# Mihailo Petrović ALAS

## Life Work Times

Serbian Academy of Sciences and Arts

MIHAILO PETROVIĆ 150th ALAS birth anniversary


MIHAILO
PETROVIĆ
150th ALAS
birth anniversary

SERBIAN ACADEMY OF SCIENCES AND ARTS

MIHAILO PETROVIĆ ALAS: LIFE, WORK, TIMES
ON THE OCCASION OF THE 150th ANNIVERSARY OF HIS BIRTH

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# MIHAILO PETROVIĆ ALAS
# LIFE, WORK, TIMES

## ON THE OCCASION OF THE 150th ANNIVERSARY OF HIS BIRTH

SERBIAN ACADEMY OF SCIENCES AND ARTS

Exclusive editions, such as this monograph, call for the engagement, enthusiasm and cooperation of a number of individuals and institutions. We would like to use this opportunity and extend our gratitude to everyone who has taken part or in any way contributed to, or supported the creation and publication of this monograph.

First of all, we would like to express our gratitude to the authors of papers for their effort taken to provide expert and high level insights into some main points of Mihailo Petrović Alas' life and work, at the same time preserving an important aspect of being easy to read and appealing to a broader readership. In addition, we would like to thank to Ms. Snežana Krstić-Bukarica and Ms. Nevena Đurđević from SASA Publishing Section for performing a thorough proofread of the papers, thus making the writing even more articulate.

The monograph features a number of photographs and the copies of documents that have been obtained owing to the kindness of the SASA Archive, SASA Library, SASA Mathematical Institute, Archive of Serbia, Mr. Viktor Lazić from the "Adligat" Society, Mr. Jovan Hans Ivanović and his "Mihailo Petrović Alas" Foundation, "Mihailo Petrović Alas" Primary School, "Svetozar Marković" University Library, Belgrade City Museum, Zavod za udžbenike (Institute for Textbook Publishing) in Belgrade, Virtual Library of Faculty of Mathematics in Belgrade and Digital Legacy of Mihailo Petrović Alas.

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Finally, we would like to express our gratitude to Mr. Mirko Milićević from the publishing house "Dosije Studio" for excellent prepress preparation of the monograph.

S. Pilipović, G. Milovanović, Ž. Mijajlović

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# EDITOR'S FOREWORD

As soon as one first encounters the work of Mihailo Petrović, it becomes evident that he was a person that according to its numerous traits was a polymath. Above all, the academician Petrović was a gifted mathematician and a renowned professor at the University of Belgrade, but also a fisherman, writer, philosopher, musician, world traveler and a travel writer. He earned a degree in mathematics at the Belgrade Grand School and a licentiate degree in mathematics, physics and chemistry at the Sorbonne. At the age of 26, only a year after he had completed his studies, he defended his PhD degree in mathematics at the same university, as a student of the famous French mathematicians Henri Poincaré, Charles Hermite and Charles Émile Picard. In the same year (1894) he was elected to the position of professor at the Grand School to which he brought the spirit of the French mathematical school. It was at that point that his long and prolific journey through science began, whereas, owing to him, Belgrade achieved parity with other major European centers in mathematical sciences. He became an initiator and a leader of the Serbian mathematics and strongly contributed to the spirit of the modern European science in Serbia.

Petrović's expertize spanned several mathematical areas in which he achieved scientific results of world-class relevance: differential equations, numerical analysis, theory of functions of a complex variable and geometry of polynomials. He was also interested in natural sciences, chemistry, physics and biology, and he published scientific papers in these fields, too. In his scientific endeavor he managed to meet the most rigorous standards of the most developed European countries. In a brilliant rise, in a few years' time, up to the early 20$^{th}$ century, he wrote around thirty papers that he published in the leading European mathematical journals. It was due to this fact that he was elected a member of the Serbian Royal Academy as early as at the age of 30, and soon after he became a member of a number of foreign academies and prominent expert societies. He won the greatest respect of the global mathematical community: he was among few mathematicians (13) who delivered at least five plenary lectures or lectures as a visiting lecturer at the International Congress of Mathematicians (ICM). He delivered five such lectures (1908, 1912, 1924, 1928 and 1932). One such invitation has been considered by the mathematical community as an equivalent of an induction to a hall of fame. In addition, it has been considered that Petrović was a founder of new scientific disciplines, namely mathematical phenomenology and spectral theory. He invented several analogue computing machines, possessed technical patents and was the main cryptographer of the Serbian and Yugoslav Army.

Up to the Second World War he was the mentor of all doctoral thesis in mathematics defended at the University of Belgrade. Aforementioned is related to one of professor Petrović's greatest and most important achievements – he was a founder of the Serbian mathematical school that has produced a great number of renowned and successful mathematicians not only in Serbia but also around the world.

In 2018, the Serbian Academy of Sciences and Arts and mathematicians in Serbia celebrate the 150th anniversary of the birth of Mihailo Petrović Alas. Throughout this year, the Academy has organized a large exhibition dedicated to Petrović, alongside a solemn gathering and a conference. This monograph commemorates this important jubilee of the Serbian mathematics. Given the fact that a lot of articles on Petrović have already been written, and that his collected works were published at the end of the last century, the editors and authors of the papers in this monograph were faced with a daunting task of finding some new details from professor Petrović's life and career. Even more so given that his body of work is immense, spanning different scientific areas and encompassing topics that at first glance one finds difficult to combine. As Dragan Trifunović, Petrović's biographer and a man who most thoroughly studied his life and work, noted on one occasion that almost an institute was necessary that would encompass professor's entire body of work. Therefore, we set a relatively modest goal to ourselves to shed light upon some main points of Petrović's life and work, times and circumstances he lived in, as well as to elaborate on the present developments in relation to the Serbian mathematical school, through a selection of papers. The authors of the papers steered clear of technical details and excessive use of mathematical language. Hence, the monograph is intended for a broader readership, in particular to those readers who are interested in the history of Serbian science and its evolvement at the turn of the 20th century, but also to those who want to gain a deeper insight into the life of a brilliant mathematician and a polymath, and, we can quite freely say, an unusual personality.

Ž. Mijajlović, S. Pilipović, G. Milovanović

# MIHAILO PETROVIĆ ALAS: LIFE AND WORK

# MECHANICS AND ENGINEERING IN MIHAILO PETROVIĆ'S WORK*

Katica R. (STEVANOVIĆ) HEDRIH
*Mathematical Institute of SASA*
*University of Niš, Faculty of Mechanical Engineering*

> „Not only do true poetry and true science have common points, but they also share deep common characteristics. One such characteristic, so much so that it is sometimes difficult to differentiate science from poetry, is *discovering and utilizing similarities among disparate elements and facts*."
>
> Mihailo Petrović, 1925.

It is evident that Mihailo Petrović, as the founder of the Serbian School of Mathematics and having been an inspiration to numerous Serbian mathematicians of his "first generation of doctoral students", was spiritually hugely influential man of his time. It is for this reason that Mihailo Petrović has primarily been celebrated as a mathematician, whereas the promotion of his numerous ideas and achievements in other various fields, which are equally important, has been neglected. It is only now, when we mark 150 years since the birth of Mihailo Petrović, that the SASA Gallery is hosting an exhibition offering a major retrospective

* A revised and supplemented version of the paper initially published in the catalogue *Mihailo Petrović Alas: the Founding Father of the Serbian School of Mathematics* (SASA, 2018)

of his achievements spanning a significant number of subject areas, which is made available to modern generations [11, 12].

Mechanics, as a fundamental science in mechanical engineering, and in other technical sciences, is a very complex science, but also a basis for application in many mathematical and technical sciences, as well as in many multidisciplinary researches. This points to the fact that one who wants to deal with mechanics and mechanical engineering needs to possess expertise spanning a significant number of fundamental subject areas, as well as to be able to link a multitude of multidisciplinary ideas and materialize them into realistic and useful engineering systems of practical interest.

Mihailo Petrović was a unique and brilliant Serbian mathematician, an inspirer and a scientist with broad scientific culture and possessing knowledge ranging through all the fields of theoretical and applied disciplines and capable of materializing his ideas into the constructions in the field of mechatronics and mechanical engineering.

Petrović's theory that was expounded in his books titled *Elements of Mathematical Phenomenology* [5, 6] and *Phenomenological Mapping* [3, 10], is interpreted by many as "the mathematical foundations of natural philosophy", reminiscent of Newton's work *Philosophiae Naturalis Principia Mathematica* (*Mathematical Principles of Natural Philosophy*), which was published in May 1687. This comparison is acceptable and highly significant for cognitive sciences studies. However, in my view, Petrović's theory rises in importance when it comes to the application and identification of the same non-linear dynamics models in physically totally disparate areas of sciences, through knowledge transfer from one field of natural and technical sciences to another, including humanities as well [1, 2, 13].

Figure 1. The depth measurer of the land artillery: "Télémètre à sextant", patent no. 413.730

## MECHATRONICS AND MECHANICAL ENGINEERING IN MIHAILO PETROVIĆ'S PATENTS

It is evident that for devising mechatronic devices, machine constructions and the invention of hydro integrator, besides mathematical knowledge, one undoubtedly has to apply knowledge of non-linear dynamics and fluid mechanics, which are fundamental sciences in mechanical engineering.

Mihailo Petrović often stressed the phrase – *materialization of differential equations*. Engineers love the phrase, because if an idea can contribute to science, it can make a difference in everyday life only if it is realized into a specific device, mechanism or machine. Mihailo Petrović was a theorist and a scientist, but also an experimenter and a constructor who knew how to apply his theoretical and mathematical knowledge to such a degree that through the desired dynamics model, it could be handed over to engineers for realization. Some examples of such practically oriented discussions and realized ideas are: *work*

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OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

# BREVET D'INVENTION.

XII. — **Instruments de précision, électricité.**

3. — Poids et mesures, instruments de mathématiques, compteurs et procédés d'essai. **N° 413.730**

**Télémètre à sextant.**

Mm. PETROVITCH et Milorad TERZITCH résidant en Serbie.

**Demandé le 11 février 1910.**

Délivré le 5 juin 1910. — Publié le 17 août 1910.

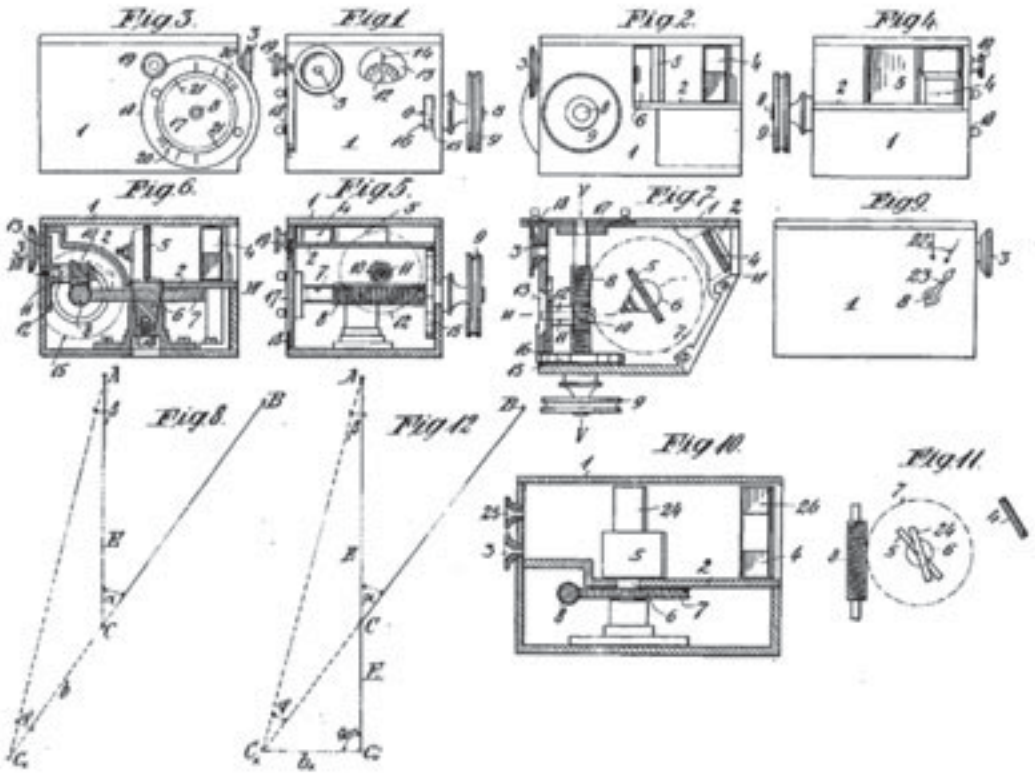


Figure 2. A sketch of the part of the mechanism of the depth measurer – named "Télémètre à sextant", patent no. 413.730

*on mathematical modelling and analogue calculating machines*, on *the hydraulic integrator – hydro integrator,* and on the *range indicator* made for the needs of the Military-Technical Institute in Kragujevac.

Here we will present several mechatronics inventions and machine constructions through the presentation of ten patents that had interesting and important applications. Each of these inventions and devices illustrate a high level of Petrović's creativity and his capability of transforming abstract ideas and sketches into very usable devices and inventions in the field of mechatronics and mechanical engineering.

From the bibliography of his works and archive documents of the Patent Offices in France and Great Britain, we can learn that Mihailo Petrović patented ten inventions. For nine of them he was granted a patent in France, and for one in Great Britain.

The first patent is *the range indicator*, construed for the needs of the Military-Technical Institute in Kragujevac. He made this device together with the general of the Serbian Army Milorad Terzić. The patent was bought and realized in Serbia and in Russia (Paris-1910; No. 413730.). Petrović submitted an application for this patent to the French Patent Office on February 11, 1910, and the patent with number 413.730 was granted to him on August 17, the same year (Figures 1 and 2).

Petrović's *Eternal calendar* was recorded in his bibliography as an original author's contribution, and made official under the patent number 480.788, granted to him on September 21, 1916 by the French Patent Office, based on the documents and applications submitted on January 27, 1916 (Figure 3).

His next invention is *the construction of the cogwheel transmitter* (Paris-1913; No. 463082), in the field of machine constructions and mechanical engineering. This patented machine construction, according to D. Trifunović, PhD, is a precursor of automatic gearboxes for cars and it enables a constant transmission of the number of revolutions per minute. Petrović applied for this patent together with Svetolik Popović, a machine


BIBLIOTHÈQUE
RÉPUBLIQUE FRANÇAISE

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION.

XII. — Instruments de précision, électricité.
1. — Horlogerie. N° 480.788

Cadran calendrier pour objets d'horlogerie, de bijouterie et autres.

M. Mihajlo PETROVITCH résidant en Serbie.

Demandé le 27 janvier 1916, à 15h 50m, à Paris.
Délivré le 1er juillet 1916. — Publié le 21 septembre 1916.

Figure 3. Sketches of Petrović's Eternal calendar

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# BREVET D'INVENTION.

**V. — Machines.**

3. — Organes, accessoires et entretien des machines.

**N° 463.082**

**Changement de vitesse.**

M. Michel PETROVITCH résidant en Serbie.

**Demandé le 29 septembre 1913.**

Délivré le 8 décembre 1913. — Publié le 13 février 1914.

*Fig. 1*

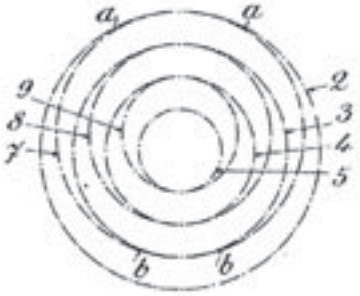


*Fig. 2.*

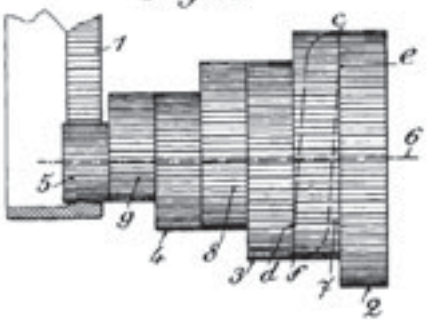


Figure 4. A sketch of the *construction of the cogwheel transmitter* model (Paris 1913; no. 463082) patent no. 463.082, issued on 13 February 1914

nautical engineer from the Serbian Nautical Society. The application was submitted to the French Patent Office on September 29, 1913, and patent with number 463.082 was issued to him on February 13, the following year (Figure 4).

The invention named *multiple compression ration cogwheel transmitter with bending conical cogwheels* was submitted on August 31, 1912, and it was approved by the French Patent Office on January 17, 1913 with number 447.861. He applied for this patent together with Svetolik Popović, nicknamed Suljim, a machine-boat engineer from the Serbian Nautical Society. This patent model has similar structure as the patented model named ***the construction of the cogwheel transmitter*** (Paris-1913; No. 463082), with number 463.082, which was issued on February 13,

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# BREVET D'INVENTION.

V. — Machines.

3. — Organes, accessoires et entretien des machines. N° 447.861

**Changement de vitesse avec pignons étagés raccordés par des engrenages en hélice conique.**

MM. Svetolik POPOVITCH et Michel PETROVITCH résidant en Serbie.

**Demandé le 31 août 1912.**

Délivré le 9 novembre 1912. — Publié le 17 janvier 1913.

FIG. 1.

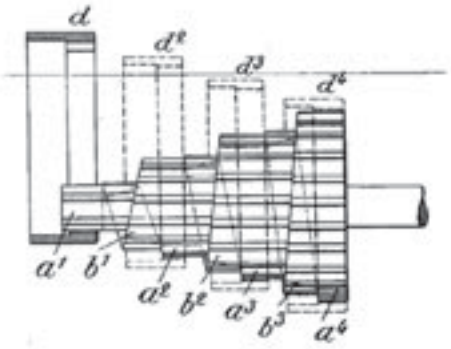


FIG. 2.

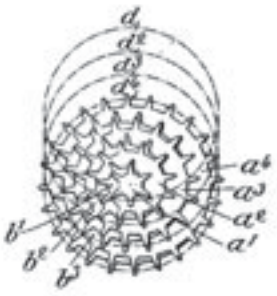


Figure 5. Discovery named *Multiple compression ration cogwheel transmitter with bending conical cogwheels* was submitted on 31 August 1912, and the patent was granted on 17 January 1913, with the no. 447.861, by the French Institute for Patents.

1914 based on application dated September 29, 1913, and represents new generation of helical gear for automobile transmissions (Figures 4 and 5).

The next invention by Petrović also belongs to this group of mechanical constructions in the form of cogwheel transmitters of the number of revolutions per minute. It was patented under the name *automobile gearbox* under the patent number 476.320, based on application dated October 17, 1914, and the patent was granted on June 27, the following year, in 1915 (Figure 6).

A device for quick launching and ejecting of missiles, intended for the use on the old type of cannons, in the air and water, as well as on land and at sea, was patented by the French

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# BREVET D'INVENTION.

X. — Transport sur routes.
4. — Automobilisme.

N° 476.320

**Changement de vitesse.**

M. Michel PETROVITCH résidant en Serbie.

**Demandé le 17 octobre 1914, à 14h 55m, à Paris.**
Délivré le 4 mai 1915. — Publié le 27 juillet 1915.

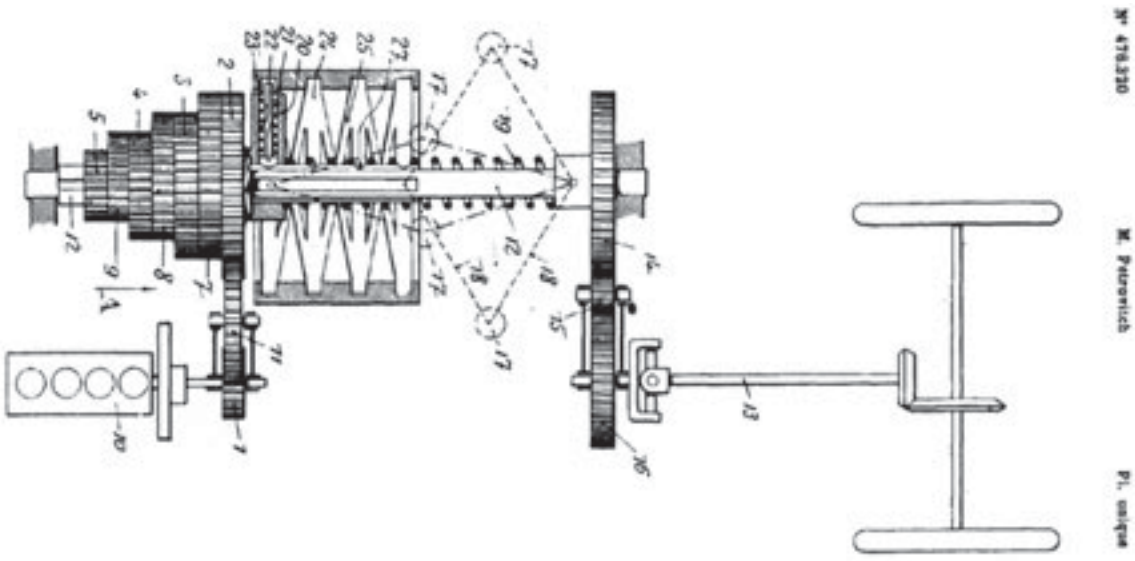

Figure 6. A sketch of an automobile gear, patent no. 476.320

patent number 503.321. Petrović submitted the application for this invention on February 22, 1918 to the French Patent Office, and the French patent under the number 503.321 was granted to him on June 8, 1920 (Figure 7). With this device, the initial axial-rotation of the missile fired from old-type smoothbore cannon was achieved. This initial axial-rotation of the missile resulted in the decrease of the resistance of the environment (air or water).

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# BREVET D'INVENTION.

**XI. — Arquebuserie et artillerie.**

4. — Armes diverses et accessoires.

**N° 503.321**

**Appareil imprimant un mouvement rapide aux bombes, mines aériennes et torpilles aériennes lancées par un canon lisse.**

M. Michel PETROVITCH résidant en Serbie.

**Demandé le 22 février 1918, à 15h 52m, à Paris.**
Délivré le 15 mars 1920. — Publié le 8 juin 1920.

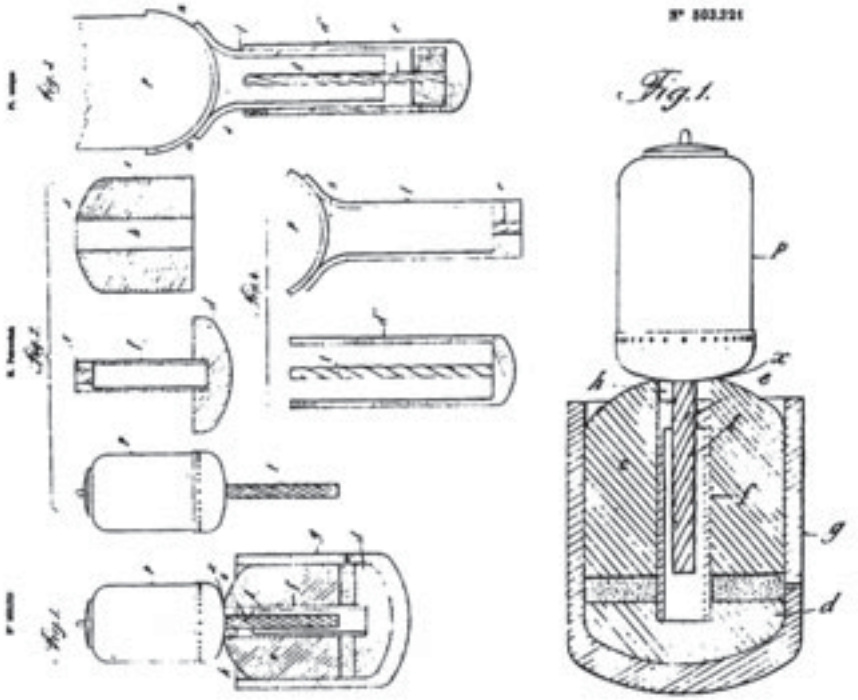
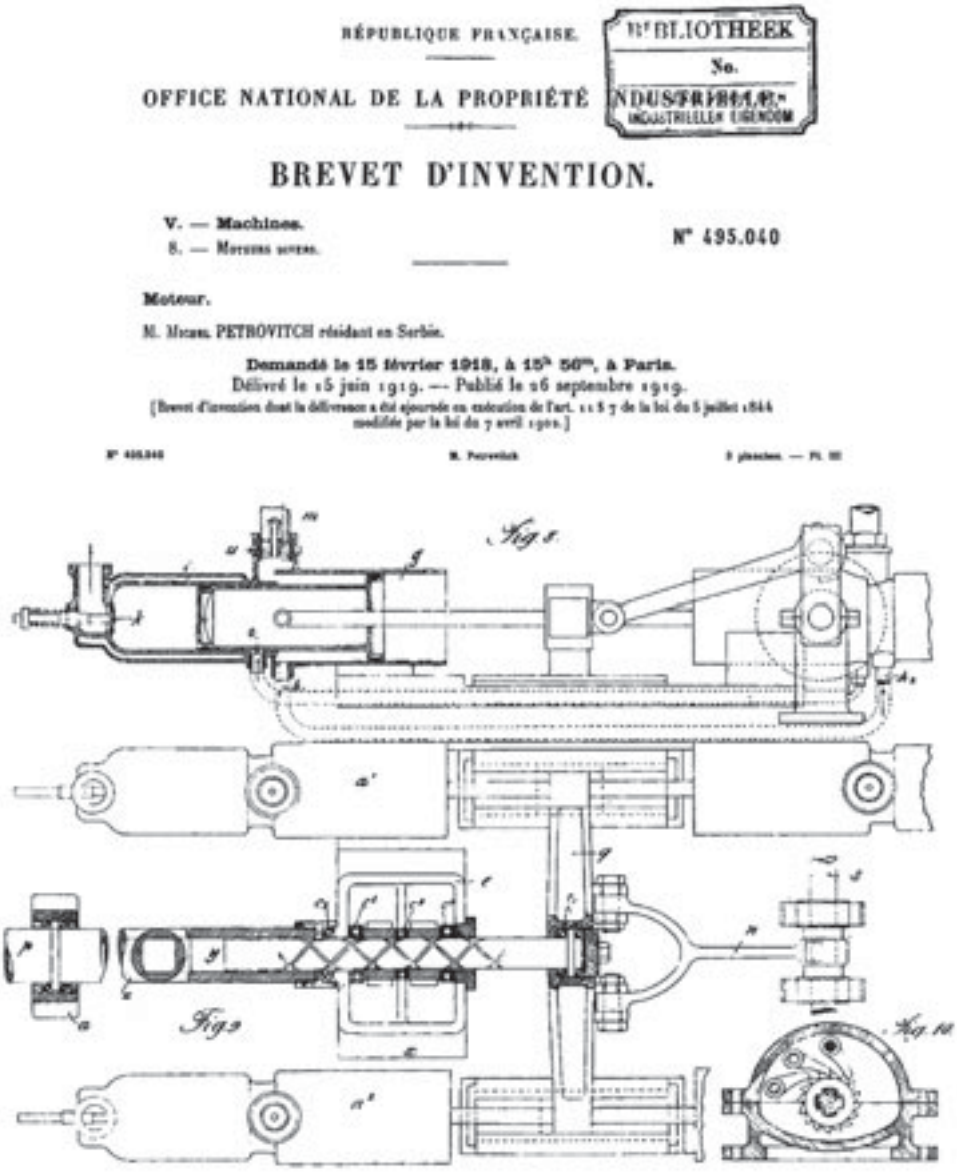



Figure 7. Sketch of the device for ejecting and launching missiles, meant for usage both in water and air, as well as on ground and on sea. Protected by French patent no. 503.321

The last patented invention, which we find recorded in Petrović's bibliography, is a *model of the motor with a piston of alternating impact*, the main spindle of which was made with the coil for transmission of the piston movement. Petrović submitted an application for patenting this invention on February 15, 1918, and the patent under the number 495.040 was granted to him on September 26, the following year (Figure 8).



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BIBLIOTHEEK
No.
INDUSTRIELE EIGENDOM

BREVET D'INVENTION.

V. — Machines.

N° 495.040

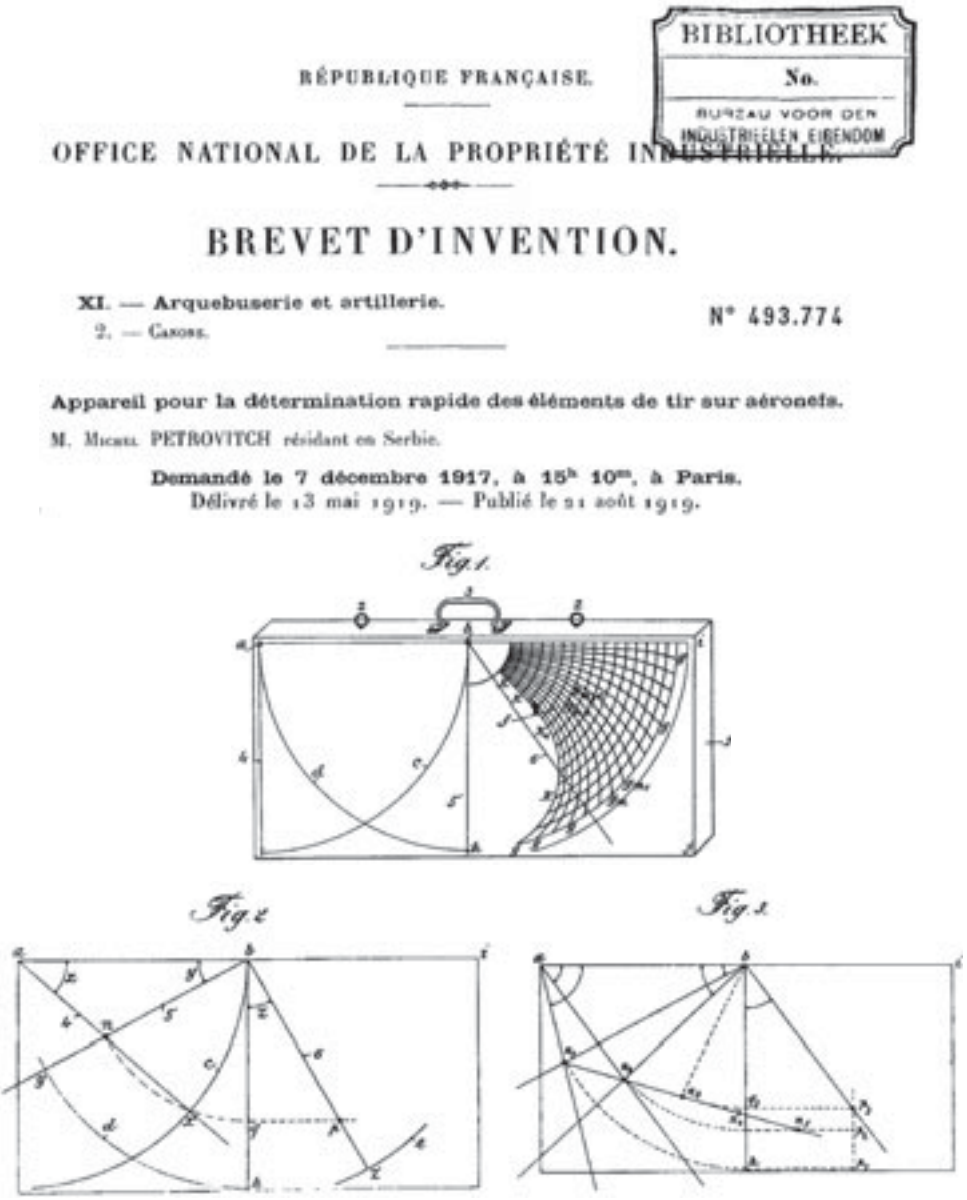
Moteur.

M. Mcrcm. PETROVITCH résidant en Serbie.

Demandé le 15 février 1918, à 15h 50m, à Paris.
Délivré le 15 juin 1919. — Publié le 26 septembre 1919.

Figure 8. Sketch of a *model of a motor with the piston of alternating impact*, patent no. 495.040

The *device for rapid launching and rapid determination of fire* was an important invention of Petrović for military use. Petrović submitted the application for this invention on December 7, 1917 to the French Patent Office, and the French patent number 493.774 was granted to him on August 21, 1919 (Figure 9).



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BREVET D'INVENTION.

XI. — Arquebuserie et artillerie.
2. — Canons.

N° 493.774

**Appareil pour la détermination rapide des éléments de tir sur aéronefs.**

M. Milan PETROVITCH résidant en Serbie.

**Demandé le 7 décembre 1917, à 15h 10m, à Paris.**
Délivré le 13 mai 1919. — Publié le 21 août 1919.

Fig. 1.

Fig. 2

Fig. 3.

Figure 9. The device for quick launching and quick determination of elements of fire. Petrović submitted his application for this device on 7 December 1917 to the French Institute for Patents, and the French patent no. 493.774 was granted to him on August 21st 1919.

To these patents one should also add the model of *the efficient avoidance of a minefield* (Mémoire No. 120, 1920). Petrovć also protected with a patent in France his device named *the means for assuring the buoyance of ships following damages caused by collision, mine, torpedo or stranding*. This device consists of a large number of bodies, in the form of a balloon, with appropriate sources of gases under pressure for inflation, which can be handled manually, remotely or automatically, with an appropriate electromagnetic device. The inflation of the elements of this device prevents or slows down sinking of a vessel (a ship). Petrović submitted the application for this device to the French Patent Office on November 24, 1917, and patent number 515.072 was issued to him only on March 24, 1921 (Figure 10). He also patented this invention in Great Britain in 1918 under the patent number 121.279 (Figures 10, 11 and 12).

In addition to the patented technical devices in the area of mechatronics and mechanical engineering, Mihailo Petrović is also an author of a series of inventions for which there are no records that they had been protected by a patent. One of those devices is the hydraulic integrator, to which a separate chapter in this monograph is dedicated. Here we described a certain number of devices based on the original patent elaborates available in electronic form.

*The depth measurer* is Petrović's invention intended for measuring depth at which an object is submerged into water – partially (e.g. a boat) or fully (e.g. a submarine). Available information show that number 96371 is associated with this patent from 1918, and that *English Admiralty gave a positive opinion about it*. According to some sources, Petrović received an invitation from British admirals in relation with this invention, but there are no written records about it. It is possible that the number associated with this invention represents the number of the application submitted to the French Institute for Industrial Property (Institut national de la propriété Industrielle) or to some other patent institution.

* * *

While researching Petrović's patents, Snežana Šarboh, MA, searched available European patent databases, and quoted my article published in the monograph titled *Legende Beogradskog Univerziteta (The Legends of Belgrade University)*. Particularly useful in that regard were the databases of the European Patent Office (ESPACENET) and the German Patent and Trade Mark Office (DEPATISNET). Upon request of the author of this article, Ivana Atanasovska, PhD, continued the search of the *Espacenet* (European Patent Office) database and found patent documentation for all ten Petrović's patents. Based on the search of these databases, a total of 10 (ten) granted patents of Petrović was confirmed, and consequently the table in the appendix was drawn up. Nine patents were registered in France and one in Great Britain. Nevertheless, we cannot in all certainty claim that this is the final number of Mihailo Petrović's patented inventions.

RÉPUBLIQUE FRANÇAISE.

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

# BREVET D'INVENTION.

VI. — Marine et navigation.

1. — Constructions des navires et engins de guerre.

N° 515.072

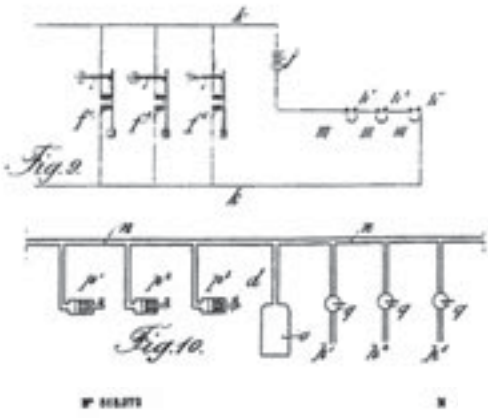
**Dispositif pour assurer la flottabilité des navires en danger.**

M. Mlcan. PETROVITCH résidant en Serbie.

**Demandé le 24 novembre 1917, à 15h 57m, à Paris.**

Délivré le 20 novembre 1920. — Publié le 24 mars 1921.

[Brevet d'invention dont la délivrance a été ajournée en exécution de l'art. 11 § 7 de la loi du 5 juillet 1844 modifiée par la loi du 7 avril 1902.]



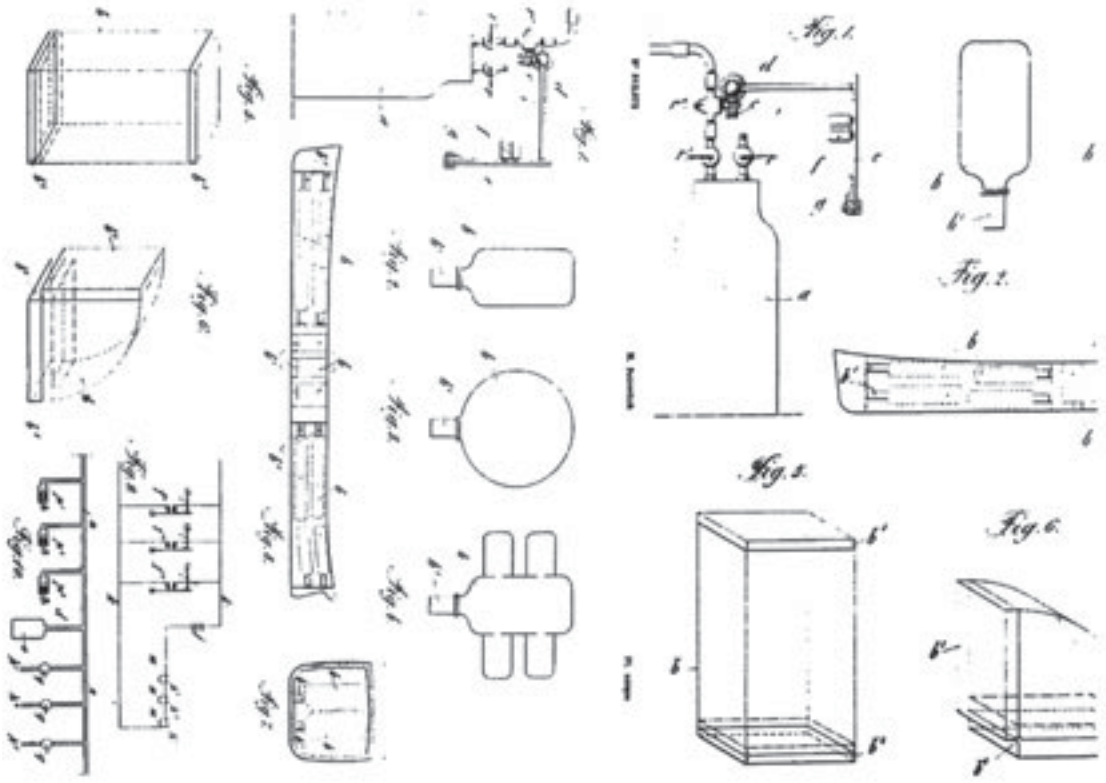




Figure 10. The means for assuring buoyoncy of ships following damage made by crash, mine, torpedo or stranding

NOTE.—*The application for a Patent has become void.*
*This print shows the Specification as it became open to public inspection.*

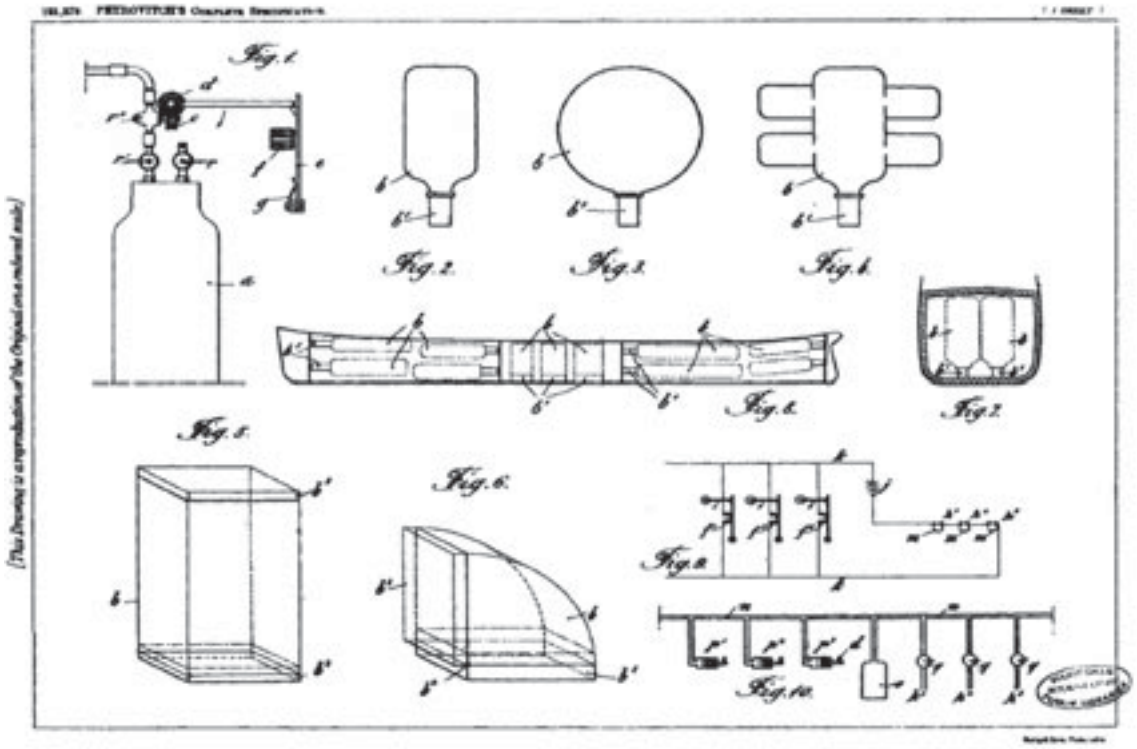
**121,279**

**PATENT SPECIFICATION**

*Convention Date (France), Nov. 24, 1917.*
*Application Date (in United Kingdom), Oct. 23, 1918. No. 17,344/18.*
*Complete not accepted.*

COMPLETE SPECIFICATION.

**Means for Assuring the Buoyance of Ships.**




Sketch 11. One of the sketches of the patent granted in Great Britain, patent no. 121.279, for the discovery named *The means for assuring buoyoncy of ships following damage made by crash, mine, torpedo or stranding.*

NOTE.—*The application for a Patent has become void.*
*This print shows the Specification as it became open to public inspection.*

**121,279**

# PATENT SPECIFICATION

*Convention Date (France), Nov. 24, 1917.*
*Application Date (in United Kingdom), Oct. 23, 1918. No. 17,344/18.*
*Complete not accepted.*

COMPLETE SPECIFICATION

## Means for Assuring the Buoyance of Ships.

I, MICHEL PETROVITCH, formerly of 26, Kossanth Venac, Belgrade, in the Kingdom of Serbia, whose present address is c/o The Consulate of Serbia, 2, rue Leonce Reynaud, Paris, in the Republic of France, an Officer in the Serbian Army, do hereby declare the nature of this invention and in what manner the the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to a device for ensuring the buoyancy of ships in danger, for example when they are, or run the risk of being damaged by a collision, a mine, or a torpedo, or by running aground.

This device consists essentially of a certain number of extensible receptacles fixed at various points to the ship and each connected to a separate source of compressed air or gas through the medium of a cock or equivalent member, which can be opened on the one hand at will and on the other hand automatically under the action of the damage to which any part of the ship is subjected.

These receptacles are preferably distributed in a number of groups, the volume and the number of receptacles in each group being determined in such a way that the latter, when once they have been inflated, broadly ensure the buoyancy of the ship. The device fitted up in this way exhibits the following properties:—

(1) Before the time of danger the extensible receptacles are deflated, and only occupy a limited amount of space, not hampering or encumbering and not appreciably diminishing the carrying capacity of the ship.

(2) At the time of danger a certain number of the receptacles, the ones of which the working is found advantageous at the time, are released, suddenly increase in volume, and acquire a sufficient emersive power to maintain the buoyancy of the ship.

(3) The release and inflation occur automatically in apparatus the voluntary controlling of which is rendered impossible by accident. The working may be supplemented voluntarily, instantaneously, and to the desired extent, by releasing at will other extensible receptacles, if the automatic releasing has not produced a sufficient increase in emersive power to keep the ship afloat.

(4) The damaging of the apparatus is localised, in the sense that the damaging of one piece of apparatus does not in any way prevent another from working and the damaging of the installation for the voluntary controlling of one group

[*Price* 1/-]

Figure 12. The first page of the granted patent under patent number 121.279, for the discovery named *The means for assuring buoyoncy of ships following damage made by crash, mine, torpedo or stranding*. This discovery was submitted in Great Britain on 23 October 1918, and granted under patent number 121.279.

## THE TABLE OF MIHAILO PETROVIĆ'S PATENTED INVENTIONS

| | Patent number | Original title of the patent | English translation of the title of the patent | Application submission date | Date of granting of patent | Patent co-applicant |
|---|---|---|---|---|---|---|
| 1 | FR 1413.730 | Télémetre a sextant | Range indicator | February 11, 1910 | August 17, 1910 | Terzić Milorad |
| 2 | FR 447.861 | Changement de vitesse avec pignons étagés reccordés par des engrenages en héllice conique | Multiple compression ration cogwheel transmitterwith bending conical cogwheels | August 31, 1912 | January 17, 1919 | Popović Svetolik |
| 3 | FR 463.082 | Changement de vitess | Construction of the cogwheel transmitter | September 29, 1913 | February 13, 1914 | |
| 4 | FR 476.320 | Changement de vitess | Automobile gearbox | October17, 1914 | July 27, 1915 | |
| 5 | FR 480.788 | Cadran calendrier pour objets d'horlogerie, de bijeouterie et autres | Eternal calendar | January 27, 1916 | September 21, 1916 | |
| 6 | FR 515.072 | Dispositif pour assurer la flottabilité des navires en danger | Means for assuring the buoyance of ships following damages caused by collision, mine, torpedo or stranding | November 24, 1917 | March 24, 1921 | |
| 7 | FR 493.774 | Appareil pour la détermination rapide des elements de tir sur aéronefs | Device for rapid launching and rapid determination of fire | December 7, 1917 | August 21, 1919 | |
| 8 | FR 495.040 | Moteut | Motor with a piston of alternating effect | February 15, 1918 | September 26, 1919 | |
| 9 | FR 503.321 | Appareil imprimant un movement rapide aux bombes, mines aériennes et torpilles aériennes lamcées par un canin lisse | Device for launching and ejecting of missiles | February 22, 1918 | June 8, 1920 | |
| 10 | GB 121.279 | Means for Assuring the Buoyance of Fhips | Means for assuring buoyance of ships following damages caused by collision, mine, torpedo or stranding | October 23, 1918 | | |

FR and GB represent two-lettered designations of France and Great Britain, in accordance with the appropriate standard of the World Intellectual Property Organization, WIPO.

## FINAL COMMENTS ON PETROVIĆ'S INVENTIONS AND PATENTS

Based on the results obtained by various searches of scientific papers and numerous patent databases one may conclude that Mihailo Petrović was an authentic author of at least ten original inventions in the field of mechatronics and machine constructions, and of at least ten patents. In addition to the five French patents, which Dragan Trifunović, PhD, mentioned and elaborated on [7, 8, 9], the latest research has come upon additional four French and one British patent. However, we cannot in all certainty claim that this is the final number of Mihailo Petrović's patented inventions.

With the passage of time, it may be concluded that Mihailo Petrović's work in various fields of science and engineering had stimulated scientific progress in Serbia, not only in mathematical sciences, but also in other natural sciences, humanities and technical sciences as well. Since Petrović was primarily celebrated as a mathematician, this aspect of multidisciplinarity of his life and work was somewhat neglected in historical reviews. In all likelihood, Petrović developed an interest in practical side of science in the period from 1889 to 1894, during his stay in Paris, where he acquired thorough knowledge, not only in mathematics, but also in other sciences, primarily in physics and theoretical and applied mechanics, and when he managed to understand the difference between geometry and dynamics. At Sorbonne, as an excellent student, he earned diplomas in mathematics and physics and a PhD degree in mathematical sciences having been taught by the distinguished French mathematicians Hermite, Painleve and Picard, nevertheless he developed his talents under the influence of Poincaré, as one of the three doctoral students of this unique scientist with numerous multidisciplinary achievements. He came to Belgrade in 1894 and soon showed his exceptional talent through a wide range of scientific achievements and practical discoveries, inventions and patents in the field of mechatronics and mechanical engineering, nevertheless it was with his hydraulic integrator that he became a precursor in the field of computing. As he himself mentioned on several occasions, when it comes to his practical work, he found inspiration in his paper dealing with natural philosophy, titled *Mathematical Phenomenology*. His book titled *Elements of Mathematical Phenomenology* is a *powerful tool* for the application of *philosophy of phenomenological mapping* in other sciences. In this respect, each invention and its patent was an example of materialized idea. The great Serbian scientist Milutin Milanković [3] pointed to the importance of this theory immediately upon its publishing, having said that "it is a pity that it has been published only in the Serbian language", and consequently not available to the global scientific community of that time.

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