Giuseppe Antonio Borgnis and Significance of His Handbooks on Representation and Terminology of Machines

Michela Cigola and Marco Ceccarelli

University of Cassino and South Latium, Italy
{cigola,ceccarelli}@unicas.it

Abstract. This paper presents considerations on the valuable contributions of Giuseppe Antonio Borgnis in the 19-th century developments on Mechanism Design in terms of representation of machine mechanical designs and terminology for the rising discipline on Theory of mechanisms.

Keywords: History of MMS, Past Handbooks, Theory of mechanisms, Past personalities, Borgnis.

1 Introduction

A need to survey available variety of machines arose since Renaissance both to show designers' expertise and to attempt classification of mechanisms and machines, [3]. A tradition was established with the Theatrum Machinarum treatises that evolved into technical handbooks in 19th century during Industrial Revolution. The book collection by Borgnis is one of the first of those technical handbooks of machinery in which a historical background is still present but it also contains novel characters in terms of contents as well as approaches of presentation of machines. The Borgnis handbook collections started a modern discussion and elaboration of machine classification that was initiated by Monge's concepts in the milestone work by Lanz and Betancourt in 1808, [5]. Even the presentation of machine designs is attached with modern perspectives of technical views with the aim to direct a machine survey specifically to professionals of a technical community growing rapidly.

This paper is an attempt to identify those characters of novelty in Borgnis handbook collection mainly as related to graphical aspects of drawing representation as results of such a technical approach for a technical community. In this study examples of machine representations are reported to show an evolution of graphical representation operated by Borgnis as linked both to a modernization of that time for traditional machines and enhancement of machine performance in old and new solutions.

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2 Biographical Notes on Giuseppe Antonio Borgnis

Giuseppe Antonio Borgnis, Fig. 1, was born on April 15, 1781 in Craveggia, Italy, from a well established family since the father Giovanni was a banker in Paris. He was well educated with special interest on mathematical disciplines and although the revolution time affected the family he was able to graduate as engineer. He got a position as naval engineer in Venice where he gained so valuable expertise to write a book on machines on 1809. This gave him a good reputation and got the possibility to attend the Ecole Polytechnique in Paris. During this period he deepened his expertise on machine design both on theoretical studies and practical applications. He evolved views from the Monge's approach as to propose his own classification on mechanism variety for machine applications, [5]. Developing in more details his views he published ten books from 1818 up to 1823 [1-2], as a handbook on machine designs and applications, as a practical implementation of his new classification for an overall view, Fig. 2 b), [1]. Once returned in Italy he got the position of professor at the University of Pavia where because of his repute and further activities he became also rector in 1848.

He was well reputed professor of applied mathematics and civil transportation architecture, as combining his interests and activities in theory and engineering designs, during the first period of industrial revolution all around Italy, although he was in the north east state within in the Austrian-Hungarian Empire.

Fig. 1 A portrait of Giuseppe Antonio Borgnis (1781-1863)

(The grand-grand child Massimo Borgnis is thankfully acknowledged for the portrait and additional biographical notes)

3 Handbooks by Borgnis

The encyclopedic handbook is organized by Borgnis from a classification overview up to specific studies of category of machines, by discussing design and operation characteristics, [1]. A last book is on terminology with synthesis of concepts and understanding of terms that are related to design, operation, and manufacturing of machines. In particular, the content of those volumes [1] is summarized in the following:

1 – **"De la composition des machines"** (450 pages, published in 1818), Fig.2, which contains classification and description of mechanical devices in agreement with the approach proposed by Gaspard Monge. The treatise is completed with drawing of 1,200 mechanical devices, which are also compared in term of figure and operation 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), which contains a description of mechanical design and operation characteristics of the machines that can be used for transportation and lifting all kind of weights.

3 – **"Des machines employées dans les constructions diverses"** (336 pages, published in 1818), 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.

4 – **"Des machines hydrauliques"** (295 pages, published in 1819), 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), which contains description 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), which contains the description of machines used in industrial plants for production of metal components, paper products, textile manufactures, and tannery products.

7 – **"Des machines qui servent à confectioner les ètoffes"** (335 pages, published in 1820), which contains description of procedures for spinning of vegetal or animal material, comparative analyses of mechanical means for industrial spinning and equipment of different kind of machines for different kind of products in textile manufacturing.

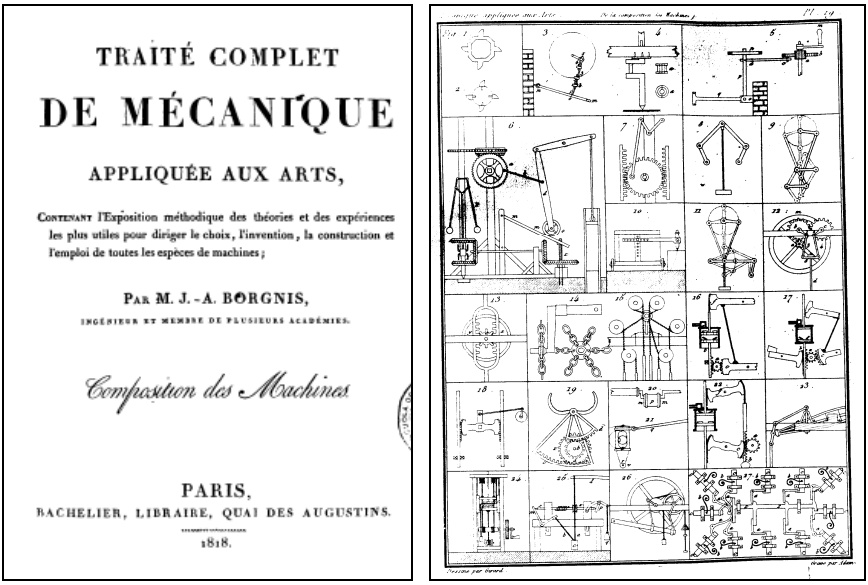
8 – **"Des machines imitatives et des Machines théatrales"** (285 pages, published in 1820), which contains a description of mechanical device that are used for any kind of transportation and movement, including devices mimicking animal motions. The text includes an Appendix with interesting description 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), 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 main mechanical transmissions.

Borgnis completed the encyclopedic work with publication of the **"Dictionnaire de Mecanique appliquèe aux arts"** in 1823, [2]. This is a brilliant synthetic dictionary with technical terminology for Mechanical Science, with a vision anticipating the modern time that lead only in 2003 to IFToMM terminology, [4].

The encyclopedic work by Borgnis on mechanisms and machines in 9 volumes was used as reference handbook by practicing engineers along the whole XIX century, as a first modern technical handbook, in Italy and in whole Europe. It was also considered as reference for further studies on classification and evolution of mechanical engineering handbooks.

Borgnis attached the variety of machines by looking at practical aspects from successful operations. Thus, his classification is an amplification of the theoretical approach of Monge in indicating operation characteristics as related to the action of motor components and output purposes of machines. The background of mechanism analysis is till persistent as shown in table 2 b) from the first volume, but the structures are more near to full machines than basic mechanisms. In fact, as indicated also of the organization of machines in the above-mentioned volumes, Borgnis focused the attention on full machines and important has considered the mechanical and operation performance of functioning in quite long descriptions and discussions.



a) b)

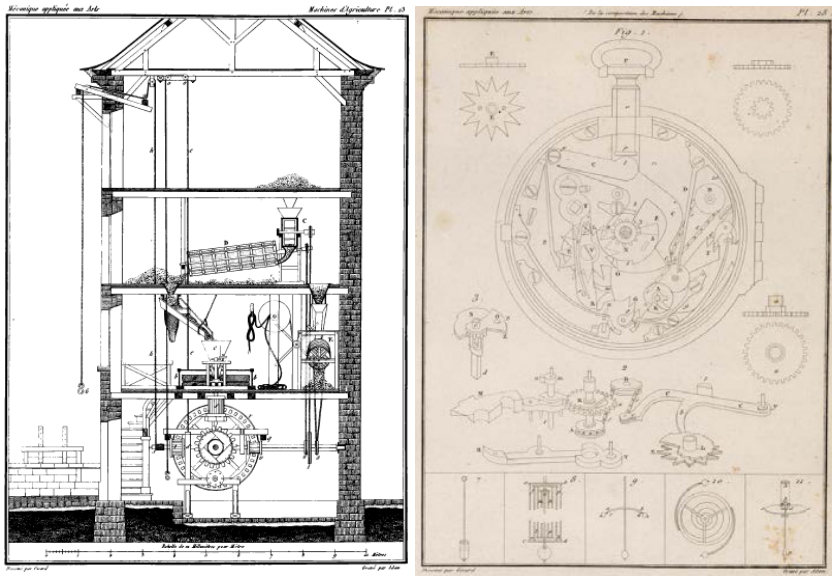
Fig. 2 Mechanism classification by Borgnis: a) book title page; b) part of a summary table

4 Machine Representation

The machine representation by Borgnis with clear drawings is considered part of the presentation and discussion of machine properties even for further developments. Although he represented machines with drawings of mechanical design along the well established tradition, nevertheless he attempted to advance technical representation of machines in approaching descriptions with essential characters for a full understanding by professionals (not really a large public) whose community was growing rapidly within the merging Industrial Revolution. Few examples of those aspects are commented in the following

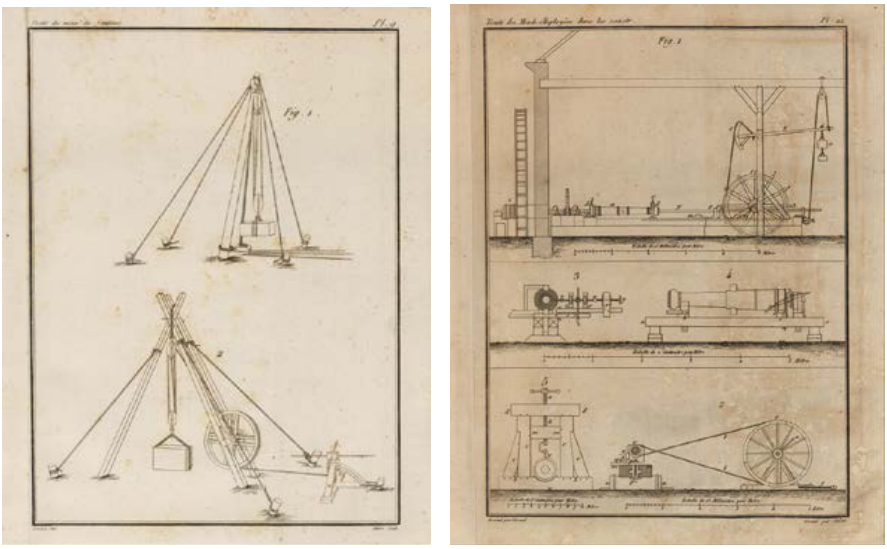
Figure 3 a) shows a water pump system whose drawing is within a tradition of the representation of hydraulic machines that appear frequently in the manuals and texts since the oldest times. Everything is drawn with strong definition and precision. The drawing of mechanical parts is synthetic and essential, while the drawing of the building in which the machines are located, is expressed with more naturalistic representation, such as a pictorial figure of stone pieces in the walls.

Figure 3 b) demonstrates clearly the French formation of Borgnis as focused on Encyclopèdie by Diderot and D'Alembert. In fact, the clock assembling recalls very closely a table of Encyclopèdie, but nevertheless the representation is much more concise with less characteristics towards chiaroscuro and decorations. This is a sign that Borgnis well understood coming trends towards abstraction and synthesis that characterizes the modern technical drawing as directed to professionals.



a) b)

Fig. 3 Machine designs by Borgnis: a) a water pump system; b) clock assembling



a) b)

Fig. 4 Mechanism designs by Borgnis: a) a on-field crane; b) mechanical system for gun production

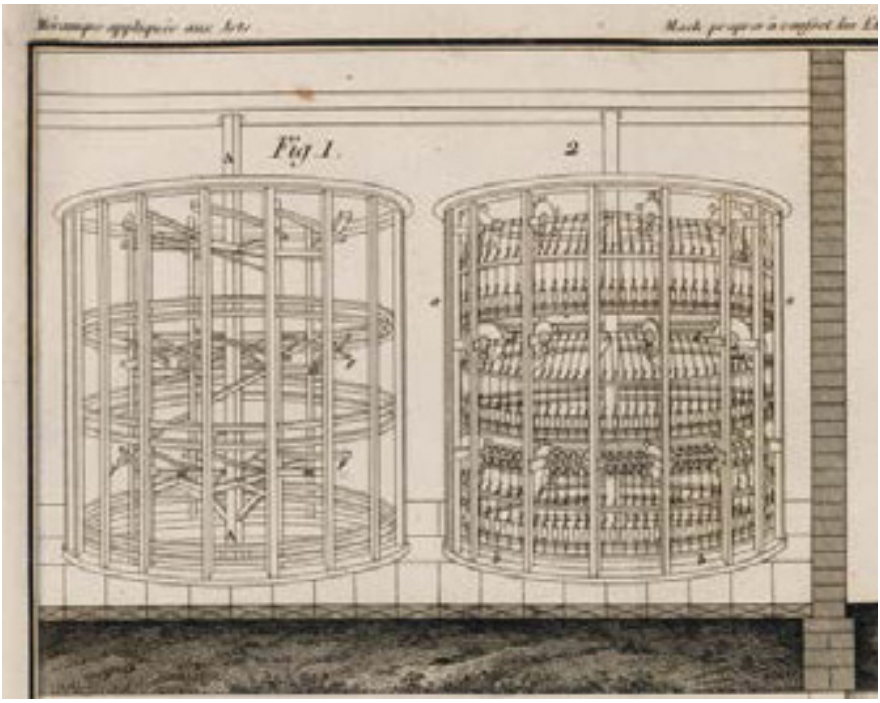


Fig. 5 Machine design by Borgnis for a textile manufacturing system

Figure 4 a) shows one of the machines that are part of patrimony of ancient technological heritage. The same machine are presented by Vitruvius in De Architectura book X. We can find this type of machine for lifting weights (on-field crane) in all editions of Vitruvius, since Frà Giocondo edition in 1511 to Perrault's French edition of 1673. In this drawing Borgnis seems to be inspired by Perrault edition, [7], but even in this case he deleted graphic complacency and landscape details as to focus on the device and its functioning only.

Figure 4 b) is another proof of the importance of French period in Borgnis' formation and later professional experience. He studied at the École Polytechnique, where he certainly came into contact with Gaspard Monge. In this figure he recall almost exactly Monge text on guns [6], bringing nearly identical portions of the plates of Monge. Even in this case, the drawing is more concise without shadows that enriched the volume of objects as represented by Monge.

Figure 5 presents a textile manufacturing system which you can find in many of the treatises of Theatrum Machinarum from the 16th and 17th century. Also in this case the Borgnis' representation gives the object without decoration that can confuse the attention of a professional reader. Even machine location is indicated with synthetic and concise frames as focused on the functioning of the machine, although the representation of the cylindrical complex is not without a certain graphic virtuosity.

5 Machine Terminology

The technical presentation of machines led Borgnis to the need to identify and to collect a commonly accepted terminology for machinery as a natural complement of the language of a graphical representation. The 10^{th} volume of the handbook is on terminology as a milestone work attempting a technical dictionary that today is well recognized necessary in all scientific areas, as stated in the several standards of ISO. In the specific area of machine design Borgnis started a need that was solved only in 1990_s within IFToMM activity leading to the last IFToMM collection of standardization and terminology in 2003, [4].

As Borgnis stated in the book preface, the terminology collection is aimed to summarize the most used terms on machinery with a well defined and accepted understanding. Examples are reported in this paper to show the synthetic characters but technical clarity of Borgnis description of the terms. A comparison is proposed with the corresponding IFToMM terminology. Machine is described by Borgnis as "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 machines of lever, pulley, inclined plan, screw, wedge and belt machine". In IFToMM machine is defined as "Mechanical system that performs a specific task, such as the forming of material, and the transference and transformation of motion and force".

While in IFToMM even the term of mechanism is specifically described, in Borgnis terminology it is not defined. But specific components are properly indicated, like 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 IFToMM a crank is "a link able to rotate completely about a fixed axis".

Borgnis specified terminology also for machine operation within the definition of a term. Thus, for example he defined as lifter a combination of gears with a worm and a crank whose aim is to produce a large force through a small sized device. Within brackets he indicated to refer to the motion of weights as additional characterization of the device. In general, definitions of terms by Borgnis are synthetic but additional indications are suggested to a reader as to refer to other terms. In addition specific hints are given to mention literature on arguments of a wide topic. For example in specifying the term steam, as also referring to steam machines, Borgnis added a quite long list of references on the topics, even by mentioning past designers like Watt, Wolf, and Evans.

Thus, the terminology by Borgnis contains technical definitions and operation descriptions with theoretical background including historical notes and indications of common applications.

6 Conclusions

Giuseppe Antonio Borgnis was a personality in TMM developments in the first half of 19-th century both for his life activity and his works. In this paper we have stressed his contributions mainly in term of machine design as graphical representation combining with the novel need of a terminology for a common understanding both by professionals and users.

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