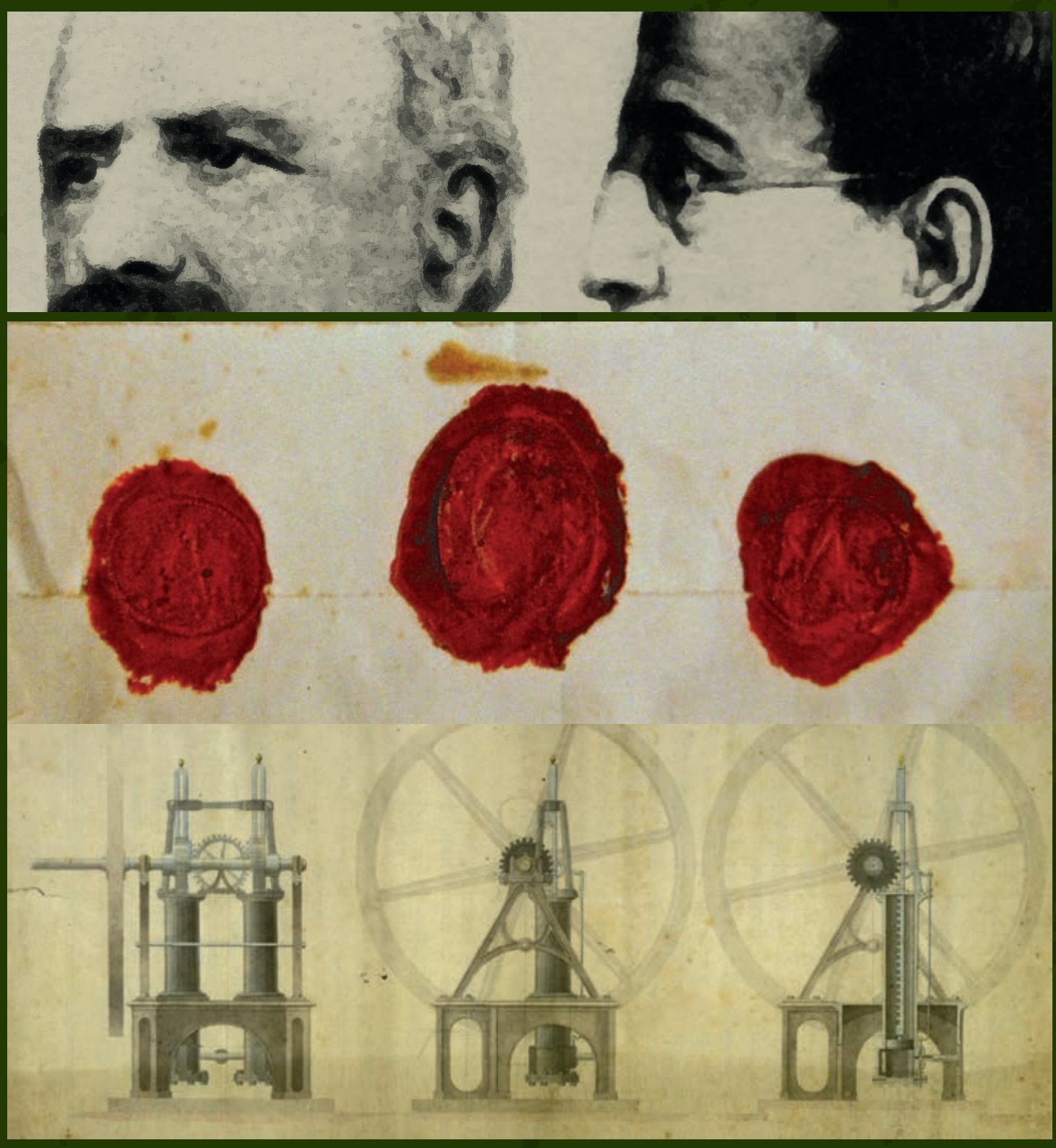
2015

# Barsanti & Matteucci

1821 - 1864 1808 - 1887



## The invention of the internal combustion engine

*A spark of italian creativity*

BROVEDANI GROUP

TO BE PRECISE

**THANKS TO**
Fondazione Barsanti e Matteucci - Lucca

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**CONCEPT, COPYWRITING, GRAPHIC DESIGN**
www.primalinea.net - Pordenone

.

**STILL LIFE**
Renato Bianchini - San Vito al Tagliamento

## BARSANTI & MATTEUCCI: 1 + 1 > 2

**June 5, 1853.** A brief filed with the Academy of Georgofili in Florence represents a milestone in human history. It was a *"...report on several new experiments carried out by Eugenio Barsanti and Felice Matteucci"*. What did the envelope contain that was so important and exclusive? The document dealt with the *"...concept of using as a driving force an exploding combination of oxygen gas and hydrogen gas, to be set off by an electric spark"*. This is the principle of the **internal combustion engine**, which was exhaustively described with complete technical and functional details in the report. Thus began an epic "poem in motion" that continues to this day. It includes constant innovations and begins with the following opening line: from the first diesel engines to the development of Common Rail technology...with Brovedani as a leading player.

Today, using incontrovertible documents, we can say that modern mobility is the offspring of the ingeniousness of these two inventors from Tuscany, not only because they were first off the starting line, but also because of the quality of their creation. Theirs was an efficient engine with a yield that reached 14%, as compared with the 4% and 12% attained by Etienne Lenoir in 1860 and Otto-Langen in 1867, who had long been considered the fathers of this invention. The recent recognition of Barsanti and Matteucci as its true inventors was also due to the crucial scholarly work of the **Barsanti and Matteucci Foundation in Lucca**. In view of their research, the internal combustion engine thus appears to be the result of a "society of trust and ideas" that originated with the extraordinary encounter of two different, yet complementary personalities who were capable of shining **together** in the firmament of Italian creativity.


N. 1.

Rapporto riguardante alcuni nuovi esperimenti
dei signori Eugenio Barsanti e Felice Matteucci,
da loro depositato sigillato presso l'Accade-
mia dei Georgofili nell'adunanza del 5 Giu-
gno 1853, come rilevasi dal processo ver-
bale di detta adunanza.

Il Segretario degli Atti
Raffaello Buracca

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*The introduction to the brief filed by Barsanti and Matteucci with the Academy of Georgofili in Florence on June 5, 1853. It is followed by twelve pages of detailed technical descriptions of "several new experiments".*
*On the cover: the sealed envelope that contained this important document.*

## A DOUBLE TRIBUTE TO ITALIAN TALENT

For Brovedani, the 2015 calendar devoted to Barsanti and Matteucci is a double tribute.

It pays "universal" homage to the **innovative force that stems from a respectful, "attuned" meeting of intelligence and skills**; that is, from team work and a systematic approach.

And, it particularly honors Brovedani's **sparks of creativity**, consisting of ideas that have become components which add value to mechanical systems in the automotive and aerospace fields. In the footsteps of the remarkable technological inspiration that opened up great highways over land, on the water and in the air.

BROVEDANI GROUP

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## B&M: A JOINT BIOGRAPHY

**12 February 1808.** **Felice Matteucci** is born in Lucca, Italy. He is the son of Attorney Luigi Matteucci, the Justice Minister for Prince Felice Baciocchi, and of Lady Angiola Tomei-Albiani from Pietrasanta, Italy. He attends the Royal Elementary School in Lucca and the Royal Bourbon Academy in Paris, where his father is the Representative of the Grand Duke of Tuscany. He completes his studies in mechanics and hydraulics at the University of Florence.

**12 October 1821.** **Niccolò Barsanti** is born in Pietrasanta, Italy. He is the son of Angelo Barsanti, a stonemason, and Angela Francesconi. This slender boy from a humble family attends the Institute of the Pious Schools, operated by the Piarist Fathers in the St. Augustine Convent in Pietrasanta, until the age of 17. In 1837, he begins a novitiate in Florence and ultimately becomes a Piarist with the name of "Father Eugenio". He concludes his spiritual journey and continues his studies in mathematics and physics at the San Giovannino Academy and the *Osservatorio Ximeniano* in Florence.

**1835 ca.** At the age of only 27, **Felice Matteucci** authors a project (which is never implemented) for drying up the swamp at Bientina, Italy.

**1841.** **Eugenio Barsanti** is transferred to the San Michele academy in Volterra, where he teaches mathematics and physics. It is here that he conceives the principle of the internal combustion engine in 1843.

**1845.** **Eugenio Barsanti** is ordained as a priest and, in the meantime, continues to teach. In 1849, becomes an instructor of mathematics and physics at the San Giovannino Academy in Florence.

**1850 ca.** Barsanti and Matteucci meet and begin working together.

**5 June 1853.** Barsanti and Matteucci file a technical brief on the first internal combustion engine with the Academy of Georgofili in Florence. Over the next decade, they increase their efforts in this field, but obtain only varying results. They build many models of their invention and are granted numerous patents.

**14 October 1859.** The *Società anonima del nuovo motore Barsanti and Matteucci* company is founded.

**1862.** After suffering a nervous breakdown, Felice Matteucci resigns from the company.

**19 April 1864.** Exhausted and overcome by typhoid fever, **Eugenio Barsanti** dies in Seraing, Belgium. In effect, the great challenge of Barsanti and Matteucci's internal combustion engine comes to an end.

**13 September 1887.** **Felice Matteucci** experiences another bout of severe depression and dies at his home in Capannori, near Lucca.

*Lucca*

*Pietrasanta.*


# DETERMINATION AS A CREATIVE PRINCIPLE

## *EUGENIO BARSANTI*

**T**he story of the invention of the internal combustion engine includes little biographical material on the inventors themselves. The only portrait of Niccolò Barsanti suggests the slender physique and young age of a "little master" in the San Michele boarding school in Volterra.
Niccolò, who became a Piarist with the name of "Father Eugenio", was actually a remarkable example of determination. The son of a stonemason from **Pietrasanta** at the foot of Apuan Alps, his DNA was suffused with the temperament of his native land, where marble is mined and sculpted. He had an uncommon ability to pursue an idea in order to give it form and specific substance. In the spring of 1843, during a school experiment with **Volta's pistol**, Barsanti envisioned the principle of detonation as a possible mechanical driving force. From that moment on, and for over twenty years, he worked hard on turning his project into reality. His stubbornness - combined with an awareness of his own limits - led him to the "fatal" encounter with Felice Matteucci. His extreme doggedness as a businessman ultimately took him to Belgium to produce his internal combustion engine. And it was there that he died on April 19, 1864, perhaps because he was exhausted by his overly strenuous efforts. He was on the very threshold of what was could have been the fulfillment of his dream.

## *THE PERSEVERANCE OF AN IDEA*

**Eugenio Barsanti** exemplified the concept of **determination as a creative principle and as the engine that powers human inventiveness**, thus establishing him as a moral and motivational model for Brovedani as well. As Edison taught, "Genius is 1% inspiration and 99% perspiration". It is an achievement that is attained with the sweat of one's brow. It is the perseverance of an idea.

1. *Volta's pistol.*
2. *Cathedral Square in Pietrasanta.*

# DETERMINED TO REACH OUR GOALS

Becoming Europe's leading supplier of tempered shafts for highly advanced automotive applications. Creating these components with advanced materials, precision down to the thousandth of a millimeter, heat treatments with absolutely no defects, and levels of finishing that reduce wear, in order to handle the increasing stresses our cars are subjected to. Operating with automatic, multi-technology production lines that Brovedani was first to introduce back in 1989. Producing more than **40,000 shafts a day**. Contributing to ongoing improvement of the performance of our customers' products. Such as **Start&Stop starting motors** that work ten times harder during the life of a car to reduce fuel consumption, and **air conditioning compressors** that are becoming lighter and more powerful every day, and which use refrigerants that pollute less, thanks to increasingly sophisticated and better performing mechanical systems.

**Obtaining this performance and consolidating it over the long term** involves basing one's industrial strategies on the type of conscious determination that is essential for maintaining the creativity of the processes that have been implemented.

**Shafts for compressors and Start&Stop starting motors**

## AN INSPIRING EXPERIMENT: THE SINGLE-CYLINDER ENGINE

Can the culture of a local area affect creativity in the technological sphere? With its great treasures, the Tuscany of Barsanti and Matteucci seems to answer this question. Where Michelangelo lives on, so does Galileo. Where art is complex perfection, the mind can conceive the balanced mechanics of the internal combustion engine. The discussions of Barsanti and Matteucci's internal combustion engine in the 2015 Brovedani calendar revolve around a stimulating combination of beauty and technology, of the sublime and the useful, of *humus* and ideas. It follows, then, that the Galilean icon of the Tower of Pisa enables us to better understand the **first experimental internal combustion engine, built in 1853**. This **single-cylinder** gravimetric model with piston and valve operated on the **three cycle** principle:

1. **Intake** → the engine is fed oxygen and hydrogen, which comprise the "explosive mixture"
2. **Power** → a Ruhmkorff coil (a transformer used to generate high voltage pulses from direct current at low voltage) produces an electric spark that causes the mixture to explode, thus pushing the piston upwards until it reaches the highest point of its outward travel
3. **Exhaust** → as the piston descends by effect of gravity and expels the exhaust products, its straight motion is converted into the circular movement of a flywheel by a rack that is "engaged" with a pinion which is freed by a jack during the piston's outward travel. Mechanical transmission is thus **delayed until the piston returns**.

The principles of **three cycles** and **delayed action** would be the fundamental constants of all subsequent models of internal combustion engines created by Barsanti and Matteucci.



*Barsanti and Matteucci's first single-cylinder engine, against the background of a page from the brief filed with the Academy of Georgofili on June 5, 1853: theory and application!*

**MARCH**

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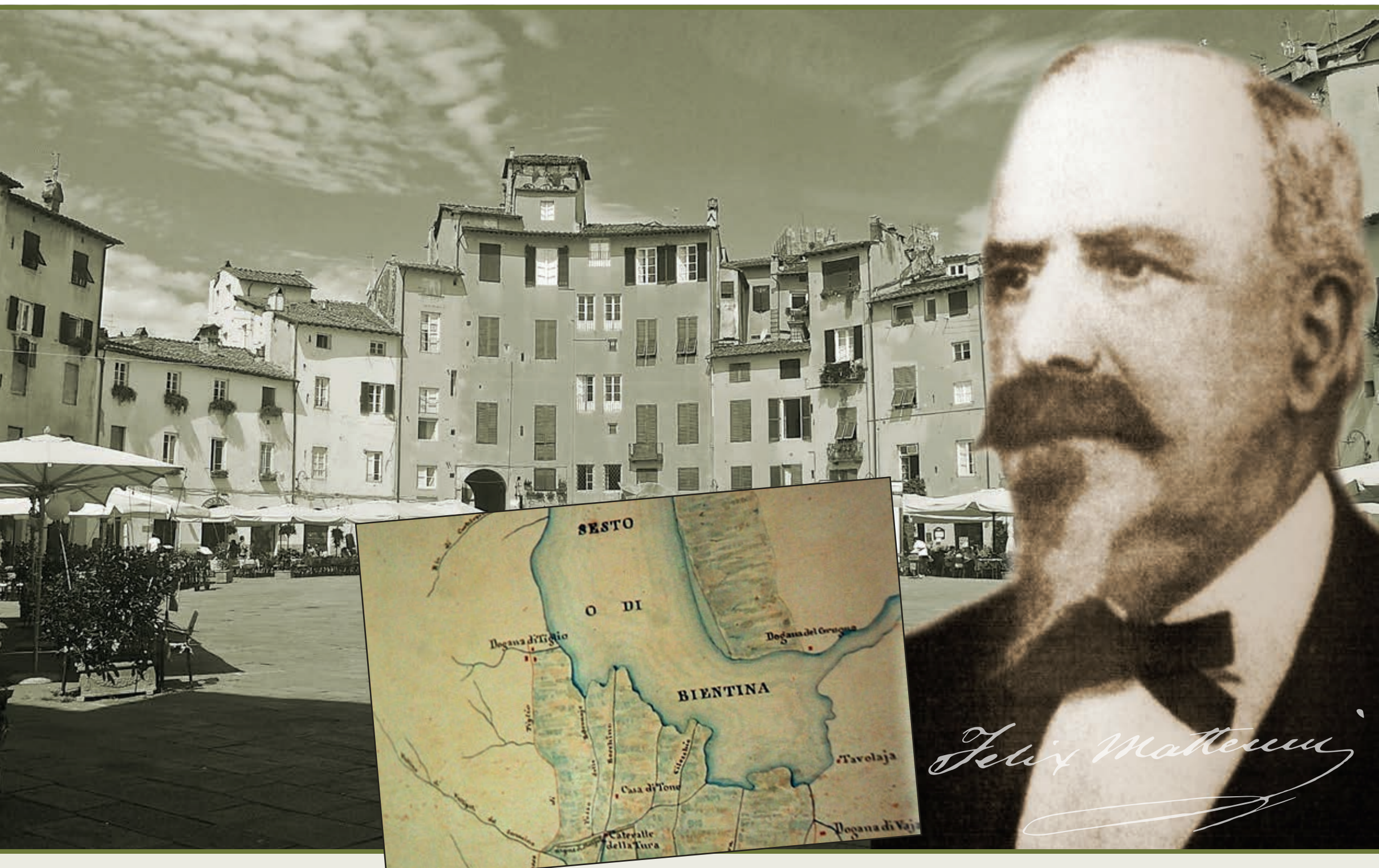
**APRIL**




# PASSION NURTURED IN EVERY DETAIL

**W**hen Barsanti and Matteucci met, it was an encounter between the theoretical insight of a physicist and the mechanical abilities of an engineer, a combination which enabled their idea to be effectively realized. Unlike the clergyman from Pietrasanta, Felice Matteucci was a fragile, tormented soul. He could tackle major projects with relentless resolve, yet he also fell victim to painful bouts of depression.

## *FELICE MATTEUCCI*

A product of the moneyed, principled middle class in Lucca, and a young author of respected poetry and a scholar who was both eclectic and profound, he divided his passion between hydraulics and mechanics. At only 27, he came up with an ambitious **project for drying up Bientina Lake** - an idea that was recognized and valued for its impressive comprehensive vision and the accuracy of its calculations and details. However, it remained a mere *"sweet, enchanting dream of my youth"* that Matteucci nostalgically cherished for the rest of his life, but never completed due to unfortunate circumstances.

In 1850, Felice Matteucci vigorously pressed on with the internal combustion engine project, which he pursued with his friend and partner until 1862, when he succumbed to a nervous breakdown. And when Eugenio Barsanti died in 1864, his second great dream was effectively shattered.

**A** figure who was both complex and restless, Felice Matteucci personified the **ingeniousness of an engineering solution, supported by meticulousness**. Documents and letters reveal his methodical thoroughness, even in his relationships with suppliers and assistants. His propensity for *"being precise"* that turned the impossible into reality is the same spirit embodied in Brovedani's corporate philosophy.

## *TO BE PRECISE*

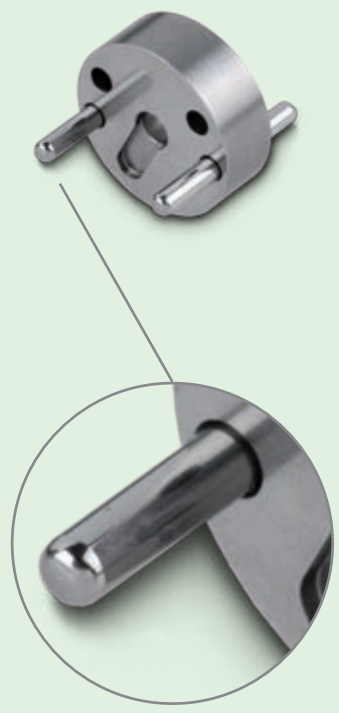
1. *A detail of Felice Matteucci's original project for drying up Bientina Lake.*
2. *Amphitheater Square in Lucca.*

# MULTIPLYING PRECISION

In the field of Common Rail diesel injection, Brovedani has made important contributions to the industrializatoin not only of injectors with solenoid valves, but also of **piezoelectric injectors**. In this field, **a tolerance of 2 tenths of a thousandth of a millimeter** is required by components that operate at a pressure of **2500 bars** and are produced in quantities of **30,000 units a day**. Reductions in automotive fuel consumption and emissions depend on achieving an extremely high degree of precision in the mechanical components in the injection systems, as well as obsessive care taken with each and every detail, multiplied by the number of production processes involved. These include high-productivity turning, heat treatments with exceptional repeatability and reliability that ensure the stability of the product over time, and finishing which creates “perfect” surfaces that hydraulically seal the system using mechanical seals - the only ones capable of resisting the enormous pressures involved.

Only in this way can the impossible become possible thousands of times a day, over long periods of time, as evidenced by the **more than 60 million components produced in 13 years, with zero discards**.

Brake disk



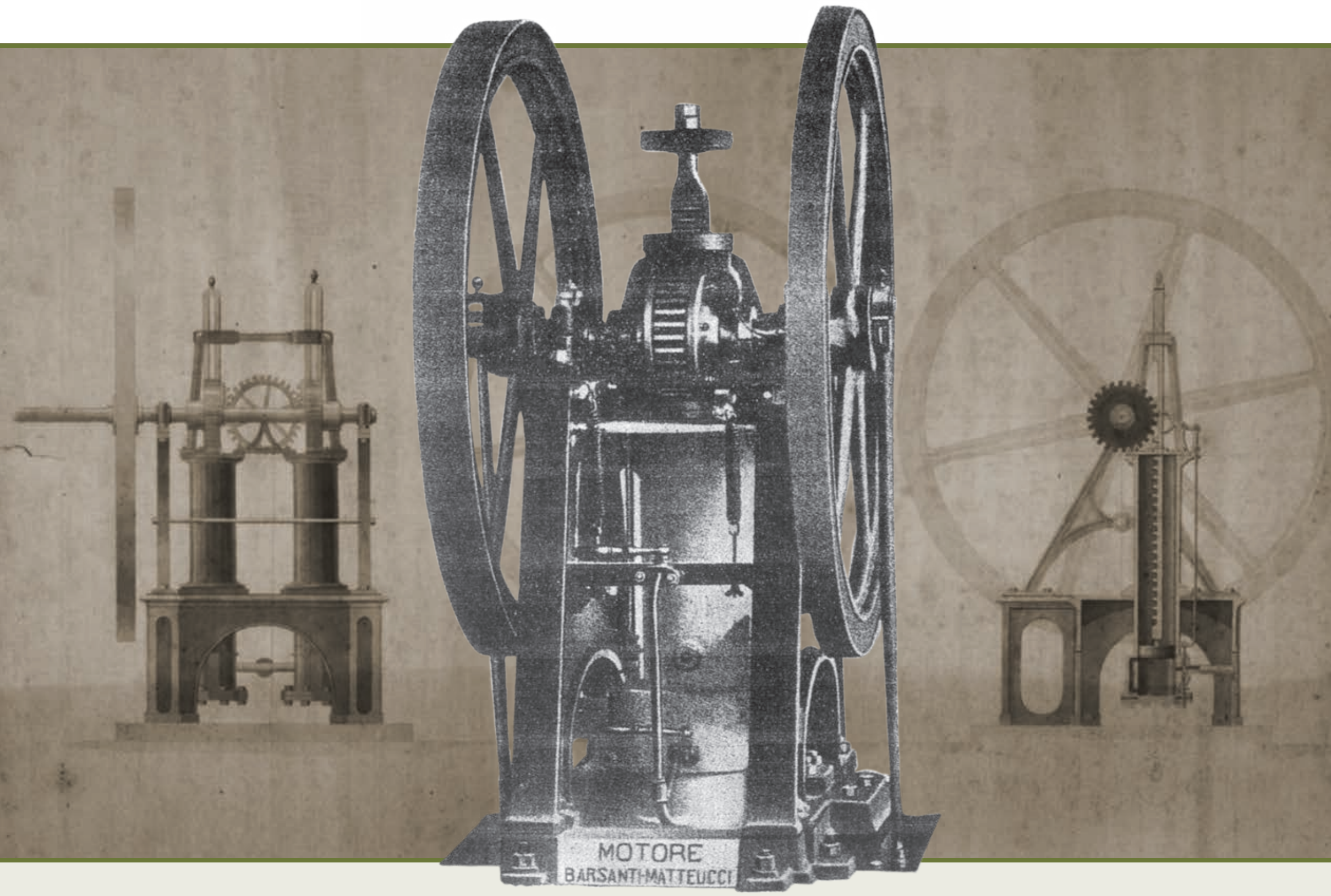
## AN IDEA, DOUBLED: THE TWO-CYLINDER ENGINE

Is it possible that Barsanti and Matteucci were inspired by the Tower of the Guinigi in Lucca, with its **two** bell towers placed close to each other? The model built according to the English certificate of 1854 is the most famous and most typical example of the invention developed by the two geniuses from Tuscany. In all probability, it was **the first useful example of this technology**, which was employed in several machine tools in the workshop at Maria Antonia railway station in Florence, as detailed in vol. III, file XVII of the Documents of the Royal Institute of Science, Letters and Arts of Lombardy, Milan, 1863.

The mechanical action of this gravimetric **two-cylinder internal combustion engine** was delayed until the return travel of the piston. Operating on a mixture of hydrogen and air, it was again based on the three-cycle concept of intake, power and exhaust strokes.

The underlying operating principle was the same as the first prototype, but with the **essential new feature of two pistons coupled by a toothed wheel**: the movement of one in a given direction forced the other to move in the opposite direction. Each piston was in turn equipped with a rack that “meshed” with a pinion on the crankshaft only during the return travel of the piston. Thanks to the out-of-phase oscillations of the two pistons, **motion was imparted to the crankshaft continuously** and resulted in virtually uniform circular movement.






# THE STEADFAST DEVELOPMENT OF AN IDEA

## THE INTERNAL COMBUSTION ENGINE

**B**arsanti and Matteucci's adventure with **internal combustion engines** spanned a dozen or so years.

The first prototype, which was built in 1853 by Officina Benini in Florence, was a **single-cylinder gravimetric unit**. As was true for all subsequent models, it was a three-cycle engine (intake, power, exhaust) operating with **delayed action**: during the return travel of the piston, straight motion is converted into the circular motion of a flywheel by a rack which becomes "engaged" with a toothed pinion.

A **two-cylinder** version made its debut in 1856. Its two vertical pistons ran on the same shaft, thus providing the engine with continuous motion. A similar unit at Maria Antonia railway station in Florence even powered a drill and a shear! To equip boats for sailing on Lake Como, Barsanti and Matteucci built a **horizontal, single-cylinder engine with opposed pistons**, which evolved into a **model with two horizontal cylinders** and a *new transmission system* with cranks and connecting rods.

The Bauer engine built in 1863 according to the 1857 English patent was designed for the manufacturing industry. It was a new **single-cylinder unit with an auxiliary piston** and revived the rack-and-pinion transmission.

## ONGOING IMPROVEMENT

**T**he invention created by Barsanti and Matteucci is a mechanical system that is constantly re-examined. It is therefore distinguished by the kind of ongoing improvement which is the *modus operandi* of Brovedani. Theirs was an **innovative tenacity** based on brilliant ideas such as the use of a **hydrogen-oxygen mixture for combustion**: thrifty, environmentally friendly, and up-to-date!

*A Bauer engine from 1863, reconstructed and displayed in a permanent exhibit at the Barsanti and Matteucci Foundation in Lucca. In the background: the design of the two-cylinder engine based on the English patent granted on June 12, 1854.*

# ONGOING IMPROVEMENT

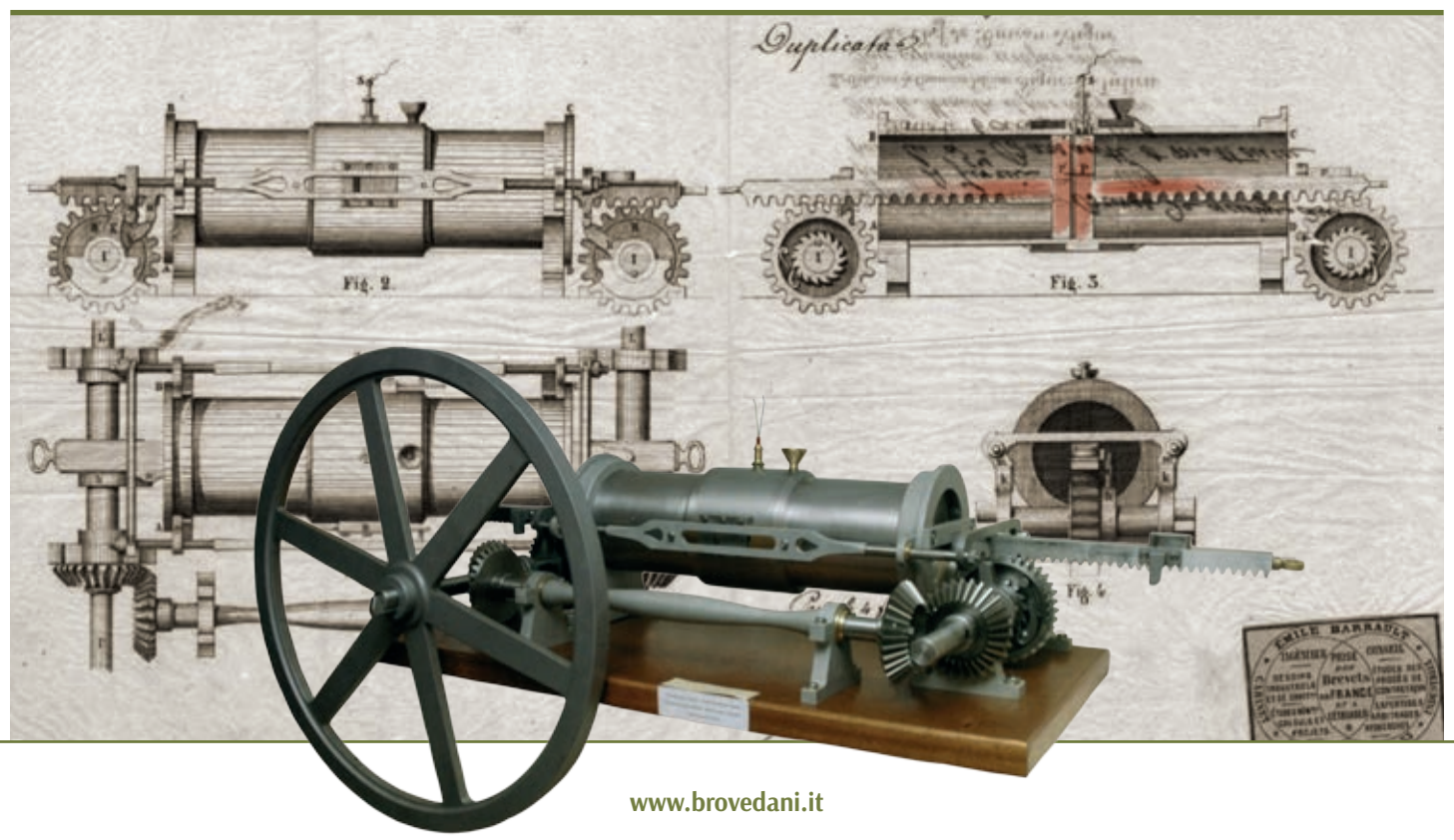
The creation of new technologies for attaining **tolerances of 5 tenths of a thousandth of a millimeter** on the cylindrical surfaces of **pistons for diesel pumps operating at a pressure of 2500 bars** requires the ability to learn, combined with persistence in effecting ongoing improvement. To **produce thousands of units a day with zero discards**, enhanced performance at the very highest levels is required. Specifically, such production demands capable production processes and technologies, advanced production methods with precise management/control, and human resources with the skills and the correct attitude for handling such complexity. This must be accompanied by a constant effort to improve the product in each and every aspect - such as quality, cost and delivery - in order to provide our customer every day with something "new" that helps improve its service to the final customer. It's an unrelenting daily commitment that is fulfilled with a 100% effort!
Only in this way can Brovedani reach standards of product quality and degrees of operational efficiency which ensure that the customer enjoys quality together with quantity, from production levels reaching **500,000 pieces per month**, through complex industrial processes that provide such performance consistently and over life cycles lasting many, many years.

Pump piston

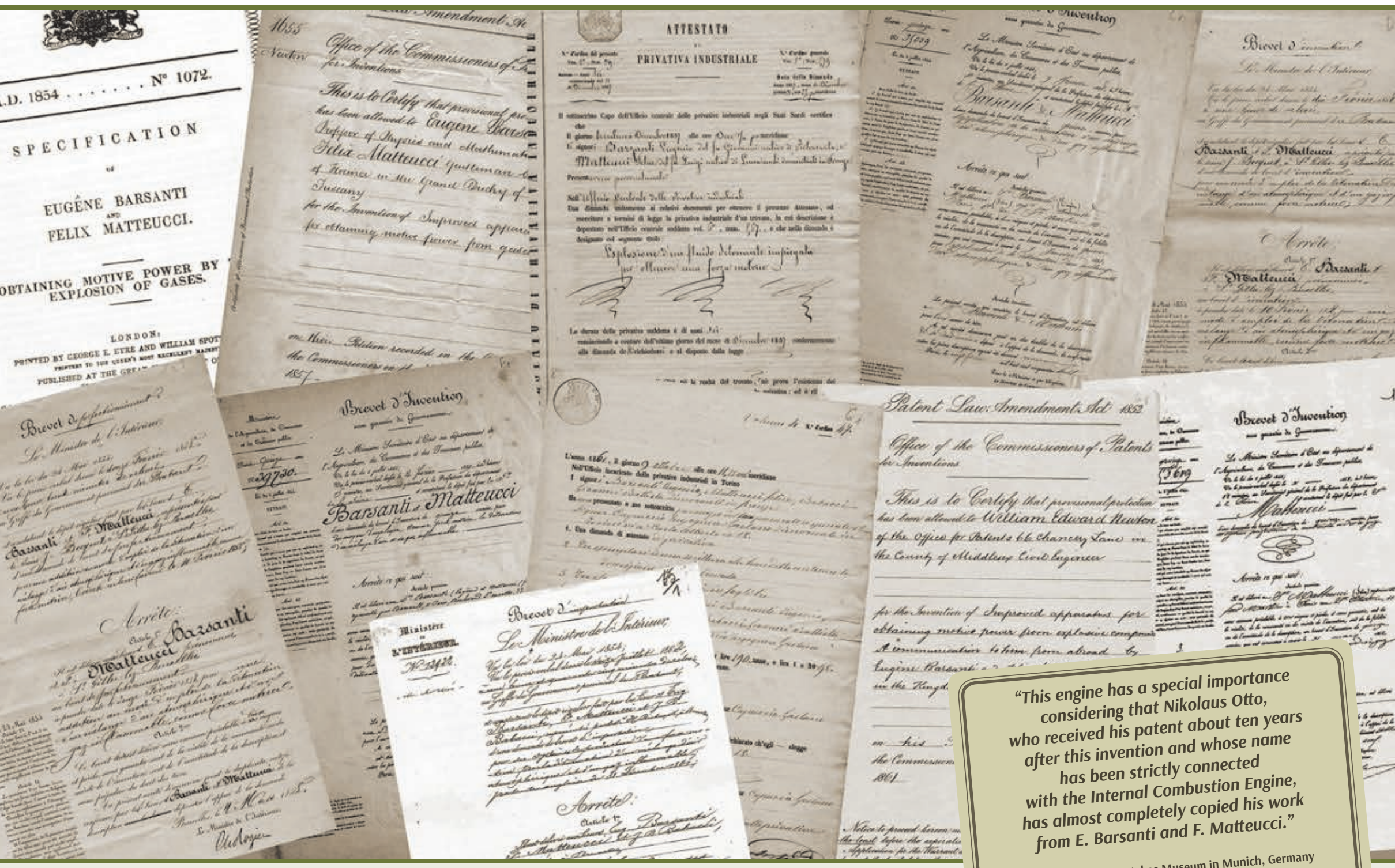
## EXERCISES IN LOCOMOTION: THE OPPOSED-PISTON ENGINE

In 1857, Barsanti and Matteucci seized on the opportunity to build an internal combustion engine for the Lariana sailing company in Como, which had recognized the superiority of this technology over the steam engine.
The need to prevent vertical oscillations, which is crucial to the stability of the hull, inspired the development of an **opposed-piston engine with two pistons housed in the same horizontal cylinder (!)**. These pistons almost came into contact and had slightly different travels. Ignition of the mixture between the two pistons caused them to move in opposite directions. When the impulse of combustion was balanced by atmospheric pressure, the return stroke began, and racks fixed to the pistons meshed with pinions to impart a circular motion to two auxiliary shafts. The latter in turn were "engaged" with the main crankshaft, and a flywheel was included to ensure that the engine operated smoothly.
Two versions of the prototypes were built in 1858 amidst numerous problems. The 20 HP **single-cylinder engine** constructed for the Calegari company in Leghorn did not prove to be satisfactory, while documentary evidence shows general approval of the performance of the 8 HP unit at the Benini foundry in Florence. In all likelihood, as can be seen on the invoices, this was an **engine with two cylinders**, each equipped with opposed pistons.






*A partial model, **limited to a single cylinder**, of the type of two-cylinder engine installed at the Benini foundry. In the background: a diagram of a single-cylinder engine with opposed pistons (highlighted in cross-section), which was taken from the French patent issued on 4 February 1859.*




"This engine has a special importance considering that Nikolaus Otto, who received his patent about ten years after this invention and whose name has been strictly connected with the Internal Combustion Engine, has almost completely copied his work from E. Barsanti and F. Matteucci."

Klaus Freyman – Deutches Museum in Munich, Germany
October 28, 2004

# INNOVATION: AN ASSET TO BE PROTECTED

## A DECADE OF PATENTS

**The priority of the invention of the internal combustion engine by Barsanti & Matteucci** over the unit developed by Lenoir and Otto-Langen is glaringly obvious in the chronology of the patents and franchises obtained by the Italians: **brief filed with the Academy of Georgofili in Florence on June 12, 1854**; English certification on June 12, 1854; English patent on December 1, 1857; Piedmontese franchise on December 30, 1857; French patent on January 9, 1858; two Belgian patents on February 10 and 12, 1858; Piedmontese franchise on July 26, 1858; French patent on February 4, 1859; 3 Piedmontese franchises on October 9-14-15, 1861 (with Babacci); English patent on December 31, 1861 (with Babacci); French patent on March 31, 1862 (registered with Matteucci, only); Belgian patent on July 16, 1862 (with Babacci). Compare this with the French patent granted to Etienne Lenoir on January 24, 1860 and the English patent granted to Nikolaus August Otto on August 24, 1863. The former is for a **direct action** engine, which was installed in a motor vehicle only in 1863, and the latter is virtually identical to the one granted to Barsanti and Matteucci. Despite the above evidence, success did not smile at the two Italians, as they were forced to operate in a primitive technological and industrial climate.

## THE STRENGTH OF A VIRTUOUS SYSTEM

On the other hand, the fortunes of Lenoir and Otto-Langen took a sharp turn for the better, since they could **produce and test their engines on a vast scale** by operating in countries that were more advanced than Italy, which was just becoming unified. Brovedani's experience demonstrates that innovation is safeguarded not only by protecting ideas, but also - and especially - by exploiting the strength of a virtuous system which can promote their **industrialization and marketing**.

BROVEDANI GROUP

SPARKS FROM BROVEDANI

# A UNIVERSAL VALUE

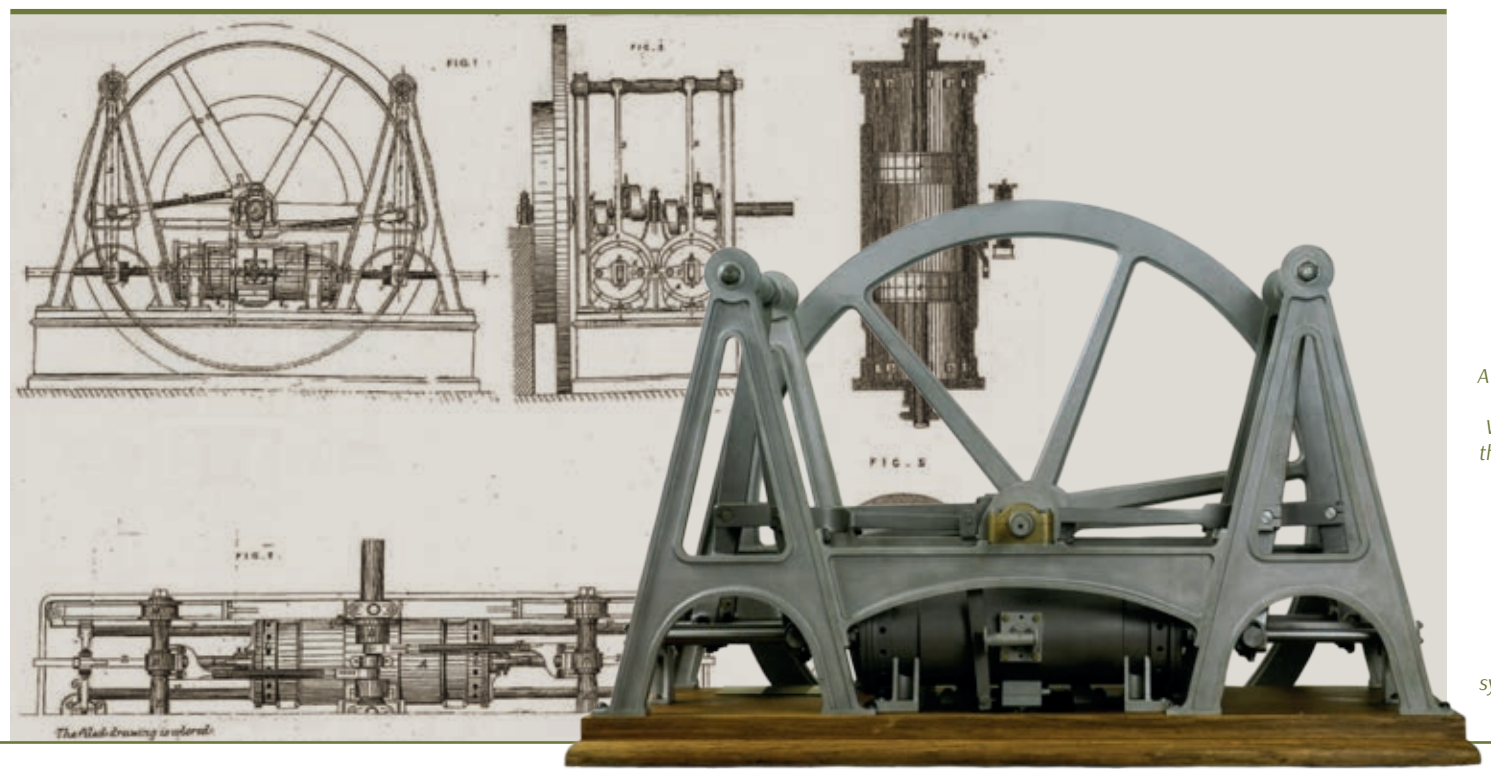
Technical skill alone is not enough. Highly advanced technologies must be brought to the world in a professional, industrial manner. Value must be conceived and certified on a planetary scale. And it must be created with supplementary resources and a predisposition for interaction and mutual integration of diverse business units into a single company with no limitations. Today, Brovedani is helping introduce **direct gasoline injection** on the NAFTA market. Using technology that was conceived, designed and tested in Italy, the company is producing in Mexico an entire series of components created in Germany for direct gasoline injection! Production will be increased **from zero to 10 million pieces in 2015 - in less than 3 years!** It's a **global production system** with world-class precision, quality and efficiency. "Old technologies" are not being exported to so-called "emerging" countries. Instead, production processes requiring the highest levels of skill are being sent abroad, thanks to Brovedani's entirely Italian talent for generating them. What is most important is the ability to transfer experience and technological know-how to the various cultures around the world, and to take advantage of the opportunities that are offered by cultural differences, while minimizing risks. Only in this way can the company's competitive advantage be maintained on its markets.

**Components for direct gasoline injection**

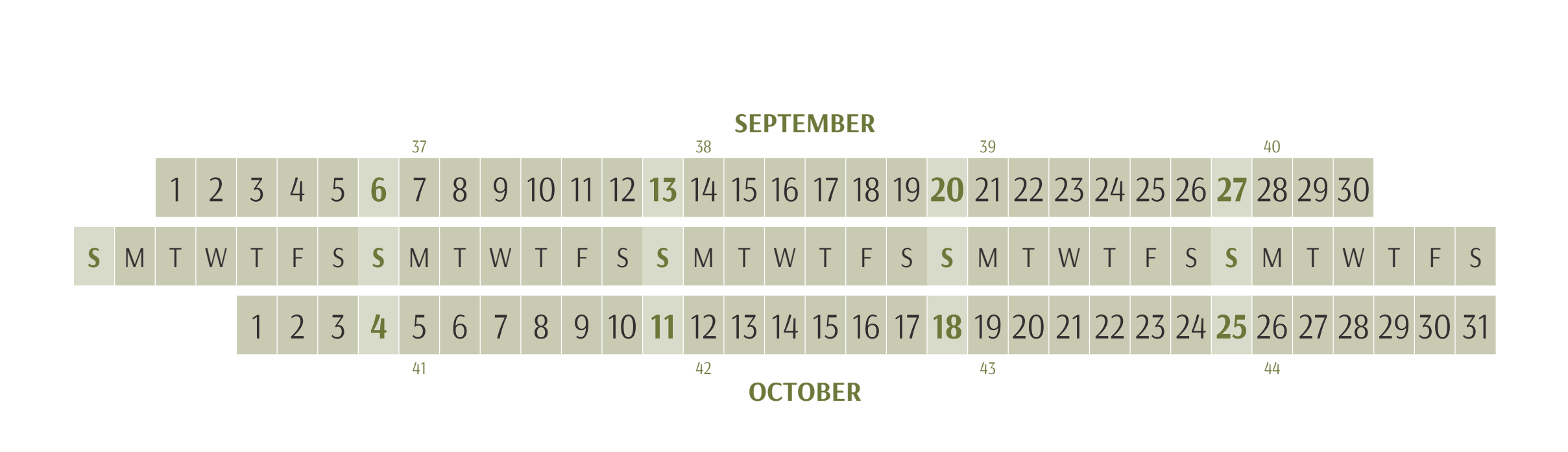
SPARKS FROM B&M

## A "NEW SYSTEM" WITH ADVANCED TRANSMISSION TECHNOLOGIES

In 1861, Barsanti, Matteucci and Giovan Battista Babacci registered a Piedmontese franchise and, subsequently, an English patent for an engine designed according to a "new system". It was an **engine with two cylinders, each containing two opposed pistons**. Its radical innovation was its **advanced transmission mechanics**; the racks and pinions were replaced by a pair of levers with rocker arms that conveyed an oscillating movement to the crankshaft through connecting rods, and this movement was then converted into circular motion by a set of eccentrics. Mounted on the crankshaft were a pulley, which transmitted motion to whatever was being powered, and a flywheel for storing kinetic energy and for enabling the crankshaft to travel past its dead center points.
Construction of the prototype was assigned to Escher Wyss and Co. of Zurich, which completed it in only two months. This two-cylinder 12 HP engine was introduced in 1861 at the 1st Italian Exposition of Arts and Manufacturing in Florence, where was hailed for its smooth, silent operation, as reported in the 1863 Documents of the Royal Institute of Lombardy in Milan: *"It must be said that its drive motion seemed to be satisfactory, since it persuaded many industrialists to ask for it."*



*A reconstruction of the Escher Wyss engine. In the background: drawings from the second English patent issued in 1861, where the new connecting rod/crank transmission system is clearly shown.*

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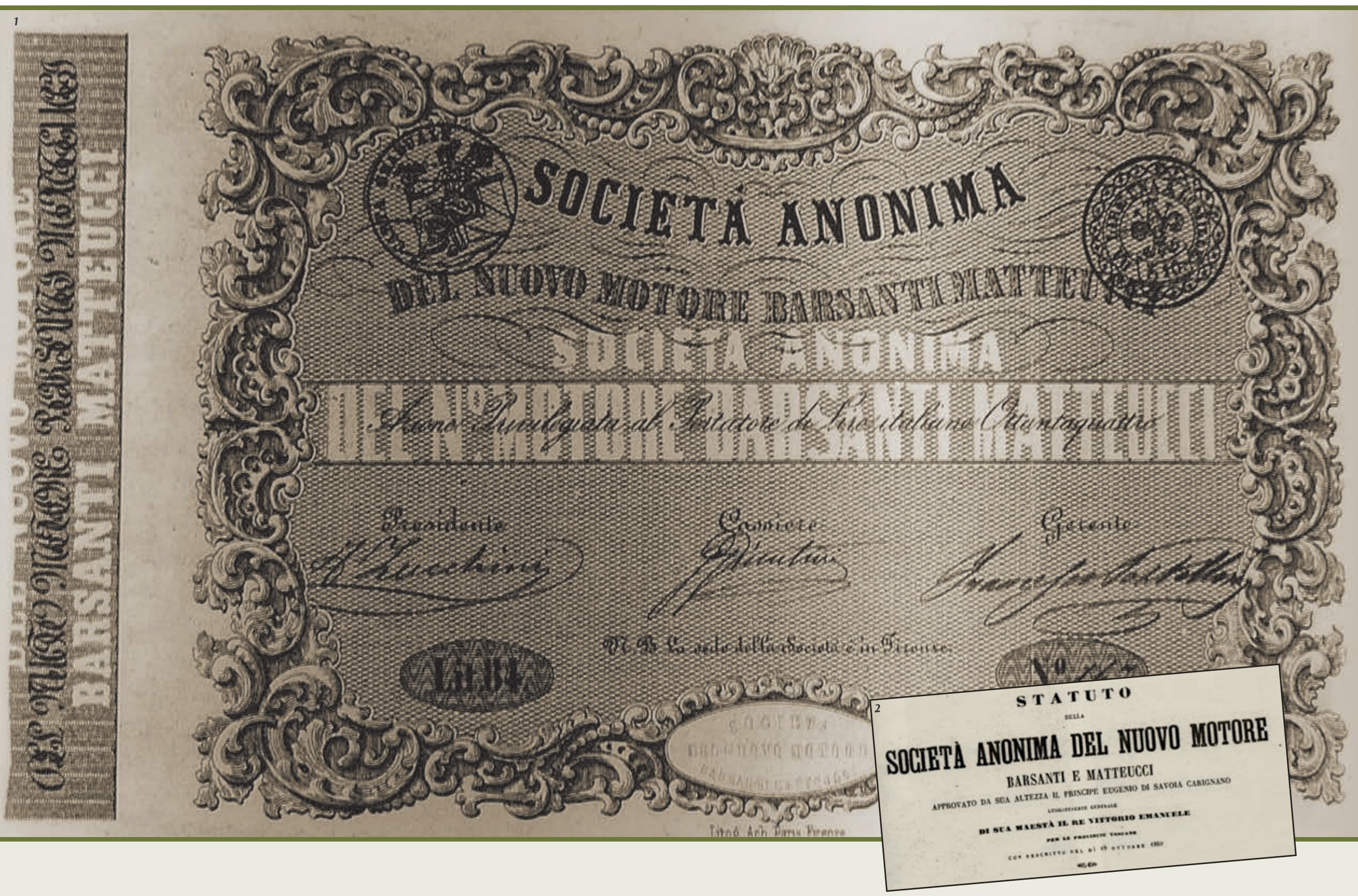



2

# A NETWORK OF TECHNOLOGY AND PASSION

## THE COMPANY AND ITS COLLABORATORS

**T**he story of Barsanti and Matteucci's internal combustion engine, with its "highs and lows", highlights **the importance of "team work"**. A major contribution was made by the cultural *humus* of the *Osservatorio Ximeniano* in Florence, a religious and scientific organization run by impassioned, magnetic personalities such as Father Inghirami, Father Antonelli and Father Cecchi. The second in particular was the mentor of Eugenio Barsanti and the person who arranged his encounter with Felice Matteucci. On the production side, collaboration and exchanges of ideas with machinery manufacturers were of crucial importance. They included the *Officine Benini* factory in Florence (which would become the celebrated *Fonderia del Pignone* foundry), the *Fonderia Calegari* foundry in Leghorn, Escher Wyss and Co. in Zurich, and the Bauer company in Milan. A continouous search for producers who were skilled enough to tackle the complex challenge of industrializatoin in a country were most things were still made by hand led Barsanti to the Cockeril factory in Seraing, Belgium, the town where he eventually died. In Italy as well, the relationship between the partners became stronger and more extensive. On October 21, 1854, the two inventors joined forces to found the *Associazione per la Costruzione di un nuovo Motore*[1], and also established the *Società anonima del nuovo motore Barsanti e Matteucci*[2] on October 14, 1859, which included Giovan Battista Babacci as a collaborator. Father Antonelli and Father Cecchi would also be its technical directors in the future.

## A STRATEGIC NETWORK

**I**t was a process that originated with a personal insight, took concrete form in a magnificent creative duo, and involved a **network of "human resources", "research centers", competent suppliers, and stakeholders** - the kind of "strategic network" that is indispensable to advanced industrial companies, such as Brovedani.

[1] *Association for the Construction of a New Engine.*
[2] *Joint Stock Company for the new Barsanti and Matteucci Engine.*

1. *A share of stock in the* Società Anonima del Nuovo Motore Barsanti e Matteucci *(an original certificate, kept at the* Osservatorio Ximeniano *in Florence).*
2. *Frontispiece of the Charter of the* Società Anonima del Nuovo Motore Barsanti e Matteucci.

# PERFECT TEAM WORK

Producing components for **high-pressure diesel pumps** requires multiple technologies and people with multifaceted skills, in order to reach extremely high levels of precision: **zero discards per million and 20 million pieces produced since 2010**.

When a company must produce complex products requiring ten different operations and six technologies to obtain a result with the necessary functionality, nothing must be left to chance. Each operation must have its own "supplier" in the form of the previous operation, and its own "customer" in the subsequent operation. This sequence must be suitably prepared in every detail, since the integrity of the chain depends on the weakest link...and not on the strongest.

Integration of all technologies and their management in a single work environment with a single team - from process design to production - constitute the added value that Brovedani offers its customers. Such value has earned Brovedani two awards as the world's best supplier, which shows how team work and intersecting skills are the only effective way to confront and tackle highly complex challenges.

Riders and Tappets

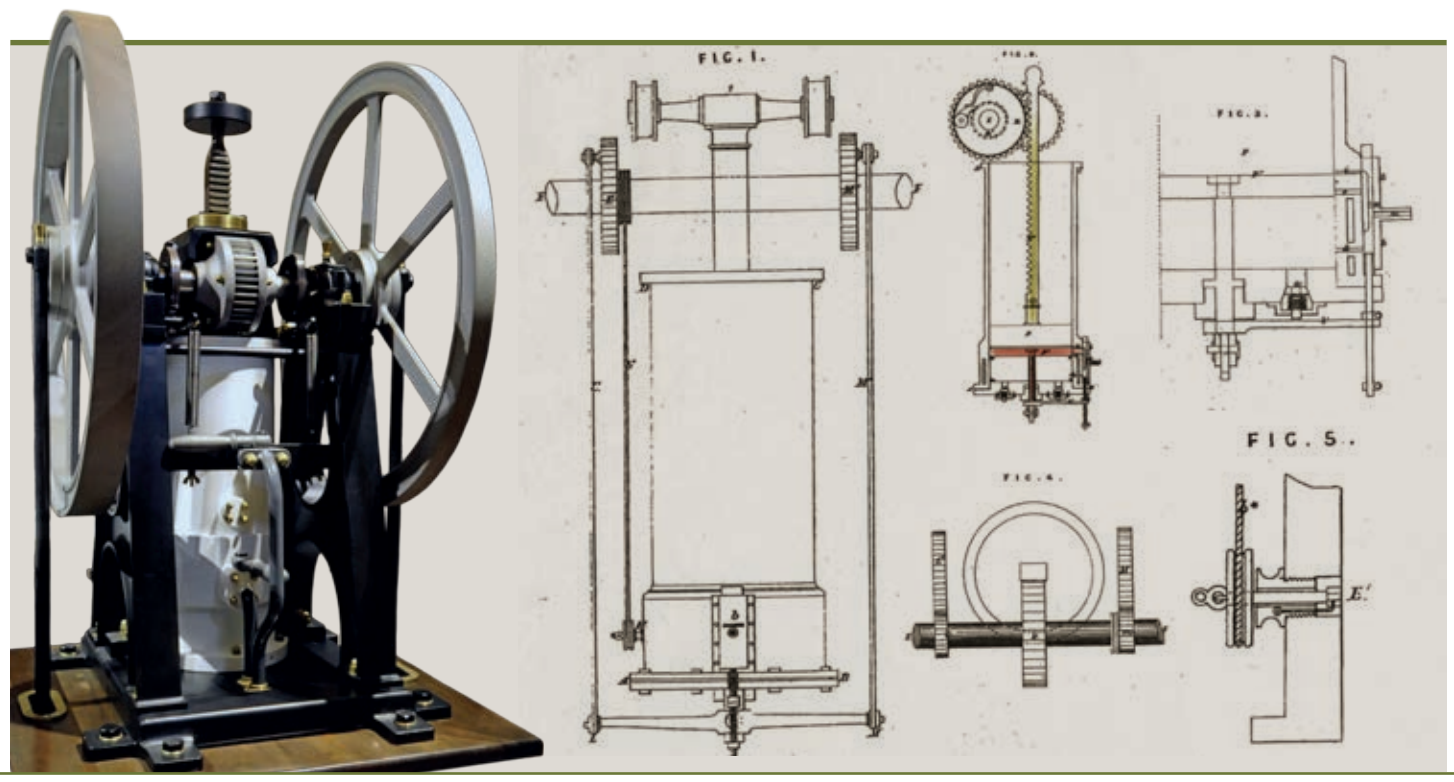
## A SINGLE-CYLINDER ENGINE FOR LIGHT INDUSTRY

On December 1 in 1857, Barsanti and Matteucci registered their first English patent for the invention of a **single-cylinder engin**e with or without a **counter piston** for aspirating the mixture and expelling exhaust products. However, its construction was put off for years, as work was focused on building prototypes for naval propulsion.

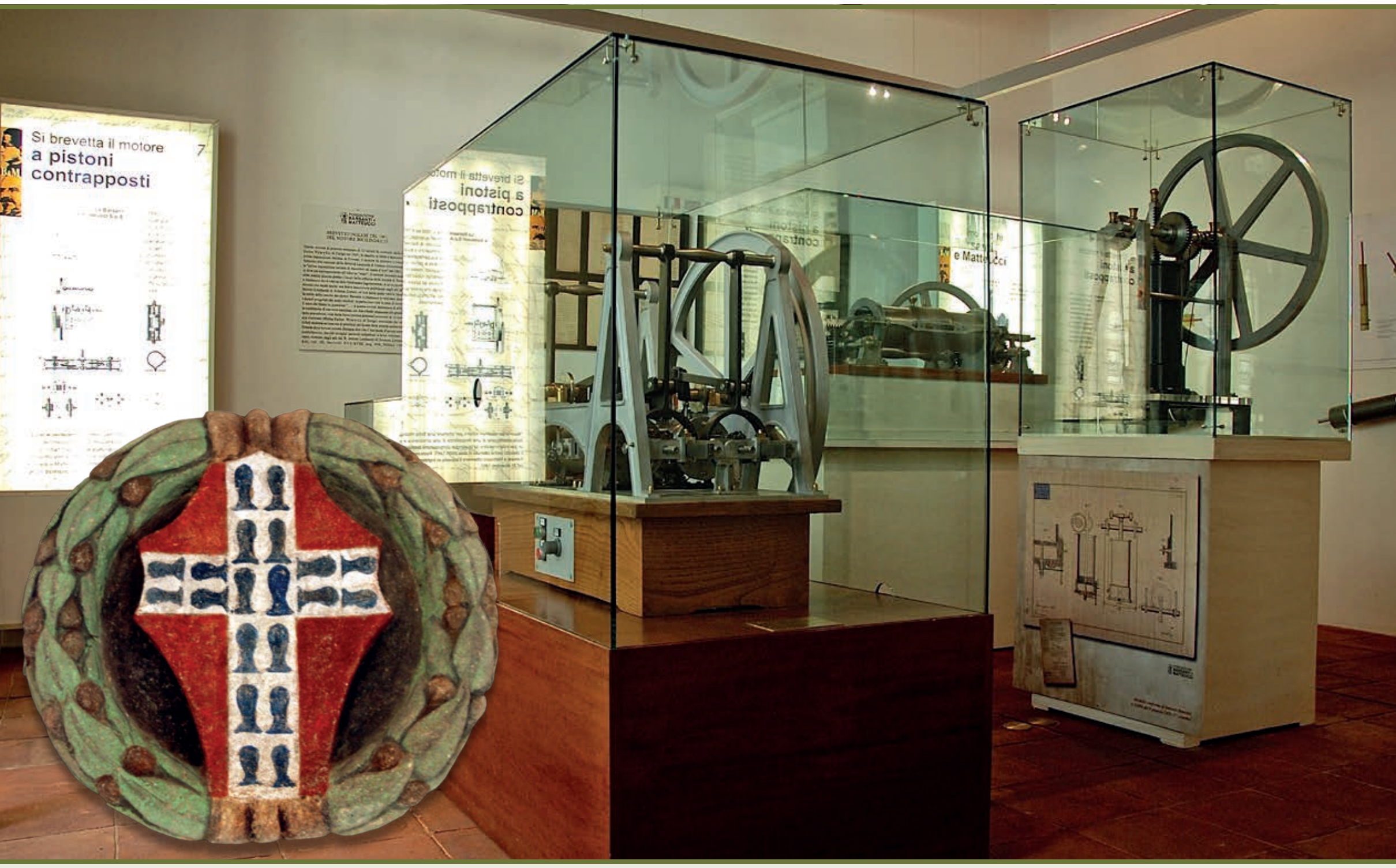
The opportunity to create a light, economical engine for light industrial applications revived the patent of 1857, which was used by the Bauer company of Milan as the groundwork for building a new model: **a single-cylinder engine with counter piston, and with transmission of movement by rack and pinion to a flywheel**.

The Bauer engine was submitted to a commission at the Royal Institute of Lombardy. Its members found that the engine offered better performance than the Lenoir unit and awarded a silver medal to Barsanti and Matteucci. Nevertheless, the two inventors were disappointed; they had rightfully expected to win the highest honor, since they were fully aware of the absolute superiority of their "creature", as underscored by Barsanti in a commercial brochure: *"This official data clearly shows that from the economic standpoint,* ***the ratio of the Italian to the French engine is 0.34 to 2.75; in other words, it uses eight times less fuel****"*.






*A photo of the Bauer engine, which is stored in the historical archive of the Ximeniano Institute in Milan. In the background: a diagram of the single-cylinder engine, with counter piston, from the first English patent. The two pistons can plainly be seen.*




# MAKING THE MOST OF ITALIAN EXCELLENCE

## THE BARSANTI AND MATTEUCCI FOUNDATION

**A**t its headquarters in Lucca – in an old building erected by the Guinigi family, the lords of the city in the 1400s – **the Barsanti and Matteucci Foundation** has been committed since 2003 to establishing the truth about the invention of the internal combustion engine and to exalting the unqualified Italian creativity expressed by the two geniuses from Tuscany. Barsanti and Matteucci must be remembered not only as inventors, but also as men of high moral caliber who consciously devoted themselves to creating a sustainable, practical and safe technology, *"without the prior fuel consumption, final losses, inconvenience and danger of steam."* They viewed it as a technology designed to benefit mankind, as can be gathered from **a letter written by Barsanti to Pope Pius IX**: *"... the thought has consistently enlivened and sustained me that even though my work is aimed at procuring a thoroughly material and earthly gain, it can and must be directed toward a higher and nobler end, in the moral and religious interest of the people..."*. This crystal-clear ethic is mainly based on the altruistic recognition of one's fellows, as evidenced by Barzanti's denial of an assertion that he was the exclusive inventor of the internal combustion engine, which had appeared in an article in the 1858 Almanacco Toscano. The inventor retorted , *"The invention dealt with in the article (...) mutually belongs - in both origin and gradual development - to the undersigned and to his* ***friend*** *Mr. Felice Matteucci of Florence, an accomplished scholar of the physical/mathematical sciences.* ***I make this declaration as a duty to fairness****."*

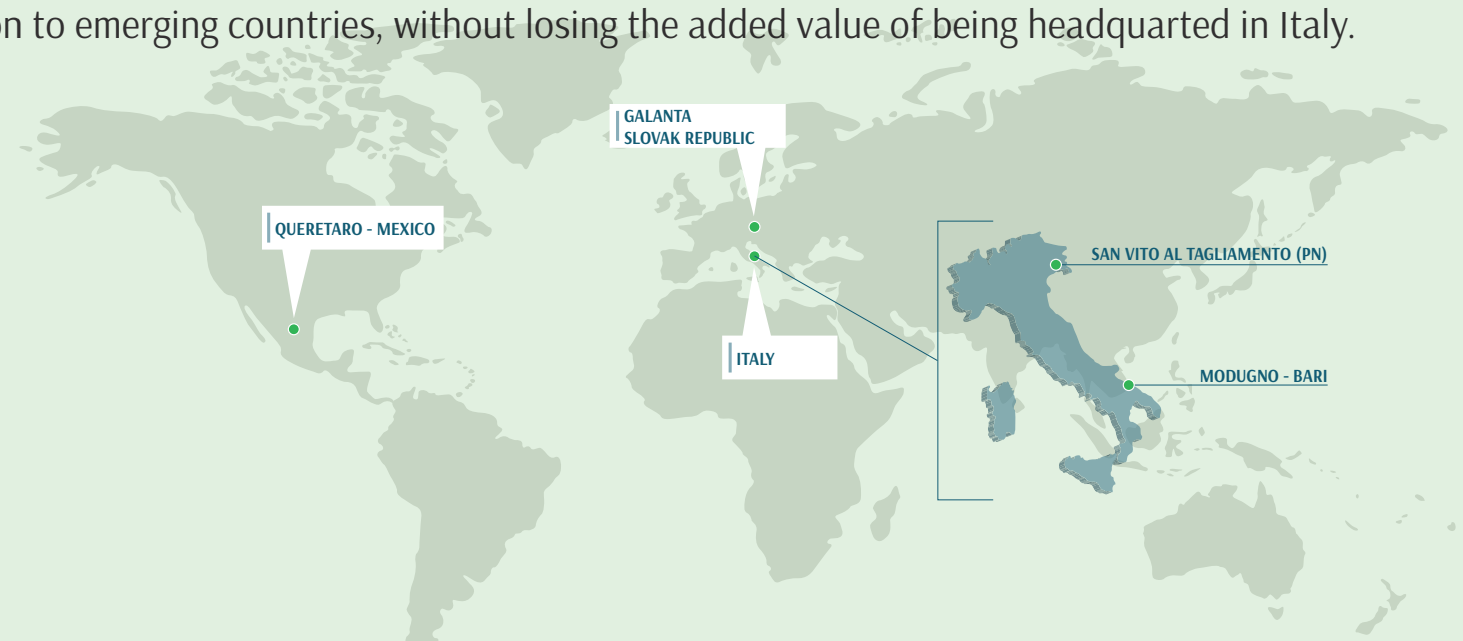
## KEYMEC: LEADING THE WAY

**D**efending and conveying ideas and values is essential to the prestige and the future of a nation, of a society and of a company. Each step forward is based on the awareness, consolidation and transmission of one's excellence in both the technological realm and in other fields. *Leading the way* is a signature characteristic of the corporate culture of Brovedani, which to this end created the **Keymec Center of Innovation, Research and Training in Mechanics** in 2006.

*The crest of the Guinigi family, which was uncovered during a renovation of the permanent exhibit of the Barsanti and Matteucci Foundation in Lucca - a vital guardian of technological history and historical recollection!*

# EXPORTING CREATIVITY

For Brovedani, taking full advantage of "made in Italy" excellence not only means offering the finest products available, but **also involves exporting highly advanced production processes throughout the world** in a competitive, constantly changing sector such as automobiles and internal combustion engines. It's a field that requires increasingly refined technologies for reducing fuel consumption and improving performance, preferably at lower costs. Nowadays, a company must be GLOCAL; that is, it must think globally and act locally. Although technology can be conceived anywhere in the world, it must be applicable wherever the market demands it.
This philosophy is implemented with a strategic localization model consisting of independent, rapidly operating companies located near client companies, but with corporate **headquarters in Italy**: the engine and creative reservoir of the Brovedani network. Its exceptional expertise is available to the entire group, so that nothing from the past is lost, and a great deal for the future is developed. It's a network that is linked to a single SAP information and management system, which keeps trends of individual companies and individual products under constant, real-time control. In less than 10 years - from 2005 to the present - Brovedani has transferred around half of its production to emerging countries, without losing the added value of being headquarted in Italy.



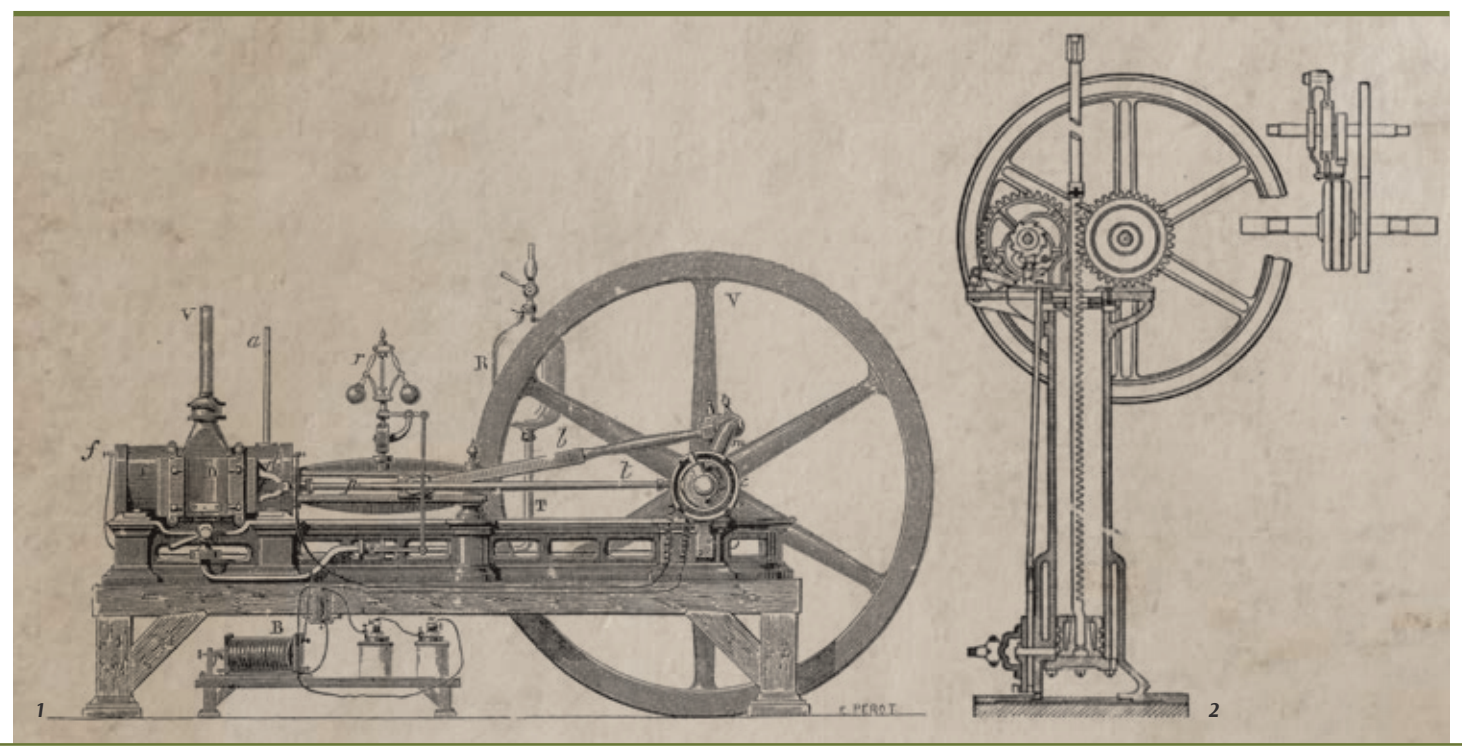



## A STORY OF TECHNOLOGY THAT CONTINUES TO THIS DAY

The story of the internal combustion engine teaches two major lessons. The first has to do with the **value of an idea**, which necessarily depends on the environment that accepts and promotes it. In this regard, the misadventure of Barsanti and Matteucci offers a striking example. The two Tuscan geniuses failed to exploit their revolutionary invention after struggling for more than ten years, in an Italy that was just seeing the light of day. Simply put, the country was untrained and unable to meet this technological challenge. This did not happen to Lenoir in France or to Otto and Langen in Germany. The former was immediately able to manufacture 400 of his direct-action internal combustion engines. The latter had a 1864 patent that imitated those of Barsanti and Matteucci, but could count on the solid industrial terrain of Germany, and their invention was awarded a gold medal at the 1867 Paris Universal Exposition. On the heels of this success, the **four-cycle engine** was developed in 1876, and 50,000 of them were produced in the United States alone over the next decade!

The second lesson is related to the **longevity of a radically innovative idea**. Like an Arabian phoenix, the internal combustion engine continues to be reborn again and again **through successive revisions** that improve and diversify its remarkable operating principle. Four-cycle. Two-cycle. Self-igniting diesel. *Common Rail* diesel injection system... More than 160 years after it was first conceived, the marvelous spark of Barsanti and Matteucci continues to jump more alive (and more perfectly) than ever.





*1. Lenoir's engine (1860)*
*2. A cross-section of the Otto-Langen engine (1867).*