stone's views on mathematical instruments and, in particular, their connection with practical mathematics.

The Gardener and the Duke

Edmund Stone was the son of a gardener at Inverary (Scotland) in the service of John Campbell (1680–1743), second Duke of Argyll and first Duke of Greenwich. Master-General of the Board of Ordnance from 1725 until 1740, the Duke was a leading figure in the military and political context in England and Scotland at the time. Most of Stone's biographies were based on a letter from Chevalier Andrew M. Ramsay (1686–1743) to the Jesuit Father, Louis B. Castel (1688–1757), published in 1732 in the *Journal de Trévoux* (t. 32, 103–113).[2] Ramsay had met Stone around 1730, probably when visiting the Duke in London. According to this letter, Stone learned to write and read at 18. He also taught himself mathematics and managed to master geometry and arithmetic, as well as French and Latin. The Duke, who discovered Stone's abilities by chance, "provided him with an employment which left him plenty of time to apply himself to the sciences" (*Journal de Trévoux*, t. 32, 112). In fact, as we will see, the Duke would play a relevant role in Stone's career. For instance, in 1725, Stone was elected Fellow of the Royal Society, proposed by John T. Desaguliers (1683-1744), no doubt thanks to the Duke's patronage (Figure 1).[3]

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[2] For general biographical facts, see Aikin (1799–1815), Carey (1825, II, 127–128), Chalmers (1812–1817), Guicciardini (2004).

[3] Why was Stone proposed by such a relevant figure as Desaguliers? On 31 July 1721 Desaguliers met the Duke of Argyll, brother of his friend, the Earl of Ilay, at a dinner held by the Duke of Chandos, Desagulier's patron. The Duke of Argyll was, at the time, Lord Provost of Edinburgh, and seemed to be concerned about Edinburgh's water supply problems. Some weeks later, Desaguliers was invited to Edinburgh on account of his knowledge on water engineering (Carpenter, 2011, 140-141). Being aware of Stone's skills, it was not unlikely, and here I am just speculating, that the Duke of Argyll recommended his *protégé* to Desaguliers upon this occasion. After 1742, Stone's name was withdrawn from the list of Fellows of the Royal Society. His resignation could be connected with two facts: the death of the Duke of Argyll and the loss of influence of the Campbells around the same time (Emerson, 2008, 89-100).
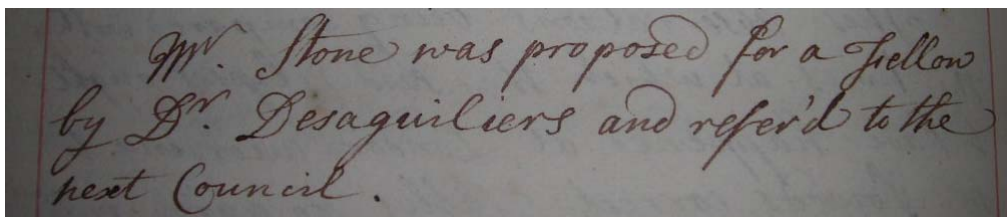
Figure 1. Extract from the *Journal Book of the Royal Society* (11 March 1724, v. XIII, 456)

Stone moved to London, where, allegedly, it was not known for sure what he did, although it is was likely that he worked as a tutor of mathematics.[4] However, his name can be found on the list of the members of the Board of Green Cloth, first as Messenger (1725), then as being appointed Groom of the Accompting House in 1730, worth about £100 per year, and finally, as Deputy Sergeant Porter to his Majesty in 1736.[5] The Board of Green Cloth was a board of officials belonging to the Royal Household, whose head was the Lord Steward. Since John Campbell, the Duke of Argyll, held the position of Lord Steward of his Majesty's Household between 1718 and 1725, it is then not by chance that the Board of Green Cloth employed Stone.

From 1721 onwards, Stone published a large number of mathematical works. His contributions were confined mostly to translating and editing. His knowledge of French and Latin enabled him to translate several works into English. These works cannot, however, be regarded as mere translations. For, on the one hand, not only did Stone revise and correct the works he translated, but he also expanded upon them with additions. On the other hand, there was a clear educational motivation behind his projects, with additional explanations to render the text clearer for the learner's sake. The following extract from his preface to the translation of Barrow's edition of Euclid's *Elements*, regarding the most convenient position of the figures, illustrates this point:

> (It) is much better to have the schemes of the propositions in the same pages with the propositions
> (as they are in this tract) singly, than to have many of them together in one cut, because the

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[4] See, for instance, Blanco (2014, note 22).
[5] *Read's Weekly Journal or British Gazetteer*, 26 December, 1730; *London Evening Post*, 11-13 November, 1736; *London Daily Post and General Advertiser*, 12 November, 1736; *Daily Journal*, 15 November, 1736.

> learner's attention to the proposition he is reading, will be interrupted not only by constantly taking his eye off from the place he is reading, to view the scheme, which will always be too distant. (Stone, 1728, preface)

Likewise, in the preface for his revised version of David Gregory's edition of Euclid's *Elements*, Stone explained why he undertook such a revision:

> The notes which I have added do explain and clear up some difficulties and obscurities that may occur to learners, and easier demonstrate some propositions, and clear Euclid from some seeming faults and oversights. (Stone, 1752, preface, p. xv)

Besides the abovementioned work on the method of fluxions and a mathematical dictionary (1726), Stone's works can be arranged into two groups. Strongly convinced of its usefulness, geometry was the subject of the first group of translations and revisions tackled by Stone, for instance, his revised and annotated editions of Barrow's and Gregory's editions of Euclid's *Elements*, and the translation into English of L'Hospital's *Traité analytique des sections coniques*. A second group was centred on practical mathematics, namely "sphericks", mathematical instruments, perspective, the working of ships and astronomy.[6] Stone's inclination towards practical mathematics mirrors the utilitarian view of mathematics in 18th-century Britain described in Sorrenson (1997) and Turner (1973), among others. In the next sections, I will elaborate more on Stone's views on practical mathematics, in general, and on mathematical instruments, in particular.

On the most serviceable branch of learning

In August 1720 a notice appeared in the *Post Boy* that invited subscriptions for Bion's *The Construction and Principal Uses of Mathematical Instruments*, translated into English from the last French edition by Edmund Stone, *philomath*. A number of "English instruments, which are more complete than those of the French, and which Bion has omitted" would be annexed to this work (*Post Boy*, 13, 20, 27 August, 1720). Subscriptions were to be taken by John Senex (cartographer, globe maker, engraver),

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[6] For a detailed list of his works, see Blanco (2014).

William Taylor (bookseller), Andrew Johnston (engraver) and Jonathan Sisson (mathematical instrument-maker). For reasons unknown, the work was not printed by subscription in the end, but, apparently, the Duke of Argyll did finance it (Wigelsworth, 2010, 49). Actually, in his dedication to the Duke, Stone acknowledged the role played by his patron in the production of the work:

> The subject of the following treatise seems of importance enough to claim your Grace's patronage, and of use enough to deserve it. (...) Indeed, **as the first design of its appearing in English was laid in Your Grace's family, and as it was carried on and finished in the same**, it seems to have some title to Your Grace's countenance: it naturally seeks protection where it found its birth, and lays claim to the privileges of a native of your family, as well as those of a domestick. (Dedication to the Duke, Stone, 1723, iv, my emphasis)

Although the initial plan was to have the publication out by the end of 1721, the finished work finally came out in 1723 (Figure 2), though advertised in newspapers such as the *Daily Courant* as early as December 1722. Printed in folio and illustrated with 26 copper plates engraved by the eminent Senex, it was no doubt a very exclusive work at the time. In fact, its price was around £1 (1 Guinea), whereas, for instance, Adams (1791), which was printed in two volumes in octavo, with 35 copper plates, cost 14s and Robertson (1747), printed in octavo as well, around 3s.
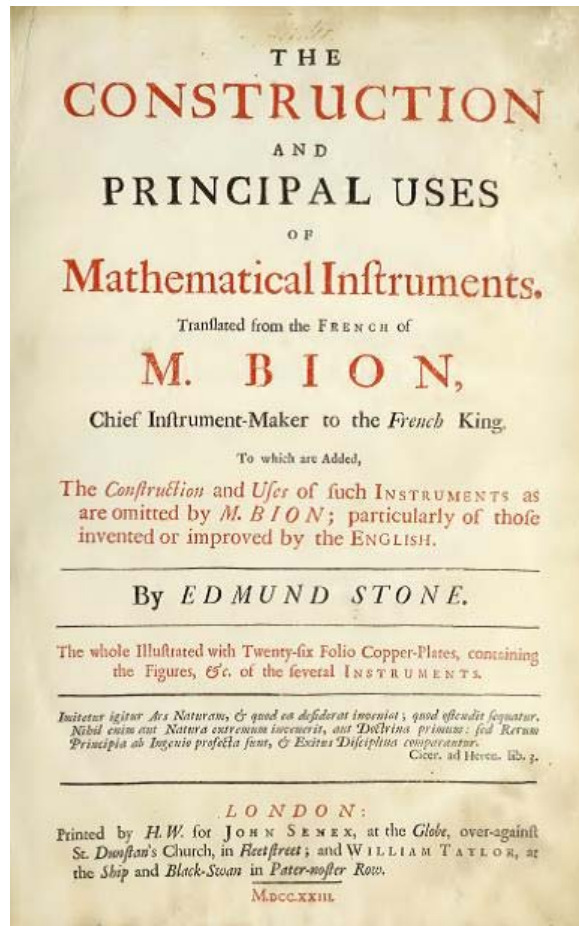
Figure 2. Title page of Stone's *The Construction and Principal Uses of Mathematical Instruments* (1723) [digitized by the Internet Archive, 2012, with funding from Gordon Bell, available at http://archive.org/details/constructionprinOObion]

The book seems to be addressed to gentlemen, since, as Stone stated in the translator's preface, the study of mathematics "made a part of the education of almost every gentleman" (Stone, 1723, v), without any reference to architects, engineers or surveyors, as such was the case of Robertson (1747) or Adams (1791). As Turner (1973, 51-52) points out, from the late 16th century onwards, the study of mathematics was an essential element in the education of a gentleman "to maintain his position and engage in the activities traditional to his class" (Turner, 1973, 51), such as astronomical navigation, warfare, surveying or trade, among others. Hence, it is worth noting that the Duke of Argyll, like his brother, Archibald Campbell, Earl of Ilay (1682-1761), studied mathematics during his stay in the Netherlands (Emerson, 2002, 25). It is also remarkable that from 1725 to 1740, the Duke of Argyll was Master-General of the

Board of Ordnance, an institution in charge of the Royal Observatory of Greenwich, which had to be provided with instruments, in general, and in particular, mathematical instruments (Millburn 1988; Sorrenson, 1997, 266-268).

Stone defined mathematics both as a science, with regard to the theory, and as an art, with regard to the practice. But, while many works on the former were published, there were not enough works on instruments, on which the latter depended:

> There seems, then, but little wanting to Mathematicks, considered as a Science: If there be any defect, 'tis when considered as an Art. I mean, Mathematicks appears more accessible, as well as more extensive, on the side of their theory than on that of their practice. Not that the latter has been less laboured by authors than the former, but because a sufficient regard does not seem to have been had to the instruments, whereon it wholly depends. (Stone 1723, The Translator's Preface, v)

Mathematical instruments connected these two sides of mathematics. Since the knowledge of mathematical instruments led to the knowledge of practical mathematics, the study of mathematical instruments could be regarded as one of the most useful branches of knowledge in the world, which, therefore, had to be spread:

> Mathematical instruments are the means by which those sciences are rendered useful in the affairs of life. By their assistance it is, that subtile and abstract speculation is reduced into act. They connect, as it were, the Theory to the Practice, and turn what was bare contemplation, to the most substantial uses. The knowledge of these is the knowledge of practical mathematicks: so that the descriptions and uses of mathematical instruments, make, perhaps, one of the most serviceable branches of learning in the world. The way then to render the knowledge of mathematicks general and diffusive, is by making that of mathematical instruments so: with a view of which kind, our author seems to have engaged in the following treatise; at least, 'twas from a view of this kind that I undertook to translate it. (Stone, 1723, The Translator's Preface, v-vi)

From his preface, it is clear that Stone was highlighting the usefulness of mathematics "in the affairs of life", in keeping with the notion of practical mathematics that would appear in his *Mathematical Dictionary*: "Practical, which teaches how to demonstrate something useful, or to perform something that shall be proposed for the benefit and advantage of mankind" (Stone, 1726, entry *Mathematicks*). Stone seemed to share his interest in usefulness with his patron, the Duke of Argyll, who was allegedly inclined "to promote every kind of useful knowledge, and polite learning" (Muller, 1736, dedication to the Duke of Argyll).

However useful it might be, Stone lamented the lack of a general treatise on mathematical instruments, like Bion's, in English:

> The design of the work, however useful, yet seems to be new among us. Particular authors have indeed touch'd on particular parts. One, for instance, having described the globe, another the sector, and a third the quadrant: but for a general course, or collection of mathematical instruments, I know of none that has attempted it. 'Tis true, in Harris's Lexicon, we have the names of most of them, and in Moxon's Dictionary the Figures of many. But the accounts given of them in both are so short, lame and deficient, that there's but little to be learn'd from either of them. (Stone, 1723, The Translator's Preface, vi)

The two works Stone mentioned were actually dictionaries or encyclopaedias, rather than manuals on mathematical instruments. Regarding the description of mathematical instruments, Harris indicated that "some of them (as the most useful) are largely done, but the others as briefly: for as it would have taken up a large volume to have described them all" (Harris, 1704, preface to volume I). Yet, other instruments, such as globes, quadrants, telescopes, microscopes, baroscopes and air-pumps, were largely described "because these are of vast use and benefit to mankind, and have served to improve and raise up the knowledge of nature to that good height it is now arrived to" (Harris, 1704, preface to volume I).

When it comes to Moxon and Tuttell's mathematical dictionary (1700), a short supplement was added to the 1701 edition, which contained the description and explanation of mathematical instruments. It was to give the reader "a brief account of the general meaning and signification of the instrument itself, with the advantage of every improvement" (Moxon and Tuttell, 1701, To the Reader, i). Moxon and Tuttell were aware that such a small tract could not contain all the particular uses of the instruments. Therefore, when possible, they would refer to particular books, where instruments were described at large.

Almost 70 years later, George Adams (1750-1795) would complain about the same drawback in the preface of his *Geometrical and Graphical Essays* (1791).[7] Although

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[7] As to why the books on mathematical instruments were so scarce, Stone believed it was "because the able geometricians, who are the most capable of making one, have the least inclination for it, because of

Stone's translation of Bion's treatise, was, according to Adams, the only standard treatise on mathematical instruments published up to that moment, it had become obsolete after all those years:

> Monsieur Bion's treatise on the construction of mathematical instruments, which was translated into English by Mr Stone and published in 1723, is the only regular treatise we have upon this subject: the numerous improvements that have been made in instruments since that time, have rendered this work but of little use. (Adams, 1791, v)

While in the 16th and 17th centuries, many manuals on a single instrument, or a set of instruments, were published (Bennett 2011, p. 698), in the 18th century, there was a growing interest in the publication of general treatises on mathematical instruments. This seemed to be the reason why Stone undertook the translation of Bion's treatise, which he regarded as "a good safe model" (Stone 1723, The Translator's Preface, vi).

In 1709, Nicolas Bion (1652-1733), chief instrument maker to the French King, published the *Traité de la construction et des principaux usages des instrumens de mathématique*, which became a key work on mathematical instruments (Adams, 1791, v; Knight, 1975, 202).

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the small honour and reputation they would acquire by it; and thus it has happened that there never has yet been a very good book upon this subject" (Stone, 1758, Advertisement, ii). This situation contrasts with the increase in reputation of the instrument makers, as pointed out by Bennett (2011, 705).
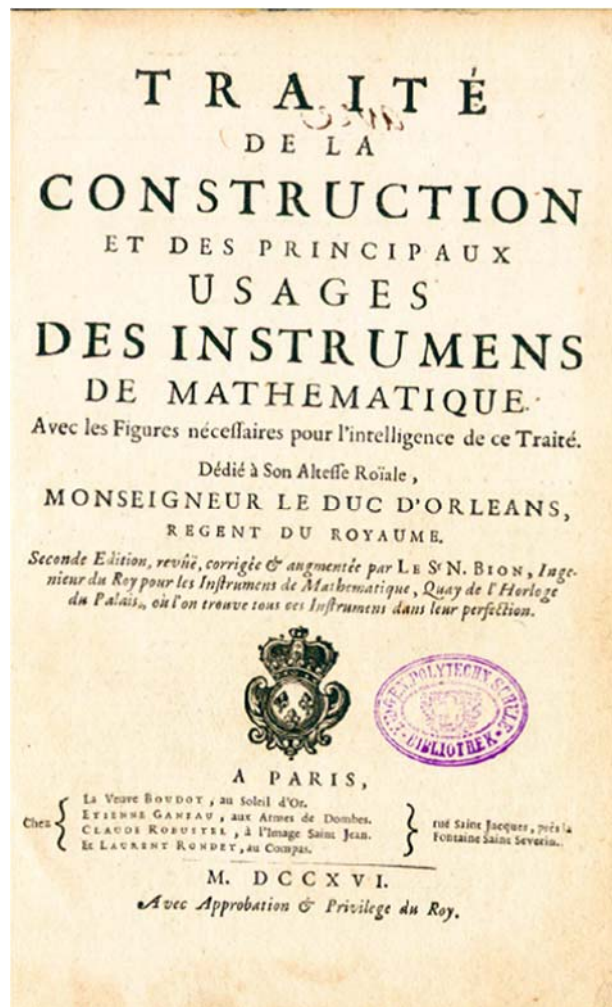
Figure 3. Title page of Bion's *Traité de la construction et des principaux usages des instrumens de mathématique* (2nd ed. 1716) [digitized by E-lib.ch: Elektronische Bibliothek Schweiz, available at www.e-rara.ch]

As a thorough comparison of the contents of both works reveals, Stone's translation was based on the second edition (1716) of Bion's treatise (Figure 3). It consisted of eight books, which described the construction and uses of instruments in the areas of drawing, surveying, artillery, astronomy and navigation, as well as a book on the "compas de proportion" (or "French sector", as Stone translated it) and another one on sundials (see Table 1). Each book presented the structure traditionally adopted by this type of work (Bennett, 2011, 698): the first part containing the construction of a specific instrument followed by a collection of applications and uses of the instrument in question.

Table 1. Contents of Bion's *Traité* (1716) and Stone's additions (1723)

Books	BION	STONE's additions
	Définitions nécessaires pour l'intelligence de ce traité.	
I	Des instrumens les plus ordinaires; comme sont le compas, la regle, le tire-ligne, le porte-craïon, l'equerre et le rapporteur.	Additions of English instruments. Of the construction and uses of the Carpenter's joint-rule, the four-foot gauging-rod, Everard's sliding-rule, Coggeshall's sliding-rule, the plotting-scale, an improved protractor, the plain-scale, and Gunter's scale.
II	De la construction et des usages du compas de proportion.	Of the construction and uses of the English sector.
III	De la construction et des usages de plusieurs compas et autres instrumens curieux, qui servent ordinairement au cabinet.	Additions to Chap. I. Of the turn-up compasses, and the proportional compasses, with the sector lines upon them.
IV	De la construction et des usages des instrumens de mathematique. Qui servent à travailler à la campagne, pour arpenter les terres, lever les plans, mesurer les distances et prendre les hauteurs. Les plus usitez sont les piquets, les cordeaux, la toise, la chaîne, les equerres d'arpenteur, les recipiangles ou mesurangles, les planchetes, le quart de cercle, le demi-cercle et la boussole.	Additions of English instruments. Of the theodolite, plain-table, circumferentor, and surveying-wheel.
V	De la construction et des usages de plusieurs differens niveaux pour la conduite des eaux. Comme aussi des instrumens servant à l'artillerie.	Of the construction and use of the English callipers.
VI	De la construction et des usages des instrumens qui servent à l'astronomie, tirez des tables astronomiques de M. de la Hire, et des observations de l'Académie Roïale des Sciences.	Additions of English instruments. Of globes, spheres, the astronomical quadrant, a micrometer, and Gunter's quadrant.
VII	De la construction et des usages des instrumens qui servent à la navegation.	
VIII	De la construction et des usages des cadrans au soleil.	The use of the sector in the construction of solar eclipses.
	Description des principaux outils dont on se sert pour la construction des instrumens de mathematique.	

English instruments *versus* French instruments

At the end of each book, Stone annexed a section on the construction and uses of a number of instruments that had been omitted by Bion, in particular those that were invented or improved by the English:

> The French instruments described by him [Bion], are, in the main, the same with those used among us. Such English instruments as he has omitted, I have been careful to supply: and throughout, have taken the liberty not only to make up his deficiencies, but amend his errors. (Stone, 1723, The Translator's Preface, vi)

Table 1 shows the "English instruments" added by Stone. Hence, for instance, after the translation of Book II, *Of the Construction and Uses of the Sector*, Stone added a chapter on the "English sector" (Figures 4 and 5).
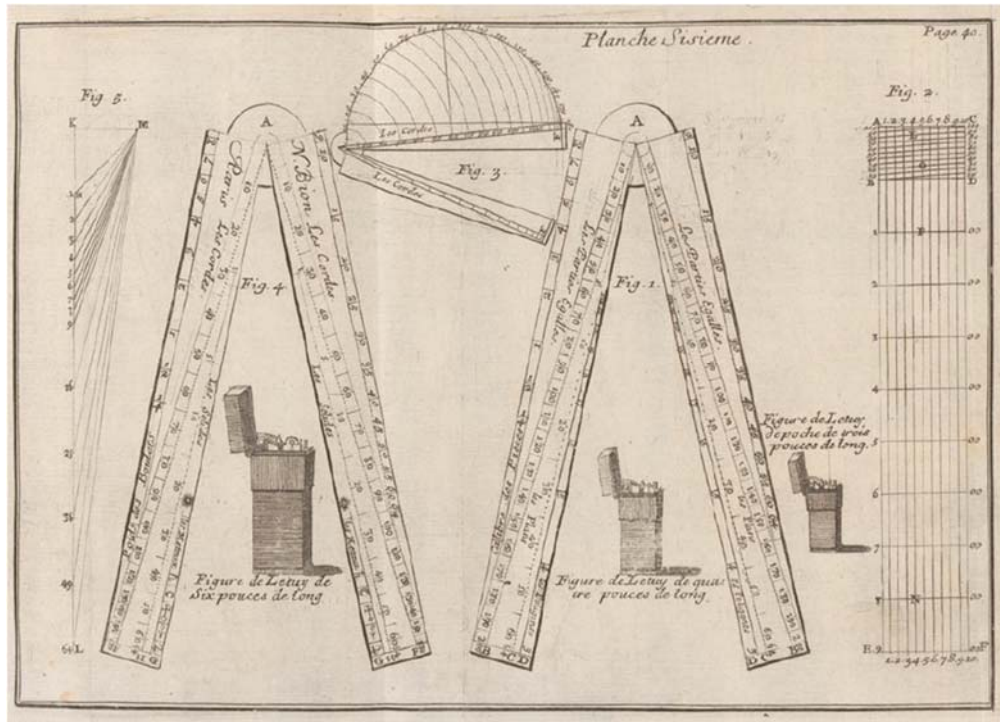

Figure 4. The "compas de proportion" in Bion's *Traité de la construction et des principaux usages des instrumens de mathématique* (2nd ed. 1716), plate VI [digitized by E-lib.ch: Elektronische Bibliothek Schweiz, available at www.e-rara.ch]
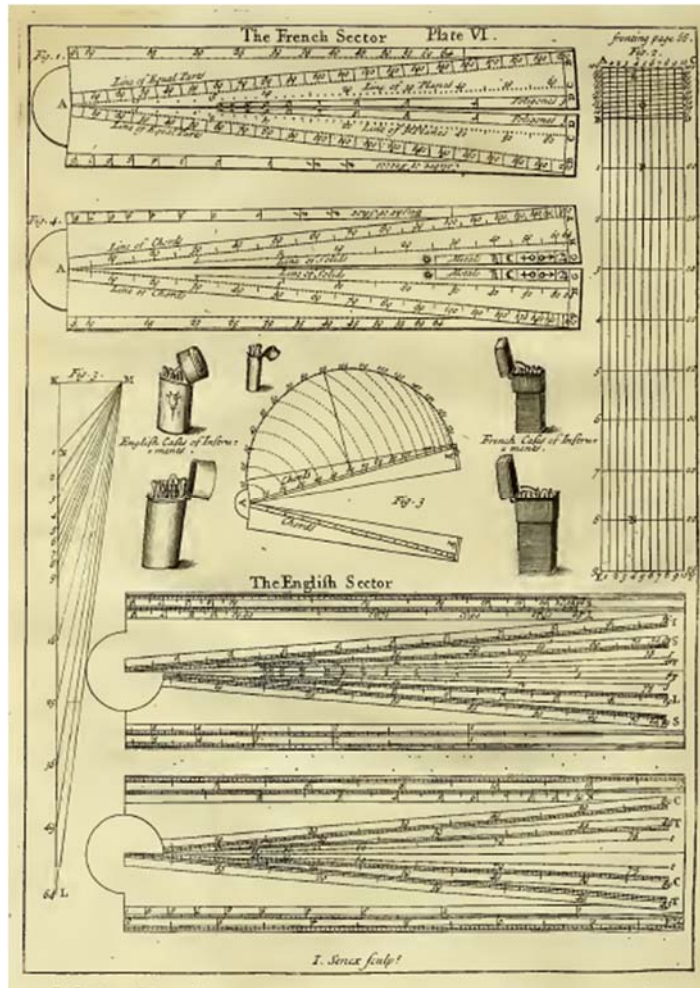
Figure 5. The French sector and the English sector, in Stone's *The Construction and Principal Uses of Mathematical Instruments* (1723), plate VI [digitized by the Internet Archive, 2012, with funding from Gordon Bell, available at http://archive.org/details/constructionprinOObion]

This was not an isolated practice. Johann G. Doppelmayr (1677-1750) also annexed a

number of instruments to his German translation of Bion's treatise (Doppelmayr, 1727),

yet without any reference to the nationality of such instruments (Figure 6).
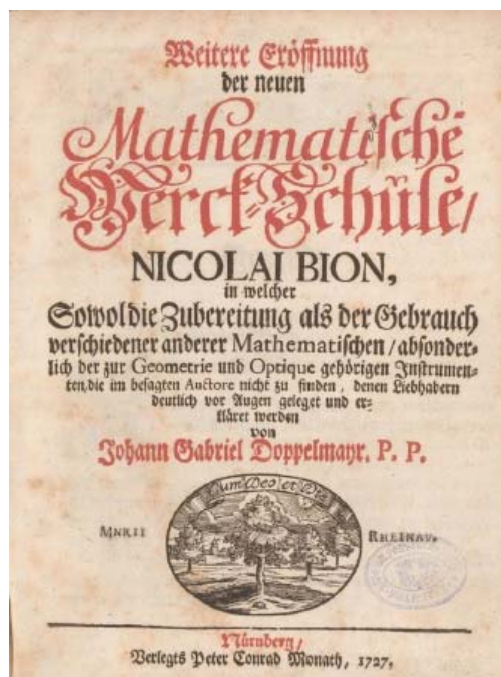
Figure 6. Title page of Doppelmayr's *Weitere Eröffnung der neuen Mathematische Werck-Schüle* (1727)
[digitized by E-lib.ch: Elektronische Bibliothek Schweiz, available at www.e-rara.ch]

The nationalist connotations became more explicit in the second edition of Stone's work (1758).[8] In the advertisement of the second edition, Stone insisted on the superiority of the English over the French in the making of mathematical instruments:

> … many French instruments of Mr Bion's were excelled by some of ours, of the same kind in contrivance; and as to workmanship, I never did see one French instrument so well framed and divided, as some of ours have been (…) And many more curiously contrived, and well executed mathematical instruments which I could mention, far exceed those of the French, or indeed any other nation of the world. The making good mathematical instruments is almost peculiar to the English, as well as their skill in all branches of the mathematicks and natural philosophy has been generally superior to that of other nations (Stone, 1758, Advertisement, i).

As Bennett (2011, 701 and 705) pointed out, it is true that in the 17th century, the English workshops grew in importance and that the English instrument makers gained in reputation, as illustrated by the fact that John Senex was elected Fellow of the Royal Society of London in 1728. Nevertheless, the "nationalisation" of instruments in Stone's work was no doubt the consequence of the thorny relationships between France and Great Britain at that time, in particular, concerning the Jacobite cause. The Duke of

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[8] A supplement was added to this second edition, containing the account of some more instruments and four extra copper plates. For those readers who already had the first edition, the supplement could be obtained alone (price 4s). See, for instance, the advertisement in the *Whitehall Evening Post or London Intelligencer*, 29 April – 22 May 22, 1758). The second edition went on to be advertised up until the 1770s.

Argyll, a supporter of the Hanoverian succession, led the British army against the Jacobite rebellion in 1715, on account of which he was rewarded with the title of Duke of Greenwich. Once again, Stone had a distaste for the Jacobites in common with his patron, to the extent of referring to them as "the disagreeable bushes, prickly briers, unprofitable and poisonous weeds, of Jacobite and republican politics" in his dedication to the Duke of Cumberland (Stone, 1752), who in turn beat down the Jacobite rising in 1746. Under these circumstances, mathematical instruments could be considered a symbol of political and scientific authority, as well as of national identity, borrowing Withers and Wood's terms to stress the importance of mapping in Enlightened Scotland (Withers and Wood, 2002, 56).

Final remarks

With the translation of Bion's treatise, Stone attempted to make up for the lack of general treatises on mathematical instruments in English. The circulation and study of mathematical instruments proved to be essential for the acquisition of knowledge regarding practical mathematics, which was so in-demand during the 18th century. However, beyond its contribution to practical mathematics, the study of Stone's work allows for the placement of mathematical instruments at the centre of a socio-political network. No doubt did the patronage of the Duke of Argyll play a key role in the production of Stone's general treatise on mathematical instruments. Yet, the Duke's influence could be read from other perspectives. On the one hand, the study of mathematics, in general, and of practical mathematics, in particular, was an essential part in the education of English and Scottish gentlemen during the 18th century. With the publication of Stone's work, the Duke of Argyll could have been contributing to the training interests of his own class. On the other hand, Stone did not translate Bion's

treatise literally, but he added a collection of "English instruments", whose superiority over the "French instruments" Stone praised in his work, especially in his second edition. The nationalist perspective regarding the mathematical instruments that Stone presented could have emerged as a consequence of the political and military disagreements between France and Great Britain during the first half of the 18th century, of which the Duke of Argyll was greatly involved.

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