Lightening the *Furieux*: Engineer Moissenet's Annular Drill

Luc Feron and Ian Sturton

This article is abstracted by Ian Sturton, with permission, from a two-part article on the *Furieux* by Luc Feron in *Marines* magazine[1].

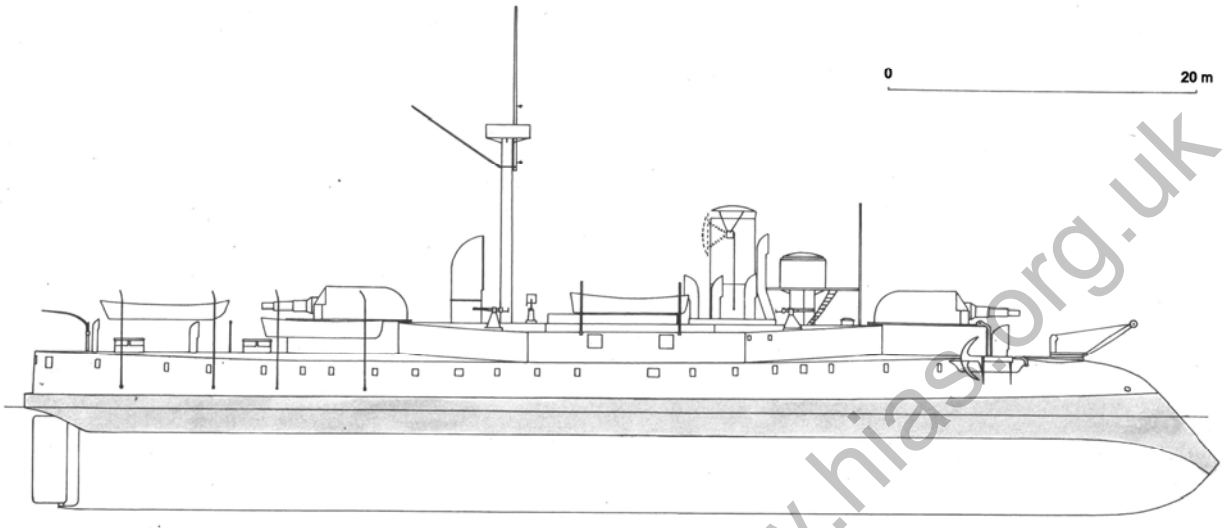


Figure 40. An elevation of the *Furieux* as built showing the armour belt (shaded) from the ram bow to the stern. The waterline is drawn for 80 cm of armour above the water.

The French coast-defence ironclad *Furieux* was built at Cherbourg between 1875 and 1887. She took so long to build because major changes in the armament, machinery and protection, from the original design, were made during construction and these contributed to her being seriously overweight. In particular, the thick, narrow steel armour belt, 50 cm thick, from bow to stern was almost under water under normal conditions. The top of the belt was designed to be 80 cm above water, but by the end of 1892, it was reported to be no more than 20 cm. Above the belt, the hull was unprotected and poorly subdivided. Damage to the outer plating could lead to flooding as the ship rolled, endangering stability. Thus, as completed, the *Furieux* was a vulnerable ship, and, despite the design changes, obsolescent because of the

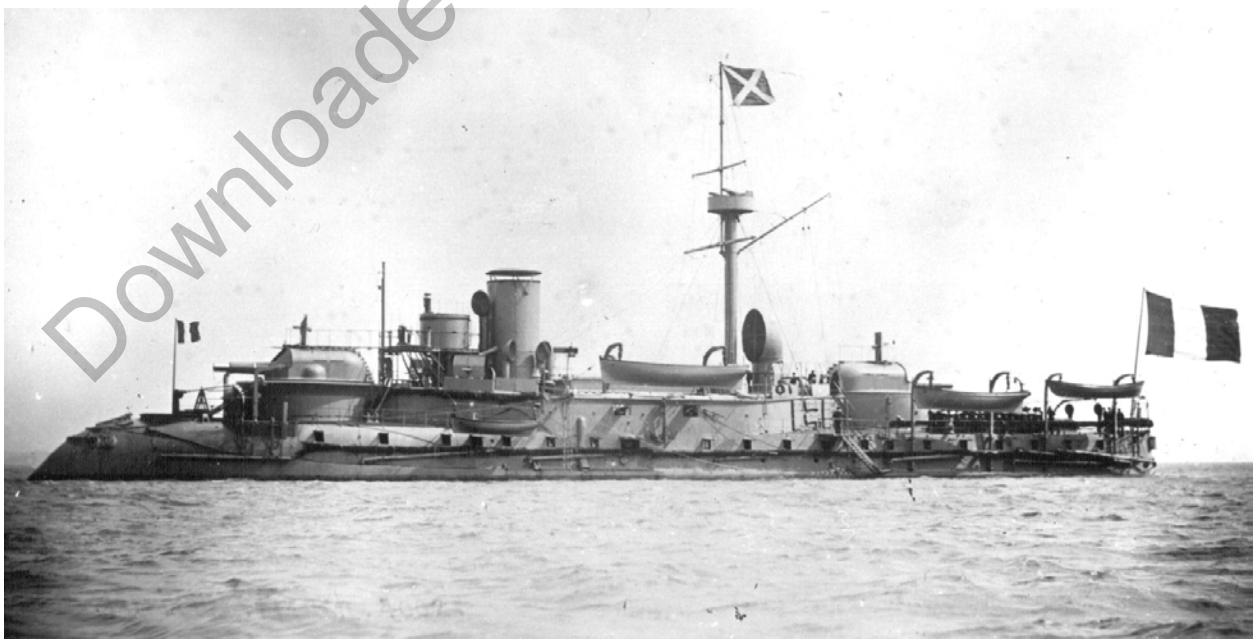


Figure 41. The *Furieux* before rebuilding. She is seen here at Portsmouth on a visit of the Northern Division of the French fleet in August 1891.

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protracted building period. Five years later, she urgently needed modernisation, but any additions of weight would only further submerge the belt and increase her vulnerability. Accordingly, in August 1892 the Minister of Marine issued a requirement for lightening the ship by removing part of her armour.

The initial investigation was entrusted to Engineer Moissenet at Cherbourg. The engineer had a difficult task. Oxyacetylene cutters were many years in the future, so any serious dismantling prior to reconstruction – or actual ship-breaking - was a protracted, labour-intensive process. A few years earlier, it had taken shifts of 200 men working 24 hours a day, seven days a week nearly two years to break up the *Great Eastern*, and the sound of hammers and chisels removing rivet heads, and the wreckers' balls separating rusted plates on the iron hull, made sleep almost impossible in parts of Birkenhead. In an armoured ship, fixing bolts countersunk into the back of an armour plate would additionally have to be drilled out. Moissenet investigated two possibilities in detail: to cut adjacent holes 60 cm in diameter through the armour along the lower edge of the belt, or to drill adjacent small-diameter holes along a line 50 cm above its lower edge to remove the bottom 50 cm of armour. There were two other solutions: the plates could be removed and planed down ashore, or a special machine developed to plane them down *in situ*. These methods would be feasible because the belt was of untreated mild steel, rather than of a hardened steel or compound type of armour. All of these solutions would require a considerable period in dry dock.

Moissenet preferred the first method, which required the development of a special machine referred to by him as an 'annular drill'. A prototype drill was constructed and used for full-scale trials in October 1892 on a spare piece of armour plate. The engineer's report gives details of how the machine operated.

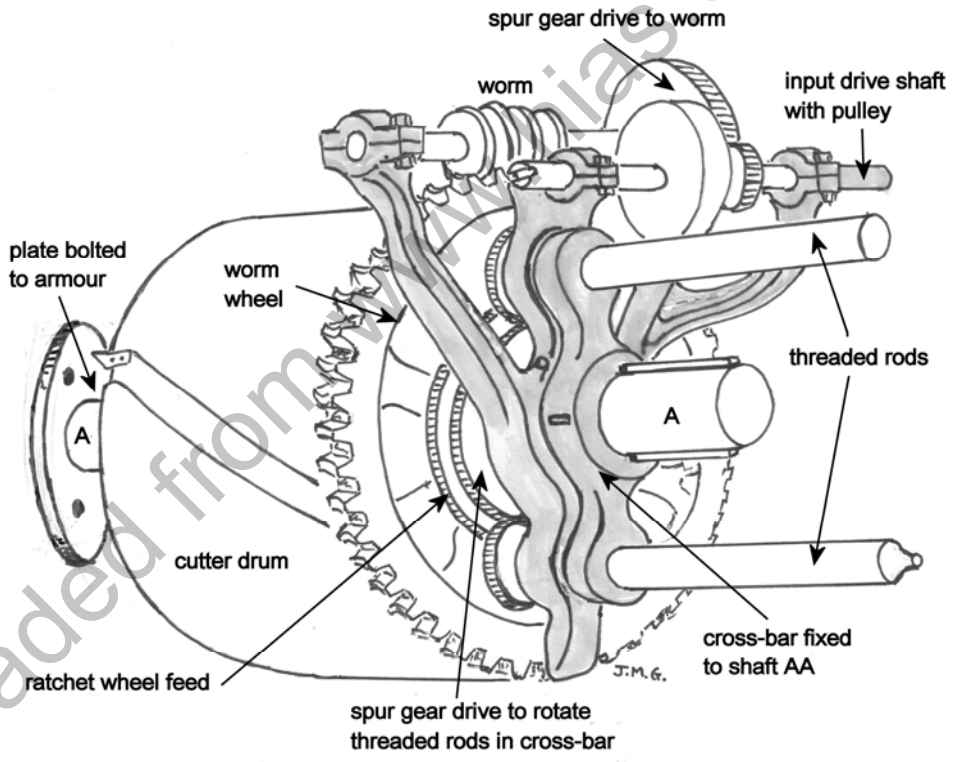


Figure 42. Diagram of Moissenet's 'annular drill'.

'In order to attach the device to the plate which is to be cut, three recessed holes are drilled into the section of plate to be removed and are threaded. These serve to attach a circular plate which has a shaft at right-angles to it, to the armour. The machine turns about this shaft and can slide along it.'

'The frame of the appliance is made of bronze and slides freely along the shaft but is prevented from rotating about it by two longitudinal keys. The means of imparting motion to the cutting head consists essentially of a gear wheel on the same axis as the fixed shaft, fitted to a hub which forms part of the frame. It is rotated by a worm whose bearings form part of the frame and which itself derives its motion via a second shaft and a take-off pulley belted to the power source.'

'The cutting-head holder is a metal ring about 1cm thick bolted onto a cylindrical part integral to the gear wheel. From each cutter there is a spiral groove about 5 mm deep cut into the outside of the ring to remove the turnings.'

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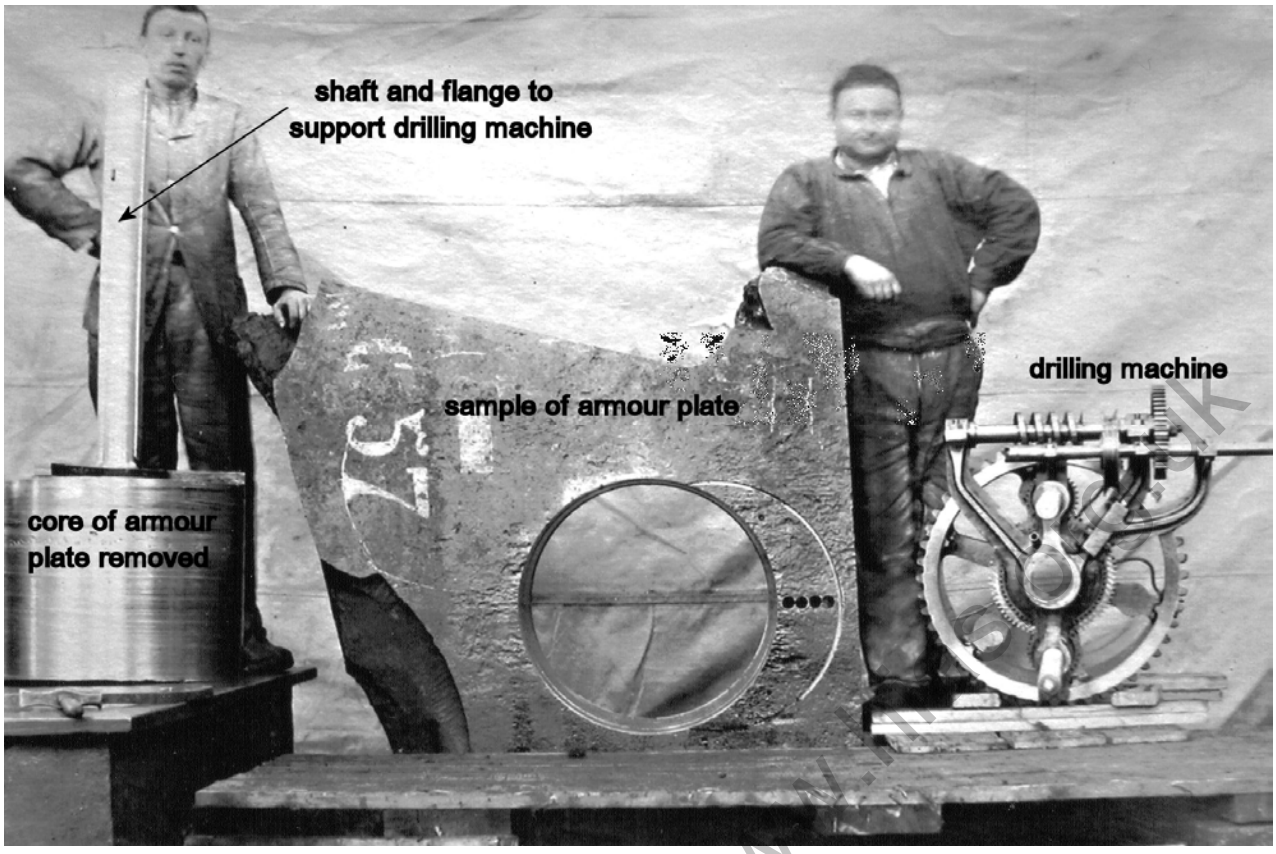


Figure 43. A photograph taken at the end of the trial drilling of armour plate. With the operation completed the drilling machine has been removed from its shaft which has been upended and is shown on the left. The small holes in the armour plate were part of a trial of the chain drilling method.

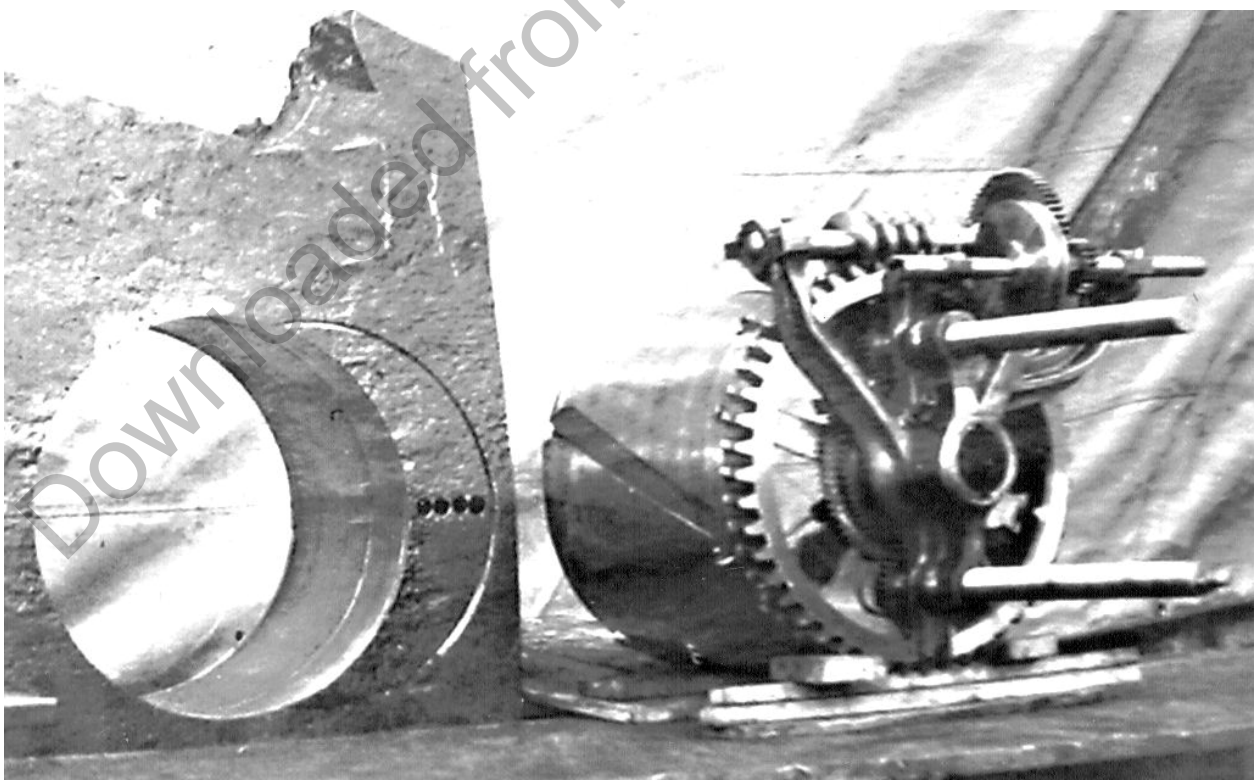


Figure 44. Moissenet's 'annular drill' removed from its supporting shaft after having drilled a hole in a piece of armour plate. The keyways locking its position on the shaft can be seen in the hub of the cross-bar.

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'The appliance advances into the plate by means of two threaded rods whose heads are journalled in the frame and whose threads engage in a cross-piece clamped to the fixed shaft. The rods are rotated through a ratchet feed, both in the same sense, by a pawl off the gear wheel which powers the cutting head. As the rods rotate their threads engage with corresponding threads in the cross-bar, thus moving them forward and communicating their forward motion to the cutter frame. For lubrication, the cutters are liberally sprayed with soapy water.'

The trials established that with improvements the procedure could be used on a ship. A rate of one revolution per minute of the cutting head would be attainable with an advance of 0.15 mm per revolution. This would give a penetration rate of 9 mm per hour. The cut was 11 mm wide. To cut a hole 45 cm deep through the armour plate would take 50 hours of actual work. If work continued night and day, allowing 15 hours of actual work per 24 hour period, the other 9 hours being used for maintenance and sharpening of the cutters, the drilling of one hole would take 3½ days. As the total number of holes required was estimated at one hundred, it would take a year to do the work, or 35 days if ten drills were available. In dockyard terms, the operation would require the employment of 40 men for three months.

Moissenet's superior, Engineer Champenois, agreed with these calculations, but preferred the second method, of drilling a line of small holes. This would require the development of a multiple drill allowing a number of holes to be drilled simultaneously. Following the good results obtained by the annular drill, yet a further method of removing armour was suggested: it consisted of drilling one 60 cm hole at each end of each plate, and joining up the holes by a straight cut with a planing machine. A paper battle ensued.



Figure 45. Another view of the *Furieux* at Portsmouth in August 1891. In this view the ledge at the top of the armour belt can be seen almost at the waterline.

The Engineers' suggestions did not meet with the approval of the distinguished naval constructor Emile Bertin, the new *Directeur du Matériel* for the French Navy. Reviewing the files in March 1895, he concluded that proposals which might involve the construction of up to three different special machines implied poor project control by the management. In addition, the effect of the lighter armour belt on the ship's stability had not been studied. In any case, lightening the ship was only a part of the extensive work

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that would be required. Full modernisation would also mean new boilers, possibly new engines and very probably replacement of the main armament, resulting in considerable additions and subtractions of weights. By May 1896, work on removing the side armour had still not started. Returning to the problem, Bertin pointed out that, apart from considerations of stability, if the ship were to be returned to her original design draft with 80 cm of the armour belt above water, the reduction of the width of the belt to 1.75 m would leave her with inadequate protection below the waterline. In fact he calculated that with lighter big guns in closed turrets, new, lighter and more economical water tube boilers, new cylinders to utilise the higher boiler pressure, a reduced fuel load and other minor economies, no side armour need be removed.

While the debate progressed, the *Furieux* followed a typical late 19th century peacetime routine, swinging around her moorings at Cherbourg, periodically in dock at Brest, or on an occasional sortie to other French Channel and Biscay ports. One major event in her life helped to make history. As a unit of the Northern Division under Admiral Gervais, she participated in the celebrated visit of the French fleet to Kronstadt in July 1891. This visit was the public prelude to the Franco-Russian agreement signed on 27th August 1891. On its return journey, the Northern Division called at Portsmouth between 19th and 26th August, where the representatives of France were received by Queen Victoria.

The *Furieux* was eventually rebuilt in leisurely fashion between 1900 and 1904 along the lines recommended by Bertin; new Belleville water tube boilers, new cylinders to convert the engines to triple expansion working and new big guns. After the years of discussions, and modifications which had cost upwards of 2 million francs, she spent her remaining career in reserve or as a depot ship, with not so much as a single day as part of a naval force of any kind. Condemned in 1913, she sat out the 1914-18 war at anchor and sank at her moorings at l'Auberlac'h near Brest on 16th November 1920. Although lying at a depth of just 12.5 m, with the superstructure only 1.2 m below the surface at low water neap tides, she was not refloated. The wreck is marked on current Admiralty charts. Details of the ingenious annular drill were allowed to gather dust in the files for around a century before (unlike the ship itself) again seeing the light of day. The fate of the actual drill is not known; it might have been preserved in the naval museum at Cherbourg, but, as this was destroyed in World War 2, it is most unlikely still to exist.

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[1] The original article by Luc Feron appeared in *Marines* magazine, issues 29, September 2002, and 30, January 2003. It was translated and edited by Jean Roche and reprinted in *Warship International*, issues 3 and 4 of Vol. **40**, 2005.

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