Preface to the Second Edition

According to the authors, writing about History of Mechanism and Machine Science not only consists of examining gears, pulleys and mechanical parts in general. It also means, to investigate devices that were born in a specific historical period, made to increase production or to alleviate fatigue. These purposes were achieved by using natural energies or optimizing muscular energy, certainly making use of gears and drivelines, but on a rational basis. With the advent of the Roman Empire much knowledge was acquired from the scientific and technical knowledge of India was acquired, and was followed up in Mesopotamia and Egypt during the epic of Alexander the Great when wide disclosure and use was found.

From them the Romans were able to tap into real opportunities, avoiding testing themselves on abstract problems; so that the Romans, although they were not good mathematicians, became among the best engineers of antiquity.

The term engineer in English clearly comes from engine while in Italian and Latin languages it derives from the Latin *ingenium* (= inventiveness, ability, talent), suggesting a speculative faculty. However, the root of the Latin word may be derived from the Sanskrit *gen* (= give birth, produce, woman). The engineer therefore was never only a scientist but a prolific 'parent' of new devices. Thus, despite the Roman's learning limits, little inclination for science and propensity for the only practical use of scientific discoveries, the osmosis between the Hellenistic and Roman technology was widespread, stimulated by military and commercial needs.

With regard to the word "technique", the ancient Greek word *techné* was used to indicate every professional skill, but catching up further back, we find the root *tak, tak-s* in Sanskrit, having the generic meaning of to make, manufacture, produce, build. The technology is therefore the discipline that studies all the professional abilities and artisan skills: ultimately, the sum of the competences behind all productions.

Mechanics, then, in turn derives from the ancient Greek *mèchané* that can be translated as tool to do; the oldest root is still in the Sanskrit *mahate* that means increase, make it big. In other words, an artificial entity capable of increasing the strength, production, growth. Concept that, in broad terms, is well suited to

machines and to our mechanics in general, while in antiquity included also the meaning of cunning and guile. Persons like Odysseus were able to devise *mechanaì* (devices) to resolve critical situations; his horse had, in fact, already all the characteristics of the nascent mechanics, being the outcome of a rational assembly of more pieces.

The following pages attempt to provide an overview of the most remote engineering and related mechanics, thus suggesting how much of our disciplines are directly derived from those distant premises.

For this second edition, the book has been increased with many of the results of our research in the last 8 years.

In addition, some entirely new topics were added and paragraphs of especially engineering interest were also added. In some of the latter the work provided by men, animals, wind engines, water wheels and torsion engines for throwing machines are evaluated; models of machines such as siege towers and throwing machines are also proposed. For the throwing machines some examples of performance and projectile trajectories are also reported.

Finally, many unpublished figures by the authors have been added.

Naples, Italy — Cesare Rossi
Torre del Greco, Italy — Flavio Russo
March 2016

Preface to the First Edition

We live in an age in which one can easily think that our generation has invented and discovered almost everything; but the truth is quite the opposite. Progress cannot be considered as sudden unexpected spurts of individual brains; such a genius, the inventor of everything, has never existed in the history of humanity. What did exist was a limitless procession of experiments made by men who did not waver when faced with defeat but were inspired by the rare successes that have led to our modern comfortable reality. And that continue to do so with the same enthusiasm.

The study of the History of Engineering is valuable for many reasons, not the least of which is the fact that it can help us to understand the genius of the scientists, engineers and craftsmen who existed centuries and millenniums before us; who solved problems using the devices of their era, making machinery and equipment whose concept is of such a surprising modernity that we must rethink our image of the past.

But there is an even more important reason to study the History of Engineering: the authors believe that it is impossible to have a true technical culture if the ideas and the work of those who came before us are ignored. Culture, in whichever field, consists ofunderstanding and not simply in know-how. For this reason it is essential to learn how a certain phenomenon was understood and how the application of that knowledge evolved through the centuries. For the same reason it is important that the scientists of our generation transmit an interest in and taste for the accomplishments of ancient engineers. Young engineers should be familiar with the knowledge of the past if they are to understand the present and perceive the future. Moreover, engineering must be considered that discipline that tries to give to man the possibility to outperform his body's limits.

This book describes the inventions and designs of ancient engineers that are the precursors of the present. The period ranges mainly from 300 BC to 1600 DC with some exceptions belonging to ages before and after these years.

As for the very ancient inventions, in the book there are descriptions of inventions (documented by archaeological finds mainly from Pompei, Hercolaneum and Stabia) of which often very little is known.

Some of the inventions are in the military field since (unfortunately) many inventions and technological innovations were conceived starting from military applications.

In this volume the authors have considered several important fields of engineering; in each of these fields, they highlight the first examples of the inventions (and workings) accomplished by scientists and engineers.

Although many of these inventions are extremely old, the ones presented in this book are the precursors of the knowledge and inventions of our era. In addition, many of them often reveal a surprising modernity in their conception, in their scientific and technical design and even in their shape and function.

The book is divided into five parts.

The first four parts pertain to definite fields and present inventions conceived up to the late Roman Empire. Inventions that are representative of the engineering genius of the ancients and that may be considered as milestones, each in their respective field.

The fifth part also refers to separate fields of engineering innovations (such as textiles and automation), but concentrates on more recent centuries.

The last chapter (16th) deals with building construction techniques and not devices. These building techniques, in the authors' opinion, can also represent inventions.

For each of the inventions presented, even the ancient ones of many centuries past, the authors provide three elements of research and reference:

Written documents (the classics)

Iconic references (coins, bas-reliefs, etc.)

Archaeological findings.

The only exception is when an exhaustive and detailed treatise by the inventor himself is available (e.g. Vitruvius).

Many devices and building constructions described in the book pertain to the age of the Roman Empire; it could be presumed that this is so because the authors are Italians, but this is not the reason. Undoubtedly, the Roman Empire represents something of very great (and probably not yet completely understood) in many fields of science, technology and law; it started within the Italian peninsula but it does not belong to the Italians alone. First of all, most of the inventions and technology of the Roman Empire were not invented by Latin inventors; in fact, one of the merits of the Romans consisted of recognizing, appreciating and using the intellectual abilities of other peoples. In addition, the quality of the organization and the "sense of the State" has been retained more by the German and Anglo-Saxon peoples than from the Latin ones; hence the heritage of the Roman Empire, today, belongs to the ones that study and appreciate those ages and those men. Moreover, living in Italy, the authors have had more chance to see and investigate roman relics. However, certainly a large number of the inventions that are precursors of the present were developed at that age.

Based on a wide reading of many references, the authors concluded that a first industrial revolution started during the Roman Empire. Many aspects suggest this hypothesis: the Romans made a large use of unification and standardization in the

productions of goods. At certain periods, the Roman Armed Forces had up to 500000 men; this means that it was necessary to equip such a number of men with everything they needed to live, wear clothes and fight. An army needs, necessarily, unified and interchangeable equipment also because a military unit can be sent anywhere; this means that something like an industrial and unified production had been certainly necessary for the army's needs.

The standardization, that probably was fashioned specifically for military use, was certainly extended to civil applications: many of the components used in various systems like hydraulic valves and pipes (see Chapter 8), cart wheels and gauge (see Chapter 10) and so on had standardized dimensions and were interchangeable all over the Empire. This was clearly written by Vitruvius, the most famous Roman engineer.

Finally, the authors did not write this book for engineers only; hence they describe all the devices without assuming wide technical knowledge. The authors' main aim is to try to communicate their enthusiasm for the inventions and inventors of the past and, possibly, to make their contribution to the fascinating study of the History of Engineering.

Napoli
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