XXV CONGRESO NACIONAL DE INGENIERÍA MECÁNICA
Santander, 11-13 junio 2025
UC Universidad de Cantabria
IFToMM

A note on History of Rome School of TMM

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In this paper a historical survey is presented on distinguished figures and activities evolution in the fields of TMM (today MMS) within the academic frames of the school of engineering in Rome. As in many other Italian University, the modern academic tradition of the University of Rome started since the Renaissance time and the specific activity on Mechanical Engineering was officially established and well developed in 19th century. The background from an early University in Rome is remembered as a base for the well-focused interests in TMM during the 19th century with significant results by distinguished figures. The early modern historical developments are outlined as starting in the second half of 19 the century referring to Carlo Saviotti, Lorenzo Allievi, Anastasio Anastasi, and later to Manlio Oberziner, Arnaldo Castagna, and Giovanni Scotto Lavina. Many others also contributed significantly and their achievements are reported in the historical account, like for example Adalberto Vinciguerra who, with his international views and activities, was the first to be well involved in the International Federation IFToMM: In more recent times the Rome school proliferated following the establishment of the second University of Rome in Tor Vergata in early 1980s and later the third University of Rome near Viale Marconi in the early 2000s. Short account is discussed to give a panorama of the different groups in the three universities that very soon developed their own community with a differentiated identity and activities. It is possible to recognize two generations of figures in the other two Rome Universities who did not start their activity in La Sapienza University of Rome. The paper gives an account of a cultural heritage in TMM and MMS by Rome school frames in TMM/MMS by reporting information on main distinguished figures of teachers-investigators and their achievements. Main contributions are outlined referring to the development of mechanical engineering and specifically TMM or MMS with values of national and international interests. The goal of the paper is also to refresh consideration of the past looking at technical contents for more technical-historical investigations that can be useful to keep memory of past mentors, but to track local evolutions like the one of the Rome school of TMM-MMS as awareness source of future trends.

1. Introduction

The identity and value of a community is also defined by its historical development with the personalities who have achieved the results of merit that characterize their peculiarities in society. This importance of the past is equally significant also in technical-scientific fields, as explained in [1].

Unfortunately, the history of science and technology, in general, focuses in detail on technological results and innovations, giving little importance to the historical-technical aspects that determined its success with the significant contribution on a personal level of scholars, designers and inventors. This approach is especially evident in encyclopedic works that are aimed to examine scientific and technological development at a macroscopic level, although still citing names of personalities, as for example in [2]. At Italian level, there is however a certain specific interest in tracing the historical profiles of the Italian community active in the development of the theory, design and practical implementation of mechanisms and machines, as well as referring to the current academic community of Mechanics Applied to Machines (Meccanica applicata alle machine). A first panoramic work is reported in [3] by the author, with the attempt to give a unitary vision of the evolution of the fragmentation of the Italian local machine engineering communities linked to social and political developments towards cultural unification as well. Examples of historical studies with technical-scientific contents of specific analyzes of local communities at Italian universities are the works by Prof. Della Pietra for the University Federico II of Naples, [4], Angotti et al. for Florence University, [5], and Dr. Dameri for the Polytechnic of Turin, [6].

This paper reports an attempt, not yet complete, to present the technical-scientific cultural heritage of the Roman school of Mechanical Engineering focused on the disciplines referring to current Mechanics Applied to Machines through attention to the historical developments linked to the personalities who with their academic activity has created a substantial community with still today's impacts at a national and international level. The incompleteness of the information and the historical examination is due to the scarcity of both archival information and biographical information which does not allow well-focused attention to the roots of the past. In this regard, the work also aims to be a stimulus for further biographical and thematic research that can better clarify not only individual contributions towards a well-established community, but also to propose attention to historical tracing which is often underestimated in those short times based on personal memory do not allow adequate documentation.

2. A short history of the Rome School of Engineering

Figure 1 summarizes the main dates of the historical evolution of the Roman school of TMM (Theory of Machines and Mechanisms) today better called MMS (Mechanism and Machine Science) as for the expansion of disciplines and horizons of educational and scientific interests. The Roman school of TMM-MMS was centered on the engineering faculty of La Sapienza University until the foundation of other universities in Rome and Lazio subsequently in the early 1980s.

The engineering school of La Sapienza University in the modern era was founded on 23 October 1817 by Pope Pio VII to satisfy specific needs for the training of local engineers for the Papal state in a 'corps water and road papal engineers' following the French model, surpassing the programming of traditional academic studies on the Arts and Sciences of the Rome University begun since 1303, [7]. A first plan of technical engineering formation for civil applications was attempted in 1798 with the National Institute of the Roman Republic also with the contribution of Gaspard Monge. This need was recognized to provide skilled people for the development needs of the city of Rome and the Papal State autonomously, differently from what happened in previous centuries with the use of experts and engineers coming from outside since the Papal State did not have its own military system from which, as in other countries, engineering professional figures could also be created.

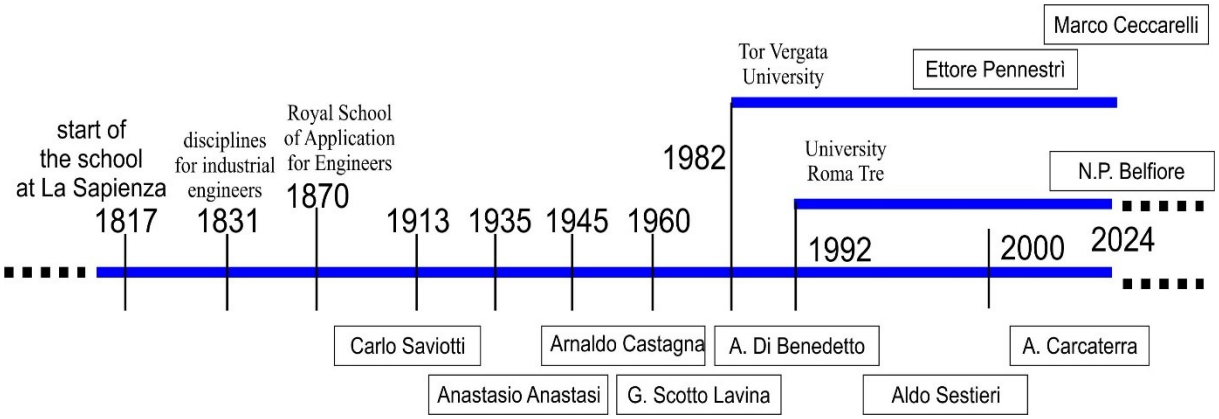


Figura 1: A timeline of the evolution of the Rome school on TMM (today MMS) with main figures

Subsequently in 1826 Pope Leone XII confirmed the engineering formation by strengthening the autonomy of technical studies from the university and already planning in 1831 an expansion of the courses including more specific disciplines such as Machine Design, Applied Mechanics, Applied Physics, Agriculture and others in fields no longer limited to civil engineering, as for the nascent railway industry and for the manufacturing industry. In the last period of the Papal State before the reunification of Italy, notable works were carried out not only in the restoration and expansion of the urban frames of the city of Rome and the Papal State but also in innovative initiatives such as the installation of a first railway network and modernizations of the road network. Examples of this modernity following the training of industrial engineers are the creation of the railway network from Rome to Velletri and Terracina, started in 1846, and the start and completion of the construction of the Appia Nuova, started in 1574, with works significant as the great Ariccia bridge completed in 1854 based on a design by the engineer Giuseppe Bertolini.

Following the national reunification and annexation of the Papal State to the Savoy Kingdom of Italy in 1870, the engineering schools were reformed into Royal Application Schools for Engineers and so in 1873 the Rome school was confirmed with its independence from the university, but it was reorganized according to new Italian national plans. At academic year 1877-78 eight graduates were recorded as civil engineers. In this reorganization in 1913 new curricular programs were initiated in industrial engineering fields with reforms in programs that evolved until 1935 leading to the organization of the engineering school as an engineering faculty of the University of Rome La Sapienza with specific curricula in mechanical engineering and electrical engineering, and schools of aeronautical engineering, and mining engineering. Then they were all included in the engineering faculty in 1945. The success of technology in the development of the Italian economic, social and technical boom in the 1960s further promoted mechanical engineering with the planning of 9 curricula in which Mechanics Applied to Machines was confirmed as a fundamental course for the training of modern industrial engineers. The subsequent reforms of the national programs in the last decades have determined a variety of courses in the ever-growing area of mechanical engineering, however still giving a central role to the disciplines linked to the science of machines and mechanisms not only in mechanical engineering programs but for the entire area of industrial engineering.

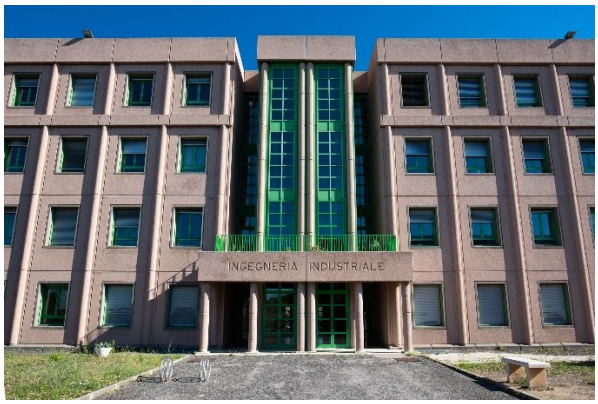
Since 1870 Rome Engineering School has been located in the central area near the Colosseum with portions of buildings dedicated to activities on theory (science) of machines and mechanisms with entities that have evolved from chair to institute to today's specific department on mechanical and industrial engineering topics. The growth of the student community and the need for an increase in the professional training of engineers also motivated the foundation of other engineering faculties in the new universities that were established in the urban frames of Rome since the early 1980s.

Figure 2 shows the main buildings of the current three engineering faculties in Rome where activities in the disciplines of MMS are carried out with a central role of Mechanics Applied to Machines.

Since 1870 the prestigious Faculty of Engineering of Sapienza University (https://www.uniroma1.it/it/structure/facolta-di-energia), Fig.2 a), has been housed near the church of San Pietro in Vincoli in the former convent of the Canons Regular of the Congregation of the Santissimo Salvatore in Laterano, which stands on the Fagutale, the highest of the Esquiline hills. The University of Rome “Tor Vergata” (https://web.uniroma2.it/it/) began its teaching activity in 1982 in a large campus in the south-east outside the ring road. The Department of Industrial Engineering, Fig. 2 b), formerly the Department of Mechanical Engineering, was established in 1982. The University of Roma Tre (https://www.uniroma3.it) is founded in 1992. The buildings in which the activity of the Department of Industrial, Electronic and Mechanical Engineering takes place, Fig.2 c) are located in the Ostiense – San Paolo area.

A peculiarity of the historical evolution, indeed typical of the Italian community, is related to the proliferation of disciplines that the Mechanics Applied to Machines has also produced following the ministerial academic reorganizations of the formation of engineers. In fact, since the first modern definition of the discipline at the beginning of the 19th century with the works following the course, [8], started by Gaspard Monge in the Ecole Polytechnique of Paris, among which worthy of note are those by Gian Antonio Borgnis are, [9], and Carlo Giulio, [10], it was experienced the creation of disciplines with the relative definition of a specific promoted the Industrial Revolution and the modern formation of engineers. The first discipline that could be identified is related to Machines which in Italy too has for a long time been a parallel subject to mechanics applied to machines with teachers from one teaching courses from the other and vice versa. Topics that have proliferated from mechanics applied to machines can be recognized in the mechanics of structures, in the mechanics of production machines, in the machine design, in the drawing of machines and so on, as well as being segmented into specific topics such as kinematics of mechanisms, dynamics of multibody systems, mechanics of mechanical transmissions, regulation and control of machines, up to the current integration with mechatronics of machines and mechanisms. The current declaration of the scientific disciplines in the disciplinary sector referring to mechanics applied to machines includes a large variety of topics that include traditional aspects while also looking at developments with multidisciplinary and mechatronic approaches as required by the current structure of modern machines and systems, [3].

. a)



b) c)

Figura 2: Today Rome schools of engineering: a) at La Sapienza University; b) at Tor Vergata University; c) at third Rome University.

3. TMM Figures the second half of 19th century

During the first period of the Rome school of engineering the activities were planned within the programming of the Papal State and unfortunately no information is available on the teachers who were probably still experts coming from abroad or referring to the University of Bologna, the most prestigious and oldest pontifical state university. The development with modern characteristics for engineering education can be recognized starting from the second half of the nineteenth century both for the development of aspects of the Industrial Revolution and mainly for the reorganization of academic education on a national basis following the reunification into a single Italian state. In fact, the historical evolution of the La Sapienza engineering school in Rome is well traced starting from the re-foundation in 1873 as the Royal School of Application for Engineers.

The figures that characterize this period can be recognized in Luigi Cremona (1830-1903), Carlo Saviotti (1845-1928) and Lorenzo Allievi (1856–1941), Fig.3.

a) b) c)

Figura 3: Portrait of: a) Luigi Cremona (1830-1903); b) Carlo Saviotti (1845-1928); c) Lorenzo Allievi (1856–1941).

The first distinguished academic figure that characterizes this period can be recognized in Professor Luigi Cremona who was called to direct the school and to plan the recruitment of teachers as well as to start teaching with a modern vision combining teaching with research activities. Luigi Cremona probably held the first courses on the Mechanics of Machines but already in 1875, he called the young Carlo Saviotti, who was formed in Milan, to work in the field both in teaching and research activities.

Luigi Cremona was born in Pavia on 7-12-1830 and died in Rome on 10-6-1903, [7, 11]. He studied in Pavia under Antonio Bordoni (1789-1860) and Francesco Brioschi, graduating in engineering in 1853. For several years he was a teacher in the middle schools of Pavia, Cremona and Milan until 1860, when the pontifical government in Romagna ceased, and he was called to teach Geometry in the University of Bologna. In 1867, on the initiative of his teacher Brioschi, he was called to the Polytechnic of Milan to teach Graphical Statics, [12] of which together with professor Culmann of Zurich he can be considered one of the founders. He kept teaching the course until 1877 in Rome where, in 1873, he was called to reorganize and direct the School of Engineering. Senator of the Italian Kingdom since 1879, he was also vice-president of the Senate and in 1898, for just one month, Minister of Public Education. His influence on the organization of mathematical studies in Italy, however, was enormously influential to that which could derive from this single month of direct ministerial responsibilities and was expressed mainly in teacher recruitment competitions and in Parliament, in which his authority was considerable in matters on academic formation and organization. His contributions were notable, as well as in teaching, to Algebraic Geometry and Graphical Statics, also with the identification of an Italian community centered on these interests. Significant at an educational level were the courses and related textbooks on Projective Geometry and Graphical Statics with graphic calculation procedures, [13, 14].

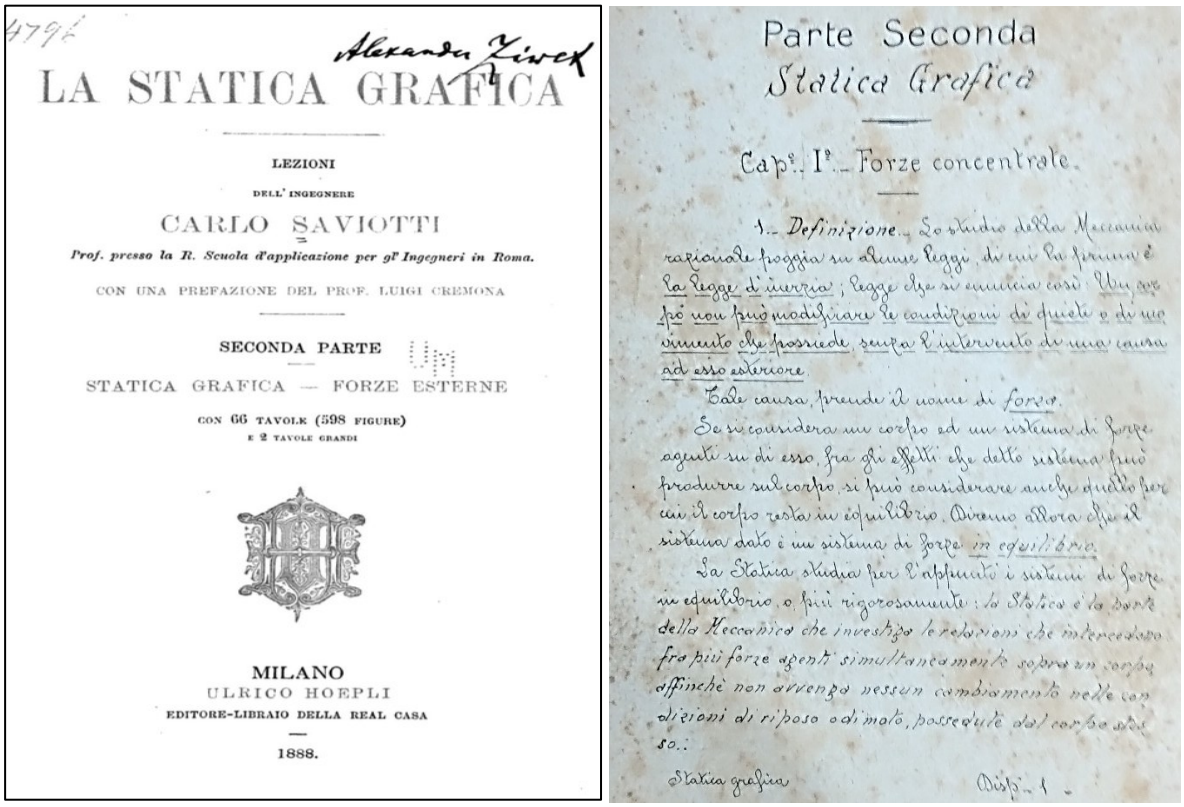
Prof Carlo Saviotti was born on 19 October 1845 in Calvignano (Pavia) where he died on 3 January 1928, [15]. He studied in Pavia and then at the Higher Technical Institute of Milan where he graduated in January 1871 in Industrial Engineering. Immediately he was active as assistant to Prof Luigi Cremona for Projective Geometry and Graphical Statics, and then he became assistant to Prof Giovanni Colombo for Industrial Mechanics. These disciplines were of passionate interest throughout his life. Prof Luigi Cremona called him to Rome in November 1873 where he succeeded in teaching Graphical Statics from 1875. Subsequently he was appointed chair of Mechanics Applied to Machines, a position he kept until he retired after reaching the age limit. In both disciplines he efficiently combined research activities with teaching with the aim of offering modern and updated formation. In 1873 he married Giulia Menegoni and three children were born from the marriage.

At the beginning of his career as a professor prof Saviotti contributed several important works to the progress of graphical calculation procedures, even with results for thesis for his pupils (like for example Lorenzo Allievi who graduated with a significant work on the topic). Finally, in 1888 he published his treatise La Statica Grafica (Graphical Statics), [16], Fig. 4, in three volumes with a preface by prof Cremona, which long remained a reference not only for the entire Italian community. A very hot topic of the time, Graphical Statics allowed the calculation and sizing of reticular beams for public and industrial buildings with innovative solutions and materials. Due to his availability and interest in teaching, he also gave other courses such as Strade Ferrate (Railways) for a few years. In the field of Industrial Mechanics, in addition to publications on research activities, he concentrated his activity on the Machines course, [17], which also included Mechanics Applied to Machines as an important part, for which he produced various editions of lithographed volumes with various updates in preparation for a printed version he never proposed. Then he focused specifically on a course on Mechanics Applied to Machines, [18], Fig.5. In the book preface he clarified: 'The study of the machines includes applied kinematics, applied dynamics, the study of the functioning of the machines, the constructive study for the design and construction of the machines. Kinematics and Dynamics applied to machines are included under the title of Mechanics applied to machines or General Theory of machines in Italian engineering schools', [18]. In this context he also dealt with mechanics of agricultural machines with attention to the mechanisms and machines that could improve efficiency and productivity. Specific inters and activity was directed to mechanism design and the related Kinematics during the second half of 19th century and prof Saviotti also addressed attention and efforts to the topic with significant results. Following his publication preference, he summarized his work in a textbook for a course on Applied Kinematics, within the frame of Mechanics Applied to Machines with several updates up to the one iodate 1919, [19] Fig.6. The applied Kinematics to mechanism is attached for teaching purposes but with practical considerations suitable for proper design and operation of machines, considering theory, design and applications.

There were numerous tasks conferred on him by the Public Administrations where his competence and honesty were highly appreciated. For several decades he was an authoritative member of the Commission of the Higher Metrics and Precious Metals Assay. He founded and chaired for some years the Association of Steam Boiler Users of Lazio and Umbria regions. Prof Saviotti held also the position of Mayor of the city Borgoratto Mormorola (Pavia) for 48 years from 1872 to 1920, administering with rigidity and wisdom.

During his activity prof Saviotti supervised several students for the thesis projects also with the aim of forming them for academic career and several of them remained under his supervision at different levels of position up to have few of them reaching the position of professor. Emblematic examples are prof Anastasio Anastasi and

Lorenzo Allievi, who both worked on Graphical Statics under his supervision. Prof Anastasi was active with impact in the first half of 20th century as outlined in the next section.



LA STATICA GRAFICA

LEZIONI

DELL' INGEGNERE

CARLO SAVIOTTI

Prof. presso la R. Scuola d'applicazione per gl' Ingegneri in Roma.

CON UNA PREFAZIONE DEL PROF. LUIGI CREMONA

SECONDA PARTE

STATICA GRAFICA — FORZE ESTERNE

CON 66 TAVOLE (598 FIGURE)
E 2 TAVOLE GRANDI

MILANO
ULRICO HOEPLI
EDITORE-LIBRAIO DELLA REAL CASA

1888.

Parte Seconda
Statica Grafica

Capº. Iº. — Forze concentrate.

1. — *Definizione.* — Lo studio della Meccanica razionale poggia su alcune leggi, fra cui la prima è la legge d'inerzia; legge che si enuncia così: Un corpo non può modificare le condizioni di quiete o di moto in cui si trova, senza l'intervento di una causa ad esso esteriore.

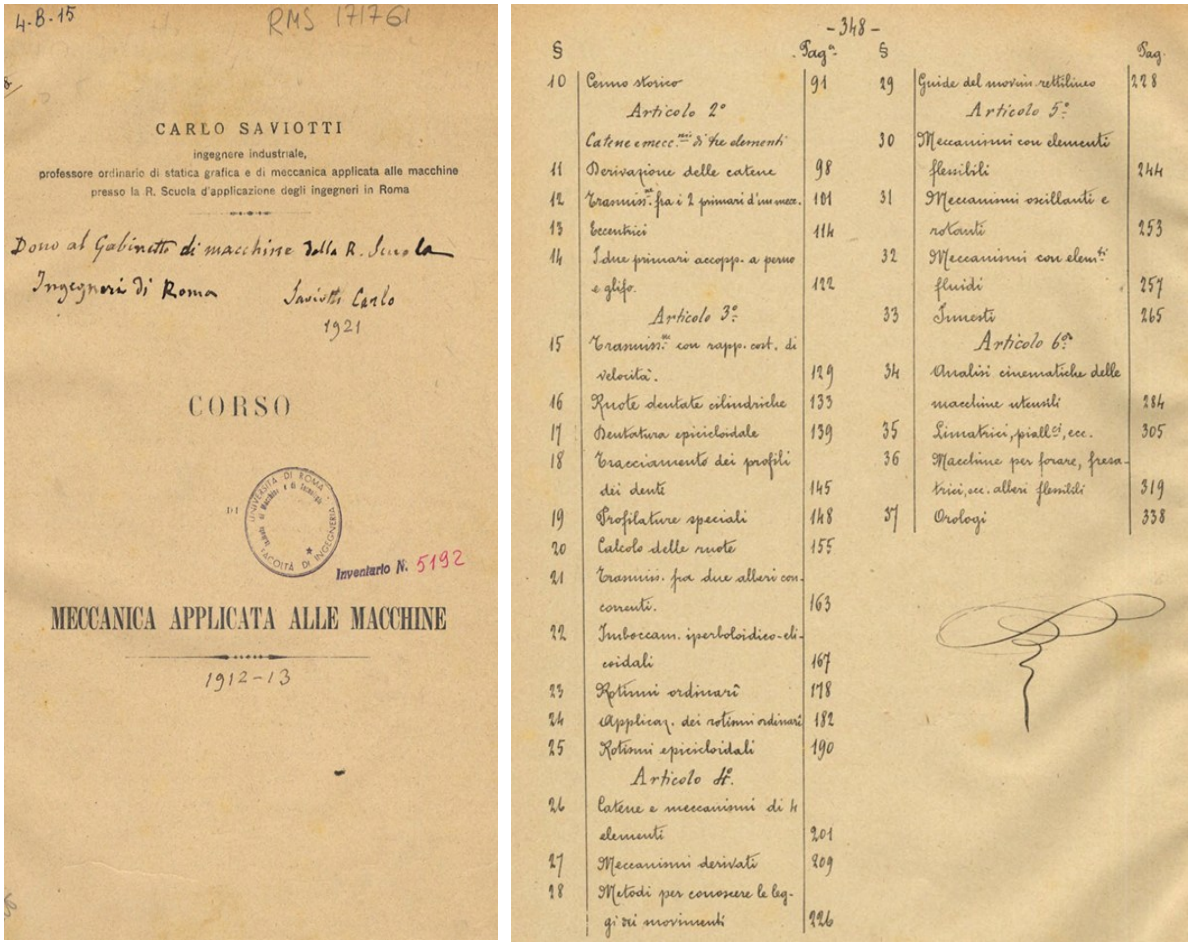
Tale causa, prende il nome di forza.

Se si considera un corpo ed un sistema di forze agenti su di esso, fra gli effetti che detto sistema può produrre sul corpo, si può considerare anche quello per cui il corpo resta in equilibrio. Diremo allora che il sistema dato è un sistema di forze *in equilibrio*.

La Statica studia per l'appunto i sistemi di forze in equilibrio, o più rigorosamente: la Statica è la parte della Meccanica che investiga le relazioni che intercedono fra più forze agenti simultaneamente sopra un corpo affinchè non avvenga nessun cambiamento nelle condizioni di riposo o di moto, possedute dal corpo stesso.

Statica grafica — Disp. 1 -

Figura 4: The second volume of La Statica Grafica by Carlo Saviotti of 1888,[16].



CARLO SAVIOTTI
ingegnere industriale,
professore ordinario di statica grafica e di meccanica applicata alle macchine
presso la R. Scuola d'applicazione degli ingegneri in Roma

Dono al Gabinetto di macchine della R. Scuola Ingegneri di Roma — Saviotti Carlo 1921

CORSO

MECCANICA APPLICATA ALLE MACCHINE

1912-13

- 348 -

§		Pagᵉ	§		Pag.
10	Cenno storico	91	29	Guide del movim. rettilineo	228
	Articolo 2°			*Articolo 5°*	
	Catene e mecc.mi di 4 elementi		30	Meccanismi con elementi	
11	Derivazione delle catene	98		flessibili	244
12	Trasmiss.ne fra i 2 primari d'un mecc.	101	31	Meccanismi oscillanti e	
13	bicentrici	114		rotanti	253
14	I due primari accoppiati a perno		32	Meccanismi con elementi	
	e glifo	122		fluidi	257
	Articolo 3°		33	Innesti	265
15	Trasmiss.ne con rapp. cost. di			*Articolo 6°*	
	velocità	129	34	Analisi cinematiche delle	
16	Ruote dentate cilindriche	133		macchine utensili	284
17	Dentatura epicicloidale	139	35	Limatrici, pialle, ecc.	305
18	Tracciamento dei profili		36	Macchine per forare, fresa-	
	dei denti	145		trici, ecc. alberi flessibili	319
19	Profilature speciali	148	37	Orologi	338
20	Calcolo delle ruote	155			
21	Trasmiss. fra due alberi con-				
	correnti	163			
22	Imboccam. iperboloidico-cilin-				
	cidali	167			
23	Rotismi ordinari	178			
24	Applicaz. dei rotismi ordinari	182			
25	Rotismi epicicloidali	190			
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26	Catene e meccanismi di 4				
	elementi	201			
27	Meccanismi derivati	209			
28	Metodi per conoscere le leg-				
	gi dei movimenti	226			

Figura 5: The textbook of Mechanics Applied to Machines by Carlo Saviotti in the 1912-13 version, [18]

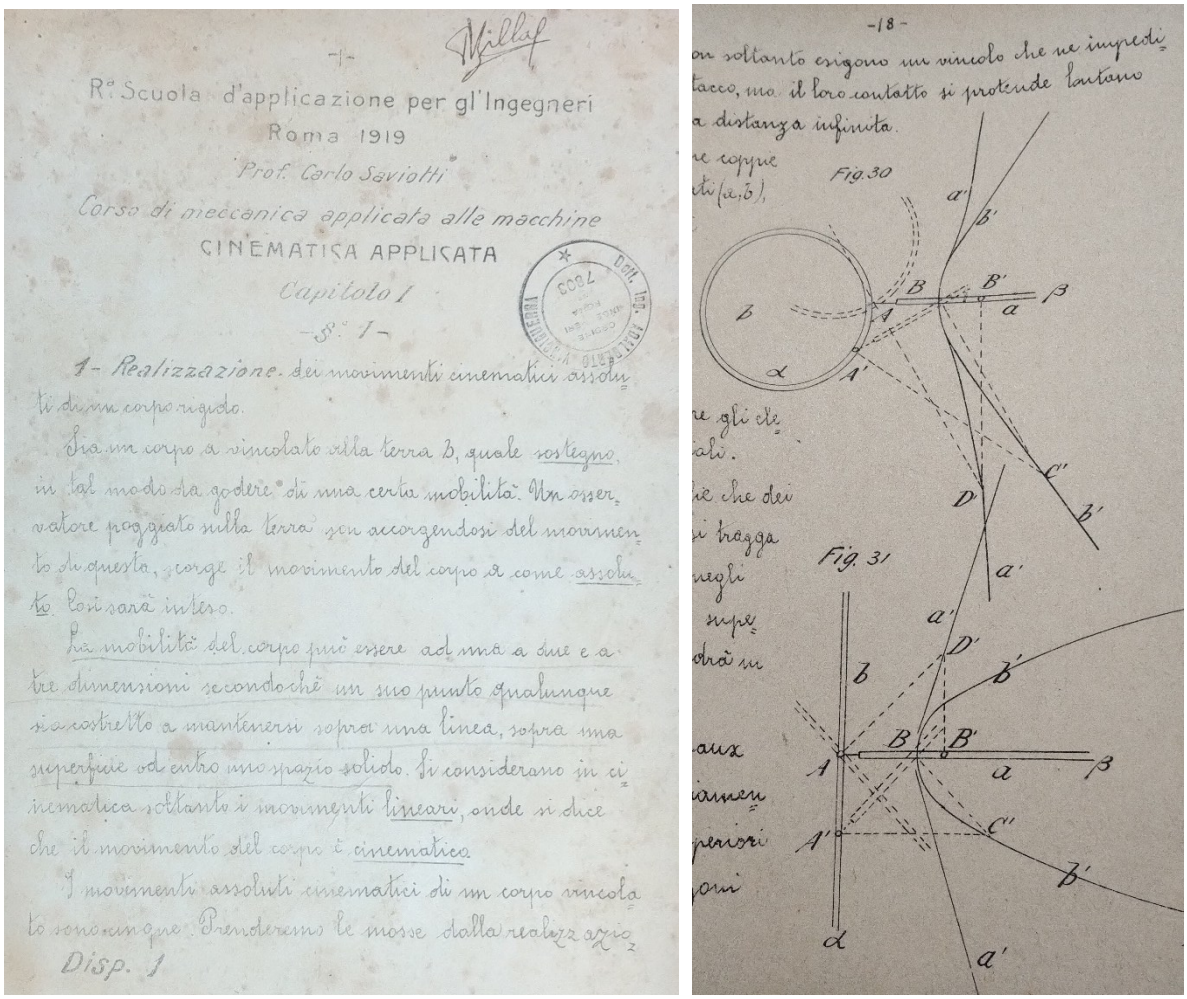
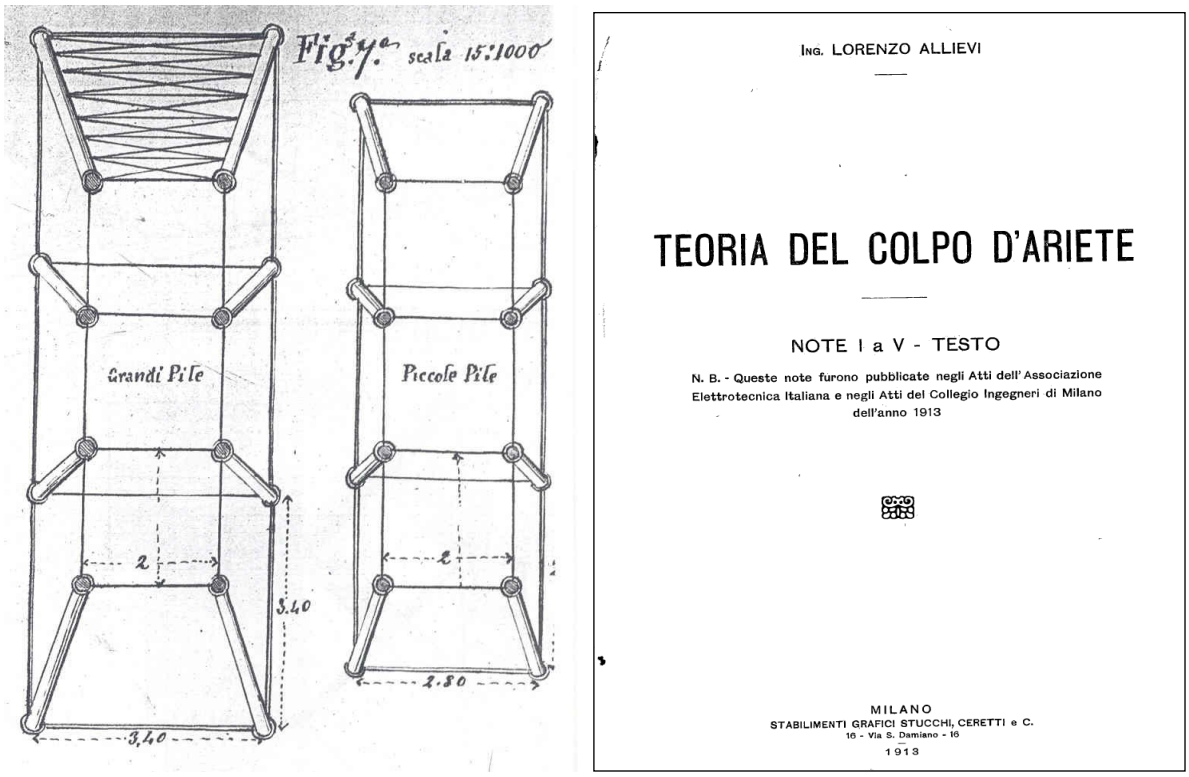


Figura 6: The textbook of Applied Kinematics by Carlo Saviotti in the 1919 version, [19]

Lorenzo Allievi, Fig.3c), was born in Milan on 18 November 1856 and died in Rome on 30 October 1941, [20-22]. He was the son of Francesca Bonacina Spini and Antonio Allievi. Lorenzo started the school in Como but when the father was appointed Senator of the Italian Kingdom in 1871 the family moved to Rome where he completed the college and got the Engineer degree on 24 October 1879 with the thesis on 'Internal equilibrium of metallic pylons according to elastic behavior', Fig. 7a), following the studies by prof Saviotti, [16], his mentor and supervisor. He received a grant to spend a period as visiting scholar in Germany and successively he got a temporary position at the Royal School of Engineering in Rome where he dedicated his efforts mainly Mechanism Design, another research line at the institute chaired by prof. Saviotti. On 31 August 1885 Lorenzo Allievi married Anna Brenna, who later gave him three children: Francesca, Raimondo, and Antonio. Since he realized no possibility for an academic career, in 1893 he left Rome to get the position of Director of the industrial enterprise 'Risanamento di Napoli' in Naples where he promoted industrial development until 1901 when he came back to Rome. There he got positions in many industrial enterprises (Carburo Calcio, Risanamento della Romana Gas, Anglo-Romana, Terni, Romana Elettricità, Banca Commerciale, Meridionale di Elettricità, Elettrochimica, Saline Eritreee) and because of them he even became President of the Association of User Electrical Companies. This successful activity brought him to the position of President of the Industrial Union of Region Lazio and later he became vice-President of the Italian Industrial Union. Particularly interesting is his activity in the hydraulic plant for electricity production at Papigno in Terni where in 1902 a hydraulic pipe exploded with great damage to the structures. Since then, Lorenzo Allievi studied the perturbed motion of water in pipelines. The study of Hydraulics always attracted his attention, even after he solved the problems in Papigno plants by solving the regulation of Water Hammer in his first publication in 1902 that was reprinted in 1903 with very successful next advanced results put to most distributed version in 1913 ,Fig 7b). He continued to work on the theory of Water Hammer, also for his technical work positions, but he never considered again problems on Kinematics of mechanisms that were the subject of his first scientific publication in 1895, [24], Fig.8. The work was very likely a results of his studies in Germany in contact with the German studies on kinematics of mechanisms so that he elaborated in 1892 his original work that still today is well recognized and referenced as addressing to the Instantaneous Kinematics, with results summarized in the reported table in Fig, 8. The work is focused on theory but towards practical formulation and application in analysis and design of planar mechanisms.



a) b)

Figura 7: Publication by Lorenzo Allievi: a) schemes of reticular pylons in his published thesis on 'Internal equilibrium of metallic pylons according to elastic behavior' for Engineer degree; b) title page of the1913 publication of the Theory of Water Hammer

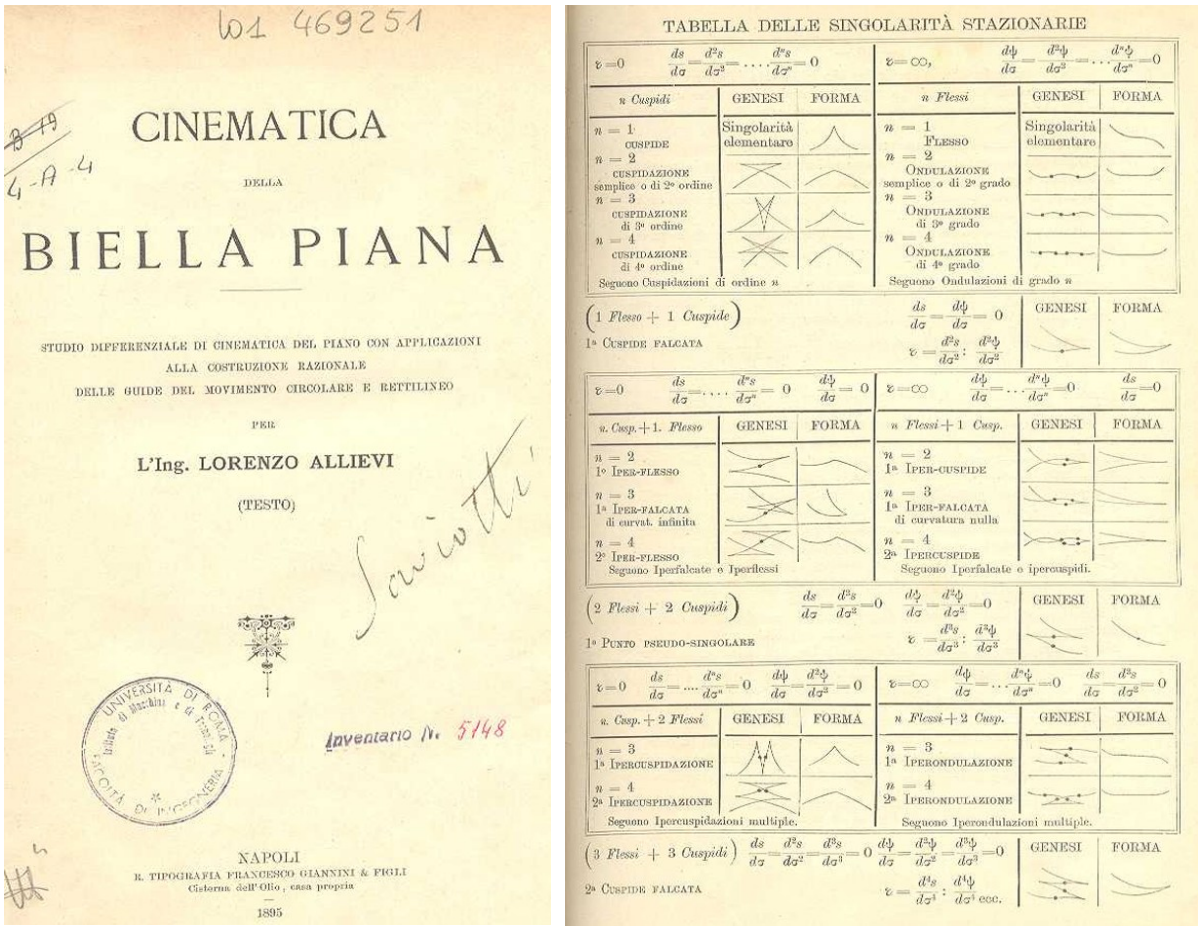


Figura 8: Th kinematics milestone work by Lorenzo Allievi written in 1892 and published in 1895

This first period of the Roman school was characterized by an intense activity directed mainly to teaching, that nevertheless was supported by research and on issues of interest for the time with applications in professional and industrial fields, by a local community with the participation of several students and researchers for specific periods in the then role of 'liberi assitenti' (research assistants). The main topics of the activity can be recognized in the development of theory, design and solutions of reticular structures and mechanics for industrial machines, even for educational purposes. These interests characterized also the beginning of the next period and in any case gave results of national impact with a production that in some cases also had an international diffusion.

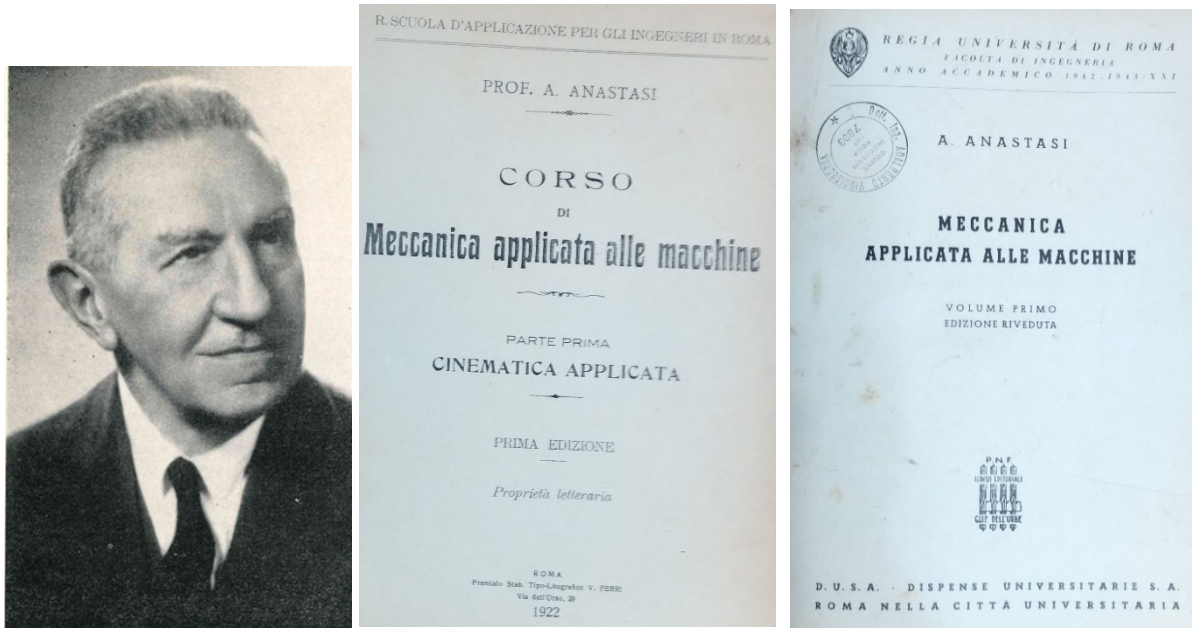
4. TMM Figures the first half of 20th century

The period in the first half of the twentieth century, the tumultuous period between the two world wars, is characterized by activities which, continuing previously developed interests, determined insights and new interests as solicited and required by the technical and social developments of that period. Due to political situations and war events, there is little information on the developments of research and on the personalities involved in the school's activities also because they were often involved in programs and projects for war purposes.

The most representative personalities of this period can be identified in Anastasio Anastasi (1877-1969), and Manlio Oberziner (1893-1973) who with their role as full professors had greater visibility also due to the significant results, probably with the work of the group that they themselves coordinated.

Professor Anastasi was successor of Saviotti, continuing topics of interest in Mechanics applied to Machines but broadening his interests in the areas more specifically on machine designs following the significant technological evolutions that occurred during the war events of the two world wars.

Professor Anastasia Anastasi, Fig. 9a), was born in Messina on 25 May 1877 and died in Rome on 22 February 1969. He spent his entire academic career at the University of Rome with the role of professor from 1922 to 1950, reaching the role first of full professor of Mechanics applied to Machines and subsequently of Thermal and Hydraulic Machines. For these disciplines he gave regular courses during his whole career producing textbooks with updates up the last days of his teaching activity as following the evolution of the needs and solutions in the field and in mechanical engineering at large. Figures 9 b) and c) show the title pages of versions of this publication evolution for the course of Mechanics applied to Machines with printed versions in 1922, [25] and in 1942-43,[26]. Similarly for the course on Machines he produced updated textbooks up as for example [27].



. a) b) c)

Figura 9: Anastasio Anastasi (1877-1969): a) portrait; b) titlepage of textbook of 1922, [25]; c) titlepage of textbook of 194-432, [26].

His activity began as an assistant of the professor Saviotti, interested in the same didactic fields, so much so that professor Saviotti commissioned him to hold the Graphic Statics course in which he made original contributions also as a consequence of the evolution of technology in the field, [28]. He also worked out Mechanism Design for machine designs like in the work [30] with a driving mechanism for shaper tools. Despite having won the position of full professor at the University of Naples in 1911, he was called to Rome to teach at the specialist military

engineering battalion and also to work designs and experiments for the first aeronautical constructions as reported in [30]. In this context he had a long and fruitful collaboration with the military air force, not only throughout the First World War. In fact, he was one of the pioneers in the development of aeronautical engines and also in the design of high-altitude airships, being the first to propose supercharging the engines, [31]. Even during the Second World War he was active in aeronautical engineering with research design activities at the Guidonia research center in Rome. In addition to his intense teaching activity in the fields of Mechanics applied to Machines and Machines resulting from his pioneering activities, Anastasi also dedicated himself to the promotion of engineering sectors by founding the Italian aerotechnics association in 1920, of which he was also president from 1922 to 1924.

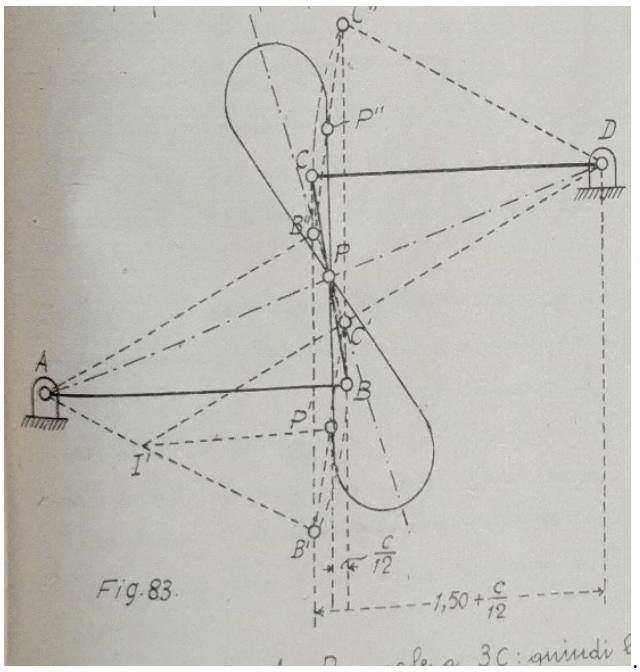
In 1921 he come back to the faculty of Rome where they established the first chair of Mechanics applied to Machines that was assigned to him. Also, professor of the chair of Machines, he held various roles in technical commissions, especially of the ministries of public works and industry, also coordinating wide-ranging studies such as for example those for the organization of the 1942 universal exhibition, proposing a bridge over the Tiber river in aluminum alloy which, however, was not built only due to the high cost of the materials. For many years until January 1969, he was part of the central metric committee as well as an active and authoritative member of the technical committee of the naval and aeronautical register and subsequently of the specific Italian aeronautical register. He also promoted the dissemination of the technical-scientific activities of engineers and architects by directing the magazine 'annals of the Society of engineers of Rome' which then allowed him in 1927 to start the magazine 'l'ingegnere' which will be the reference magazine of the order of engineers. His scientific activity is remembered mainly for his research and solutions regarding the inertial forces in combustion engines with rotating cylinder, the torsional vibrations of axles to calculate the robustness of propellers in airplanes,[32] and for the high-altitude aeronautical engines for which he had designed supercharging. In addition to these topics, he had very broad interests as reported by an interesting 1963 publication on the 'mechanics of rowing' since he was a sport enthusiast who also practiced as a rower. He also addressed attention to track historical evolution of engineering and related technology with published studies like for example [33].

The modernity of Anastasi's activities can also be recognized in the current value of the contents not only of his pioneering solutions but also of his teaching texts in which the concepts, models and formulations are clearly expressed and developed so much so that they can also be a reference for the most modern teaching and research approaches. Figure 10 shows examples of such analysis in mechanisms for design purposes with details and complexities of current interest, as well as based on graphical procedures that can be used in modern computer algorithms.

Little is known of Manlio Oberziner even though he was active for a long time at the engineering faculty of Rome, covering the role of professor not only of Mechanics applied to Machines but also of Thermal and Hydraulic Machines, of Mechanical Technology, and finally of Machines, from 1942 to 1963 as mentioned in the yearbook volume [7].

Manlio Oberziner was born in Sardinia in 1893 and died in Rome in 1973. Student of Professor Saviotti and Anastasi, he began his academic career under his guidance in the field of Mechanics applied to Machines and subsequently expanded his interests in the areas of machines. His intense teaching activity covered various disciplines of mechanical engineering also for the role of full professor he achieved in various disciplinary sectors, producing texts with lecture notes which unfortunately are not available considering the fact that his main teaching production took place before the Second World War and only partially immediately after. His scientific activity on various topics, also linked to his teaching activity, has produced significant results especially in the technology of metallic materials, as for example in [34] and in the design of thermal machines and mechanical systems with original ideas of both a theoretical nature and practical-professional application as for example in [35]. His dedicated service to the faculty is also remembered for his contribution in the reorganization of the faculty library to serve not only the students but also for reference of research activities.

It is important to note that in the first half of the 20th century, especially due to the stimuli and needs of war during and in the intermediate period between the two world wars, engineering education evolved enormously so much so as to differentiate the main courses into as many disciplines as well as requiring an increasingly numerous teaching staff. However, the main disciplines, especially in the training of mechanical engineering remained Mechanics applied to Machines and Machines within which, in addition to the figures of full professors, there was a teaching body with several assistants and young professors who were coordinated by the full professors yet. The positions of full professor in this period was kept in a very limited number, and often merging the two disciplines as per the strong connections both in teaching and research. Many of these teacher-researchers, although aspiring to an academic career, were unable to achieve sufficient experience and skills to allow them to achieve permanent academic roles and therefore often after a more or less long period they left the academic frames and dedicated themselves to other professional and entrepreneurial activities. Little is published during this period, especially in relation to research activities and results, probably also as due to the need for secrecy due to war purposes and situations. Nonetheless, there has been consistent production of didactic texts, especially in consideration of the aims of promoting engineering professions and environments as carried out personally by Professor Anastasio Anastasi.



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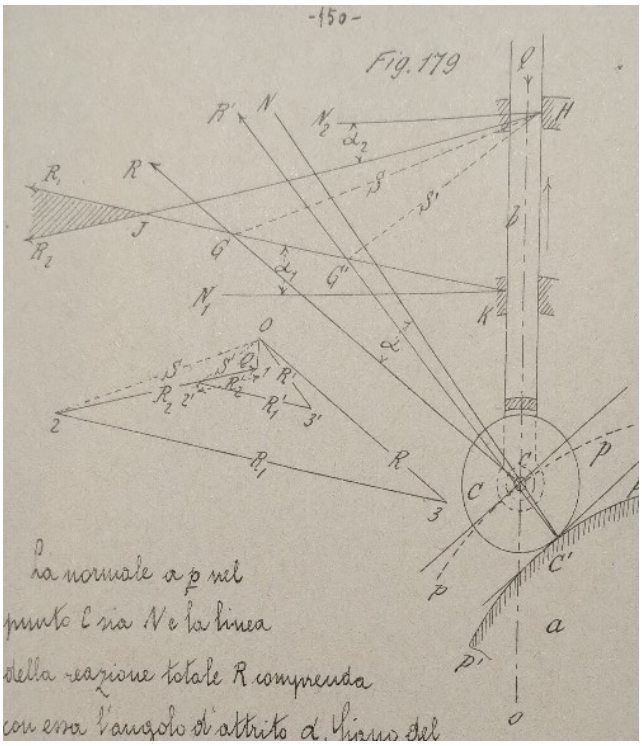


c)

Figura 10: Examples of analysis of mechanism design by Anastasi from the textbook [26]: a) kinematic study of the trajectory of coupler point in Watt mechanism; b) model for analyzing complex mechanisms with many slider joints by reduction to revolute joints; c) force analysis in the follower system for valve regulation

5. MMS Figures the second half of 20th century towards the future

The post-war period was characterized not only by an industrial economic boom but also by the revitalization of academic activities throughout the Italian country as well as in the Roma school of engineering and in which there was also a considerable increase of the student population. This period is characterized by significant technological changes that affected also engineering training which saw the teachers of the Roma TMM school active successfully thanks to the work of teachers coming from other universities and Roman teachers with experience in the same Rome school, with experience and participation in national and international initiatives.

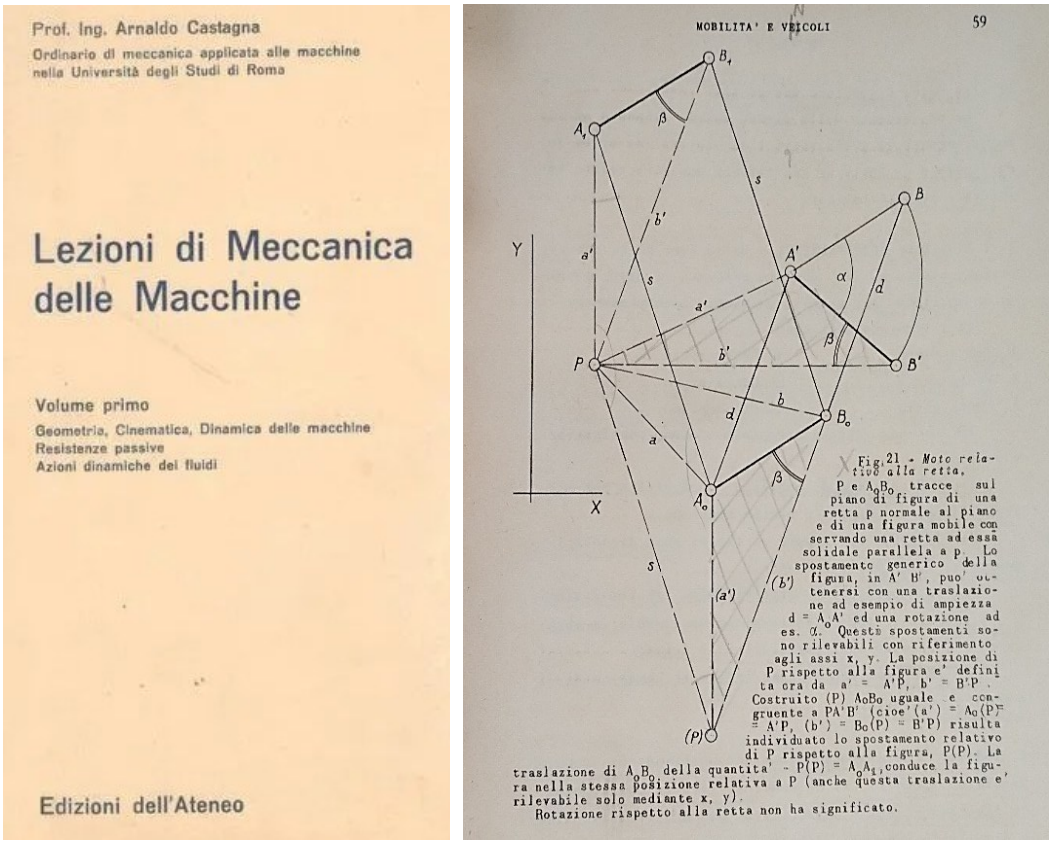
The characteristic personalities of this period can be recognized in Arnaldo Castagna (1877-1969) and Giovanni Scotto Lavina (1905?-1988?).

Curiously, little is known about the biography of the teachers of this period, although their students are currently active with prominent roles as professors in the three academic institutions.

Professor Arnaldo Castagna was born in Cremona in 1905 and since 1951 taught at the La Sapienza University of Rome as professor of Machines and Mechanics applied to Machines with significant activity on the mechanics of machines and fluid dynamics with particular attention to the motion of gases and high speeds and reaction propulsion, [7]. Probably as a student of Professor Oberziner, he maintained great attention to teaching for the course on Mechanics applied to Machines, producing texts of notable clarity in various editions during his academic career. An example is the textbook shown in Fig.11, [36]. In addition to the basic contents specific to the teaching subject, results of research activities can also be found in consideration of the existence in those years of few editorial frames for the dissemination of research results when not application fields. Some content in the teaching text is shown in Fig. 11b) where the kinematic synthesis of a mechanism for a coupler movement problem in three configurations is represented. The computational model is presented from a graphical point of view which however allows an analytical procedure which in the next years will also be implemented in computer algorithms.

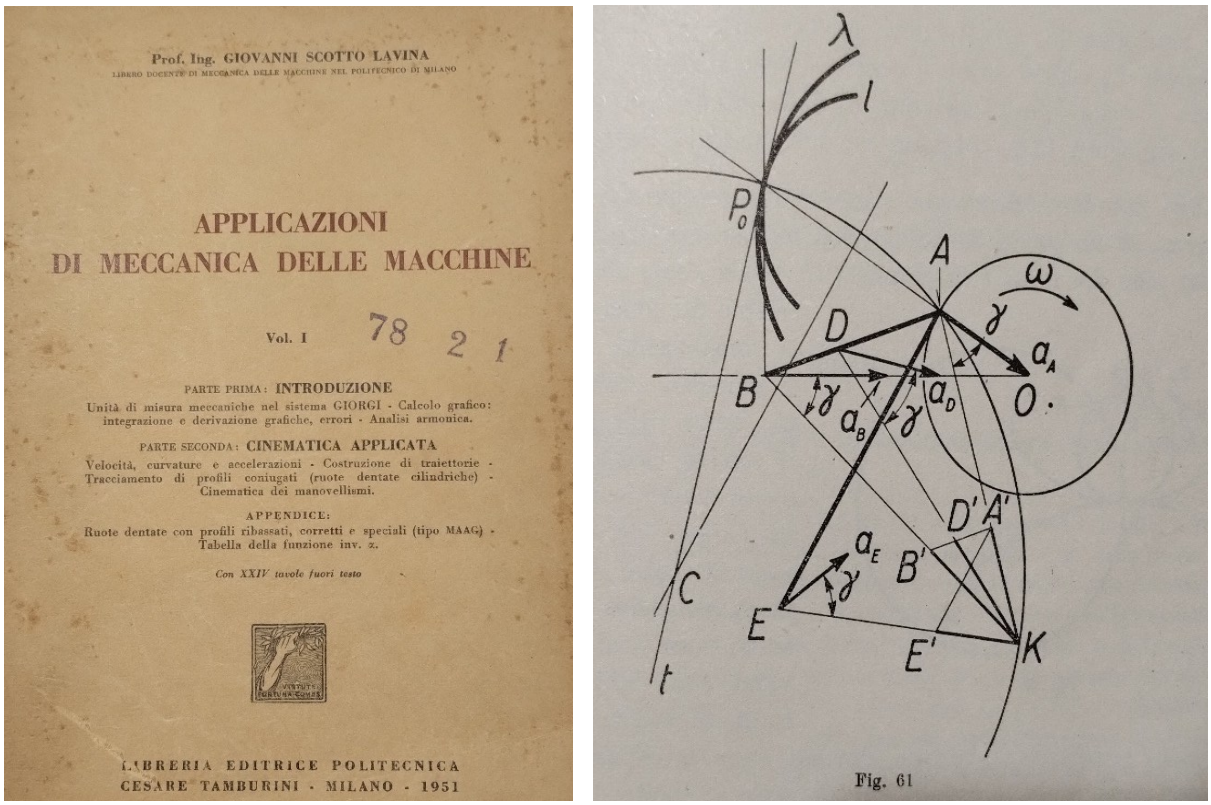
In next periods, the Rome school of Mechanics applied to Machines was enriched in activity and distinguished figures through an evolution by the enrollment of students who grew up within the same school but also by new members from other Italian Universities who gave new vision. In this period several young engineers were involved in the activities for rather short periods.

Professor Giovanni Scotto Lavina arrived in Rome in 1964 after a previous academic career at the Polytechnic of Milan and a short period at the University of Cagliari, giving new vitality to the group inherited from Professor Castagna and inserting new members necessary for the increasing demand for teaching and research activities due to the increase in the student population and the need for professional engineers. He taught at La Sapienza in Rome until his retirement in 1980, transferring and increasing his experiences and skills gained at the Polytechnic of Milan under the guidance of Professor Ottorino Sesini, as reported in the significant volume of 1951, Fig.12, [37]. The text [37] of Fig.12 can be considered a manual of modern kinematics even if based on graphical procedures, as in the example of Fig.12 b) referring to the analysis of the accelerations of planar motion using the center K of the accelerations and the kinematic invariants for the determination of the Bresse circles.



. a) b)

Figura 11: Textbook of Lectures on Mechanics of Machines published by Arnaldo Castagna in 1955, [36]: a) cover page; b) a model for kinematic design for 3-position problem



. a) b)

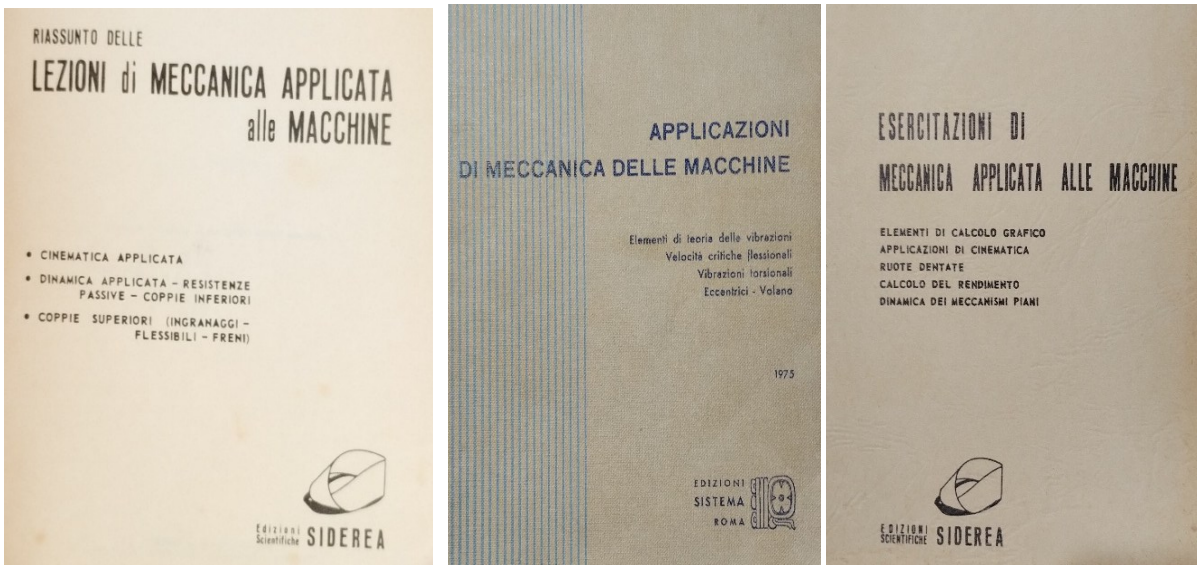
Figura 12: Textbook of Applications of Mechanics of Machines published by Giovanni Scotto Lavina when in Milan in 1951, [37]: a) cover page; b) a model for kinematic analysis of acceleration in planar systems

He developed research with the coordination of activities with his collaborators, among whom are worthful to remind Augusto di Benedetto, Luigi Papa, and Adalberto Vinciguerra, in the figures of various levels of assisting professor positions. He achieved significant results in research, design, and teaching, especially in topics on mechanisms, although he was interested in machine dynamics, lubrication, and vibrations. Of particular impact are his works of educational texts which are of reference even today at the Italian national level, i.e. the texts whose cover pages are shown in Fig.13, [38-30]. The three texts are a complete compendium for the study of the mechanics of machines and transmission parts with analysis procedures also oriented towards design formulated with rigorous models, based on graphic representations typical of the 1960s-80s rich in conceptual details. The schemes in Fig. 14 are examples of such clarity in modelling and formulating analysis and design procedures for mechanisms and gear systems. Fig. 14a) refers to the traditional procedure of kinematic analysis of planar mechanisms using the vector polygons with a procedure that can be formulated from the reported graphical approach to a computer-oriented calculation. Fig.14 b) shows the scheme for the design of a gear coupling with indications of design parameters and analysis of the contacts for an evaluation of the mechanical efficiency in transmitting the power from one to another gear.

Following professor Scotto Lavina reference professors can be identified in Augusto di Benedetto (1933–2019), Adalberto Vinciguerra (1938-2012), and Aldo Sestieri (1944- living), Fig.15.

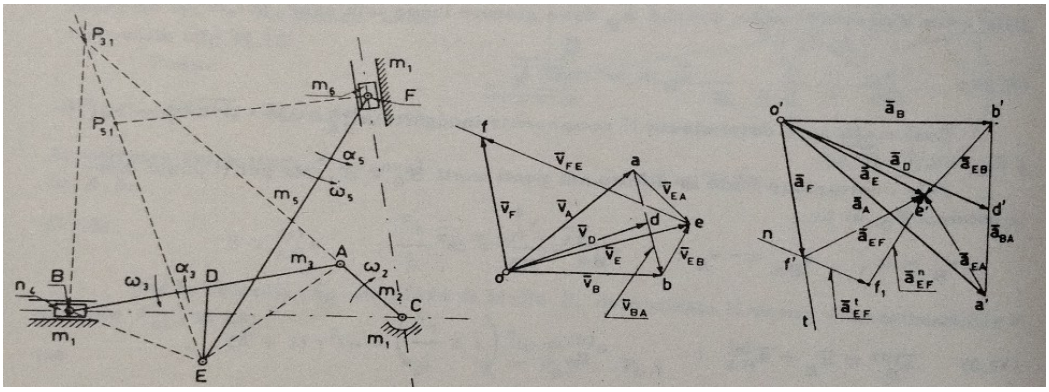
Direct successor of Professor Scotto Lavina with whom he collaborated until his retirement, Augusto di Benedetto, Fig. 15 a), carried out his academic career entirely at the La Sapienza headquarters, covering the various roles in the academic progression until reaching the role of full professor of Mechanics applied to Machines in 1980 and dealing with teaching not only of Mechanics applied to Machines. His research activity was mainly focused on kinematics and mechanism design with interests also in topics referring to machine dynamics and biomechanics. His great attention to teaching has produced several texts for the lectures of the Mechanics applied to Machines courses, written with the help of his most direct pupils, such as the text in Fig.16a), [41], part of a set of three volumes produced in more than a decade. Being the first pupil, he collaborated strongly with the other pupils of Scotto Lavina as in particular with prof Adaleberto Vinciguerra.

Prof. Adalberto Vinciguerra was born in Pisa on 22 April 1937 and passed away on 22 December 2012 in Rome. After receiving an engineering degree, he worked as an industrial engineer in companies abroad. He returned to the academic world in 1972 and since then has been very active in teaching and research activities at the School of Engineering of La Sapienza University in Roma. There he lectured continuously in Mechanics applied to Machines, he supervised many young engineering students, and he formed several young researchers on MMS.



. a) b) c)

Figura 13: Cover pages of the textbook set of Mechanics applied to Machines published by Giovanni Scotto Lavina in Rome: a) main lecture notes, [38]; b) on applications for vibration analysis, cam systems, and flywheels, [39]; c) on exercise developments on kinematic and dynamic analysis of mechanisms, gear designs, and mechanical efficiency, [40]



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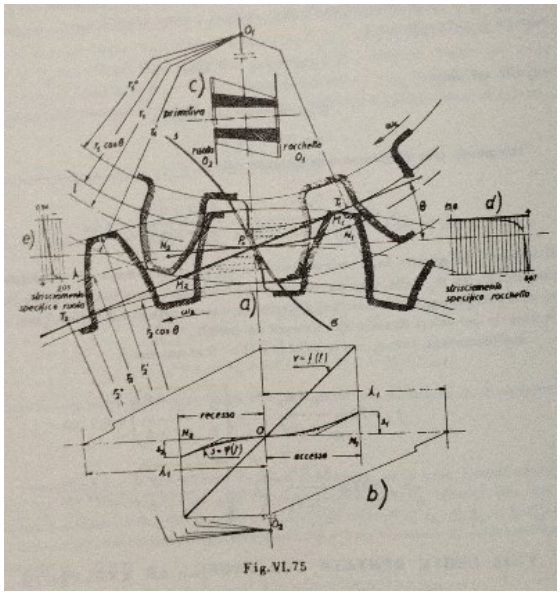


. a) b)

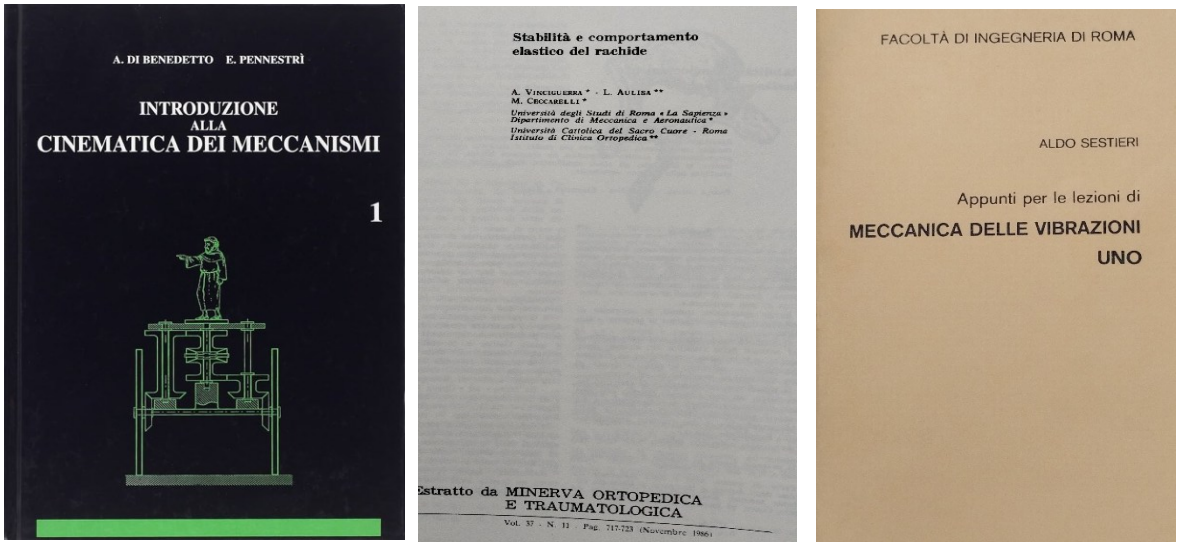
Figura 14: Examples of teaching models by Giovanni Scotto Lavina: a) vector polygons for kinematic analysis of planar mechanisms in [38]; b) analysis of design and mechanical efficiency in gear transmissions in [40]

His specific interests were focused on Mechanism Design, Mechanics of Robots, and Biomechanics on which he gave relevant contributions as documented in many conference and journals papers. Significant was his collaboration in medical fields on applied research in biomechanics with achievements in prostheses for spine surgery like in the publication in Fig. 16b), [42]. He was a member of the PC for History of MMS from the beginning and contributed to activities also in Robotics and Linkages Committees from late '70s up to 2004, when he retired. His relevant achievements can be recognized in algorithms for analysis and synthesis of mechanisms, robot designs, and biomechanical studies. He was an enthusiastic IFToMMist of the first generation, contributing to several fields of MMS (Mechanism and Machine Science) with collaborations and contacts with colleagues all around the world. Worth remembering is his attention and active participation in the conference activities not only of the Italian community but also of the Spanish community which has seen him as an author since the first conferences in the early 1980s with the start of solid Italy-Spain collaborations.

Professor Aldo Sestieri was born in Montevideo but soon the family came back to Rome where he carried out his academic career entirely at La Sapienza University, covering the various roles in the academic progression from the fields of Machines disciplinary sector until reaching the role of full professor of Mechanics applied to Machines in 1986 and dealing with teaching until his retirement in 2015. He combined his research and teaching activity with programs and initiatives for international collaborations that have also influenced the development of his team. His research activity was centered mainly on the analysis of dynamic systems and mechanical vibration phenomena with also interests in machine diagnostics and tribology. His intense teaching activity, with the training of many doctoral students, was centered on the mechanics of vibrations, with the elaboration of lecture notes published in the faculty in constantly updated versions. The example in Fig 16 c), [43], refers to a book collection of lecture notes he was used to provide to the students with update during each academic course.

. a) b) c)

Figura 15: Portrait of: a) Augusto di Benedetto (1933–2019); Adalberto Vinciguerra (1938-2012); Aldo Sestieri (1944- living)



. a) b) c)

Figura 16: Cover pages of books by: a) Augusto di Benedetto and his pupil Ettore Pennestrì published in 1993, [41]; b) Adalberto Vinciguerra and other published by in 1986,[42]; c) Aldo Sestieri published in 1988, [43]

The further development of the Roman school at the beginning of the new millennium is characterized by branching into groups of teachers at the three Rome Universities while La Sapienza remains in a condition of prominence as the initial and reference venue. In fact, young teachers migrated to the University of Rome Tor Vergata and then others to the Third University of Rome also due to the possibility and need of an academic career, maintaining a strong link, at least initially, with the reference professors at La Sapienza.

We can cite as teachers of reference in recent years Antonio Carcaterra (1964? - living) at La Sapienza, Ettore Pennestrì (16 May 1957- 29-August 2024) and Marco Ceccarelli (26 May 1958-living) at the University of Rome Tor Vergata, and Nicola Pio Belfiore (1962 - living) at the third University of Rome. In each university there are active groups of teachers with various levels of role and with PhD programs who carry out increasingly intense teaching and research activities both in traditional fields and in emerging and frontier topics regarding the development of mechanical engineering with mechatronic implications. The topics of main interest with activities in theoretical developments, design, and application can be identified mainly in diagnostics of mechanical systems, mechanics of actuators, robot mechanics, design of service robotic systems, mechanics and design of biomechanical and biomedical systems, vehicle mechanics, mechanics of automatic machines, vibration mechanics, multibody dynamics, mechatronics, modeling and simulation of mechanical systems, functional mechanical design, regulation and control of mechanical systems, lubrication, tribology.

The academic community in the Rome school of Mechanics applied to Machines has been growing in recent decades in the three Rome Universities and also in other regional Universities with the recruitment of members from new generations, also expanding the interests and activities both in teaching and research in agreement and following the evolution of the disciplinary sector at the Italian national level.

6. Conclusions

This paper presents a first historical account of the cultural heritage of the Rome school of Mechanics Applied to Machines (Meccanica Applicata alle Macchine) within the disciplines of TMM (today MMS: mechanism and machine science), referring to the major personalities and their contributions in outlining contents and merits at both a national and international levels. The historical excursus, although referring to the main figures, remains incomplete because of lacks of archival sources and published information and therefore the work can be considered a stimulus for future further attention to historical analysis which can better determine the identity and historical development of the TMM-MMS school of Rome that begun in within the La Sapienza University and in recent modern times expanded with groups at the second University of Rome Tor Vergata and the Third University of Rome.

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Acknowledgements

The author thanks the late Prof. Adalberto Vinciguerra (1937-2012) of Rome also for the donation to the author of many recent and past texts of Applied Mechanics. Special thanks to Dr. Anna Cividini of Biblioteca dell'Area di Ingegneria at Università degli Studi di Roma Tor Vergata are expressed for the last hep in this work. The author is aware of the limitations of the overview that certainly did not allow to highlight many other important contributions and list all the significant publications.