



Review: Renaissance Theaters of Machines

Reviewed Work(s):

The Various and Ingenious Machines of Agostino Ramelli by E. S. Ferguson; M. T. Gnudi;
Agostino Ramelli

Le Machine (1629) by Giovanni Branca
Alex Keller

Technology and Culture, Vol. 19, No. 3. (Jul., 1978), pp. 495-508.

Stable URL:

<http://links.jstor.org/sici?sici=0040-165X%28197807%2919%3A3%3C495%3ARTOM%3E2.0.CO%3B2-3>

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Review Article

RENAISSANCE THEATERS OF MACHINES

ALEX KELLER

The Various and Ingenious Machines of Agostino Ramelli. Edited by E. S. Ferguson and translated by M. T. Gnudi. Baltimore: Johns Hopkins University Press, 1976. \$100. London: Scholar Press, 1976. £50. Pp. 604, 16 figures, 195 plates.

Le Machine (1629). By Giovanni Branca, with introduction by Luigi Firpo. Facsimile reproduction. Turin: Unione Tipografico-Editrice Torinese, 1977. Pp. 175.

The appearance of the "theaters of machines" was a revolutionary moment in our history. Here for the first time was a literature which portrayed, not what was, but what might be; not in terms of spiritual improvement or social reform, but as the machines of a possible, mathematically guided future. To us they reveal the beginnings of an age which transferred its hopes of future betterment to science and technological progress. Whether we love this age or no, such early stirrings must be of great historical value. Were the expectations of the 17th century founded in part on this publicity for novel mechanisms, as much as on the real economic effects of waterwheels, windmills, and clocks? If that is so, we should find a growing public interest in these documents.

Indeed, recent years have seen facsimiles and editions of most of the great illustrated books of inventions which ushered in our age of machines. Not only the oldest manuscripts, like those of Taccola and Kyeser, but the printed works too have appeared in print with scholarly commentary. The latter are now so prohibitively expensive when they do appear for sale as to be almost as inaccessible as manuscripts. There have already been two versions of Verantius, a Zonca, and earlier editions of both Branca and Ramelli.¹ The only absentee is

DR. KELLER, of the University of Leicester, is the author of *A Theatre of Machines* and of many articles on the history of Renaissance science and technology.

¹G. Branca, *Le Machine*, intro. G. Lenzi (reprint ed., Milan, 1965); A. Ramelli, *Le Diverse et Artificiose Machine* (reprint ed., London, 1970); Faustus Verantius, *Machinae*

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Besson, in his own day the most popular. Some of these editions lack even an introduction, however, and none has had a detailed exposition which alone could let the ordinary lover of history or of machines appreciate what the author had in mind.

Ramelli's was the most splendid and comprehensive of all early books in this genre, with almost 200 plates, more than twice as many as its nearest rival. The abundance of ideas is matched by the artistic style which makes his pictures so distinctive. His achievement is properly honored by Ferguson and Gnudi's magnificent edition. As a work of book production nothing has been spared; from the binding, with Ramelli's signature, in the shaky hand of his extreme old age, tooled in gold; to the fine paper, the variety of elegant typefaces, and reproduction of the original margins to surround the new English text opposite each plate. Besides the plates, we are given sixteen figures in the text and a pictorial glossary to interpret the machines, each item illustrated with its own attractive line drawing by M. A. Hammond. Evidently the publishers have put a great deal into this book; the result surely comes up to their expectations, and if inevitably it is also expensive, they have after all produced a book that is as beautiful as it will be useful to those interested in the history of the machine, and they deserve their reward.

To preface the reproduction, M. T. Gnudi, the translator, has contributed a biographical study of Ramelli and an analysis of the book's structure, with notes on the UCLA proof copy, on the pen-and-ink drawings bound in with it, and on the seven drawings on vellum in the Burndy Library (incidentally, there are four more in private possession). She discusses briefly Ramelli's manuscript on his Triangle, now at Chatsworth, in Derbyshire. The editor, E. S. Ferguson, adds an essay on precedents and other influences and on Ramelli's own influence on later generations. It must be said that this introductory material is relatively short and concentrates, as the subtitles imply, on *quellenforschung*: How independent was Ramelli of his sources? Did his pupil Bachot simply steal his ideas without alteration?

Branca's *Le Machine* is less rich in material and less beautiful, but not without repute. When the Istituto Italiano per la Storia di Technica decided to launch their new journal years ago, they called it *Le Machine* as if to recall the title of Branca's collection of inventions and reproduced as a cover picture his most famous woodcut, which is so

Novae, brief notes on chaps. by A. Wissner (reprint ed., Munich, 1965), with essay (one page in length) on Verantius by A. Klemm; the same (Milan, 1968), pub. as vol. 1 of *Classici Italiani di Pensiero Scientifico*, under direction of U. Forti, who wrote an intro. to this vol., the only detailed preface to these facsimiles prior to the two discussed in this review; V. Zonca, *Novo Teatro di Machine et Edificii*, ed. K. Weiss (Acuto, 1969).

often claimed as an anticipation of the steam turbine, for it shows a boiler in the shape of a human head which ejects steam against a paddlewheel geared to a powdermill. This picture alone has appeared in countless books on the history of technology and so made Branca's name, while his other seventy-six have almost faded into obscurity. So although the Istituto had already sponsored the publication of a facsimile edition of *Le Machine*, with an introduction by Guido Lenzi, it was quite appropriate that when the Union Tipografico-Editrice of Turin decided that this year's "strenna," their New Year's gift, should be a book in the history of technology at once important and little studied, they should choose this volume. This too is an attractive edition on glossy paper, with pretty blue vignettes and a reproduction of the cuts that is faithful even to the yellowing and foxing of the original paper, with the Italian text not reproduced but printed opposite, and with Firpo's commentary below in place of the Latin translation. As a piece of bookmaking, it is of course more modest than the new Ramelli, but that is in a class of its own. Firpo's introduction is certainly superior to Lenzi's apart from the commentary he has supplied to nearly every cut. Evidently there are advantages in asking an eminent general historian of the culture and thought of the 17th century to write the introduction, rather than an engineer. The historian knows where to find obscure sources in local histories and is familiar with the archives where information may be found. Branca is the only one of the mechanicians of that era for whom we possess entries in registers for both baptism and death. For nearly half his life he served that triumph of divine engineering, the Virgin's Holy House at Loreto. He supervised repairs to the structure, but he was also designer of funeral monuments, responsible for improvements to Loreto's fortifications, prominent in local government, land agent of the Sacra Casa in the administration of its properties, and active in its lawsuits. Over thirty years in the service of one institution—and that a religious foundation which is a good steward of its records—have left a reasonable amount of evidence—if only we had half as much archival material on Ramelli or Besson! For Branca is really a minor figure. His inventions were mostly backward-looking, even in 1629, with some notable exceptions such as the steam-driven powder mill, a coin press powered by a smokejack, and a wind-powered threshing machine. An air of quaintness pleases the modern reader, not least because of the woodcuts, "appealing in their very roughness," says Firpo.

Not that Branca was such a quaint archaism for his contemporaries. One of the clerics who witnessed the ecclesiastical innocence of *Le Machine*, as the censorship law demanded, was Benedetto Castelli,

friend of Galileo and “father of hydrodynamics.” Firpo remarks that “Libri attests the existence of some letters of Castelli which reveal esteem for Branca, but does not furnish proof or reference.” He appears to have been misled by a footnote in Libri’s *Histoire des sciences mathématiques en Italie* (4:60). For Libri does quote in full in an appendix a letter from Castelli to Branca, dated 1641.² In this letter Castelli explains how he had been criticized for an unwelcome opinion as to why the Venetian Lagoon was silting up. He had defended himself vigorously and urged Branca to do the same if his plans were opposed by naive or interested parties. For if a physical cause be only established, it remains the case, whether or not it disagrees with our prejudices. It does Branca some honor to know he was the recipient of such a letter. Perhaps in his old age he had acquired some reputation as a progressive engineer. In his popular handbook, *Manuale d’Architettura* (published in 1629, the same year as *Le Machine*, with half a dozen further editions through the 18th century), he mentions that he knows that Castelli is preparing a treatise on the theory of river movements (which did indeed appear the year after). Another letter from Castelli to Branca had been published well before Libri, in the *Raccolta d’Autori che Trattano del Moto dell’Acque*.³ This letter is undated and may well be somewhat earlier than the other. Branca had consulted Castelli about a novel air vent for an inverted siphon, to serve a fountain which he was to install at Loreto. Its operation is explained in Castelli’s letter, in which he refers to the principles of hydrostatics “as Archimedes and Signor Galileo demonstrate.” The mechanics of *Le Machine*, however, are strictly pre-Galilean. His sources of theory are the pseudo-Aristotelian “Mechanical Problems” and, in the last of his three sections, Heron of Alexandria as developed by Giovanni Battista della Porta. Perhaps he did not grasp even Heron and della Porta fully. His explanations reveal a certain confusion between the force of air and the supposed abhorrence of the vacuum (which was indeed in reality the force of air—but Branca certainly had no notion of atmospheric pressure). Many of these drawings assume that effects that are performed in little table fountains and such Heronian toys can be repeated to any scale.

But should we devote much time to the biography of Branca and to discussion of his intellectual limitations? Did he design the inventions of *Le Machine*? As Firpo points out, he himself states in his introduction that “these present drawings . . . by me expounded came into my hands” [mi vengono alle mani queste presenti figure . . . da me dichiarate]; two of the captions mention “the author” in the third per-

²G. B. I. T. Libri, *Histoire des science mathématiques en Italie* (Paris, 1841), 4:364.

³*Raccolta d’Autori che Trattano del Moto dell’Acque* (Florence, 1768, 4:188, illustrated in tav. 1, fig. 14).

son; once Branca admits himself baffled. Elsewhere too the caption misses the point or leaves vague precisely what needs to be explained. The phrase “came into my hands” is used by the printer Bertelli when he published Zonca’s *Novo Teatro di Machine et Edificiù* in 1607, four years after Zonca’s death. Whether he acquired the drawings by purchase, inheritance, or accident we do not know; if he knew the true author, Branca kept silent, although if this was a case of outright piracy, perhaps he would not have admitted the existence of an “author,” and no complaint has come down to us.

Who then was the true inventor? We have no idea. Probably the drawings were not so very old in 1629. The rolling mill for striking coins, driven off a smokejack, is unlikely to have been designed before the diffusion of these two devices in the course of the 16th century. The third part is dependent on Della Porta’s *Pneumaticorum Libri*, probably in the expanded Italian version, *I tre Libri de Spiritali*, which came out in 1606. In our ignorance, we shall have to go on thinking of “Branca” as Branca.

No such doubt hangs over the author of the *Diverse et Artificiose Machine*, the “Various and Ingenious Machines.” Nor was Agostino Ramelli so remote from the center of intellectual life. Involved in court and siege, he had his part to play on the great stage of war and politics, even if it was only a bit part. Curiously then, there is little trace of Ramelli in contemporary documents. His name does not appear in two lists of artillery officers including the king’s engineers, the “ingénieurs du Roi,” drawn up in 1585 and 1595.⁴ Two accounts of the famous siege of La Rochelle in 1572–73 mention an episode in which he was captured by the Huguenots, returning from their abortive expedition to the Île de Ré, while he was with a party “scouting out the situation and harbour of La Rochelle, and measuring the depth of the water.” So wrote Jacques Auguste de Thou, the leading historian of the French wars of religion, whom Gnudi prefers as a source to the Huguenot La Popelinière. Although La Popelinière was on the wrong side from Ramelli’s point of view, he does write much nearer to the events; indeed, his is the first reference to Ramelli in print, even earlier than the publication of the *Diverse et Artificiose Machine*, so he may be more reliable. Gnudi has also uncovered references to a journal of Count Gonzaga-Nevers, one of the officers in the besieging army, who mentions an Italian engineer Augustin, surely

⁴D. J. Buisseret, Department of History, University of the West Indies, private communication (November 16, 1976). The first “estate general du payement des officiers de l’artillerie” is preserved at Paris, Bibliothèque Nationale MS Fr. 16692, fols. 6–15; the second, fols. 17–31. May I take this opportunity to express my thanks to Dr. Buisseret, who first guided my steps through the thickets of the historiography of the French wars of religion, for his helpful advice with regard to this review.

the same. Yet there are so many other accounts of the siege—and none have anything to say about him—amid all the countless anecdotes in Brantôme, not one about our Agostino. However, there is an incident a little later in La Popelinière's story not mentioned by Gnudi, which may mark a trace of Ramelli, although his name is not attached. On April 7, the king's forces attacked the bastion of l'Évangile, "upon a bridge of wood which they had erected, advancing on wheels, on which three soldiers could stand abreast, and thirty-six feet long, with sliding mantelets covered with iron for fear of fire."⁵ Could this be Ramelli's design? It is certainly reminiscent of the great siege bridges which stride across moats in plates 141–45—those *mantelets coullans* suggest the master's hand. If Ramelli was still imprisoned within the town, then no. Now that Gnudi has shown from Gonzaga-Nevers's journal that Ramelli was released and engaged in the assault on the same bastion of l'Évangile a month or more earlier, perhaps we can indeed give him the credit. In La Popelinière's earlier narrative of the civil wars, *La Vraye et Entière Histoire des troubles*, he tells us only that the enemy advanced over a "bridge of wood," which might be any simple construction; only when he adds that a Protestant officer went out at night to have a look at this bridge and was shot dead by a sniper does he reveal that it was something out of the ordinary.⁶

In the volume after his account of La Rochelle, de Thou also mentions Ramelli again in a picturesque incident that has escaped the notice of all his biographers. In July 1588, one of Henri III's principal commanders, the Duke of Épernon, was attacked in the castle of Angoulême by a group of extremist conspirators who believed he had seduced the king into conciliating the Protestants. Dislike of his influence and arrogance by the Guise family, leaders of the ultra-Catholic party, no doubt lay behind the plot. Among Épernon's suite, as de Thou relates, was "Augustinus Ramellius, highly skilled in the fortifying of places, who was the designer of a new fortification to be constructed."⁷ The attempt on the duke reads like the synopsis of an old Douglas Fairbanks film: sword fights on the spiral staircase, doors slammed and bolted in the face of armed men who shout, "Kill him, kill him," a desperate dash across the courtyard. Ramelli was in the town, apparently in the escort which accompanied the duchess to

⁵L. V. de La Popelinière, *L'Histoire de France* (Paris, 1581), 2:142v.

⁶L. V. de La Popelinière, *La Vraye et Entière Histoire des troubles et choses memorables* (Basle, 1579), chap. 15, p. 45. In *La Vraye et Entière Histoire*, moreover, La Popelinière makes no reference to the capture of Augustin and his reconnaissance party. Presumably in both cases, some years had to pass before he heard details of what happened on the other side.

⁷J. A. de Thou, *Historiae sui Temporis* (Paris, 1604–8), bk. 92, 4:329.

church—some were slain, the duchess captured, Ramelli “ran the same risk to his life, but escaped to the curtain of the city wall, and found refuge in the bishop’s palace.” And all this only just after he had completed his magnum opus!

But was it really Agostino? A news pamphlet published that same year, 1588, attaches the story of the conspiracy against Épernon to reports of Henri of Navarre’s campaign not far off, in Poitou.⁸ An anonymous reporter, a Protestant himself according to his editors, tells the story in the same words, almost verbatim. Instead of Agostino, however, he says that Épernon ordered a plan of the fortification to be drawn up by “Captain Ramelle, son of Captain Augustin, grand engineer of the King.” It does cast new light on Ramelli’s machines if we think that when he finished his book his son was on active service and in peril of his life hundreds of miles away, but certainly that is more likely than to suppose he was down in the southwest himself that summer. Captain Ramelle appears again, seven years later, this time at Doullens in Picardy, soon after the town was recovered for Henri IV. While the Duke of Longueville was inspecting his troops, “entering the city gate on horseback and talking with Captain Ramelle (a man who was very knowledgeable in the making of fortifications) the garrison fired him a salvo with their arquebuses to honour him.”⁹ Alas, “whether it be on purpose or unknowingly, there was one of them who had left his arquebus loaded, who with one shot killed the said lord duke and Captain Ramelle.” The duke indeed lingered for a few days, and his tragic death—for he was still quite a young man—is frequently mentioned, but only the one chronicler, Palma Cayet, mentions Ramelle. Is this the same Ramelle as in the Angoulême incident? Surely any Ramelle who was an expert military engineer must be some relation of Agostino. A Paul de Ramel, king’s engineer and son of Augustin, married one Claudine Prévost in September 1595; in 1603, his wife made over some property, apparently as part of a marriage settlement, to Marie, “daughter of the late Nicolas de Ramel.”¹⁰ He must have been some kin to Paul and Augustin; perhaps he was another son, and it was he who fell at Doullens. Not

⁸“Advertissment sur les exploits d’armes faits par le Roi de Navarre sur ceux de la Ligue au Bas-Poitou . . . et sur la conspiration de ceux d’Angoulême contre M d’Épernon,” ed. L. Cimber and F. Danjou, *Archives Curieuses*, Ser. I (Paris, 1836), 12:32–41.

⁹V. Palma Cayet, *Chronologie novenaire contenant l’histoire de la guerre* (Paris, 1608), bk. 7, p. 492.

¹⁰Archives Nationales de France, Paris: “Insinuations du Châtelet,” Y 135, fol. 48; Y 143, fol. 61. The social standing of the Ramellis back in Ponte Tresa remains uncertain. Adriana Ramelli of Lugano has been investigating the history of her family and kindly informs me that she has unearthed a document of 1587 which names the wife of “Deodato de Ramellis Pontis Tresiae,” but Agostino could equally well be a brother or a distant relative.

knowing Paul's age at his marriage, it would be impossible to judge which of the two was nearly cut down in the streets of Angoulême and which had been protected by Henri III while he was still Duke of Anjou, before 1572, for which Ramelli thanks him in his dedication.

If these events only involved Ramelli's sons, not himself, need they interest us? They do surely cast light upon his world. Skirmishes and surprise attacks echo through his work: No other contemporary book of machines devotes so much ingenuity to military devices. Would it not have been worthwhile to expand on these matters in a biographical study? As it is, Gnudi's biography is a little unbalanced in the amount of space it devotes to Bachot's piracy of Ramelli's ideas. The detective who identified the thief was Gnudi herself, and it was a pretty piece of sleuthing of which she was justly proud, but not perhaps the most important thing in Ramelli's life, especially when she does not analyze the pirated fortification drawings by comparison with others of his generation. Unfortunately, we cannot ascribe any particular French fortification to Agostino or any other Ramelli, despite his great reputation at the time. Yet he was certainly more famous for this than as an inventor. From the few documents on his life we know he was elevated to nobility, for he and his son are "noble homme"; the marriages suggest a solid financial position. Indeed, the expense of publishing his book from his own house would imply either considerable wealth or, more likely, the king's especial favour, for production must have been a very costly business. Titles like "grand engineer" or "grand architect" confirm a status close to the monarch; indeed, his absence from establishment lists may in itself indicate a more personal association. Unhappily so much of the French royal archives of this period has disappeared that no trace of any payment to Ramelli can be found.

We are therefore obliged to have recourse to the historical narratives, which tell us little. It may be significant that both at La Rochelle and at Angoulême, the name of Ramelli appears in a group of Italian names. In the latter case the source of the narrative was certainly an Italian, Pietro del Bene, perhaps also in the former. The French nobility used the professional skill of their Italian engineers but did not think them worthy of mention when telling the history of their own deeds. A mere "Captain Ramelli" could not appear among the great generals and colonels whose exploits were lauded by Brantôme. Few chroniclers troubled to identify by name the alien technician. Because of these prejudices, the part played by Italian engineers in the fortifications and sieges of the French wars of religion has been played down, so Ramelli's name disappears from sight in what must have been his fifteen most active years, from 1573 to 1588. The engineers kept close

to the great lords, to the king himself and to dukes like Longueville and Épernon—a proximity that could prove dangerous at times, but which afforded them shelter and employment, in spite of the jealousies they may have aroused.

Was this great work intended to win Ramelli fame with a wider public, or to establish him more firmly in the favor of his king, Henri III? Did he build entirely on the literature of mechanical invention that went back to Leonardo, and beyond him to Taccola, Fontana, Kyeser? Or did he draw on a fund of his own experience? In 1588 Ramelli was fifty-one, according to the frontispiece portrait, quite elderly in the 16th century. Although in fact he lived on for another twenty years, he was more likely to think of his magnum opus as the honor of his old age than of its use to launch himself in his career, as Errard may have hoped when he published his book of machines four years before.¹¹ Since we really have Branca's book at second hand, such questions are even harder to answer for him. He may simply have seen *Le Machine* as an attractive companion to his *Manuale d'Architettura*. If any of his drawings were based on experience, it was hardly Branca's; certainly they look like armchair inventions which seldom ever had any three-dimensional working counterparts. The relation between Ramelli's plates and the world of the real machine is more complex. Models of Ramelli's engines have been built in our day, notably by D. Gnudi; were any built in his own? Better still, were any constructed to full scale? Small handmills, jacks, and wrenches look so lifelike it is hard to believe they were not engraved from life, and so, too, do some of the mills. But what of those marvellous rotary pumps and the double-acting wing pumps; or those monsters which extend themselves across enemy moats, so much more elaborate than the "bridge of wood" at the bastion de l'Évangile or other siege equipment of the day? He himself only once actually claims to have used one of his inventions—significantly, it is the simple collapsible two-way winch for hauling cannon over a bad patch in the road. The editors do not tackle this question—admittedly a difficult one—but seek only to establish Ramelli's originality in that remarkable flowering of imaginative engineering on paper, of which he was after Leonardo the most illustrious figure. And yet, more than Leonardo, he did have the opportunity to build some of his machines. Did he ever do so?

Ferguson and Gnudi stress Ramelli's independence, the advance he made—on paper—over his predecessors. Comparable designs in the sketchbooks of Taccola or Kyeser (not mentioned in the chapter

¹¹J. Errard, *Le Premier Livre des instruments mathématiques et mécaniques* (Nancy, 1584).

notes, but surely plates 146–47 reflect Kyeser 59 and 60)¹² do look very crude next to Ramelli's versions, but is this an improvement in machine design or in the technique of artistic representation? When we reach Francesco di Giorgio or Leonardo, Ramelli's modifications are often quite slight. When Ferguson observes that plate 113 differs from a corresponding sketch by Francesco because an overshot waterwheel is replaced by an undershot, we ought to remember that Ramelli does not try to explain the superiority of the undershot version. With the toroidal and rotary pumps, Ferguson can claim with justice that the merest hint in Leonardo has become a full-blown working drawing. But elsewhere he has not entirely answered Reti's assertions in his article "Leonardo and Ramelli."¹³ In plate 41, surely as close a resemblance as any between Leonardo and Ramelli, Ramelli seems only to have added an idle wheel, but does not explain why—would it not rather be a disadvantage?

For all his introductory hymn in praise of mathematics, Ramelli gives no dimensions. In the machine literature they only appear twenty years later, with Zonca's *Novo Teatro di Machine et Edificii*. Ferguson points out that if you count the teeth on some of Ramelli's sector gears, and so the degrees of revolution they can turn, the pistons they motivate will not complete their travel before reversing. The conclusion must be that Ramelli did not count teeth. He remained rooted in a world of visual impression and even of symbol, despite all his mechanism, so that he could alter minor details to designs he had seen, without really knowing whether he had improved them or not. Why else repeat the same idea in several versions, unless to display his "virtue" as an engineer? His imagination puts forward a series of variations on the same basic theme, not unlike the old-fashioned piano virtuoso and for much the same reason. Even a modest and perhaps irrelevant modification could add to the impression, strike a note of originality. To choose the most efficient among these possibilities was not his intention. Lacking a theory of dynamics, it would probably not have been easy for him to do so. These remarks apply even more to Branca and other authors of machines. Not because they were daydreaming scholars: Errard and Ramelli were both military engineers; Branca, like Zonca, was a civil architect. All of them would have made maps and surveys, worked in land drainage or irrigation, so that all would have had a similar practical experience of materials and construction, but of static bodies rather than moving parts. Besson, primarily a mathematics teacher, and Verantius, a re-

¹²K. Kyeser von Eichstatt, *Bellifortis*, ed. G. Quarg (Düsseldorf, 1967), 59r, 60r, and trans., pp. 38–39.

¹³L. Reti, "Leonardo and Ramelli," *Technology and Culture* 13 (1972): 577–605.

tired bishop, do not suffer much more from these failings than the authors who made their living as engineers.

With very few exceptions, the plates are clear and precise, the captions equally clear and written in a bald prose which describes a sequence of actions in objective tones and simple vocabulary. Indeed, the historian may regret the want of personal comments that could have told us if any machines had been tried and how well they had performed, with such data as to location and occasion that might help to plot the development of these technologies. Bachot inscribed on one of the plates he took with little alteration from Ramelli, "Veue enussage a la citadelle de Turin en Fevrier 1577."¹⁴ No doubt it was Ramelli who saw it at Turin and mentioned it to Bachot, but Ramelli himself tells us nothing of this. The translation is of a lucidity to match the original. The preface and dedication, and the note "to kindly readers," which resumes in part the praises of mathematics in the preface, are all written in another style, florid, rhetorical, adorned with erudite allusions, as if to show that Ramelli could compose an address in the grand manner as well as the next man, even if he was a mathematician and an engineer. This oratorical prose cannot easily be translated into an English that will not sound stilted, and indeed there are a few infelicities here. Perhaps that is a matter of taste, but one wonders why a word "geometrist" had to be coined to translate *geometra* when we have the perfectly adequate "geometer"; why *angusti tugurii* should be tight, rather than narrow or cramped, huts; and the *tenebrose nottole* (*chauve-souris* in the French version) are bats of darkness, not brown owls. And surely the *Prima Philosophia* is the hermetic cosmology, rather than religion in general.

Still, these minor flaws will not detract from our enjoyment of so handsome a volume, nor from its value as a prime source of knowledge. Besides the rich bibliography and notes, which illustrate the editorial material (in which however we do miss any reference to the work of D. J. Buisseret, particularly his "Les Ingénieurs du Roi au Temps de Henri IV"),¹⁵ chapter notes have been provided to the plates themselves, discussing possible sources for Ramelli's inventions and where similar designs appear in the literature, and explaining

¹⁴This is the twenty-fourth of the mechanical drawings in A. Bachot, "Le Gouvernail de Guerre"; for repro. and discussion, see A. G. Keller, "The Oblique Treadmill of the Renaissance: Theory and Reality," *Transactions of the 2nd Symposium on Molinology* (1969), pp. 223–31.

¹⁵D. J. Buisseret, "Les Ingénieurs du roi au temps Henri IV," Ministère de l'Éducation Nationale, Comité des Travaux Historiques et Scientifiques, *Bulletin de la Section de Géographie* 77 (1964): 13–84. Valuable information on the political and administrative background to the activities of these engineers may be found in Buisseret's *Sully and the Growth of Centralized Government in France* (London, 1968).

problems in the operation of the machines. Last, but not least, the choicest of all the editorial contributions is the pictorial glossary, in Ferguson's own words "a systematic visual record of the richness and range of Ramelli's mechanical repertoire." Hammond's eighty-four line drawings depict all the main elements of Ramelli's designs; for each Ferguson has written a brief note on its history and contemporary use. Nobody has thought of doing this before, in all the editions and reproductions of old machine books and manuscripts. When so many devices have more than one name, and names cover more than one device, such a vocabulary of Renaissance mechanism will be more than useful. Even those of us who imagined we knew our Ramelli have much to learn from this glossary, for even today a clear and simple drawing can tell more than any verbal description. Those who are so fortunate as to own or have access to this magnificent new edition will often turn to the plates elegantly laid before them, all the more useful for the interpretations of Ferguson and Gnudi. But surely a good many readers will find themselves turning to these back pages quite independently, to look up some item in this glossary.

Firpo's introduction is less ambitious than Ferguson and Gnudi's, more strictly biographical, even though he has to explain why Branca was not the true author. Only the one machine is discussed in detail, for he does investigate the history of the aeolipile and Branca's place in what has been called the "pre-natal history of the steam engine."¹⁶ Hardly anything else is said, in introduction or commentary, to set either the book as a whole or the individual machines in their context as was done for Ramelli by Ferguson and Gnudi. Perhaps there is a disadvantage after all in leaving the job to a general historian rather than a historian of technology. The bibliography, excellent for the 18th and 19th centuries, collapses in the 20th century. Most of the entries for the past fifty years are encyclopedia articles. Thorndyke's *History of Magic and Experimental Science* is the most recent general work: Firpo seems quite unaware of modern studies in the history of technology. He does not even mention Lenzi's edition and is equally innocent of the various recent books and articles which deal with aspects of *Le Machine*. A book entitled *Giovanni Branca*, by E. Camilli, appeared in 1971. Was it a biography? It appears in the bibliography but is never cited in the introduction. In his commentary, in a few instances, Firpo makes up the deficiencies of Branca's comment by his own helpful interpretation. But mostly he just explains Branca's meaning. One feature of these explanations may prove helpful. Very

¹⁶H. P. Spratt, "The Pre-Natal History of the Steam Engine," *Transactions of the Newcomen Society* 30 (1955-57): 13-23.

often he translates obsolete or dialect technical terms into standard Italian. All these words are assembled in a glossary, which foreign readers will find no less useful than Italians.

If we maintain that books like these opened a new era in history, we ought to look for evidence of their impact on the consciousness of the times that followed, as indeed both Firpo and Ferguson do. Probably awareness of their significance only penetrated slowly into the public mind, and then first among readers rather than makers. Few practising millwrights or engineers could have afforded *The Various and Ingenious Machines*. Of course, we do not have much information on the libraries of these ordinary folk. We know that de Thou the historian possessed a copy, and so did Henri IV's chief minister, Sully, as appears from an inventory of his books.¹⁷ Copies are to be found in the libraries of bibliophiles, although the superb collection of books on science and technology left by Robert Hooke does not include a Ramelli, whereas he did own a Besson and a Branca, the first that can be located outside Italy.¹⁸ Nor do the names of Ramelli or Branca occur in the correspondence of Galileo. Perhaps these books had greater impact in northern Europe, although Bacon does not seem to have heard of any of them. John Wilkins's *Mathematical Magick* of 1648 cites Ramelli in particular for plates 130 (the weight-driven mill) and 160 (the engine to force open window bars).¹⁹ Levinus Hulsius, the well-known deal in (and author of) mathematical and cartographic material, was offering Ramellis for sale in 1603, as he notes against Ramelli's name in a bibliography of books on mechanics in his *Mechanische Instrumente*, "bei mir zu finden." According to Draud's *Bibliotheca Classica*, Hulsius's widow had some in stock in 1609.²⁰ Doubtless this accounts for the German translation, with its appalling plates, issued by Henning Gross, "citizen and bookseller," at Leipzig in 1620, for he would be unlikely to publish a book if he did not expect it to make a profit. A century after the original edition of 1588, the *Variou and Ingenious Machines* continued to be influential. Ferguson notes the use of several Ramelli machines in late 17th century exhibitions of models like those of Grollier de Servière and of M.C.D.O. (an unknown exhibitor) at Paris in 1683 and in later books

¹⁷For de Thou's copy, *Bibliotheca Thuana*, ed. J. Quesnel (Paris, 1679), 2:84. D. J. Buisseret advised me of Sully's copy by private communication (May 15, 1967).

¹⁸Hooke's library catalogue, published as *Bibliotheca Hookeana* (London, 1703), is reproduced in *Sales Catalogues of Libraries of Eminent Persons* (London, 1975), vol. 3, *Scientists*, ed. H. A. Feisenberger (London, 1975).

¹⁹J. Wilkins, *Mathematical Magick* (London, 1648), pp. 91, 171.

²⁰L. Hulsius, *Mechanische Instrumente* (Frankfurt, 1604), p. 9; compare G. Draud, *Bibliotheca Classica* (Frankfurt, 1625), p. 1038.

such as those of Böckler and Leupold, although the latter seldom reproduces a Ramelli picture without a word of scorn for some error. The British Library's copy of this German edition contains a Swedish note, in what looks like an 18th-century hand, in which Polhem is cited as recommending some thirty machines as still employable. Indeed there is said to be a copy in Sweden with more extensive notes of that period.²¹ One early annotated copy, the Honeyman Ramelli, was discovered by Gnudi. Since Ferguson and Gnudi give such extensive details on the proof copy and extraneous drawings, it is a pity that we are only given a few tantalizing references to this annotated copy, little more than a footnote, for this material would surely have illuminated Ferguson's chapter notes. Perhaps that is a treat to come. Meantime we can rejoice that the study of early mechanical innovation has moved into a new phase with the publication of these two books, more particularly this grand Ramelli.

²¹Private communication of Marie Nisser, Department of History of Art, University of Uppsala.