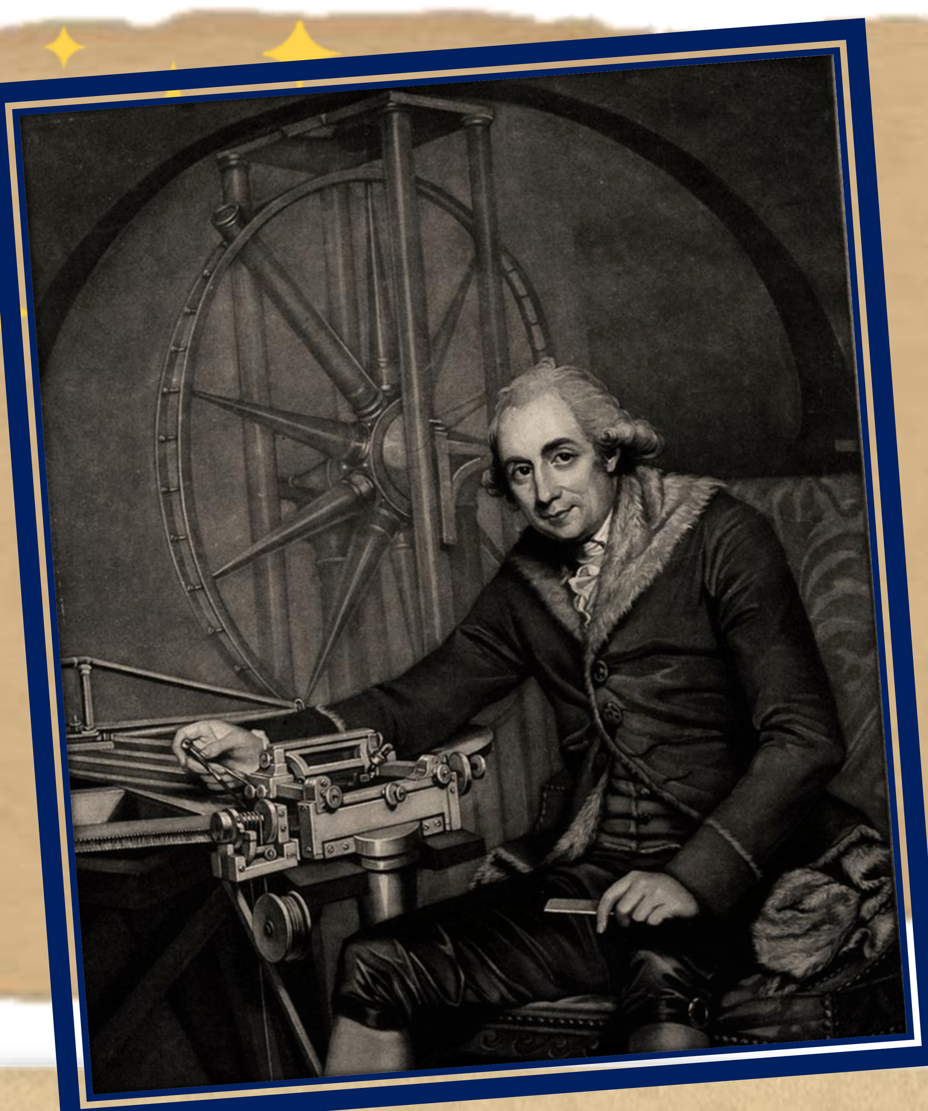


HOW RAMSDEN WENT BEYOND THE LIMITS OF THE TECHNIQUE OF HIS TIME

THE 'IMPOSSIBLE' CIRCLE

Filippo Mirabello, Maria Rosalia Carotenuto*, Aurelio Agliolo Gallitto

Dipartimento di Fisica e Chimica - Emilio Segrè, University of Palermo, Italy

*Contact: mariarosalia.carotenuto@unipa.it

INTRODUCTION

Giuseppe Piazzi (1746-1826), first director of the Palermo Astronomical Observatory, went to London in 1787 to meet the famous instrument maker Jesse Ramsden (1735-1800). He meant to commission Ramsden a state-of-the-art instrument for his program of positional astronomy: a telescope equipped with a large circular scale that would reduce the error in measurements to less than one second of arc. The idea was not new, but no one had until then tried to achieve something similar, due to the technical limits imposed by the technology of the time. Ramsden himself, the most brilliant instrument maker of his century, had previously attempted to build large circular scales but he had to give up discouraged by the manufacturing process difficulties.

At Piazzi's request, Ramsden ended up accepting the challenging commission for Palermo Observatory. Piazzi stayed in London during the construction of the circle, supervising the advancement of the work and "breathing down Ramsden's neck". Ramsden was known for being unreliable in completing his instruments, but in this case, in less than two years, the circle was surprisingly delivered!

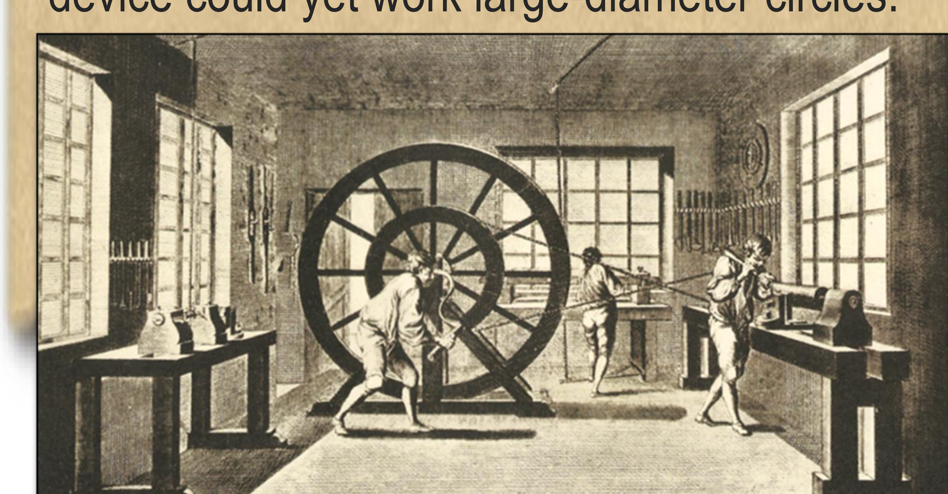
THE CHALLENGES

BUILDING AN ALTAZIMUTHAL TELESCOPE

Before Piazzi's order, Ramsden was already working on circular instruments and testing some technical solutions. The gained experience will certainly come in handy for the new project, but taking on this job was a risk for him. Moreover, Piazzi requested the addition of a 3-ft azimuthal circle to the telescope, which would have been equipped only with a vertical circle.

LIMITS OF THE TECHNIQUE OF THAT TIME

Ramsden worked in a stimulating context surrounded by ingenious inventors and instrument makers, such as his father-in-law John Dollond (1706-1761), Edward Troughton (1753-1835), James Watt (1736-1819) and John Bird (1709-1776). He took advantage of what the technology of his time offered but also actively contributed to its development, thanks to tools and machineries made in his workshop. At that time, no device could yet work large-diameter circles: only in the 19th century, did machineries made for this purpose appear. In 18th century, the machineries had wooden bases and were powered by pedals or cranks that rotated a flywheel, which imparted rotating motion to the workpiece, as shown in the figure aside.



A lathe with a flywheel in a typical late 18th century workshop.

HOW DID RAMSDEN SUCCEED TO MAKE THE CIRCLE?

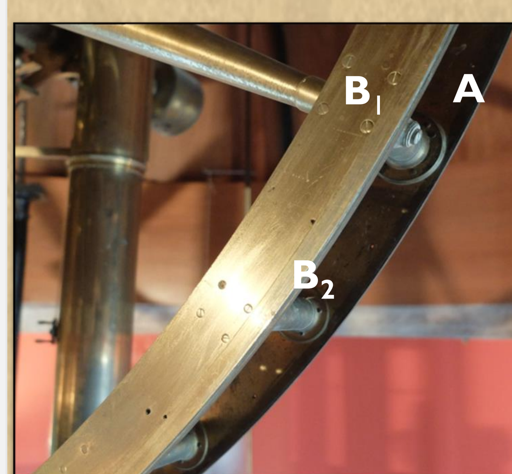
Piecing together the *modus operandi* of the 18th-century instrument-makers is not easy: they preferred to keep the manufacturing processes a secret, for reasons of competition, and prints of the machineries are usually rare. Piazzi, in his writings, says nothing about the circle making, as if Ramsden had imposed silence on the topic: in our opinion, the particular project and Ramsden's personality may justify the above hypothesis!

REVERSE ENGINEERING: From appraisal of the instrument to hypothesis on manufacturing processes

PROCESS MARKS

Filippo Mirabello and Paolo Brenni in Florence, 1990s

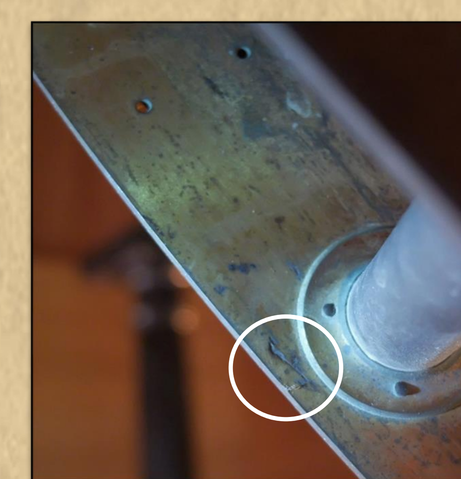
The conservation treatment of the Circle, carried out in Florence in the 1990s, under the scientific supervision of Paolo Brenni, was an extraordinary opportunity to analyze the instrument thoroughly. Some process marks have given us an idea of how Ramsden managed the construction of large-diameter circles.



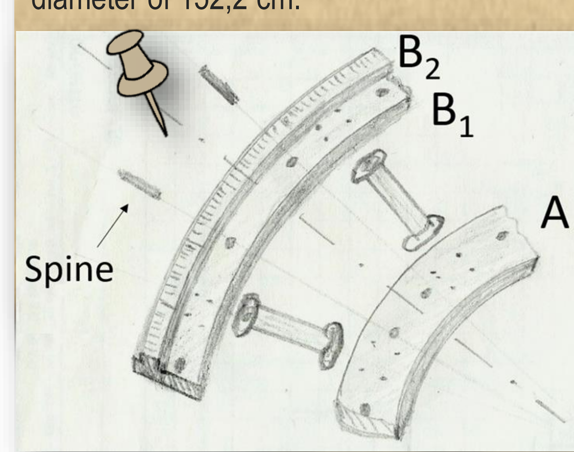
The circles called "A" and "B_1" have a diameter of 152.4 cm, a width of 43,4 mm and a thickness of **3 mm**! B_2 has a diameter of 152,2 cm.

A set of 2 mm calibrated holes are spaced 110 mm apart throughout the whole circumference of both circles, forming a large vertical circle.

Dead-end holes and through holes are also evident.



Dead-end holes and through holes. The white circle highlights a melting defect



Sketch of the vertical circle.

In mechanical constructions, this type of hole is used to insert calibrated brass pins to fix very thin mechanical components that are difficult to handle during the manufacturing process. At that time, no mandrel or alternative systems was available to block such large and thin objects, which confirms the hypothesis of the use of calibrated pins. The other holes would also have been used to fix the piece to a worktop.

OUR HYPOTHESIS

Our hypothesis is that RAMSDEN MODIFIED ONE OF HIS DIVIDING ENGINE to work such large brass circles previously obtained probably by fusion

WHY DID HE USE IT?

Ramsden's dividing engine had a solid and vibration-free structure, perfect for a work of great precision, thanks to its:

- ✓ robust central shaft in ground steel, rotating on a precision bushing, and
- ✓ three rollers, placed on the periphery of the large brass wheel

HOW DID HE MODIFY IT?

- ➢ A worktop with a diameter fitting for the new project was most likely mounted on the engine's 114 cm-diameter wheel;
- ➢ the upper carriage was changed, and, on it, Ramsden put the tools for turning the circles;
- ➢ a rotational motion was applied via a pulley and a flywheel for the machining processes of the circles.

If Ramsden engraved the circle B_2 on this modified engine, it is reasonable to assume that he worked all the three circles on it. The holes detected on the circles back up this theory: they were used to fix the circles on the large revolving base.

Thanks to these modifications, Ramsden was able to engrave B_2: he only changed the tool to engrave the brass and re-engaged the worm on the 2160 teeth of the engine's 114 cm-diameter wheel.

Ramsden with his deeply modified dividing machine.

CONCLUSIONS: Ramsden succeeded in constructing the Circle for Palermo as he went beyond the technique limits of the period thanks to his ingenuity. It was such a challenging task that his successor, Thomas Berge, could complete the Circle commissioned for the Dunsink Observatory (Ireland) in 1808, eight years after Ramsden's death. We have here speculated on how Ramsden managed the construction of large divided circles, but we are sure that it has not yet disclosed all its secrets by now.

BIBLIOGRAPHY:

Chinnici I. et al. (2001). *The Ramsden's Circle at the Palermo Astronomical Observatory*, Bulletin of the SIS, **71**, 2-10

Piazzi G. (1792). *Della Specola Astronomica de' Regi studi di Palermo*, Reale Stamperia, Palermo

Cerchio altazimutale di Ramsden (a cura di M. Coniglio), www.beniculturali.inaf.it

In memory of Paolo Brenni (1954 - 2021)