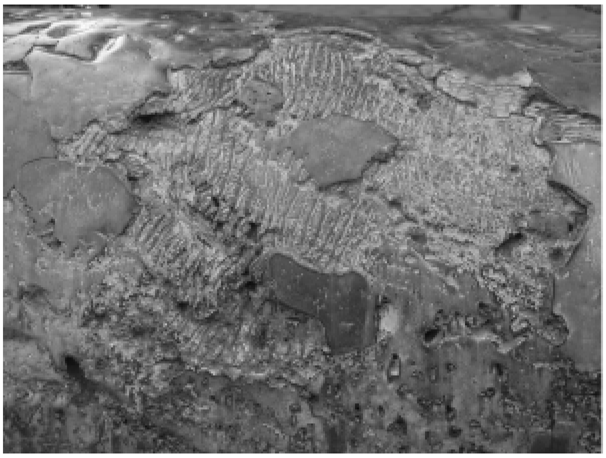
Section 6: 18th Century Gunfounding

SOJ-6(22)
'Screws', or tricks of trade: secret repairs of solid cast cannon by Jan Verbruggen

By Drs. J.R. Verbeek, the Netherlands

The process of manufacture of ordnance can be considered a very delicate one, requiring a highly skilled craftsmanship of all those involved. This article will concentrate on the secret repairs conducted by the Dutch gunfounder Verbruggen of his solid cast bronze guns.

When his tricks were unveiled a row arose, leading to the premature dismissal of Verbruggen as state gunfounder (*Lands geschutgieter*). He then went into the service of England. There are many doubtful circumstances surrounding this case, as research initiated by Jan Thade Semeijns de Vries van Doesburgh has proved. However, until recently, it was thought that the Verbruggen case was local to the Netherlands and that the 'political troubles', leading to Verbruggen's downfall were over once he became master of the Royal Brass Foundry in Woolwich. Then in SOJ-4(11) Tim Mahon presents a part of Favé's *Histoire de l'artillerie* in translated form: '*Discussions on the Gribeauval System'*. The article mentions a test firing of two 12-pdr cannon, when screws came out of the bore and muzzle. These cannon were found unsuitable for service and in order to indicate this status the dolphins or handles were broken off[277]. When translating the French text, Mr. Mahon was puzzled by the meaning of '*vis'*[278]; I was startled[279] by the fact those screws, used for secretly repairing faulty bores, are also associated with the French gun-founder Maritz, or at least practiced in France, since screws, hundreds of them, were the main reason of Verbruggen's problems. The first conclusion to be made is that repairing cannon with screws was a well-known trick practiced by a greater number of gun-founders than previously thought.




It was difficult to cast a good quality bronze gun and gun founders who were confronted with impurities preferred to repair those guns rather than recast them.

In the 17th century an unnamed Javanese gunfounder cast the 'Kjai Pantjawoera' and then made these extensive repairs, showing a wide variety of techniques, undoubtedly also known by Jan Verbruggen, like the dented patches, seen on the photo on the left. Incredibly the gun was actually fired in anger against the Dutch. Today the gun is displayed near the Sultan's Palace, Surakarta, Indonesia.

[Photographs: J.R. Verbeek.]

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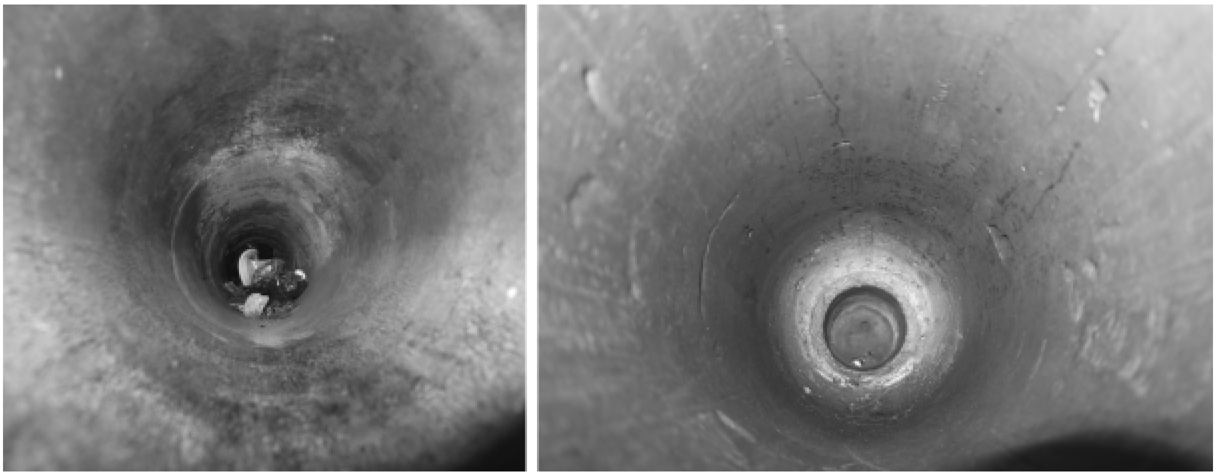
277 In the 18th century it was common to brake off one or both of the dolphins or handles to indicate that a cannon was found unsuitable for service. This action was clear for all, without any paperwork.

278 Tim Mahon: Discussions on the Gribeauval System,SOJ-4(11). In: Smoothbore Ordnance Journal, p. 60 and footnote 172.

279 In preparing this article I found a note by Bentinck, dated 19 December 1763, in which is stated that in France gunfounders caught utilizing screws and patches for secret repairs were fired and 'chased away'.



Two photographs showing the bore of a gun.

LEFT: The bore of a 24-pdr cast in the traditional (hollow) way by the Dutch gunfounder Coenraet Anthonisz at The Hague in 1599. This is what an proofmaster or artillerist liked to see: a smooth, flawless bore. The gun in question was given in 1616 by the VOC to the Sultan of Mataram. Today the gun is displayed near the Sultan's Palace, Surakarta, Indonesia.

RIGHT: An early Dutch howitzer, cast by Johannes Niepoort at The Hague in 1693. Several impurities can be seen (however some of these are the result of prolonged use). The howitzer is in the collection of the Dutch Army Museum.

[Photographs: J.R. Verbeek.]

Problems with Dutch gunfounding

From the 1740's the Dutch gunfounding was in crisis. For years, The Hague gunfoundry (the largest foundry in the Netherlands) produced cannon of inferior quality. There were many reasons for this: mismanagement by incompetent and possibly corrupt gunfounders, like Adriaen and Cornelis Crans and their heirs (Jan Crans), who took over operating the foundry. Also, there was an accumulation of technical problems at the Hague Foundry, concerning the quality of raw materials, the quality and composition of the gun metal, the smelting-furnace and the vertical boring machine. To the dismay of the Colonel of Artillery Glabbeeck even deformed cannon were accepted. In order to stamp out corruption the States of the Province of Holland[280] issued on 20 January 1741 new regulations for proofing of cannon.[281]

Gun founding was done in several phases, every one of them presented specific risks that influenced the quality of the finished product. According to the regulation of 1741 every single gun was closely inspected and proofed, as general samples were not reliable. In consequence the inspection and proofing had to be conducted in a non-destructive manner. As a rule a new gun was first inspected optically and measured, then the interior of the bore was closely inspected, followed by an inspection of the consistency of alloy and quality of the metal. Finally the gun was proof fired. The ultimate proof at that time was the waterproof. For this the vent was closed and the cannon placed at an angle, then the bore was filled with water. With a close fitting sponge the water was compressed. Any spongeousness or fistulas were revealed by the water seeping out. In order to prevent corruption the inspection and proofing of new guns was done by independent proof masters, using their own gun powder and equipment. In the 18th century both production and proofing were closely observed by expert artillery officers, who reported directly to the Inspector General of Artillery on any relevant circumstances, like weather conditions, weight of charges, observations made etc.

From then on Major-General Leonard Stephen von Creutznach, as Inspector General of Artillery, introduced many reforms. He clashed with Jan Crans when it was discovered that Jan secretly repaired his guns prior to proofing[282] and 25 tons of gun metal was missing. Also the construction of a new smelting-

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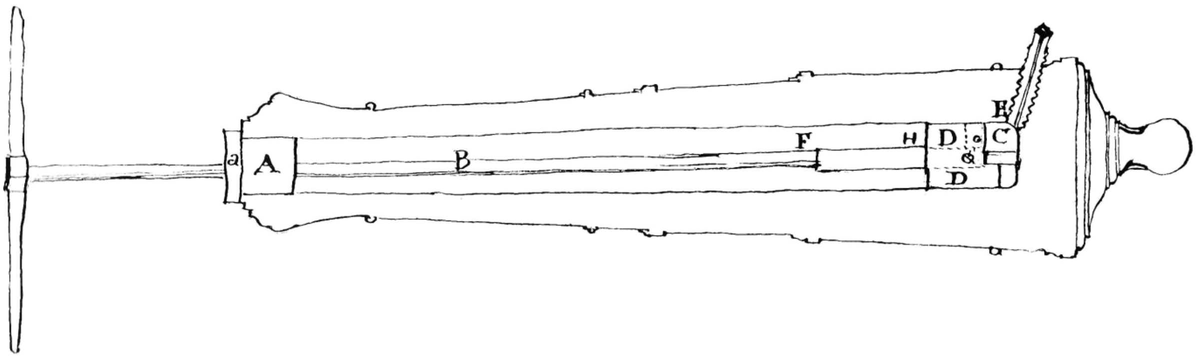
[280] The Raad van State was a state organ, that regulated at state (national) level all military matters, including artillery and fortification. The Provinces covered the same subjects on provincial level. This resulted in ordnance of the States General co-existing with provincial ordnance. From 1772 the ordnance of both the States General and the Province of Holland adhered to the same pattern; those of the Province of Zeeland joined in the 1780's.

[281] National Archive The Hague, inventory 1.10.96: Archive Van Hees, No. 57.

[282] Usually the proofing of guns was done quite some time, sometimes several months, after delivery of the castings by the gunfounder. Finishing of the guns was done after passing the proof. The guns awaiting proofing stayed during that time unattended at the foundry, giving the gunfounder ample time to make repairs, in order to hide any production flaws.

furnace was under suspicion of corruption. As result on 24 February 1755 Jan Crans was fired as state gunfounder.



Instrument for cutting off the copper vent-screw associated with the Verbruggens give an indication of the construction of the secret tool used by the same to repair the bore of guns.
[Source: C. de Beer [ed]: The art of gunfounding, p. 201.]

A new era of Dutch gunfounding (I)

In 1715 the gunfounder Johan Maritz introduced the horizontal boring machine at Burgdorf in Switzerland. With help of this machine the bore of a solid cast cannon could be bored more precisely than previously with a vertical boring machine. This was due to the fact that in the new construction the cannon turned around while the drill remained fixed. External turning and finishing could also be done with the Maritz machine. The production time was reduced drastically: from 6 days with the vertical boring machine to 2½ days with the horizontal boring machine. Of course Maritz was keen on keeping his machine secret in order to make profit on his patent. Only through Maritz sons the new technique spread into France and Spain. Johan Maritz succeeded for many years keeping his invention out of the hands of others, but the better quality of the guns produced with his machine did not go unnoticed in the Netherlands. Solid casting and vertical boring was already in widespread use; conversion to the better suited horizontal boring machine was a matter of time. According to De Beer it was Jan Crans who in 1725 rejected the introduction of the Maritz horizontal boring machine, but he gives no particular reason why Crans adopted this view[283]. In 1747 the States of the Province of Holland decided to introduce the Maritz production system and ordered Major-General Von Creutznach to implement the new technology.

Obviously the present state gunfounder Jan Crans lacked the knowledge to make the conversion to the horizontal boring method. Von Creutznach then consulted the other Dutch gunfounders who worked for the VOC and Admiralties. Their negative reaction was interpreted by later historians as extremely cautious, or even reactionary, but there is a reason for this. There was no 'officially authorized' technology transfer by Maritz, but instead one of his former employees had offered his knowledge for sale. This was Johan Jacob Siegler, who had worked as boring-master at Douai. Although he knew his job well, several details of the Maritz machine were unknown to him, as the design of the machine evolved in due time. Finally Jan Verbruggen, a young ambitious gunfounder, working at the Enkhuizen gunfoundry, promised to fulfill the Major-General's request[284]. The transfer from the insignificant Enkhuizen gunfoundry to the State gunfoundry would give him rise in prestige and income. In 1754 Von Creutznach recommended Jan Verbruggen for the post of gunfounder. Princess Anna, a daughter of King George II, then acting regentess for the future Stadholder Prince Willem IV, personally supported the candidature of Jan Verbruggen. Many years later this relation proved to be very usefull to Jan Verbruggen, paving the way to yet another career movement[285].

The introduction of a new production method was carefully planned: first Jan Verbruggen had to prove his abilities by producing four short 3-pdrs using the horizontal boring machine, set up at the Enkhuizen gunfoundry. When the quality of those four guns was found excellent, Jan Verbruggen was on 24

[283] C. de Beer [ed], *The art of gunfounding. The casting of bronze cannon in the late 18th century*. Rotherfield, 1991, p. 4.
[284] National Archive, The Hague, inventory 3.01.24: Archive of Pieter Steyn 1749-1772, No. 167: *Memorie van de controlleur Redelijkheid houdende een conversatie met den Generaal-Majoor Von Creutznach.*
[285] P. Opperdoes Alewijn, "De geschutgieters Verbruggen,"In: De Navorscher, New Series, Vol. 4, 1871, p. 235, 236.

February 1755 appointed gunfounder in the service of the States of the Province of Holland, followed by his appointment to State gunfounder on 23 September 1755[286]. When settling in the Hague Jan Verbruggen started the construction of the new boring machine with help of Johan Jacob Siegler. A bronze commemorative plaquette was made, with a latin text, stating that Jan Verbruggen and his son Pieter had built the horizontal boring machine at the Hague in 1757. In his book De Beer compares the Verbruggen machine with the original Maritz design and draws the conclusion that Jan Verbruggen 'must have been at a loss as regards the forces to be expected during boring operations'[287]. The murky and improper transfer of technology by one who indeed had worked with the Maritz machine, but lacked real understanding of its design and working, was taking its toll. However Jan Verbruggen himself was a well educated engineer, who designed specialized equipment to overcome problems caused by the unfamiliarities of his doubtful informer.

Seeds of conflict

Another unwelcome inheritance was the smelting-furnace, imperfectly made by his predecessor Jan Crans under personal instruction of Von Creutznach. As the solid casting required more metal a larger capacity smelting-furnace was necessary. In 1759 Jan Verbruggen constructed a new smelting-furnace of his own design during the absence of Von Creutznach, who obviously was not pleased. De Beer remarks on this: 'When he [Von Creutznach] returned in 1760, he found that 'his' furnace in the Foundry had been torn down, and replaced by one of Jan Verbruggen's own design. Thereafter De Creutznach, mortally offended, relentlessly sought the destruction of Jan Verbruggen'[288]. In the ensuing conflict the production of the gunfoundry came to a complete standstill for nearly ten years.

In human resources management it is an adagium never to thrust someone who has betrayed his former employer. When he regarded his further employment of limited value Jan Verbruggen in 1760 fired Johan Jacob Siegler, an act Jan was to regret. On 24 January 1761 Johan Jacob Siegler wrote a letter to the Raad van State, revealing inside information on the secret repairs made by Jan Verbruggen to hide the defective quality of his guns, pointing to a specific batch of twelve 12-pdrs. The newly introduced production method caused new risks for the quality of the castings. The solid casting involved a larger quantity of molten metal cooling down in the form. Unevenly cooling from the outside caused problems to the composition of the bronze in the centre, as the tin component tended to crystallize within the alloy, forming local tin concentrations impairing the properties of the gun metal. The worse part in the centre of the casting was partly drilled out during the boring process, but inevitably some impurities were left in the wall of the bore. These could be in the form of cracks, cavities, holes or tin concentrations and were considered reasons to reject a gun. The larger or thicker the form, the more the problem of uneven cooling played part. For this reason the French were in 1764 the first to reintroduce the hollow casting method for mortars[289]. The solution of a regulated cooling process and a heated feeding-head was not introduced before the end of the 18th century. Confronted with flaws in the bore of his guns Jan Verbruggen decided to make repairs. Most gunfounders made repairs, but usually not prior to proofing of the guns. Jan Verbruggen used a virtual invisible way of repairing guns and he did it prior to proofing.

Alarmed by the accusations of Johan Jacob Siegler the Verbruggen guns were carefully proofed, but no defects or repairs were detected. It was realized that a destructive proofing method was necessary. Two 3-pdr guns were sawn through in order to check the quality of the gunmetal. In the mean time Jacob Spithout, another former employee, who was fired by Jan Verbruggen, made more accusations about malversations with regard of solid cast bronze mortars. In 1764 those mortars were proofed by the Artillery officers Martfeldt and Mooser. When they found nothing Spithout indicated the presence of more than 200 screws and patches, which he had placed himself in one of the mortars. Von Creutznach then concluded that Spithout had lied, because in his earlier accusations he had mentioned the presence of only 30 screws and patches. It was decided to proof the mortars in the normal way.

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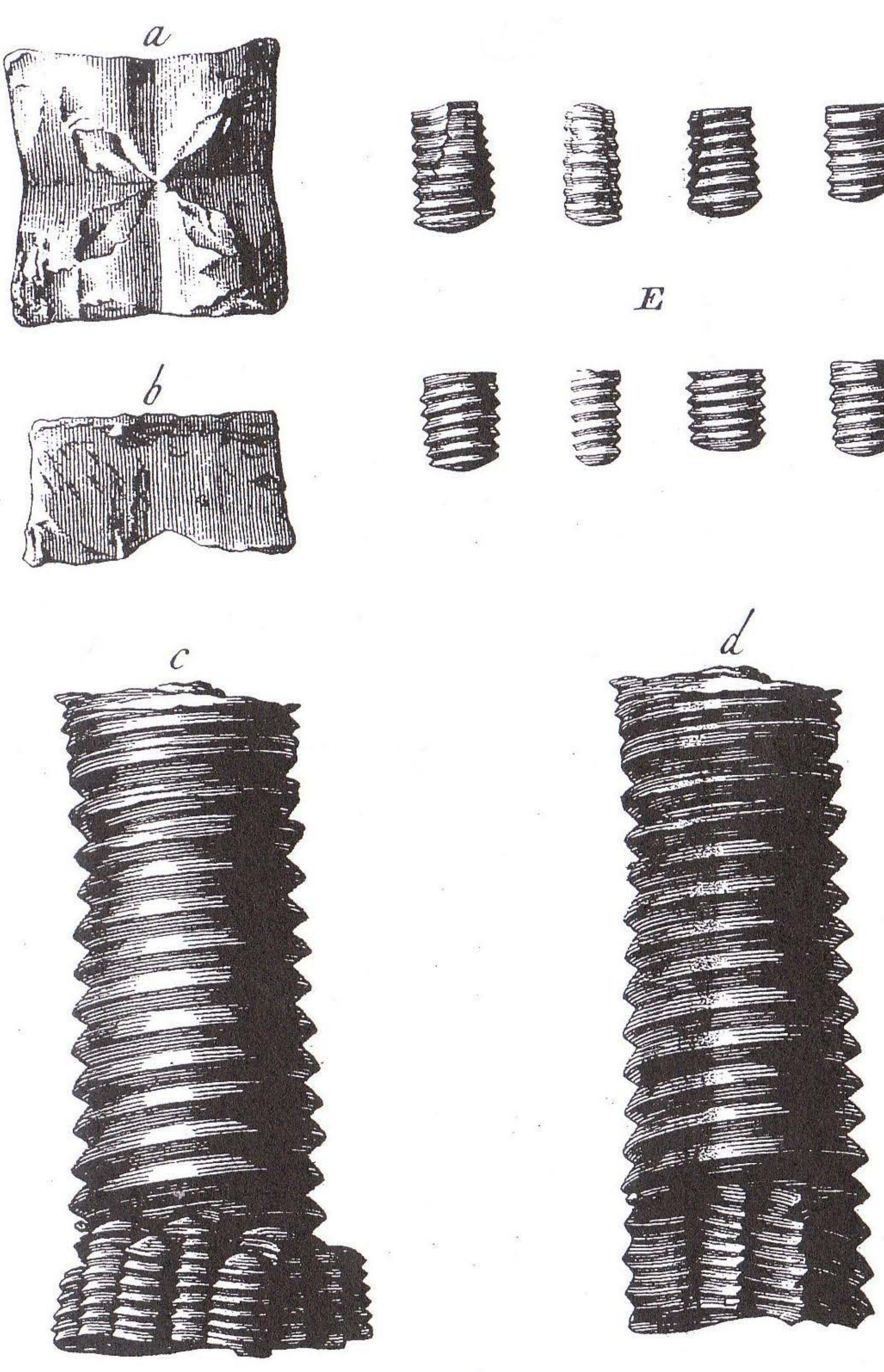
[286] National Archive, The Hague, inventory 1.01.43: *Archief van de Generaliteitsrekenkamer* 1586-1799, No. 47: "Conditiën en voorwaarden waarop de ondergeteekende Heeren Commissarissen van den Raad van State der Vereenigde Nederlanden ingevolge resolutie van haar Ed. Mog. in dato den 19^{e} September 1755 zijn overeengekomen met Jan Verbrugge grof-geschutgieter van Holland, dat hij de Generaliteit zal dienen, wanneer haar Ed. Mog. zullen goedvinden hem te emploijeren."

[287] C. de Beer [ed], *The art of gunfounding. The casting of bronze cannon in the late 18th century*. Rotherfield, 1991, p. 95.

[288] C. de Beer [ed], *The art of gunfounding. The casting of bronze cannon in the late 18th century*. Rotherfield, 1991, p. 6.

[289] "Manuel historique de la technologie des armes à feu," *Journal des Sciences Militaires des Armées de terre et de mer*. Deuxième Série, Tome XIX, 1837, p. 9.



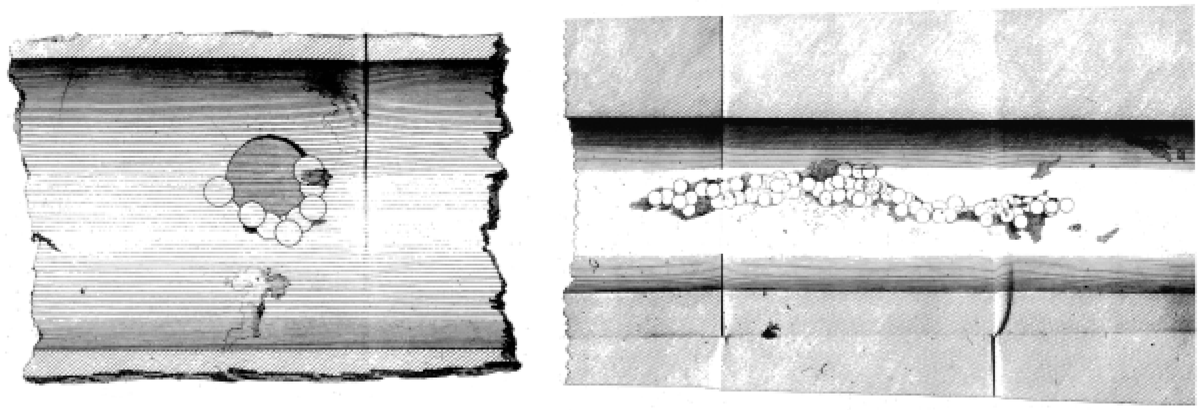
Verbruggens screws, patches and stops, as retrieved from the secretly repaired guns.

These are drawings of the remains of the screws used by Verbruggen with the screw-heads were cut off during the repairing process. The screws "c" and "d" show the complex compound of a large screw with several small screws added. These drawings formed part of the official report against Jan Verbruggen.

Results of the 1770 destructive proofing

The accusations against Jan Verbruggen did not end, as the former bore-master Pieter Schoonleven joined in. On 7 February 1770 the Raad van State decided to proof six recently founder 12-pdrs in the destructive way. The captains of Artillery Du Pont and Mooser and the Verbusser[290] Van Dijk were appointed to execute the proofing and report their findings. The results of the destructive proofing were printed in a special report that included some life-scale drawings of the cannon in question[291]. In order to avoid duplication I will concentrate on the findings of only one cannon. The canon, marked D2 No 13, was externally scoured, then scrubbed with dry warm sand and finally covered with acid. By this method 127 reparations large and small were discovered. About one hundred of the patches were hewn out and kept in a sealed box as evidence. To locate the screws inside the bore, the cannon was sawn through on indication of the former bore-master. In the bottom of the bore two screws were found, that were screwed together, forming a large composite structure or screw complex, covering a cavity of about 2,5 cms wide. The screw complex showed traces of copper rust. In a second part, located in the 1st reinforce, a large red copper 2,5 cm diameter screw was detected, fixed with eight smaller screws, covering a large cavity, that was bordered by a tin concentration. Furthermore a patch was found, that covered a large copper screw. The thread of this screw was black, from which it was concluded that powder-gas of the proof firing actually had penetrated into the hole, covered by the screw. The copper rust and spoiling influence of the powder-gas were very dangerous, as they caused the screws to deteriorate and fall out after some time. To the unaware gun crew this could mean disaster with possible loss of life. Also the safety of the nation was at risk, when a large portion of its ordnance was unreliable[292].

Then the quality and composition of the gunmetal was examined. As metallurgy was still in its infancy, most conclusions were based on color and appearance only. The various saw cuts showed the results of uneven cooling: at the second reinforce the metal looked grey, containing a lot of tin, the base proved to be even worse, but the dolphins were of good composition.



Sections of a Verbruggen gun that was examined by cutting it into pieces.

The large areas repaired and the complexity of interlocking repairs with stops, plugs and screws are clearly indicated on this (originally life size) drawing. One cannot pretend this was no forgery, but a harmless repair, not impairing the quality of the gun in question. These drawings formed part of the official report against Jan Verbruggen.

The second cannon with number 15 was presumed leaking. Upon examination a large screw was found, covering a cavity that was deeper than the length of the screw. When no fistula could be found, the cannon was subjected to the water proof. Then the waterpressure revealed the presence of one or more fistulas. To find out the location of these fistula the cannon was sawed lengthwise and then in parts. Around the cavity that was covered by the screw a clay wall was made and water was poured in the thus formed basin. Again the water seeped through. To be sure the same process was made vice versa and so it was proved that the cavity, originally covered by a screw, actually was a fistula with communication to the outside of the barrel.

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290 A *verbusser* is a specialist who lines the damaged or worn-out ventholes of ordnance.

291 *Rapport van de ondergeschreeven Capiteins van de Artillerie du Pont en Musly beneevens den Verbusser van Dyk, in gevolge de orders vervat in de Resolutie van haar Edele Mogende de Heeren Raaden van Staate der vereenigde Nederlanden*, 7 February 1770.

292 In a letter [to the Raad van State] dated 15 December 1767 Duhamel Du Monceau, chairman of the Academie Royal des Sciences in Paris, stated that the presence of screws in the bore weakened the cannon.

The results of the examination were:

Cannon D 2 No. 13	127 screws and patches
Cannon D 2 No. 14	44 screws and patches
Cannon D 2 No. 15	61 screws and patches
Cannon D 2 No. 16	66 screws and patches
Cannon D 2 No. 17	43 screws and patches
Cannon D 2 No. 18	26 screws and patches

In all 367 screws and patches were found with these six cannon, that were all casted in one founding (called D 2). All cannon were found spongeous at the breech.

With these disastrous and well documented results one cannot share tthe view promoted by De Beer that Jan Verbruggen was an innocent victim of the vicious Von Creutznach seeking revenge for the demolition and replacement of 'his smelting-furnace'[293]. However it is true that Von Creutznach created a sphere of suspicion. Perhaps we do him more credit with the explanation that somehow he felt 'screwed' and insulted and wanted to proof his right at all cost. However in the unreal political situation at that time corruption, backbiting, blackmail, and even burglary ran rampant, making life and work for the gunfounder very difficult, even resulting in a complete standstill of activities at the Hague foundry. In the end it was systematic proofing and examination that uncovered Verbruggen's secret repairs. No country would keep a gunfounder in service, who systematically corrupted his castings to the extent that Jan Verbruggen did. The Raad van State initialized legal procedures against its gunfounder to fire him. When Jan Verbruggen was appointed a Royal gunfounder at Woolwich, he resigned from his post in the Netherlands. The Raad van State confirmed his resignation by resolution of 27 March 1770.

A new era of Dutch gunfounding (II)

On 26 June 1770 the States of the Province of Holland issued an order for the Inspector of Artillery. All experiences with the examination of the Verbruggen cannon were included in a sound and coherent protocol, that left virtually no room for corruption or ignorance and was used well into the 19th century, when scientific metallurgy was included. In 1770 Johan Maritz became State gunfounder. It sounds familiar: he started rebuilding the smelting-furnace and the horizontal boring machine. In 1773, Maritz started production. He faced an enormous shortage of bronze ordnance due to the closure of the gun foundry during the Verbruggen conflict. The quality of Maritz guns was unrivalled.

Some afterthoughts

The precise method, used by Jan Verbruggen of placing screws at the inside of the bore in order to cover cavities, is unknown. Modern historians, like Den Beer and the circle around Jan Thade Semeijns de Vries van Doesburgh, who want to prove that the conflict between Von Creutznach and Verbruggen was based ónly on personal vengeance and political intrigue, do not bother with the fascinating technique. Of course the method and equipment used were the gun founder's most secret of secrets. Work was done from 20.00-23.00 hours and on Sundays, performed by Jan himself and his trusted bore master. Yet there are some intriguing clues: when Bentinck in 1762 unexpectedly visited the gunfoundry Jan Verbruggen and Pieter Schoonleven succeeded in quickly hiding 'the instrument' in a strong wooden box with a lock. From this statement by Von Creutznach it is clear that the repairing itself was not done with help of the horizontal boring machine, as any fixed cutting instrument could not be removed so quickly. Probably only the tool itself was put into the box.

Then how did 'the instrument' look like and work? Starting from the screw the instrument must deliver a rotating motion in order to fix the screw into the hole. This rotating motion was at an angle of 90 degrees of the shaft that entered the bore. Also there must be some pressure while fixing the screw. All these movements could be realized with a gear of toothed wheels. The shaft was kept in place by two brass cylinders with a central hole and hand driven with an iron bar. The dimensions of these cylinders corresponded with the caliber of the cannon. The repairing instrument looked more or less like the instrument for cutting the copper vent-screw[294]. While repairing the barrel remained in the frame, with the lanternwheel attached. In this way the barrel could be turned manually or with the horsemill and later after

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[293] C. de Beer [ed], *The art of gunfounding. The casting of bronze cannon in the late 18th century. Rotherfield*, 1991, p. 6.

[294] *The founding of bronze guns* 1793 by Isaac Landman, Professor of Artillery and Fortification at the Royal Military Academy, Woolwich 1777-1816, fig. 51. In: C. de Beer [ed], *The art of gunfounding. The casting of bronze cannon in the late 18th century.* Rotherfield, 1991, p. 201.

completing the repairs bored and surfaced. After finishing one screw the barrel was turned a little in order to fix the next one, etc. I presume the place to be repaired was either on top or at the bottom (thus omitting a complex movement of the 'screw driving head' on top of the shaft: it could remain at an angle of 90 degrees). It seems practical to fix the screw upward, in which position it just rested in the 'screw driving head'. On the other side a cavity in the bottom position could be better seen. When there was a mechanism to hold the screw into the screw head, than this position would be most favourable. The gunfounder just had to locate the cavity exactly in the length of the bore.When the cavity was at the top or the bottom it was not necessary to locate the spot inside the tridimensional tube sideways, which is very difficult, given the fact that on the frame there was little light to be able to see inside the bore. The most complex operation was the fixing of secondary screws, filling the remaining gaps. In order to make repairs the gunfounder must have a lot of screws in different sizes. Most likely the size of the screw was decided upon after the dimensions of the cavity were determinate with help of a 'feeler' or wax print. It did not matter if the screw was too long, still projecting from the inner wall of the bore. After fixing all screws the bore was once more bored out and surfaced. All traces of the presence of any screws were masked and virtually invisible to the naked eye. The same is true with patches: they were deliberately too thick. After fixing the boring or turning of the surface made them optically one with the cannon.

From the Verbruggen case and the one in France it can be concluded that the screw repairs were invented or practiced around 1762, at least both in the Netherlands and France. It is unknown to me if Jan Verbruggen continued his secret repairs in English service. Anyhow there is some correspondence on government level with regard of this practice, which is in itself unique. Correspondence between the gunfounders on this subject is obvious, but not yet found. Jan Verbruggen visited occasionally Berenger at Douay (France) and both were in communication on technical matters and salary questions (sic!). The gunfounders experienced the tendency of growing control that started in the 18^{th} century. Patterns, norms and standards were at the start of the Industrial Revolution: individual products with greatly varying quality were no longer the deal. In fact also the repairing method was part of the Industrial Revolution. With the new production method (solid casting and horizontal boring) came new quality problems and the means to fix it. The problem of unevenly cooling of large castings resulting in metallurgical problems remained; the tendency of secret repairs also, as is illustrated by the fact that in 1884 Gruson was caught repairing cracks in armoured cupolas that were destined for the Netherlands. When this act was betrayed by one of his employees the manufacturer stated to the Dutch controlling officer that the overall quality was not impaired. His repairs were just made for obtaining a smooth appearance in order to gain trust in his product. Sounds familiar, does it?

Smoothbore Ordnance Journal
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SOJ-6(23)
PROOF of ordnance

by Adye (1806)

All natures of ordnance undergo several kinds of proof before they are received into his Majesty's service;

1. They are gauged as to their several dimensions, internal and external, as to the justness of the position of the bore, the chamber, the vent, the trunnions, &c.
2. They are fired with a regulated charge of powder and shot, and afterwards searched to discover irregularities or holes produced by the firing.
3. By means of engines, an endeavour is made to force water through them; and,
4. They are examined internally, by means of light reflected from a mirror.

Proof of Iron Guns

The guns are first examined as to their proper dimensions, in which, in no case more, than 0.3 inch [7.6mm] variation is allowed, and in the diameter of the bore only one-thirtieth from 42 to 18-pdrs, and one-fortieth from 12 to 4-pdrs; but in the position of the bore $^1/_{30}$ an inch [0.85mm] out of the axis of a piece from a 42 to 18-pdr, and $^1/_{40}$ of an inch [0.64mm] from a 12 to 4-pdr; but in the position of the bore ½ inch [12.7mm] out of the axis of a piece from 42 to an 18-pdr and $^1/_3$ of an inch [8.5mm] from a 12 to a 4-pdr is allowed.

They are then fired twice with the charge in the following table, with one shot and two high junk wads; and examined with a searcher after each round. – In this examination they must not have any hole or cavity in the bore of 0.2 inch in depth, behind the first reinforce ring, or ¼ inch in depth before this ring.

Nature	Proof Charge	Proof Charge	Nature	Proof Charge	Proof Charge
42-pdr	25 lbs	11.4kg	6-pdr	6 lbs	2.7kg
32-pdr	21½ lbs	9.8kg	4-pdr	4 lbs	1.8kg
24-pdr	18 lbs	8.2kg	3-pdr	3 lbs	1.36kg
18-pdr	15 lbs	6.8kg	2-pdr	2 lbs	0.91kg
12-pdr	12 lbs	5.5kg	1½-pdr	1½ lbs	0.68kg
9-pdr	9 lbs	4.1kg	1-pdr	1 lbs	0.45kg

Iron guns are scaled with 1/12th the weight of the shot.

Proof of Brass Guns.

From 1-pdrs to 12-pdrs the diameter of the bore must not vary more than 1/40 of an inch, and in no dimensions more than 2/10th. The following are the established charges for their proof. – The heavy and medium guns with a charge equal to the weight of the shot, except the medium 12-pdr, which is proved with only 9lbs. The light guns with half the weight of the shot. The brass ordnance have not, however, been proved of late with such charges, but with the following:

3-pdrs light, 3 times, with 1lb each round.
6-pdrs light, 3 times, with 2 lbs each.
12-pdrs light, 2 times, with 4 lbs each.
12-pdrs medium, 2 times, with 5lbs each.

Any hole 0.15 of an inch deep upwards or sideways in the bore, or 0.1 in the bottom, between the breech and first reinforce; or 0.2 of an inch upwards or sideways; or 0.15 in the bottom of the bore, before the first reinforce ring, will be sufficient to condemn them.

Proof of Brass Mortars and Howitzers

The exterior dimensions are in no respect to deviate more than one-tenth of an inch in an 8-inch howitzer, and one-twentieth in the royals and Coehorn mortars and howitzers.—Their bores and chambers not to deviate from their true diameters or positions more than 1/40th of an inch. The brass mortars and howitzers are fired twice with their chambers full of powder, and an iron shell. The mortars on their own beds, at about 75° elevation; and the howitzers on their carriages, at about 12°.—Iron mortars are proved on their iron beds, with a charge equal to the full chamber, and an iron shot equal in diameter to the shell. Royals, or Coehorn mortars, having a hole 0.1 of an inch in depth in the chamber, or 0.15 in the chase, are rejected; royal howitzers the same.—8-inch howitzers having a hole 0.15 of an inch in depth in the chamber, or 0.2 in the chase, will be rejected.

Proof of Carronades

The diameter and position of their bore and chamber must not deviate 1/20th of an inch. They are proved with 2 rounds, with their chambers full of powder, and 1 shot and 1 wad. A hole of 2/10th of an inch in depth in the bore, or one-tenth in the chamber, condemns the piece.

Nature	Proof Charge	Proof Charge	Nature	Proof Charge	Proof Charge
68-pdr	13 lbs	5.9kg	24-pdr	6 lbs	2.7kg
42-pdr	8 lbs	3.6kg	18-pdr	4 lbs	1.8kg
32-pdr	6 lbs	2.7kg	12-pdr	3 lbs	1.36kg

Water Proof

All ordnance, after having undergone this proof, and the subsequent searching, are subject to the water proof. This is done by means of a forcing pump, having a pipe or hose fixed to the mouth of the piece; after two or three efforts to force the water through any honeycombs or flaws which may be in the bore, they are left to dry j and generally the next day examined by the reflected light from a mirror. If the bore contains any small holes or flaws which have not been discovered by the former proofs, they are very readily found by this: the water will continue to weep, or run from the holes, when the solid parts of the bore are perfectly dry.

Ordnance, suspected of being bad, are often subject to a more severe proof; that of firing 30 rounds quick, with the service charge and 2 shot; and in doubtful cases, where the purity of the metal is suspected, recourse has been had to chemical trials and analysis. A quantity of clean filings, taken from a part of an iron gun free from rust, are dissolved in the dilute sulphuric acid, and the quantity of gas disengaged during the solution accurately ascertained. The plumbago which remains after solution is also separated by filtration, and carefully weighed. Now it is well known, that the purer the iron, the greater the quantity of inflammable gas obtained, and the less the proportion of plumbago which remains after the solution; from these two parts, therefore, a tolerable judgment may be formed of the quality of the metal. When the plumbago exceeds 4½ per cent, the iron will always be found deficient in strength; and there has been no instance of a gun bursting where the plumbago did not exceed 3 per cent.; that is, where 100 grains of the metal did not leave more than 3 grains of plumbago. The colour of the plumbago is also to be attended to: when it is brown or reddish, it is an indication of hard metal, and when in quantities and mixed with coals, there can be no doubt but that the iron is too soft for cannon.

Proof of Iron Shells

After the shells are gauged and examined as to their dimensions and weight, they must be well scraped out, and the iron pin at the bottom of the inside must be driven down or broken off. They are then to be hammered all over, to knock off the scales, and discover flaws, and no hole, in the large shells, is allowed, of more than f of an inch deep. An empty fuze is then driven into the fuze hole, and the shell is suspended in a tub of water, in such manner that the shell be covered by the water, but that it does not run into the fuze: in this situation the nose of a pair of bellows is put in at the fuze hole, and several strong puffs given with the bellows; and if no bubbles rise in the water, the shell is concluded to be serviceable.

Condemned Ordnance

Ordnance condemned as unserviceable for any of the foregoing reasons, are marked as follows: X D, or X S, or X W. The first signifies that they are found to be faulty in their dimensions, by Desagulier's instrument; the second by the searcher; and the third, by the water-proof.