With the eyes of the witness: *Poli's Engine* for the King of Naples

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Abstract: Following the recent retrieval of unknown archival documents, I will discuss in some detail the intriguing story of the so called *Poli's Engine*, that is a steam engine based hydraulic pump developed by Boulton and Watt in Birmingham upon the request of Giuseppe Saverio Poli, who was charged by the King of Naples, Ferdinand IV of Bourbon, to acquire a pump in order to irrigate the fields in his meadow in Carditello. The documents of the Boulton & Watt Collections retrieved in Birmingham allow a thorough reconstruction of the building and functioning of that engine, to which Poli played a direct role. That story unveils that, contrary to what claimed in the literature, the first introduction in Italy of the most important technological innovation of the XVIII century did not take place with the construction of the first steamship of the Mediterranean Sea, but rather 30 years before that, thanks to the incomparable work of Giuseppe Saverio Poli. The tragic epilogue of *Poli's engine* testifies for its vanishing in the historical memory.

Keywords: Giuseppe Saverio Poli, James Watt, Matthew Boulton, Jesse Ramsden, Kingdom of Naples, steam engine, Carditello.

1. Introduction

Among the most important states of the XVIII century's Europe, the Bourbon Kingdom of Naples played a unique and incomparable role for Italy and the entire Mediterranean area during Enlightenment. Indeed, once the that Kingdom became fully independent of the same Bourbons ruling Spain, a number of important plans were developed and carried out, such as the building of novel royal residences, public works and factories. Such projects required the investment of considerable economic resources, which, in addition to obvious architectural aspects, served to solve also important complementary problems such as, for example, water supply.

One of the most important works of this epoch was certainly the realization of the *Acquedotto Carolino* – honoring the name of the Enlighted King Charles III of Bourbon with a building magnificence directly inspired to ancient Romans, as well as to that of the coeval aqueduct built by Louis XIV for Paris – planned to supply with water the *Belvedere di San Leucio*, a Royal Palace near Caserta. Equally important – but certainly far less famous – for the significant works of hydraulic engineering realized was the

Real Sito di Carditello, another Royal Estate built in the second half of the XVIII century by Ferdinand IV near Capua and serving as a farm house. Practically unknown is the key man for such realization, and who was the very author of the introduction in the Kingdom of Naples (and, more in general, in Italy) of the certainly most important technological innovation of that epoch – Watt's *steam engine*. His name is nowadays known practically only to natural scientists (and to few historians of physics), although Giuseppe Saverio Poli was one of the most influential figures of the Kingdom of Naples between the end of the XVIII and the beginning of the XIX century. A well-renowned scientist from the Apulian town of Molfetta, as assessed in a previous work (Esposito 2017) it was just through the agency of Poli that the basic roots of the scientific thought penetrated effectively (and long-lasting) in the most important Kingdom of Italy (and, as recalled above, one of the most important ones in Europe).

In the present paper, we will describe in full detail just one representative example of such penetration of the scientific revolution in the Kingdom of Naples, which is not at all known in the literature. Indeed, the introduction in Italy of the technological prodigy of the XVIII century – the steam engine – is usually dated to 1818, when the first steamship of the Mediterranean Sea was built (again, in the renamed Kingdom of the Two Sicilies). However, as we will see, the steam engine was introduced in Naples just 30 years *before* that event, and the related story is a really fascinating piece of the history of that Kingdom, as well important for the history of Watt's steam engine.

In the following Section, we will give quite a detailed account on the story of Poli's engine, while in Section 3 we describe the technological innovation brought by Watt in that engine. Finally, in Section 4, the tragic epilogue, causing even the cancelling of the historical memory of such episode, is highlighted, along with few other concluding remarks.

2. From England to Italy

The Royal Estate of Carditello, near Capua, was practically a farm for the use of Ferdinand IV of Bourbon, King of Naples. Its origins traced back to 1745, when Charles III of Bourbon (the father of Ferdinand) implanted a horse farm in the forests and marshes of the *Real Difesa di Carditello*. The works for Ferdinand's farm were completed in 1785, but very soon the problem of irrigating the fields of the Royal Estate emerged, and the same Ferdinand IV did not hesitate to assign such a problem to the reliable Court man and scientist Poli, who then immediately thought of contacting an old acquaintance of his in England.

Poli visited England at the end of 1770s (Esposito 2017), especially searching for instrument makers able to provide him with appropriate instruments for the Physics Cabinet of the Royal Military Academy in Naples, including the leading technician Jesse Ramsden (McConnell 2007). According to Boulton, it was just Ramsden that intro-

duced Poli to him,[1] and already in that occasion Poli talked with Boulton about a possible engine to be sent in Naples at the order of the King. However, despite the genuine interest in Watt's steam engine, at that time no "favorable circumstances" emerged for the King of Naples to acquire that technological prodigy. The situation, instead, changed when the Royal Palace at Carditello was completed, and when the effects of the hot summertime of 1786 appeared, Poli promptly wrote to Boulton on behalf of King Ferdinand IV to order a steam engine able to irrigate the fields of the Royal Estate.

At Boulton's later request for further details about the expected working of the steam engine pump for Carditello, in order not to give approximate and hypothetical answers, Poli performed an accurate experiment to determine the quantity of water required for the irrigation of Carditello's fields, thus providing Boulton and Watt with a detailed explanation about the power of the steam engine to employ. On February 27, 1787 Poli wrote:

> The extent of the meadows is four hundred Moggios. One Moggio is $39990^{6/7}$ English feet squares, and it contains 46656 Neapolitan Palms square, and one and 1/6 Neapolitan Palm measures one English foot.
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> The said 400 Moggios are to be divided in eight spots, each of fifty Moggios. One of these spots (that is 50 Moggios) is to be watered each day; so that all the 400 Moggios above mentioned shall be watered in eight days; and, of course, each spot of fifty Moggios shall be watered every fortnight.
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> The Engine is to work fourteen hours a day, as the watering cannot be done but from six in the evening to eight in the morning, the heat of the day not permitting its being continued any longer without hurting the product of the earth.
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> To give you an idea of the quantity of water, which is required for the said meadows I procured to get a standard in this manner. I have made my observations upon a little spot of land of the extent of five Moggios, which are watered once every fortnight; and having applied a large tube of about ten English Inches in diameter to the side of the Canal which leads the little stream employed to water the said five Moggios, I have occasioned all the stream to fall, through the said tube, into a cubical Receiver of 64 English cubic Feet, which was filled up in about 35 seconds of time. Now you must know that such a stream flows constantly during fourteen hours in order to water the five Moggios abovementioned: consequently it will be required ten times as much water for the said fifty Moggios every day; or to say better eight time as much, allowance being made for the difference of the soil, which is not so bibulous, or spongy in the said 400 Moggios. Then you see Sir, what the Engine as mentioned, capable to raise 370 cubic feet of water per minute 27 feet high, is not sufficient for our purpose. However, His Majesty having been informed by me of all these particulars, told me that such an Engine will do very well; and that he does not

[1] Matthew Boulton to James Watt, 26 September 1786. The Library of Birmingham: Birmingham Archives and Heritage. Boulton & Watt Collection: MS 3147/3/10.

> want a larger one, as He intend to water so many Moggios only as showed want the quantity of water, which shall be raised by that Engine.
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> The water raised by the Engine will run about one mile through a canal made of masonry; and then it will be distributed to the several spots of land through other canals disposed in the plain ground, so that the water overflowing from them will water the meadows as above.[2]

Later in the same year, Boulton asked Poli further details about the place where the engine was to be erected, in order to proceed in the best possible way for the preparation of all the necessary and appropriate parts of the engine. Poli provided the required technical details in a letter dated November 26, where he enclosed also two plates containing the section and the plan of the river Volturno with the Royal Meadows at Carditello.[3] He also provided a number of suggestions about where the engine could be erected, how the water of the river conveyed, where the canal built and led, and so on. Poli got fully involved in the business, not only due to Boulton's request, but also for his own interest, which was only barely concealed behind the interest of the King "to be perfectly acquainted".

From February to May 1788, all the pieces required were ordered and produced, and finally an extremely detailed invoice was provided by the Boulton & Watt company.[4] The price to be paid for only "cast iron, hammered iron and brass materials" for the steam engine was at last about 2000 pounds.

3. A double-acting engine

Poli's engine was designed explicitly by Watt, although it shared some standard features with other engines Boulton & Watt built in the same period. The engine, indeed, was based on a double-acting cylinder, where the steam acted alternatively on both sides of the piston. It also included the *parallel motion* mechanism devised by Watt for such engines, where a mechanical linkage with four bars coupled with a pantograph allowed the (approximately) rectilinear up-and-down motion of the piston rod to be transmitted to a beam moving in a required circular arc. Nevertheless, Watt introduced as well some exceptional features in the engine he prepared for the King of Naples, when compared with other engines (Dickinson & Jenkins 1927).

First of all, the working gear had an arbor for each valve (steam, equilibrium and exhaust valves), with the gears of these valves being interlocked. More specifically, the

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[2] Joseph Poli to Matthew Boulton, 27 February 1787. The Library of Birmingham: Birmingham Archives and Heritage. Boulton & Watt Collection: MS 3147/3/518/N03.

[3] Joseph Poli to Matthew Boulton, 26 November 1787. The Library of Birmingham: Birmingham Archives and Heritage. Boulton & Watt Collection: MS 3147/3/518/N09.

[4] Boulton & Watt Invoice, [*sine data*]: "List of the articles belonging to Poli's Engine for the King of Naples – Invoice of Cast Iron, Hammered Iron, and Brass materials for a Steam Engine furnished by Boulton & Watt of Birmingham in April and May 1788, to the order of Joseph Poli Esq. on account and risque of". The Library of Birmingham: Birmingham Archives and Heritage. Boulton & Watt Collection: MS 3147/3/518/N10.

opening of the equilibrium valve was subject to the closing of the exhaust valve, while the opening of the steam and exhaust valves was subject to the closing of the equilibrium valve. The injection valve was, instead, independently worked. The steam and equilibrium arbors each had a detent adapted to engage a pivoted catch, each tending to turn in the direction to open its own valve by means of a weight suspended upon an arm projecting from it. Some leather straps connected the tail of the top arbor detent catch to a lever on the equilibrium arbor and the tail of the equilibrium arbor detent catch to a lever on the exhaust arbor, while another lever on the exhaust arbor to a lever on the top arbor.

When the equilibrium arbor rotated in order to close its valve, thus shutting off the communication between the top and the bottom of the cylinder, the catch of the top arbor detent was released, the top arbor turning by means of the suspended weight to open its own valve and pulling round (through a strap) the exhaust arbor to initiate the movement of its valve. Such movement was completed by the steam pressure on its upper face, while the valve carried with it the exhaust arbor and the attached parts: in such a way, the top of the cylinder was in communication with the boiler and the bottom with the condenser, the down-stroke of the piston ensuing. In the corresponding downward movement of the plug-tree, a chock acted upon the handling arm of the top valve, while another chock acted upon that of the exhaust valve (which were now in their raised positions), thus restoring them in the original position with the top and exhaust valves shut. Instead, when the exhaust arbor rotated by means of a lever and a strap, pulled down the detent catch of the equilibrium arbor, this turning by means of the suspended weight to throw open the equilibrium valve for the up-stroke. As the piston ascended, a peg on the plug-tree engaged the lower side of a handling arm, raising it to close the equilibrium valve: with the arm restored to the position shown, it pulled a strap to disengage the catch of the top arbor detent for the down-stroke.

Injection in the engine was worked by an arm and a rod: the valve was opened by means of a peg on the plug-tree on the underside of the arm, while closed – as the piston began to descend – by chock pressing upon its upper side. The equilibrium valve was opened when the corresponding arbor was released by the rotation of the exhaust arbor; the top gear was released to open the valve by the rotation of the equilibrium arbor, and the exhaust arbor was turned to start the opening of the exhaust valve by the rotation of the top arbor. Finally, each gear was restored to the original position by the action of the plug-tree.

4. Conclusions

The story recounted above, concerning the introduction in Italy of Watt's steam engine, has unfortunately a depressing ending, especially for the history of the Kingdom of Naples. Indeed, "the great fire engine of 3 feet in diameter erected on the Volturno river near Capua, which raised 30 thousand cubic feet of water per hour to 25 feet high, thus feeding a canal extending to Carditello to irrigate those campaigns" was destroyed "for

the disorders of 1799",[5] when the Parthenopean Republic was established during the French Revolutionary Wars, after King Ferdinand IV fled before advancing French troops. As a contradiction that is often repeated in history, the Republican rebels of 1799, who asked the Bourbons for an improvement in their living conditions, saw in that technological progress only a value to be cannibalized immediately. As a consequence, even the historical memory of this first attempt at technological modernization of the Kingdom of Naples was soon lost, and this explains the absence of such an important episode also in history textbooks. These constantly report, indeed, that the first application of the steam engine was realized in Italy only 30 years later, when the Neapolitan shipyards in Vigliena built the first steamship, honoring the same King who introduced the steam engine in Carditello: the *Ferdinando I* sailed from Naples for his maiden voyage to Genoa and Marseilles on September 27, 1818 (Ressmann 2007). It was not a joke of fate that, still in the Kingdom of Naples the steam propulsion had to be introduced, first in the whole Mediterranean.

The beneficial effects produced by Poli's long lasting action in promoting Science in his Country (and even abroad, through his published works) endured well beyond his death, and brought a deserved fame to the Kingdom of the Two Sicilies as the most technologically advanced state in Italy, and one of the most influential one in Europe. Unfortunately, the Bourbons were not so far-sighted to extend such benefits to any social class of their Kingdom, and the destruction of the first steam engine in Carditello was a painful example of that politics, which unluckily produced – in the present case – even the cancelling of the historical memory of that technological prodigy.

Acknowledgments

The very precious collaboration of the staff of the Birmingham Central Library (Birmingham), British Library (London) and Biblioteca Nazionale "Vittorio Emanuele II" (Naples) is acknowledged.

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[5] See the *Rapporto generale sulla situazione delle strade, sulle bonificazioni e sugli edifici pubblici dei Reali domini* (General report on the situation of roads, drainage and public buildings of the Royal domains) in the *Giornale del Regno delle Due Sicilie*, May 3, 1827.

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