Giuseppe Antonio Borgnis and His Handbook of Machine Designs

Marco Ceccarelli

Abstract Giuseppe Antonio Borgnis (1781–1863) was an Italian University professor, who contributed to TMM developments both in theory and practice through his teaching, professional activity, and publications. In this paper, his significant 9-volume handbook of machines, which included the first technical dictionary of terminology, is presented with an illustrative approach.

1 Introduction

Modern TMM (Theory of Machines and Mechanisms) was established as a result of the demand of industrial engineers at the beginning of the 19th century, mainly with formation in specific academic courses that were established all around Europe.

Giuseppe Antonio Borgnis was among the first pupils of the Ecole Polytechnique in Paris, and when back home he transferred his expertise to the University of Pavia, where he was engaged in a long life of teaching activity. In addition, he contributed to the development of professional skills with publication of a 9-volume handbook on machines that included the first volume on technical terminology to be used in Europe in the 19th century.

This paper is a first attempt to reconsider the figure of Borgnis and his work, along with an aim to revaluate his contributions to the Italian academic frames in the modern development of theory and technology of machines.

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2 Biographical Notes on Giuseppe Antonio Borgnis

Giuseppe Antonio Borgnis (Fig. 1) (Ceccarelli 2014), was born on April 15, 1781, in Craveggia (Val Vegezzo in the province of Novara), Italy, from a well-established family, the father, Giovanni, being a banker in Paris. He was well-educated, showing a special interest in mathematical disciplines, and although the revolution of the time affected the family, he was able to graduate as an engineer. He got a position as a naval engineer in Venice, where he gained enough valuable knowledge to write a book on machines in 1809. The expertise apparent in the book led to his being appointed a member of the Venice Academy in 1812. This also granted him the opportunity to go to Paris to attend courses at the Ecole Polytechnique. In Paris, he deepened his knowledge of machine design, both in

Fig. 1 A portrait of Giuseppe Antonio Borgnis (1781–1863). (His great-grandchild, Massimo Borgnis, is thankfully acknowledged for the portrait and additional biographical notes)

theoretical studies and practical applications. He evolved his views through Monge's approach, so as to propose his own classification on mechanism variety for machine applications. Developing his views in more detail, he published ten books from 1818 up to 1823, a collective handbook on machine design and application that served as a practical implementation of his new classification.

Once back in Italy, in 1826, he got a professor position at the University of Pavia as a temporary teacher of Applied Mathematics. Then, in 1840, he was appointed full professor of Applied Mathematics, also giving lectures on Civil and Road Architecture. Borgnis was elected Rector of the University of Pavia for the academic year 1842–43, as reported in the historical records of Pavia University (1878). Because of his reputation, he was an active member of the Royal Lombard Institute of Science, Humanities and Arts, and a member of the Royal Academy of Turin. He was also granted the honour of Knight of the Order of Saints Maurizio and Lazzaro by the Italian King Carlo Alberto. He died in Monza on August 16, 1863.

He was a well-reputed professor of applied mathematics and civil transportation architecture, combining his interests and activities in theory and engineering designs during the first period of the Industrial Revolution all around Italy, although he himself was in the northeast state within the Austro-Hungarian Empire.

The circulation of Borgnis's handbook was limited, mainly to within Italy, for at least two reasons, namely the rapidly changing political situation and the reduced influence of Italian Universities at international levels.

Just after the Restoration, subsequent to Napoleon's defeat, the Italian political situation was characterized by the re-establishment of the several kingdoms under the influence of different European countries. The changes and state fragmentation are summarized in Fig. 2. After several centuries existing as several small states, the fragmentation reached the status shown in Fig. 2a, referring to 1796 just before the

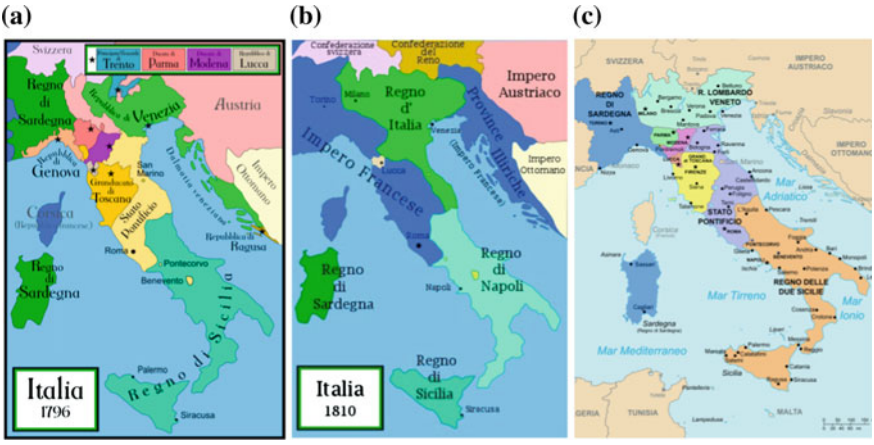


Fig. 2 Italian states in: **a** 1796; **b** 1810; **c** 1840

French Revolution. In Fig. 2b, the political situation around 1810 is represented, with the strong influence of France, as a result of the French Revolution, all over the North and Center of Italy. This is also why Borgnis was attracted to Paris as a place that he might enhance his machine expertise. In Fig. 2c, the restored situation from 1840 is illustrated, showing several kingdoms and North East Italy, which was soon included in the Austro-Hungarian Empire. But at that time, there were already considerable hopes and actions for the reunification of Italy. This is to note that Italian society of the time, although fragmented into several kingdoms, was very directed toward the possibility of a unique Italian kingdom, a goal that was actually achieved over the next two decades through the fighting of several wars and with participation of the population. This somewhat accounts for the fact that, in the subsequent decades of the 19th century, owing to the efforts towards reunification, attention was not paid to the circulation of academic works among those kingdoms, and, indeed, even after reunification, governmental programs for standardization of academic subsystems and consequent professional activities were given far greater emphasis than any attempt to circulate previous works. All this made plans for international collaboration within academic subsystems even more problematic.

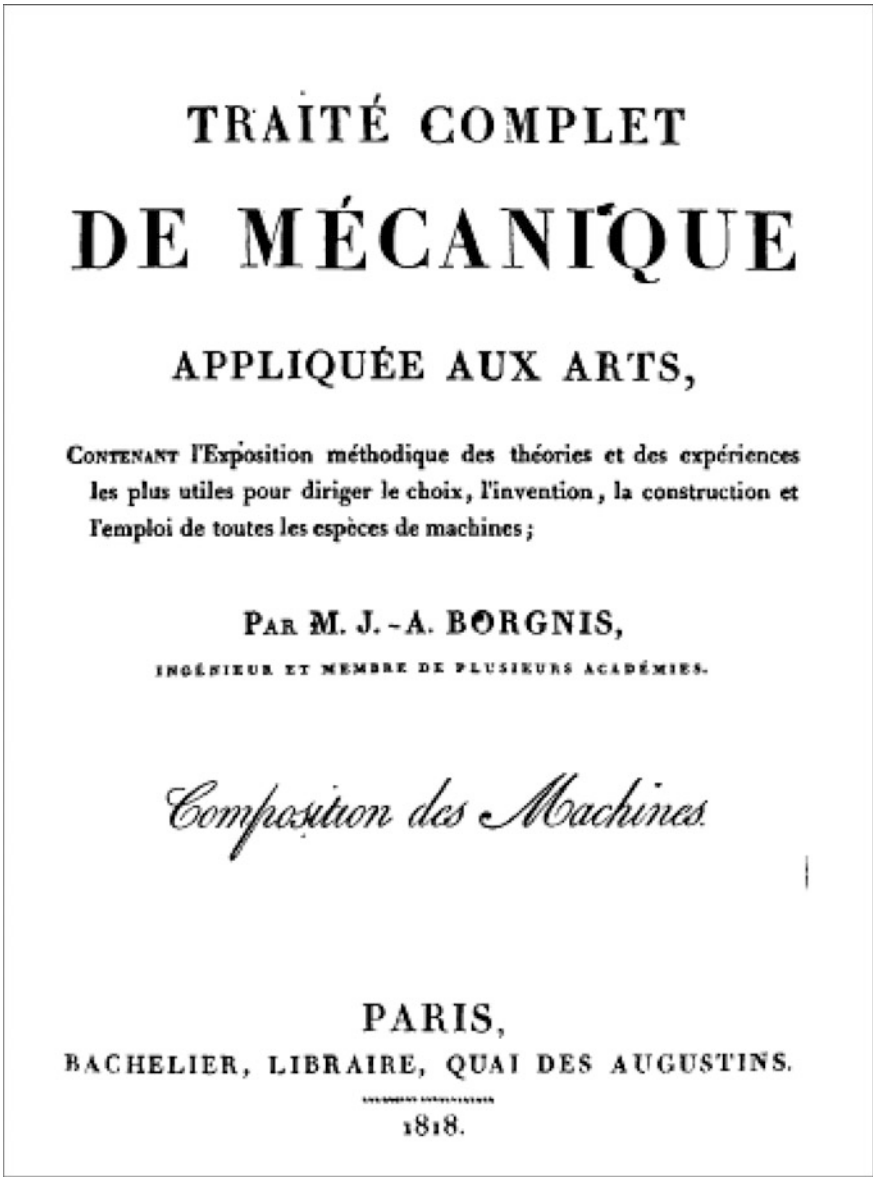
Nevertheless, Borgnis's handbook was considered and used as a reference in professional activity. But in teaching and research as well, it served as an inspiration in machine analysis and machine classification, respectively.

3 Main Publications by Giuseppe Antonio Borgnis

Herein is a list of the main publications by Giuseppe Antonio Borgnis:

- Handbooks on Machine:

1. **"**De la composition des machines" (450 pages, published in 1818) (Fig. 3) (Borgnis 1818a), which contains classification and description of mechanical devices in agreement with the approach proposed by Gaspard Monge. The treatise is accompanied by drawings of 1200 mechanical devices, which are also compared in terms of figure and operational characteristics. The classification is summarized in Tables, which give a synopsis of available mechanisms at that time.
2. "Du mouvement des fardeaux" (334 pages, published in 1818) (Borgnis 1818b), which contains a description of mechanical design and operation characteristics of the machines that can be used for the transportation and lifting of all kind of weights.
3. "Des machines employées dans les constructions diverses" (336 pages, published in 1818) (Borgnis 1818c), which describes the design and operation of machines that are used for construction in the field of civil engineering, hydraulic engineering, naval engineering and military applications.



TRAITÉ COMPLET

DE MÉCANIQUE

APPLIQUÉE AUX ARTS,

CONTENANT l'Exposition méthodique des théories et des expériences les plus utiles pour diriger le choix, l'invention, la construction et l'emploi de toutes les espèces de machines;

PAR M. J.-A. BORGNIS,

INGÉNIEUR ET MEMBRE DE PLUSIEURS ACADÉMIES.

Composition des Machines

PARIS,

BACHELIER, LIBRAIRE, QUAI DES AUGUSTINS.

1818.

Fig. 3 Title page of the book on Composition of Machines by G.A. Borgnis published in 1818 (Borgnis 1818a)

4. “Des machines hydrauliques” (295 pages, published in 1819) (Borgnis 1819a), which contains an overview of machines that can be used in hydraulic systems. An in-depth study is reported for machines applied in agriculture and mining.
5. “Des machines d’agriculture” (295 pages, published in 1819) (Borgnis 1819b), which contains descriptions of equipment and machines used in agriculture. Detailed studies are reported on mechanisms that are used for harvesting machines, winding and drilling machines, and devices for production of oil and wine.
6. “Des machines employèes dans diverses fabrications” (285 pages, published in 1819) (Borgnis 1819c), which contains the description of machines used in industrial plants for production of metal components, paper products, textile manufacture, and tannery products.
7. “Des machines qui servent à confectioner les ètoffes” (335 pages, published in 1820) (Borgnis 1820a), which contains descriptions of procedures for spinning vegetal or animal material, comparative analyses of mechanical means for industrial spinning and equipment of different kinds of machines for different kinds of products in textile manufacturing.
8. “Des machines imitatives et des Machines théatrales” (285 pages, published in 1820) (Borgnis 1820b), which contains a description of mechanical devices that are used for any kind of transportation or movement, including devices mimicking animal motions. The text includes an Appendix with interesting descriptions of old machines for theatres and how to adapt their use to current needs and other aims.
9. “Thèorie de la Mecanique usuelle” (published in 1821) (Borgnis 1821), which contains an introduction to the mechanics applied to practical industrial applications and refers to principles of Statics, Dynamics, and Hydraulics. Detailed descriptions and formulation are presented on primary mechanical transmissions.

- Terminology Technical Dictionary:
  Borgnis G.A., Dictionnaire de mecanique appliquèe aux arts, Bachelier, Paris, 1823 (Borgnis 1823),
- Other publications:
  1809: Studio delle macchine, Stamperia di Antonio Curti, Venezia (on the study of machines)
  1826: Delle Macchine Idrauliche: I trattati, Tip. Cardinali e Frulli, Bologna (treatises on hydraulic machines)
  1842: Elementi di statica architettonica, Gaspare Trufi Ed., Milano (fundamentals on Statics in Architecture)

Borgnis worked out the 9 volumes (Borgnis 1818a, b, c, 1819a, b, c, 1820a, b, 1821) of his machine handbook as a practical implementation of his classification of

TABLEAUX SYNOPTIQUES DES ORGANES MÉCANIQUES. xxvij

ORDRE CINQUIÈME — *RÉGULATEURS.*

CLASSE PREMIÈRE. — MODÉRATEURS

ESPÈCES.	VARIÉTÉS.	INDICATION DES Planch.	Figures.	Paragr.
GENRE PREMIER. — *Volans.*				
1 Volans à lentilles ou à roues.		26	13	785
2 Volans à palettes.		»	»	»
GENRE DEUXIÈME. — *Compensateurs qui corrigent de grandes irrégularités.*				
1 Condensateurs de forces.		31	1 et 2	788
2 Fusées.		26	16, 30 et 31	798
3 Courbes tournantes.		31	4	800
4 Contre-poids variables.		13	18 et 19	807
GENRE TROISIÈME. — *Compensateurs qui rendent le mouvement uniforme et règlent en même temps sa vitesse.*				
1 Échappemens à recul.	1 Échappement à roue de rencontre.	30	5	826
	2 Échappement à ancre. . .	26	22	827
	3 Échappement à deux leviers.	30	6	828
2 Échappemens à repos.	1 Échappement à chevilles.	26	25	830
	2 Échappement à repos et à ancre par *Grahan.*	30	7	832
	3 Échappement à cylindre.	26	24	834
3 Échap. à vibrations libres.	1 Échappement de *Mudge.* .	30	3	839
	2 Échappement de *Berthoud.* . . .	26	27	840
4 Échappemens à remontoir.	1 Échappement à remontoir pour les pendules par M. *Breguet.* . . .	26	28	842
	2 Échappement à remontoir pour les montres par M. *Breguet* . . .	26	29	844

CLASSE DEUXIÈME. — DIRECTEURS.

GENRE PREMIER. — *Stateurs.*				
1 Stateurs réguliers. .	1 Régulateur d'une machine à vapeur.	27	1, 2 et 3	850
	2 Machine à fendre les roues.	30	2	857
	3 Machine de *Ramsdem.*	30	1	864
	4 Plate-forme à fendre et à diviser de M. *Petit-Pierre.*	»		870
2 Stateurs dont les suspensions variables sont cependant assujetties à des loix fixes.	1 Quadrature d'une répétition.	28	1 et 2	873
3 Stateurs variables et libres qui produisent simultanément une suspension dans un sens et un renouvellement de mouvement dans un autre sens	1 Engrenage à fourchette mobile de M. de *Prony.*	27	6	877
	2 Engren. à fourchette mobile de M. *Bettancourt.*	27	8	881
	3 Anneaux à cliquets de *Berthelot.*	31	3 et 11	882
	4 Verrou simple.	17	14	883
	5 Axe à deux verroux. . . .	26	14 et 15	884
	6 Tenaille à plans inclinés. . . .	17	13	885
4 Stateurs libres qui ne produisent qu'une simple suspension	1 Mécanisme pour dételer un cheval.	31	12	886
	2 Frein pour arrêter une roue.	31	5	»
	3 Poulie à frein de M. *Fyot.*	»	»	887
	4 Poulie à frein excentrique	31	13	*Id.*
	5 Roue dentée à freins extérieurs.	31	9	888
	6 Roue dentée à freins intérieurs	31	6 et 7	889

Fig. 4 Beginning of the list of regulators in the table of machine classification in the book on Composition of Machines by G.A. Borgnis, Fig. 3 (Borgnis 1818a)

machines and mechanisms. He derived his classification as an extension of Monge's classification published in the book by Lanz and Betancourt (1808). Borgnis's criticism of Monge's classification, that was based on the possibility of motion for input-output relationships, is completed by a view of practical engineering based on his professional experiences. Thus, in 1818, in his first book on The Compositions of Machines, Fig. 3 (Borgnis 1818a), he introduced a classification for the functioning of machines and mechanisms. He classified the machines in categories, namely Receivers, Communicators, Modifiers, Frames, Regulators, and Operators. Each category was organized into classes, a list of which is summarized in the tables at the beginning of the book, as shown in the example in Fig. 4. The structure of Borgnis's classification is summarized in Table 1, with indication of the number of considered machines and mechanisms.

The last book of the Handbook is focused on the terminology, serving as the first technical dictionary in the form of a very early standardization of technical terms.

The Borgnis classification was considered in the next developments in machine classification, as cited, for example, by Willis (1841), as a basis for his improved views. The approach of analyzing machines and their mechanisms was also considered a reference for textbooks, like for example, for the book written by Carlo Giulio in 1841 (1846) at the school of engineering in Turin. Borgnis's work was well known in the 19th century, but it was quickly forgotten within Italian academic fames, as indicated, for example, by its omission in the background for machine classification in the work by Francesco Masi (1883) in Bologna.

Nevertheless, the value of the Borgnis technical handbook, that is completed with the terminology dictionary, was considered of inspiration for several machine books, even in the second half of the 19th century, although not always explicitly cited. In addition, it was used as a technical reference for professionals for the entire 19th century.

Table 1 Structure of Borgnis classification of machines and mechanisms, Borgnis (1818a)

Category	1					2		3					
Class	1	2	3	4	5	1	2	1	2	3	4	5	6
Genre	2	8	3	4	2	4	4	3	2	2	2	2	1
Type	16	17	10	7	8	11	7	6	4	5	6	4	1
Machines	45	28	18	10	11	59	27	7	10	11	8	10	1

Category	4			5			6				
Class	1	2	3	1	2	3	1	2	3	4	5
Genre	3	2	3	3	3	3	4	5	3	2	5
Type	8	7	9	10	7	8	13	9	9	13	19
Machines	17	29	15	16	24	8	67	20	24	36	25

4 An Illustrated Survey of the Handbook Collection

The collection of machines in Borgnis's handbook is organized within the tradition of Theatrum Machinarum, but with much greater technical content, as befits a book directed at experts in the fields of machinery. Each machine's design structure is described with operational characteristics outlined, and is supplemented by typical design drawings that are collected in tables at the end of each book. This description allows for derivation of formulations that do not appear in the text. Machines are grouped in each of the seven books of the collection published after the first book by their specific fields of application. The last additional book is devoted to theoretical aspects of the mechanical functioning of machines through the outlining of basic principles of Mechanics for design and analysis purposes, including formulation in the specific forms of the time that would need interpretation for modern expression.

The survey of machines in each book is completed with the most recent machines of the time, all of which were steam-powered machines. In his handbook of machines, Borgnis started with machines whose operation is based on human actions, with an early biomechanical approach. The value of human operation is recognized as necessary in some operations for which the machines cannot efficiently help or substitute for humans but are still a part of the task frame. This analysis also gave him the ability to consider solutions with what we would today call biomimetics design.

The illustration-based survey in this chapter, with Figs. 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 showing examples of the variety of machine solutions that Borgnis reports, can allow the reader to appreciate the book's encyclopaedic views, as well as the details that are used in the technical representations for each single machine and mechanism.

Figure 4 shows an example of the tables in (Borgnis 1818a) listing machines and mechanisms under Borgnis's classification, where each category is given with indication of the sub-classification, as indicated in Table 1. The reader can appreciate the way each category name is indicated, along with the other details of the classification. In particular, each machine unit is indicated in a row with a specific short descriptive name after a general group name, the referring table and figures also being listed together with the paragraph's location in the book. The figures are grouped into tables that are at the end of the book, as was the publishing tradition of the time.

Figure 5 is an example of a collection of simple mechanisms as components of more complex machines. In this table, attention is focused on mechanism schemes for mechanical transmissions as the most common mechanism types, such as linkages, cam systems and geared transmission, with synthetic drawings of design purposes that somehow include indication of the operation capabilities.

The two tables in Fig. 6 are examples of machines that are analyzed in the main book (Borgnis 1818a) and they show the importance that Borgnis gives both to simple human-actuated machines and the most recently developed steam powered

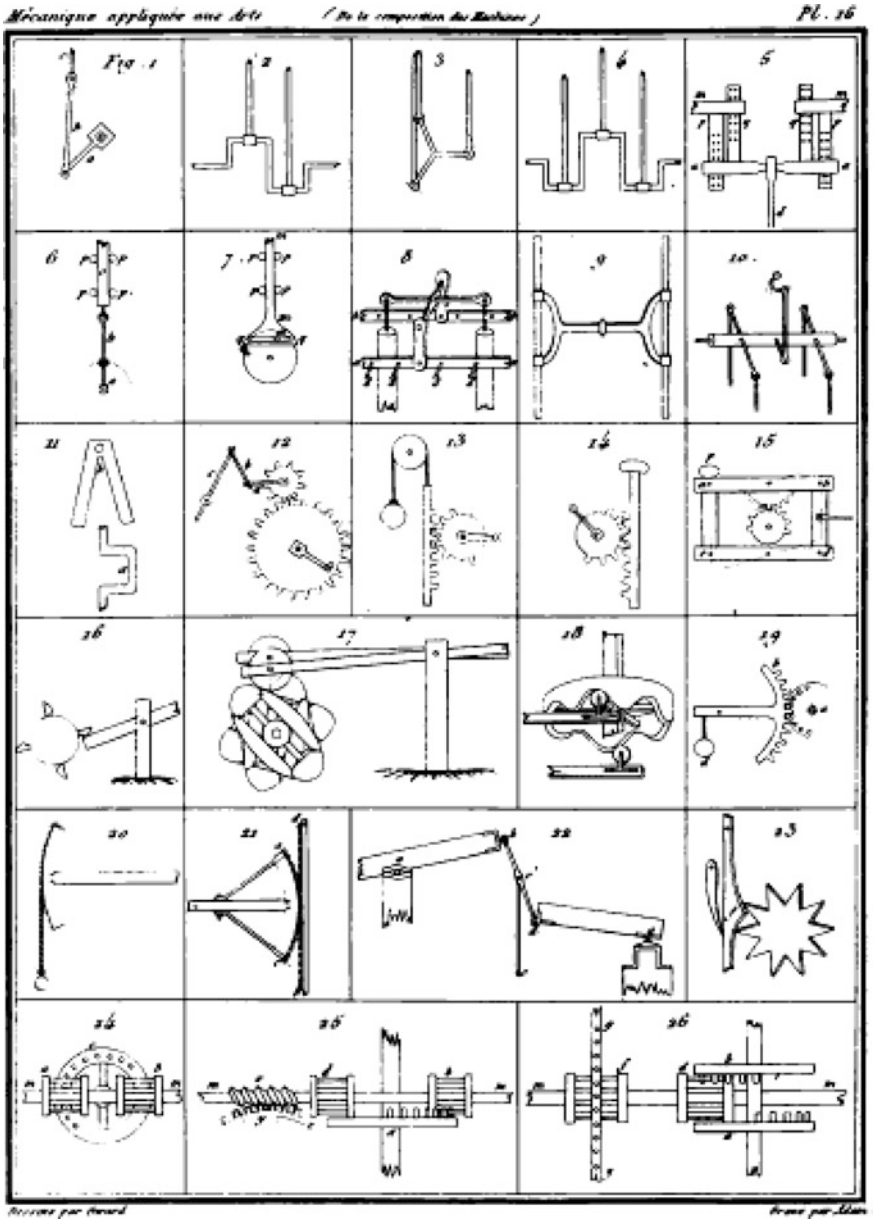


Fig. 5 Mechanism collection in the book on Composition of Machines by G.A. Borgnis in Fig. 3 (Borgnis 1818a)

machines of the time. Indeed, the human-powered machines in Fig. 6a are discussed not only for historical background but also to indicate the size of those basic machines and their standard power capability (with one or more humans in action). In Fig. 6b, the most modern machine of the time is illustrated with two emblematic examples, namely a locomotive and an industrial installation for power production. Both machines are drawn with a general mechanical design in which only some of the mechanisms are reported in detail.

Figure 7 shows two tables from book (Borgnis 1818b) in which components and grasping devices are shown lifting weights in different applications. In Fig. 7a, attention is addressed to the several solutions of pulley-cable unit with a mechanical design that works for compact efficient solutions. At the bottom of the table, the process for transporting and lifting an obelisk through the use of capstans with vertical axis for human actuation is shown. In the table of Fig. 7b, a collection of different grasping solutions are shown with mechanical drawings for practical implementation.

Figure 8 shows examples from book (Borgnis 1818c) of machines that are used in construction. The table in Fig. 8a shows solutions from elementary tools up to complex machinery. At the top of the tables, tools for manual operation are drawn, many of which resemble those still in use nowadays. Then, complex machines used

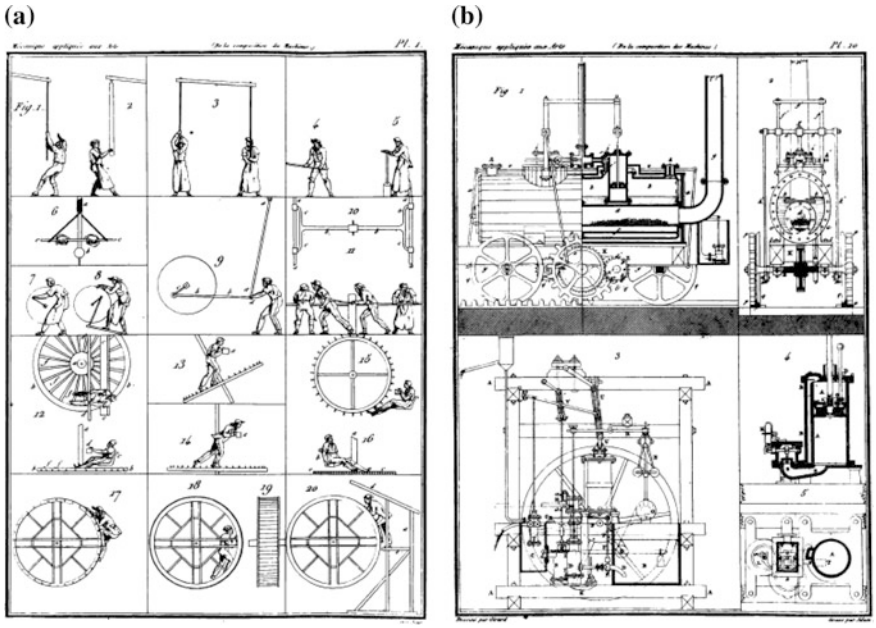


Fig. 6 Examples of drawings in the book on Composition of Machines by G.A. Borgnis in Fig. 3 (Borgnis 1818a): **a** basic components with man-powered machines; **b** steam-powered machines

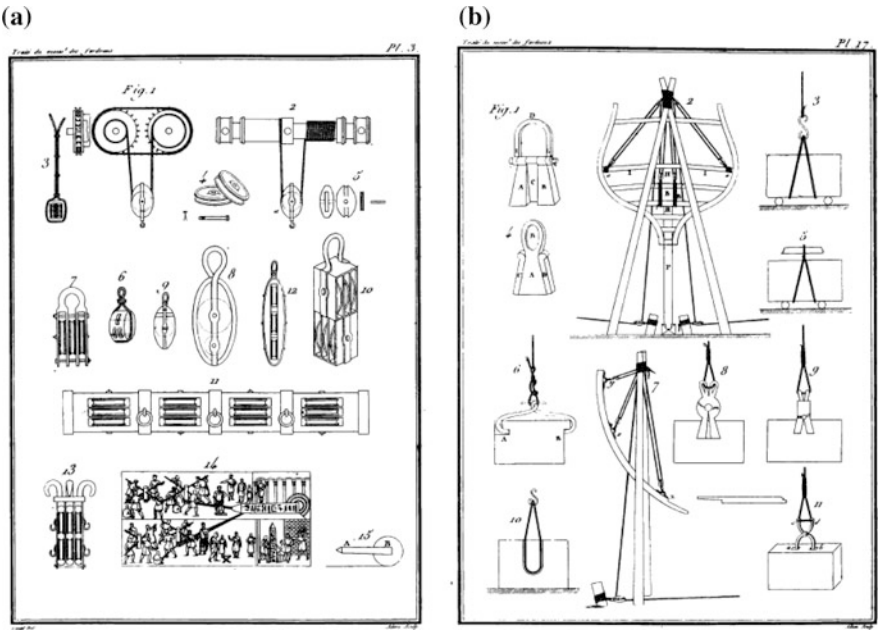


Fig. 7 Examples of machine drawings in the book on Motion of Weights by Borgnis (1818b): **a** basic components; **b** grasping systems in cranes

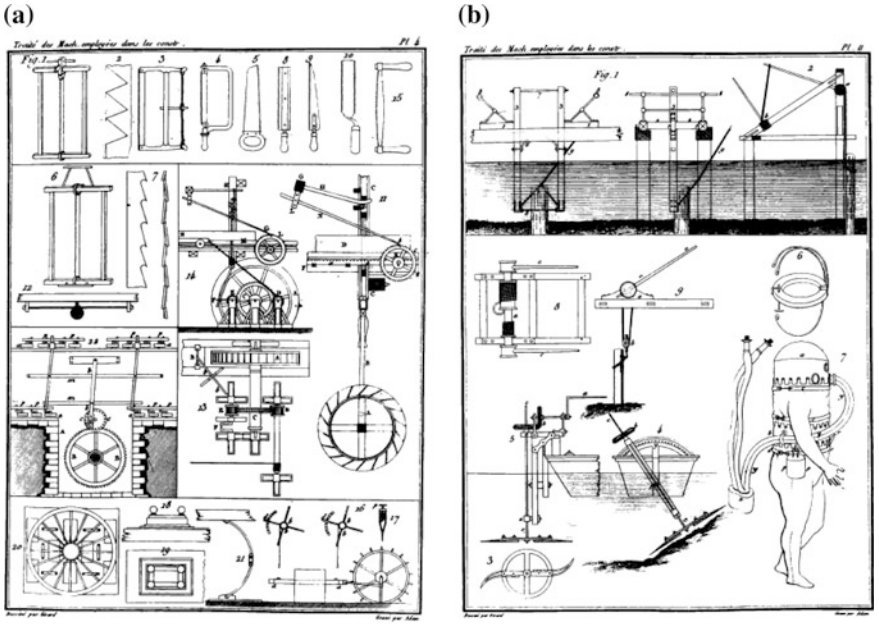


Fig. 8 Examples of machine drawings in the book on Machines used for Constructions by Borgnis (1818c): **a** basic components and machines; **b** machine for marine applications

for the purpose of cutting construction elements out of either wood or other materials are illustrated.

The machine is shown with a mechanical design that also includes the hydraulic turbine as a power source. The drawings are composed from two views, namely a lateral perspective and a top view so that all the elements are clearly identified.

Hydraulic machines are specifically addressed in book (Borgnis 1819), since at the time, they were still a major power source with multiple applications. The examples in Fig. 9 illustrate significant examples of applications, namely in Fig. 9a, structures for pumping systems, and in Fig. 9b, solutions for transposable pumping systems. The drawings in Fig. 9a are relative to complex installations of mechanical design which have several pumping mechanisms working in parallel to effect the sort of large water flow that could be needed for cities (including king houses) and industries. The solution for a single-pump structure emphasises the guiding mechanism and the design size of the stroke element. Figure 9 shows the solution for a car that very likely could be used for firefighting applications. The other installations shown in the table are drawn with modular design, with differentiated elements and the power output of the hydraulic machine synthetically represented by the fluid flowing out of the end-effector of the machine.

The mechanization of agricultural activity is addressed specifically in book (Borgnis 1819) with machines that are designed for simple tasks and more industrial-like solutions. The examples in Fig. 10a refer to simple machines for

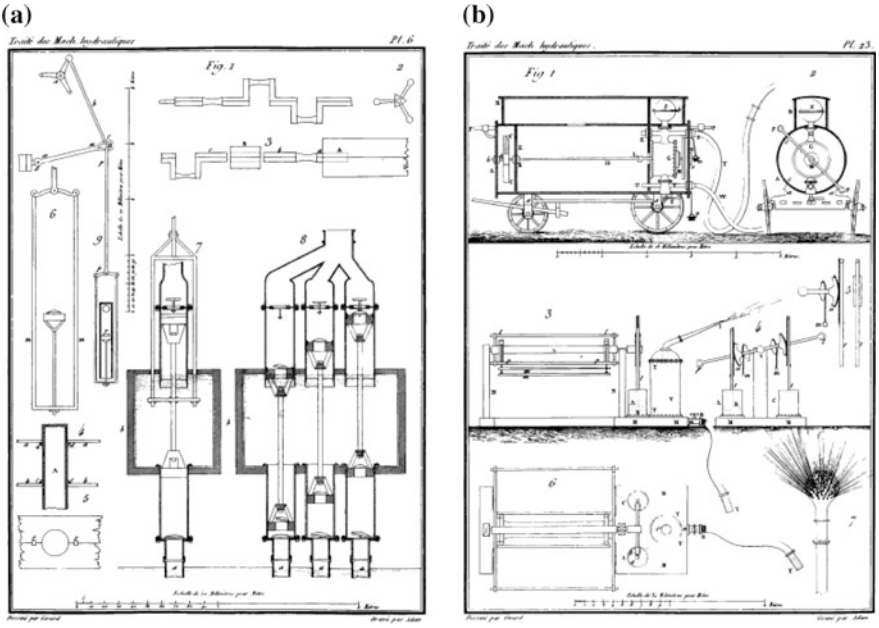


Fig. 9 Examples of machine drawings in the book on Hydraulic Machines by Borgnis (1819a): **a** composed pumps; **b** fire-fighting applications

specific actions in the treatment of agricultural products through the use of fairly simple devices with transportable solutions. Figure 10b shows a mill structure with all its parts included in a large building. It is worth full to note that the drawing includes the crane for lifting the products to be milled and even the hydraulic turbine for the power source. Of course, primary attention is focused on the milling machine on the second floor of the building. However, the milling mechanism is not clearly represented, while the mechanical transmissions from the turbine to the milling machine are, shown with a gear system for the main power flow and cable systems for complementary machines in the milling building.

Figure 11 shows examples from book (Borgnis 1819) of machines built for manufacturing activities in several fields of developing industries. In particular, Fig. 11a illustrates machines for cable production that can be powered by proper power sources. In Fig. 11b machines for printing are shown with solutions that are still devoted to human manual actuation. However, the mechanism solutions are evolved in quite complex assemblies both for work precision and force transmission suitable for human operators.

Specific attention is dedicated to textile manufacturing in book (Borgnis 1820) as one of the fields that experienced considerable advance in the early stages of the Industrial Revolution. The examples in Fig. 12 show the complexity of the machines having mechanical designs suitable for a certain automation and machine-powered solutions. Thus, the examples in Fig. 12a are relative to machines

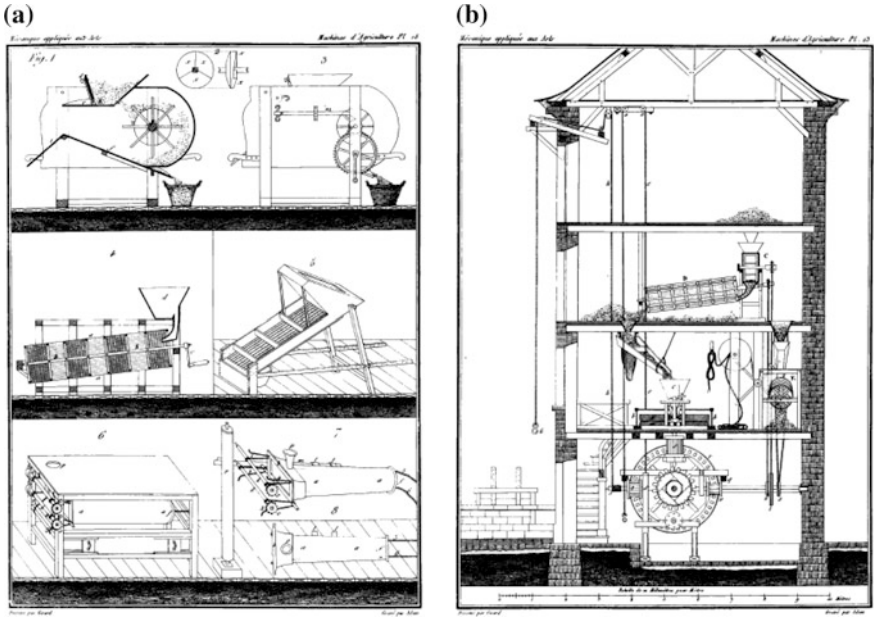


Fig. 10 Examples of machine drawings in the book on Machines for Agriculture by Borgnis (1819b): **a** machines for separation/selection of products; **b** mill machinery in a milling building

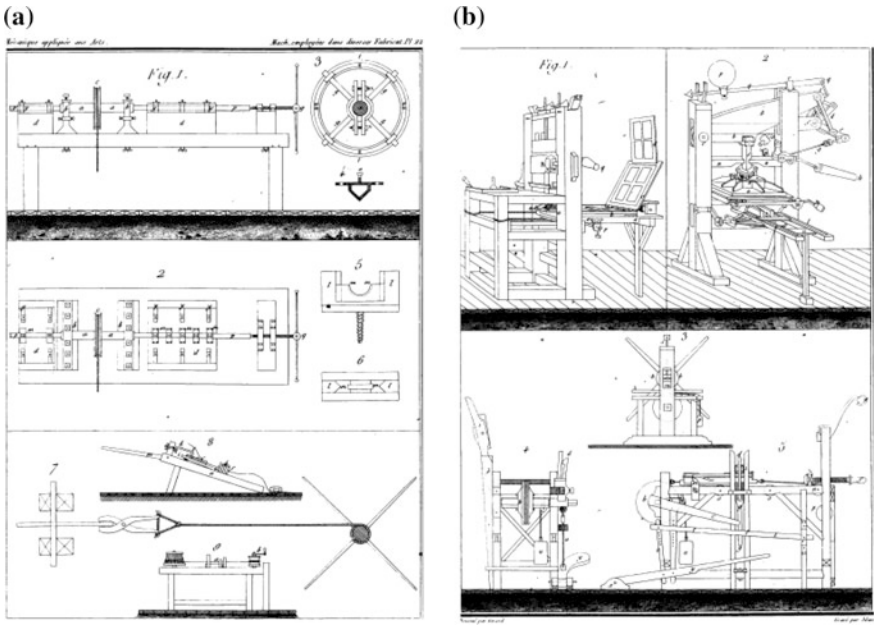


Fig. 11 Examples of machine drawings in the book on Machines for Manufacturing by Borgnis (1819c): **a** machines for cable production; **b** printing machines

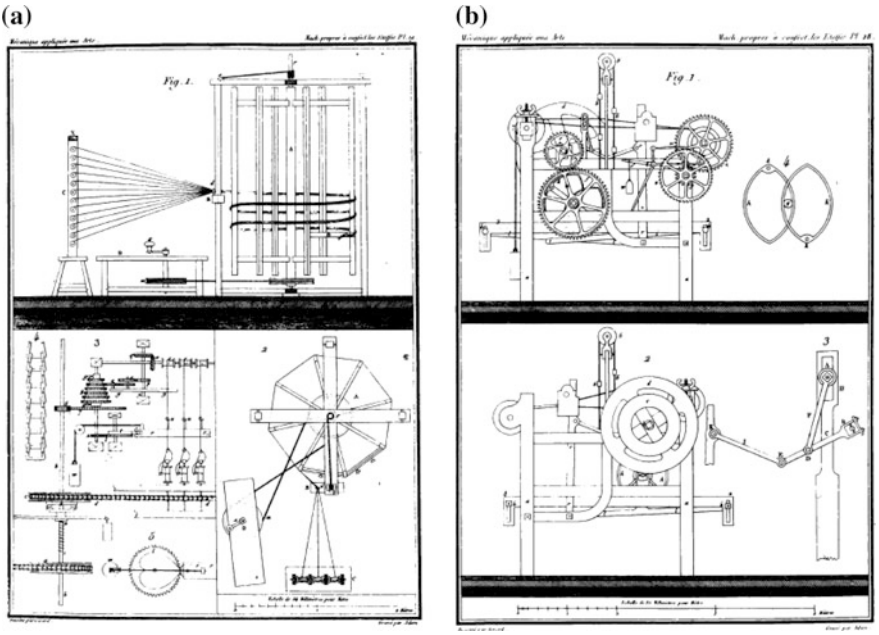


Fig. 12 Examples of machine drawings in the book on Machines for Textile Production by Borgnis (1820a): **a** machines for thread composition; **b** mechanical loom

for the preparation of treads with different characteristics, while the examples in Fig. 12b concern the mechanical design of looms increasingly based on linkages and gears with the aim of improving both the automation and productivity of textile manufacturing.

The increasing expertise in machine design with automatic operation and advanced characteristics gave increasing importance to the design and use of automata for something other than leisure, as it had been used in the past. Thus, book (Borgnis 1820b) is specifically devoted to automata, although most of the practical applications are still directed toward theatre plays. The examples in Fig. 13 show solutions that can be even recognized as early examples of robots and modern applications. In fact, in Fig. 13a, devices are illustrated that can be recognized as applicable for prosthesis in arms and hands. The mechanical solutions are illustrated with joint designs and compact mechanical transmissions that are indicated for use by humans, but they can be understood as part of more complex artificial constructions. Thus, in Fig. 13b, automata are shown that have fully automatic operation with rational solutions, such as those seen in Vaucanson's duck, and new solutions, like the marine chariot driven by a horse, as basic characteristics of a machine collection representing both the past and the novel solutions. Significant is the exploded view at the bottom of the table in Fig. 13b that is related to the mechanical design of a humanoid with mechanical elements such as gears and linkages.

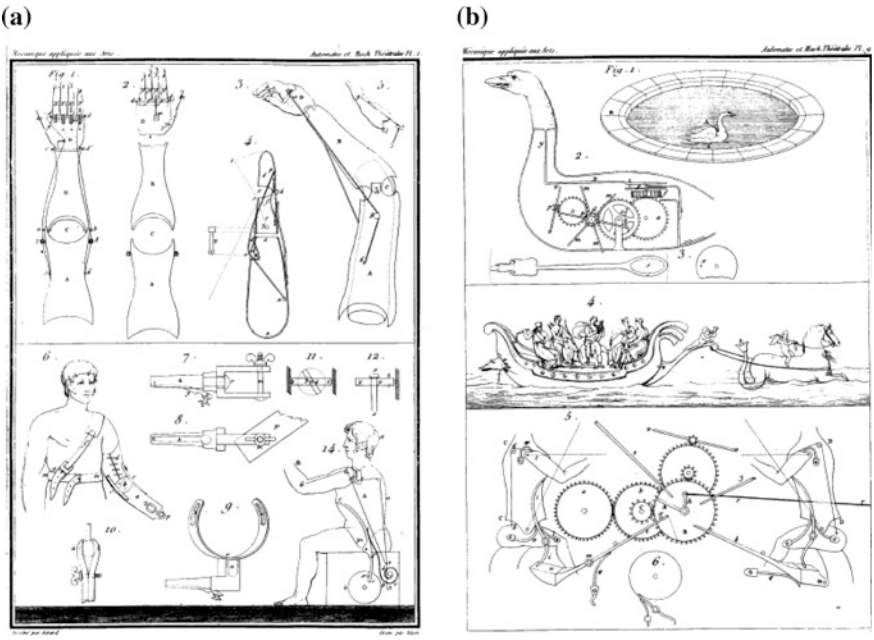


Fig. 13 Examples of machine drawings in the book on Machines for Automata and Theatre by Borgnis (1820b): **a** basic components; **b** mechanical design of past automata

In Fig. 14, examples are given from book (Borgnis 1821) that are devoted to theoretical analysis of machine operation and design functionalities through specific studies for numerical evaluations with an early modern approach. Thus, in Fig. 14a, several kinematic schemes are drawn for analyzing motion properties and capabilities of mechanisms and machines. In Fig. 14b, mechanical models are elaborated for analyzing the force transmission in those machine elements. The aim of the book is to give schemes and procedures for analyzing and evaluating the mechanical operation of machinery.

The technical collection of machines led Borgnis to the need for a commonly accepted terminology for machinery as a natural complement to the language of the graphical representations. The 10th volume of the handbook (Borgnis 1823), Fig. 15, focuses on terminology and it can be considered a milestone work, being the first technical dictionary on mechanical engineering specifically focused on machines, as Borgnis himself stated in the book's preface. The terminology collection in the book was aimed at summarizing the most frequently used and most well-defined and accepted terms in machinery at the time. The terminology by Borgnis contains technical definitions and operation descriptions with theoretical background, including historical notes and indications of common applications.

The machine term is described by Borgnis as a "general name that is used for several combinations of mechanical devices which are used frequently in Industry. Within the Statics treatment, it is possible to distinguish the names of elementary

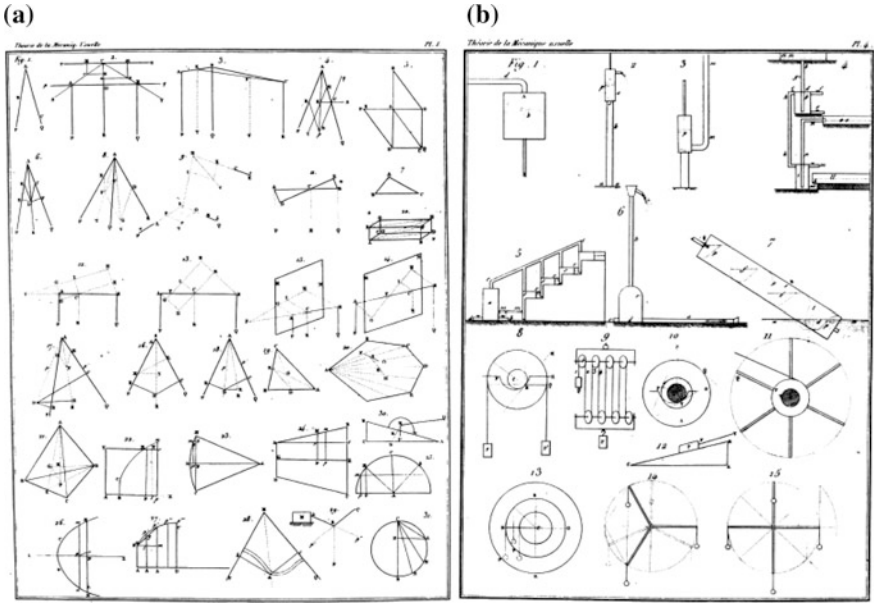
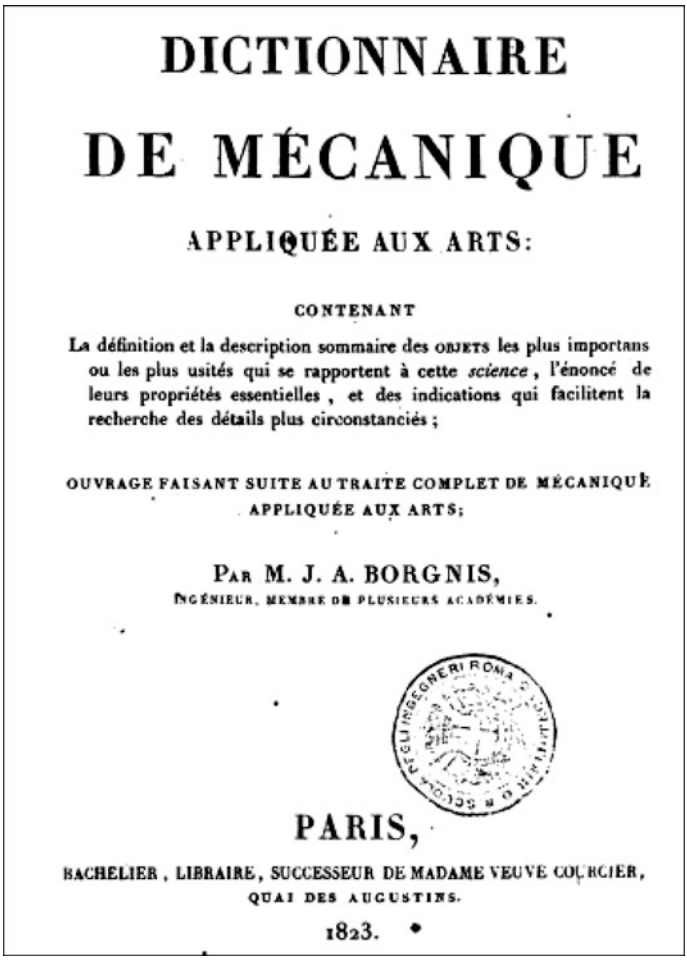


Fig. 14 Examples of tables of drawings in the book on Theory of Usual Mechanics by G.A. Borgnis (1821): **a** scheme for motion studies; **b** schemes for statics and force transmission

machines of lever, pulley, inclined plan, screw, wedge and belt machine". Specific mechanism components are properly indicated; for example, a crank is described as 'a link that rotates about an axis and at whose extremity is applied a force. There are cranks with simple, double, triple structure'.

In general, Borgnis's definitions are synthetic, but additional indications are suggested to the reader referring to other similar/linked terms. Specific mentions are given to literature on arguments of a wide topic. For example, in specifying the term 'steam' as also referring to steam machines, Borgnis added a rather long list of references on the topic, even mentioning past designers like Watt, Wolf, and Evans. Figure 16 shows an example of a text item referring to the piston element with the full above-mentioned terminology approach (Fig. 15).



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OUVRAGE FAISANT SUITE AU TRAITE COMPLET DE MÉCANIQUE APPLIQUÉE AUX ARTS;

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PARIS,

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1823.

Fig. 15 Title page of the Dictionary of Mechanics Applied Machines by G.A. Borgnis published in 1823 (Borgnis 1823)

PISTON. *s. m.* Nom générique d'un plateau cylindrique qui se meut soit dans un corps de pompe, soit dans le cylindre d'une machine à vapeur ou d'une machine soufflante.

Il faut qu'un piston bouche exactement le cylindre dans lequel il se meut, sans cependant occasioner de frottement trop considérable. Les pistons sont environnés ou de bandes de cuir, ou de filasse que l'on comprime entre deux parties annulaires, réunies par des boulons à vis; ou bien des segmens circulaires sont placés sur le plateau du piston, et poussés en dehors par des ressorts; quelques-uns des pistons sont pleins, d'autres ont des ouvertures couvertes par des clapets. Dans ce dernier cas, il est essentiel que les soupapes soient aussi grandes qu'il est possible, sans nuire cependant à la solidité. Les soupapes doivent s'ouvrir avec facilité, et se fermer avec exactitude. (Ouvrages à consulter : Bélidor, *Architecture hydraulique;* — de Prony, *Nouvelle architecture hydraulique;* — Hachette, *Traité élémentaire des machines;* — notre *Traité des machines hydrauliques*, page 44; — *Composition des machines*, page 155; — Oliver Evans, *Manuel du constructeur des machines à vapeur.*)

Fig. 16 Example of terminology in the Dictionary of Mechanics Applied Machines by G.A. Borgnis in Fig. 15 (Borgnis 1823)

5 Conclusions

The book collection by Giuseppe Antonio Borgnis (1818–1823) can be considered significant not only as a historical source of reference for machines of his time but also as an early modern approach to the study of the variety of machines for rational design and operation. The rediscovery of Borgnis's handbook collection deserves specific attention, both in analysis of the work and its influence on machine development for design and teaching in the 19th century. The handbook collection is presented in an illustrated survey to show the technical content of the machine descriptions within a frame of original classification that was elaborated by Giuseppe Antonio Borgnis with a modern view. This paper is an attempt to revitalize interest in this valuable work and give all due credit to its author.

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