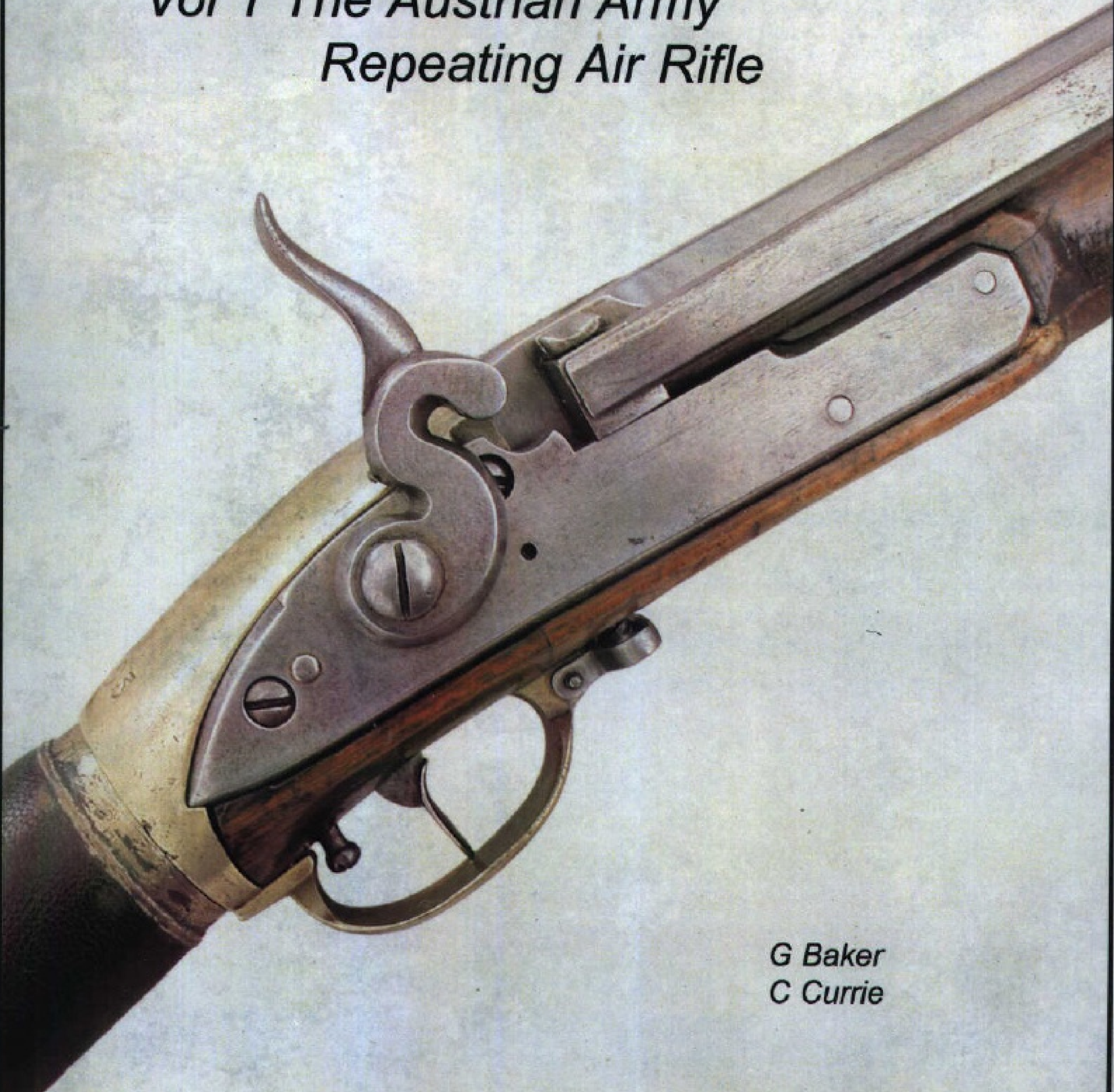
The Construction and Operation of the Air Gun

Vol 1 The Austrian Army Repeating Air Rifle



G Baker
C Currie

Revised Second Edition

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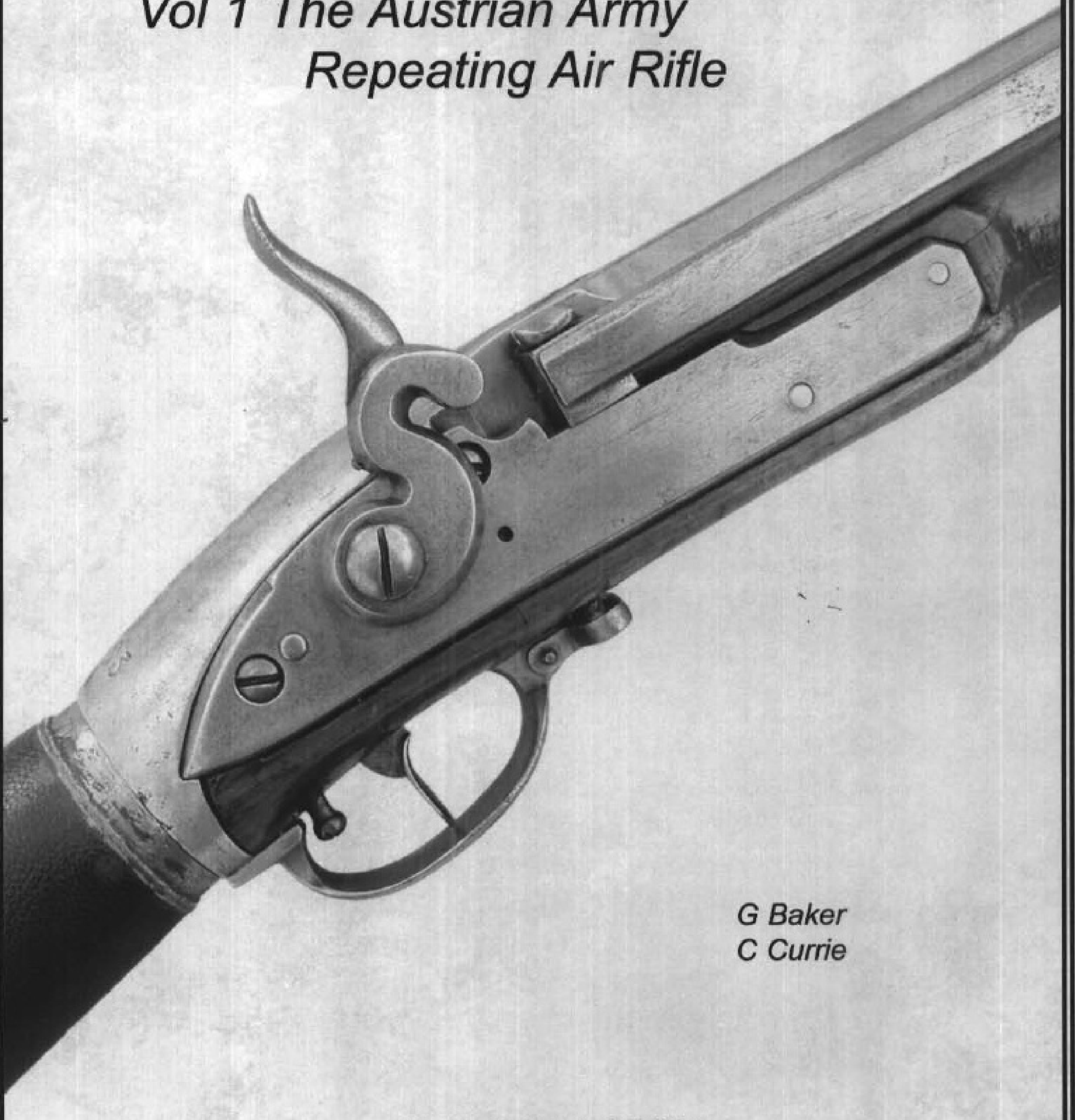

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In particular, Mark Murray Flutter of the Royal Armouries whose help has been invaluable at all stages.

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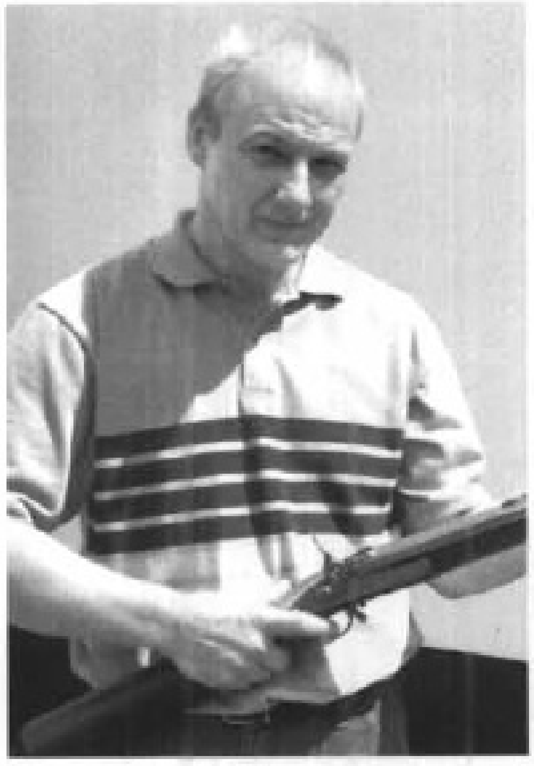
Finally and very importantly, Mrs Crescencia Baker whose continued good humoured tolerance of our activities, was essential to the completion of this revision.

email geoffrey.baker@virgin.net

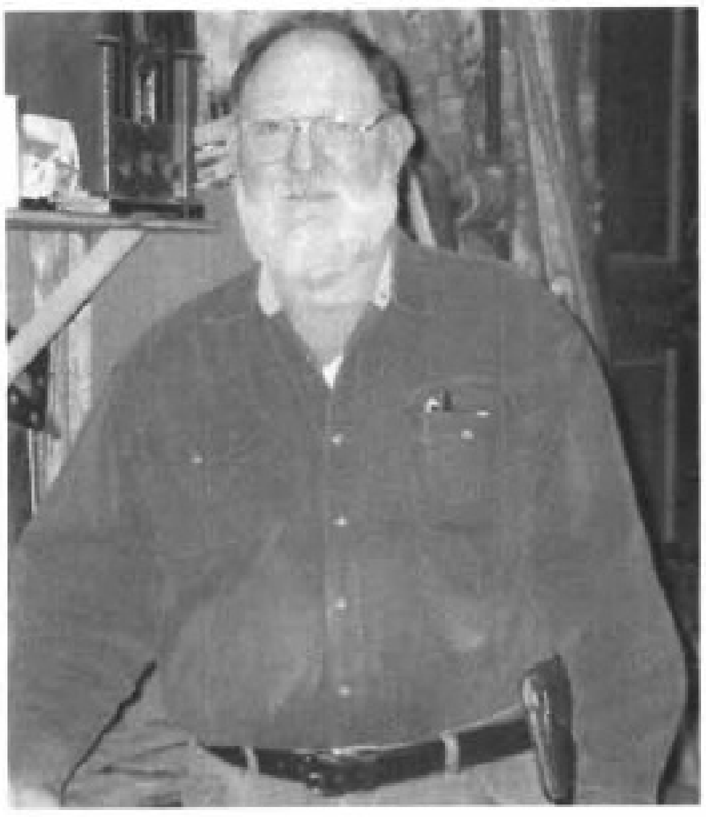
colin.currie1@virgin.net

Colin Currie

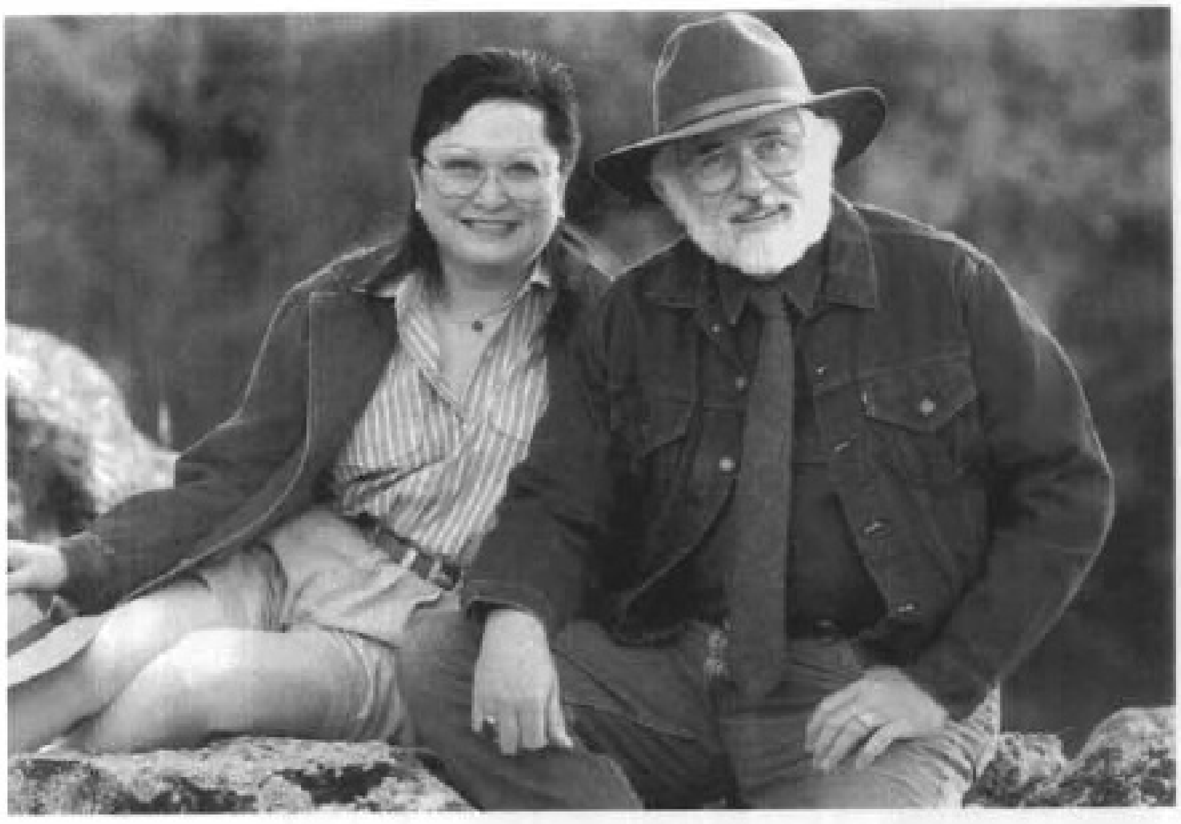


Geoff Baker

Peter Nolan

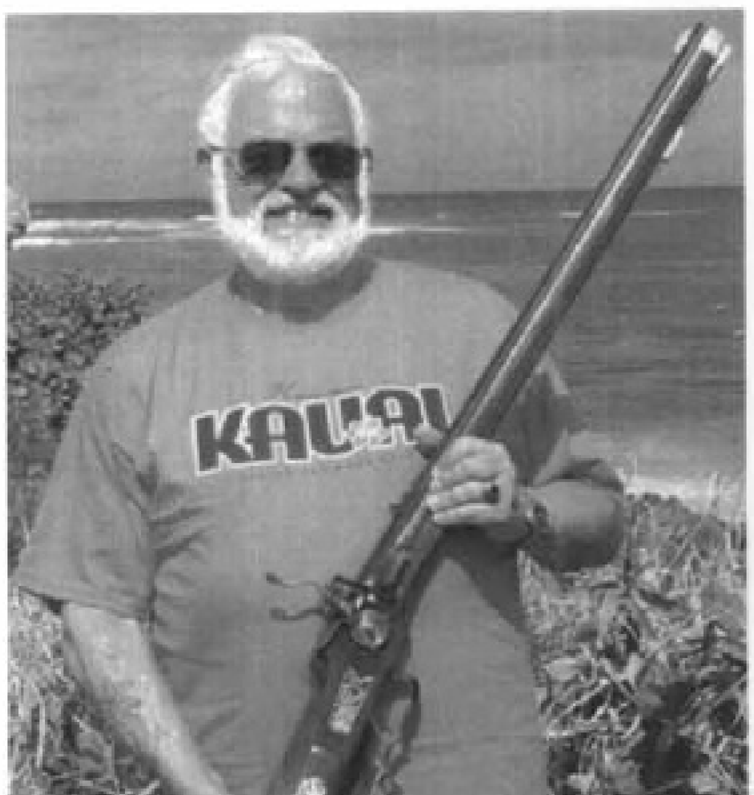


Earnie Cowen



Robert and Toshiko Beeman.

The long Suffering
Mrs Crescencia Baker



Michael Carrick

Giancarlo Melano.

INTRODUCTION

Following the publication of Vol1, a number of developments resulted in important further information becoming available on different aspects of the Austrian Service Air rifle.

The first development was the translation of a number of documents, that provided a comprehensive insight into the contemporary development and subsequent service use of the air rifle.

Given the significance of this new information to the further understanding of the subject, we considered it should be incorporated in a revised and enhanced edition of Volume 1.

The second development was access to two further examples of the rifle for evaluation, one in the collection of Mr Peter Nolan in the U.K., and the other in the Dr. Robert Beeman collection in America.

In the case of the U.K. rifle, the kindness of Peter Nolan allowed for the first time a proper comparison with a similar example to the Royal Armoury version described in volume 1.

In the case of the American example, it was at this time on loan to Mr Ernie Cowen from Dr. Beeman, to be stripped down to individual component level for the construction of a truly accurate replica.

The generous loan by Dr. Beeman of his rifle for this purpose, provided a unique opportunity to record information that would have normally only have been available at the time of construction.

There then followed a most intensive and very fertile trans-atlantic discussion, as Ernie carefully stripped the original and meticulously made a perfect copy.

These discussions and the many important questions answered, made a significant contribution to the understanding of both the design and functioning of the Girandoni.

With the help and assistance of Mr Mark Murray -Flutter, the Royal Armouries example was re-visited and a data base of information from three rifles was created.

Although the number of examples used in deriving the data base was restricted, this must be seen in the context that very few of the genuine military pattern have actually survived and are available for study.

Despite these restrictions, the examples available are in fact quite representative of both the start and finish of the production cycle.

Of the three, one example with a low serial number had heavy internal wear and evidence of much use.

Whilst in comparison a second one serial number 1493 owned by Peter Nolan, one of the last rifles made to the contract, had some external repair but was in good condition internally indicating very little use, this of course, was very important to the establishing of correct dimensions.

The final act was to visit Ernie Cowen and actually shoot the replica, an amazing experience as twenty balls were efforlessly and powerfully discharged into a tight group on the target.

Truly the rifle was a fitting tribute, both to the craftsmanship of the maker and the design skills of Bartolomeo Girandoni.

Although outside the remit of this book, the authors were also involved during this period in discussion on the air rifle carried on the Lewis and Clark expedition.

In the many contemporary journals arising from the expedition, there were frequent references to an air rifle, with detailed description of damage sustained and repair work carried out.

Frustratingly, there was no actual description of the rifle itself nor any indication of the maker, which made identification impossible.

This situation changed dramatically when Michael Carrick published his discovery of the only eyewitness description of Merriwether Lewis's repeating air rifle.[1]

1 Lewis & Clark Trail Heritage Foundation "We Proceeded On" Vol. 28, No 4, November 2002.

In the Journal of Thomas Rodney (A Journey Through The West), there is a clear and precise description of the air rifle demonstrated to Rodney by Lewis, on the occasion of their meeting at Wheeling prior to the Lewis & Clark expedition.

This description left the authors in no doubt that the rifle described was of the Girandoni type and the quoted magazine capacity indicated it was very likely the military version.

A further exciting development arose from the significance of old repair work uncovered by Ernie Cowen during the course of dismantling Dr. Beeman's rifle.

There was considerable discussion initiated by Ernie, resulting in the growing realisation that the nature and detail of this repair work, tallied exactly with that described in the Lewis and Clark journals.

Following on from this was the very strong consideration, now shared by many U.S authorities that this particular rifle is the actual one carried on the expedition.

It is now understood that Dr. Beeman is producing a book confirming this position and this will be eagerly anticipated by everyone involved in the research to date.

The drawings are of Peter Nolan's rifle, the pump and speed loading tube were done from information supplied by Giancarlo Melano, Secretary of the "Friends of the Turin Artillery Museum Society."

Where possible the pictures are of Peter Nolans rifle. Pictures of the lock components and disassembled barrel were donated by Dr. Beeman which has now made it possible to show parts of the rifle that are not normaly accessable.

SOURCES

In addition to the original source documentation previously identified, the translation of the following documents provided a valuable further insight into the history and development of the Austrian Service Air rifle.

The Austrian Military Repeating Air Rifle and its inventor Bartholomaus Girandoni (published in two parts, one in The Journal on Studies of Historic Weapons third issue, the second in Waffen-und Kostümkunde, 1964 Annual, pp. 81-95, 1965 Annual, pp. 24-53 by Dr.Walter Hummelberger and Leo Scharer.

[2] Organ der Militarwissenschaftlichen Vereine, August Haller, Vienna, 1891, Vol. 42, Pt. 1.

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Containing an article on the Girandoni by F.H.Baer.

Journal of Historical Armsmaking Technology Volume 3, June 1988 published by the N.M.R.A, P.O BOX 67, Friendship. Indiana.47021 containing Handwerke und Künst in Tabellen by P.N. Sprengel.

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Great British Gunmakers by Keith Neal and David Back, 1975 ISBN 0 85667 015 4

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Other sources for information and general interest:

Books

Airguns and other Pneumatic Arms by Arne Hoff
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Internet Web Sites

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(Lewis & Clark Trail Heritage Foundation)

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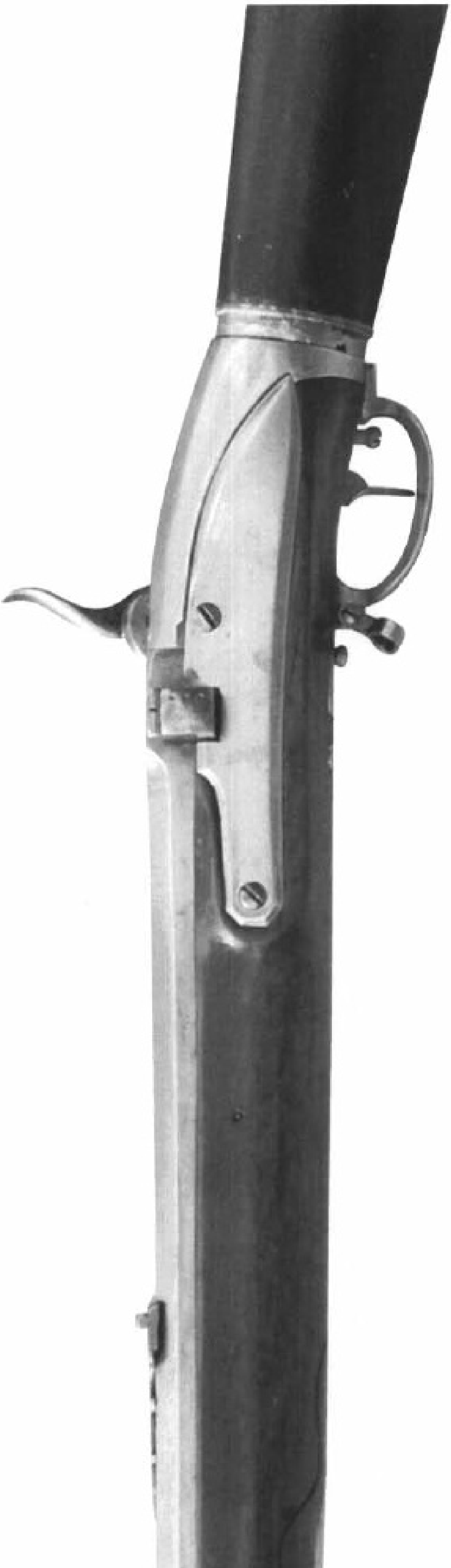
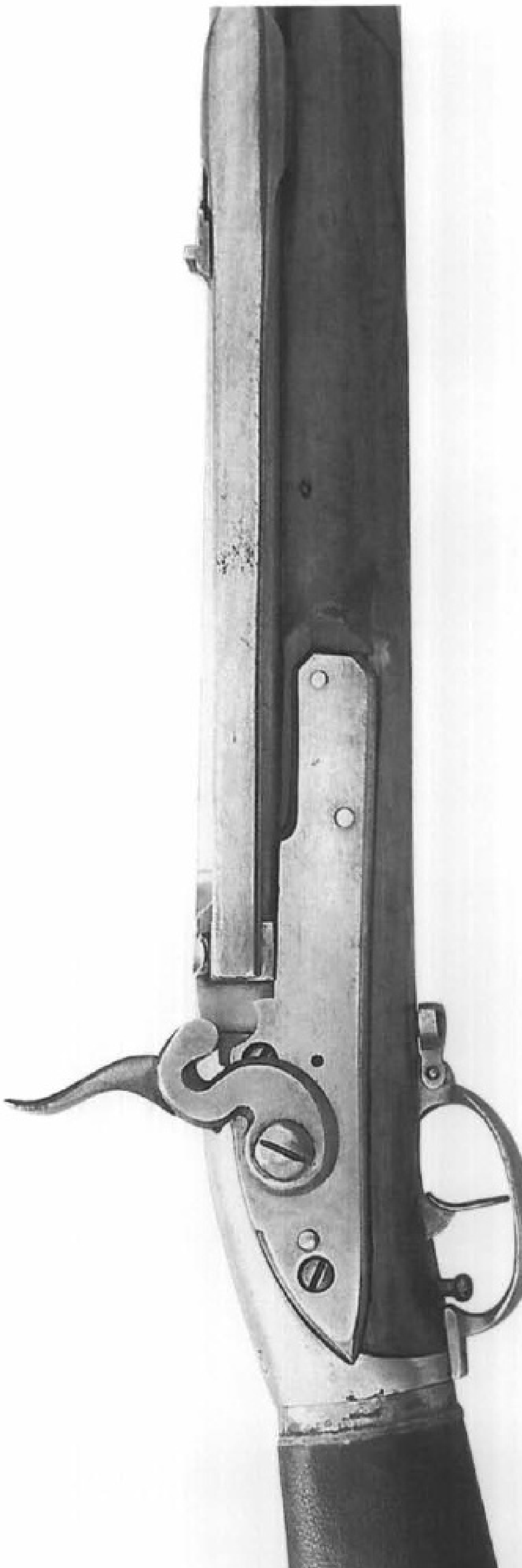
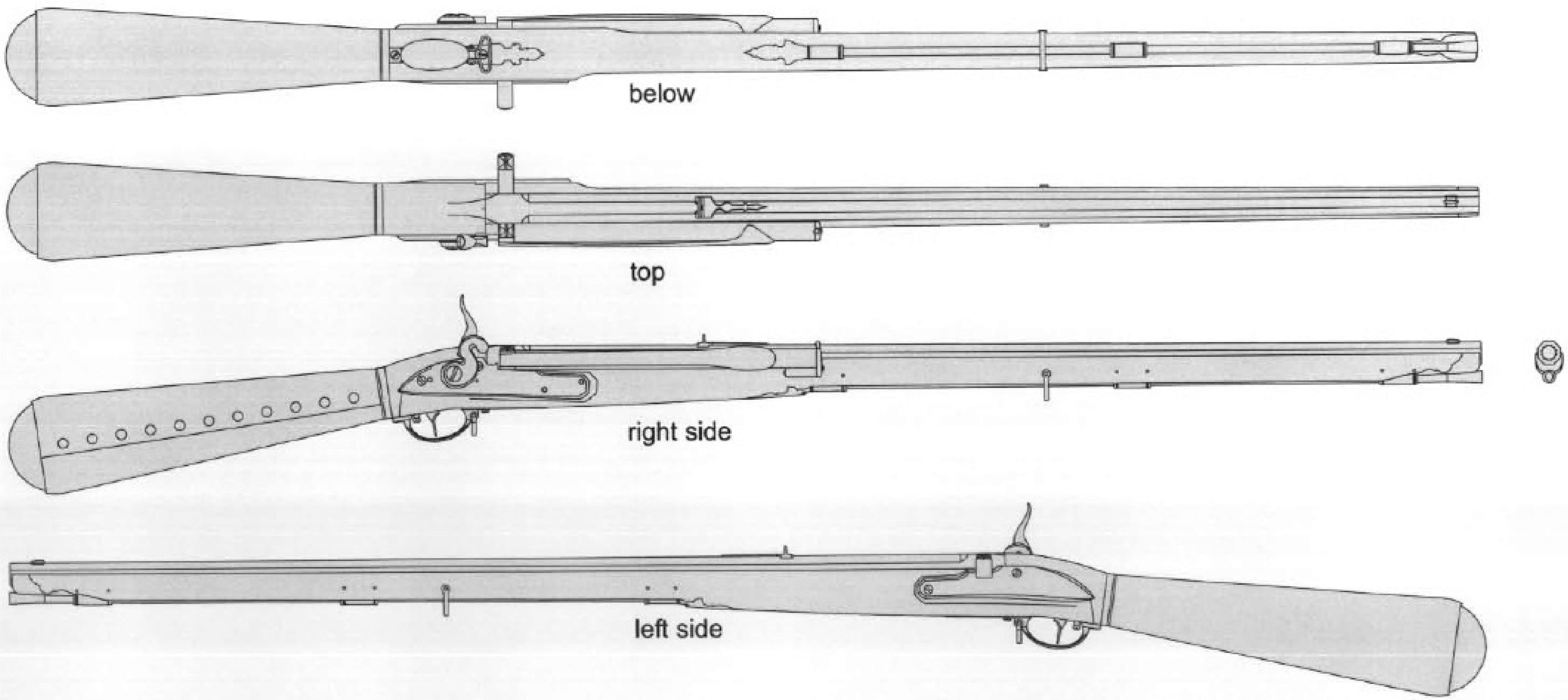




Austrian Army Air Rifle

The original specifications from a contemporary instruction book of 1788

Calibre (from measured examples)	**11.78mm (0.464in)**
Length of barrel	**834.06mm(32.8in)**
Weight loaded	**4.23kg(9lb)**
Overall length	**1,231mm(48.5in)**
Magazine capacity	**20 balls**
Barrel rifled	**12 grooves with one turn in the length of the barrel**



Original instructions for use of the Air Rifle

Before using the air rifles:

According to present regulations, each of the air rifles is equipped with the following:
With 3 air bottles, one screwed to the air rifle, the other two stored in a holder.
- ball shot
- cleaning stick
- pump machine
- lead ladle

4 tin ball tubes

1 leather container/knapsack, into which the 2 spare bottles are placed together with 4 tin tubes filled with ball shot, the pump machine and the ladle. With the ball shot, the lead is hammered into small pieces which the rifleman then melts to form the bullet. There is sufficient for 100 bullets, 20 of these are stored in the magazine which is part of the rifle. The other 80 are stored in the 4 tin tubes.

When the rifle has been used, it will become necessary to pump up the bottles from time to time. This is done using the above mentioned pump machine and - according to best practice - with 1500 thrusts. So that the bottles do not leak, they are dipped into water, thereby ensuring that the leather valve is kept moist.

After 20 shots have been fired, the magazine has to be filled up with a further 20 shots and the bottle has to be changed.

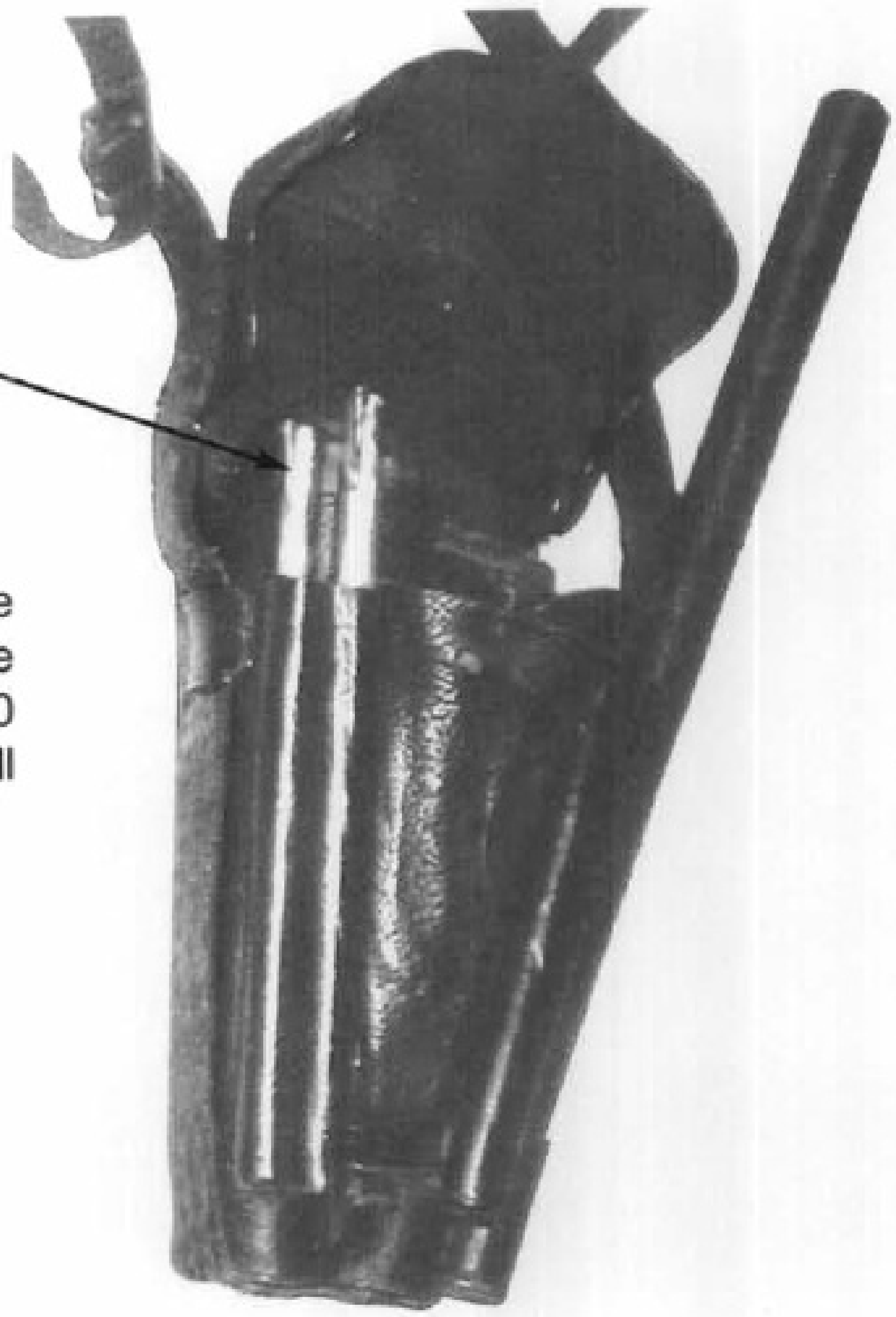
Although the shots from a full bottle are more powerful generally than from a depleted bottle, it has been proven that even after up to the 20th shot the accuracy is good at 120 paces.

Signed, Vienna, 24th January 1788.

Airgunners Knapsack

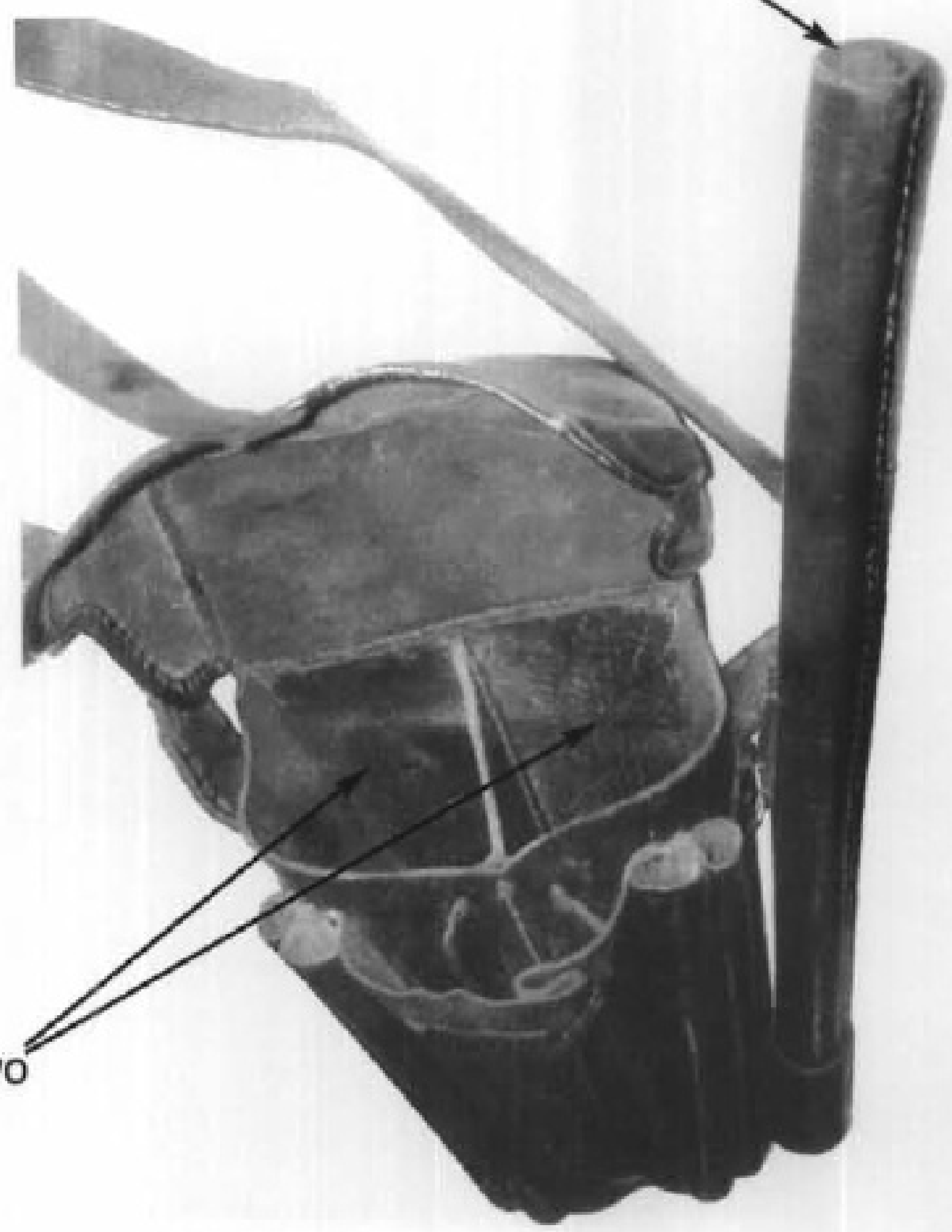
magazine speed loading
tube holding 20 lead balls

The magazine itself would actually take 21 balls but only 20 were intended to be fired from a full reservoir. More than 20 shots could be obtained from one full reservoir but at reduced velocity.



photos courtesy of
Giancarlo Melano

Compartment for
the hand pump



Compartments to take two
spare reservoirs

Contents Of The Knapsack Carried by the Airgunner

Contents
4 tubes with balls (only 3 shown)
pump
pump footplate for the pump
2 spare charged reservoirs
peg tool for valve removal
bullet mould
ladle for melting lead to make balls
pump piston adjustment tool

THE AUSTRIAN ARMY SERVICE AIR RIFLE

The inventor of the Austrian Service Air rifle, Bartolomeo Girandoni, was born on 30th May 1744 at Ampesso in the Southern Tyrol.

Although primarily a clockmaker to trade, he showed a strong interest in firearms design and was responsible for a number of suggested improvements to the basic flintlock design in use at this period.

Amongst these improvements, was a design for a repeating air rifle with a novel but simple magazine fed breechloading system.

Girandoni also applied this system to a flintlock weapon and it appears he developed both designs in parallel, albeit with the flintlock apparently at a lesser stage of development than the air rifle.

The air rifle version was unique in being the first airgun to be specifically designed for military use and in quantity.

This was reflected in the design, as it was fashioned on plain military lines and of very rugged construction, in comparison with sporting air rifles of the period.

It is very doubtful if the blackpowder version would have been so effective, and this is confirmed by it still being under development, when it was subsequently dropped by the Austrian authorities.

The first official appearance in the records of the Austro-Hungarian Empire of Girandoni and his designs was in 1779, contained in the files of Field Marshal Lacy.

photo courtesy of
Dr. R Beeman

This was in the form of a favourable report by Field Marshal Lieutenant Rouveroy to the Emperor Joseph ll.

The Emperor was clearly impressed with the potential of both designs, as in March he commissioned Field Marshall Lacy to conduct trials on both systems and report as a matter of urgency.

Following the end of successful trials in July, Lacy proposed placing an order for 1000 of the flintlock and 500 of the airgun version.

Considerable discussion and negotiations then ensued, regarding Girandoni's employment in furthering this objective.

These negotiations revolved around questions with regard to the size of the workforce required to support Girandoni, the scale of remuneration, whether his assistant Franz Colli should be also be employed and how secrecy of the project could be best maintained.

With the intervention of the Emperor, who was clearly impatient to set the project in motion, these issues were quickly resolved.

By the December of 1779 Girandoni accompanied by his family, along with Franz Colli and two workmen, were established in a workshop in Vienna.

Girandoni was now under the direction of the Artillery Head Office controlled by Field Marshall Lieutenant Colleredo, who became responsible to the War Council for the project.

Given the rigid structure of the military mind and stultifying bureaucracy of the period, it was truly amazing how something as novel as a repeating military air rifle became accepted and manufacture initiated in the short period of 9 months.

However, it is also clear that this was only achieved by the involvement of the Emperor in the process, as Girandoni's rival Joseph Nemetz discovered when he tried to have his airgun design considered.

Despite favourable reports from the authorities, without this crucial support he got absolutely nowhere and retired disheartened.

From 1780 to 1784 Girandoni and his workforce produced 274 air rifles without reservoirs and 111 of the flintlocks, given the size of the workforce this was a credible achievement by any standards.

However the Artillery Support Command were not impressed reporting to the Emperor a litany of complaints concerning Girandoni's time consuming working practices, his refusal to accept criticism and diverting effort to other projects.

These problems made the continuity of supply and procurement of materials difficult for the Artillery Support Command, in order to resolve this situation, it was proposed that Girandoni be made responsible for the supply of all material and payment of his workforce.

The Emperor supported these proposals decreeing that work on the flintlock should be suspended to allow Girandoni to concentrate on the air rifle.

Between 1785 and 1787 seven hundred air rifles were completed, a remarkable achievement given the complexity of the design and the fact that the work was on the cutting edge of the technology of the period.

Soon however Girandoni's design was to face the ultimate test of any weapon, wartime service.

In the complex political scene existing at this period, Austria had joined Russia in a mutual support alliance as a hedge against the growing might of Prussia.

When the Turkish Empire declared war on Russia in August 1787, Austria fulfilled its responsibilities to the alliance and declared war on Turkey.

There was a frenzy of activity as the Imperial Army was prepared for war.

With the Emperor involving himself in the most minute detail of the preparations for the forthcoming campaigns, the availability of the air rifle especially attracted his attention.

By this time there were roughly 1000 air rifles available with one reservoir per gun, however when a initial tranche of 200 rifles was ordered from stock for issue by the War Council, it was accompanied by a request to supply two spare reservoirs with each.

The request caused consternation in the Artillery Supply Command, as the reservoirs had proven to be the most difficult item to manufacture causing many delays in production.

This new requirement could only be met by cannibalising the remaining stock, effectively reducing the remaining airguns with reservoirs to 400, with little chance of any early replacements.

To add to these woes there were insufficient handpumps available, along with the airgunner's special knapsack still awaiting approval by the War Council.

This knapsack was designed to carry the new requirement of two spare flasks, four tubes of balls as re-loads for the magazine, also the handpump along with other accessories.

The airgunner's knapsack in particular, was the subject of very detailed instruction from the Emperor and indicated his depth of interest in the airgun.

The Emperor intervened in order to resolve the chaotic supply situation, with stern orders given to procure all missing items immediately.

These orders also contain the first known mention of the mechanically operated machine pump, designed by Girandoni for filling reservoirs.

The Supply Command were instructed to establish the status of this device immediately and if available, order one for every five airguns.

However Girandoni confirmed that the machine was slower than the handpump for filling reservoirs, and better suited for testing them.

The Supply Command reported that two machines would be supplied mounted on specially designed two axle transporters for field testing, which indicates they intended the handpump to be the primary source for pressurising reservoirs.

The Emperor's efforts were now bearing fruit, as the Artillery Command reported the despatch of the first tranche of 200 rifles, with all accessories to the depot at Peterwardein.

Clearly concerned, the Emperor issued further instructions with regard to the remaining 800 rifles, requesting they be completed by the latest date of 1st April 1788, with Girandoni to be given as many additional staff as he required to accomplish this.

Although not formally recorded, there is indirect evidence at this stage of a face to face meeting between the Emperor and Girandoni.

Normally, it would have been unthinkable for one of the most powerfull monarchs in Europe, to bypass all social convention and court protocol, in order to consult a humble tradesman.

Clearly this unusual action was the Emperors response to his growing frustration with the situation regarding the supply of the airgun.

Unable to get a sensible answer from his officials, he consulted the one person who could give him authoritative answers.

Fortunately, a copy of Girandoni's summation of the meeting that he forwarded to the Emperor survived as follows

" I have received your command to manufacture 400 pump tubes and 2400 air bottles by the end of march 1788 and would like to comment as follows: The 400 pumps will be produced by me within the given time; however the air bottles will require much more accurate and careful production which means more time. The iron for these is of poor standard, badly refined and the material defects only become obvious once the bottles are produced and are being rigorously tested. For the above reasons I am unable to give an exact date for completion. However I will do my utmost to accelerate the production under these conditions."

" Vienna, the 4th of the month, 1787
Bartolomaeus Girandoni."

The matter-of-fact tone of the reply indicates the meeting was not that of a King and obsequious subject, but rather that of a confident technocrat and his customer.

For the first time, the Emperor was made aware of the technical reality of airgun manufacture by a competent authority, awareness reflected in his later instructions.

It was also probably at this meeting that the flintlock was officially dropped due to reservations regarding its viability.

Girandoni's direct superiors, the War Council and the Artillery Supply Command, were completely unaware of this meeting and left in a state of confusion when he informed them of the Emperors intentions.

From the contemporary correspondence, both organisations were clearly annoyed at being placed in a position where only Girandoni was aware of the Emperors intentions.

Possibly to smooth ruffled feathers, the Emperor again issued clarification with regard to reservoir numbers, this time via the official channel of the War Council.

The order clearly laid down that additional to the one attached to the rifle; two more were to be retained in the knapsack, a total of three per issued rifle.

Having hopefully resolved the air rifle supply problem, the Emperor then turned his attention to the distribution within the Army, along with training in use of the air rifle and maintenance.

Two days before the declaration of war on 7th Feb 1788, the long suffering President of the War Council, Field Marshal Hadik, received yet another communication that detailed in great depth how these issues were to be addressed.

Clearly the Emperor was aware that the air rifle was a quantum jump, in both mechanical complexity and potential firepower over the simple flintlock musket of the day.

It was also apparent he recognised that placing without training, such an advanced weapon in the hands of the average soldier of the time would be disastrous.

Although the instructions contain considerable detail on the allocation of specific numbers of rifles to various battalions, the main emphasis is his concern regarding the ability of his troops to handle the new technology.

Indicated by referring to them in his advice on training, as:

"The simple soldier, whose intelligence is normally limited."

There is also further advice to the effect that training should be little and often, to avoid overburdening them with too much information at any one time.

In sharp contrast to his intense involvement in its manufacture, it is matter of some surprise that he did not appear to have the same pre-occupation with the tactical use of the air rifle.

The instructions given for the disposition of the airgunners in the battalion structure were very brief, merely that they were to join in with the rifle section.

It is difficult to see given the large investment of the Emperor's time and money, why he did not attempt to exploit the unique tactical potential of the air rifle on a broader scale.

Due to the slowness of the loading process of the flintlock rifle in comparison with the smoothbore musket, the rifle played a secondary role in military tactics at this period.

The rapid fire and long range capability of the an air rifle would have reversed these roles. Used in significant concentrations at front line level, the air rifle would have given a major advantage to any army using them.

Following the issue of the first tranche of air rifles, pressure was mounting on the Artillery Support Command to hasten the delivery of the remaining 800 along with all accessories.

In February 1788 the Emperor wrote to the Army Supply Council on this subject.

It was clear he accepted the reality that only two reservoirs per gun would be available; however the need to also provision the third one was urgently stressed.

There was an additional request, to design and produce a transporter capable of carrying safely 1000 pressurised reservoirs.

Despite all this activity, the supply of reservoirs again proved to be a problem. Girandoni reported to the Artillery Supply Command, who in turn reported to the War Council, that he could only supply two reservoirs per rifle instead of three by the April 1st deadline.

He also stated the third reservoir would be delayed till June, owing to the difficulty in obtaining the required quality of metal from his supplier, the Iron Trader "Golden Shovel."

A further report on the 18th of April by Colleredos deputy Major General Maurer, indicated that only 500 rifles were held by the Peterwardein depot.

However this situation was retrieved by May 2nd, as the Major was able to report that 700 rifles had been forwarded, with only 100 remaining rifles without their spare reservoirs.

This was a very commendable effort given the scale of the reservoir problem that was highlighted in the same report.

With a 1000 reservoirs still outstanding, the report indicated Girandoni could only achieve a production rate of 100 per week with a failure rate of 30% on test.

Clearly accepting that this was the reality of the situation, the Emperor placed no further pressure on Girandoni appearing to simply leave him to get on with it.

By 21 June Major General Maurer reported to the War Council that of the four reservoir transporters completed and available, two were on their way to Peterwardein with 300 reservoirs. The other two would follow when the remaining reservoirs were available, so at this point it appeared the end was in sight and no doubt to the relief of all concerned.

Following the rather disappointing performance of his army in their initial battles, the Emperor ordered the recall of the air rifles for storage and servicing at the end of the campaigning season in November 1788.

Surprisingly, there is a frustrating lack of information with regard to the performance of the air rifle in battle.

There is a short reference to the loss of 20 air rifles following the armies retreat after the battle of Lugos in September 1788, however the only direct comment on the air rifles performance, was that contained in a report to the war council dated July 21st 1789 by Colleredo.

The report indicated that the air rifle due to its complexity, had been more difficult to use efficiently, in comparison with the standard flintlock musket.

He then went on to highlight the need for the close supervision of the troops using the air rifles due to their lack of familiarity with their weapons.

Perhaps this unfamiliarity was also the cause of further reporting that only a third of the rifles were serviceable at the end of the campaign.

His proposal for resolving these problems was the very sensible idea of bringing all the airgun troops into one specialist unit.

He went on to state the advantages of this proposal would be to increase individual skills in handling the air rifles, with the added benefit of reducing the high failure rate.

There would also be a further benefit, in bringing all the support such as spare reservoirs, pump machines and repair workforce into one cohesive unit, rather than being scattered throughout the whole army.

The final comment in the report to the effect that a unit of riflemen would be very flexible and could be deployed quickly implies perhaps a growing awareness of the greater tactical potential of the rapid firing airgun.

In a note to the Emperor, the President of the War Council Hadik enthusiastically endorsed Colleredo's proposals, along with a very favourable opinion of the air rifle.

As Hadik was an important senior military figure, we can accept from his comments that the military regarded the debut of the air rifle in battle as a success, despite the maintenance problems.

It is also significant that both Colleredo and Hadik as military experts, realised that concentrating the air rifle expertise at corps level would make far better use of its tactical potential.

Inexplicably, the Emperor would not accept these arguments and insisted on spreading the air rifles in penny packets across the army, thus restricting the air rifle to a minor tactical role.

However by this date Emperor Joseph was a very sick man, and died shortly afterwards in February 1790.

His successor Leopold, also showed a strong interest in the air rifle and more importantly, favoured the concept of a dedicated air rifle corp.

He decreed all air rifles were to be returned to Vienna for inspection, repair and servicing, following this a special Tyrolean sharpshooting Corps was to be set up.

This Corps would complement the existing rifle corps and serve alongside them, thus allowing the air rifle to make a far greater tactical contribution than under the previous arrangement.

There was a delay of two years in issuing the air rifles to the new Corps, which indicates there must have been a considerable amount of work involved in bringing the stock of air rifles to a fit state for issue.

Another reason for the delay was perhaps the fear of the spread of French revolutionary ideas into the Emperor's own population and army.

This was a recurring nightmare for most of the European monarchies of the period, and may explain the Emperor's reluctance in issuing such an important weapon until he was assured of the loyalty of the troops concerned.

This may also explain the need for a further reminder from the War Council to the Emperor in 1793, giving further support to the formation of the air rifle corps.

Although Field Marshal Hadik had died in 1790, his successor in the War Council clearly shared his high regard for the air rifle, as the communication to the Emperor clearly indicates.

Hadik's original proposal on the need to concentrate all the air rifles, together with their accessories in one facility, was restated.

Additionaly a report from the Commander of the Tyrolean Sharpshooters, Lieutenant Fenner, was also forwarded, lauding the performance of the air rifle to the extent of the War Council suggesting all riflemen should be armed with air rifles.

Also included, was a special request by the Tyrol Sharpshooters to be re-issued with air rifles.

Based on their experience in their use during the Turkish and Prussian campaigns, they considered them to be very accurate and effective.

Convinced by the strength of these arguments, the Emperor concurred with the request.

After being informed of the Emperors decision, the Artillery Support Command responded with uncharacteristic speed.

They reported to the War Council on Jan 26 that arrangements had been made to forward to the new Corps 500 air rifles with all accessories, four 2- axle wagons for reservoirs, a machine pump and other special tools.

Accompanying these were four gunsmiths to conduct maintenance.

Five years later, following the death of Girandoni in 1799, the War Council received a report from the Artillery Support Command detailing the status of the stock of air rifles.

The report states that of 500 air rifles issued to the Tyrol Sharpshooters 362 were missing, this meant to maintain a stock of 1500 the missing rifles would need replacing.

Although 45 replacements for earlier losses had been made successfully by other gunsmiths, the Emperor decided that no further action would be taken.

The reason for the high attrition rate of the air rifles is explained in a report by Lt. Fenner January 1801.

He states that a large proportion of the missing rifles had suffered damage to parts of the weapon, such as the receiver, which could not be repaired in the field.

In light of this it is interesting to note that on one of the examples studied by the authors, there was the start of an old stress fracture on the receiver, where it abruptly changed shape.

The report then points out that many rifles were also lost, when the fortresses of Landrecy, Maastrict and Koenigstein surrendered.

It further states that no replacements were made for these losses, and requested that either the missing rifles are replaced or all the remaining air rifles held by the Corps to be returned.

Reacting to this report, the Artillery Supply Command ordered all the remaining air rifles to be returned to store and issued conventional weapons to the Corp in their place.

With this final action, came the rather abrupt demise of the Girandoni air rifle in the Austrian service.

The air rifle was never issued during the Napoleononic wars, and the ultimate fate of the surviving rifles is unclear.

Evaluating the Girandoni as a military weapon is rather difficult, as most information appears to be only available from secondary sources.

However on the balance of the information available, it would appear that the air rifle was highly regarded by the troops who had used it in battle, this opinion also being shared by the Senior ranks of the military.

On the negative side, there are a number of issues that may have contributed to the decision to abandon the air rifle.

Firstly, despite the presence of gunsmiths in the field, it is clear maintenance under service conditions was a severe problem.

Secondly, the question of replenishment if access to filled reservoirs in the transporter wagons was not possible.

In a fast moving skirmish this must have been a distinct possibility, and unlike replacing powder and ball, topping up the reservoirs with the hand pump was an exhaustive and long-winded operation.

Therefore it is difficult to accept this being feasible during the thick of a military action.

In this situation, airgun troops would have to be withdrawn and protected during the pumping process.

Given this, it is surprising consideration was not given to cavalry use where these problems could have been easier to overcome.

On the other hand, if the infantry use of the air rifle were confined to a static situation, the above problems would also be mitigated.

Perhaps this is the reason for the air rifle being specifically mentioned as most useful for fortress defence.

In fact it is noteworthy that most of the airguns lost in action were from captured fortresses.

It is surprising that the Girandoni did not make a greater impact on the military thinking of the day, especially when it is considered that only on the appearance of the Spencer repeating rifle during the American Civil War, was an equivalent to the Girandoni made available to the military.

Considering the time interval between the designs, the similarity between the operation of both rifles is striking.

Both were repeaters that required two operations prior to discharge and both had a separate quick loading facility.

However the Spencer magazine only held seven rounds, requiring frequent replenishment from the rather clumsy Blakeslee loader.

Conversely, each Girandoni had two spare reservoirs and four compact twenty round magazine refill tubes as standard issue.

Therefore it would appear on magazine capacity and potential rate of fire, the Girandoni could be considered the superior system.

In contrast to the Girandoni, the impact of the later repeaters on the battlefields of the Civil War was considerable, the essential difference being they were in the hands of the cavalry instead of the infantry, where the combination of firepower and speedy manoeuvre, gave a new dimension to battlefield tactics.

Perhaps the true potential of the Girandoni would had been realised in the hands of the Austrian cavalry, where the repair and replenishment problems were easier to resolve.

The withdrawal from military service was not the end of the Girandoni, as despite the withdrawal from Austrian service, there was still interest in the concept.

In fact the design became very popular as a basis for sporting weapons.

Gunmakers such as Contriner in Vienna and Staudenmayer in England, produced wonderful richly decorated individual pieces for wealthy aristocratic sportsmen, that were a far cry from the plain military originals.

There was even a military revival, as in 1815 the Danish King Fredrick initiated tests on copies of a Contriner model, as well as Sweden and Norway also testing similar copies.

However no further action ensued and this was nearly, but not quite, the end of the air rifle as a military weapon in Austrian hands.

Following the 1848- 49 revolt of the Czechs and Hungarians, the air rifle was re-issued for its last employment. They were presumably then disposed of, as no more was heard of them after this date.[2]

The final appearance of the Girandoni on the military stage was in WWII, where the Austrian resistance used a crude but effective copy against the Nazi.

There is unfortunately no indication of it being used, however there is no doubt it would have been just as formidable in 1945, as its ancestor was in 1795.

Figures achieved by Girandoni were quite staggering, testifying that in addition to his design skills, he also had an undoubted ability as a production manager.

Due credit should also be given to the Emperor Joseph, whose drive and determination to see the air rifle in service was a major factor in its success.

Examining the materials and techniques used in the manufacture, it is evident the introduction of the air rifle into military service, severely tested both the technical knowledge and manufacturing ability of the period.

In comparison with the standard flintlock musket of the period, the air rifle was a sophisticated design clearly reflecting Girandoni's clockmaking background.

Closely resembling a clock movement, the air rifle action consisted of a large number of inter-dependent components, working to fine tolerances.

To function at all, it had to be made to a degree of accuracy that was far in advance of that required for a military flintlock.

The design in fact did not lend itself easily to manufacture in numbers as it had to be built up from a datum with components fitted in sequence, requiring a considerable degree of hand fitting and fine adjustments to achieve correct functioning.

However Girandoni's main problem was the requirement for all the major assemblies of the 1500 rifles to be completely interchangeable with each other.

The threaded interface between the reservoirs and receivers, along with that of the pump to the reservoir was a particular concern.

To make 1500 rifles and pumps with three times as many resevoirs all interchangeable was indeed a major challenge given the technology available.

Unless any resevoir could be fitted to any rifle or any pump to any reservoir, the design would simply not be viable as a military weapon.

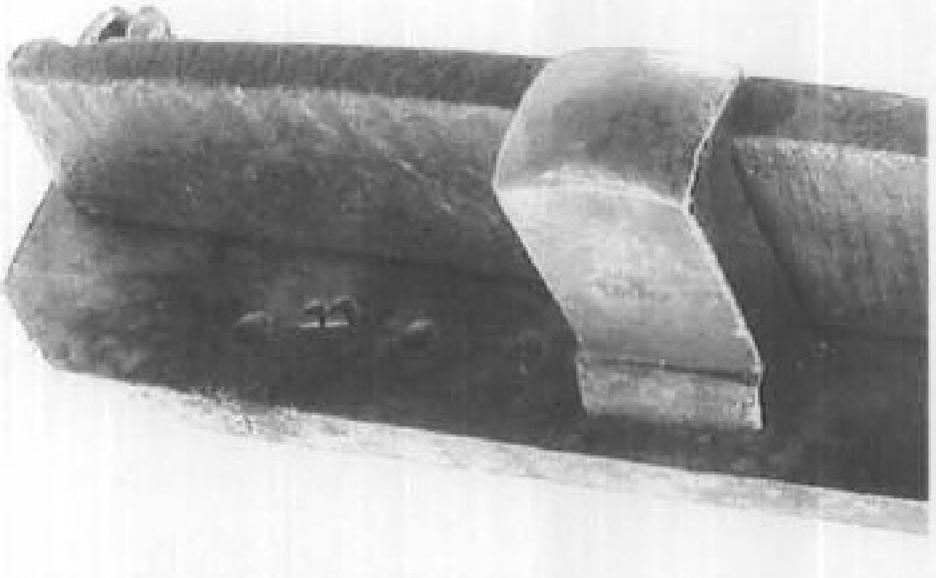
Using techniques of casting and forging, the components used in the construction of the Girandoni were as normal firearms manufacture.

However, there was a far greater degree of accuracy required in the dimensions of the finished components and their relationship with the overall assembly.

For example, the setting up and timing of the mechanism controlling both the power and efficient use of the air supply was a very critical operation, that demanded the skills of craftsmen of a very high level.

It was noticed that of the two rifles examined in depth, the components of one rifle were identified with two punch marks, and the second one with three.

One lockplate also included the letter "B" which can be easily seen in the included picture of the actual components.



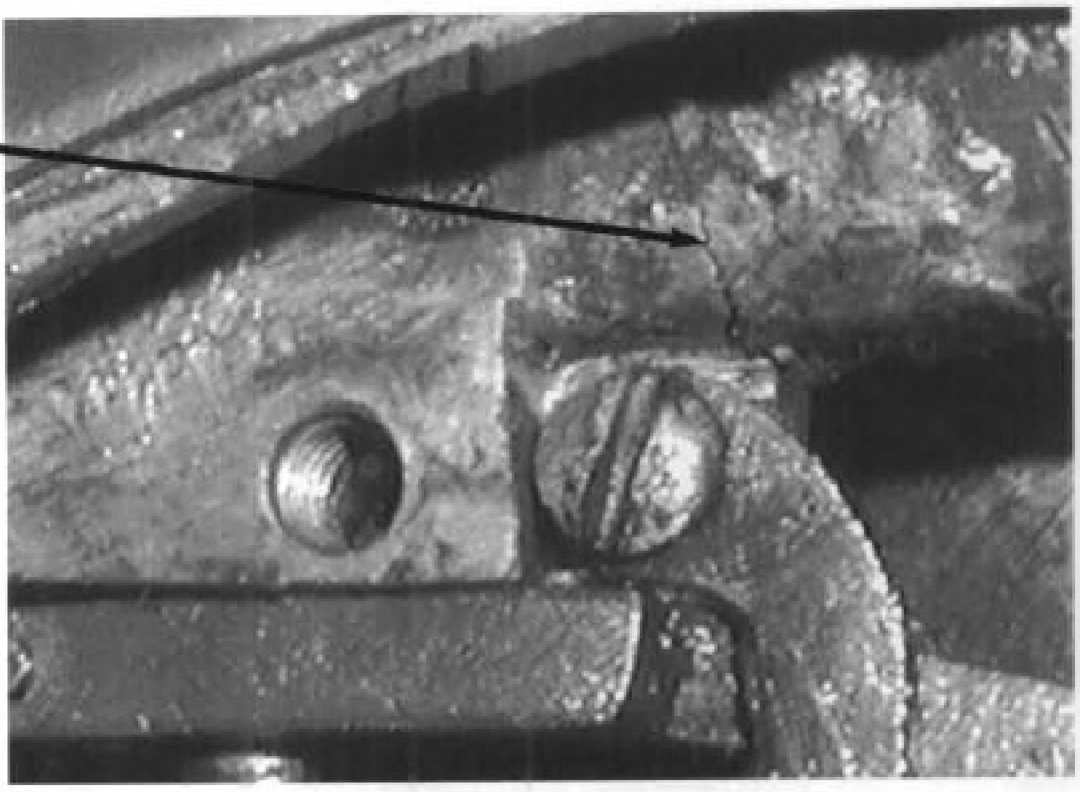
We do know that Girandoni brought two workmen plus his assistant with him when he commenced work on the air rifle.

Although we can only speculate, if these four including Girandoni himself assembled or supervised the assembly of the air rifle, it is possible the punch marks either identified the person either assembling the rifle, or acting as supervisor accepting it.

This is borne out by the fact that although each rifle is identified with a serial number, there is the no corresponding numerical marking of the individual components.

The method used clearly indicate that it was not the intention to identify components to a specific rifle.

Given the number of rifles involved only a numerical system would have been workable.



stress crack on the receiver of one of the rifles examined

The Girandoni was undoubtably a successful weapons system, so why did it disappear from history?

There is no evidence that there were any problems with the valves or the performance.

There were problems with maintenance in the field and the bronze receiver may have been a source of weakness with rough handling causing cracks but this would have been overcome in the normal course of developement.

The main problem was the sheer logistical nightmare of pressurising the reservoirs either in the field or at the supply depot, in short

all that pumping!

Even today there are problems with keeping modern precharged pneumatics supplied with air particularly if you want to be independent of dive shops and scuba tanks.

There are double acting stirrup pumps available now to fill precharged air rifles but you still cannot get round the laws of physics, you have to use more energy to fill the reservoir than you get back.

The double acting pump merely allows you to fill the reservoir with a smaller number of pump strokes compared to the original Girandoni pump.

The effort is in some respects greater with the modern pump because you have to supply muscle power on the up stroke as well as the down, you just get there quicker if you can sustain the effort.

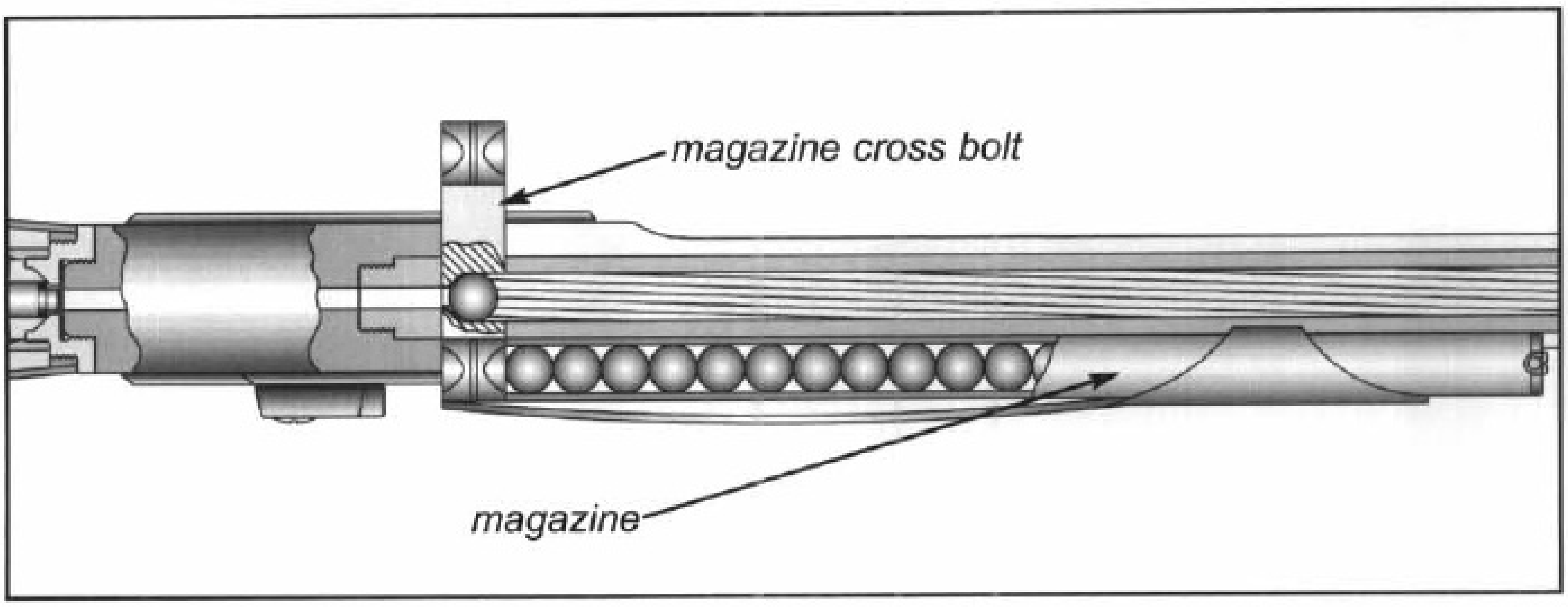
Using a walking stick aircane with a far smaller reservoir as a comparison, it takes 300 strokes of the original pump to reach 600 lbs per sq inch, a very exhausting process.

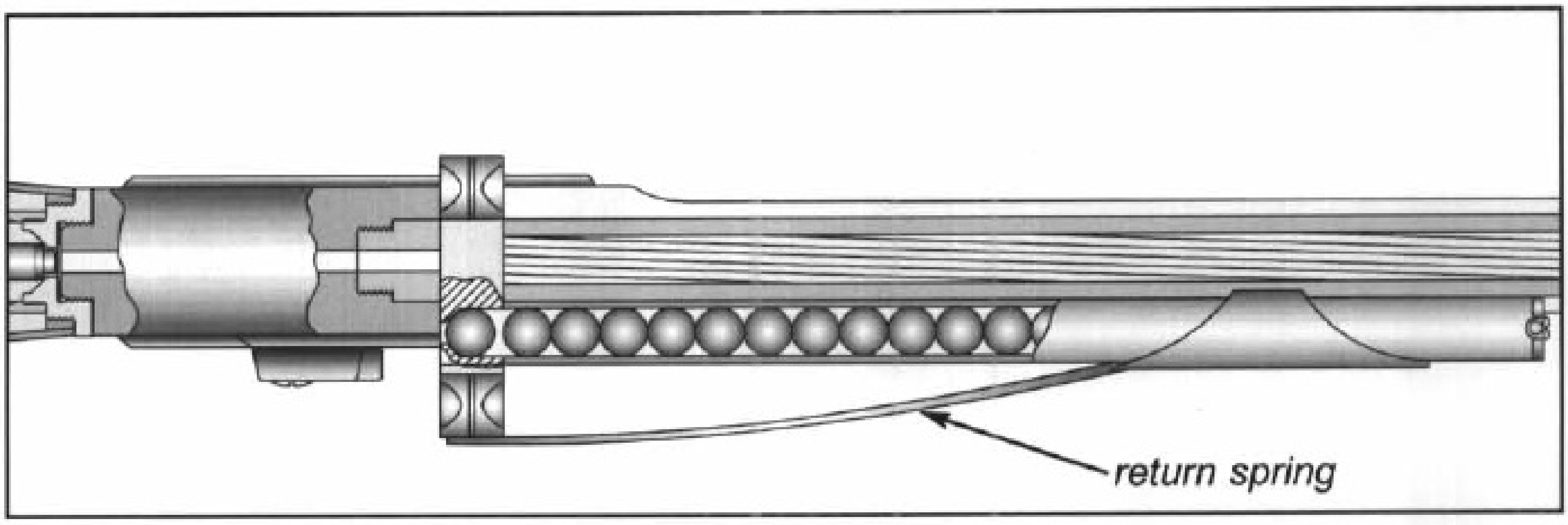
Consider the effort involved in pumping 3 reservoirs per man at 1500 strokes for each, with the resistance steadiliy increasing as the pressure rises!

Magazine operation

To operate the Girandoni, it is necessary fill the tubular magazine on the right side of the barrel with 20 balls of appropriate calibre, pressurise the butt reservoir and screw to the receiver. Elevate the rifle muzzle then press the transverse block fitted in the breech fully from left to right against the flat return spring fitted to the magazine.

Gravity then feeds a ball from the magazine tube into the block, which on release returns under spring pressure to bring the ball into line with the bore. The hammer is then drawn to full cock against the lock mainspring, the rifle is now ready to fire.

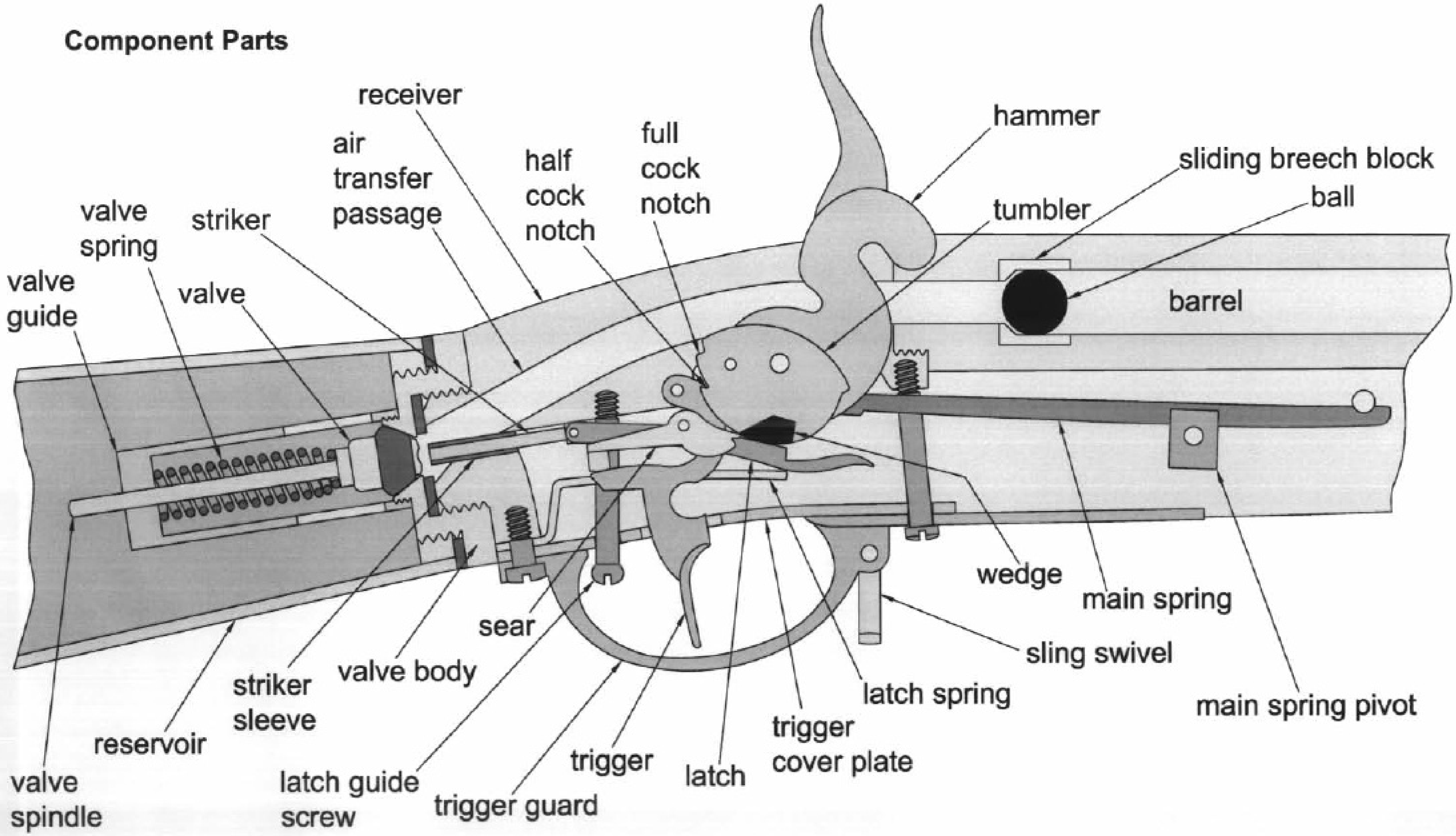


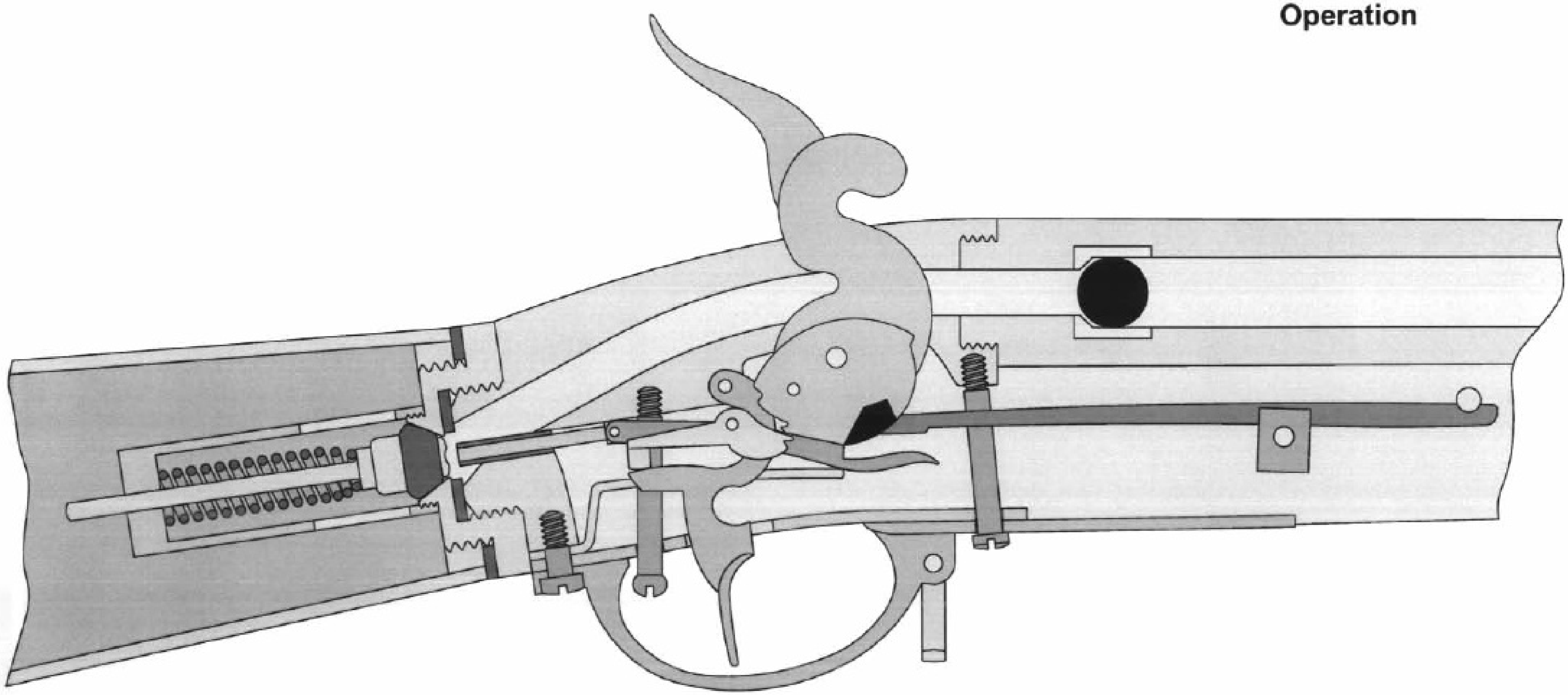


Pressure on the trigger releases the tumbler, on which a valve trip is mounted that briefly opens and closes the valve mechanism, thus allowing a small quantity of high pressure air to discharge the ball.

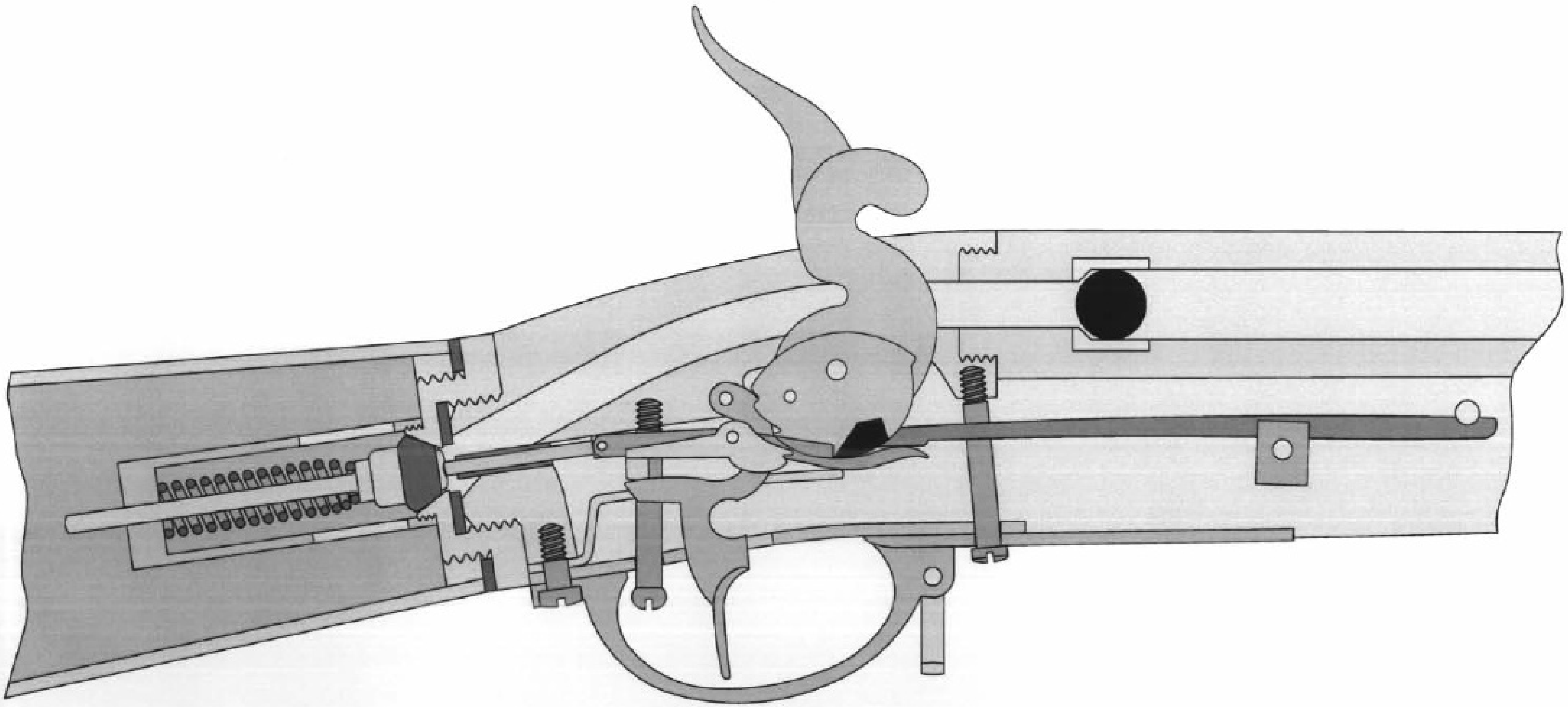
This process can be repeated rapidly for 20 shots, with a fall in performance as the reservoir pressure decreases.

Component Parts

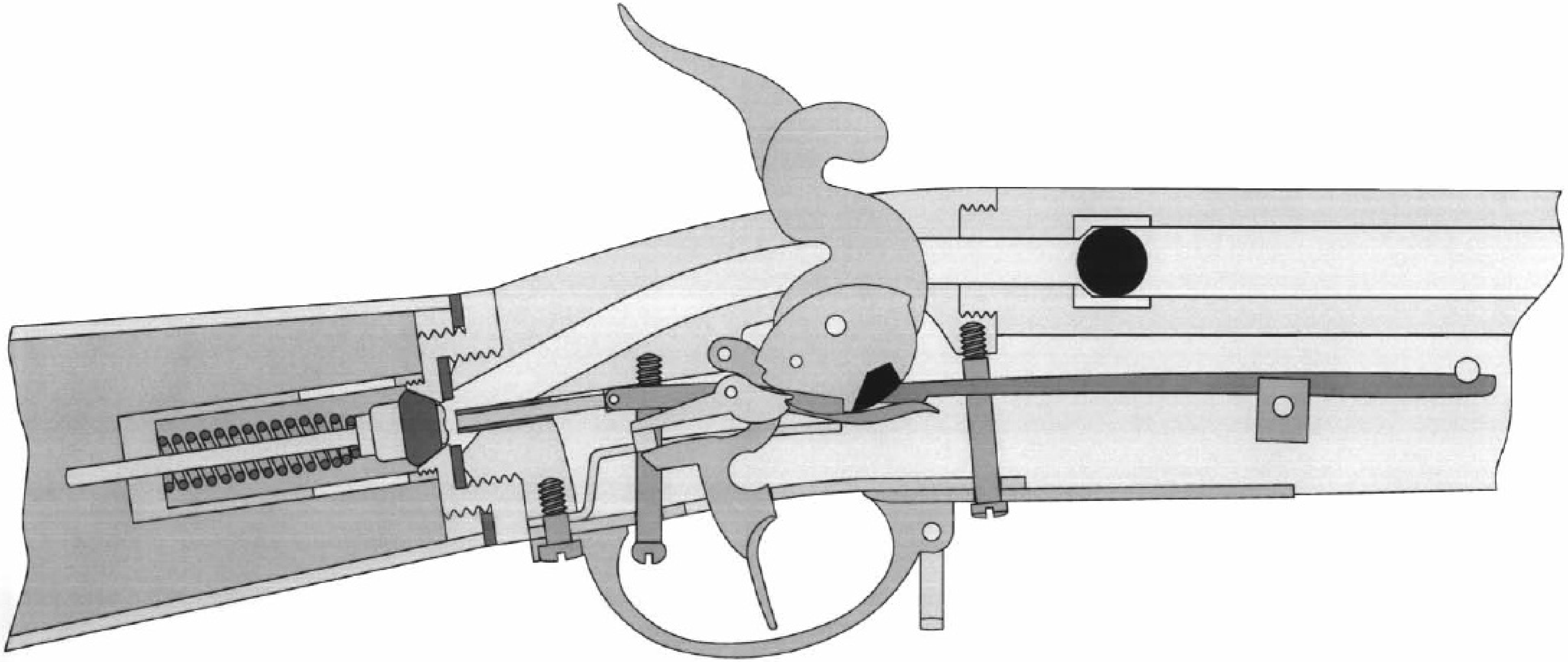


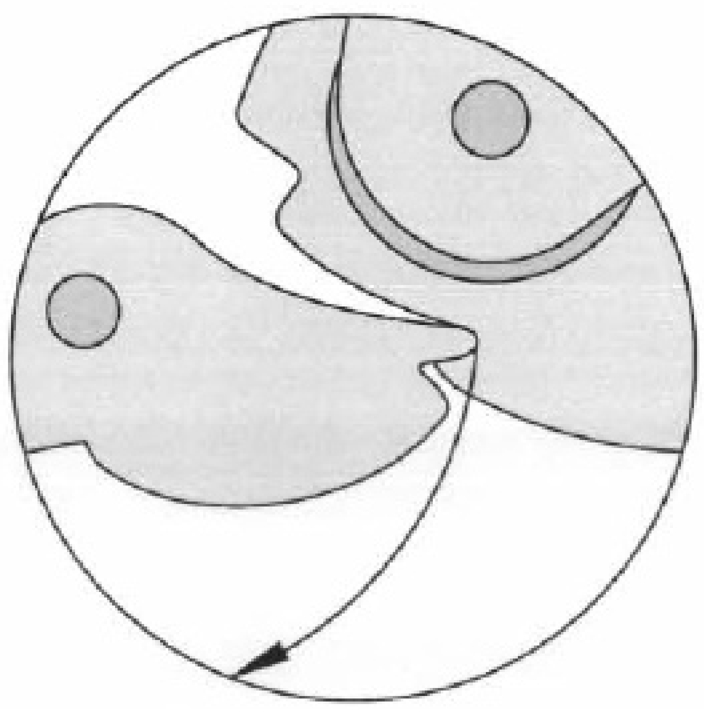


As the hammer is pulled back from rest to full cock there are three distinct tactile clicks which are felt through the hammer. As the hammer is rotated the wedge shaped projection reaches a point where it slips past the edge of the notch on the latch.

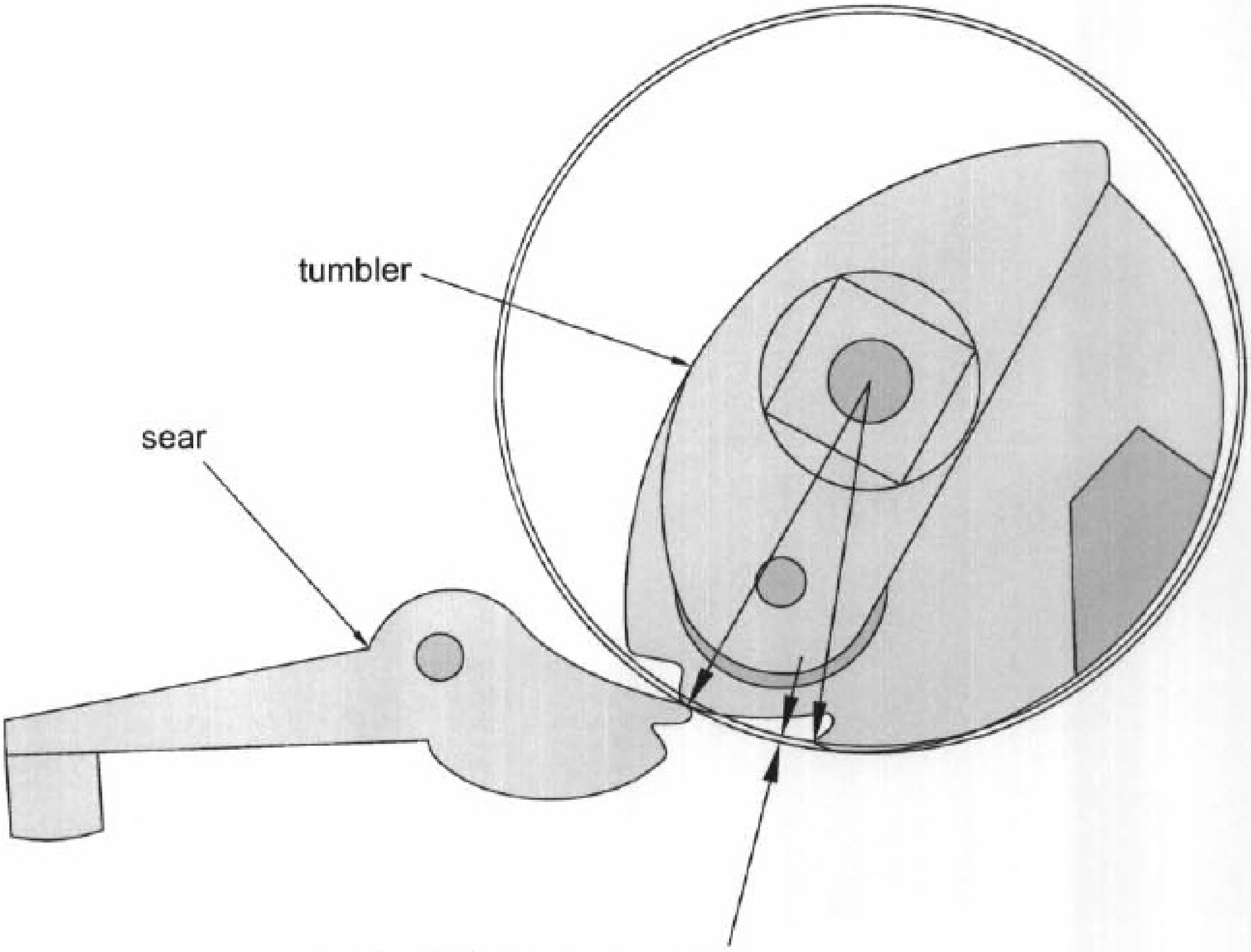


It then drops down into the notch cut into the latch, giving a distinct click, if the hammer is released at this point the wedge will push the latch back towards the valve under pressure from the mainspring. The mainspring is very strong and if the reservoir air pressure is low the valve can open resulting in an accidental disharge.
Later civilian versions have a bypass device that enables the latch to be pushed down so that the hammer can be lowered without opening the valve. With the service air rifle you would have to unscrew the reservoir to lower the hammer without discharging the weapon.





Further rotation of the hammer brings the tumbler to the half cock position giving the second click. In this position the tumbler is securely held by the sear. Pulling the trigger would cause the sear to push the tumbler back against the pressure of the mainspring, even very heavy pressure on the trigger would not allow the sear to come out of the half cock notch enough to allow the tumbler to rotate.



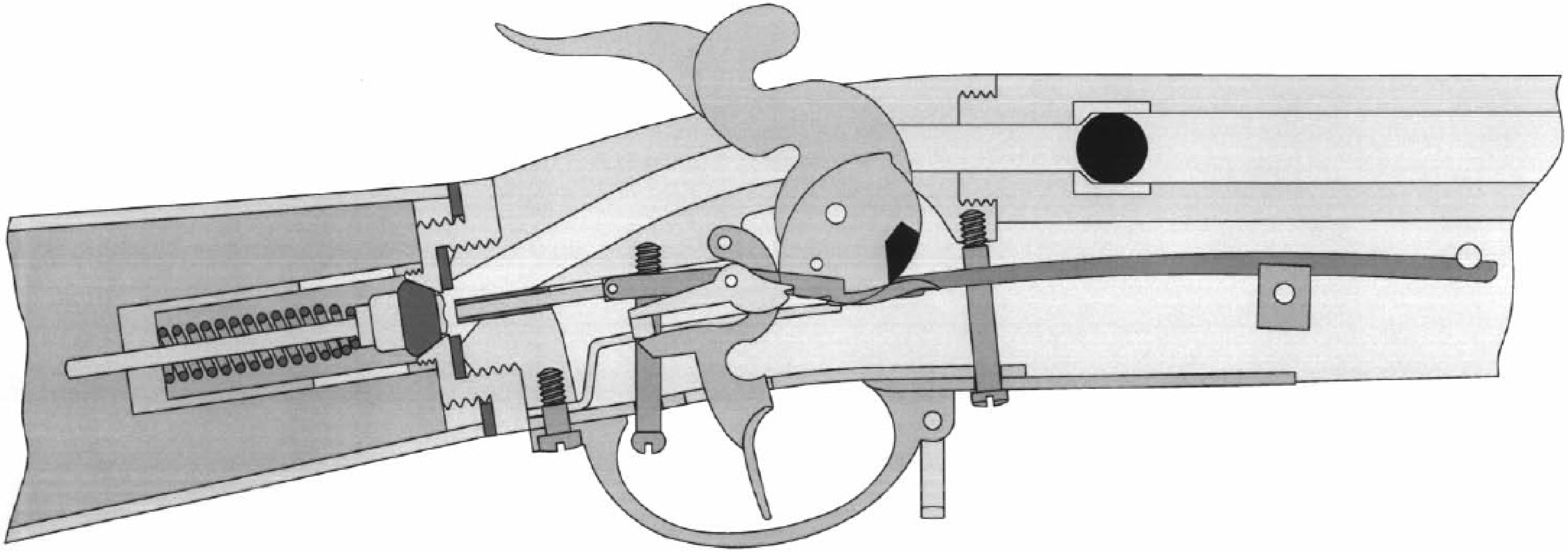
The half cock notch is cut into the tumbler on a slightly smaller radius so that if the trigger is pulled slowly the nose of the sear will not catch in the half cock notch.

If it does catch the considerable pressure from the mainspring could produce enough force to break off the projection of the half cock notch, this often happened with flintlocks.

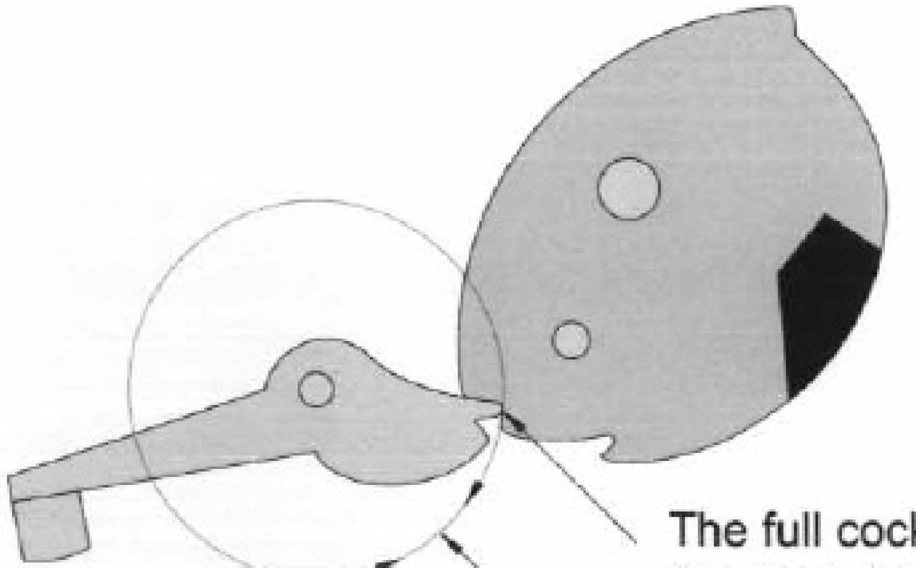
The inclusion of a half-cock position is initially rather puzzling, as it is clearly unnecessary to the functioning of the lock.

However, due to the excessive distance of throw and stiff spring movement it is soon apparent that going directly to full cock is a very uncomfortable operation, especially in comparison with a conventional Flintlock or Percussion lock.

Splitting the movement into two operations makes sense in both avoiding the danger of slippage and a faster speed of operation.

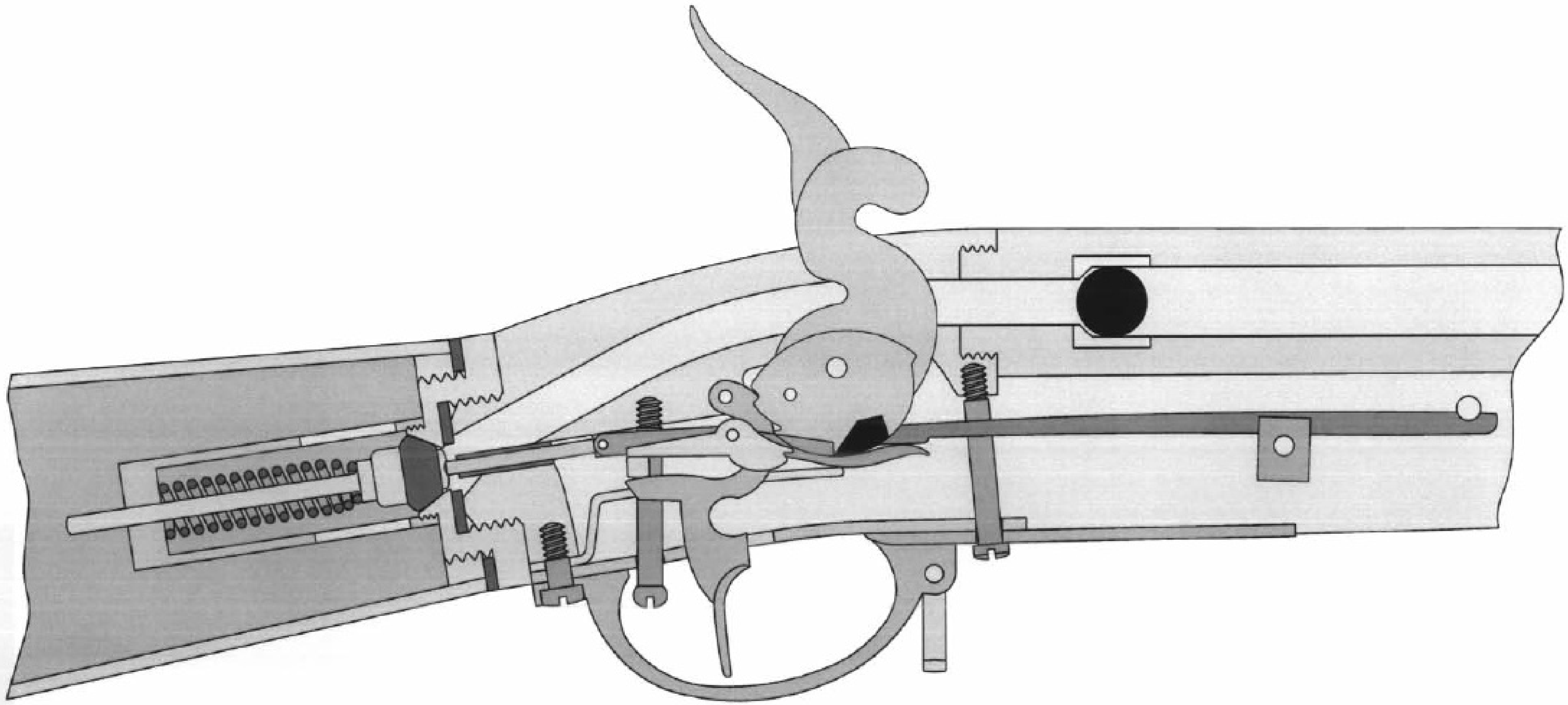


Finaly the full cock position is reached (third click), the rifle is now ready to fire.

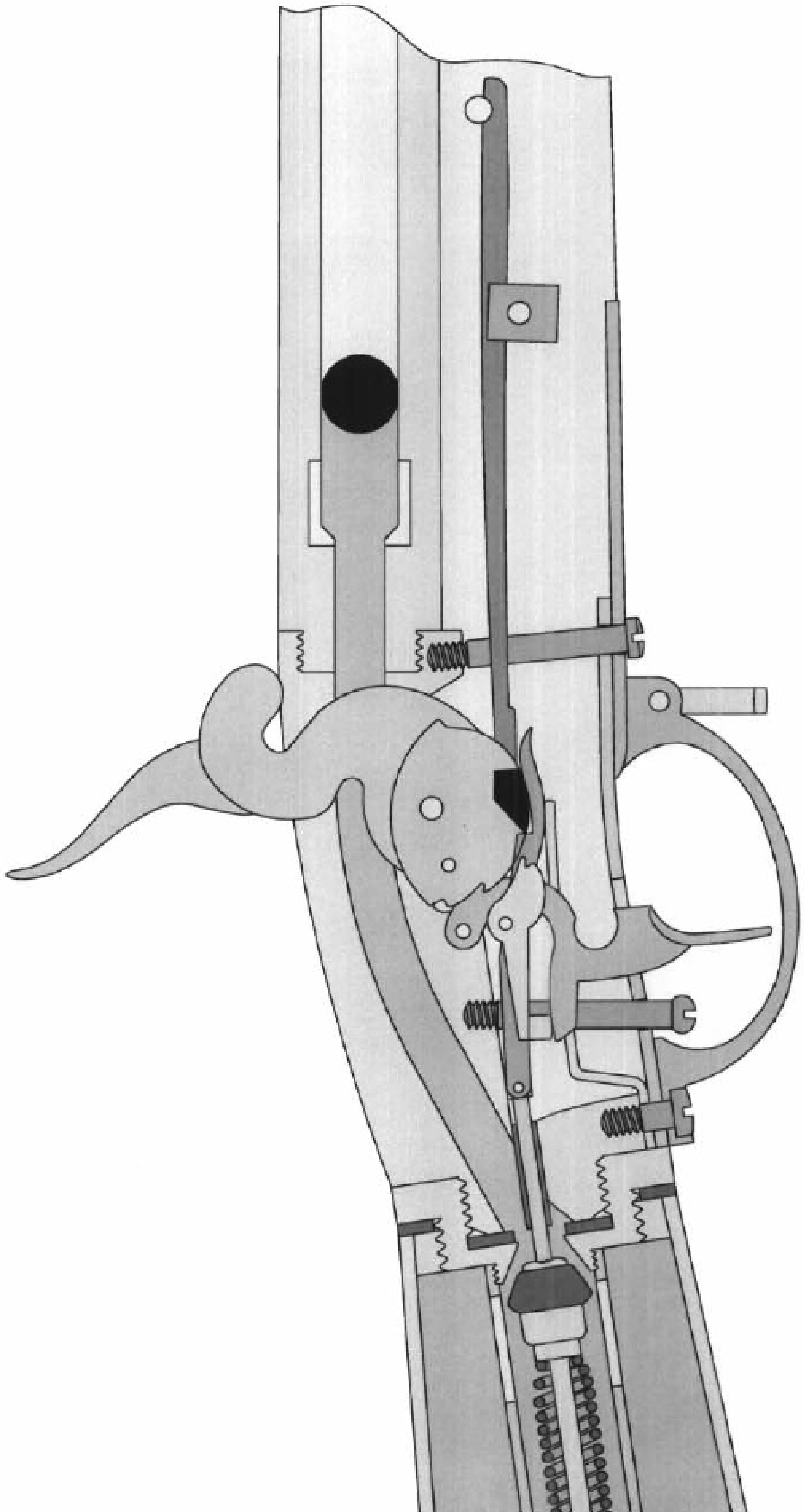


The full cock notch is cut at an angle so that the nose of the sear does not cam the tumbler backwards or forwards as it is rotated by the trigger

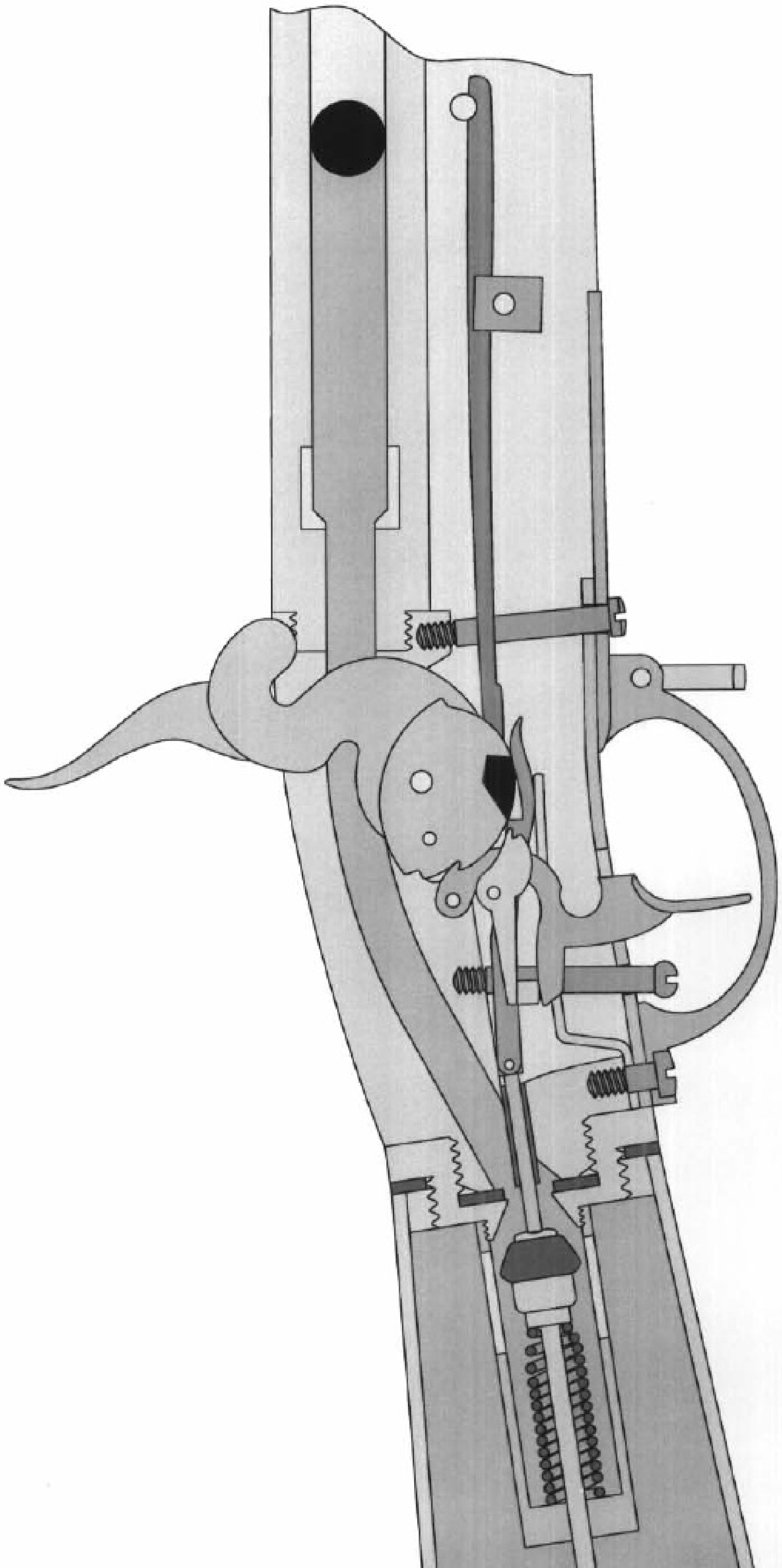
The nose of the sear moves on this circle



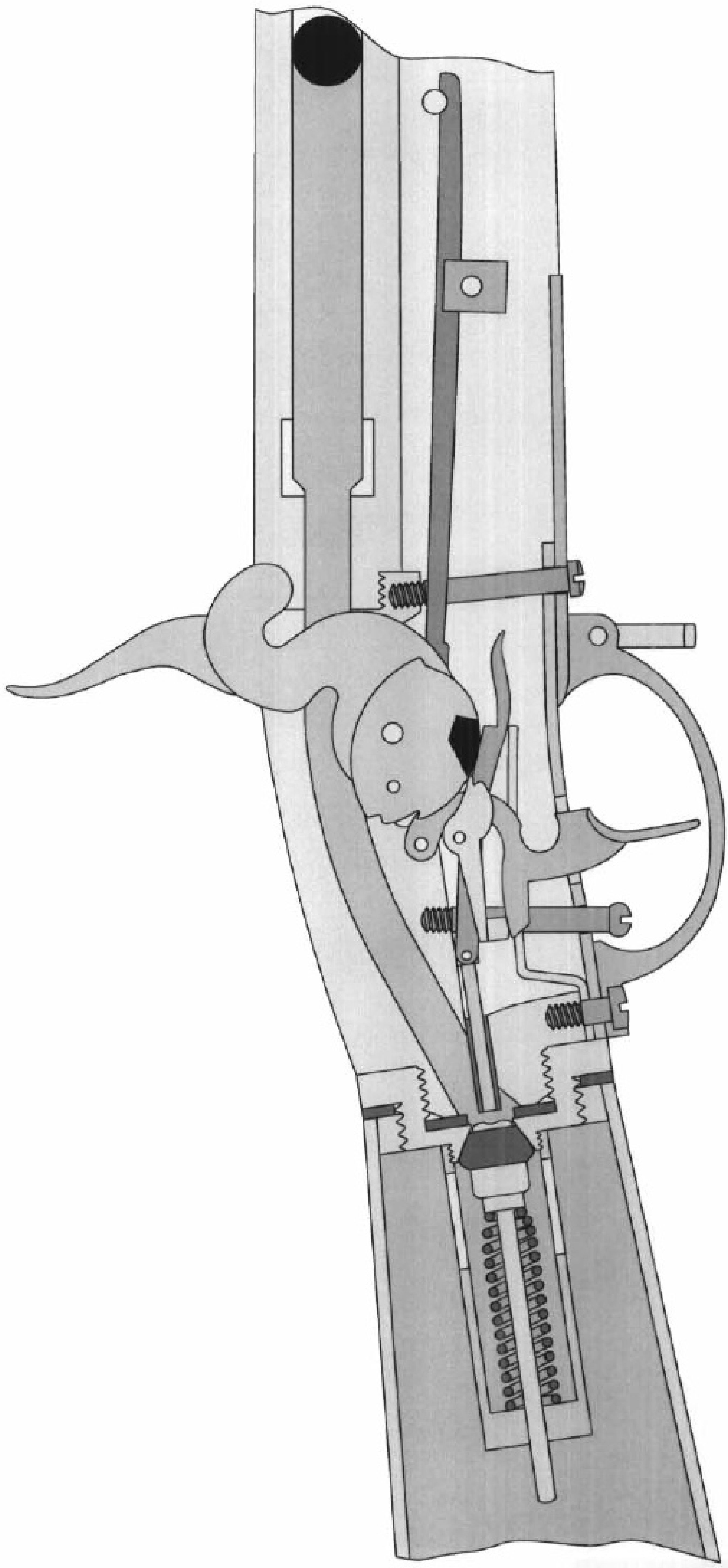
When the trigger is pulled the nose of the sear is moved downwards out of the full cock notch which allows the mainspring to rotate the tumbler. The wedge shaped trip on the tumbler pushes the latch and pin backwards opening the valve. High pressure air from the reservoir starts to propel the ball up the barrel.



As the tumbler continues its rotation the valve is opened further and the wedge is being forced out of the notch in the latch.

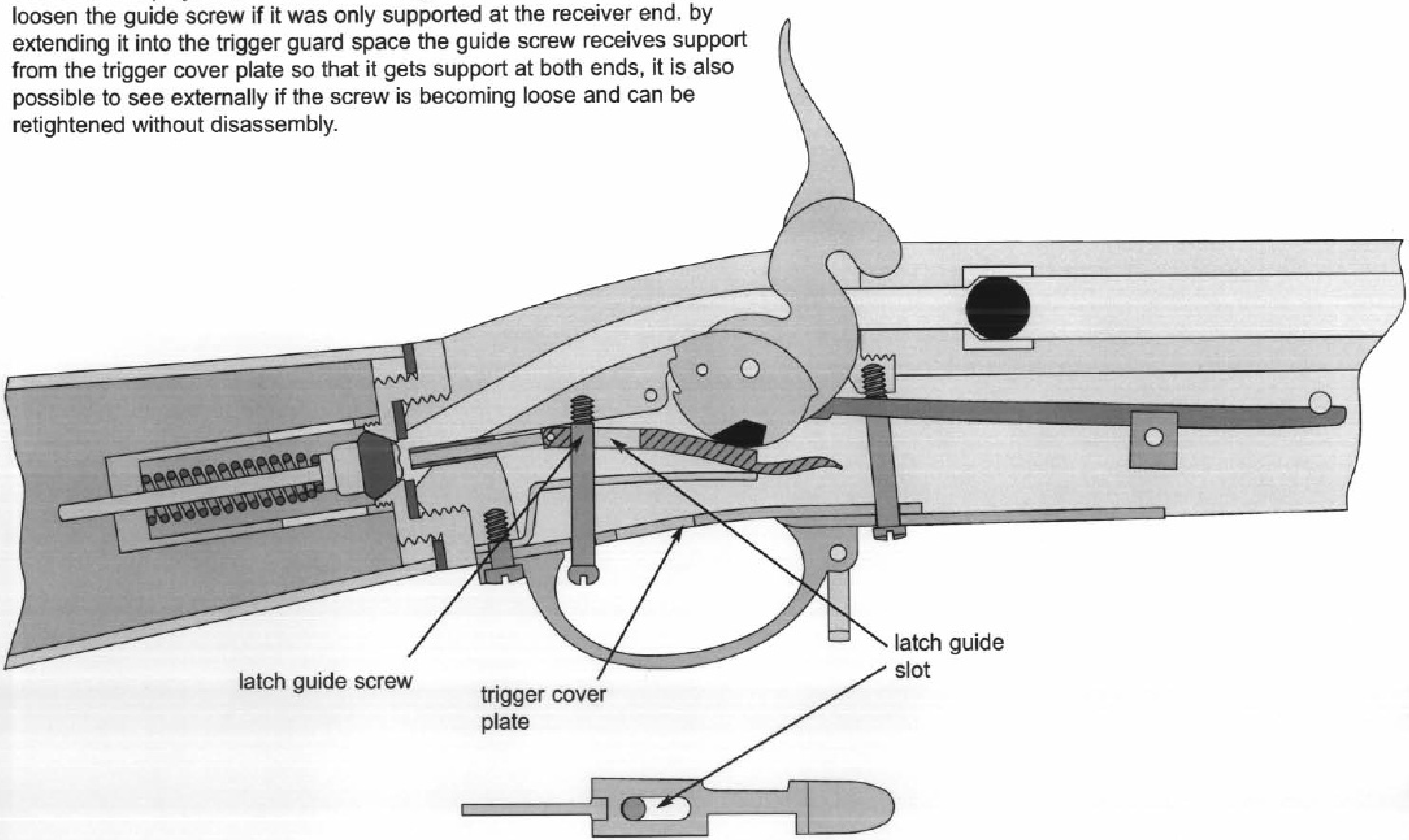


The wedge is just moving out of contact with the latch and the valve is fully opened.



The air pressure in the barrel drops as the ball travels up the barrel and the valve is forced closed by the difference in pressure between the reservoir and barrel. This pushes the pin and latch assembly back towards the tumbler until the latch slips past the wedge and comes to rest.

The latch guide screw provides a limit on the backwards and forwards movement of the latch. It receives a strong blow when the valve is being opened and another when the reservoir pressure returns the valve to its seat after the projectile has been discharged. This would either bend or loosen the guide screw if it was only supported at the receiver end. by extending it into the trigger guard space the guide screw receives support from the trigger cover plate so that it gets support at both ends, it is also possible to see externally if the screw is becoming loose and can be retightened without disassembly.



Construction

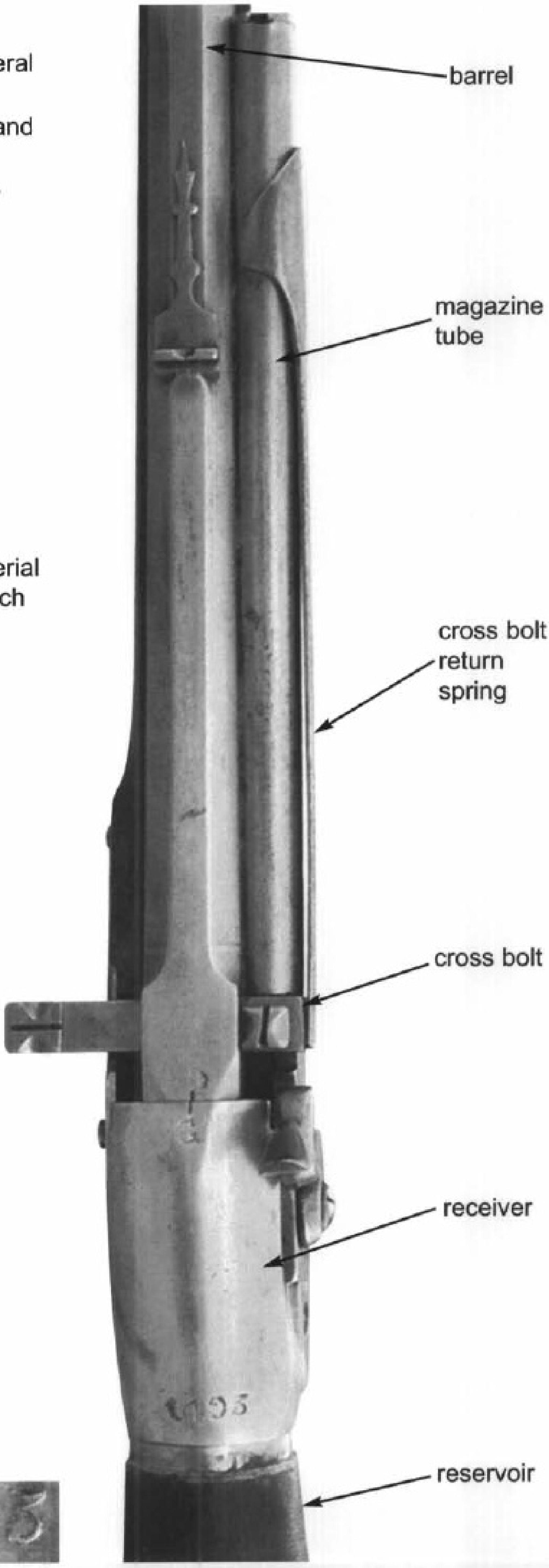
The design can be broken down into several assemblies :

Barrel with transverse sliding cross bolt and attached magazine.

Receiver and associated lock components

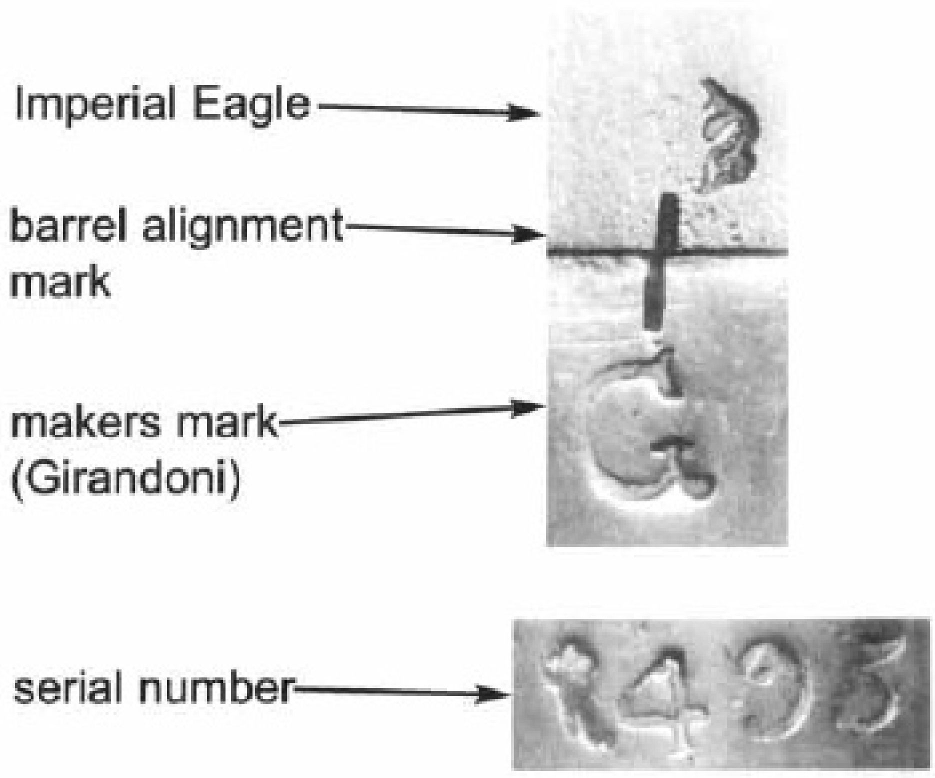
Reservoir that forms the butt of the rifle

Austrian coin of the time showing the imperial eagle that is stamped onto the barrel breech



The Imperial Eagle stamped into the barrel is not a proof mark in the accepted sense.
Air gun barrels have to withstand far lower pressures than firearms so proofing by over pressurising as with a firearm barrel is not neccessary.
This is most probably an official acceptance stamp, it would be vital that all barrels had exactly the same calibre to accept standard size ammunition.

It is probable that the barrel was filed after this point during the process of fitting it to the receiver, this would remove some of the definition of the marks.



The Barrel Assembly, consisting of the barrel, magazine, spring and cross bolt fitted with stops, did not present the technology of the period with any unusual challenge as regards manufacture.

All the materials and techniques used were in standard use by the gun trade of the time.

However, arising from the design of the air rifle, there was the problem of ensuring a far closer match of ball to bore, than previously required by the muzzle loading rifle of the period.

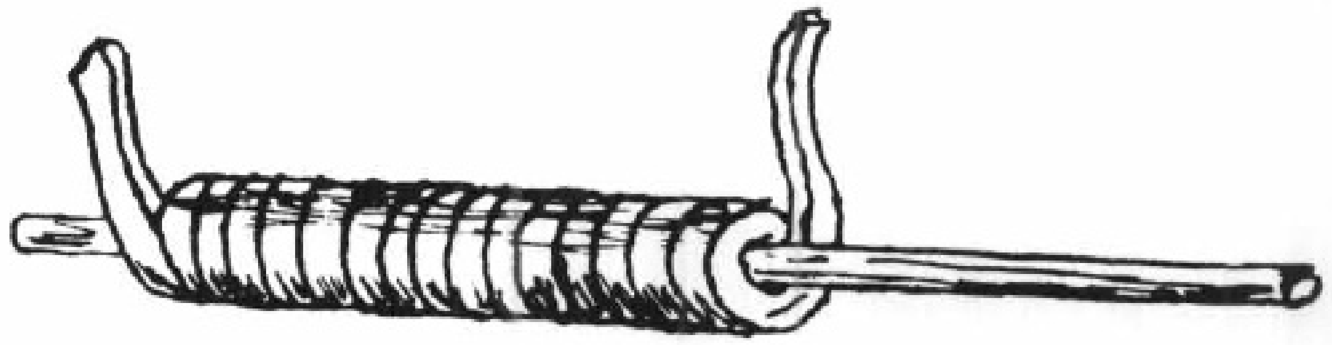
With the muzzleloader any problem with minor deviations in the bore size would automatically be corrected during loading.

In contrast, due to the breech loading design of the air rifle, a far tighter tolerance between the ball and the bore was required if any functioning or accuracy were to be achieved.

A further issue was the need for all 1500 air rifle bores to be compatible with each other.

The manufacture of the barrel only differed from normal in that it had to have sufficient material at the breech to form the cross bolt housing.

The contemporary method of achieving this was to spirally wind a thick ribbon of iron at white heat around a mandrel, then hammer weld each spiral to its neighbour until a homogeneous tube was created.



Following the opening out of the tube bore with a succession of augers, a process known as spill boring was used to allow the accurate removal of small amounts of metal to a strict tolerance that ensured the uniformity of bore of all the air rifle barrels.

This was the only stage of barrel manufacture prior to rifling, where final bore size and uniformity could be sensibly established, and Girandoni must have used some form of standard to ensure this uniformity.

Given the technology available, this standard would have been most probably in the form of a master plug gauge.

After the completion of these operations, this was probably the stage the barrel was finished to its octagonal configuration.

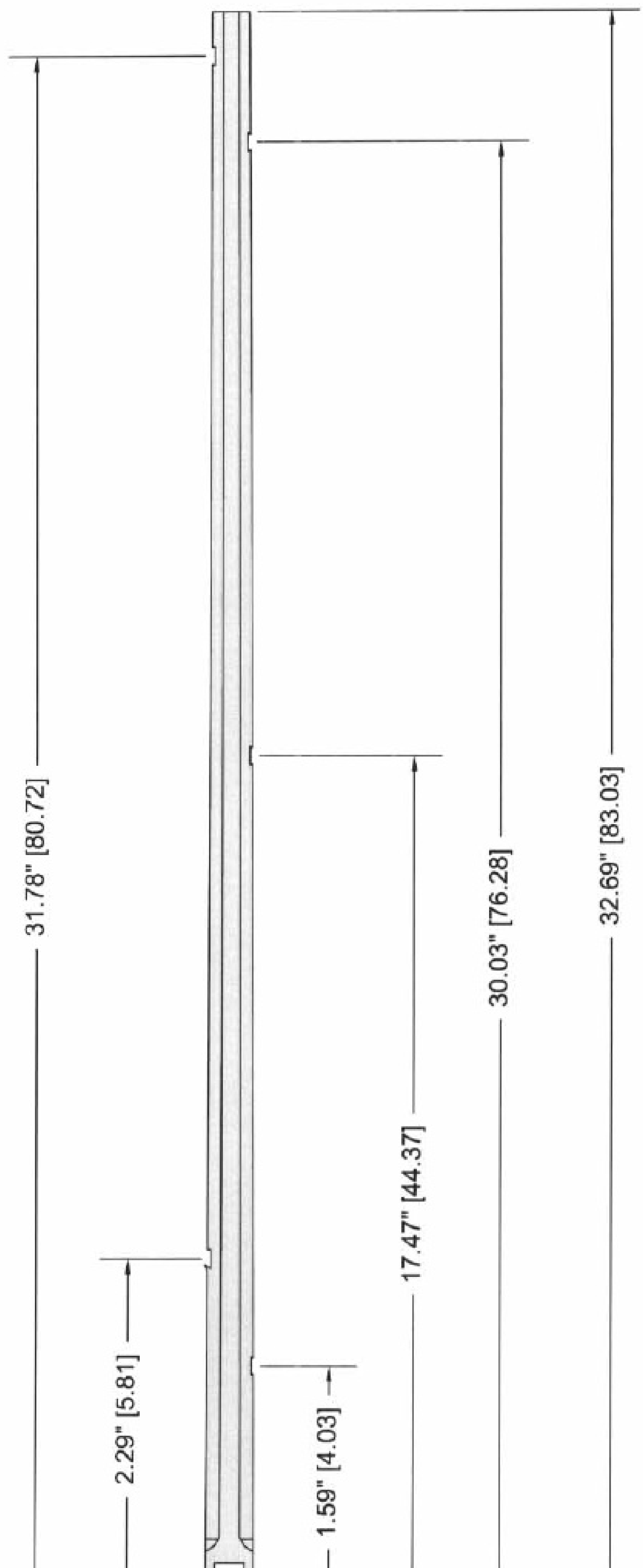
The barrel was rifled with a form known as polygroove rifling, consisting of twelve shallow grooves, with a twist of one turn in the barrel length.

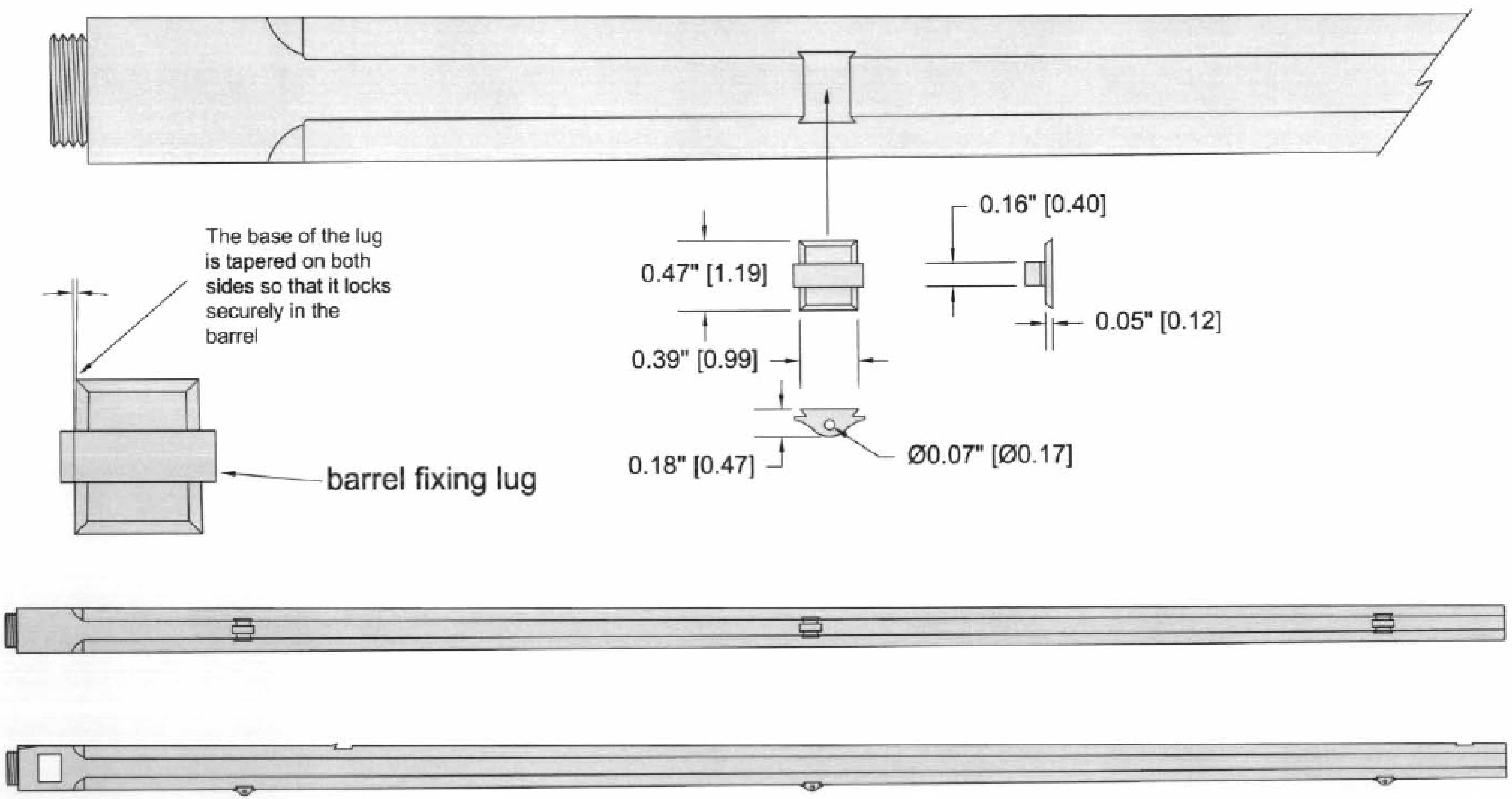
Experience gained with sporting airguns, had indicated the most efficient use of the compressed air charge occurred when airgun barrels were rifled using this method, reducing friction on the ball, whilst retaining a good seal.

Spill Boring

The bit is ground quite square, and being 20" or more long centres itself in the barrel, and has a tendency to keep the barrel quite straight. By using packing or a larger "spill" the same bit may be made to bore out several sizes of the barrel. Usually the bit has one sharp edge, the other is rounded and acts as a burnisher, whilst the two remaining edges are prevented by the "spill" from coming into contact with the barrel. The amount of "cut" is regulated by the packing; usually one paper liner is inserted between the bit and the spill, and the thickness of that paper is bored from the barrel when the bit is next inserted.

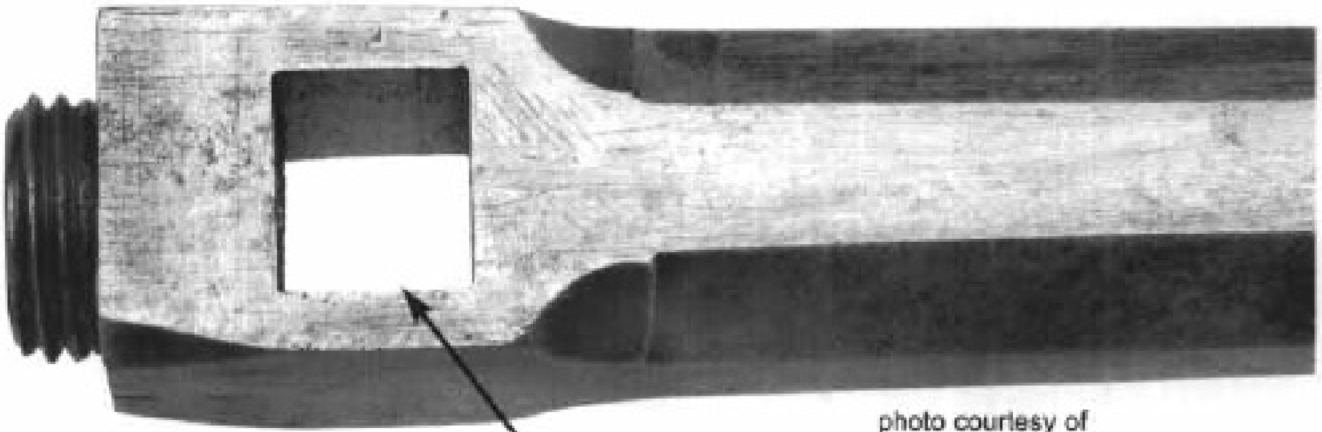
barrel





Barrel Fixing Lugs

Barrel Breech Socket

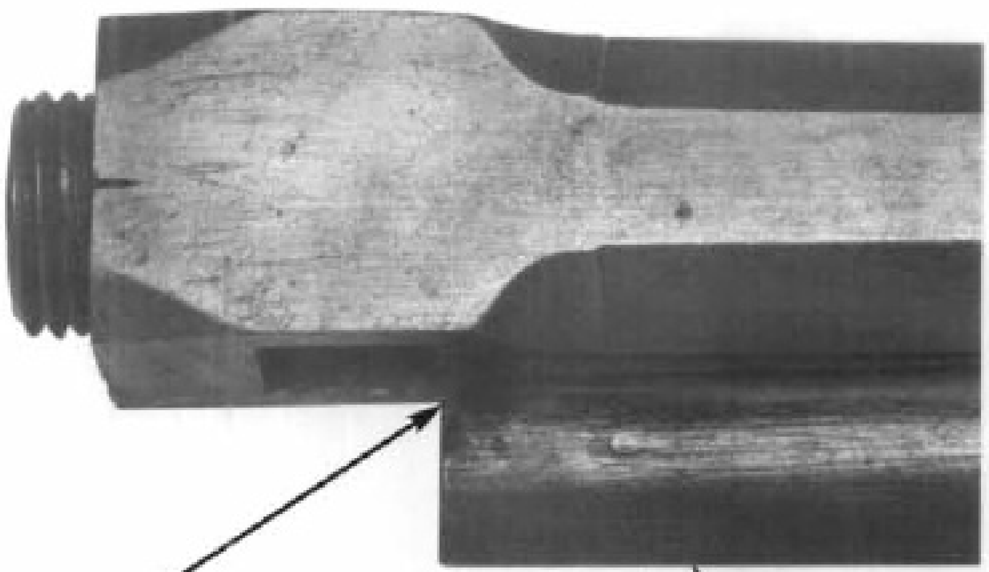


cross bolt housing

Following the completion of the rifling process, the cross bolt housing in the breech end of the barrel would be created and broached to size.

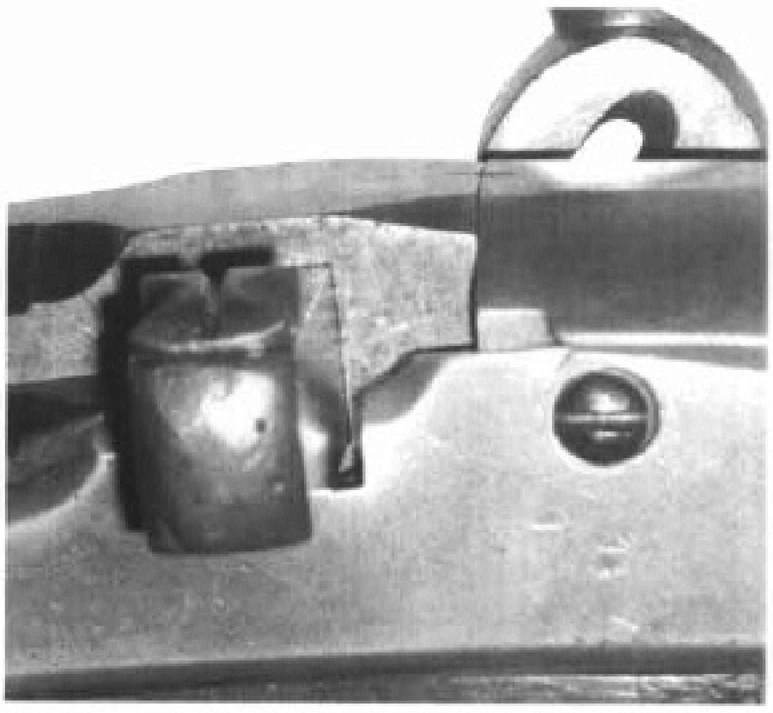
Adjustments would have been made until a close sliding fit with the cross bolt was achieved.

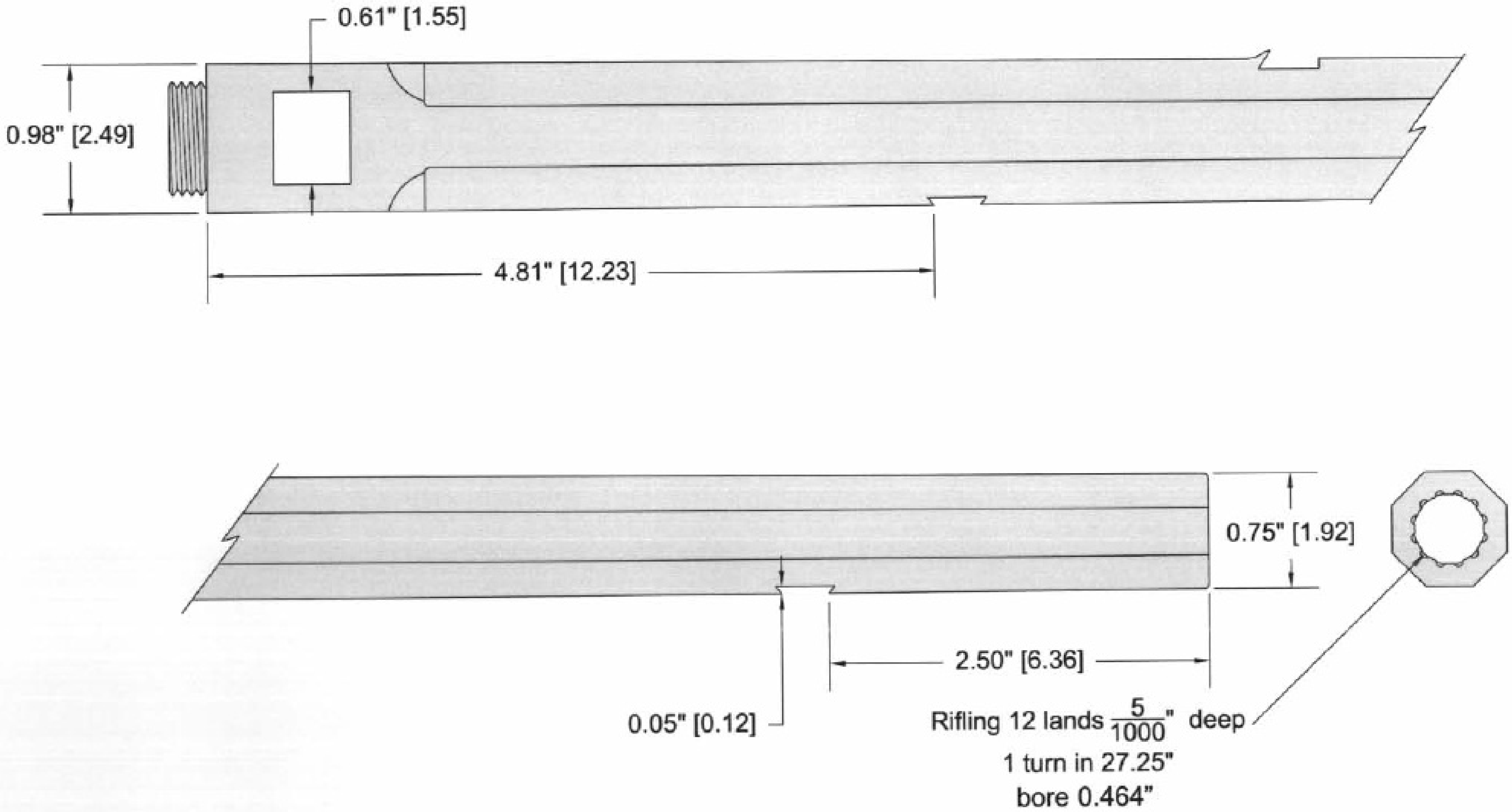
The magazine tube would then have been soft soldered into position on the barrel, with the cover plate and the cross bolt return spring being finally added.



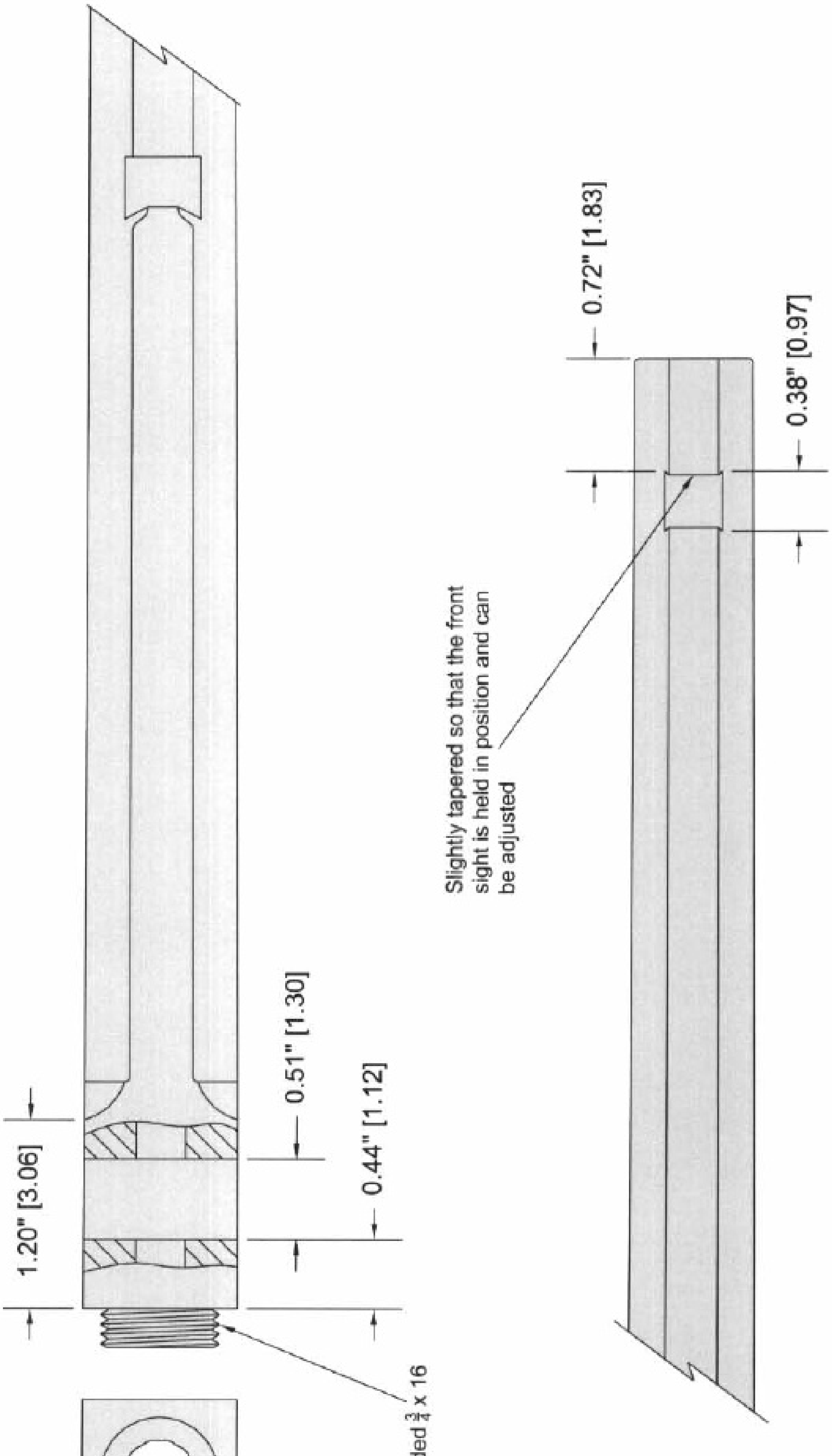
soft soldered joint

magazine tube

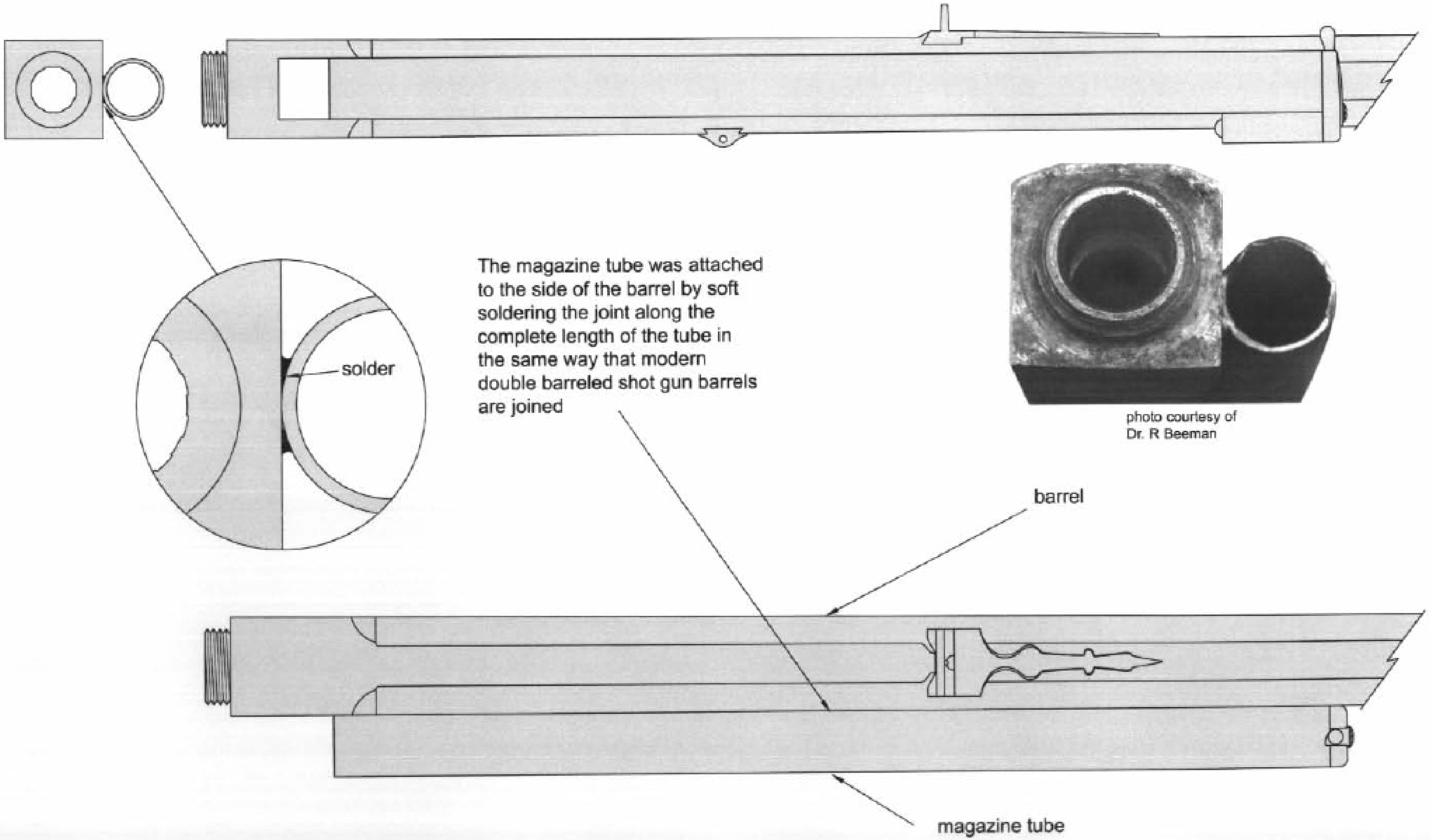


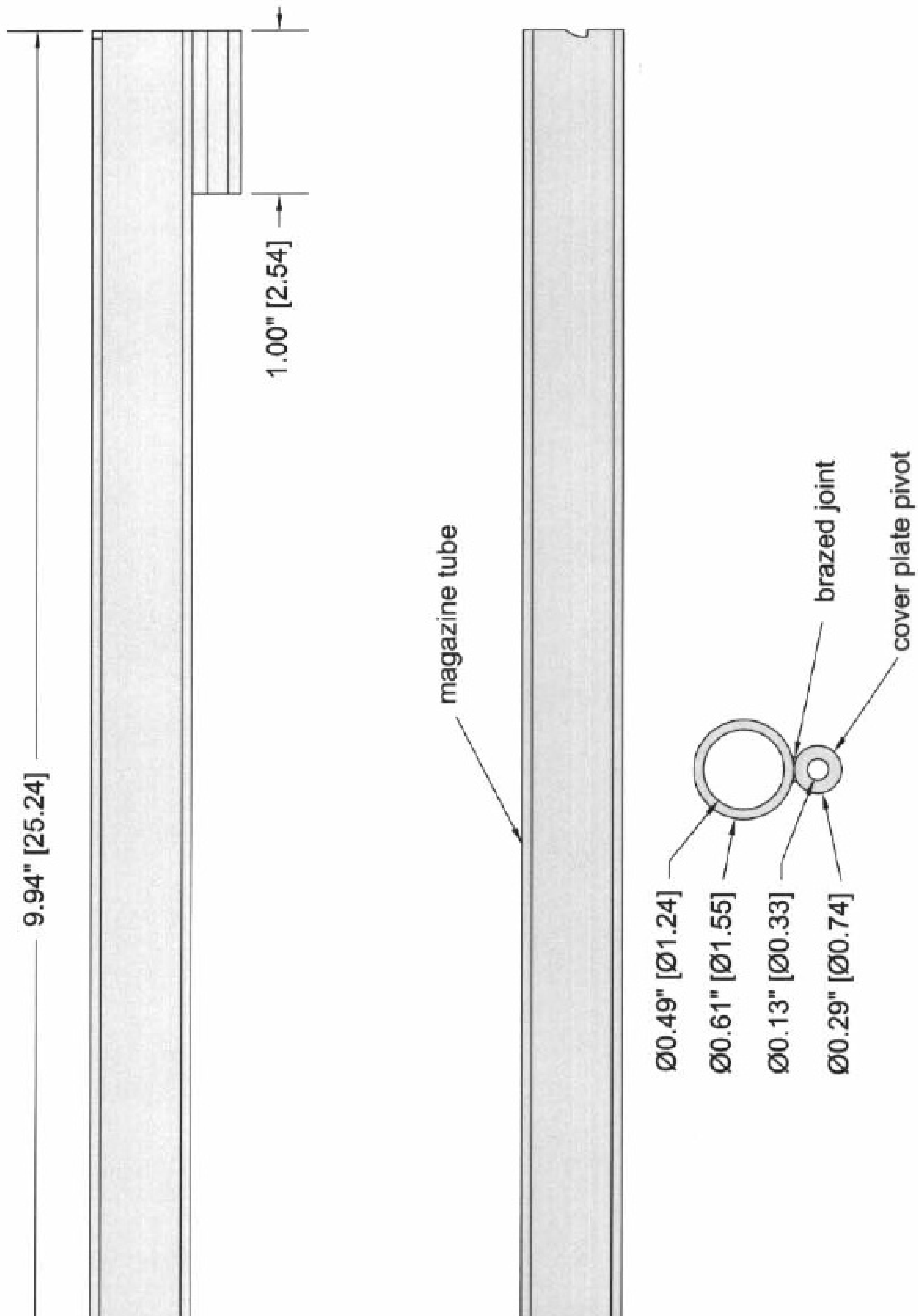


Barrel Breech Socket


1.20" [3.06]
0.51" [1.30]
0.44" [1.12]
Threaded 3/4 x 16
Slightly tapered so that the front sight is held in position and can be adjusted
0.72" [1.83]
0.38" [0.97]

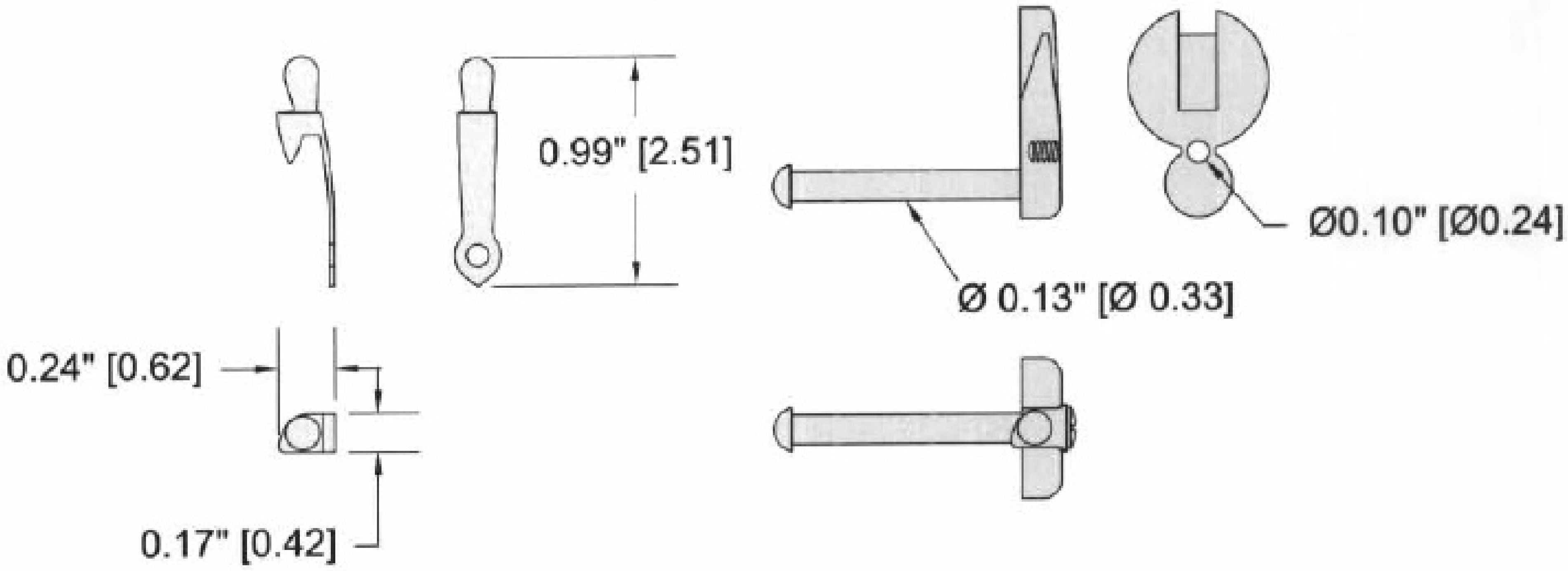
Magazine Attachment

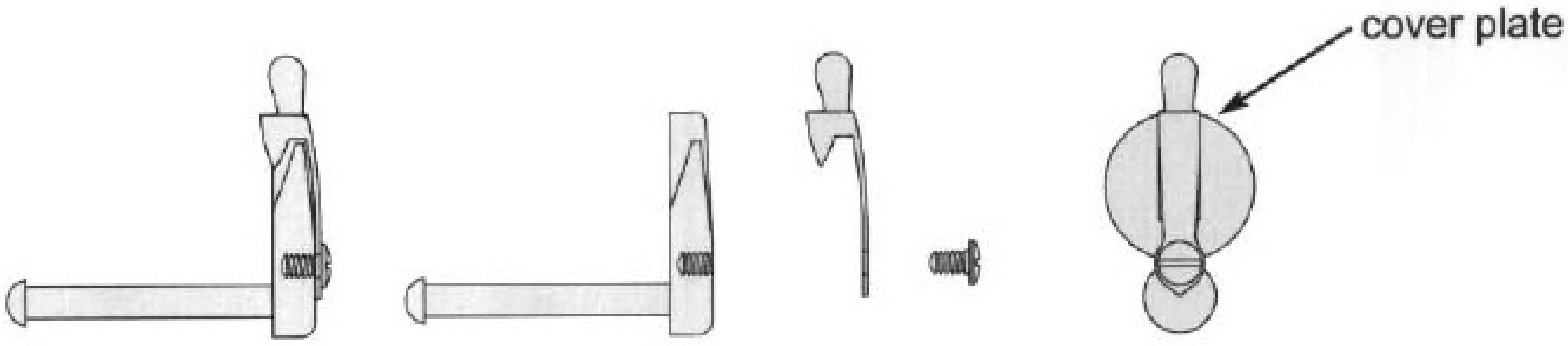




Magazine Tube

Magazine Cover Plate





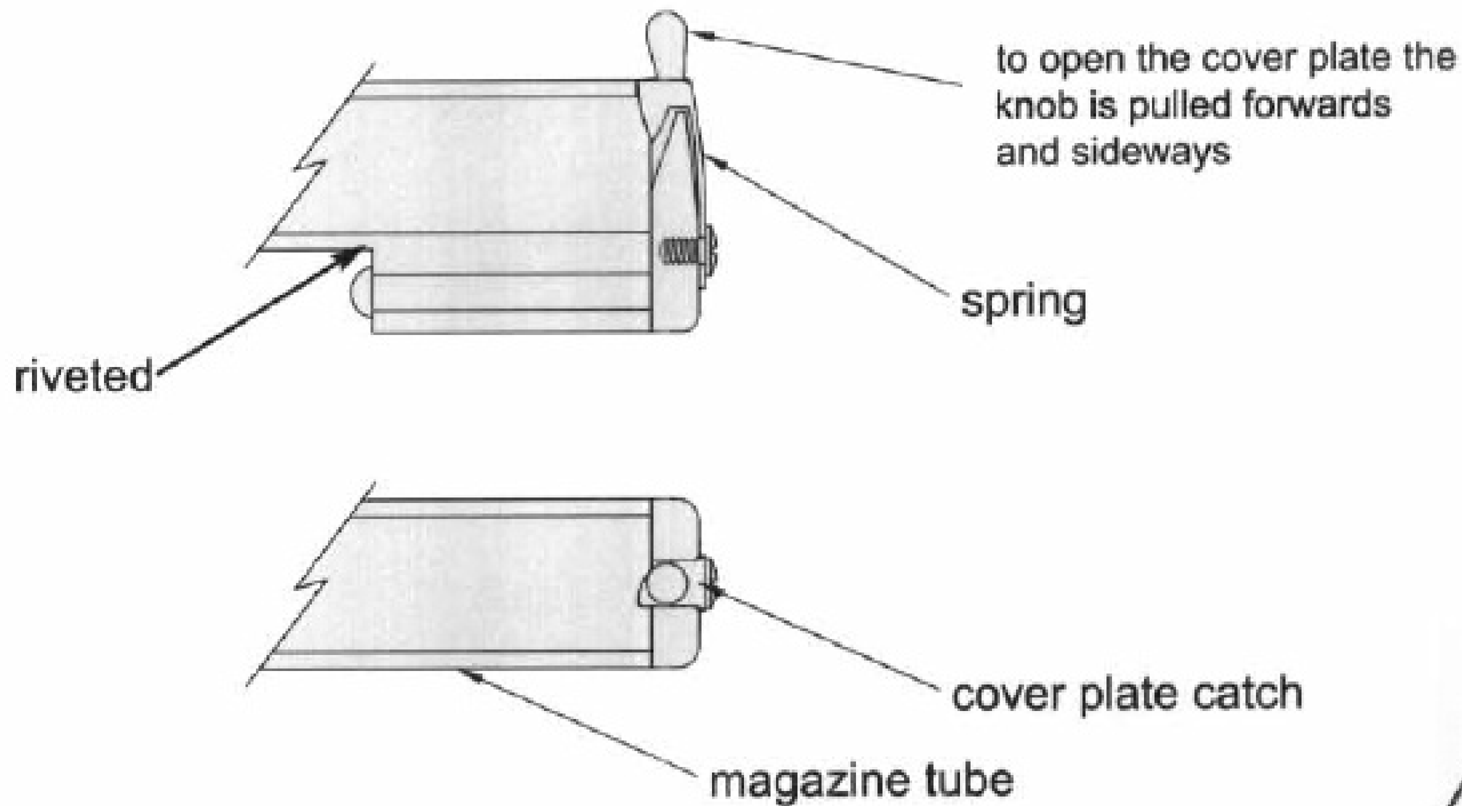


photo courtesy of
Dr. R Beeman

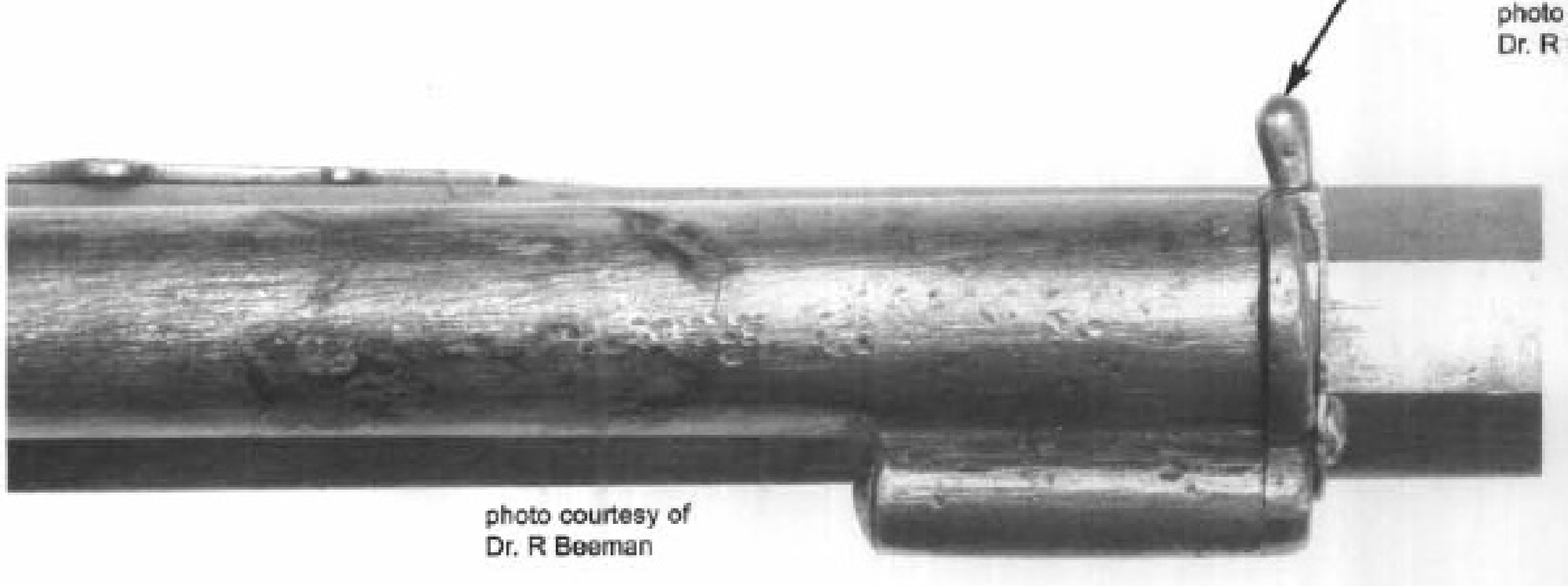
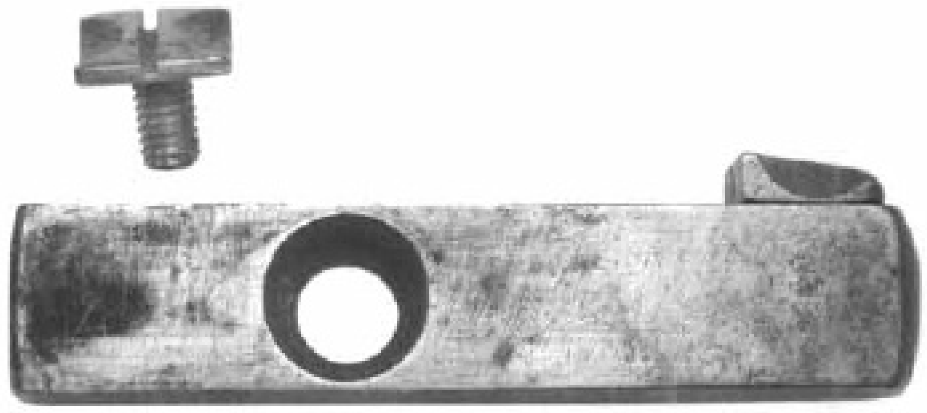


photo courtesy of
Dr. R Beeman

Magazine Cross Bolt



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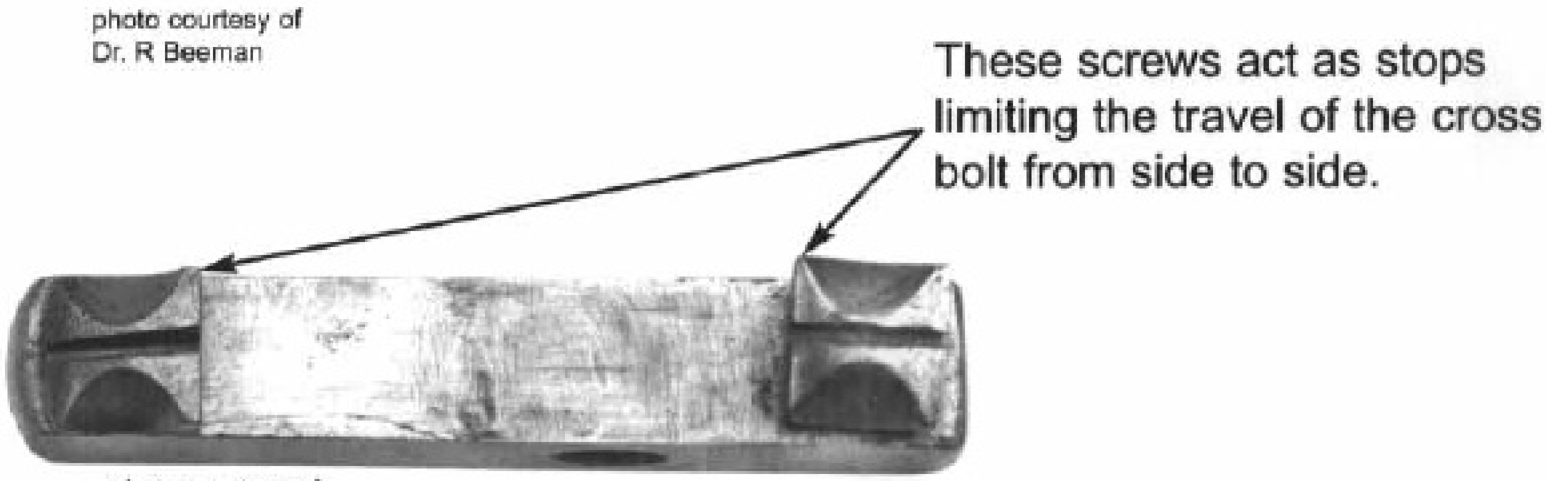
Dr. R Beeman



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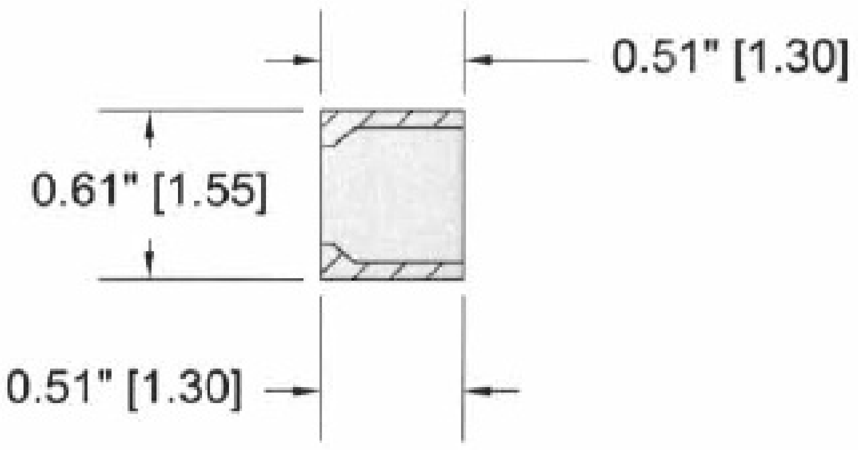
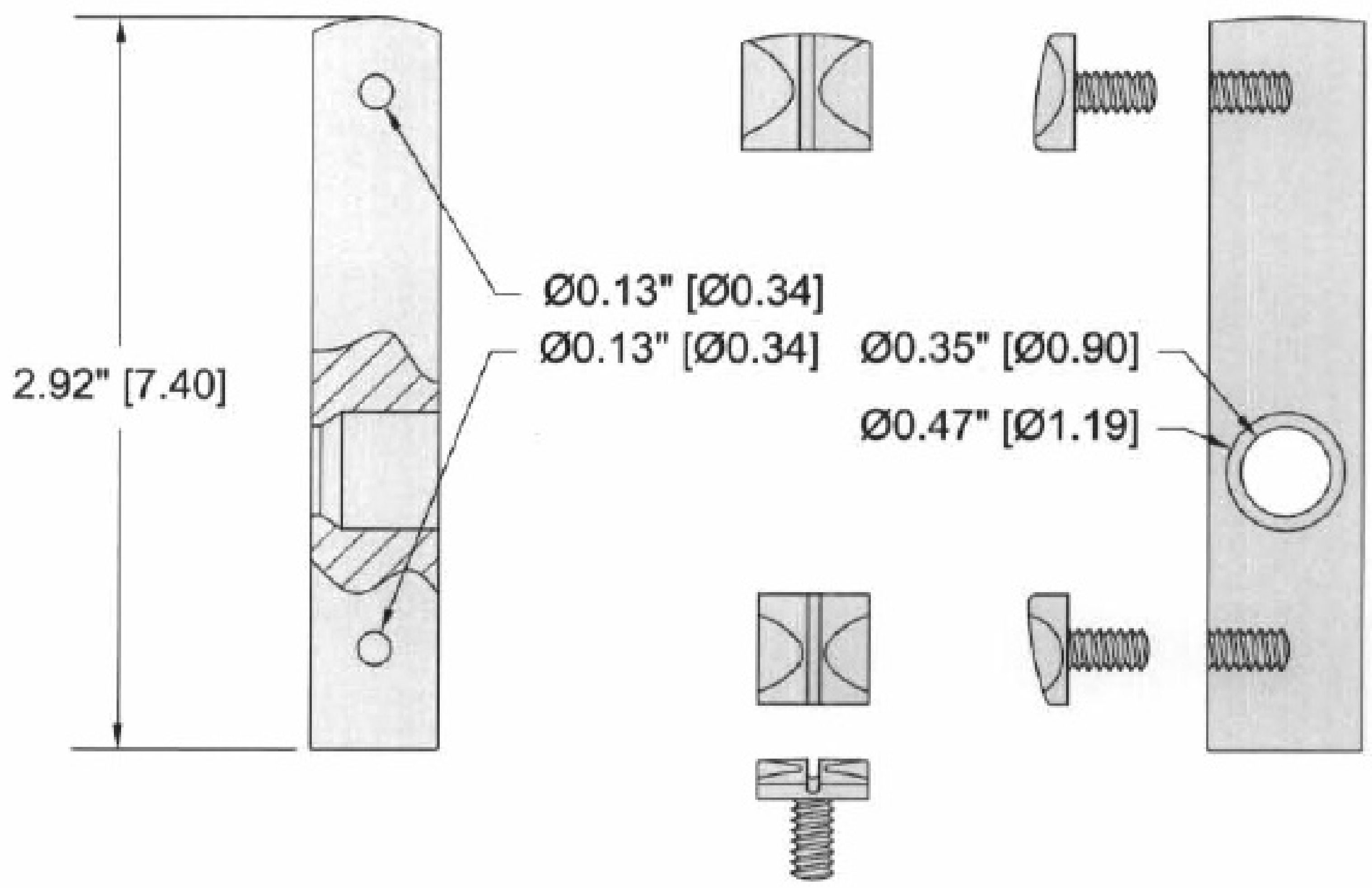




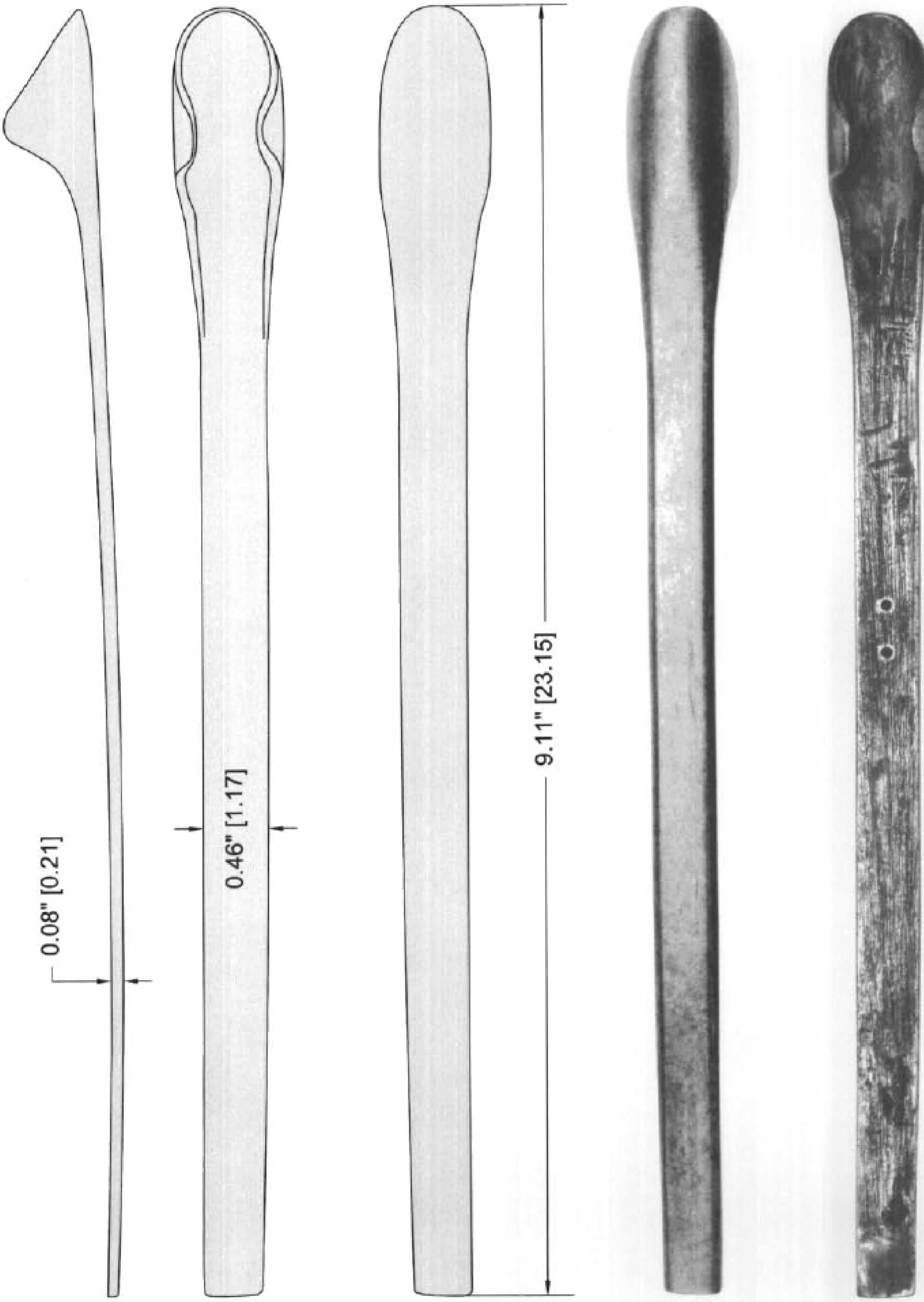


photo courtesy of
Dr. R Beeman

Magazine Spring

Receiver

The receiver body was initially a casting.
Given the need for accurate detail in the manufacture of the receiver body, especially the lockplate rebate, casting would probably have been the preferred option.
From the examination of three examples, the general consensus is that the material used was bronze. (alloy of copper and tin).

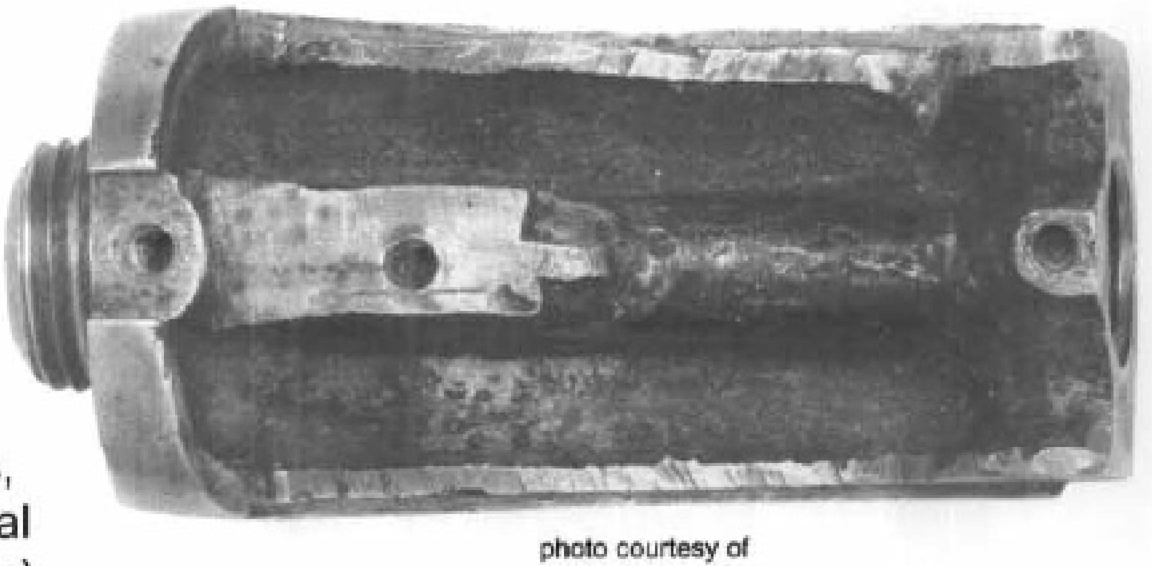


photo courtesy of
Dr. R Beeman

photo courtesy of
Dr. R Beeman

This material was particulary suitable for the application, lending itself to fine detail along with a considerable contemporary expertise in its use, for both artistic and industrial applications.

The most difficult problem in casting the receiver, would have been the provision of the internal air passage.

This problem was usually resolved in conventional airgun manufacture by using a separate iron tube, either cast in with the receiver or fitted externally.

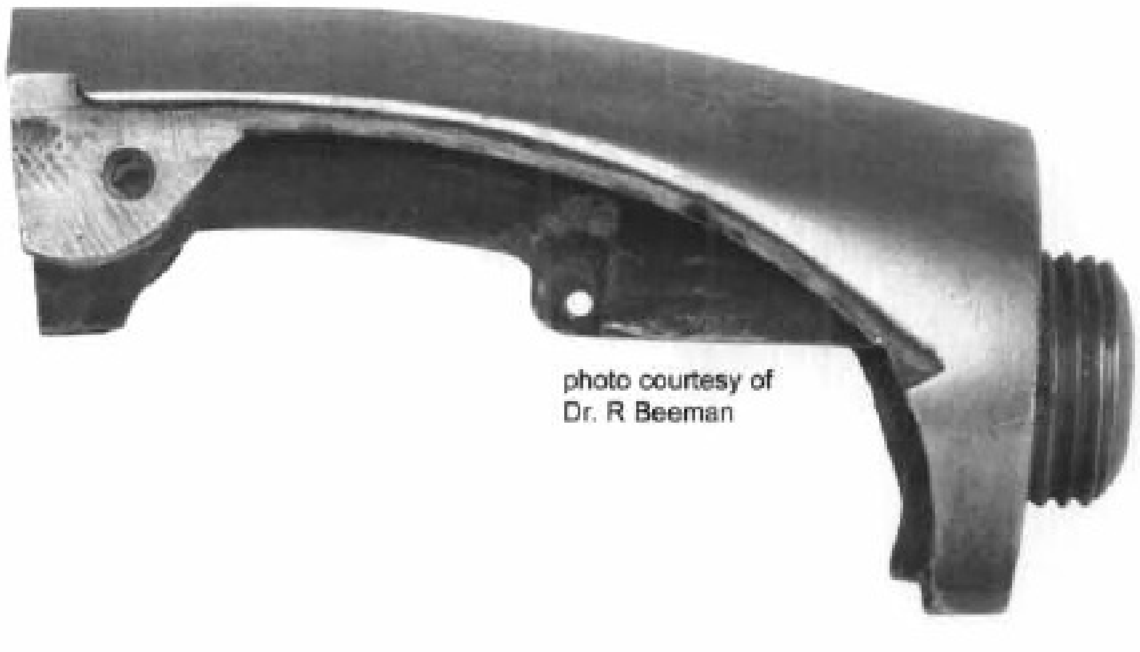


photo courtesy of
Dr. R Beeman

Receiver

photo courtesy of
Dr. R Beeman

Ernie Cowan, who has probably made the most intensive investigation of this area, has concluded that the air passage in the Girandoni was a roughly cored hole in the casting, subsequently opened out by drilling and filing.

Given the problems modern manufacturers have experienced in replicating receivers using this method, it would appear to have been the most difficult choice.

photo courtesy of
Dr. R Beeman

However, the savings in time and material in incorporating the air passage into the castings of 1500 receivers, would have been a considerable incentive.

Achieving interchangeability of large diameter screw threads so essential to his design, presented a problem for Girandoni.

This was due to the difficulty in replicating screw threads on a volume basis, as a result of the complete absence of any established standard to measure against.

Holzapffel had resolved this issue in 1795, by using a system of master male and female screw thread gauges.

These provided standardised screw threads on the lathes he manufactured.

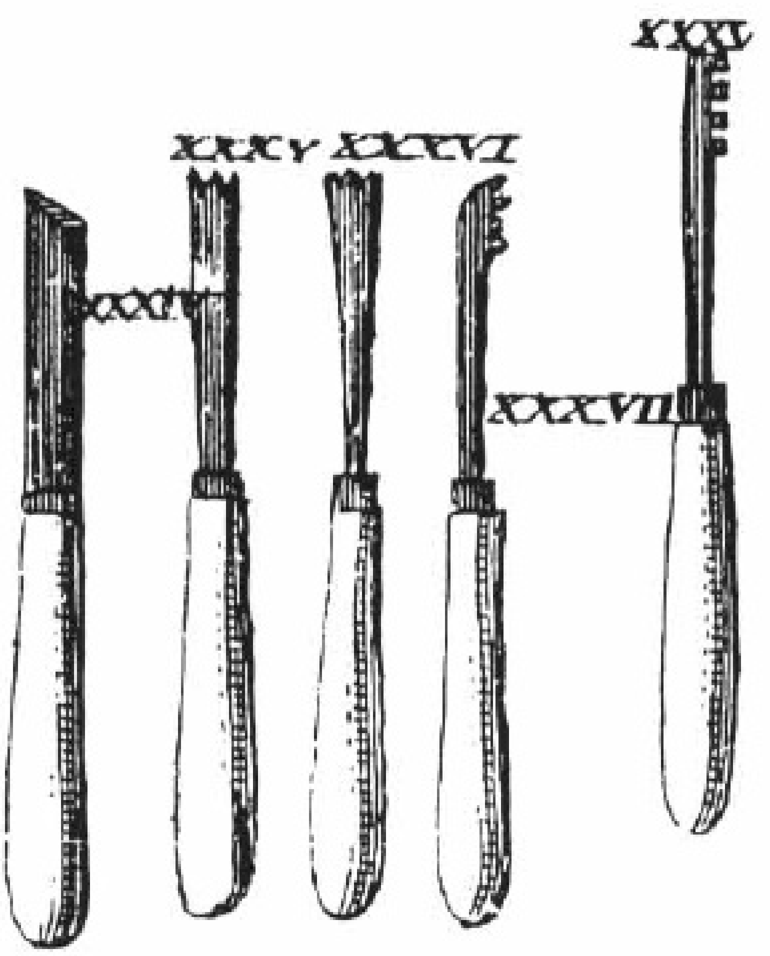
His method used a master male tap and female die, from which in turn secondary masters to make working gauges were made.

When these wore out they could be accurately replicated from the original master copies.

This meant that a large number of dimensionally similar screw threads could be produced simultaneously by a relatively small workforce.

Although we are not aware of how Girandoni resolved the problem, it is clear that the above system could have provided a very practical solution.

It is therefore possible that Girandoni used a similar system.



hand chasers shown in
P N Sprengel's essay

Firearms manufacturing methods at this period are described in depth in PN Sprengel's essay published in 1771 "Handwork and Artifice Summarized, The Gunmaker and Gunstocker" . This document presents a considerable amount of detail and illustrations of the very specialised gunmaking tools in use at the time.

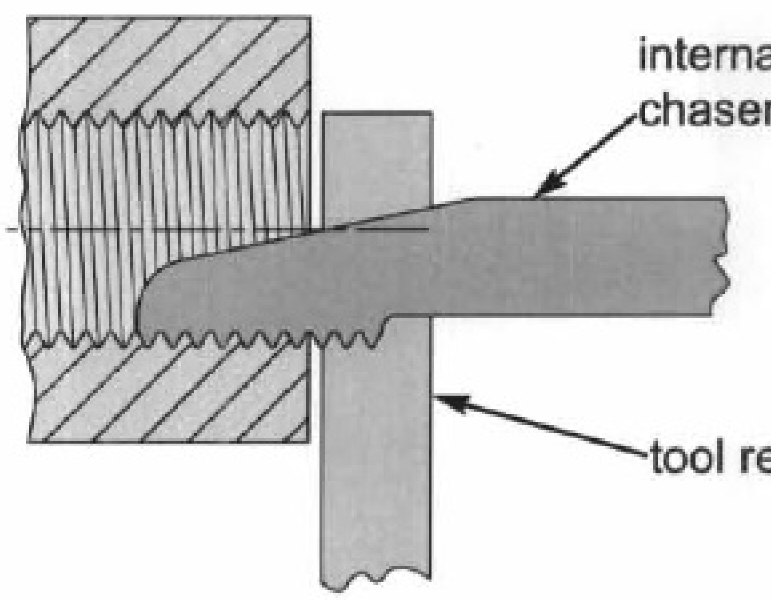
Of particular interest is the detailed description of the manufacture of air rifles.

All the turning operations are done using hand turning tools, and the larger screw threads on the valve parts and reservoir are cut using hand chasing tools.

It is interesting to note that up to the 1950s the screw threads on taps and other plumbing fittings were cut by this method using plain foot powered lathes and hand chasers.

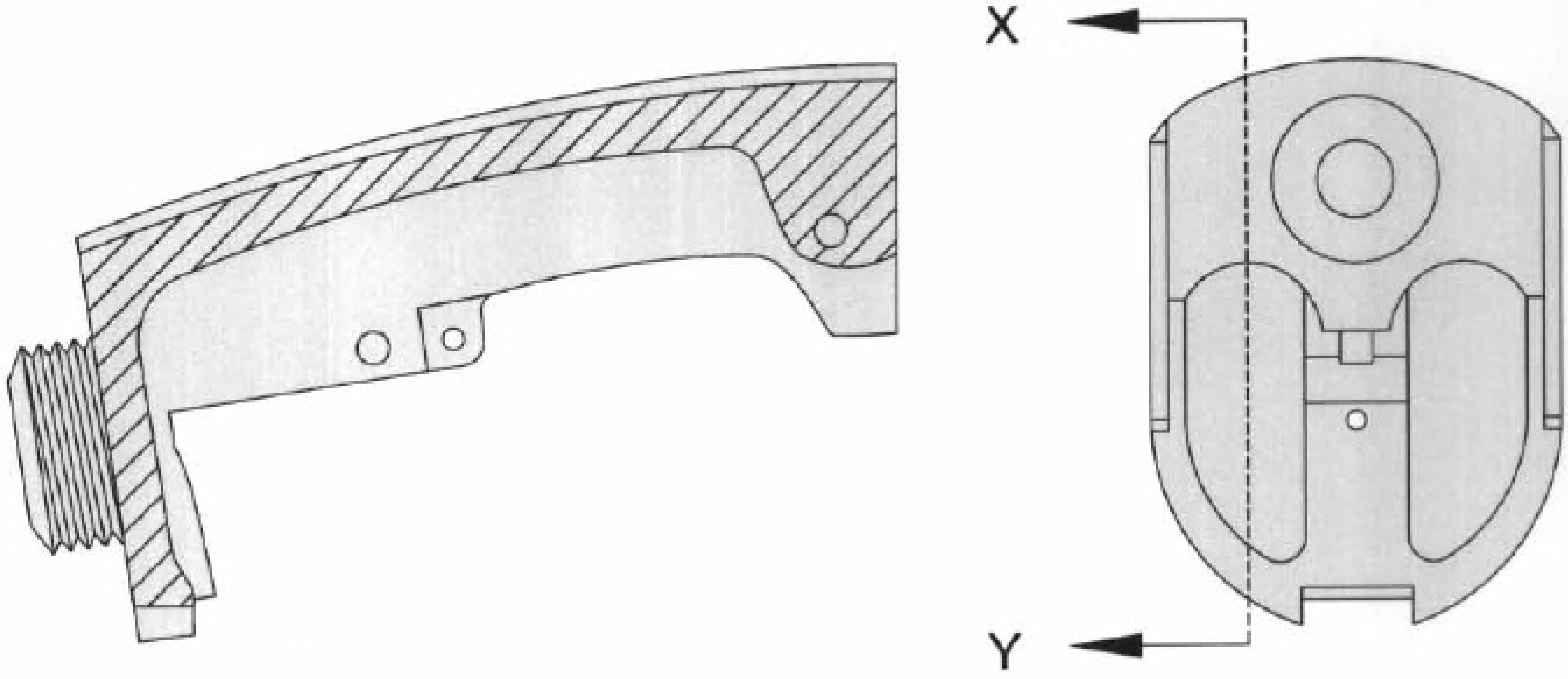
These fittings had to be interchangeable!

hand chasing an external thread on steel with a treadle powered lathe between centres

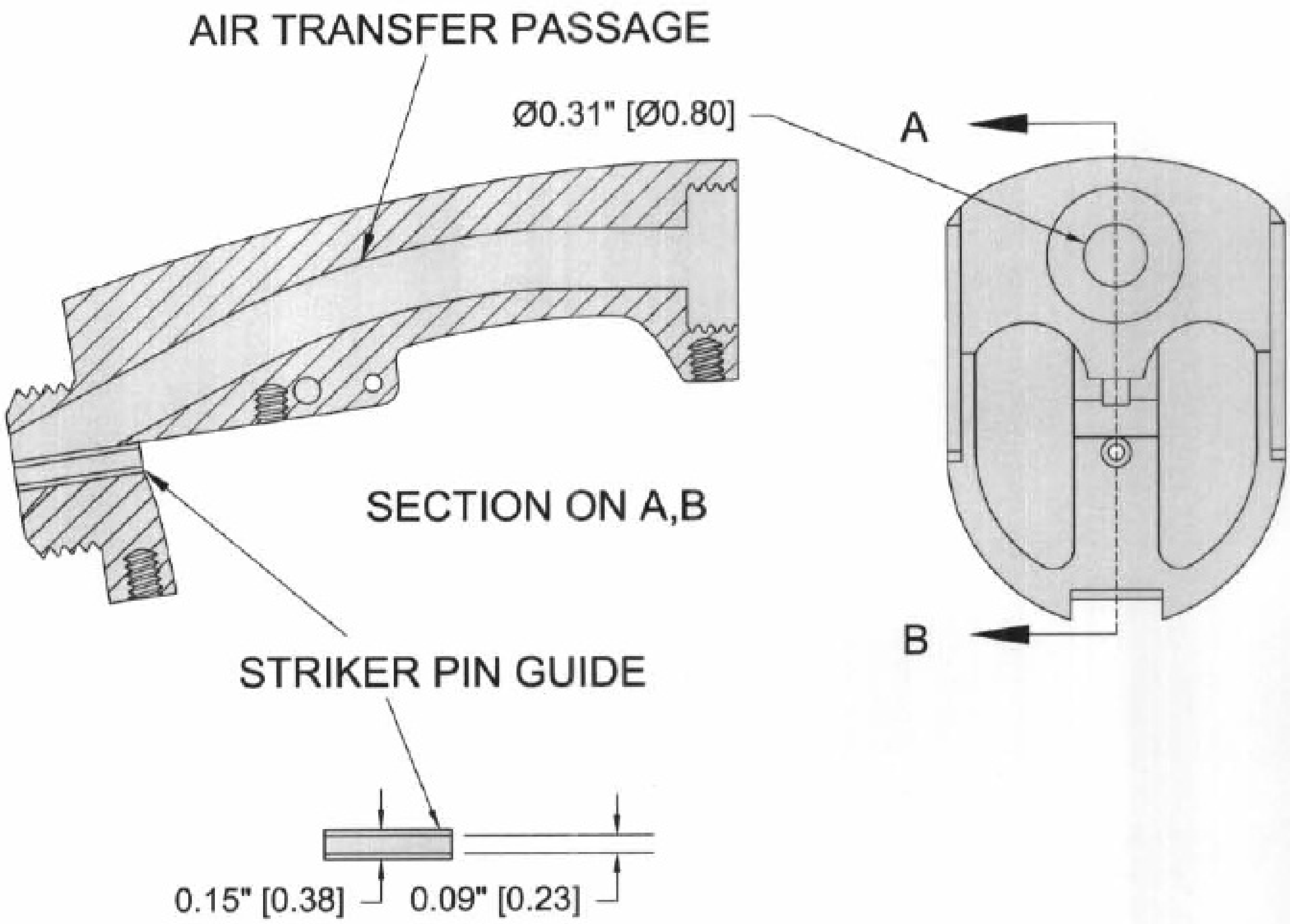


cutting an internal thread

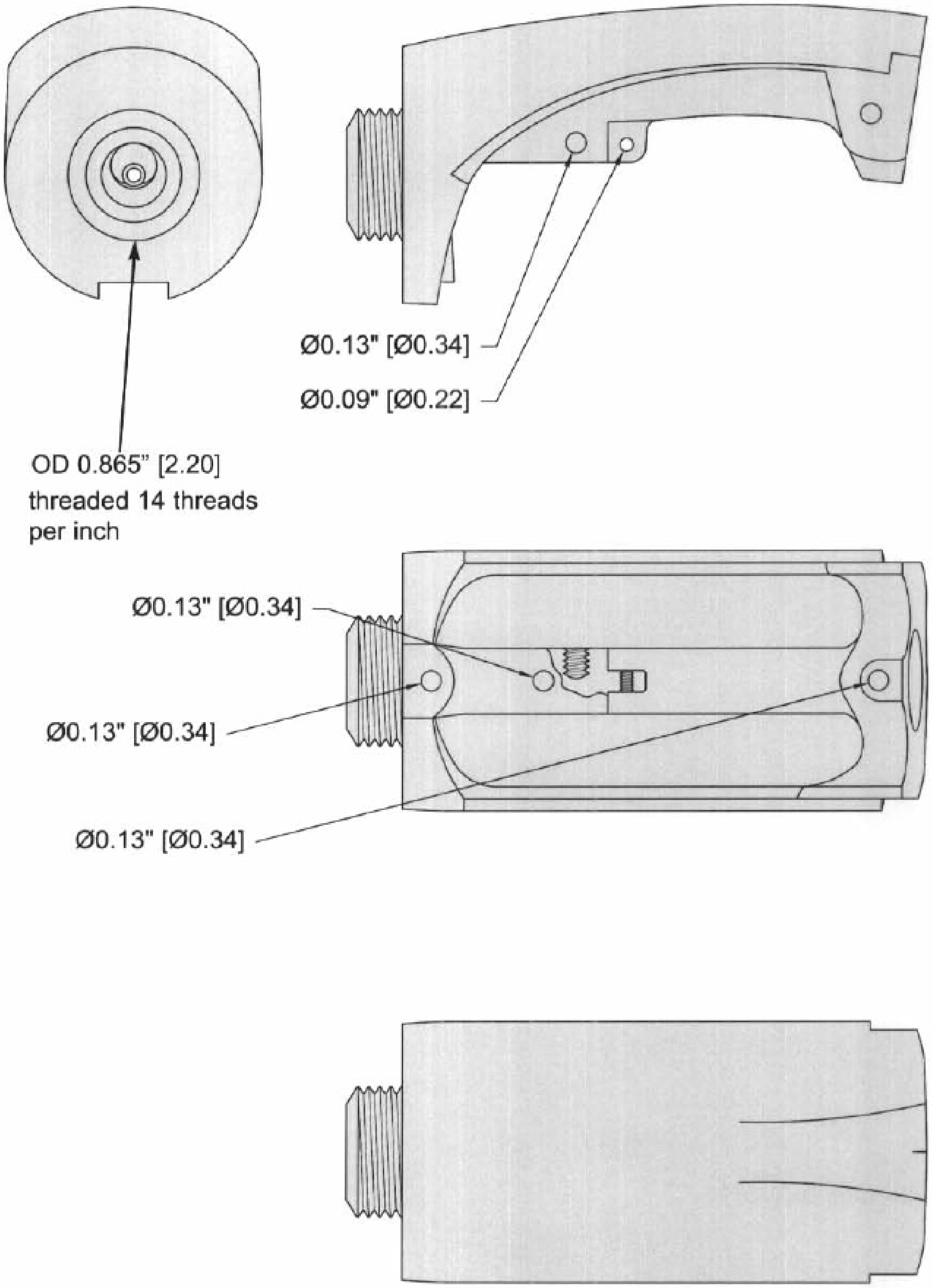
Receiver Cross Section



SECTION ON X,Y

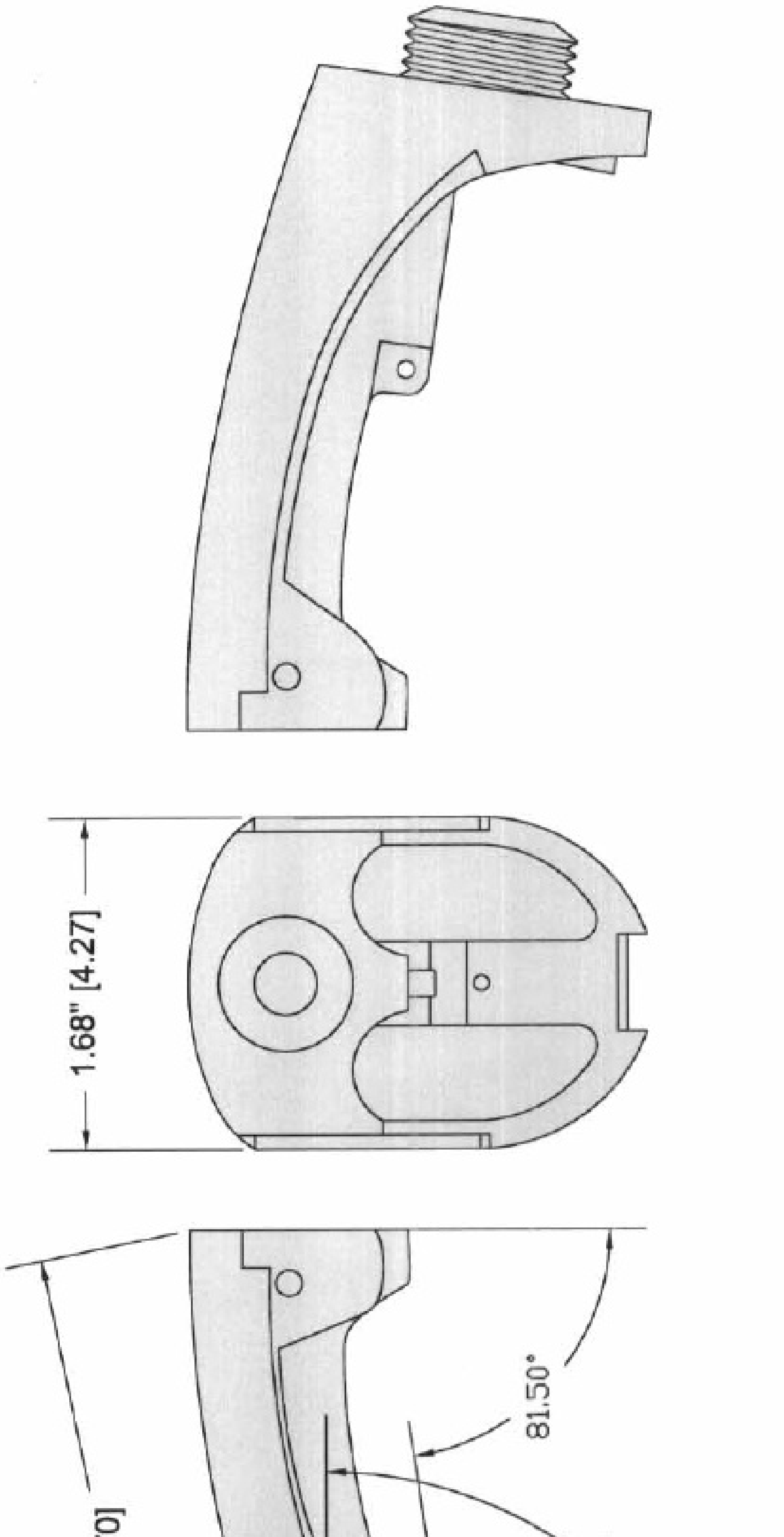


Receiver

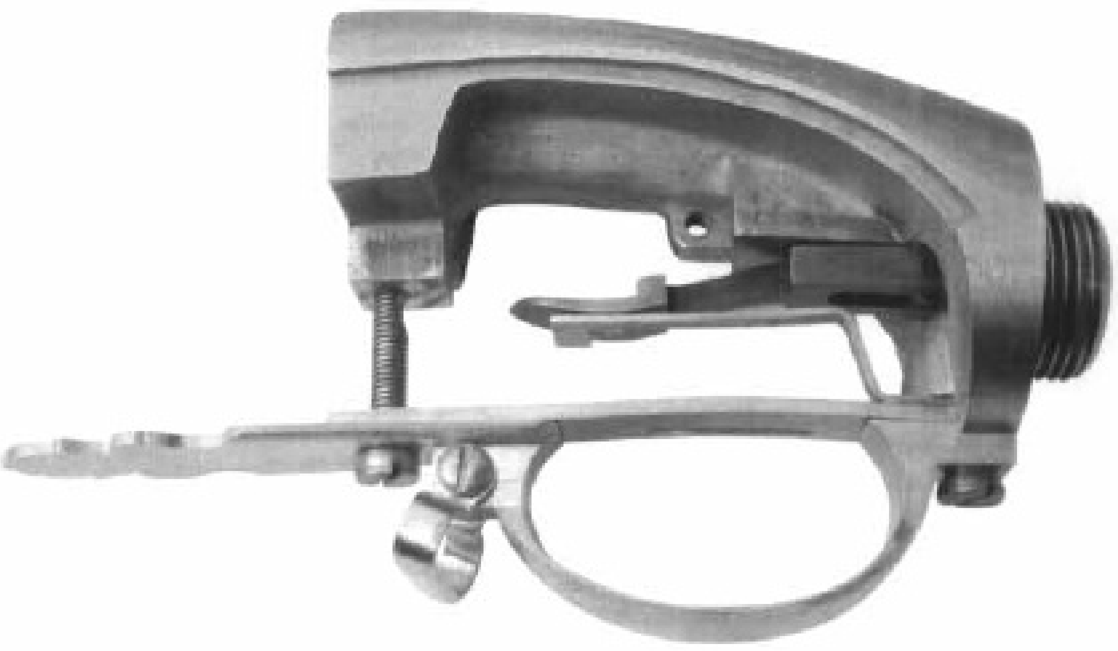


Ø0.13" [Ø0.34]
Ø0.09" [Ø0.22]
OD 0.865" [2.20]
threaded 14 threads
per inch
Ø0.13" [Ø0.34]
Ø0.13" [Ø0.34]
Ø0.13" [Ø0.34]

Receiver



Experimental lost wax casting with the air passage cast in.



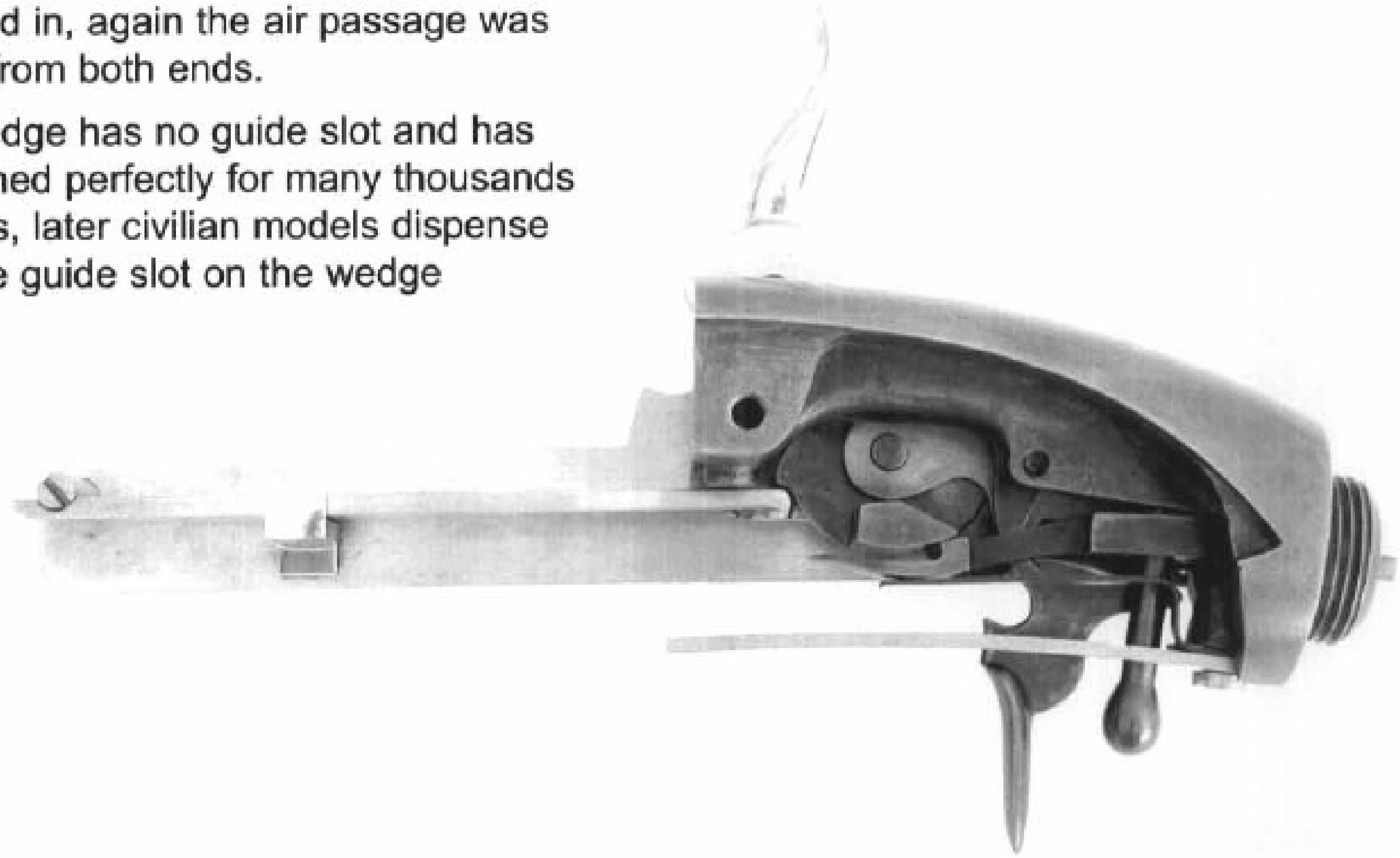
A receiver made from a solid brass block with a steel threaded insert silver soldered in.

The air passage was drilled from both ends then blended together with curved files, the other parts were carved from the solid.

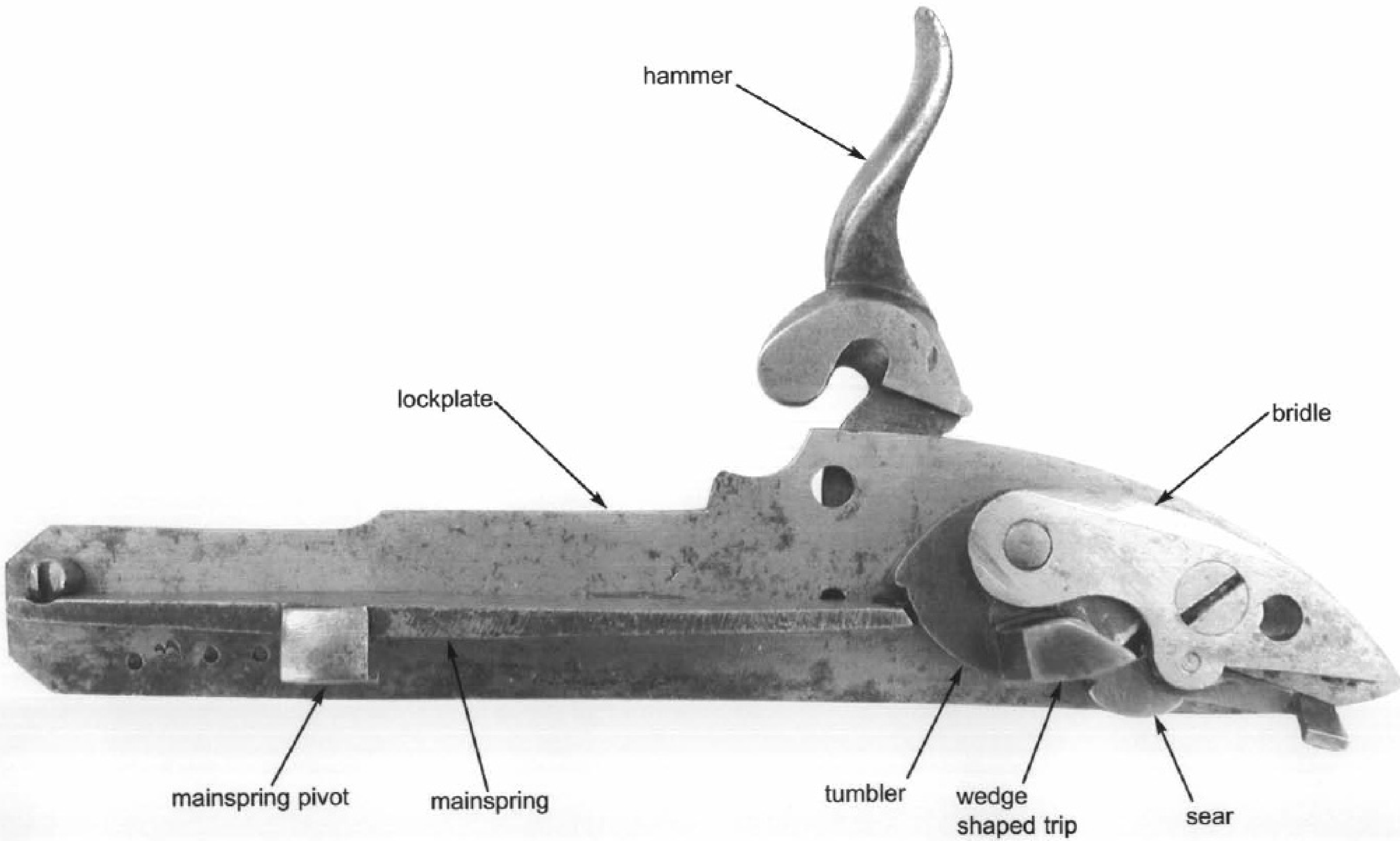
It is possible to drill the passage with the screwed end integral with the receiver before fitting the pin guide bush.

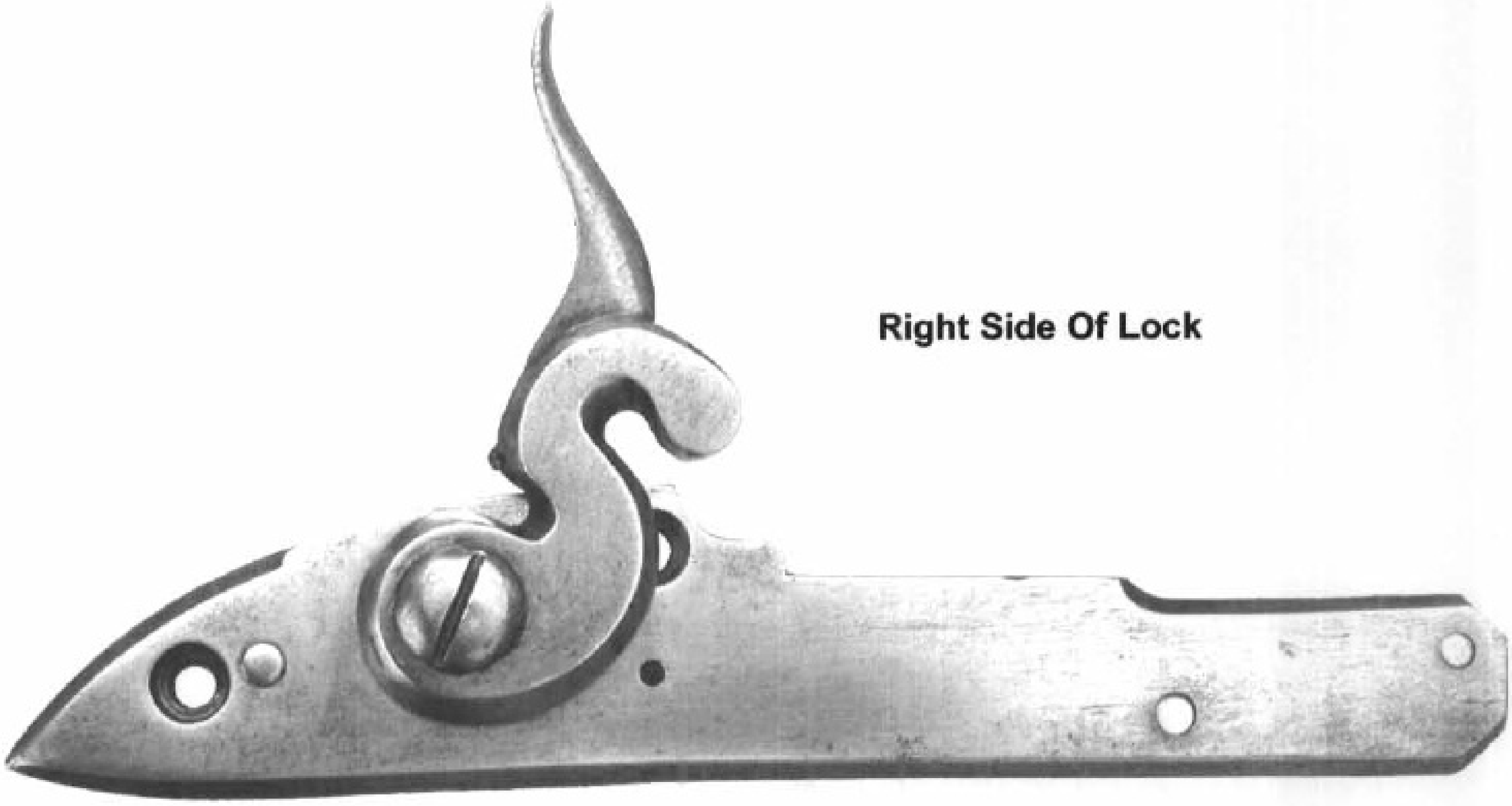
A complete lock and receiver assembly. The receiver was made from solid mild steel with a screw thread insert silver soldered in, again the air passage was drilled from both ends.

The wedge has no guide slot and has functioned perfectly for many thousands of shots, later civilian models dispense with the guide slot on the wedge



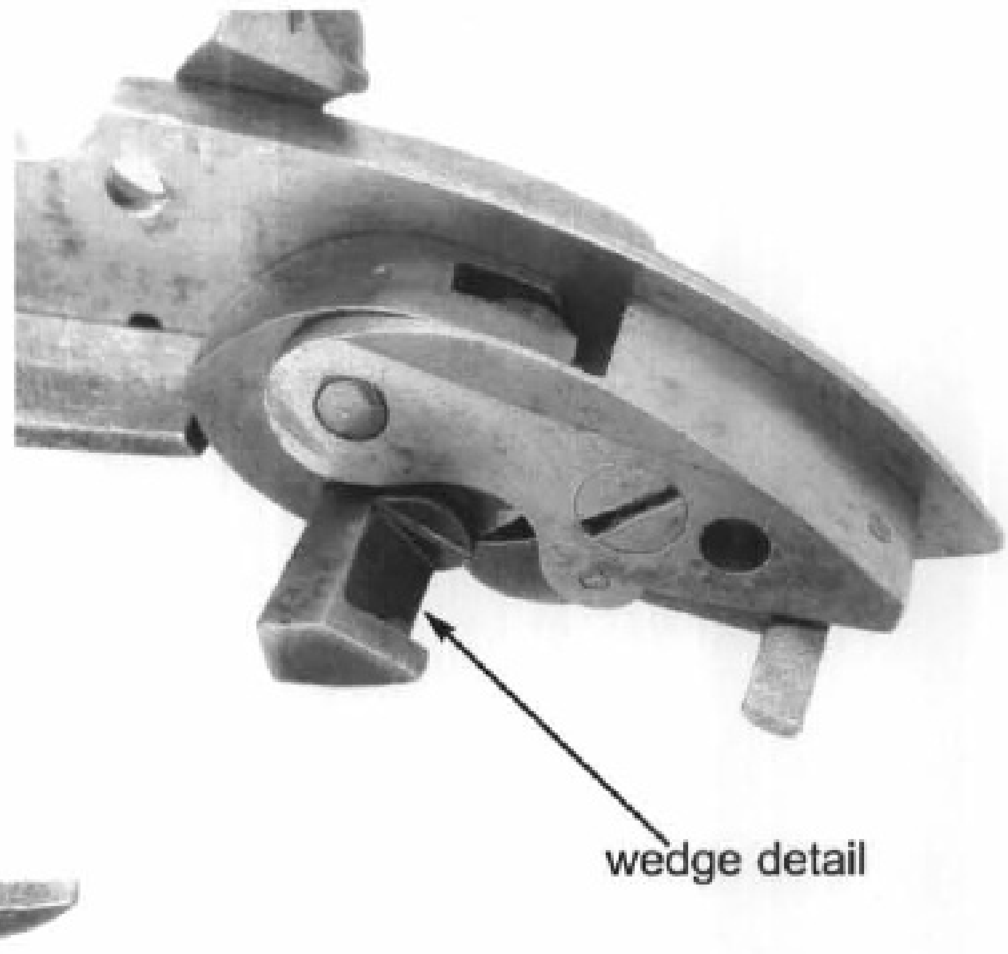
Lock Components



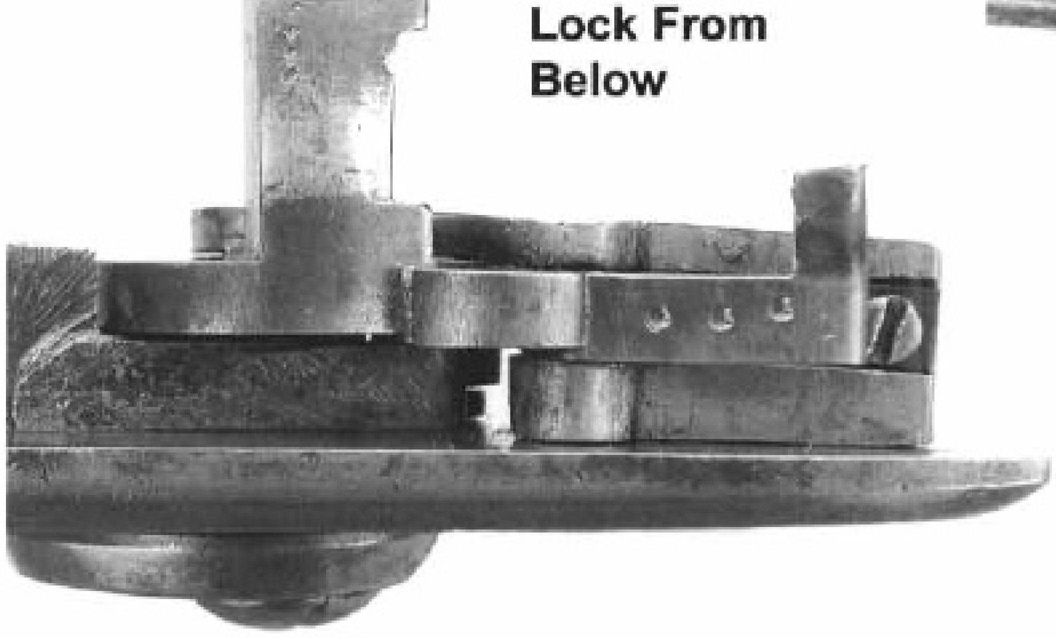


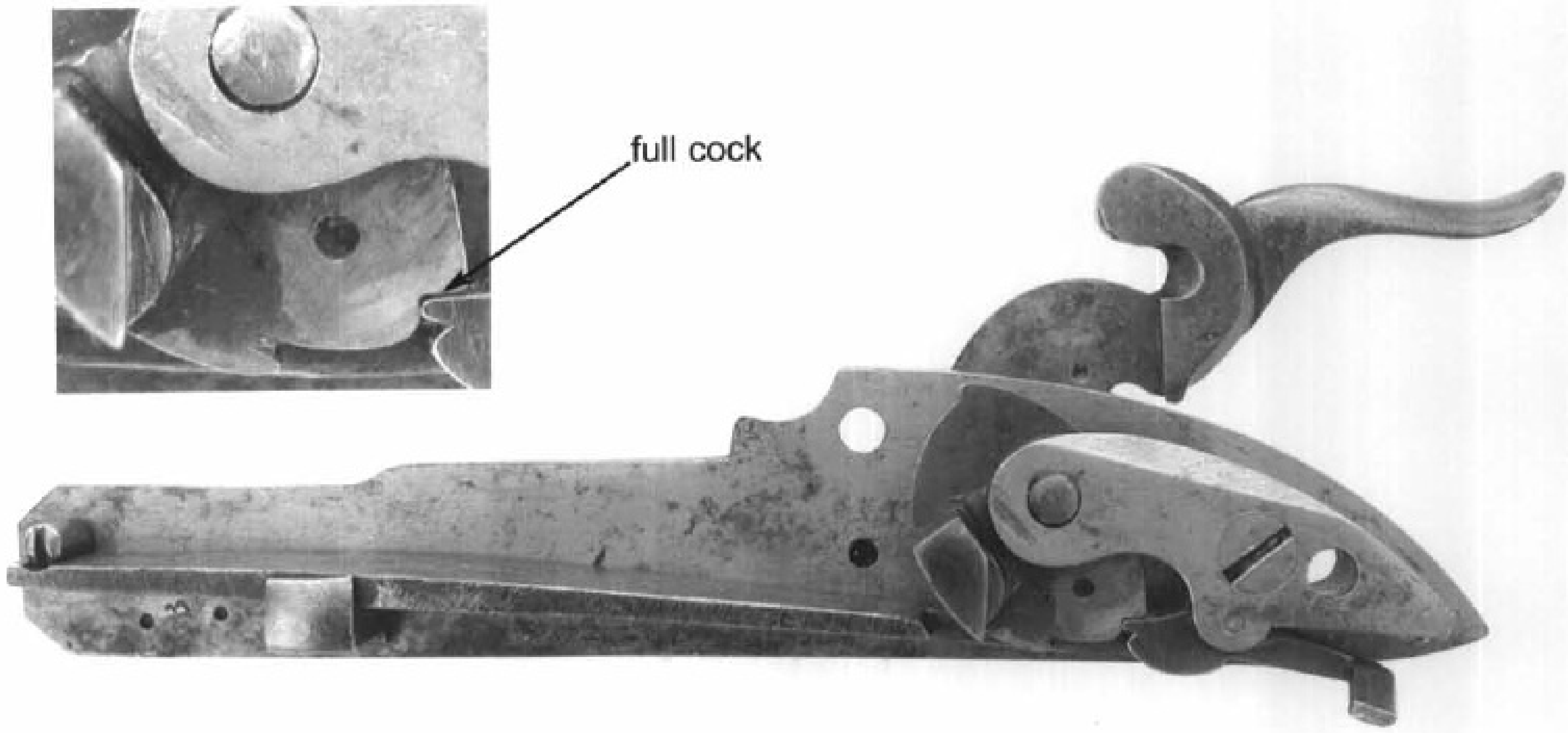
Right Side Of Lock

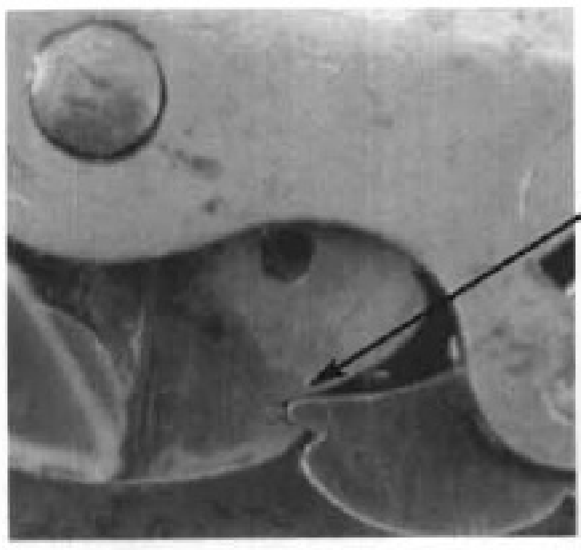
Lock From Top



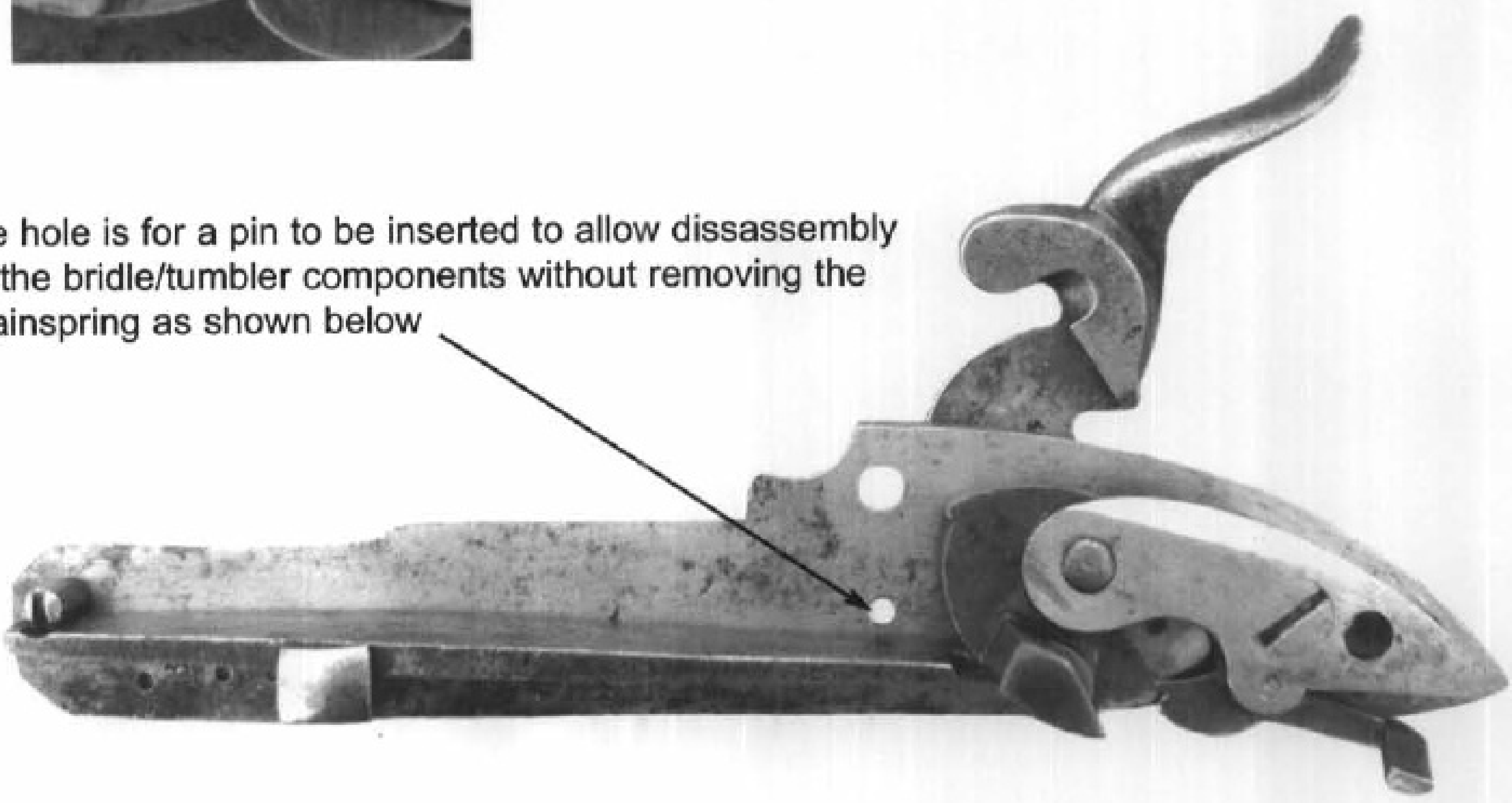
Lock From Below







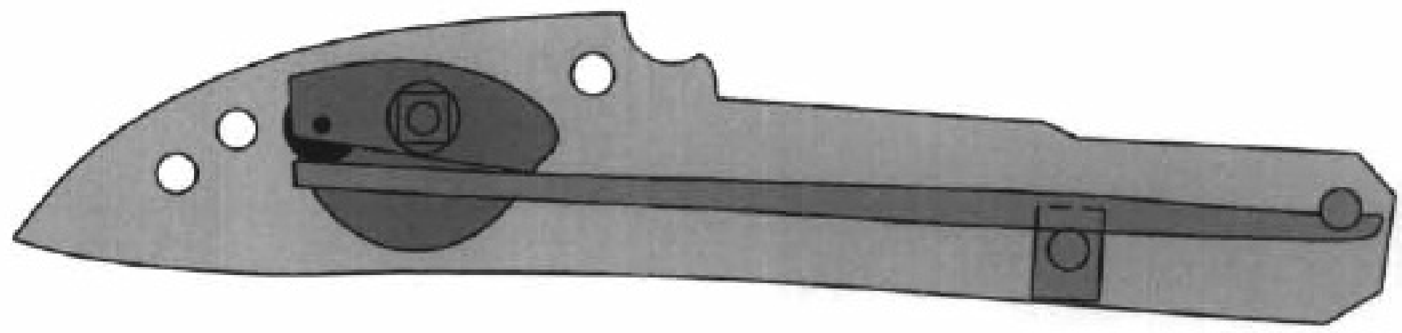
the hole is for a pin to be inserted to allow dissassembly of the bridle/tumbler components without removing the mainspring as shown below



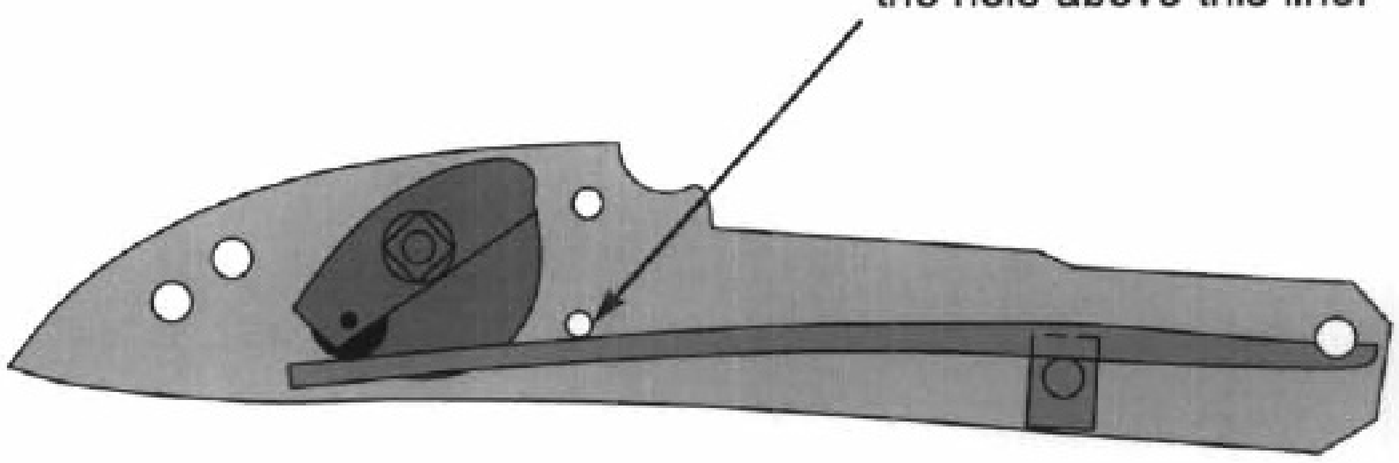
Lock Component Removal

The design allows the lock components to be removed and replaced without removing the mainspring.

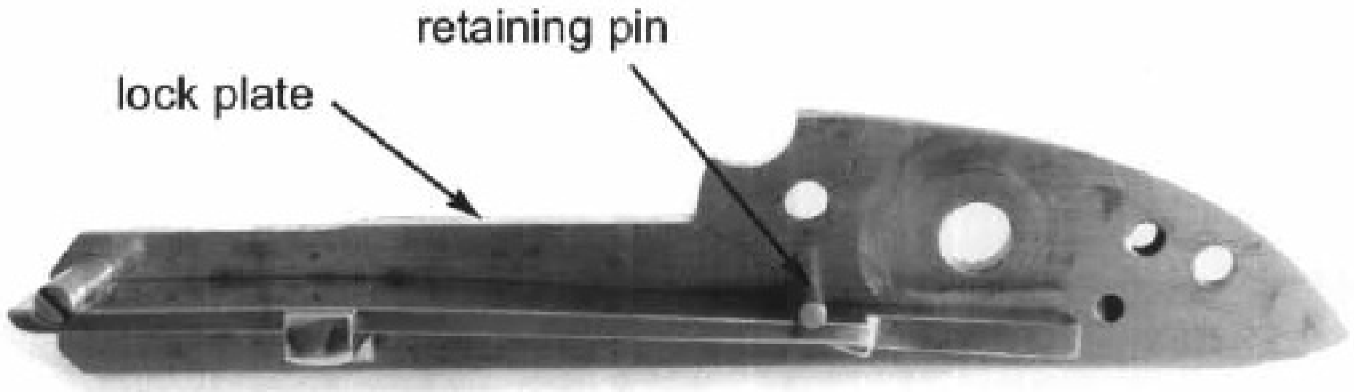
With the lock in the rest position, a small hole can be seen from the outside of the lockplate just below the spring line. This hole is covered by the mainspring at rest.



cocking the lock deflects the spring and places the hole above this line.



By placing a pin in the hole to hold the spring in the cocked position and easing the sear, the lock components can be safely removed without disturbing the mainspring.



This is a distinct improvement on the conventional flintlock where the removal of the normal V - shaped mainspring is essential prior to any component removal.

In place of the special V spring compressor all that is required is a suitable pin.

Lockplate

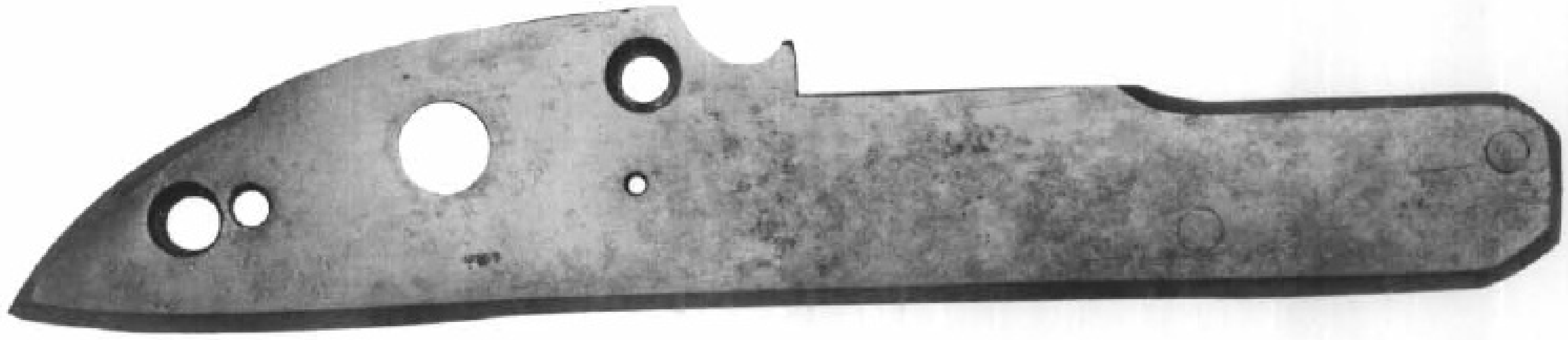


photo courtesy of
Dr. R Beeman

The techniques used in the manufacture of the lock would have been very similar to those used for the ordinary flintlock, with the main exception being the precision of fit required between the lock and the receiver components.

The shape and positioning of the lockplate in the receiver rebate, being particularly critical to the correct functioning of this interface.

This was a very complex arrangement, fitted to close tolerances in a constrained space.

In order to manufacture lockplates to the degree of uniformity required by the design they must have been pre-formed to a standard.

The technique of die forging was in common use at this time, which may have provided this standard.

In using this method, hot metal was hammered or pressed into pre-formed dies, which allowed the speedy production of a large number of uniform components.

This is supported by a comparison of the actual profiles of the three available lockplates.

This comparison clearly indicated a degree of uniformity, that could not be expected of a purely handmade component.

Casting is the other possibility with some of the other lock components, Girandoni has shown with the rifle a high level of technical expertise in metal casting.

Whilst forging was a common technique at this time for making lock plates and other components for fire arms manufacture, some of the parts of the Girandoni are more complex.

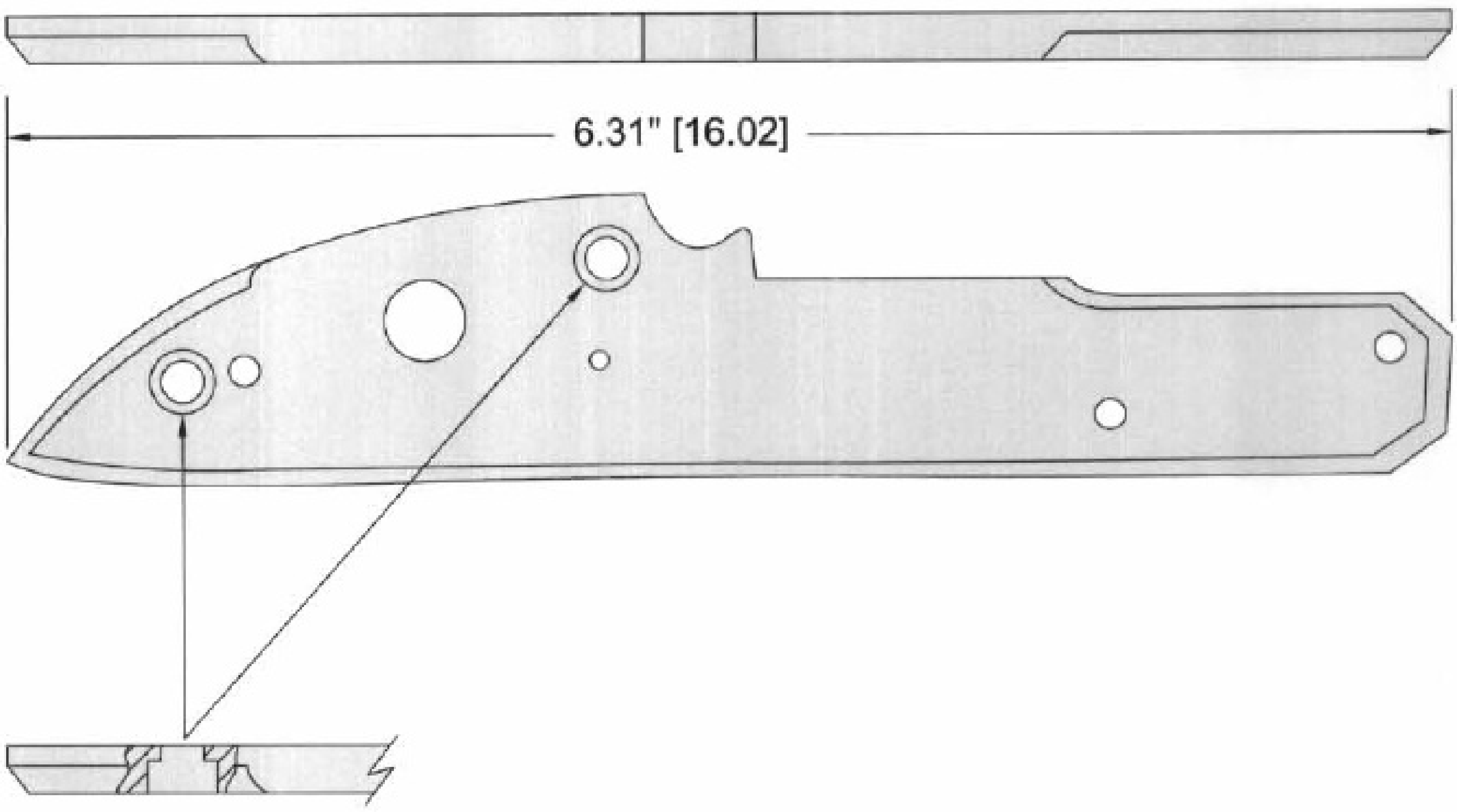
We know that walking stick airgun lock plates and other components were cast which when finished show no visual evidence of how they were made, either forged or cast.

In modern times the lost wax casting process has become prominent in the manufacture of fire arms components, these only require a finishing operation before hardening.

The lost wax process makes it possible to mass produce precise components, all that is required is to make a suitable mould to make wax copies of the component to be cast.

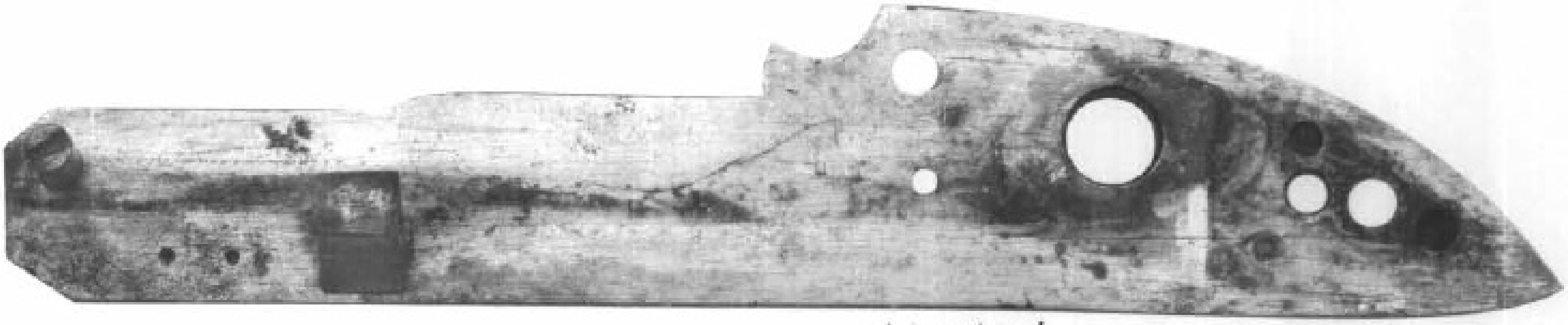
These are attached to a wax rod perhaps ten at a time then covered in a high temperature resistant material. The wax is melted out and molten metal poured in.

Lockplate



HOLES COUNTERBORED
TO SUIT THE HEAD OF THE
RETAINING SCREWS

Bridle Location



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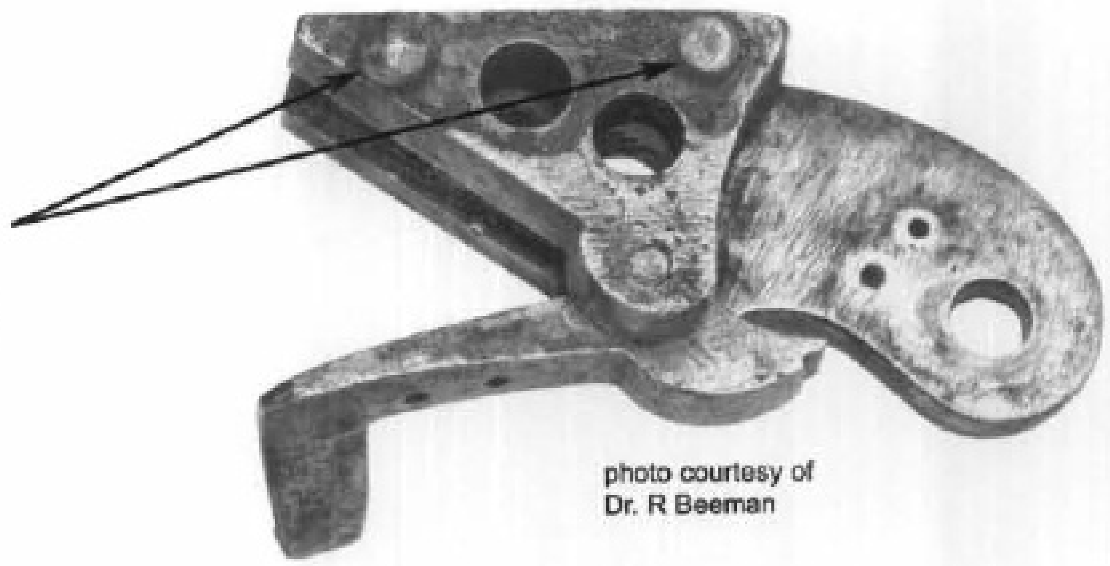
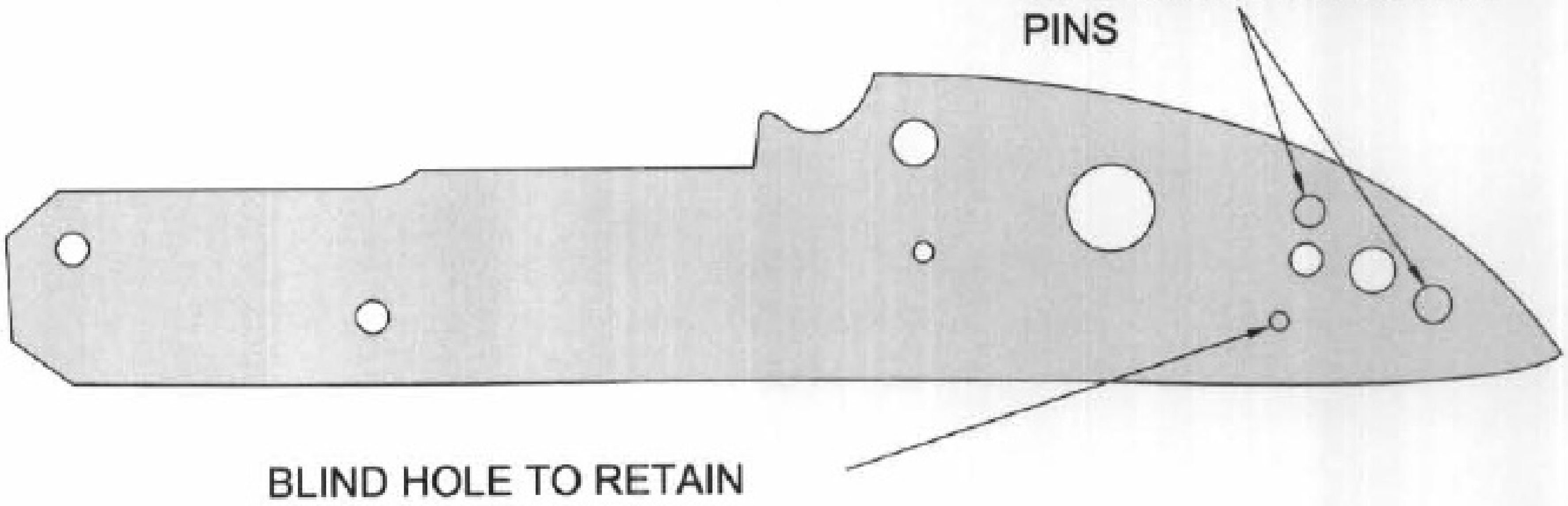
A jig of some description must have been used to allow drilling of the holes so that they aligned properly.

The holes are not drilled completely through either the lock plate or bridle.

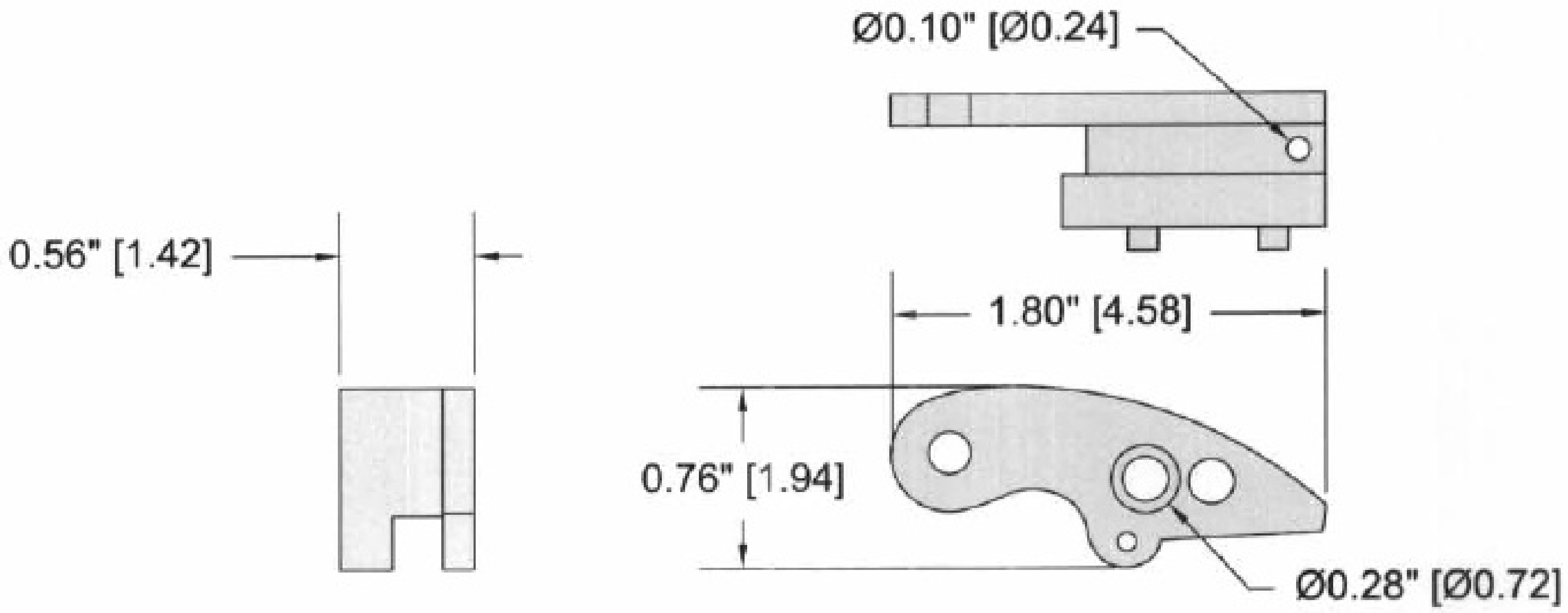


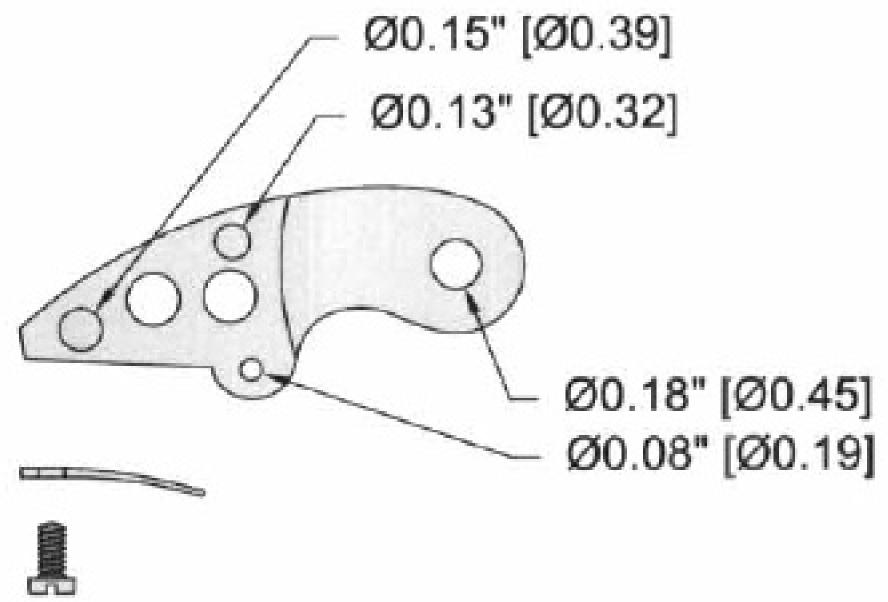
bridle location pins, these pins ensure that the bearing holes in the lockplate and bridle stay accurately in line.

photo courtesy of
Dr. R Beeman



Bridle





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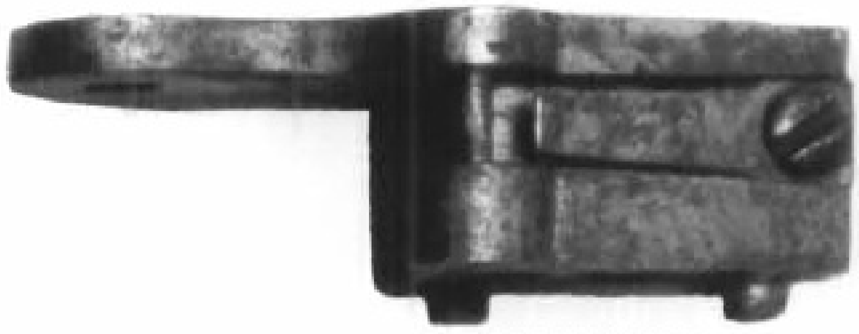
Bridle Assembly



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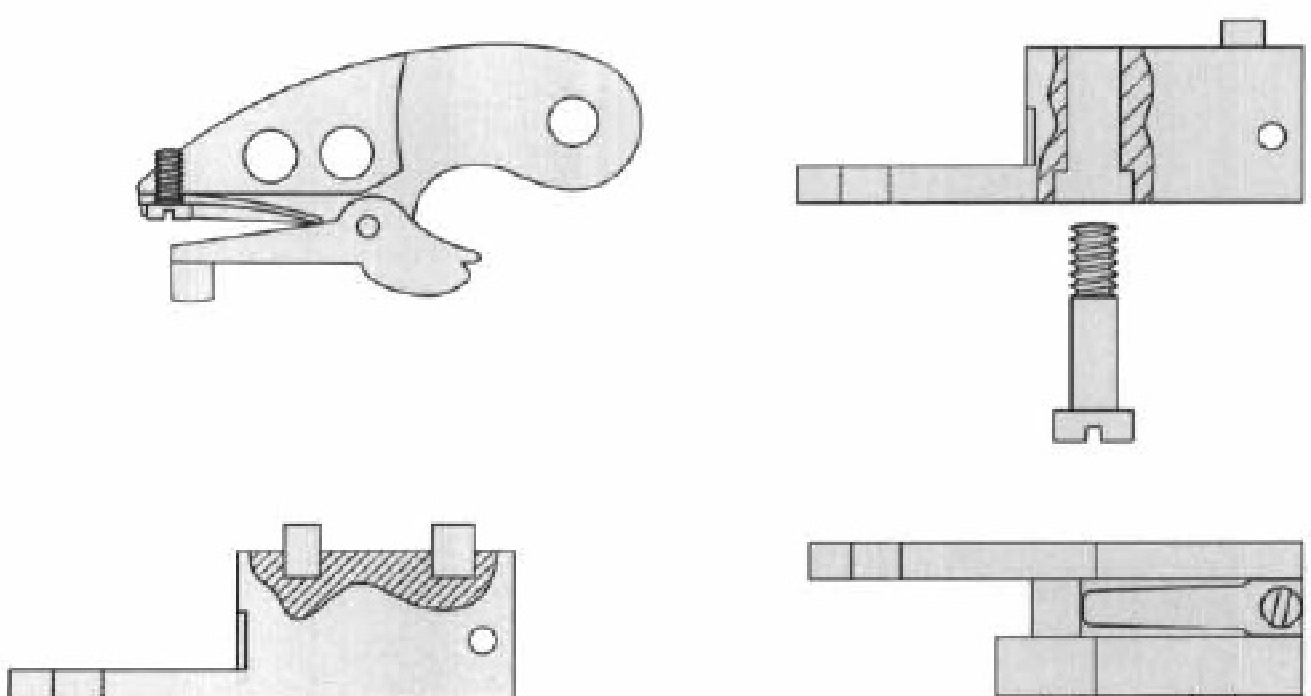
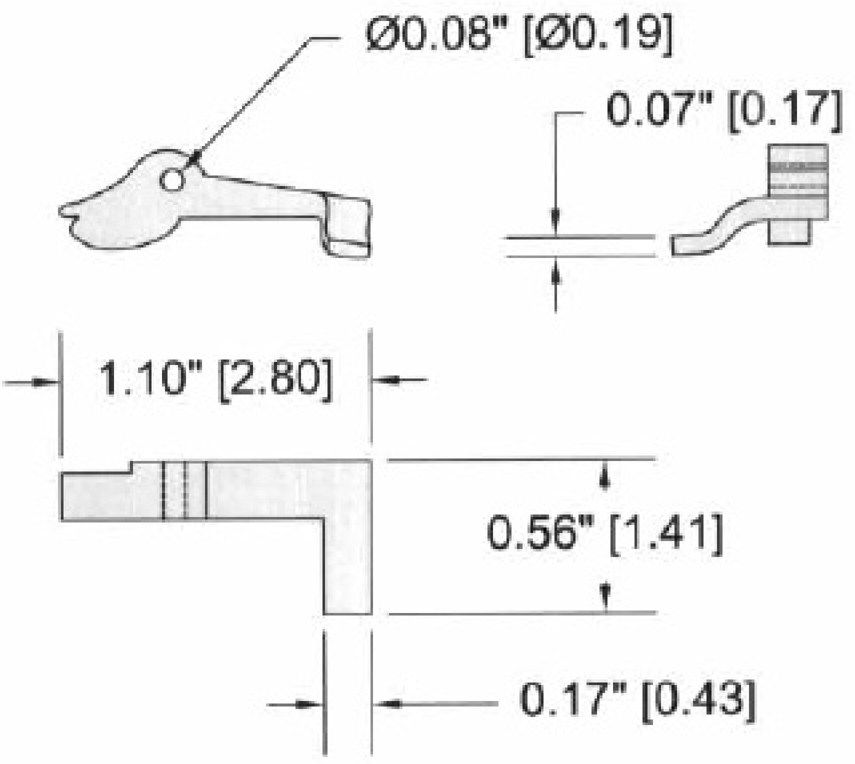
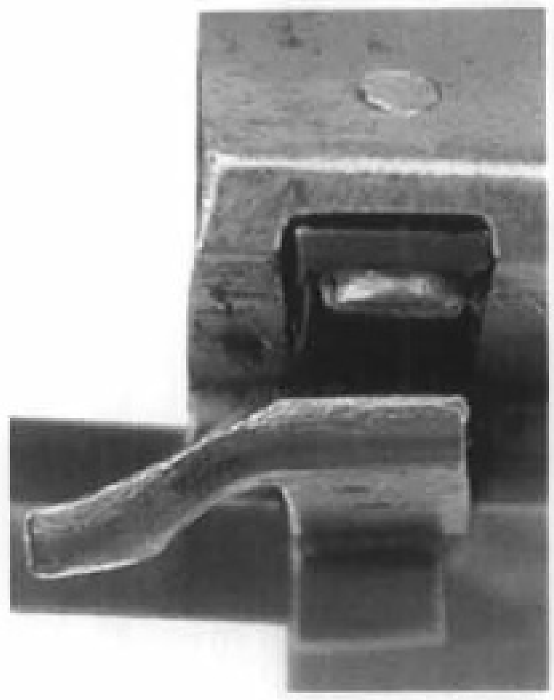
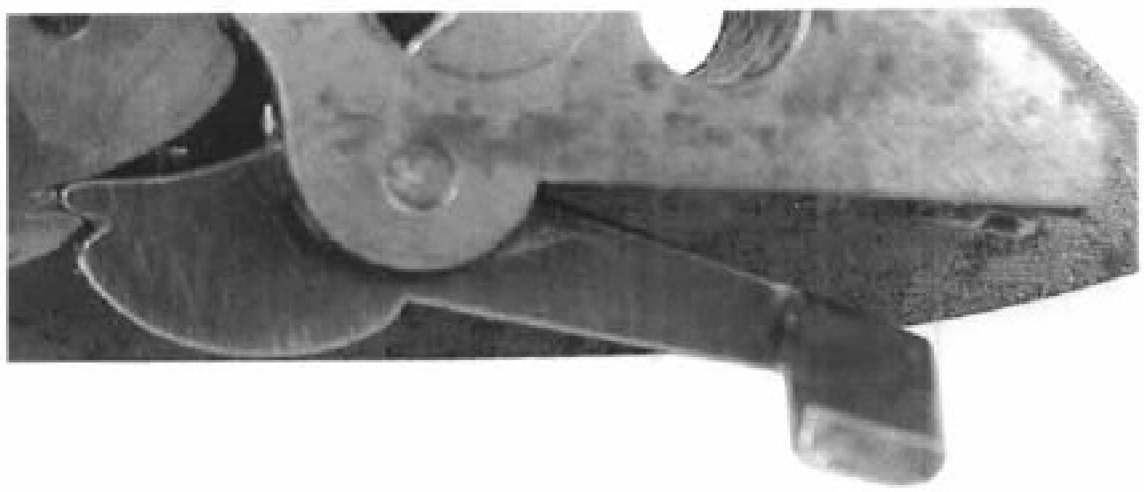
Dr. R Beeman



Sear

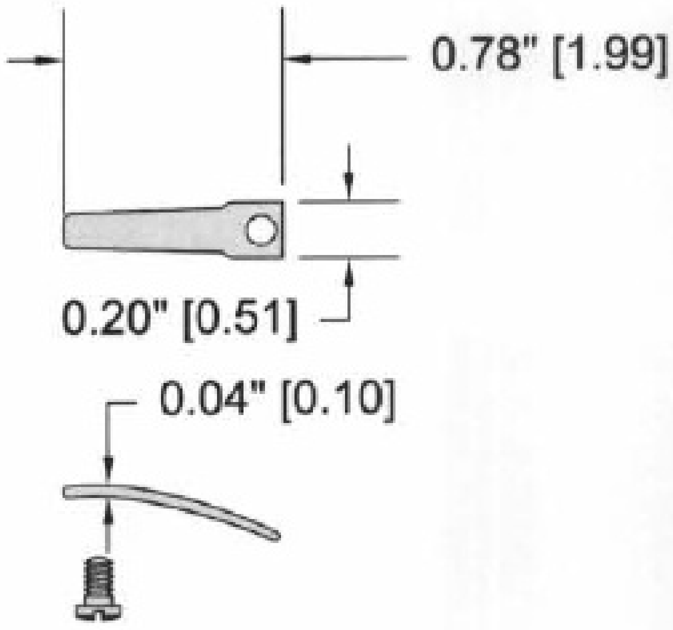




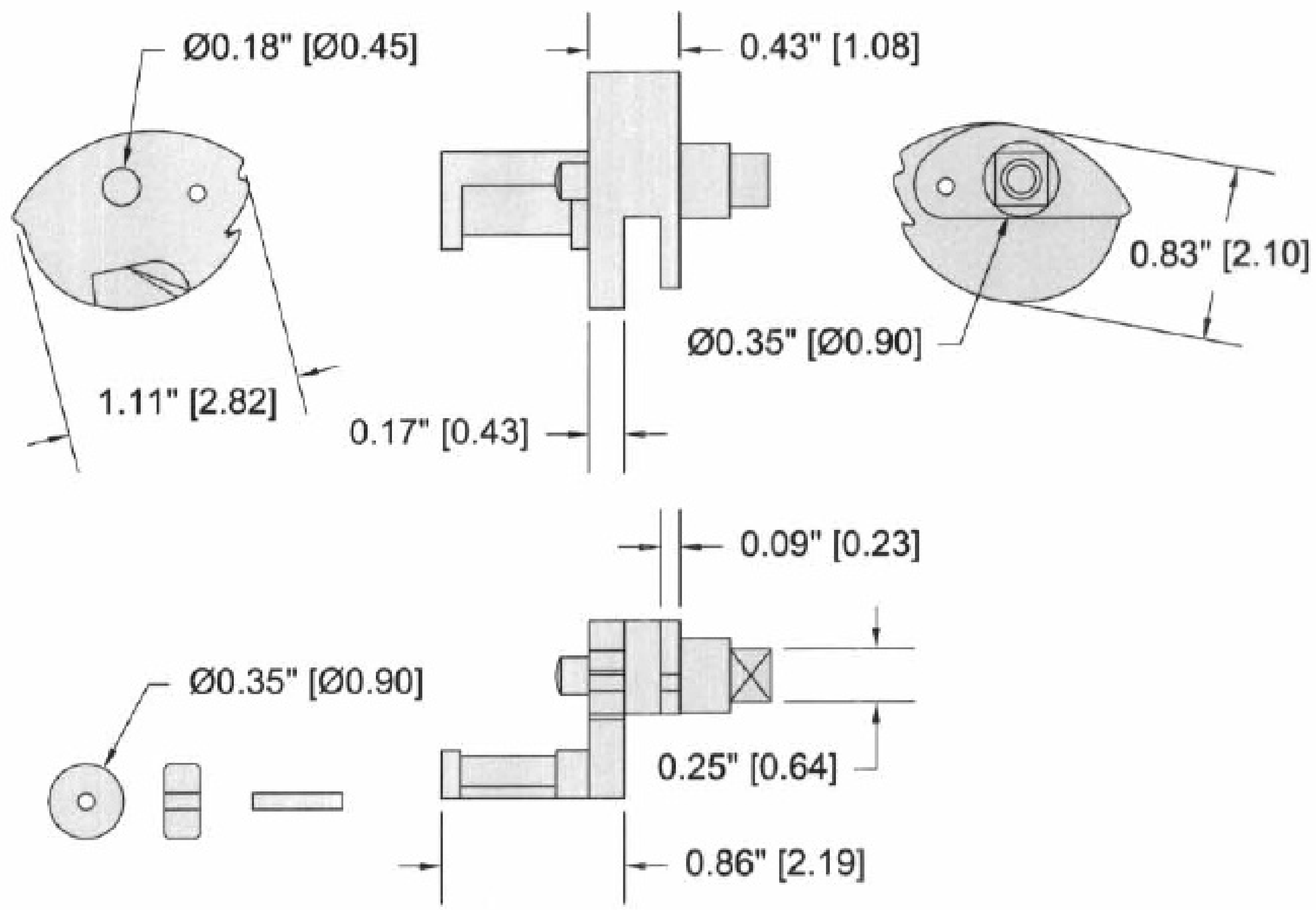


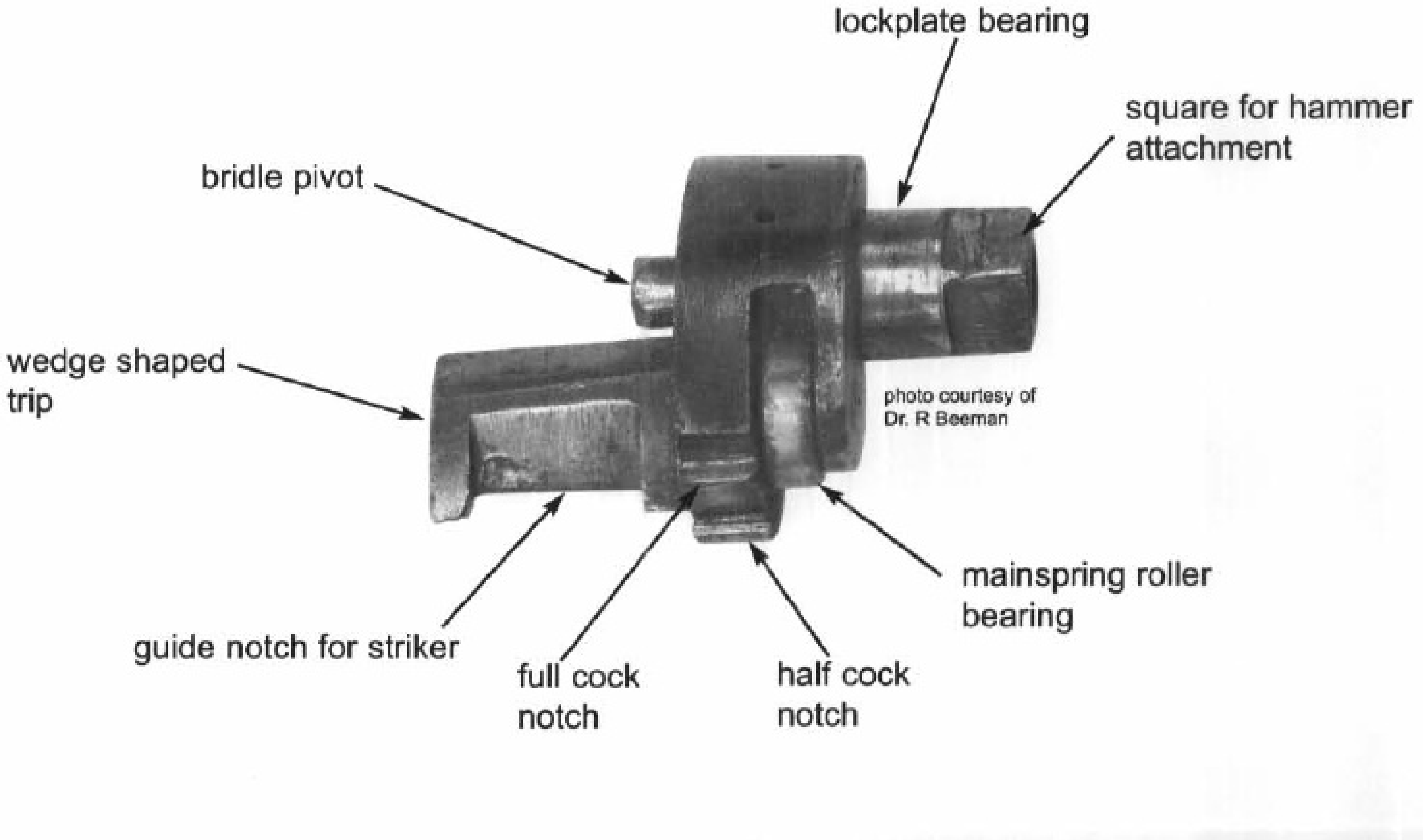
Sear Spring

photo courtesy of
Dr. R Beeman



Tumbler


Ø0.18" [Ø0.45]
0.43" [1.08]
0.83" [2.10]
Ø0.35" [Ø0.90]
1.11" [2.82]
0.17" [0.43]
0.09" [0.23]
Ø0.35" [Ø0.90]
0.25" [0.64]
0.86" [2.19]


lockplate bearing
square for hammer attachment
bridle pivot
wedge shaped trip
photo courtesy of Dr. R Beeman
mainspring roller bearing
guide notch for striker
full cock notch
half cock notch

Tumbler

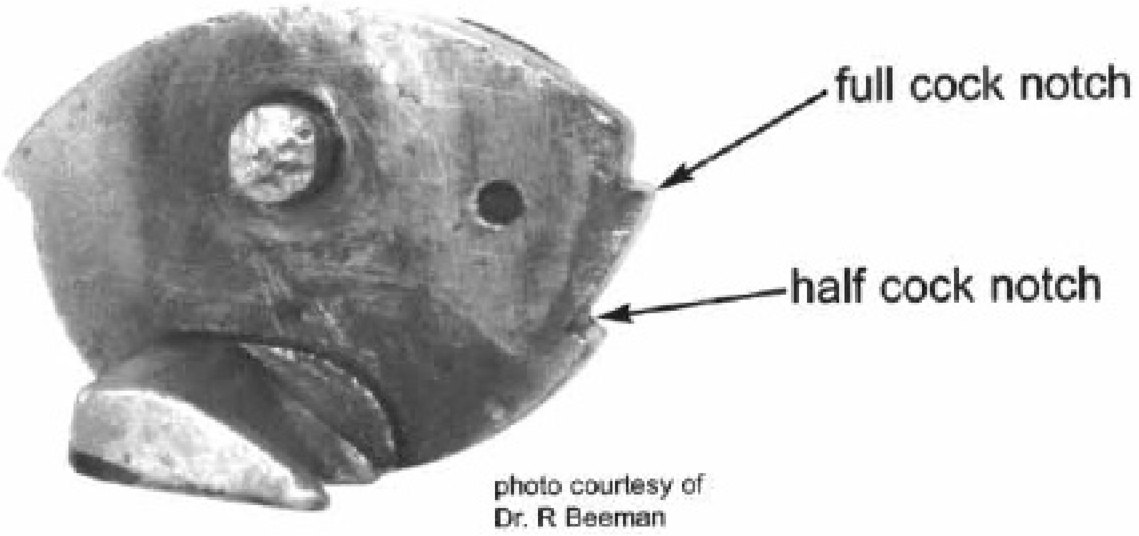


photo courtesy of
Dr. R Beeman

The tumbler is a complex component to manufacture, in particular the pivot point for the bridle which is solid with the tumbler body and has to be in line with the lockplate bearing.

Forging was the usual method of producing tumbler blanks for firearms at this time and would have given a stronger component particularly in the area of the wedge projection, which is under considerable stress at the point in the firing cycle when it opens the valve.

photo courtesy of
Dr. R Beeman

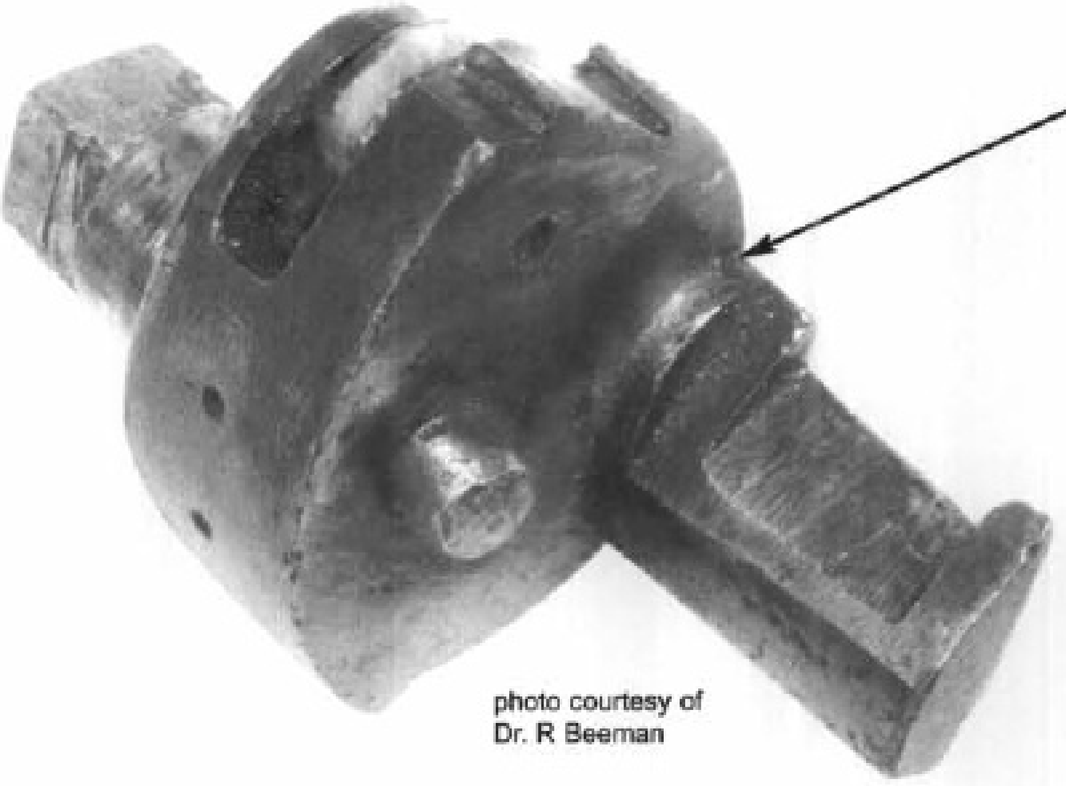


photo courtesy of
Dr. R Beeman

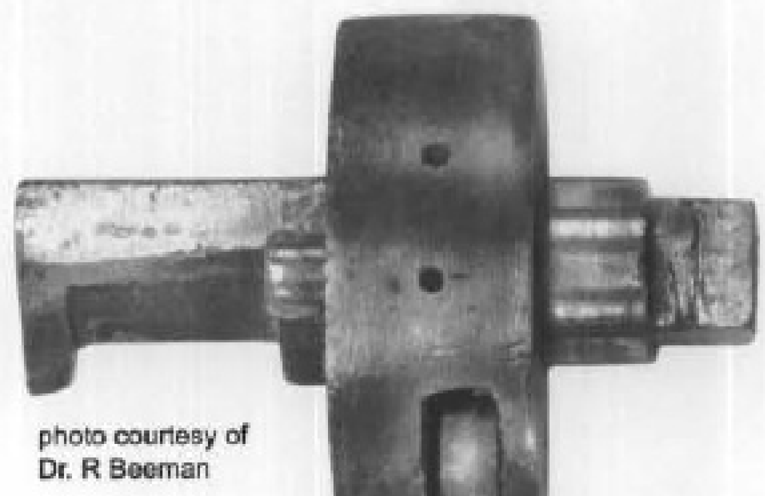
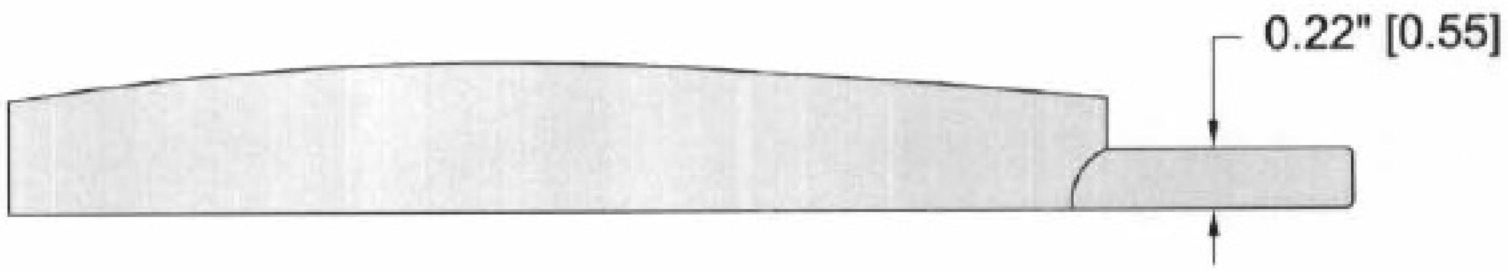
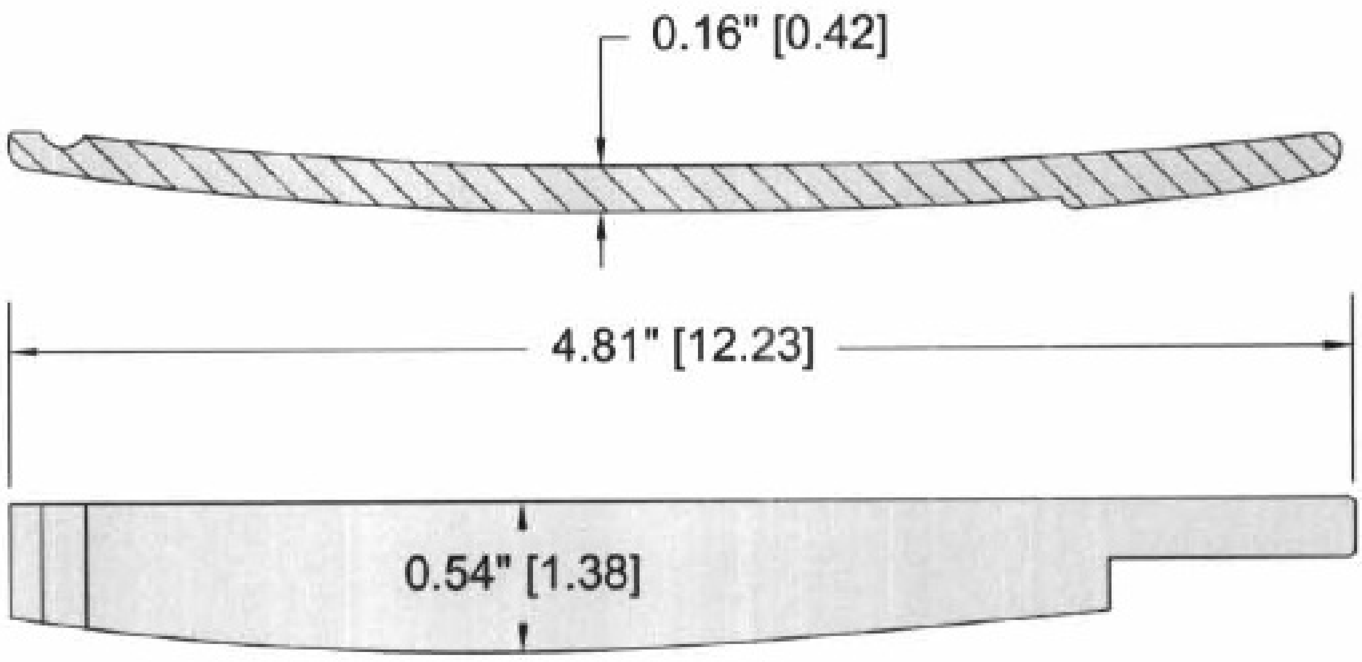


photo courtesy of
Dr. R Beeman

Main Spring and Pivot





made from spring steel hardened and tempered, a flat spring is much easier to produce than the V spring usually used on flintlock rifles.

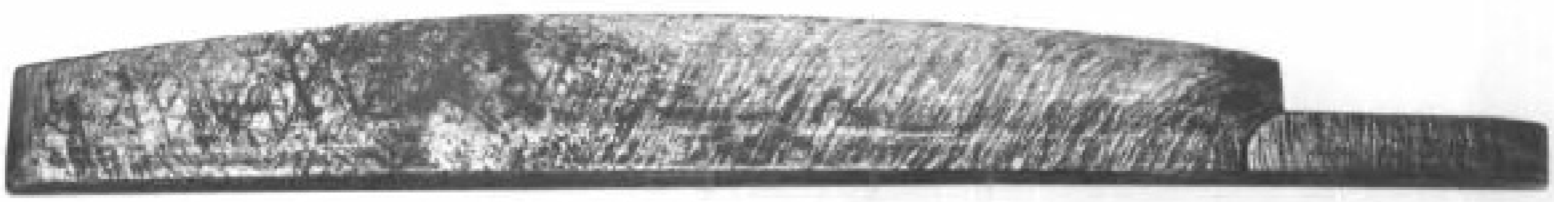
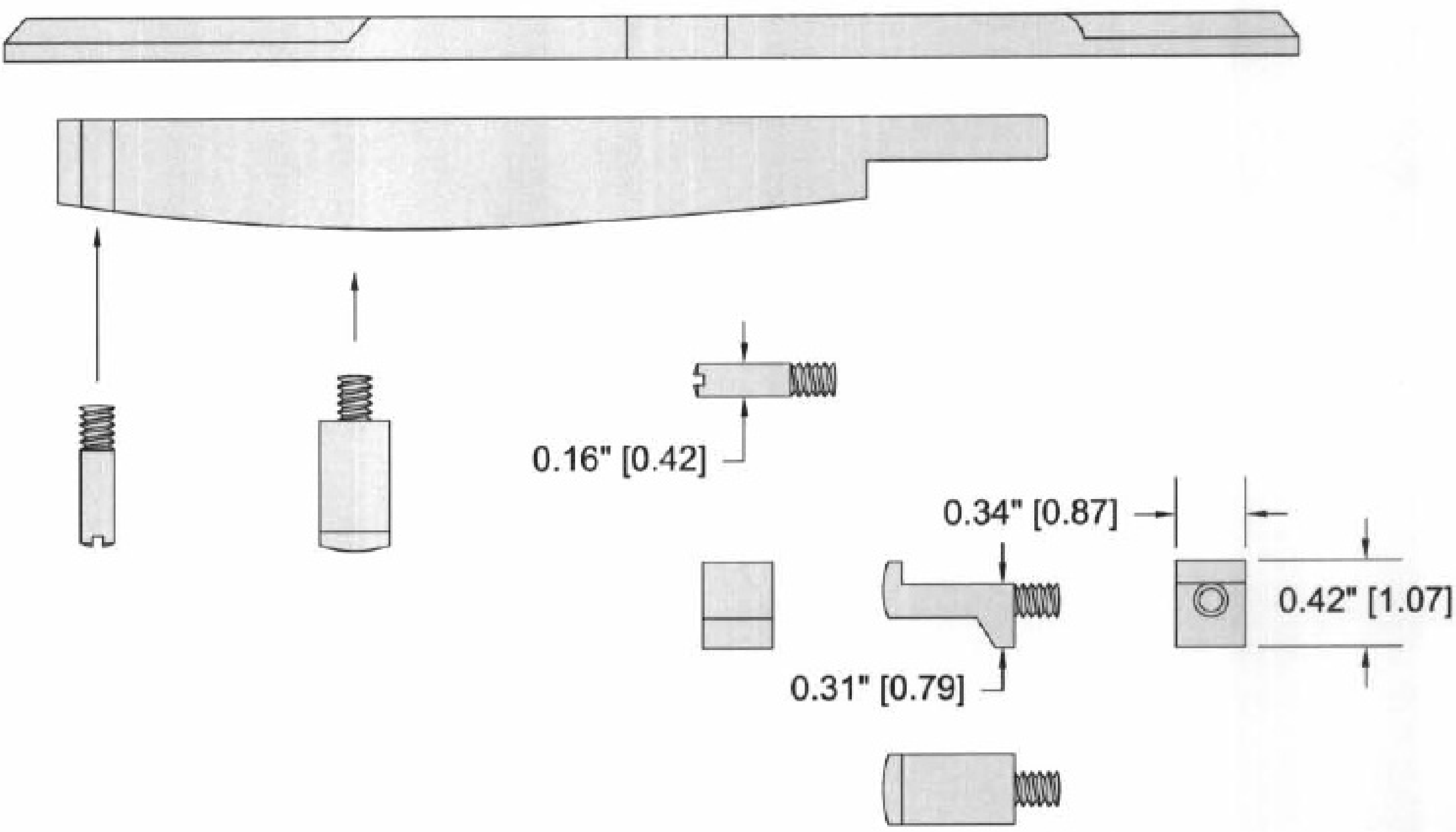


photo courtesy of
Dr. R Beeman



Hammer

photos courtesy of
Dr. R Beeman

The square on the tumbler pivot is cut at a slight angle to give a tight fit with the hammer.

The hammer is used as a spanning lever to rotate the tumbler and to provide extra mass to the system.

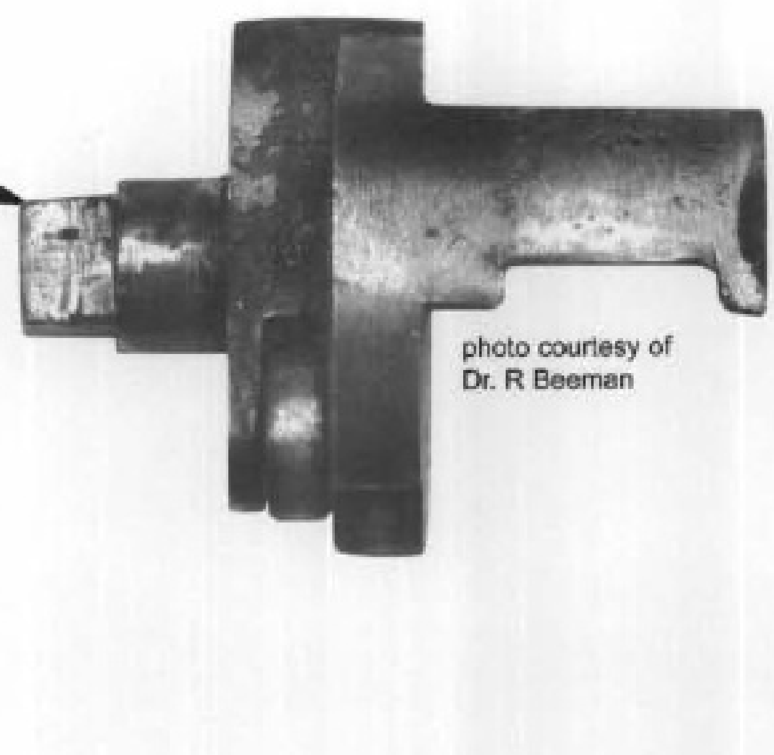
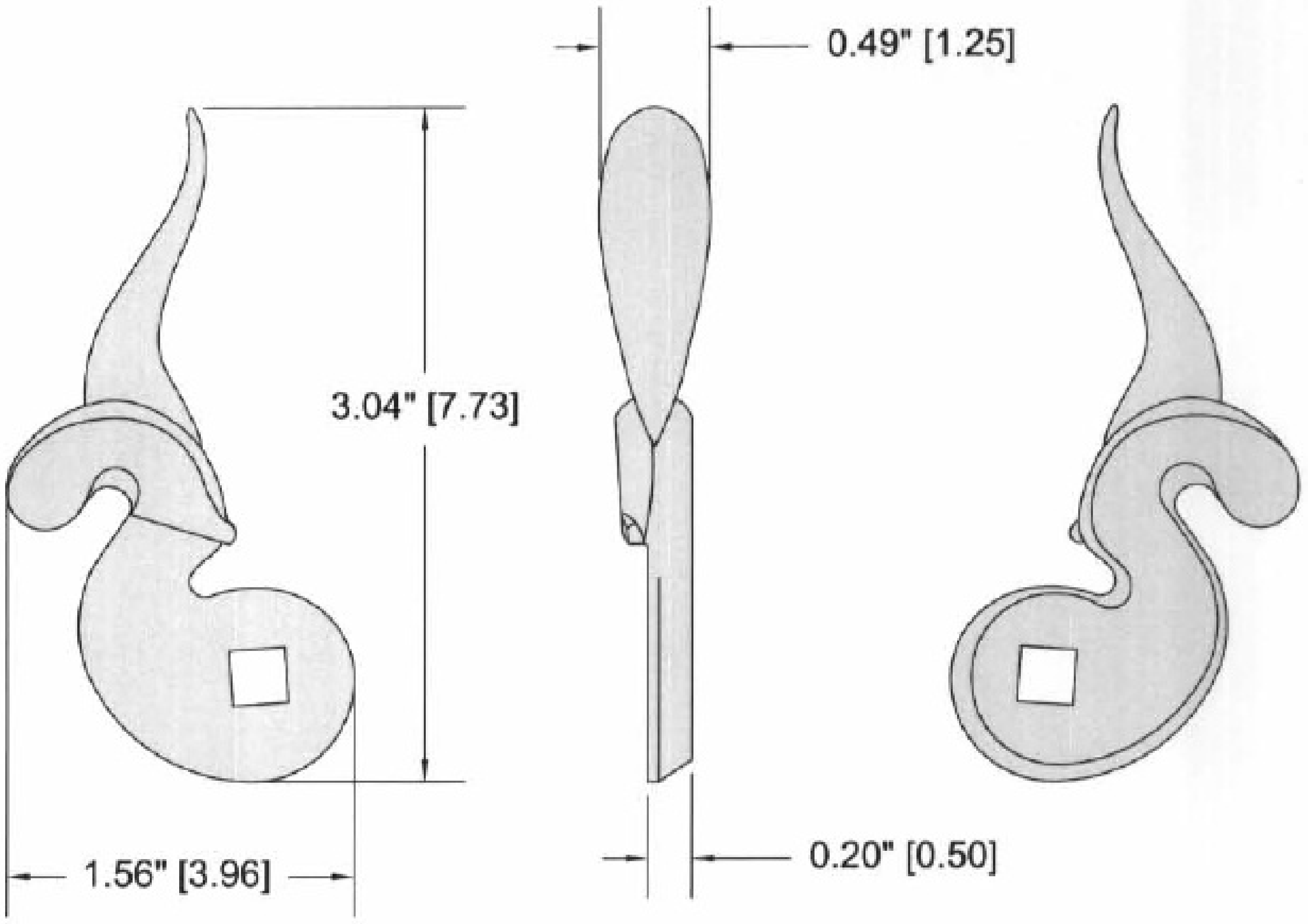
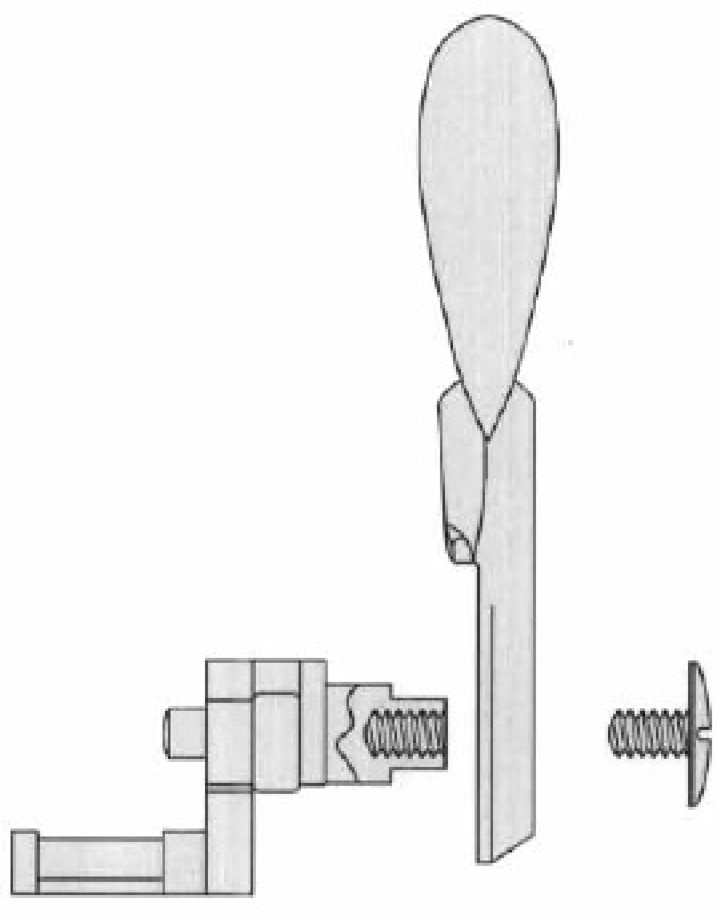


photo courtesy of
Dr. R Beeman

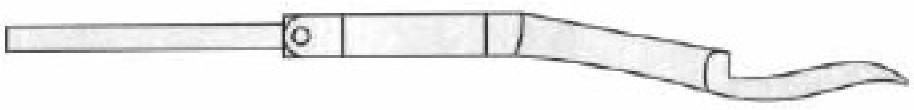
Hammer

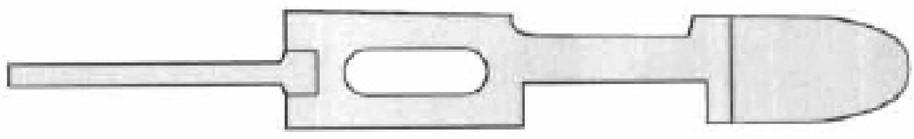


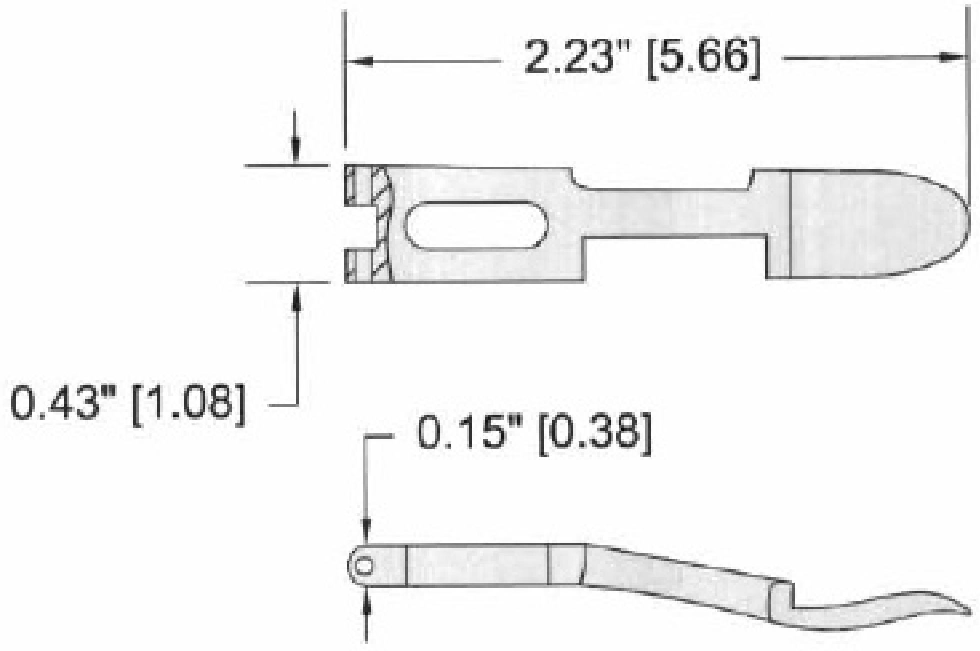
Hammer Bridle Assembly



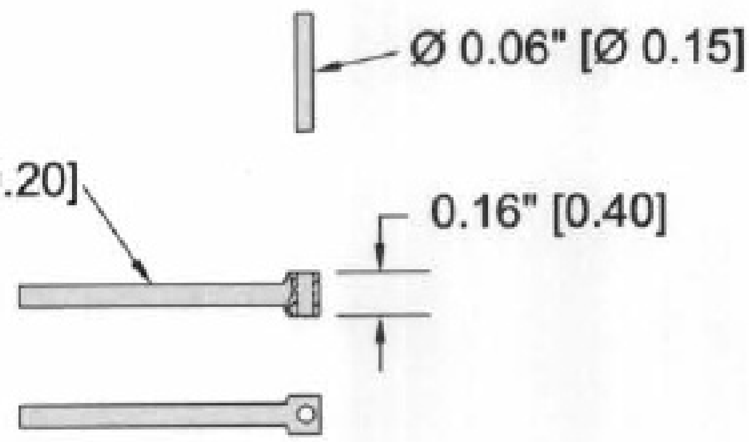
Latch



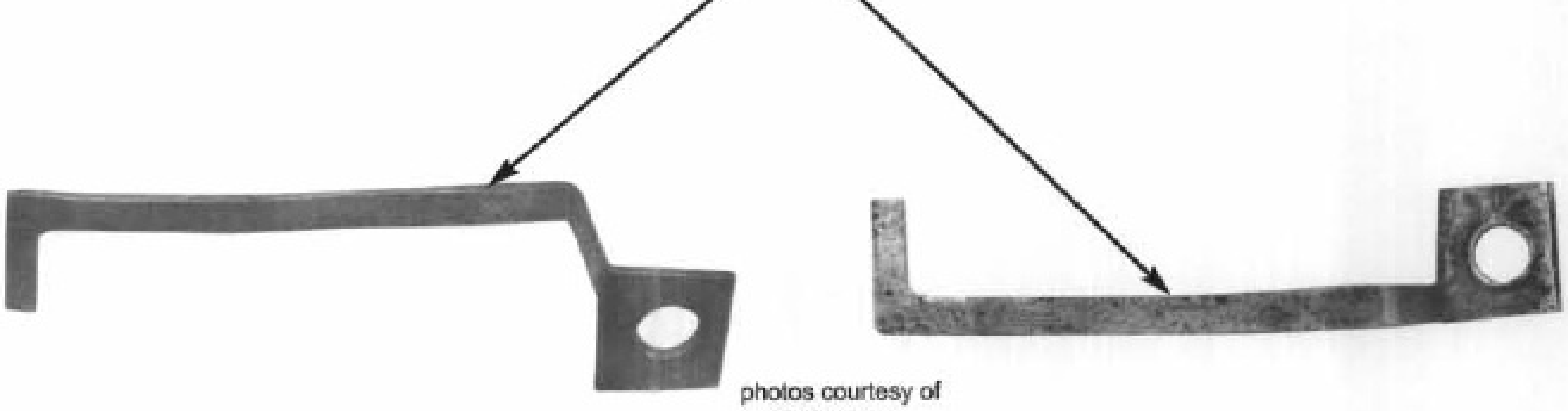




Striker Pin and Pivot

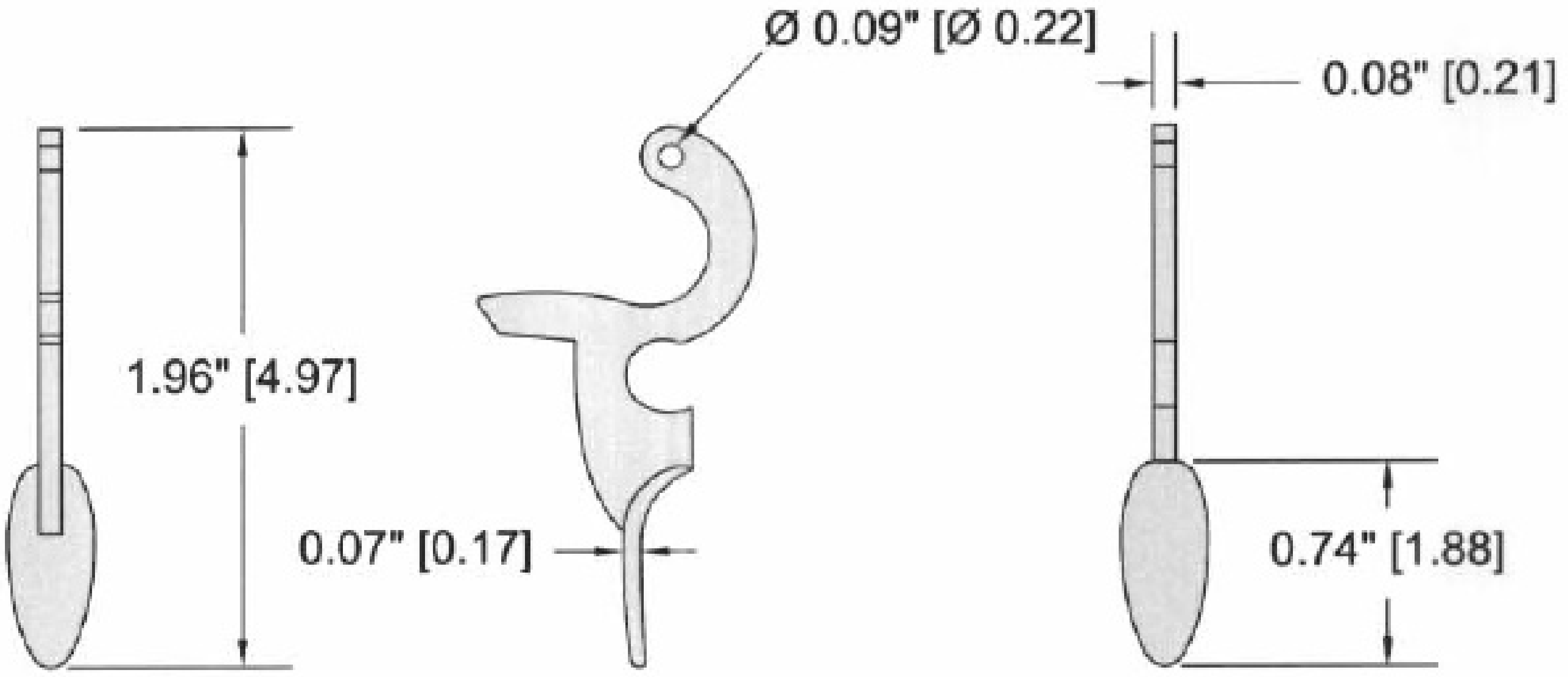


Latch Spring

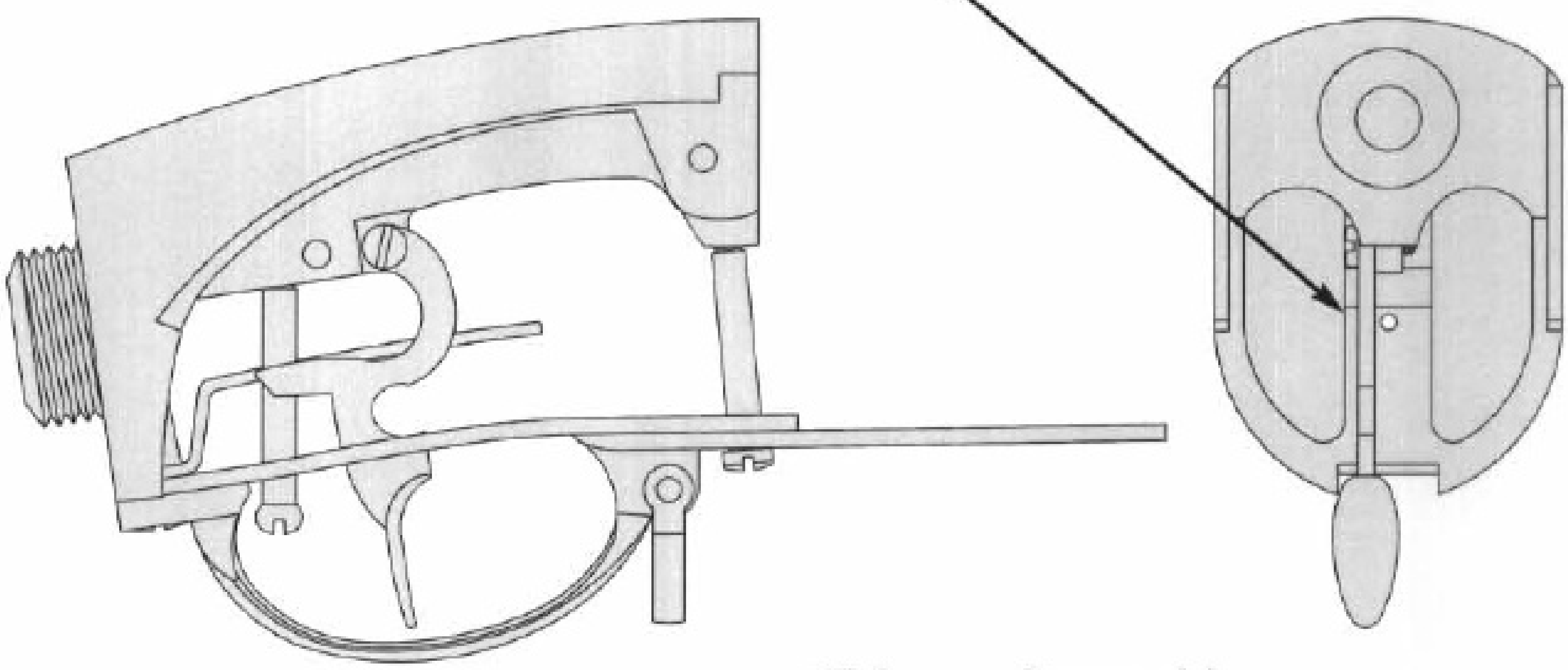


photos courtesy of
Dr. R Beeman

Trigger

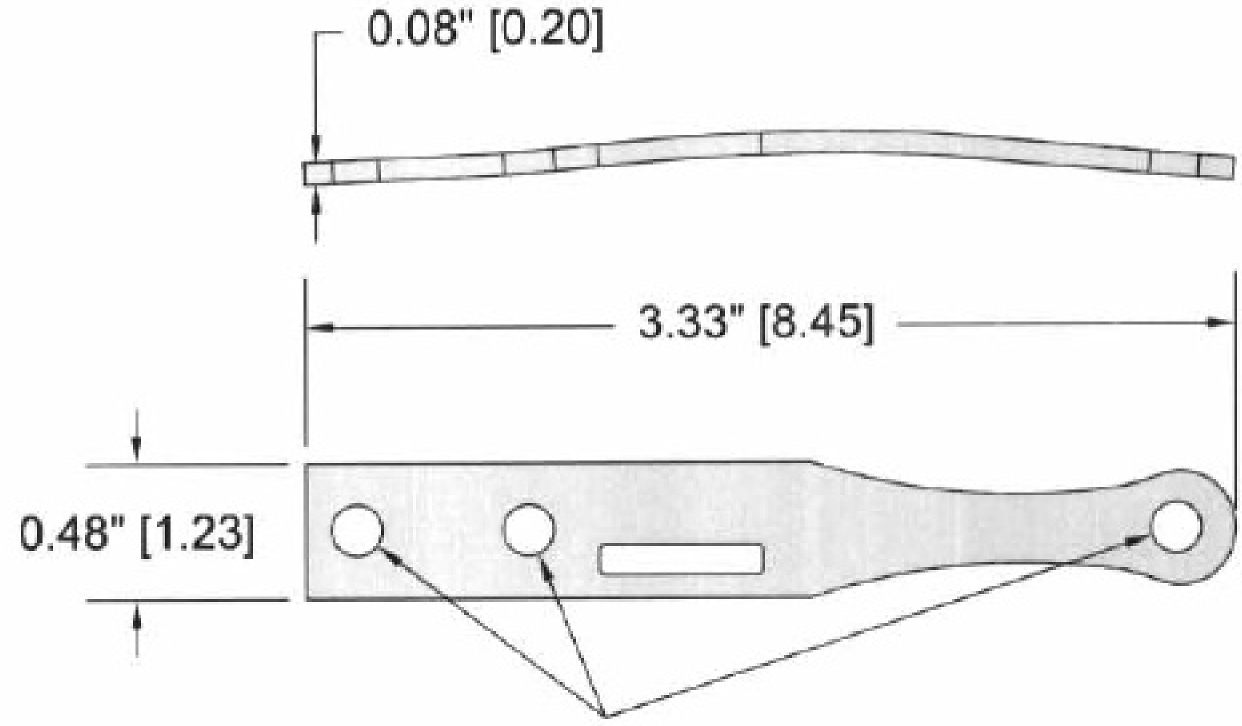


the trigger is mounted to the side rather than on the centre line

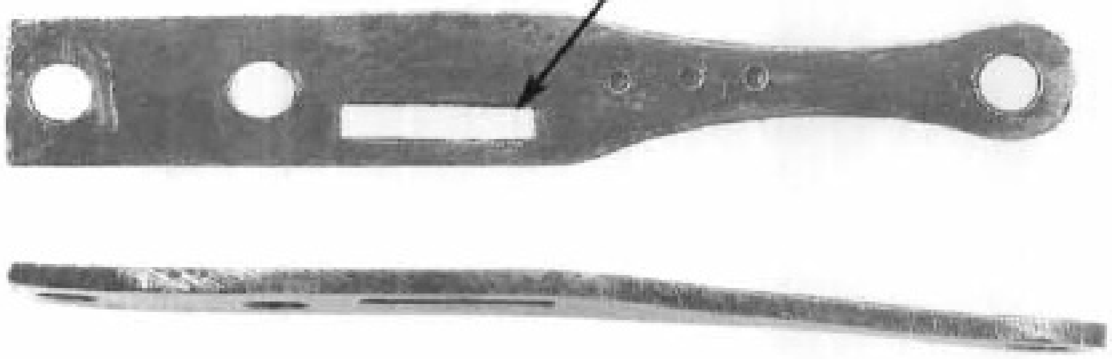


Trigger Assembly

Trigger Cover Plate

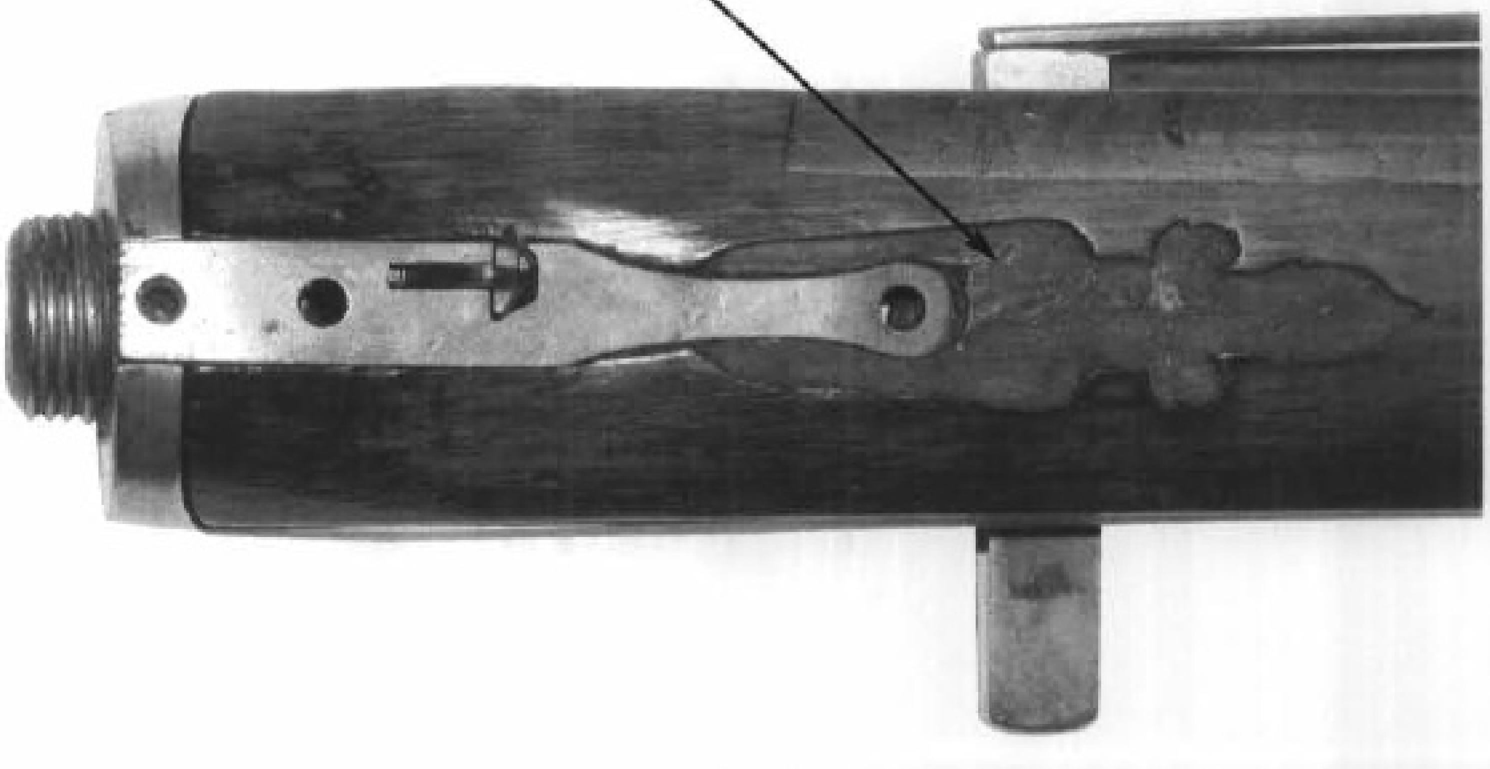


the slot in the plate limits the backward and forwards movement of the trigger and sideways movement

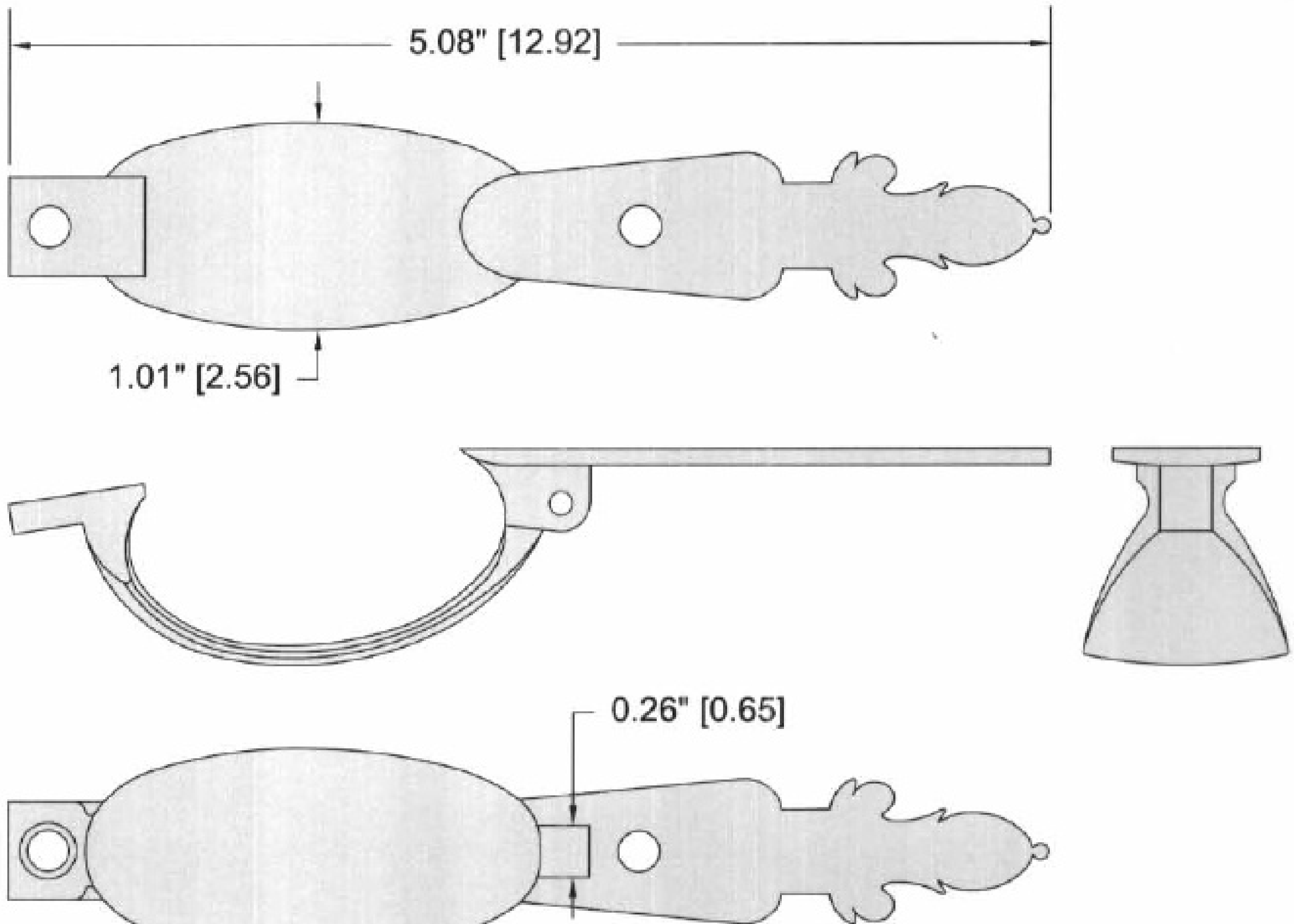


The cut out in the front of the trigger allows the trigger to be inserted through the slot in the cover plate, without it the slot would have to be longer

stock inletting for the trigger guard



Trigger Guard



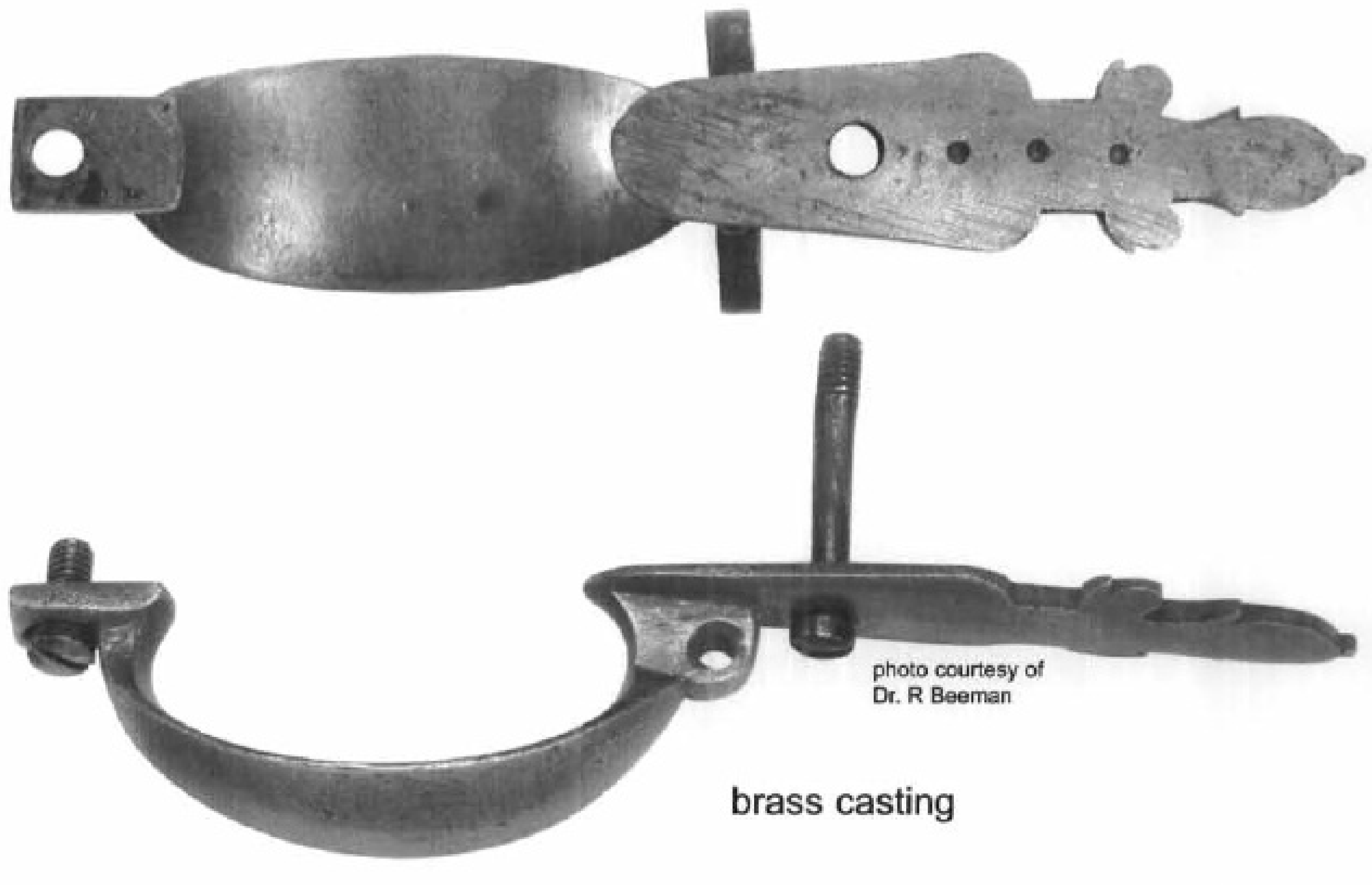
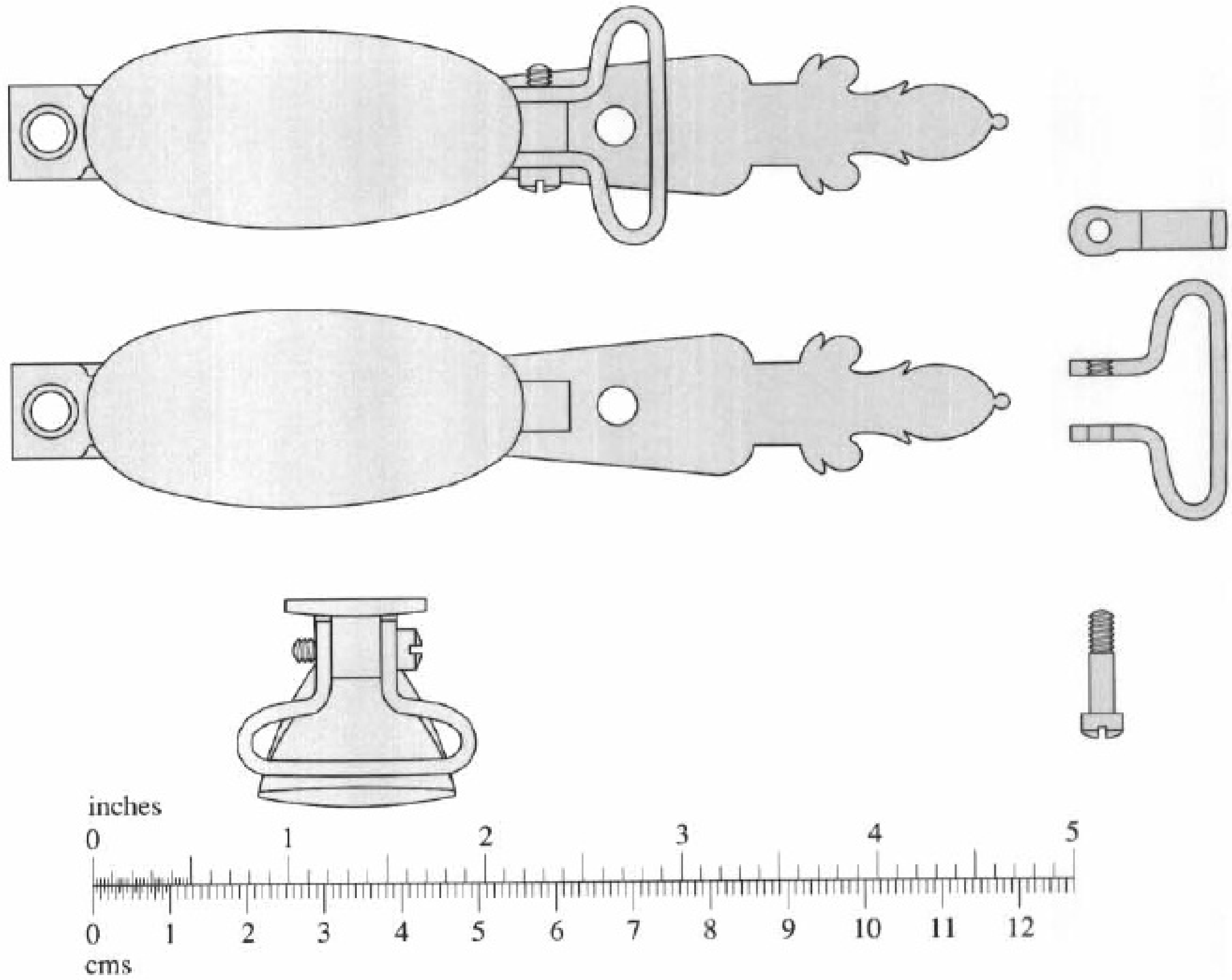
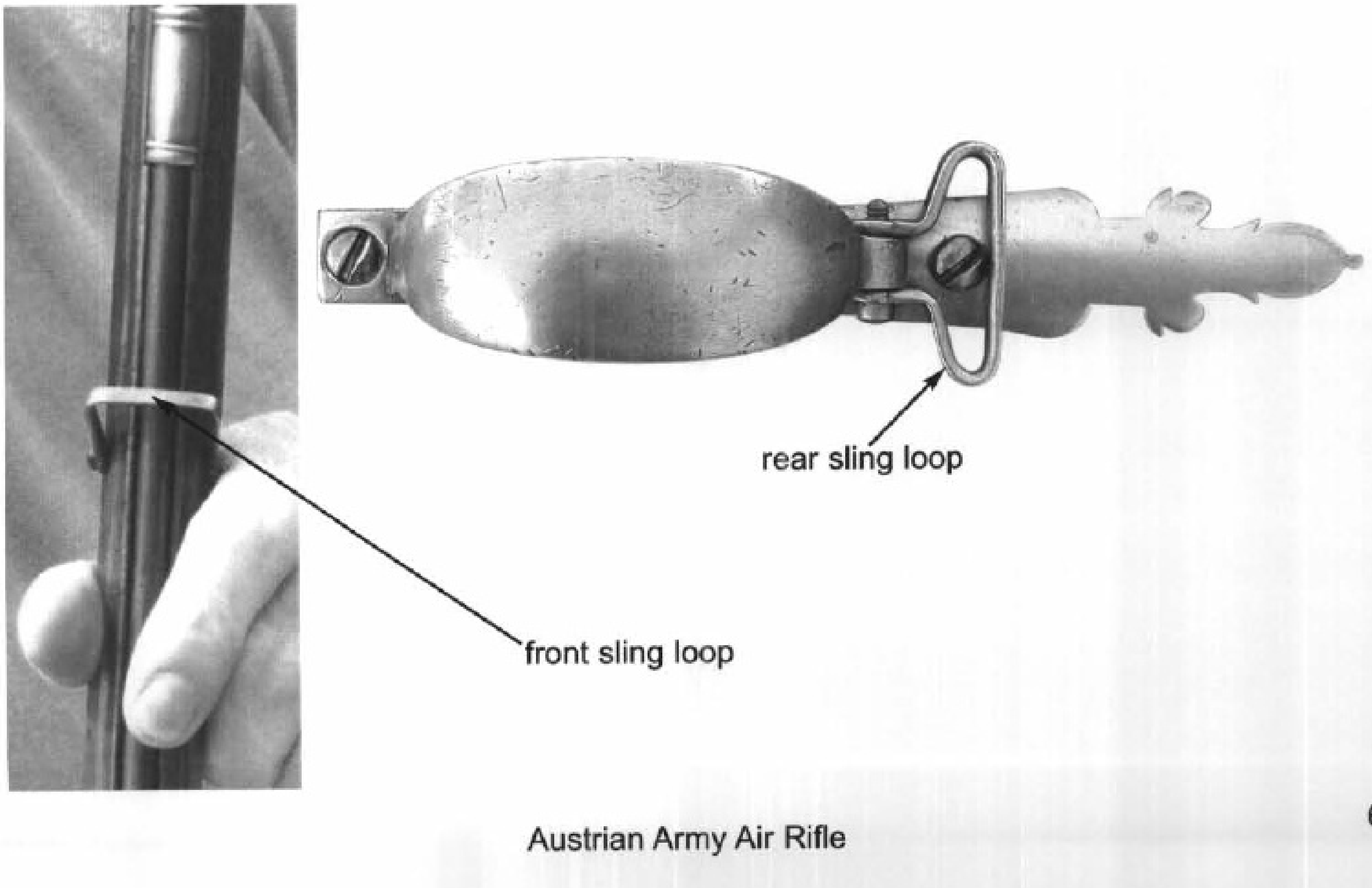


photo courtesy of
Dr. R Beeman

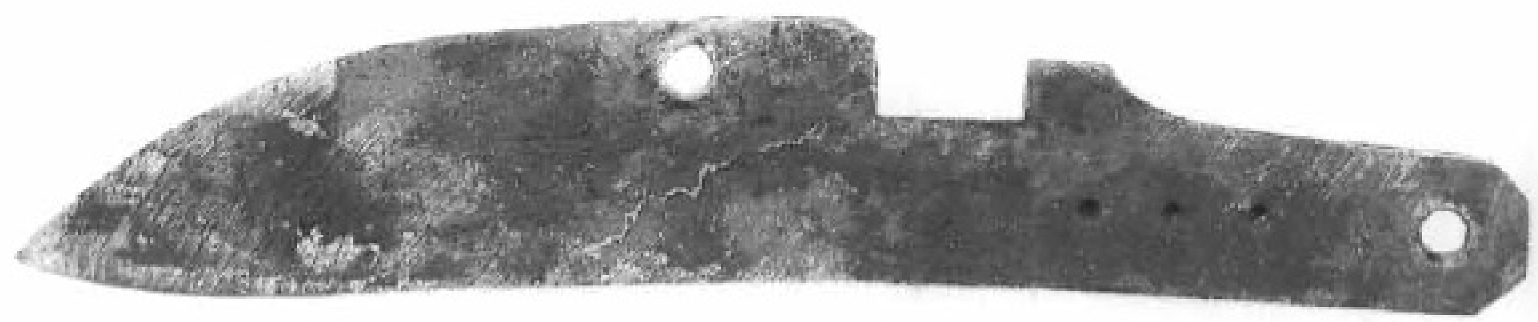
brass casting

Trigger Guard and Sling swivel

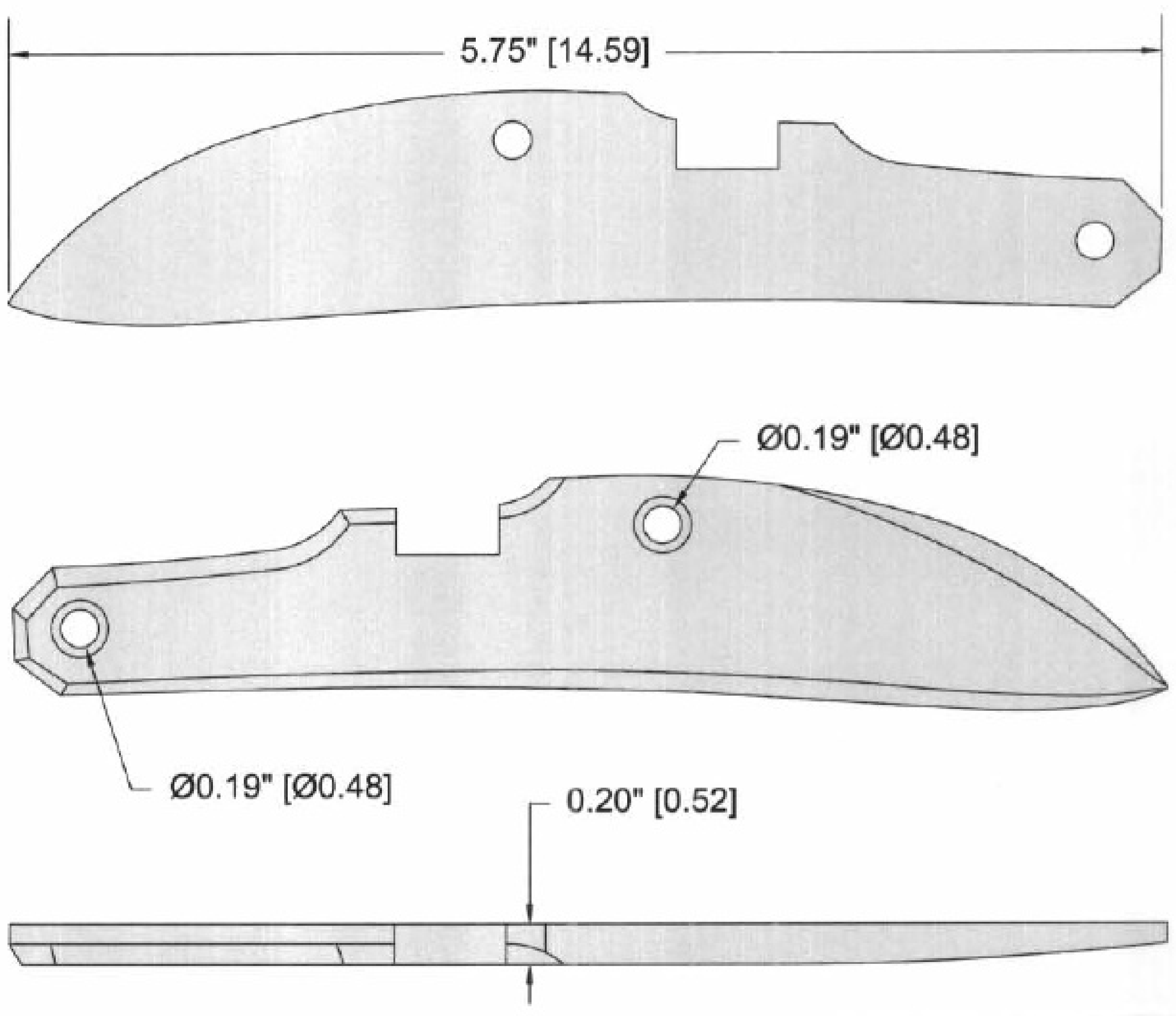




Left Side Cover Plate



cast in brass evident by the marks left from the casting process on the rear of the plate



Lock screws

Making small screw threads up to ¼" (6mm) did not present a problem.

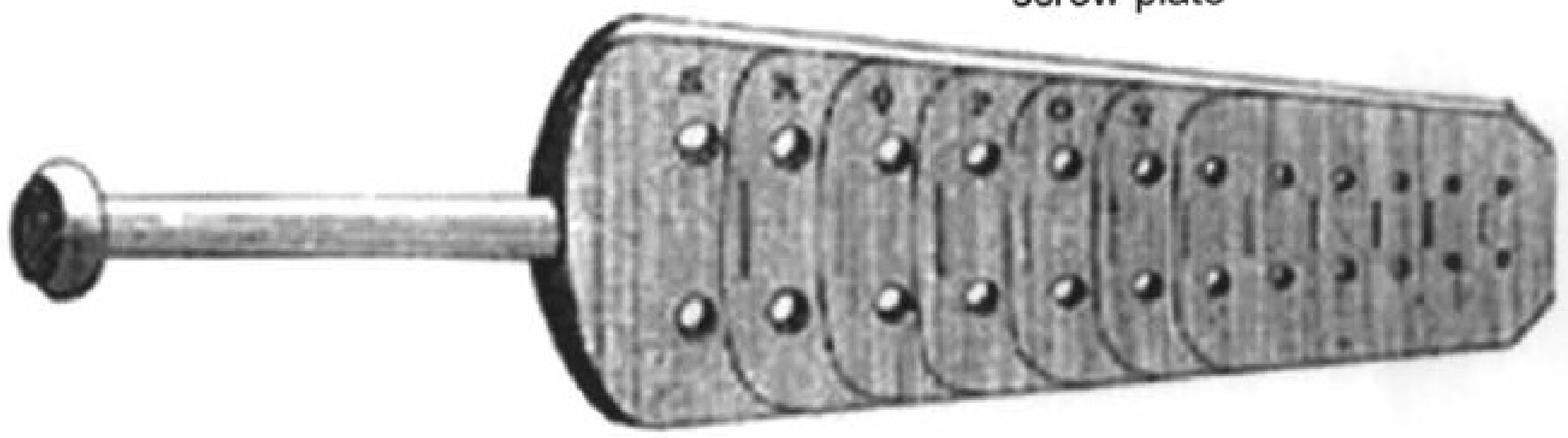
These were made in the clock making and gun making workshops of the period, as an established practice that allowed the quick manufacture of small screws in volume, with a relative uniformity of size and pitch.

Screw plates of hardened steel were used to form the threads of screws for clock and watch work.

Each plate had threaded holes, in twos or threes, of diminishing sizes for different-sized screws.

Small screws could be turned into the plate, a handle providing leverage and some had a convenient loop for hanging the plate on a hook when not in use.

A lubricant such as lard oil was essential in screw making.



The taps have shanks which could be turned by pin tongs, or a hand vise for larger ones.

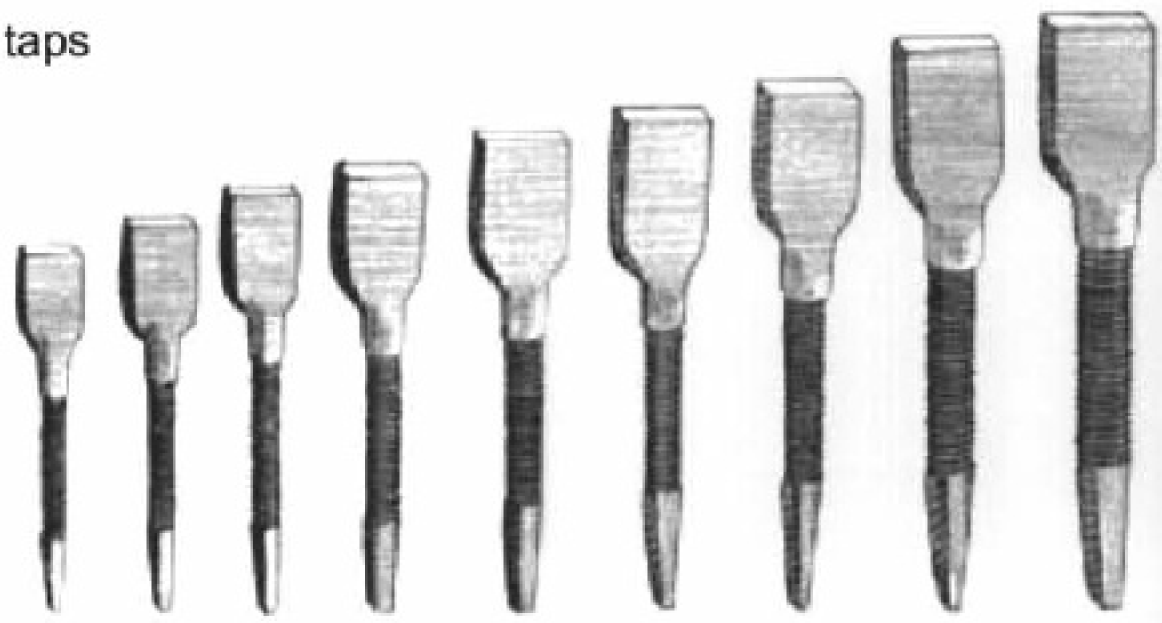
They were usually made of round steel rod, screwed, and having three or four flats filed down upon them.

Taps and dies are, or should be, true cutting tools, and if we examine any of those of approved form today we shall see that they are in fact so.

But none of the early taps or screw plates were in any sense cutting tools they ground, scraped and squeezed, but never cut.

The action in making the thread was to squeeze the thread on the softer metal of which the screw was to be made.

Pitches and sizes of screw threads are now standardised. This was not the case in the eighteenth century.



Lock screws

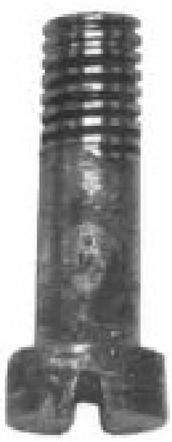
trigger pivot screw

latch guide screw

hammer retaining screw

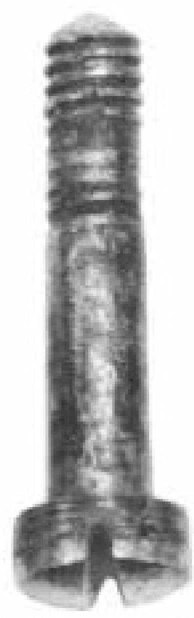
These screws used on the lock, have slightly raised threads showing that they were formed with some pressure as you would get if a thread plate were used (screws and pin from Dr. Beeman's Girandoni)

(This actually makes a stronger thread because the pressure causes the grain of the metal to follow the contours of the thread).

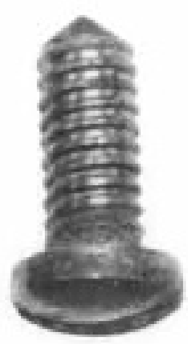


bridle retaining screw

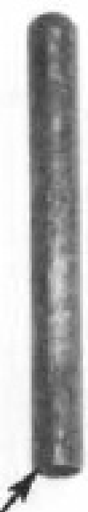
rear trigger guard retaining screw



lock retaining screw

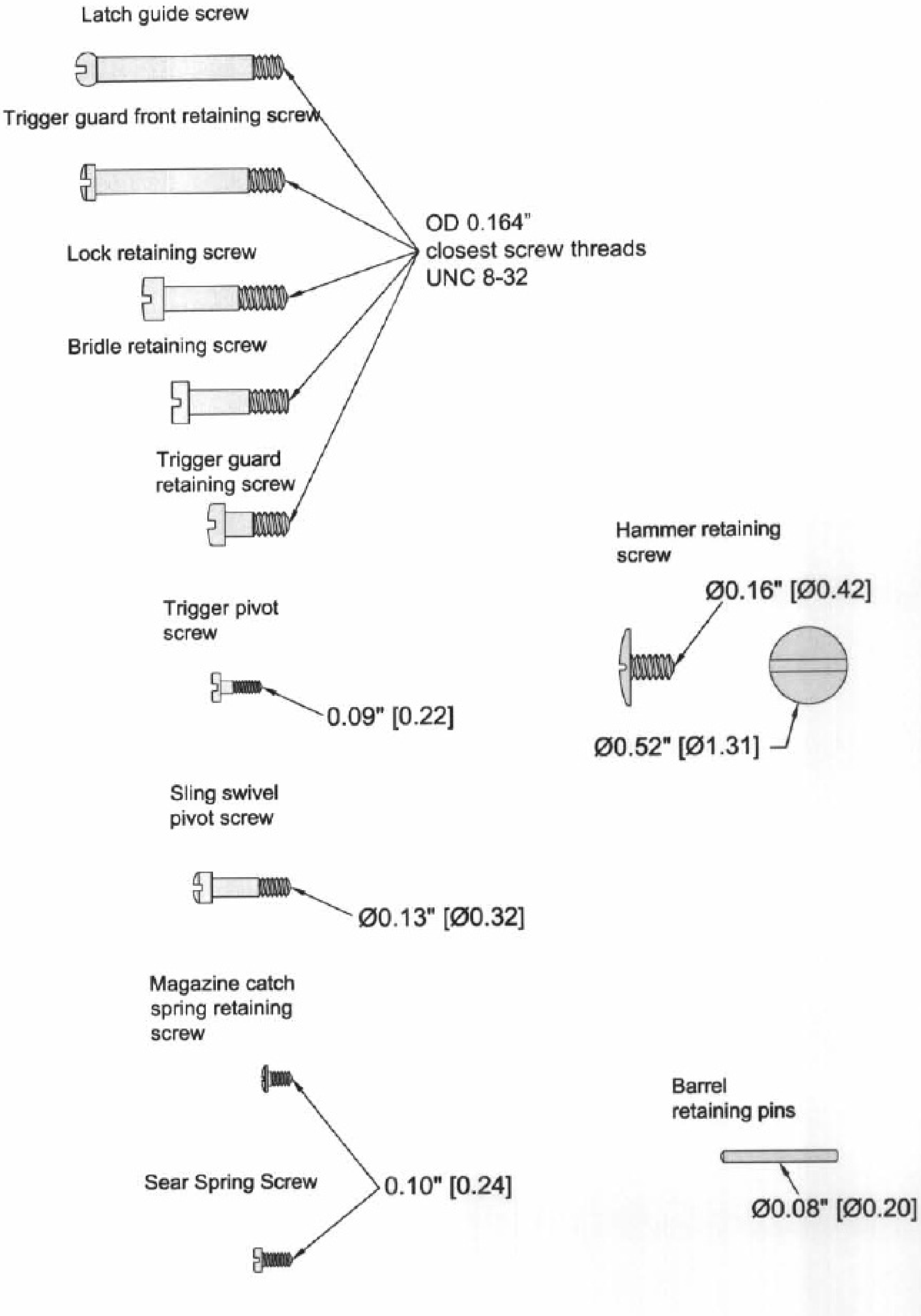


left cover plate retaining screw



one of the pins used to retain the ramrod loops, fore loop and muzzle cap in position

Lock screws



Latch guide screw
Trigger guard front retaining screw
Lock retaining screw
Bridle retaining screw
Trigger guard retaining screw
OD 0.164"
closest screw threads
UNC 8-32
Hammer retaining screw
Ø0.16" [Ø0.42]
Ø0.52" [Ø1.31]
Trigger pivot screw
0.09" [0.22]
Sling swivel pivot screw
Ø0.13" [Ø0.32]
Magazine catch spring retaining screw
Sear Spring Screw
0.10" [0.24]
Barrel retaining pins
Ø0.08" [Ø0.20]

Muzzle Cap

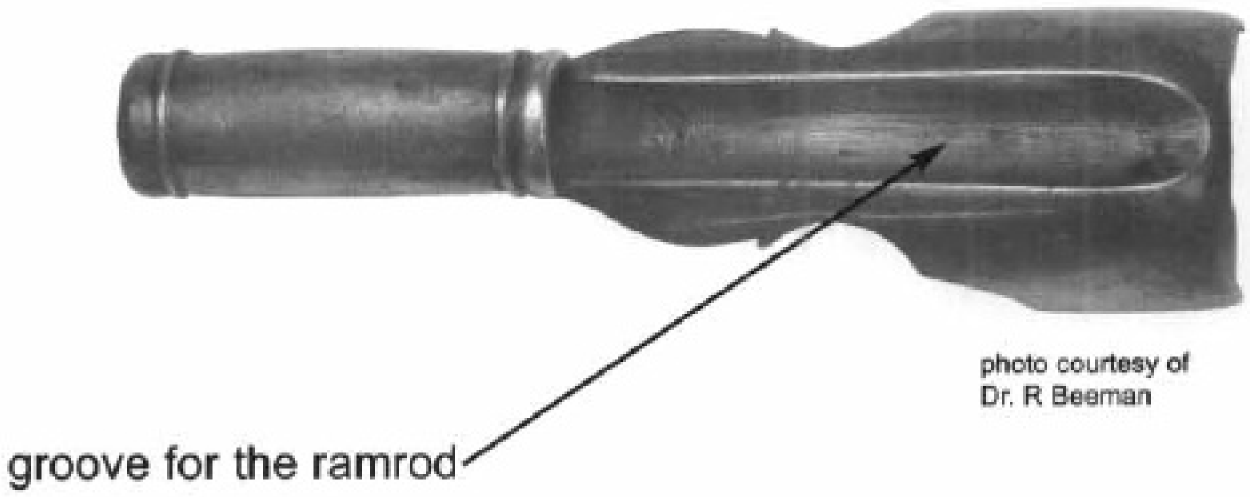


photo courtesy of
Dr. R Beeman

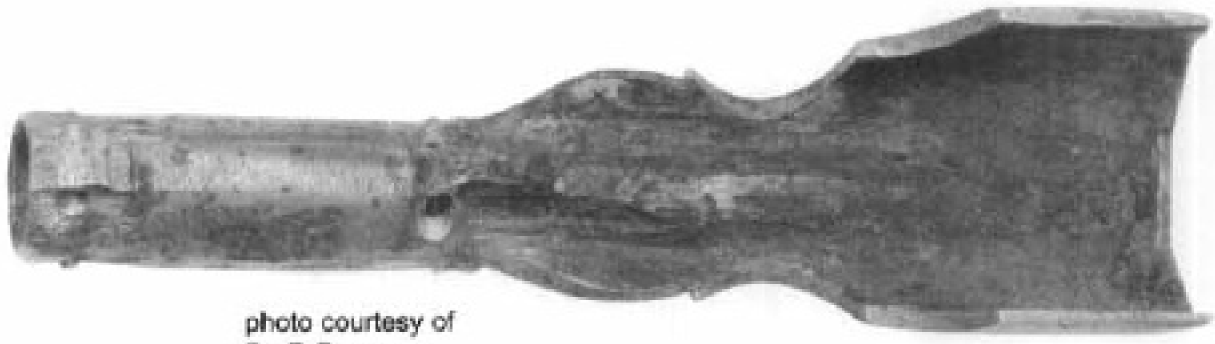
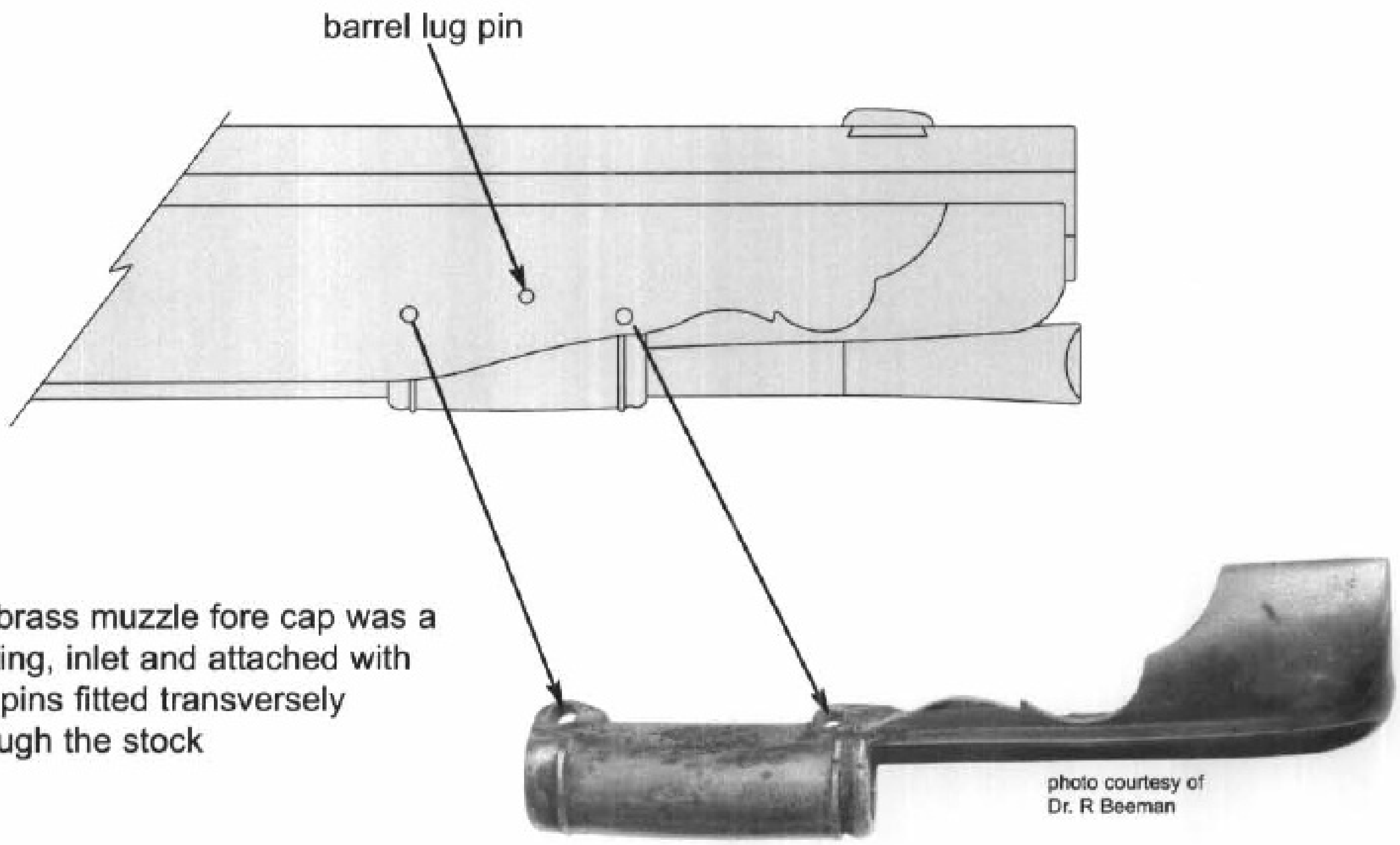


photo courtesy of
Dr. R Beeman



the brass muzzle fore cap was a casting, inlet and attached with two pins fitted transversely through the stock

photo courtesy of
Dr. R Beeman

Muzzle Cap

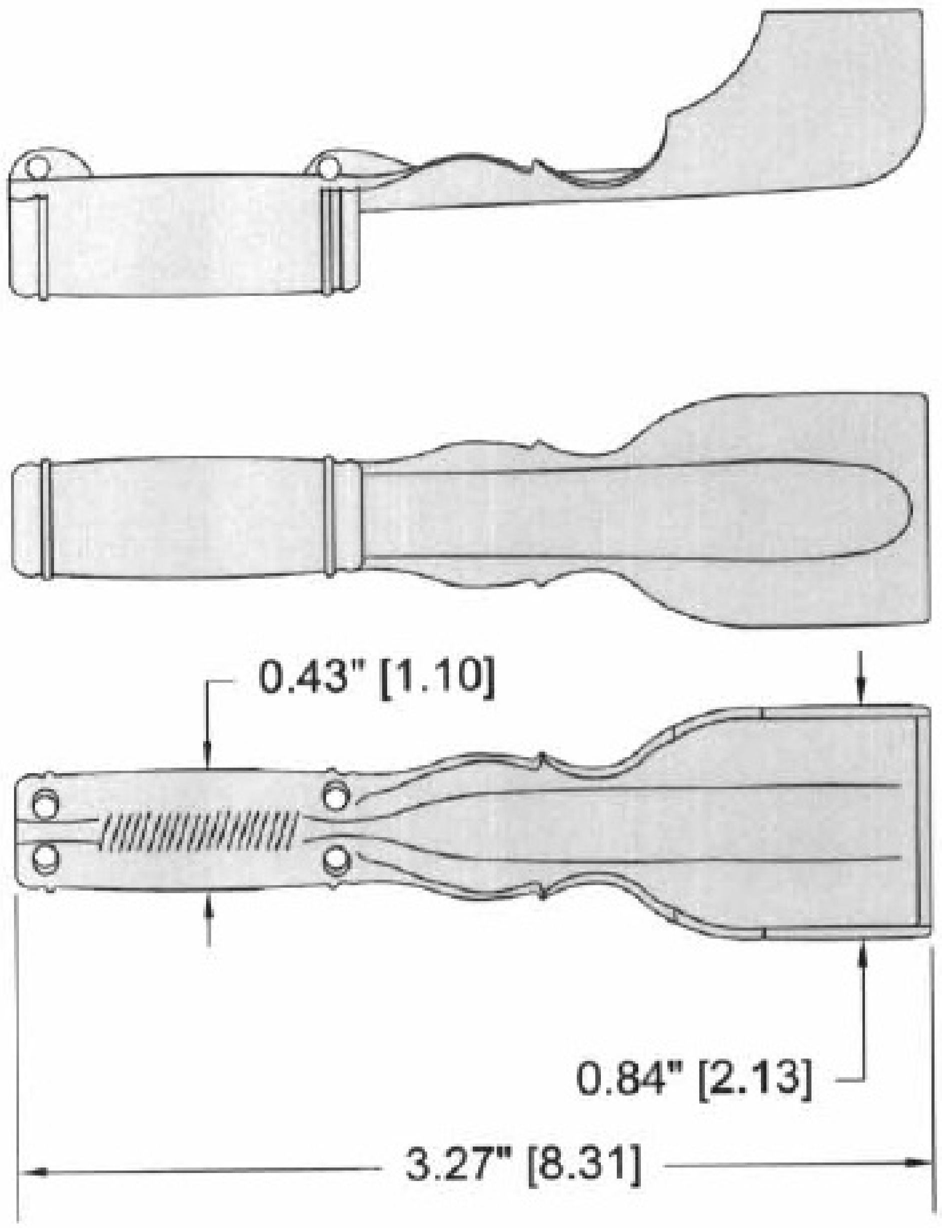
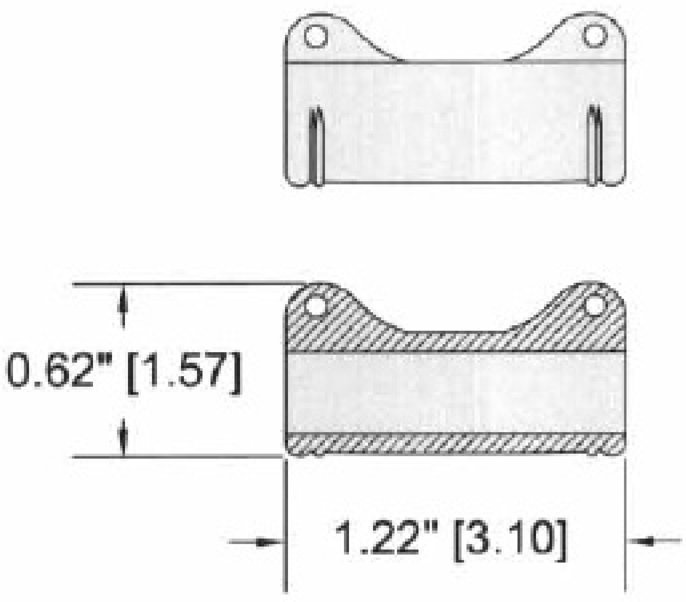
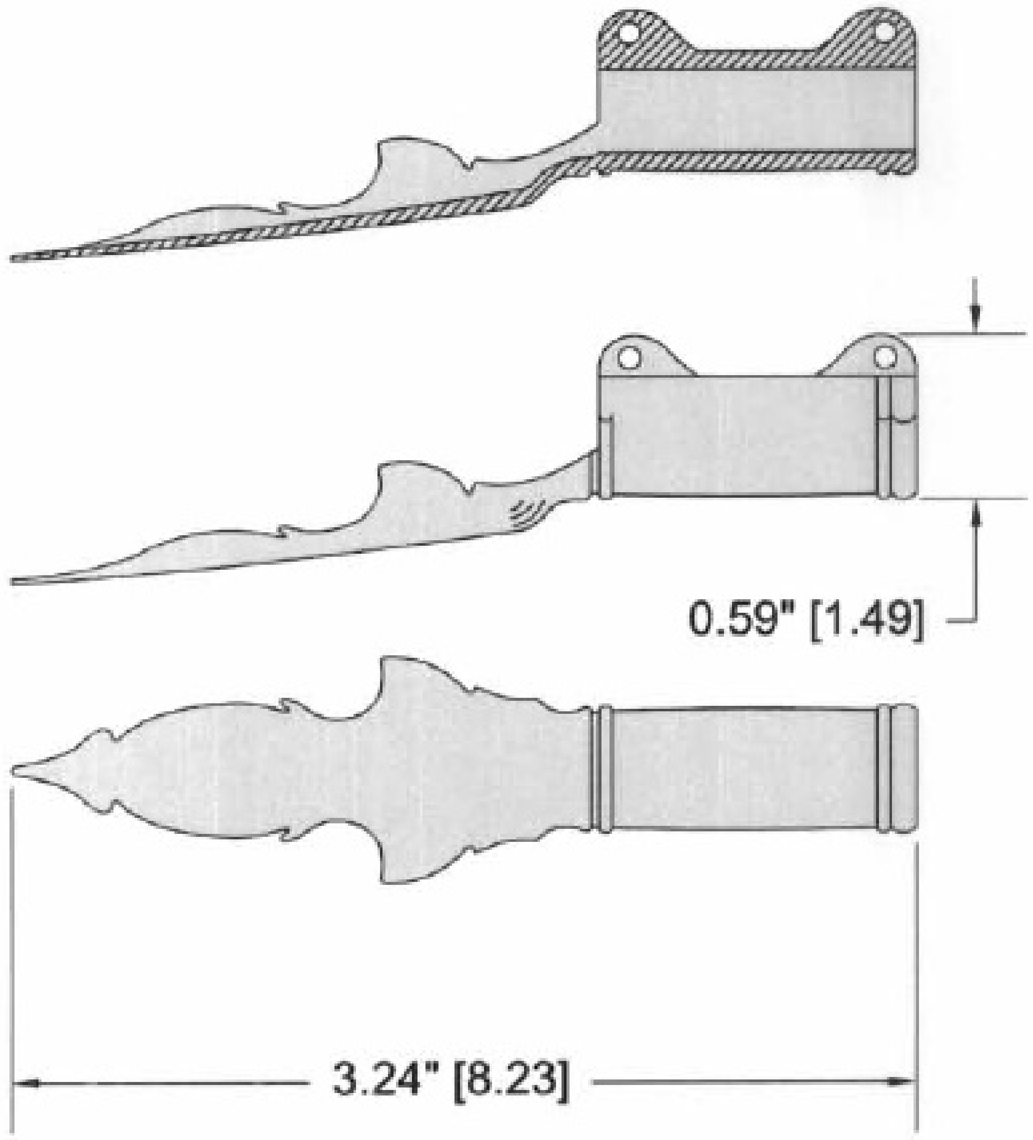


photo courtesy of
Dr. R Beeman

Peter Nolan's
Girandoni

Ramrod Loops





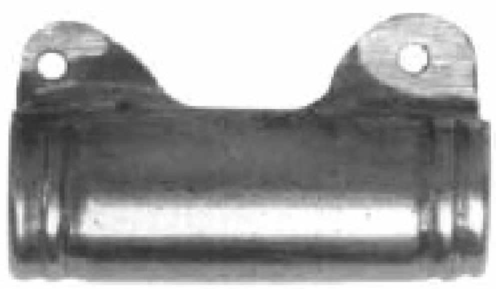
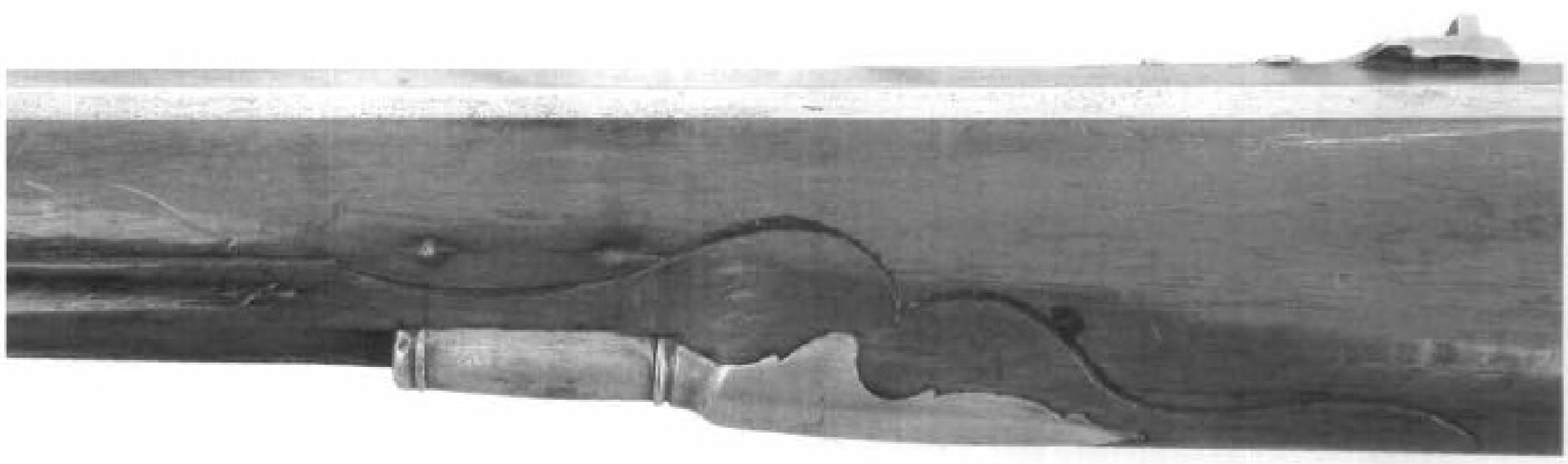
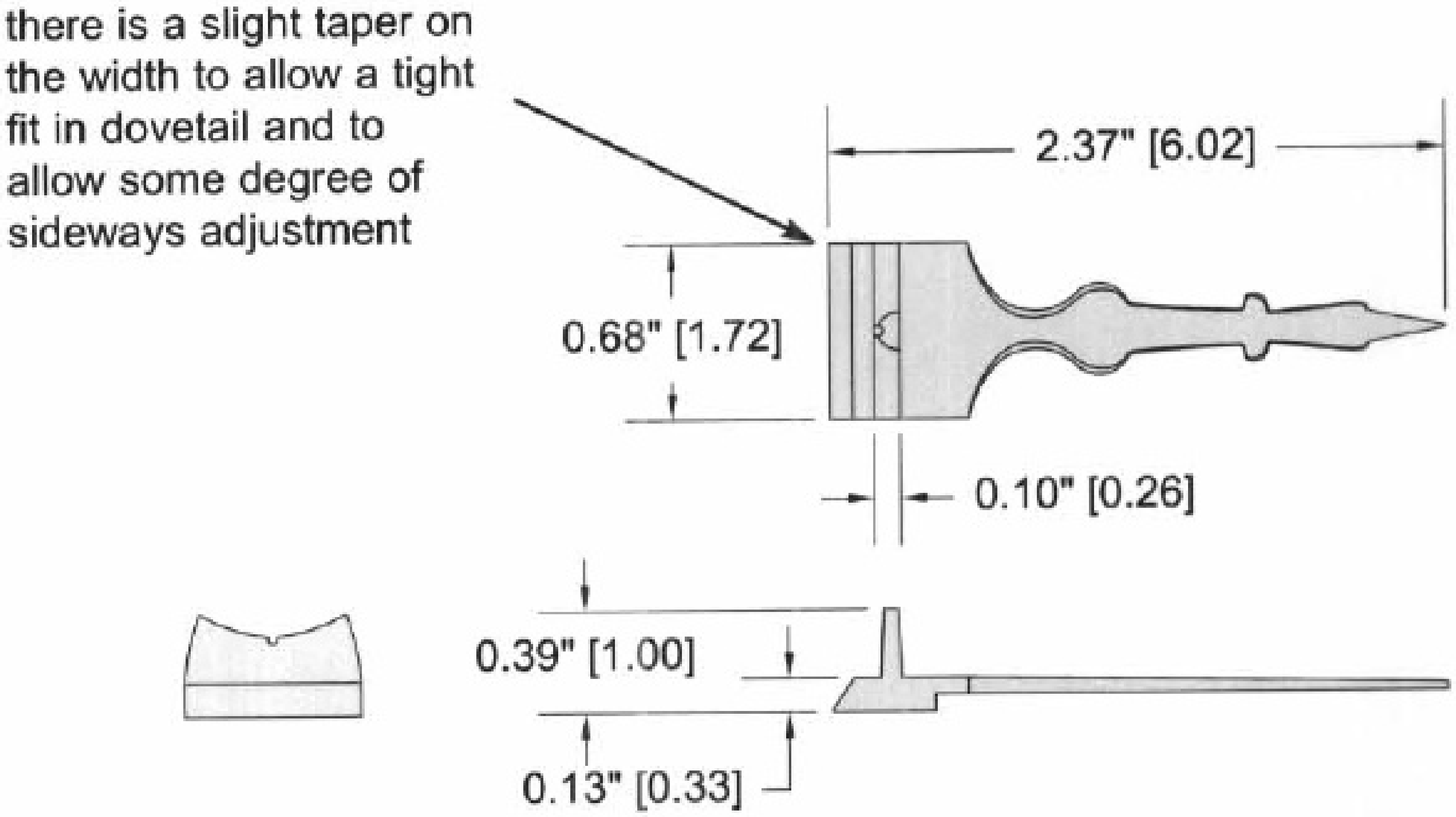
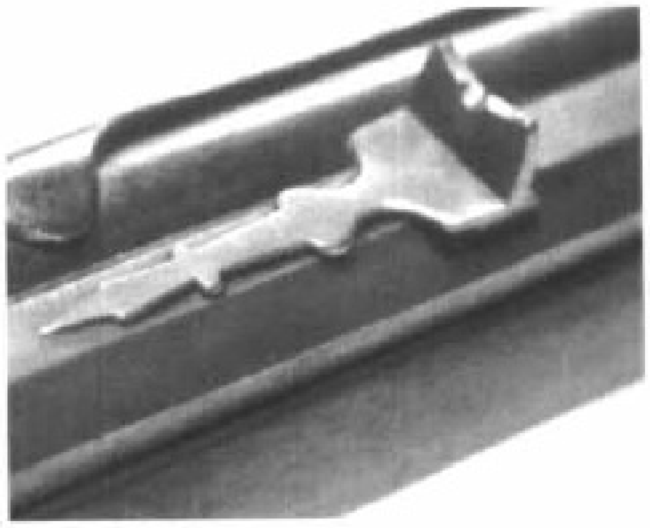


photo courtesy of
Dr. R Beeman



Rear Sight





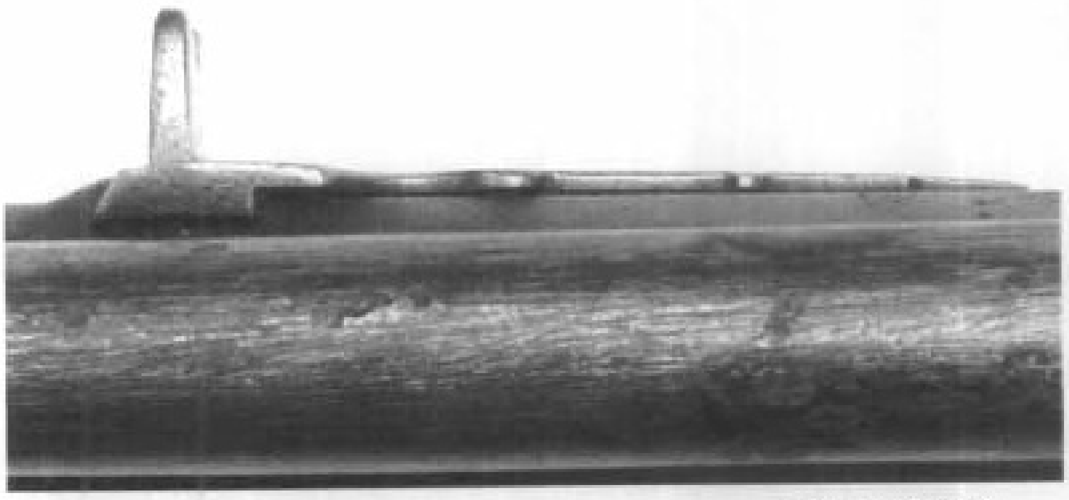


photo courtesy of
Dr. R Beeman

The rear sight had no elevation adjustment, possibly due to the steep trajectory of the ball as the pressure dropped. It would have been set for the mid range position, and other ranges accomodated by elevating or lowering the front sight in the rear notch.

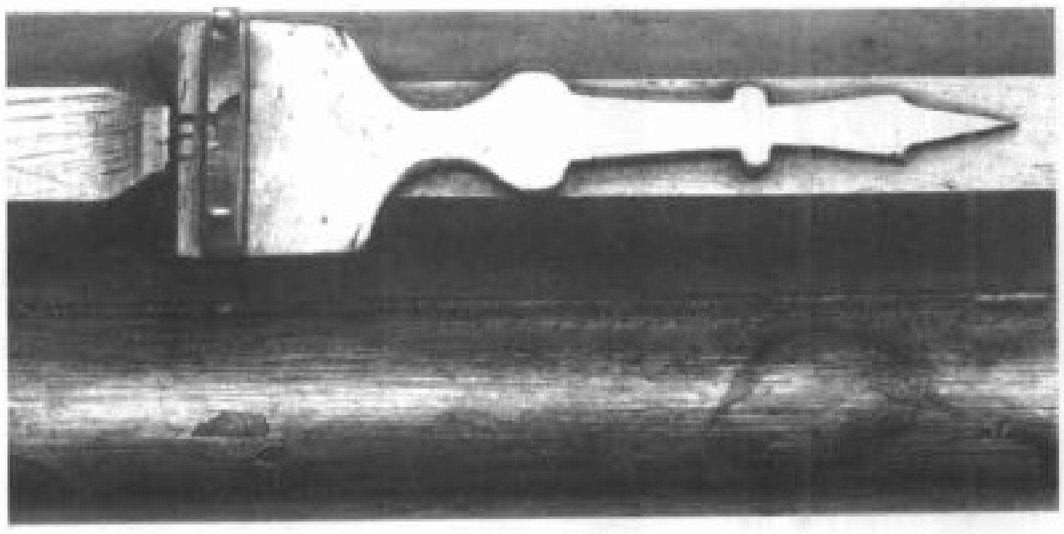
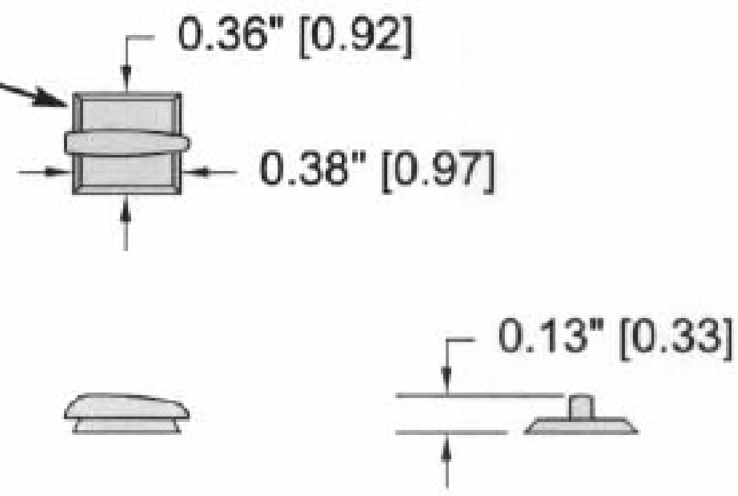


photo courtesy
Dr. R Beeman

Front Sight

there is a slight taper on the width to allow a tight fit in the dovetail and to allow some degree of sideways adjustment.



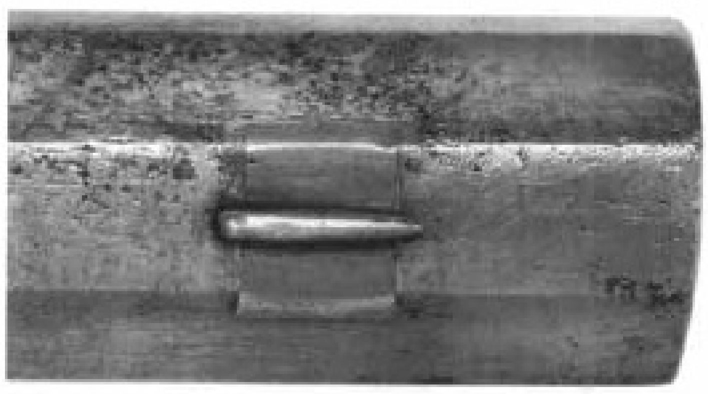


photo courtesy of
Dr. R Beeman

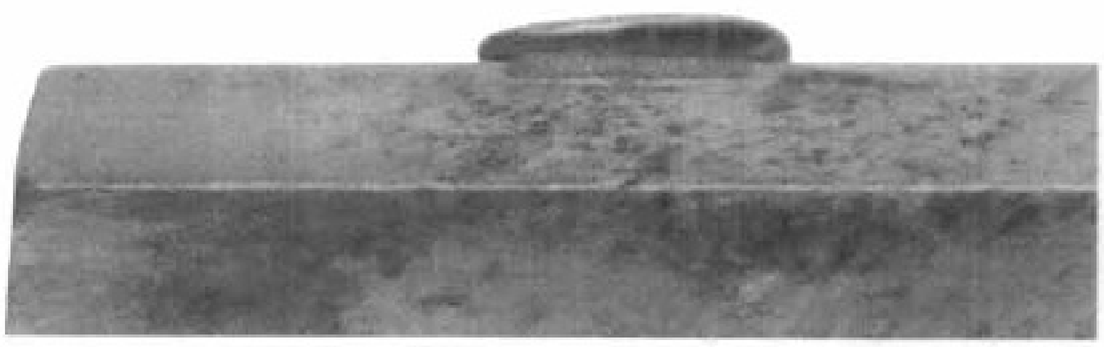


photo courtesy of
Dr. R Beeman

Wooden Stock, (walnut)

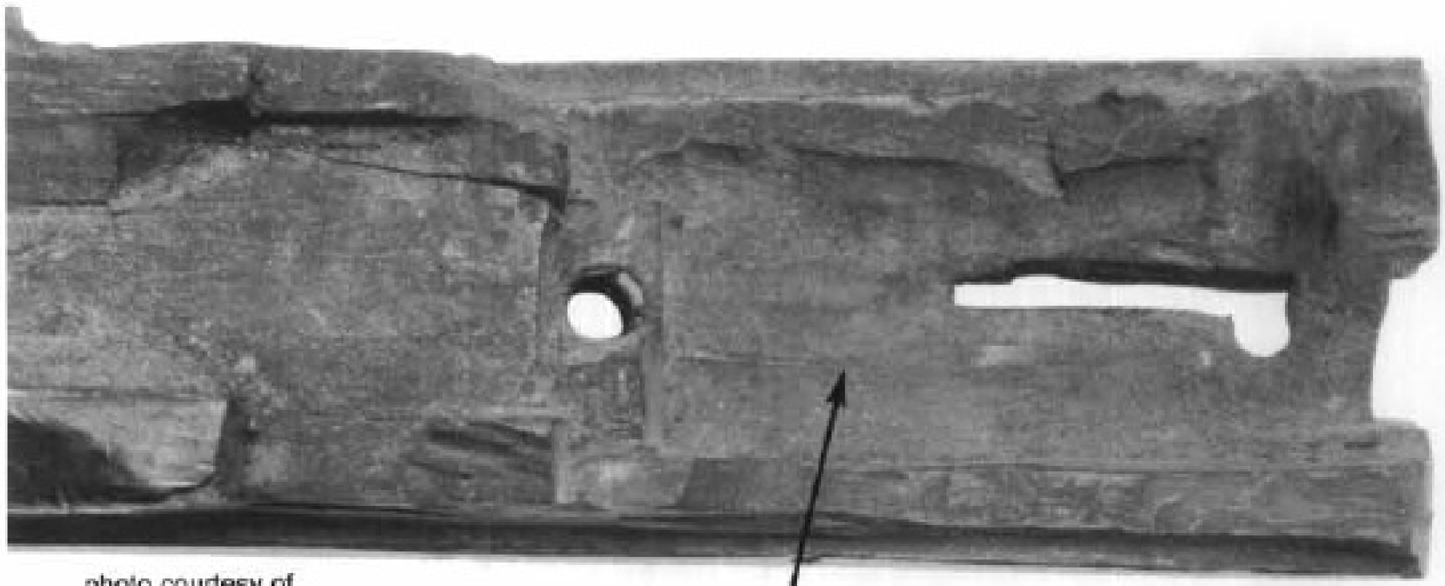


photo courtesy of
Dr. R Beeman

stock inlet to take the receiver and lock components.

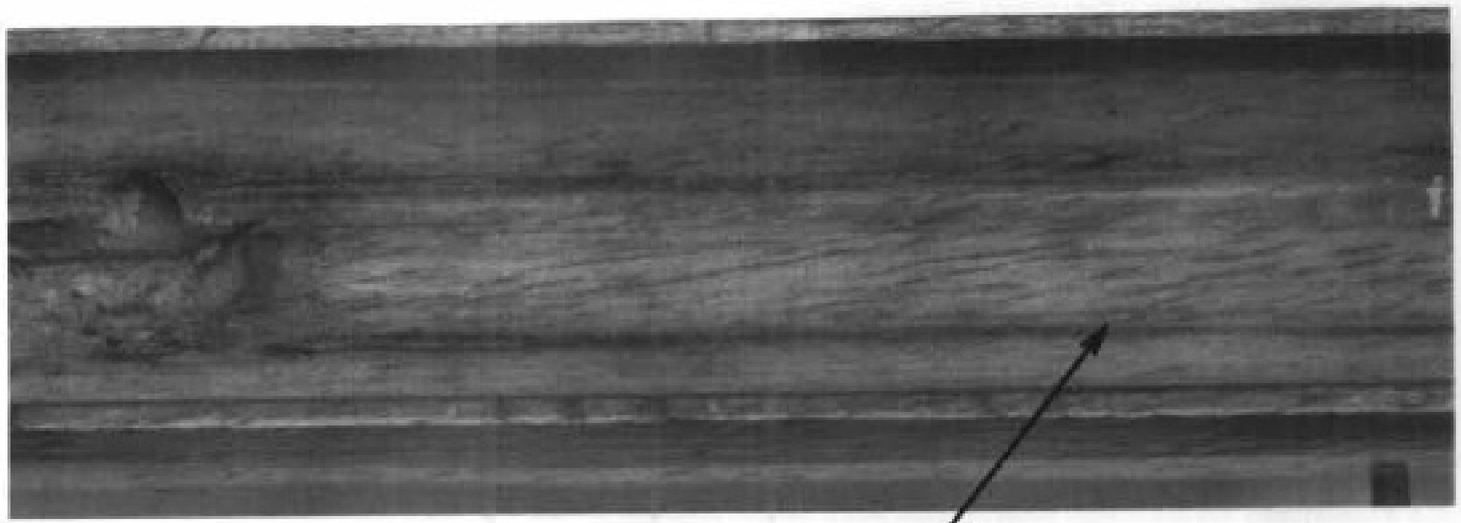


photo courtesy of
Dr. R Beeman

recess to take the barrel

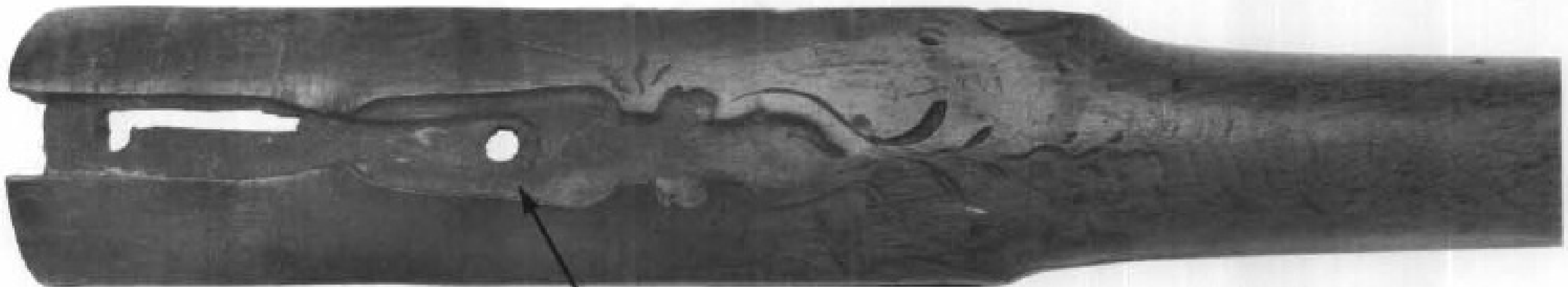
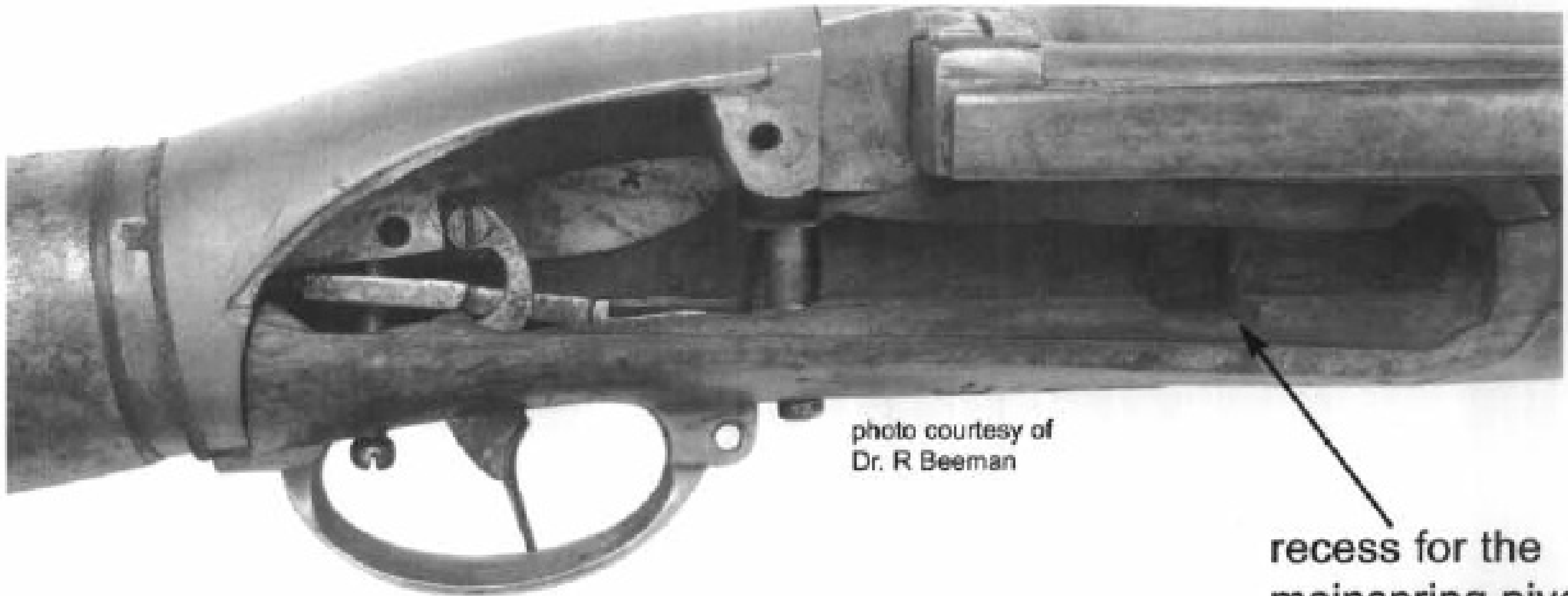
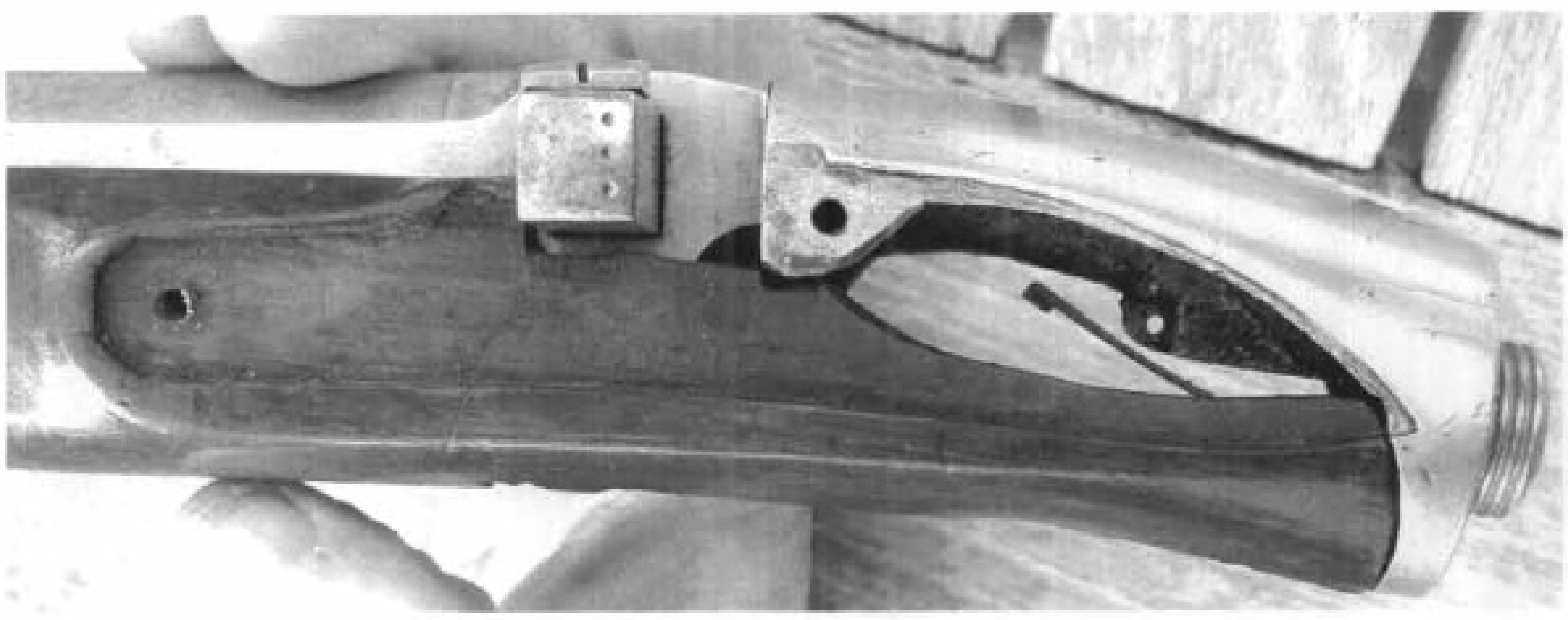


photo courtesy of
Dr. R Beeman

inletting for the cover plate and trigger guard



right view of Dr. R Beeman's Girandoni
showing the inletting for the lockplate



left view of Peter
Nolan's Girandoni
showing the inletting
for the brass cover
plate

Reservoir

The manufacture of the reservoir in the quantity and consistent quality required by Girandoni, was clearly one of the most difficult processes involved in the manufacture of the air rifle.

Any problems highlighted in official correspondence on the air rifle, generally revolve around delays in manufacture of the reservoir.

In fact this was one of the major problems, highlighted in Girandoni's discussion with the Emperor, the main difficulty being the quality of sheet iron that was available to Girandoni.

photo courtesy of Dr. R Beeman

Clearly the technology of the period struggled to provide sheet iron of the consistent quality required for reservoir manufacture.
The reservoir was comprised of a number of components, in the shape of a main body resembling a tapering cylinder, to which a hemispherical base was attached, along with a threaded insert for the valve, and the valve assembly.

Any problem of quality of material in individual components, spelt disaster for the final assembly.

The components were assembled into a complete reservoir, using the standard techniques of riveting and brazing available at this period.

Following assembly, the reservoir would have then been pressure tested.

There is no doubt this particular operation was one of the most difficult tasks carried out by Girandoni's workforce, reflected by the high failure rate of reservoirs on test.

The situation was not made any easier by the lack of means of measuring pressure, except the empirical one of counting pump strokes.

This is reflected in the machine pump used to test reservoirs, to which a mechanical counter was fitted, ensuring a constant number of pre-determined pump strokes were applied to all reservoirs under test.

Unfortunately, problems with material would only become apparent at this stage, with the consequent loss of considerable manufacturing effort resulting from any failure under pressure.

With a failure rate of 30%, it is not surprising that reservoir production was a bottleneck, and a constant cause of official concern.

Threaded insert, note there are only three threads in the reservoir insert

photo courtesy of
Dr. R Beeman

Reproduction reservoir to illustrate the process, this was rolled from steel sheet riveted then brazed along the seam. The tapered threaded insert was inserted from the rear then brazed into position.

The hemispherical end cap was formed from steel sheet hammered into shape then inserted into the end of the cone.

The end of the cone was then hammered down over the hemisphere then finally brazed into place.

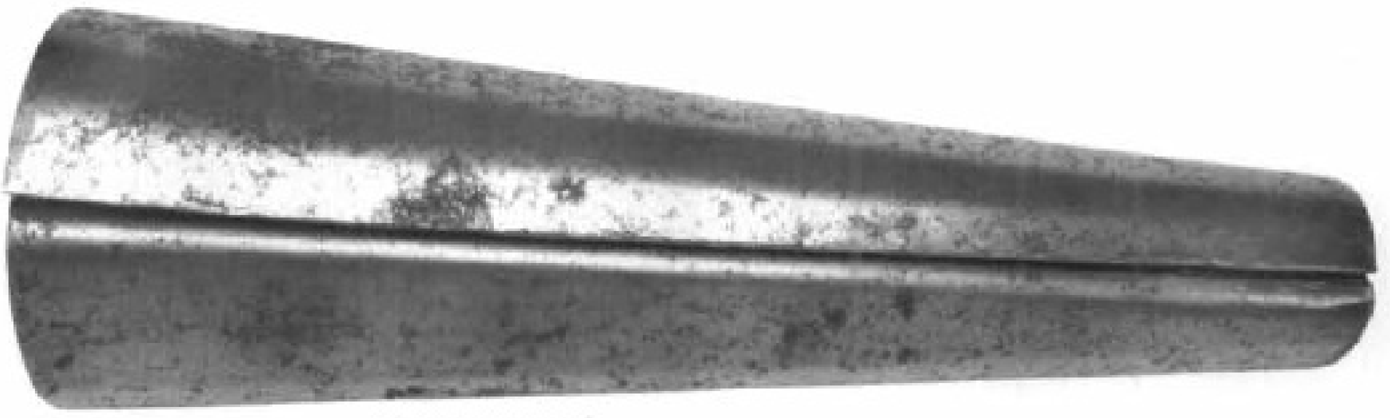
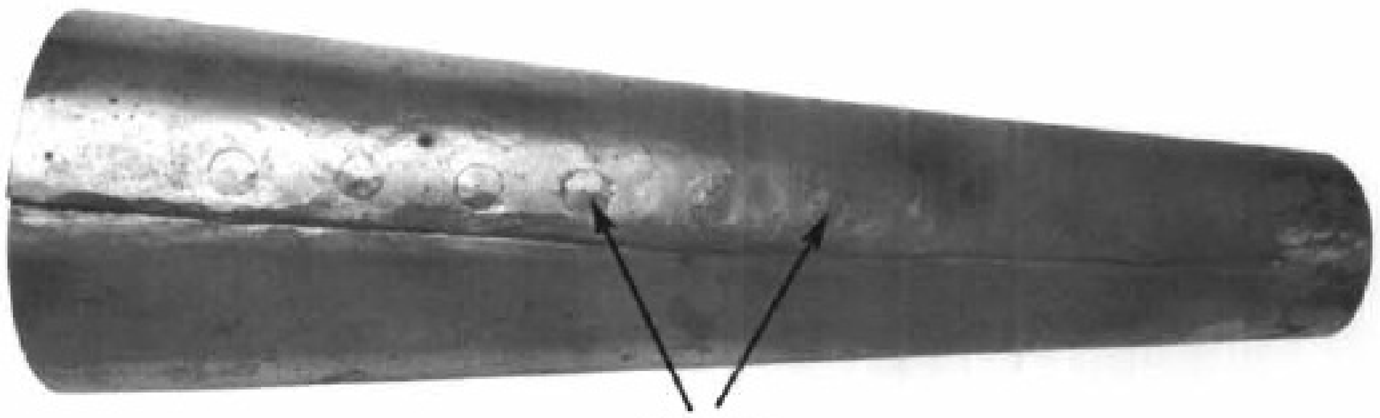


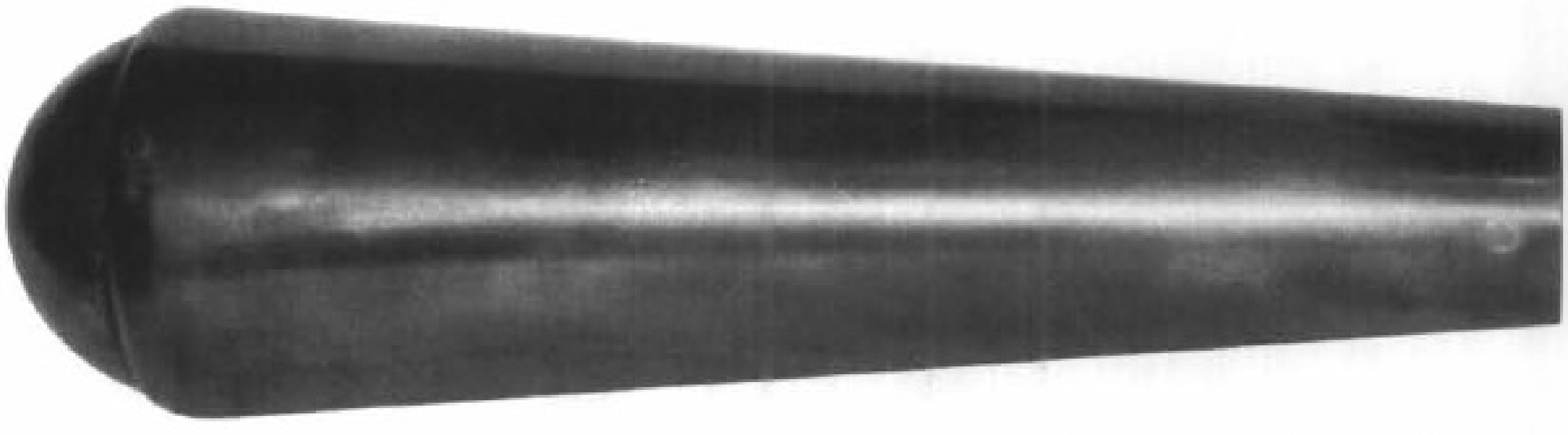
photo courtesy of
Dr. R Beeman

lap joint bent to give a flush surface when riveted together

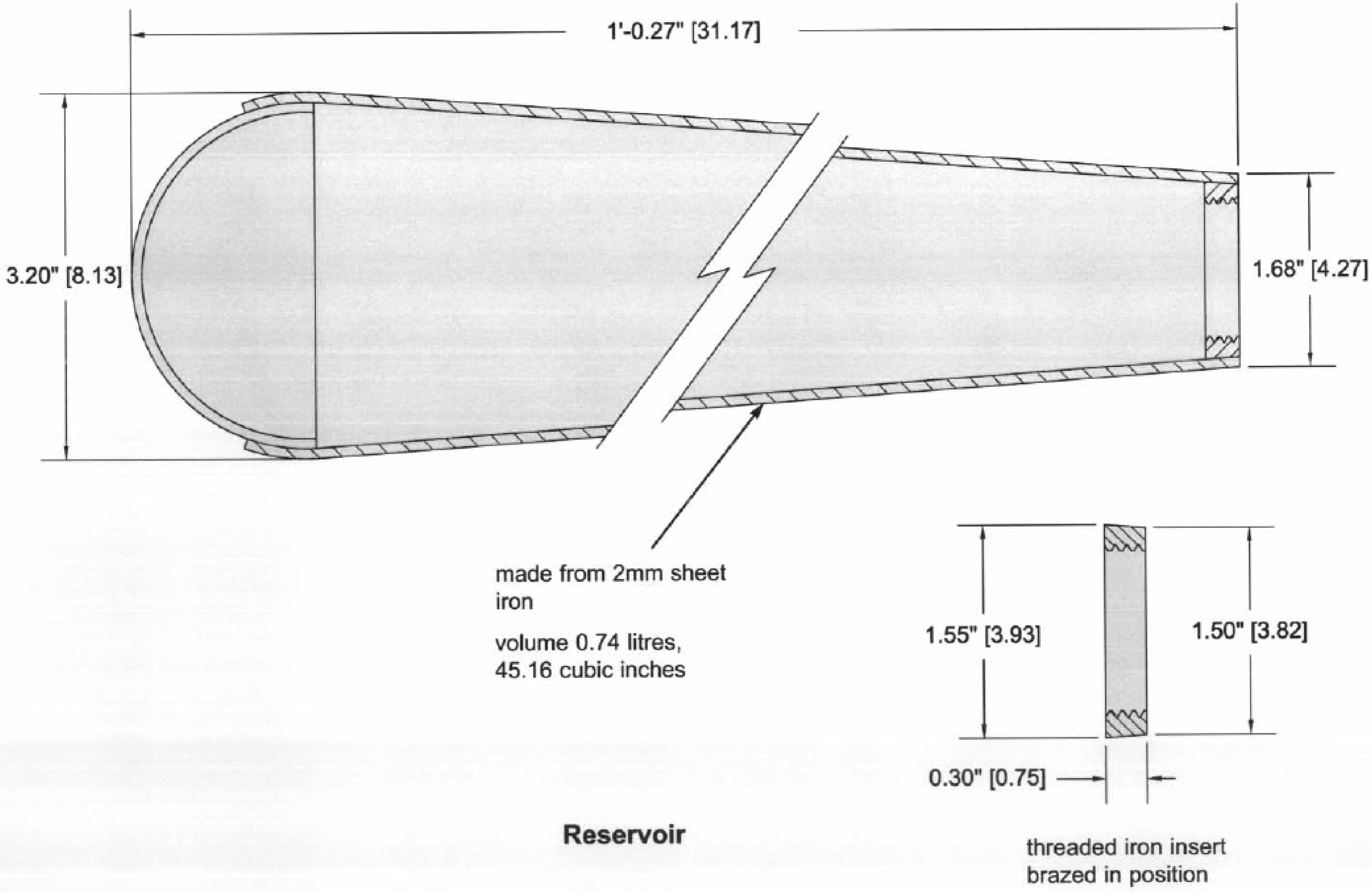


Rivets

photo courtesy of
Dr. R Beeman



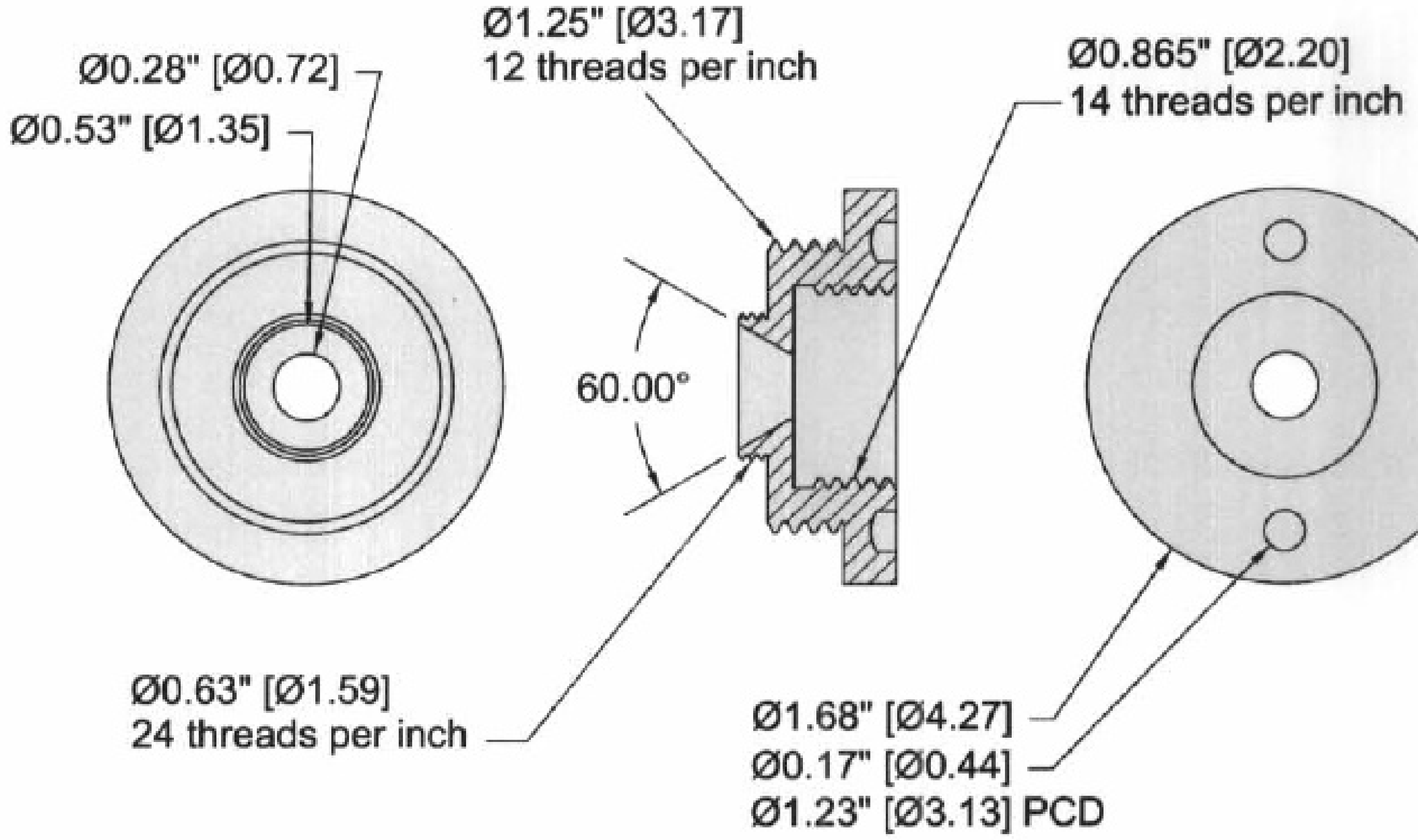
Completed reservoir



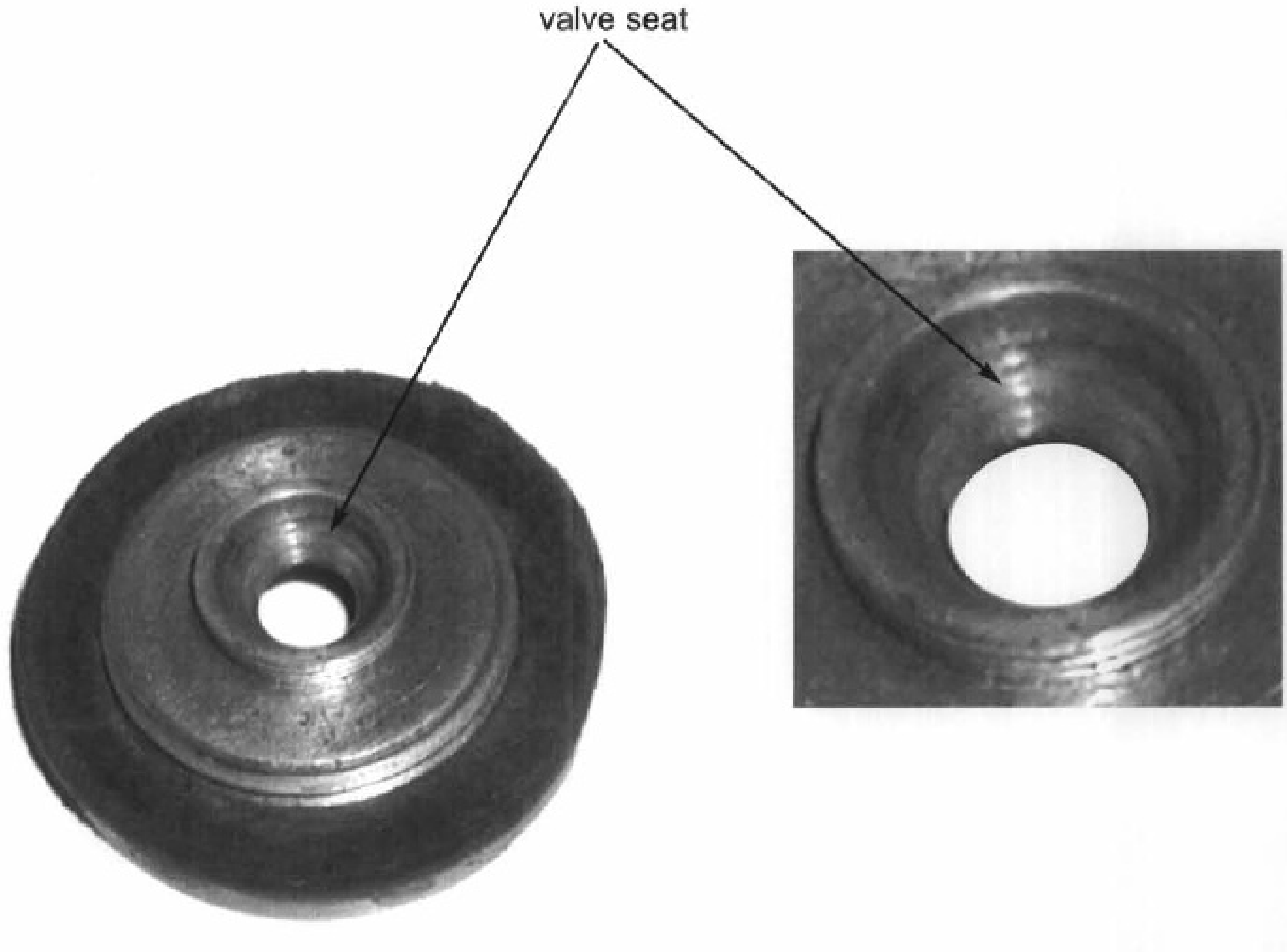
1'-0.27" [31.17]
3.20" [8.13]
1.68" [4.27]
made from 2mm sheet iron
volume 0.74 litres, 45.16 cubic inches
1.55" [3.93]
1.50" [3.82]
0.30" [0.75]
threaded iron insert brazed in position

Reservoir

Valve Body



brass



Valve Body

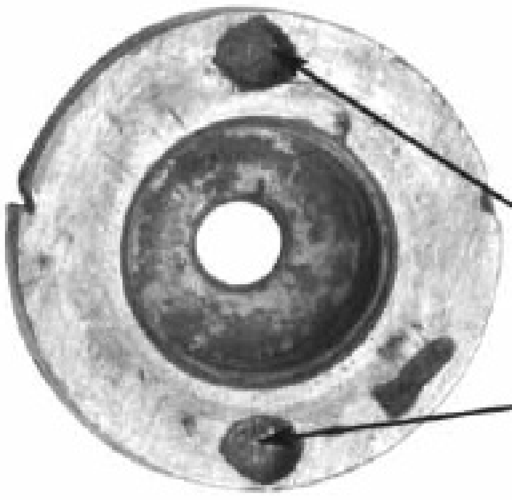


photo courtesy of
Dr. R Beeman

blind holes to allow the use of the peg tool to remove and replace the valve assembly in the reservoir

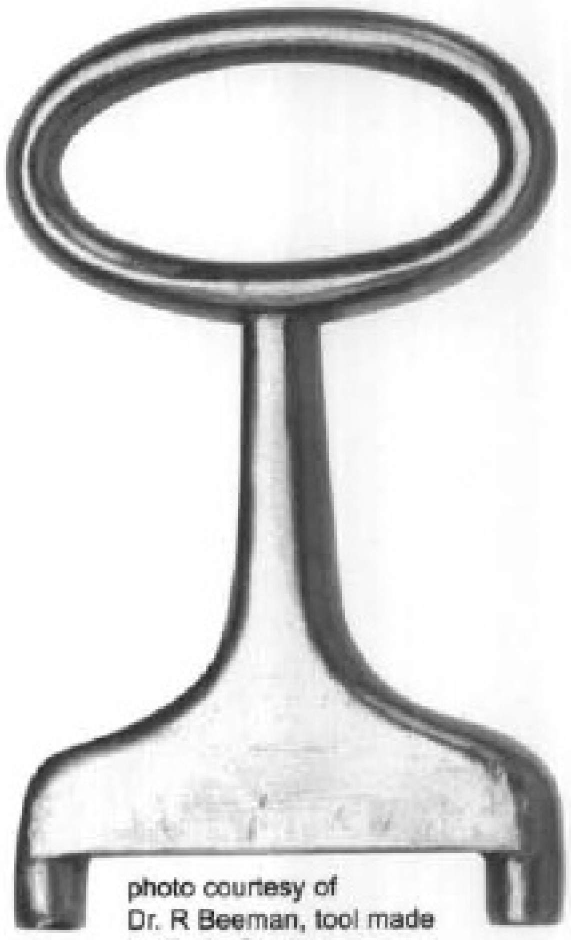


photo courtesy of
Dr. R Beeman, tool made
by Ernie Cowen

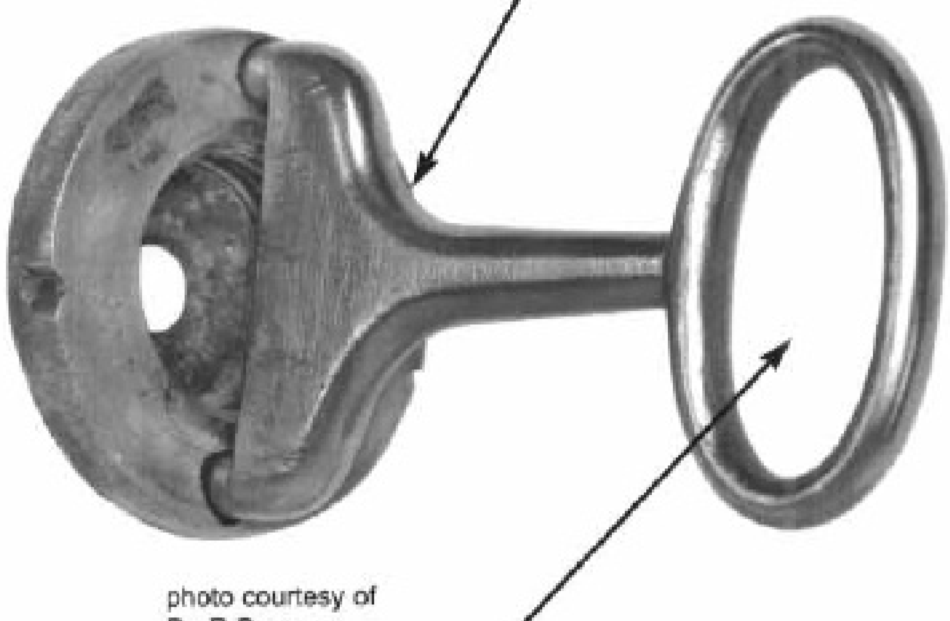
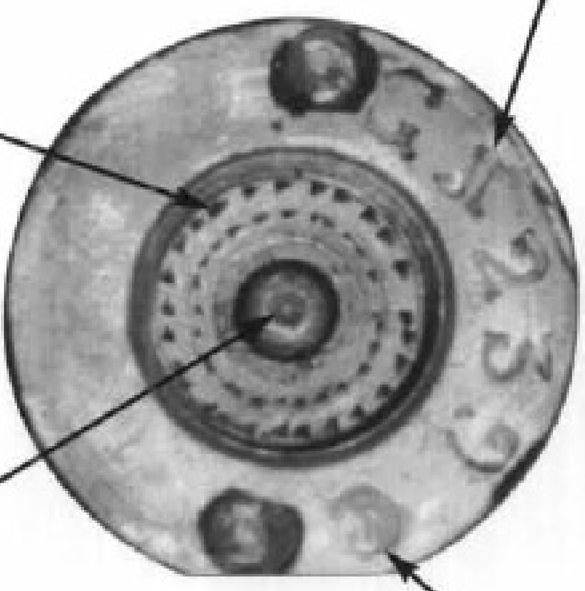


photo courtesy of
Dr. R Beeman

a bar could be put through the ring for extra leverage when unscrewing the valve body from the reservoir

note the sequential serial number marked on the valve body

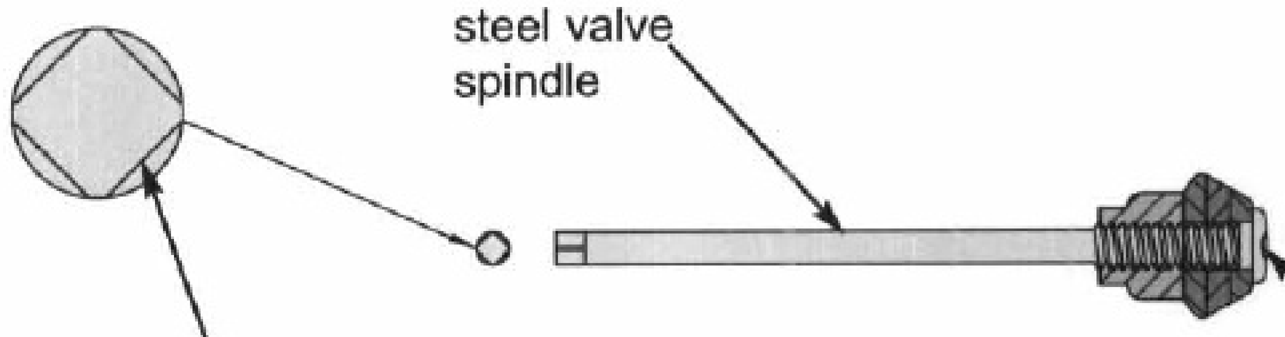
triangular cuts give a key for gluing the leather sealing washer into position



dimple cut in the valve head to provide guidance from the striker pin
(from the Girandoni rifle in the Tower Armouries collection)

Imperial Eagle

Valve



There is a square cut onto the end of the valve spindle to allow the brass collar to be tightened against the leather washers pulling them up tight.

Recess to take the end of the latch striker, this helps to guide the valve at the receiver end reducing the side thrust on the valve spindle.

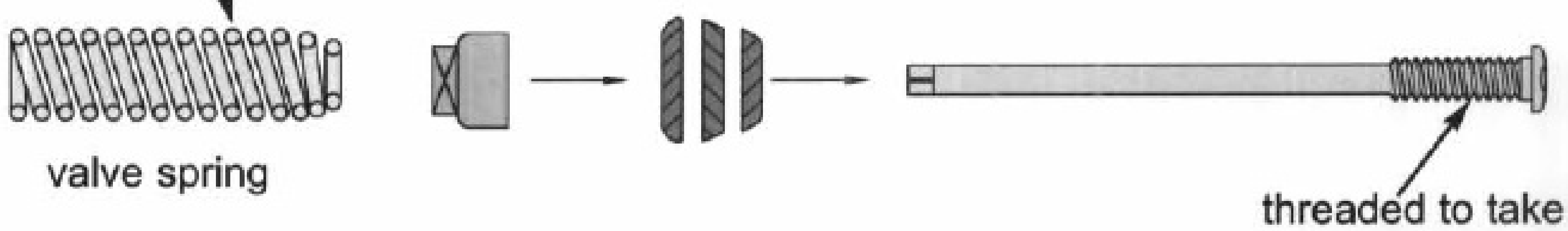
This was ommited on the later air cane valves which had a much thicker valve spindle.

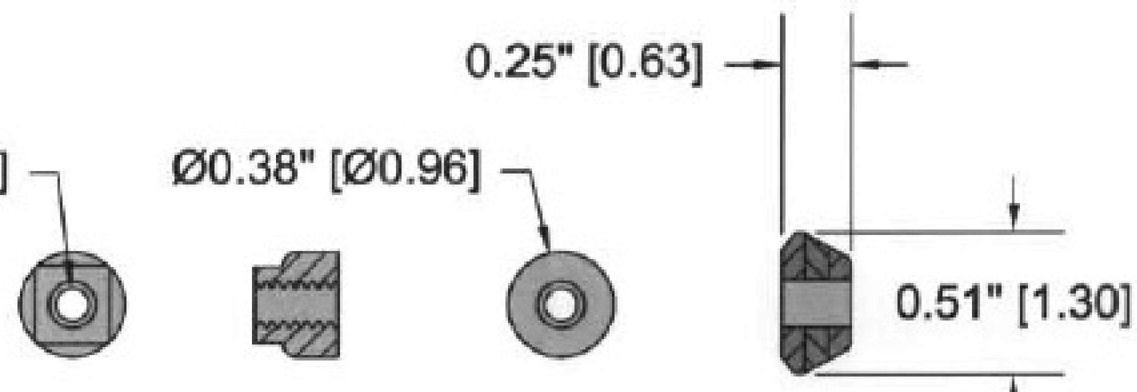
valve spring made of hard drawn brass wire

photo of spring courtesy of Dr. R Beeman

valve head made of hardened leather washers

0.62 diameter
0.375 OD





valve lift 0.289" (7.34mm)

The power of an air rifle is directly related to the hardness of the valve material. Hard materials used for valve seals have been shown to give greater power than softer more resilient materials.

In fact a hard valve is essential, both to the correct functioning of the rifle and in achieving the considerable operating reservoir pressure required.

Therefore the material used has to be a balance between being soft enough to give a good seal and hard enough to give a fast valve opening.

Leather was the most common choice for air rifle valves, however experiments have shown that untreated leather does not give good results and quickly deteriorates rendering the valve useless.

Some examples of original leather Girandoni valves examined by the authors were of a hardness that could not be explained simply by the aging process, and it was apparent Girandoni must have used some method of hardening them.

A similar conclusion with regard to air rifle valves, was arrived at by the eminent authority Keith Neal in his work "Great British Gunmakers 1740 to 1790."

He describes his efforts to put into working order an air rifle made by F.J.Bosler of Darmstadt (working in 1750).

The original valve head is described as being made of hardened leather, carefully ground into a cup seating rather like the half of a round bullet mould.

He further notes attempts to replace this with ordinary leather were a complete failure.
Hardening leather has been practiced since Saxon times by a process which is now called Cuir Bouilli. (boiled leather)
Girandoni would have been very aware of this process, as it was in universal use during this period for everthing from leather drinking vessels, to lightweight body armour.

There is evidence that the process was accomplished by moulding wet vegetable tanned leather, the leather can be formed into shape and it will retain its shape when dried.

Another method that produces an extremely hard and rigid shape, is to dip the leather into boiling water for several minutes.
This causes a partial melting of the tannin aggregates in the leather that causes them to flow and redistribute themselves throughout the fibres of the leather.

This produces a composite like material similar to glass fibre.

Further experiments with different types of leather using dry heat produced a plastic like material that was tough enough to make a valve head from.

This produced a valve that gave a good seal and was hard enough to machine.

There is also a further problem in using untreated leather, as air is pumped into the reservoir the pressure difference deforms the leather valve head inside the reservoir, this has to be pushed out of the way before more air can get past into the reservoir.

This gives a smaller and smaller gap, as the air pressure in the reservoir increases.

Pumping becomes increasingly difficult and it is nearly impossible to reach pressures much over 800lbs per sq.inch.

This is clearly well below the pressure the pump was designed to reach, you do not make a pump capable of 1300-1400lbs per sq inch, albeit at a large number of pump strokes if the valve prevents achieving over 800lbs per sq.inch.

It would in fact be better accomplished with a larger diameter pump that could reach the 800lbs per sq.inch with a much reduced number of strokes, making it easier to pump as well.

Trials were made by the Danes in about 1820 with Danish made copies of the Girandoni system, these gave a muzzle velocity of 330 ft per second, a very much lower velocity than one would expect from even the low pressure reported to have been used (50 atmospheres or 750lbs per sq.inch).

These figures agree very closely with results obtained with a modern reproduction using an unhardened leather valve, about 400 ft per second with a pressure of 800lbs per sq.inch (calibre .464").

Had the secret of the Girandoni valve been lost?

It is interesting to note that with the later highly developed air canes much harder horn was used for the valve head, even with all the problems of distortion that using this material entails.

The sharp valve opening that the harder horn gives produces much greater power and it is also easier to pump air into the reservoir.

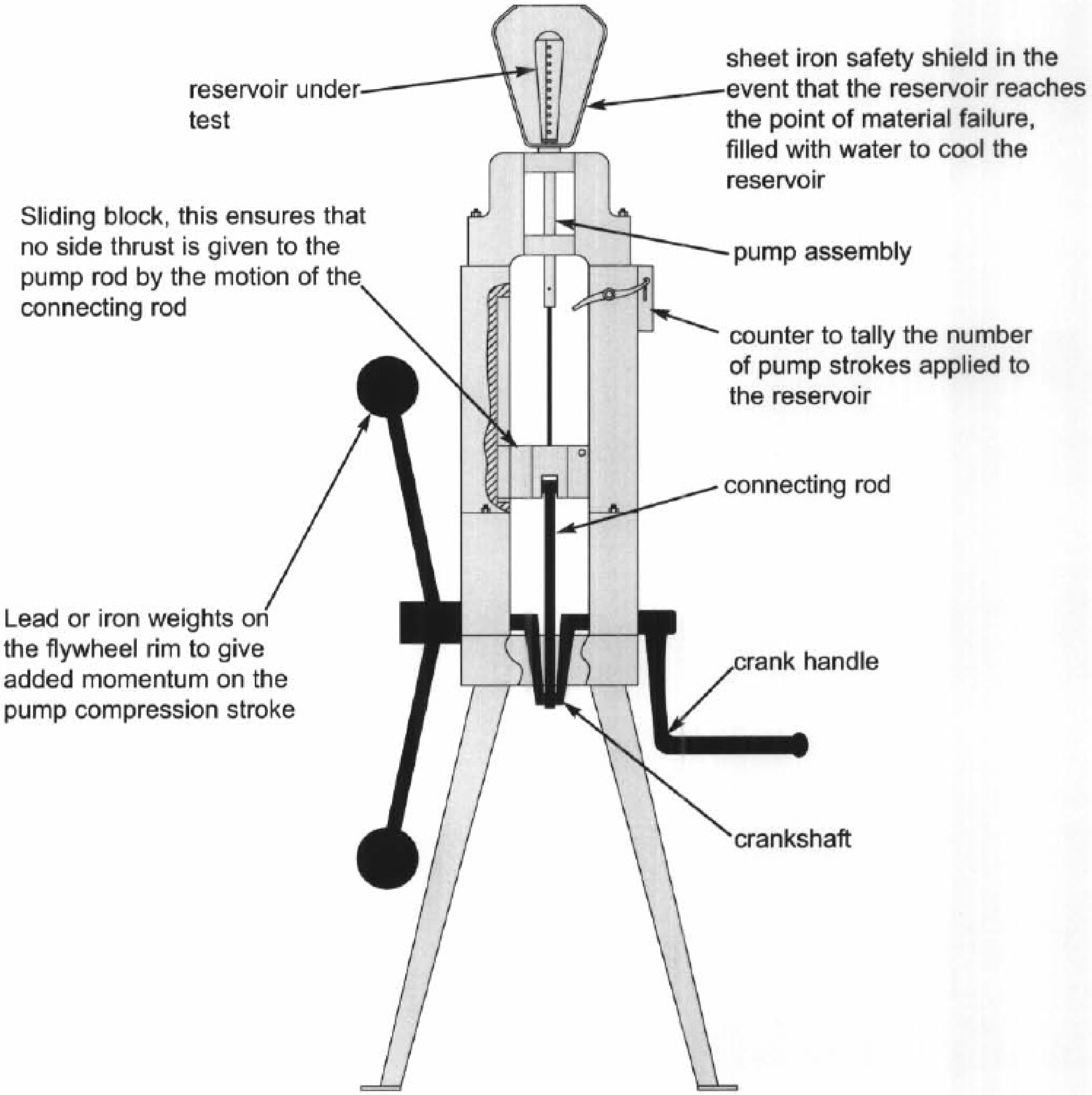
There is the possibility that the valve on the Girandoni reservoir could have been hardened by the heat generated during the process of testing the reservoirs.

The pumping machine used by Girandoni to pressure test the reservoirs, would have generated considerable heat.

This could have produced similar effects to the following described by Reilly, Junr. in his treatise "Air Guns and other Air Weapons" 1850, London when using his machine pump-for testing air cane reservoirs.

"The pumping machine, when turned very rapidly, often produces singular effects which cannot arise from friction alone."

"I have seen the metal reduced to nearly a blue colour smoking with the heat, the horn part of the valve parched up, and have often been inclined to credit the saying of the workmen that the air catches fire."



We have no surviving machine pump nor indeed any description of the one that Girandoni devised for pumping up his reservoirs but it may have been of the general arrangement shown above.

Even with some form of water cooling the air heated by compression acts directly on the valve material and would have limited how fast the machine could have been operated.

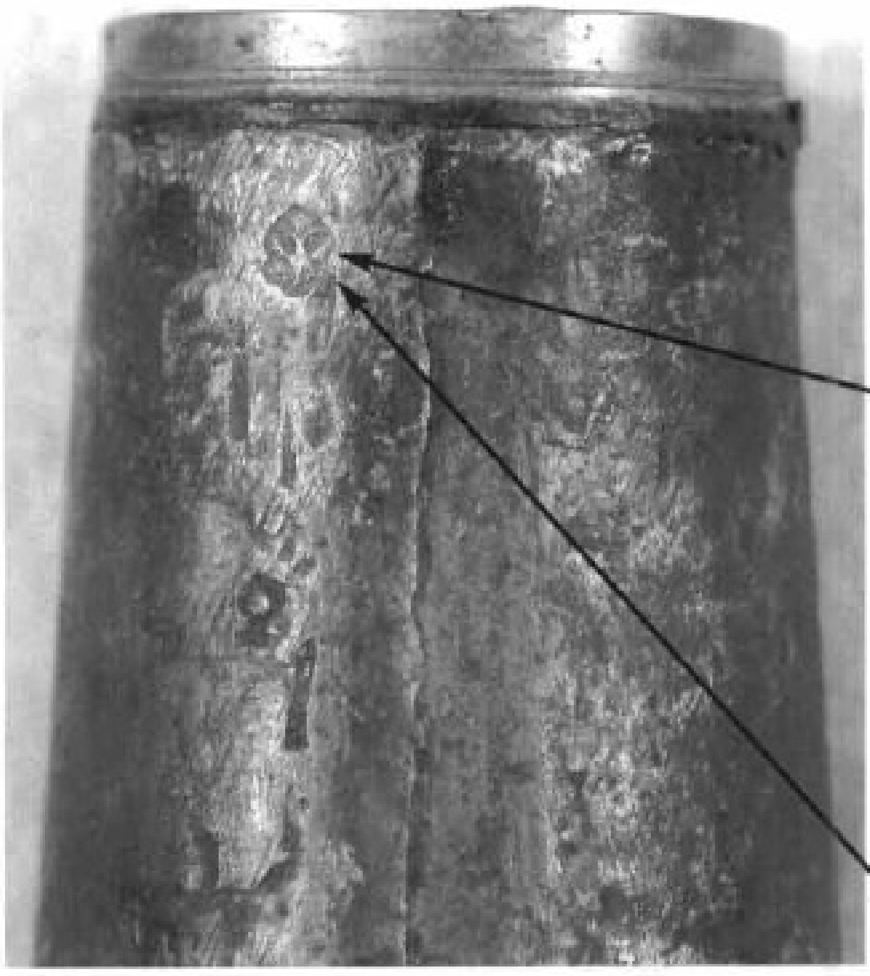
For reasons of safety, modern testing of pressure vessels is accomplished by using a compressed liquid (usually oil or water).
Liquids cannot be compressed and therefore store no energy.
The only energy stored is due to the deforming of the material from which the vessel is made.

If an oil or water filled reservoir should split while under pressure, no great harm ensues other than a mess to clear up and a reservoir to re-make.
In comparison, if an air filled reservoir gives way all the energy stored in compressing the air will be suddenly and explosively released.
Several instances are recorded of globe reservoirs exploding while they were being pumped, with disastrous results to the person doing the pumping and any by-standers.

One of the most quoted examples of this occurrence, is related in the "The Modern Shooter" by Captain Lacy 1841.
He describes how although a keen exponent of the air rifle, the death of a servant killed by over pumping a ball reservoir, persuaded him to abandon them.

This situation was a result of a lack of means of measuring pressure, and explains why it was so important for Girandoni to develop a repeatable method of pressure testing.
The machine pump developed by Girandoni allowed a constant pressure to be applied to each reservoir, giving confidence in the acceptance by authority for safe sevice use.

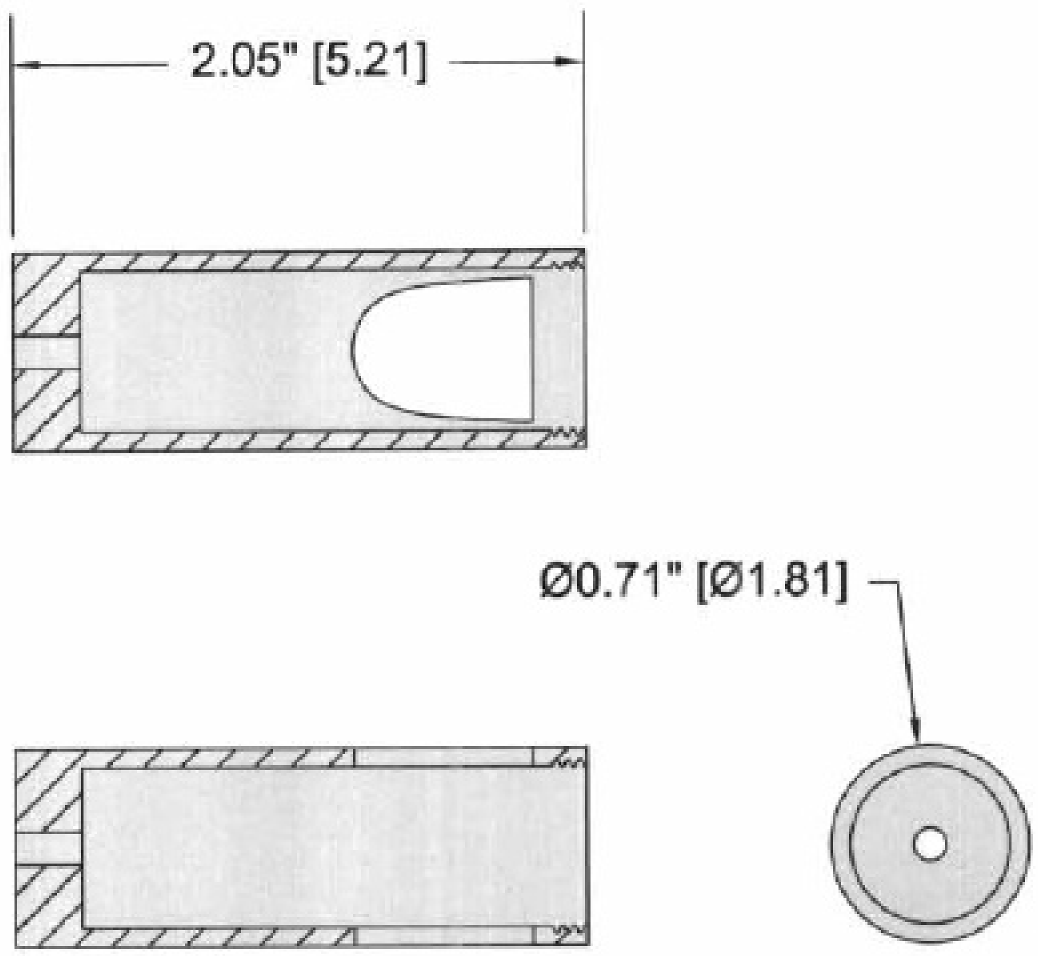
Many of the reservoir assemblies were stamped with a sequential number on the valve body, either alone or with a "G" and the "Imperial Eagle." This was most likely applied following successful pressure testing, confirming proofing or acceptance for service use.



Mark stamped onto the reservoir from what is believed to be a military pattern rifle. (thus far we have only one example of a mark stamped on a reservoir). Most of the reservoirs that we have been able to examine have been fitted with a leather cover that could not be easily removed.

photos courtesy of Michael Carrick

Valve Guide

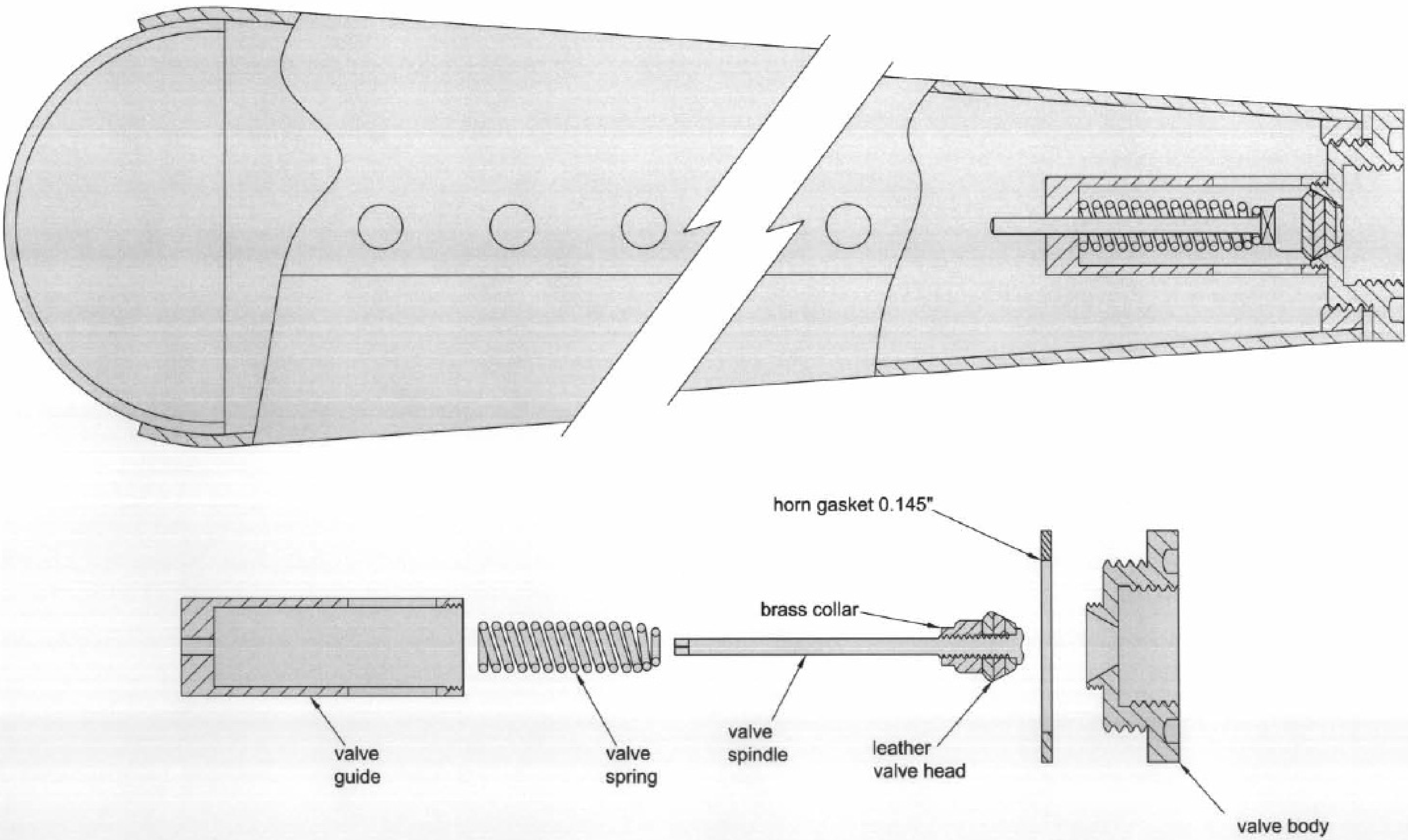


The valve guide has a hole at the end for insertion of the valve spindle this acts as a guide for the valve to move backwards and forwards.

The small depression in the other end of valve locates on the striker so that the valve spindle is guided at both ends.

brass casting

Reservoir Assembly



Reservoir Cover

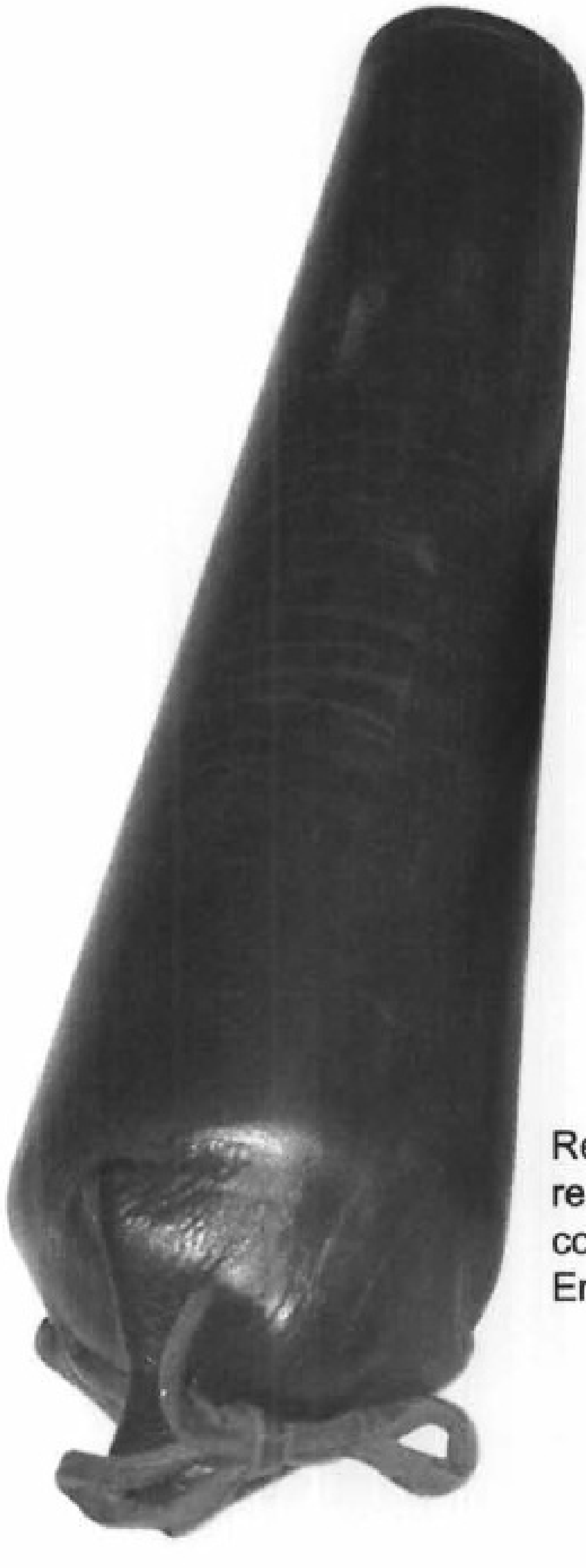
It is thought that this is the original covering used on the reservoir.
The original regulations for use of the rifle state that the reservoir should be immersed in water occasionaly to keep the valve moist.

This would have necessitated a removable cover.

The leather covering shown has holes so that a cord could be used to tie the covering securely over the rear of the receiver to keep it in place.

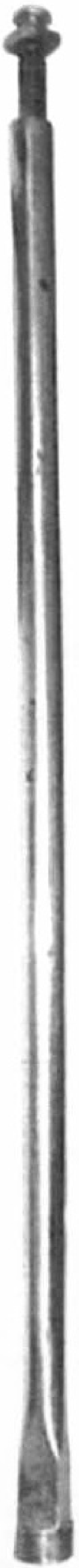
The leather covering has been moulded to the shape of the bottle, but enclosed in such a way that the bottle can be removed by loosening the ties.
It serves to prevent the bottle rusting, but mainly to prevent the soldier from hurting himself in frosty weather.

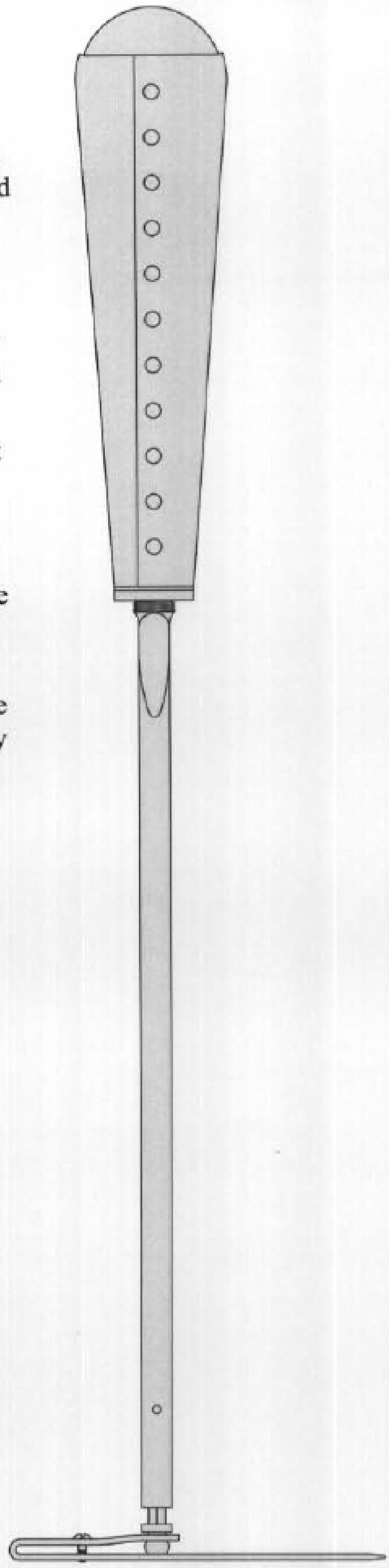
holes for fitting ties



Reproduction reservoir and cover made by Ernie Cowen

Hand Pump





The pump consisted of a tubular body, one end fitted with a male threaded spigot designed to screw into the reservoir and the opposite end with a guide for the pump rod.

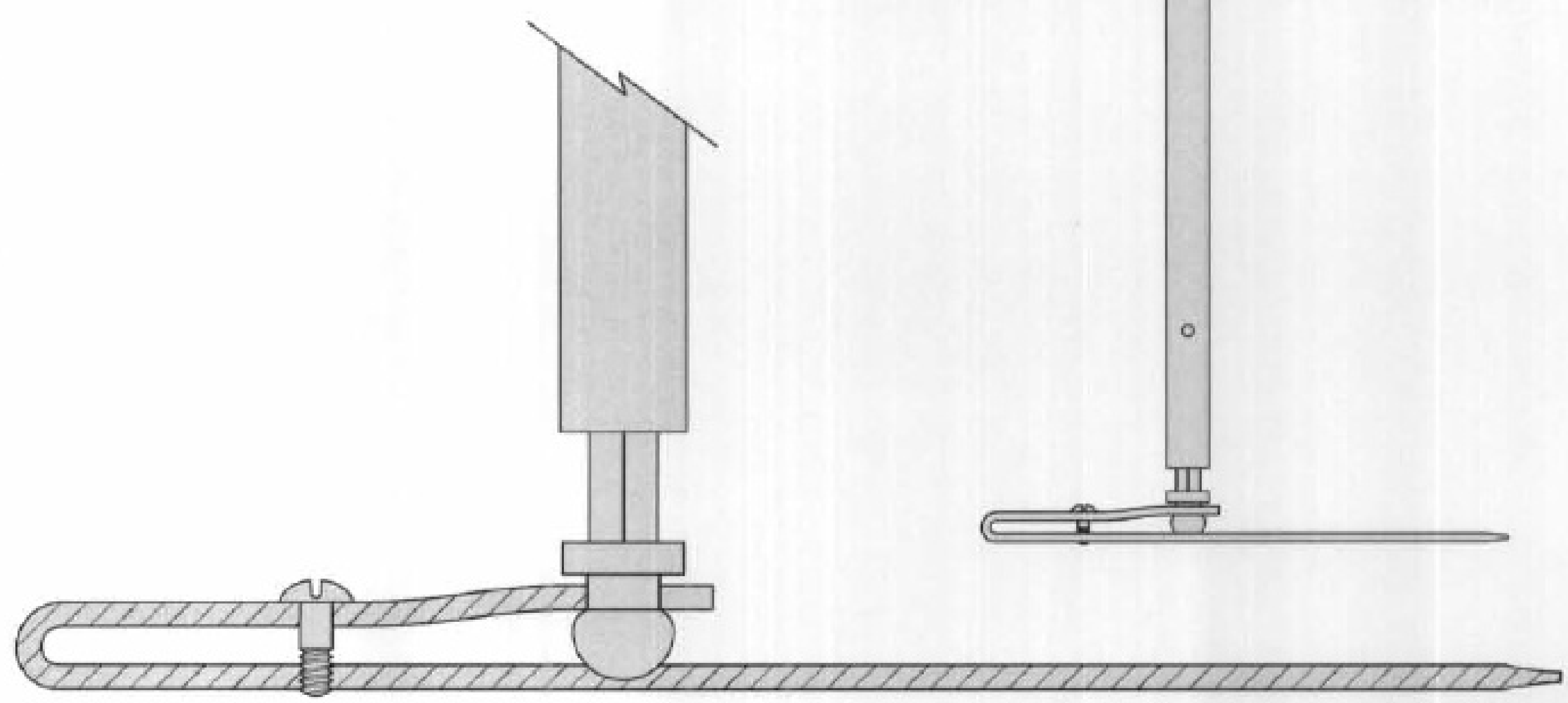
The pump rod was fitted with a plunger that had 7 leather washers fitted between a brass washer at one end and a threaded brass washer at the other and fitted with a lock nut.

The square rod was fitted with a screwed on end to fit into a transverse footplate.

The threaded washer had a square cut into one half so that it could be tightened against the washers to expand them to give a close air tight fit in the pump tube, the lock nut then being tightened.

The reservoir would be attached to the threaded spigot of the pump and the end of the pump rod would be fitted into the footplate.

Then by placing both feet on the footplate whilst holding the reservoir, a steady reciprocating movement of approximately 1500 strokes would pressurise the reservoir to the working pressure.



The Hand Pump

The pump compresses the air which provides the motive power for the rifle and generaly the higher the pressure you pump the reservoir to, the higher the power you can get.

You can only get out what you put in, actually you do not get back as much energy as you put in, heat is produced when you compress the air which is just energy that is wasted as the air cools back down.

There are other losses due to the lost volume produced by the space left between the end of the pump piston and the valve, air is compressed into this space which just expands again as the piston is moved back up the bore of the pump. The design of the pump is such that this lost volume is made very small.

What pressure did the Girandoni work at ? If you know the bore size of the pump and the force used to push the pump rod down you can calculate the pressure that could be reached by it. Until recently this has not been possible since no one had a genuine Austrian Army pump to take measurements from.

We now have the measurements of two pumps, one given in the paper by Dr.Walter Hummelberger and Leo Scharer from their researches in the Austrian archives, the other from measurements obtained from the Museum of Artillery in Turin that has the only surviving pump that we know of.

Now that we know the bore size we need to know the force that can be applied to the pump rod.

It is not sufficient to just use the weight of the person pumping, firstly the only way to exert a force equal to your body weight on a pump of this sort is to balance on the pump so that you are off the ground, a situation that is clearly impossible.

Secondly you can exert considerably more than your body weight because as you push downwards on the pump your body weight is moving, which increases the force on the pump rod. (force = mass x acceleration)

Practical experiment[1] has shown that this can produce a force on the pump that exceeds your body weight by about 50% if the correct pumping technique is used.

If you hold the ball end of the reservoir and pull this tight into the chest and use your upper body weight as you move the reservoir downwards, you are using the momentum produced by moving this weight.

Experiments performed using a walking stick airgun reservoir with a pressure gauge attached gave results that were very close to that predicted for the pump used.

A person weighing 150lbs should be able to exert a force equal their body weight plus 50% 150+75= 225lbs. In fact pumping using a longer pump gave higher results because with its longer stroke you can get a better push at it. (you get more momentum)

The measured diameter of the pump piston for the Turin example is 0.462", which is 0.167 sq. inch.

PRESSURE = FORCE/AREA, 225/ 0.167 = 1,347lbs per sq.inch minus the losses from the production of heat, the lost volume at the end of the pump and the pressure lost in opening the valve (a heavier person would obviously be able to achieve a higher pressure).

This is the sort of pressure that COULD be theoreticaly achieved (with this body weight and correct pumping technique) not necessarily the pressure that the rifle was used at.

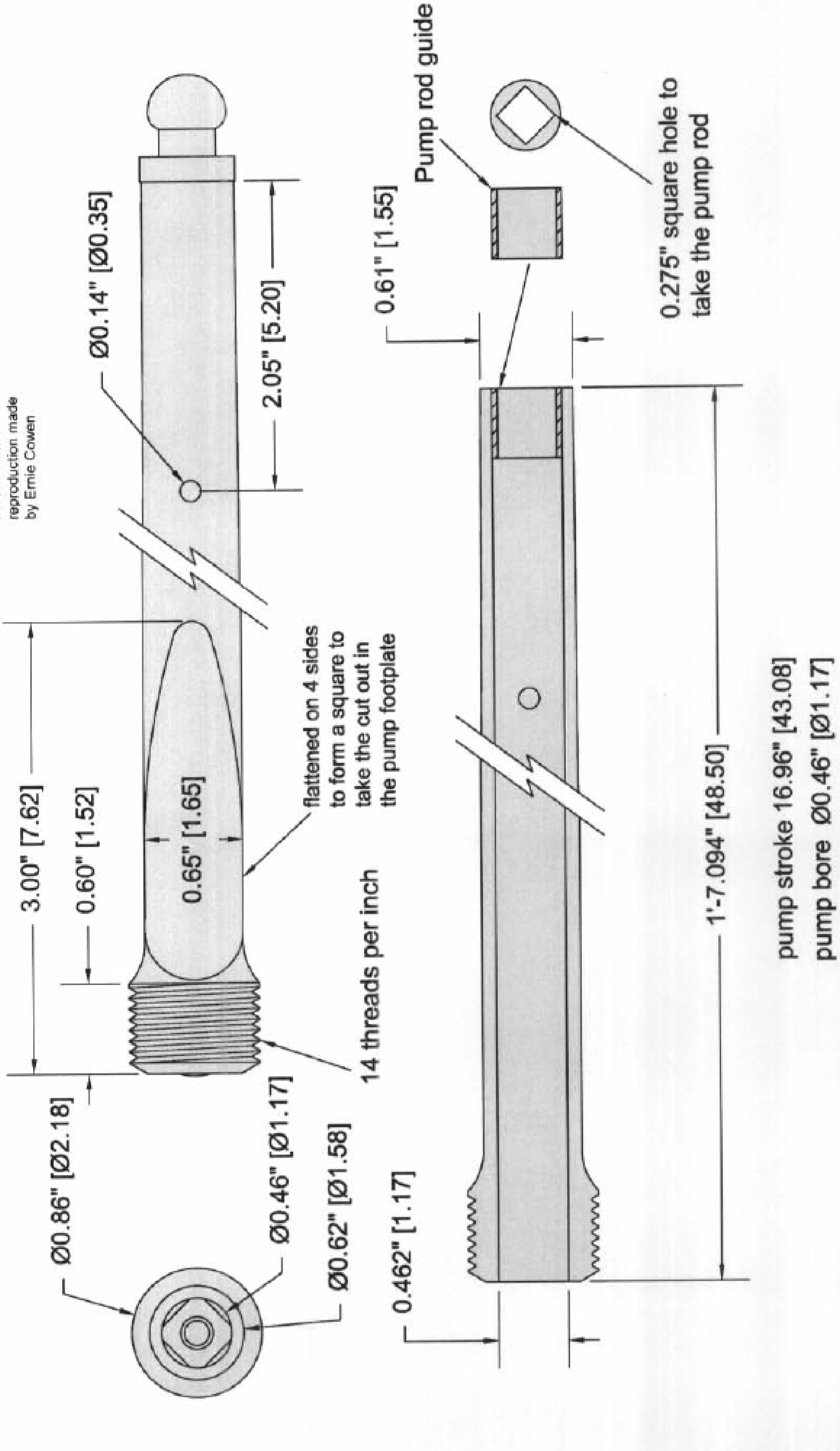
There is a pump advertised on an internet web site that is rated for over 1000lbs per sq.inch with a pump bore of 17/32 inch.

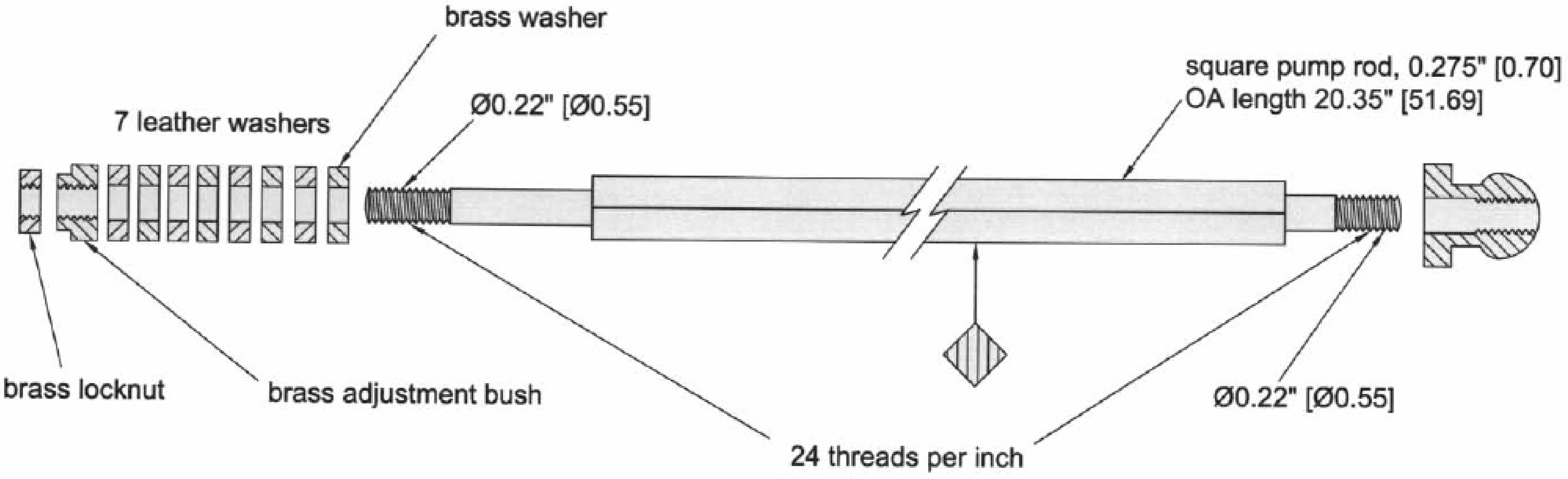
As the reservoir pressure rises, the effort you need to apply increases, and this is very hard work particularly toward the end

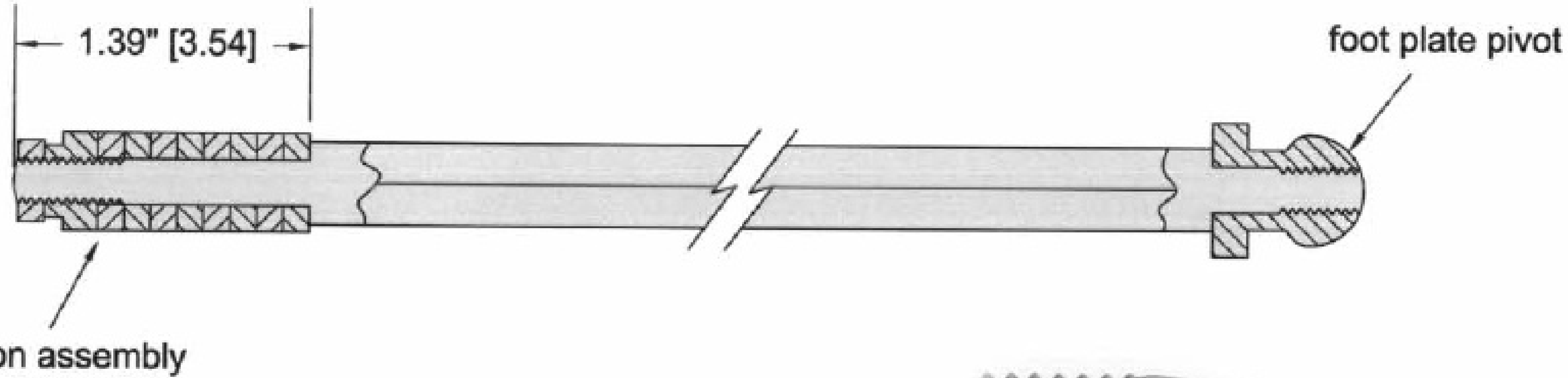
If you put handles on the pump as was done on later pumps you limit the way that you can use it, and this will reduce the force that you can apply to the pump rod!

[1] *Gerald Cardew, The Airgun from Trigger to Target 1995*

photo courtesy of
Dr. R Beeman
reproduction made
by Ernie Cowen







the leather piston could be expanded for a closer fit in the pump bore by loosening the locknut then turning the brass adjustment bush to squeeze the leather washers more tightly, finally retightning the locknut to preserve the adjustment.

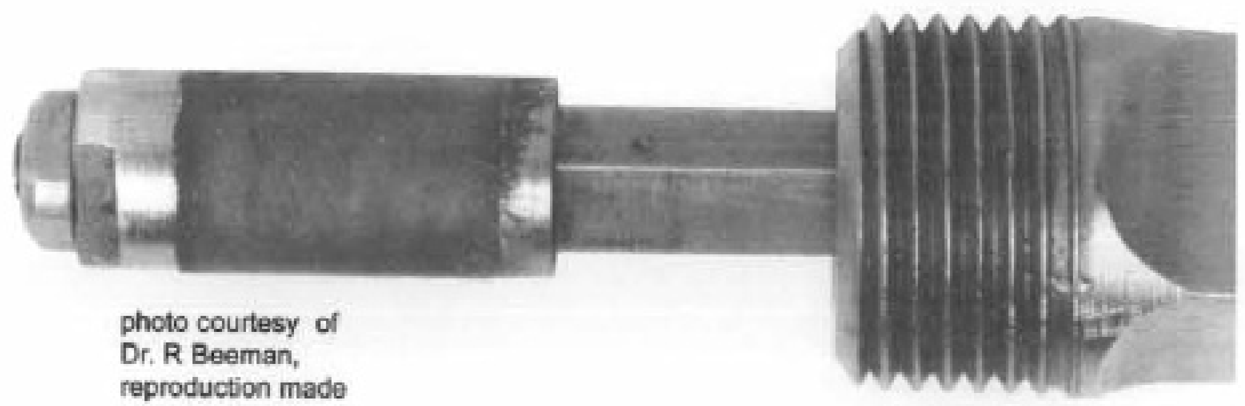
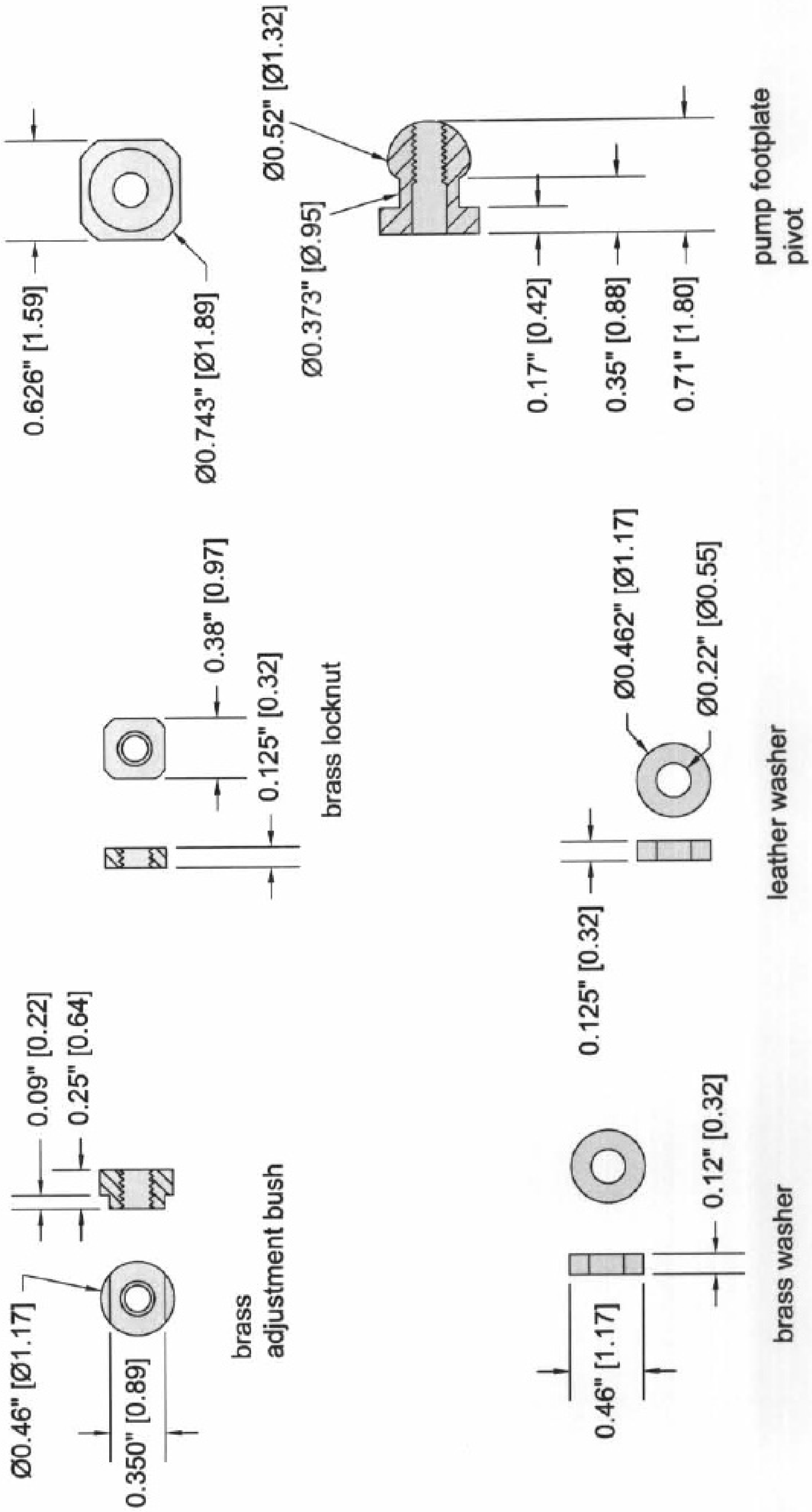
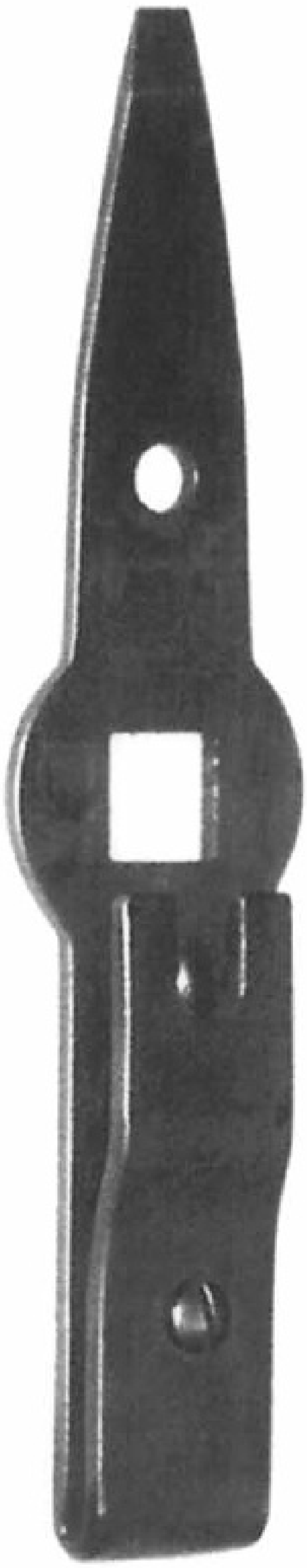
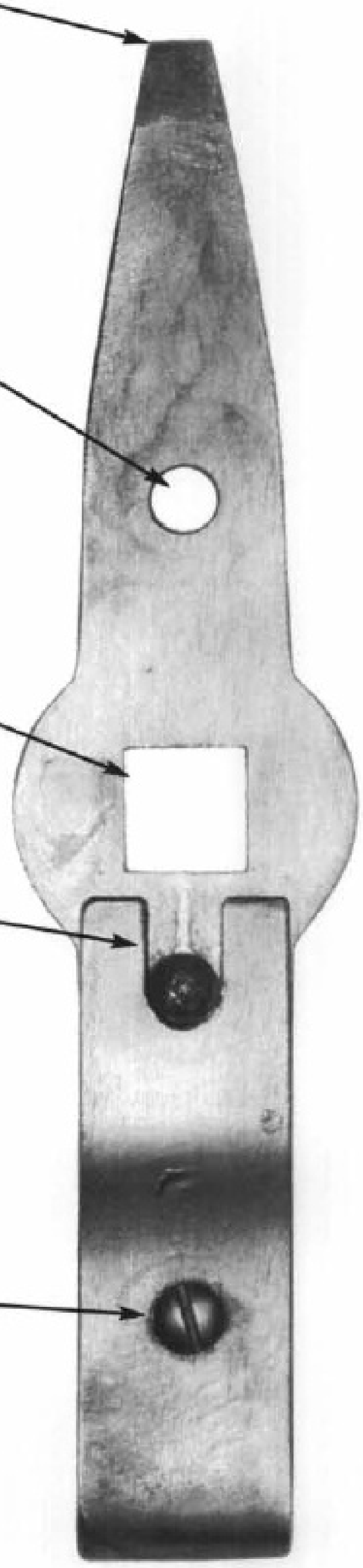


photo courtesy of Dr. R Beeman, reproduction made by Ernie Cowen


0.626" [1.59]
Ø0.743" [Ø1.89]
Ø0.373" [Ø.95]
Ø0.52" [Ø1.32]
0.17" [0.42]
0.35" [0.88]
0.71" [1.80]
pump footplate pivot
0.38" [0.97]
0.125" [0.32]
brass locknut
Ø0.462" [Ø1.17]
Ø0.22" [Ø0.55]
0.125" [0.32]
leather washer
Ø0.46" [Ø1.17]
0.350" [0.89]
0.09" [0.22]
0.25" [0.64]
brass adjustment bush
0.46" [1.17]
0.12" [0.32]
brass washer

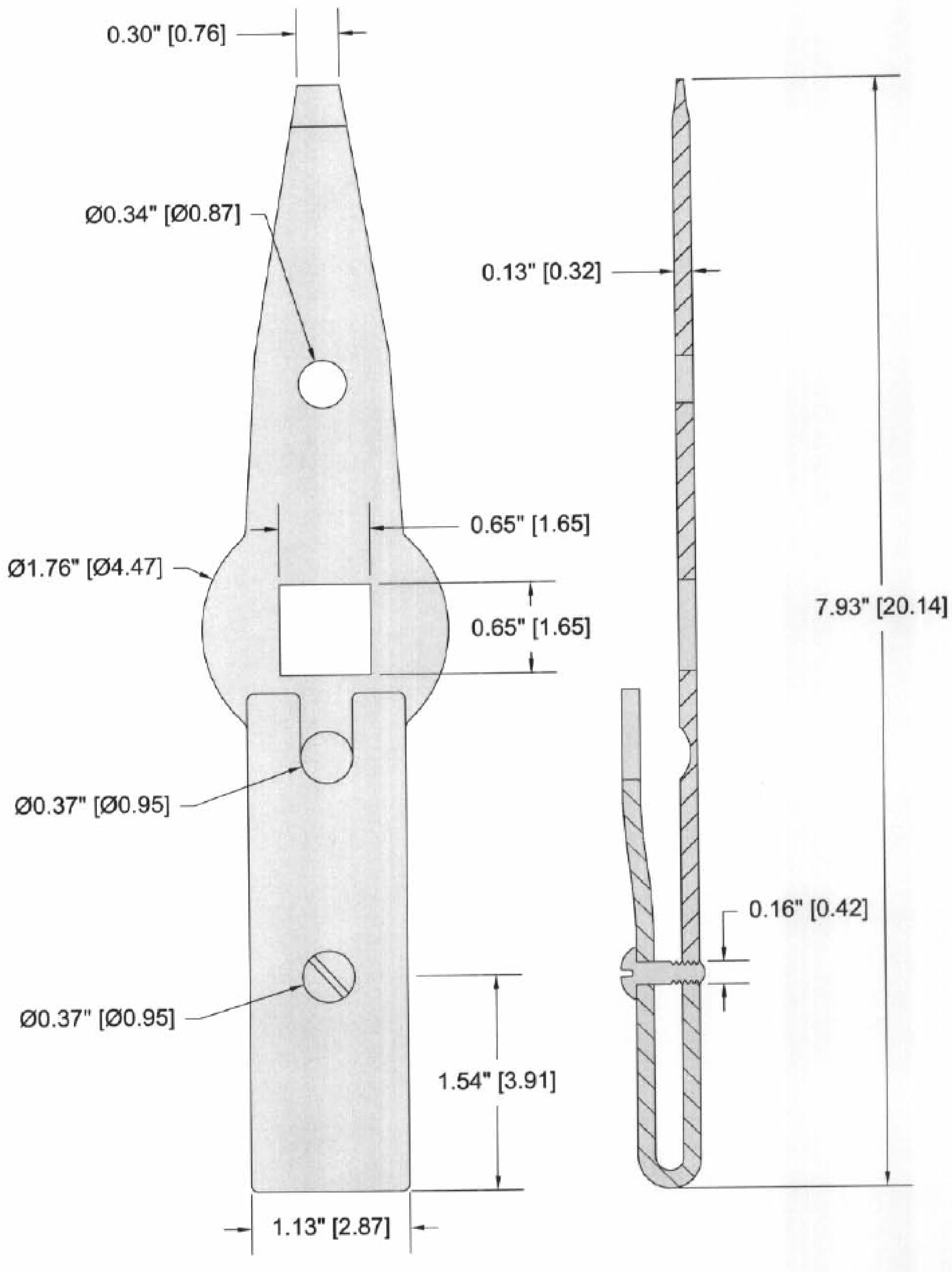
Pump Foot plate



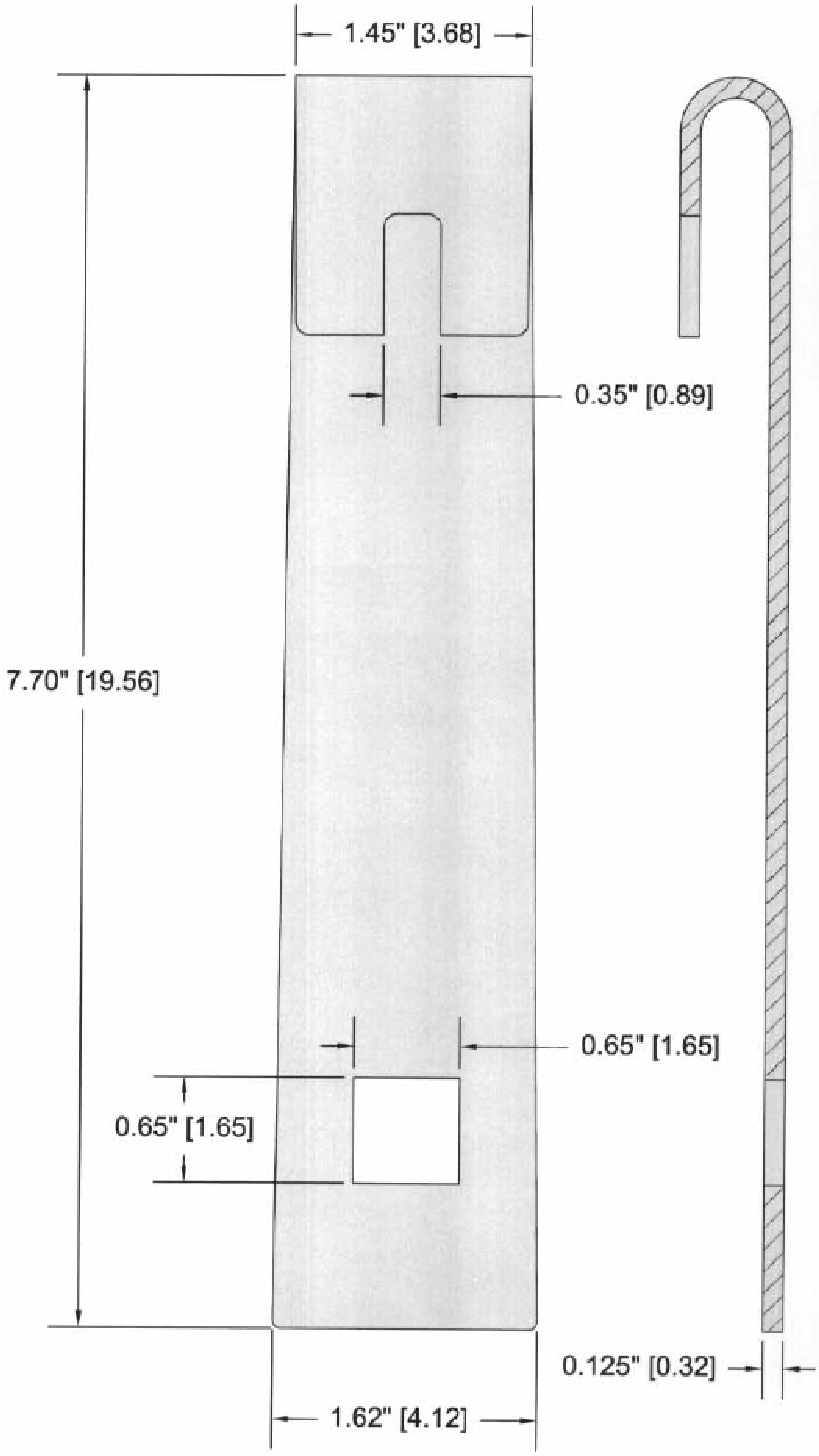


reproduction made by Ernie Cowen

Pump Foot Plate



Pump Piston Adjustment Tool



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Pump Piston Adjustment

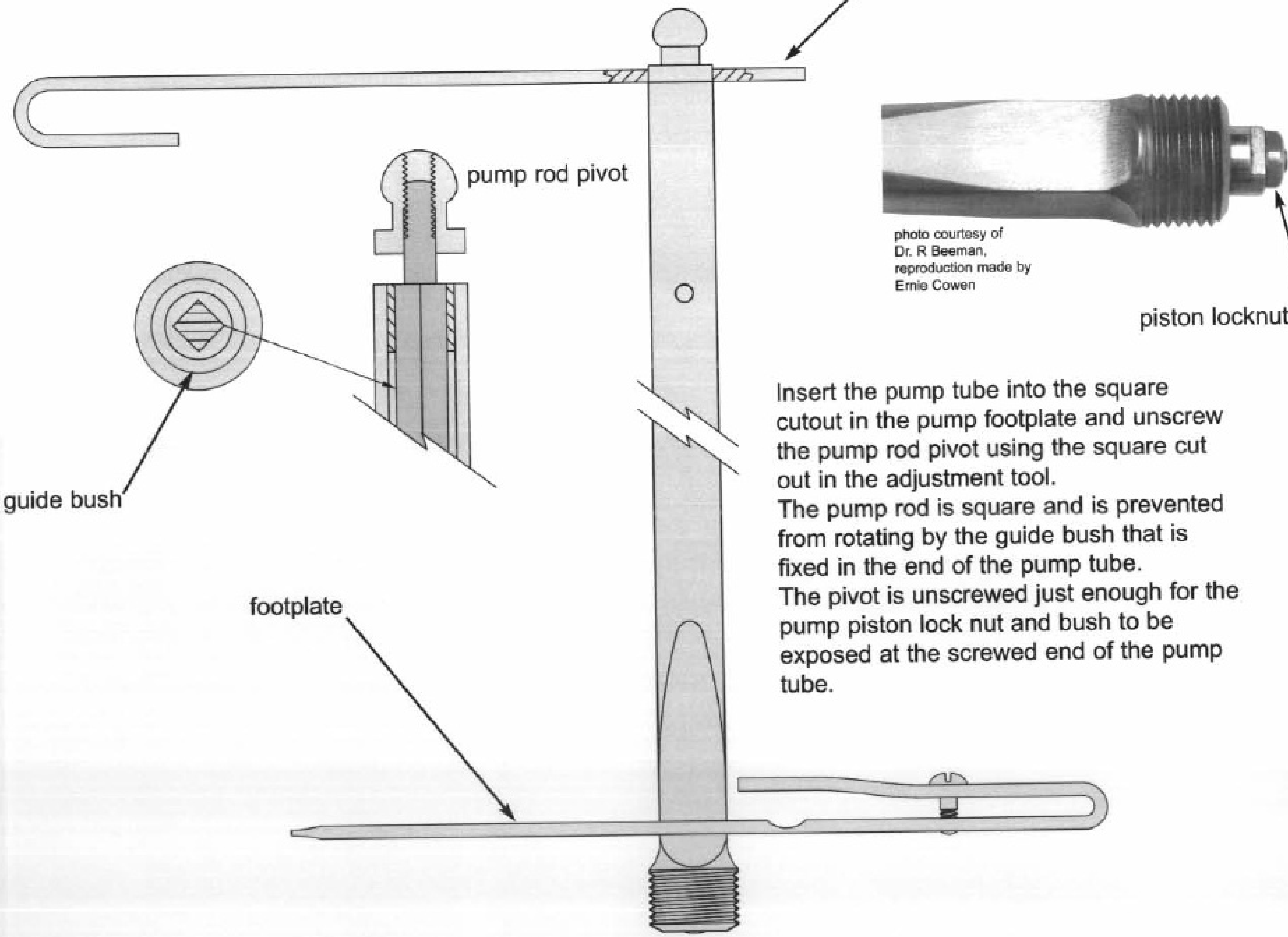
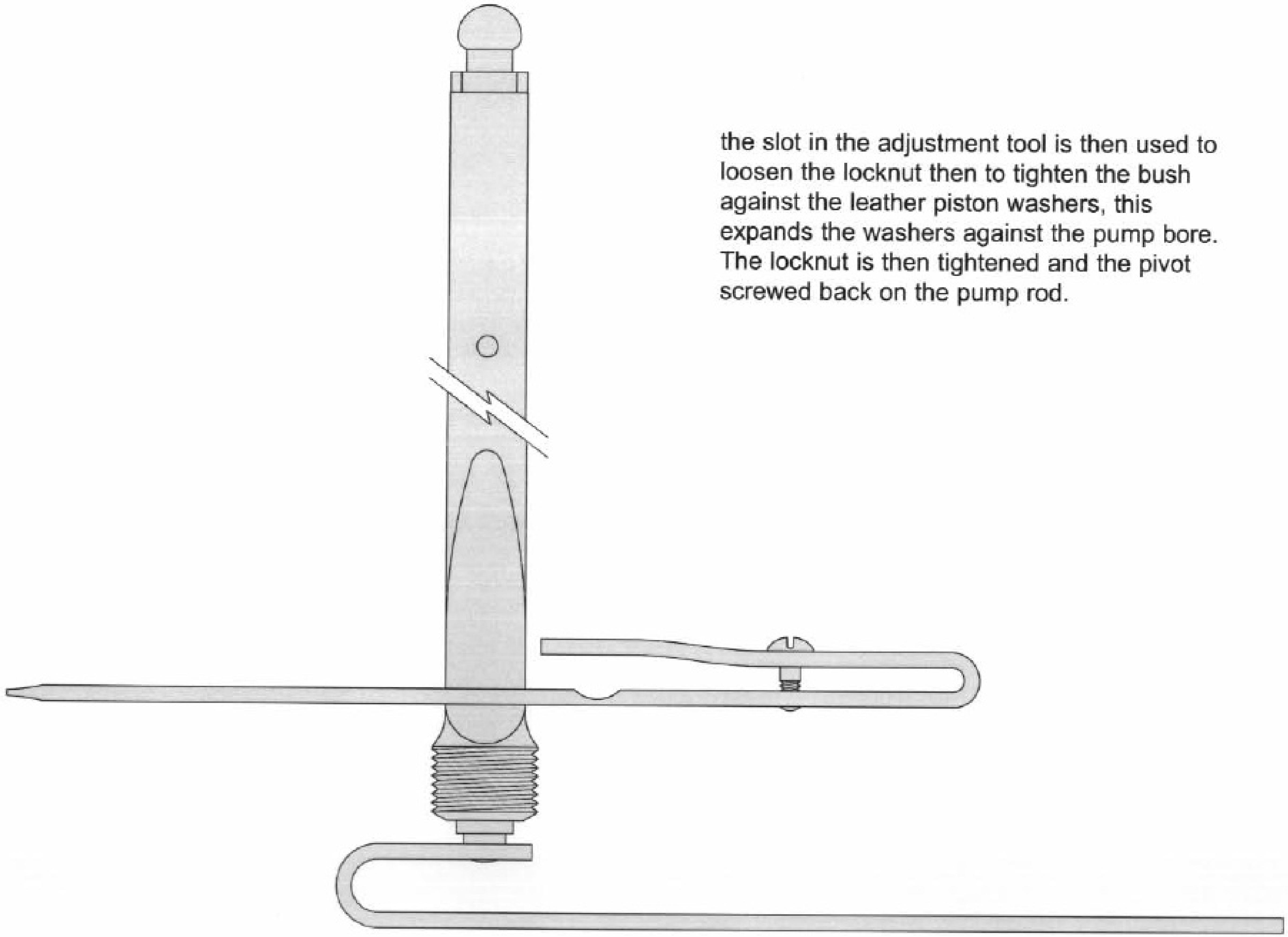


photo courtesy of
Dr. R Beeman,
reproduction made by
Ernie Cowen

Insert the pump tube into the square cutout in the pump footplate and unscrew the pump rod pivot using the square cut out in the adjustment tool.
The pump rod is square and is prevented from rotating by the guide bush that is fixed in the end of the pump tube.
The pivot is unscrewed just enough for the pump piston lock nut and bush to be exposed at the screwed end of the pump tube.

the slot in the adjustment tool is then used to loosen the locknut then to tighten the bush against the leather piston washers, this expands the washers against the pump bore. The locknut is then tightened and the pivot screwed back on the pump rod.



Power and Range

Most of the information on the power of the Girandoni system is based on information culled from the civilian versions, although as a guide it is not representative.

Due to the need to reduce the excessive pumping of the military version, it was necessary to use a lower pressure in the reservoir of the civilian rifle, this was provided by a larger bore pump.

To obtain a reasonable performance using lower pressures you have to increase the volume of air released with each shot.

With the same reservoir capacity this results in a reduced number of shots, reflected in their having smaller magazines.

Eldon Wolff in his book Airguns mentions some tests performed with a ball reservoir airgun using a pressure of 750lbs per sq.inch (carbon dioxide).

Penetration effectiveness was realised when hard pine boards which served as a target were split.

A Kentucky rifle was then tested under similar circumstances, using 35 grains of powder, the Kentucky rifle bullet penetrated only half an inch deeper than the airgun, its extreme penetration being 2 1/2 inches.

L. Wesley in his book Air Guns & Air Pistols published in 1955 describes a civilian version of the Girandoni.

The rifle was made in Austria by Joseph Lowenz in 1792.

The calibre was 0.47 inch and the magazine held 16 balls.

Wesley gives the muzzle velocity as approximately 500 ft per second, however there is no indication as to what device if any was used to measure this velocity.

The velocity quoted may have been an estimate as chronographs were not as easily obtainable then as they are today.

There is no mention as to the pressure used in the rifle other than that "600lbs per sq.inch could be reached without herculean effort." The pump bore dimensions are given as 17/32 inch.

The pressure that could be reached with this bore size could have been a little over 1000lbs per sq.inch

L. Wesley published a fuller description of this rifle in The Marksman magazine in november 1950 which gives a little more information; "using a pressure of 900 lbs per sq.inch the bullets were almost completely shattered." He also says that "30 shots were possible without noticeable drop in power from a pressure of 600lbs per sq.inch."

Fred H Baer in his paper published in Arms and Armour Annual vol 1, says the following:-
" The muzzle velocity of a bullet was about 300 meters per second (about 985 ft per second) - about that of bullets fired from most European hunting rifles of the period".
"The energy was comparable to that of a Colt 45 automatic pistol bullet."

The figures published by Baer are probably the best representation of the power of the military version, unfortunately there is no confirmation of the source, however the results from the civilian air rifles with their reduced pressures, are very supportive of these figures

Most sources such as Blackmore, Hoff and Baer are in general agreement that the range of the air rifle over 30 shots is the first 10 at 150 yards, next 10 at 120 yards, and the last 10 at 100 yards.

There is no indication in any of these references of the source of this information, or why given a magazine capacity of 20, the figure of 30 shots was used.

The only contemporary document that gives any indication of the performance of the air rifle is "Instructions for use of the air gun" published 1788.

In this document it is stated that after firing 20 shots, the air rifle is still accurate at 120 paces.

Unfortunately, until the definition of a pace as described in the document is known, the range of the air rifle must remain speculative

Calibre of the Girandoni Austrian Service Rifle

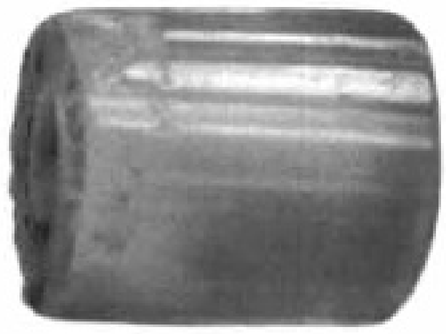
Arising from the comprehensive measurement exercise that Ernie Cowen undertook of Dr. Beemans Girandoni, a considerable discrepancy with the accepted figures of 13mm or 0.51inches for the calibre was discovered.

Despite this figure being quoted as being correct for the calibre of the air rifle by all reference authorities, it was in fact found to be 11.78 mm or 0.464 inches.

As these measurements probably represented the most accurate and in depth examination of one of these rifles made in modern times, this discrepancy had to be explained.

Following considerable discussion on this issue it became clear the only conclusive way to establish the true situation was to first compare this measurement with the calibres of other available military air rifles, secondly to re-visit the source documentation.

To ensure uniformity of measurement, hard wax plugs and a tool for insertion in the bore of the respective rifles were supplied by Ernie Cowen, along with a sample plug for comparison taken from the bore of Dr. Beeman's rifle.



Wax plug taken from a rifle bore using a tool loaned by Ernie Cowen

Suffice to say, that all samples taken corresponded with the 11.78mm or 0.464 inches measurement, confirming this dimension was the actual figure for the calibre, rather than the one previously quoted.

The source document used by most references appears to be "Regulations on the use of the Air Rifle" published by Haller nine years after the introduction of the air rifle during the war with Turkey 1787-1790.

All the dimensions are given in very precise terms, including the dimension of the ball cavity (11.865mm) in the magazine block and the internal diameter of the magazine tube (12.231mm).

The only measurement not indicated precisely is the calibre, being quoted as "nearly 13mm."

Clearly, given the dimensions of the ball cavity and the magazine tube alone this dimension is incorrect, as a 13mm ball could not possibly be loaded or fired from the air rifle.

Therefore the only conclusion that can be drawn is the calibre of the Girandoni service air rifle is in fact 11.78mm, not the 13mm quoted by most references.

The use of the metric system in the document was possibly a later addition, as at the time of publication (approx. 1800) the metric system was in its infancy.

This is confirmed by some dimensions being quoted in the local measurement of "lines" with the metric equivalent alongside.

This may have been the source of the error, as because of the difficulty in measuring the rifling precisely, "nearly 13mm" may have been the best metric equivalent.

This is further qualified in the notes (34) of the "Hummellberger and Scharer" article as a shot calibre of 11.5 mm, weight around 10 grams, (154 grains)
The total depth of the rifling grooves is 0.254mm this plus the 11.5mm gives 11.754mm as the calibre.

unfired ball

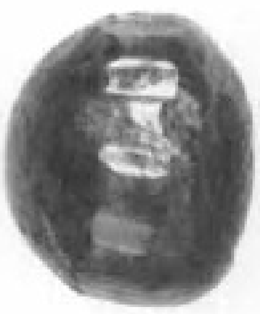
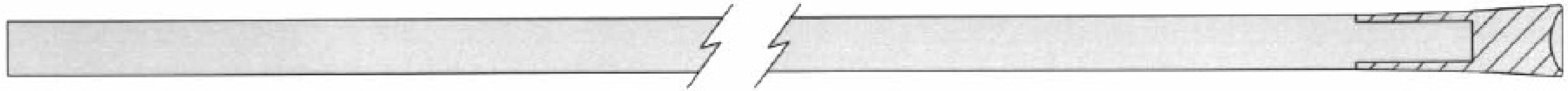
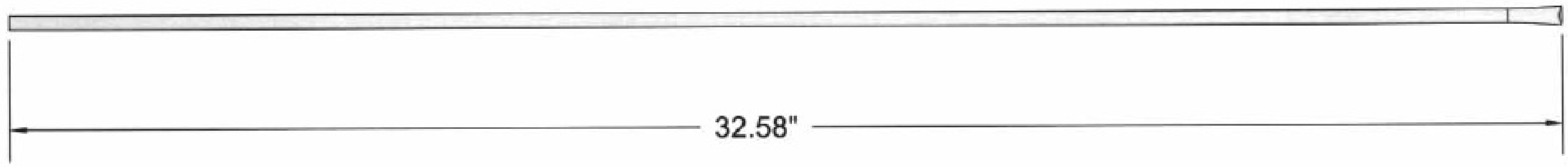


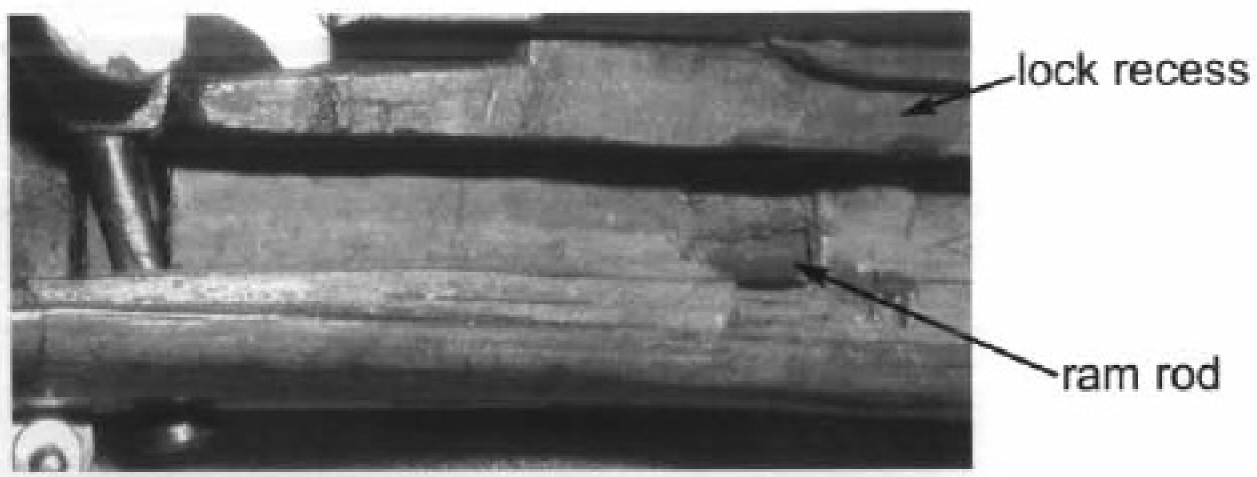
photo courtesy of Dr. R Beeman

photo courtesy of Dr. R Beeman

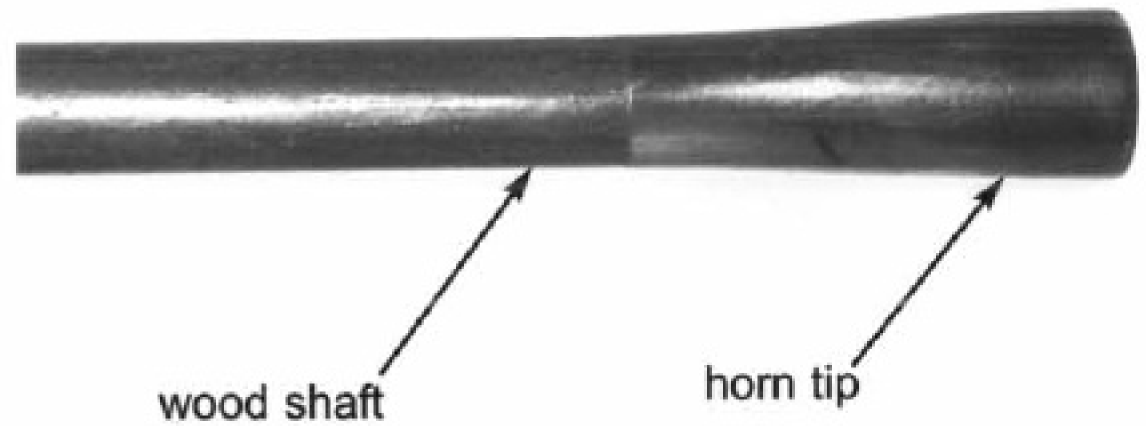
ball fired from a reproduction rifle made by Ernie Cowen



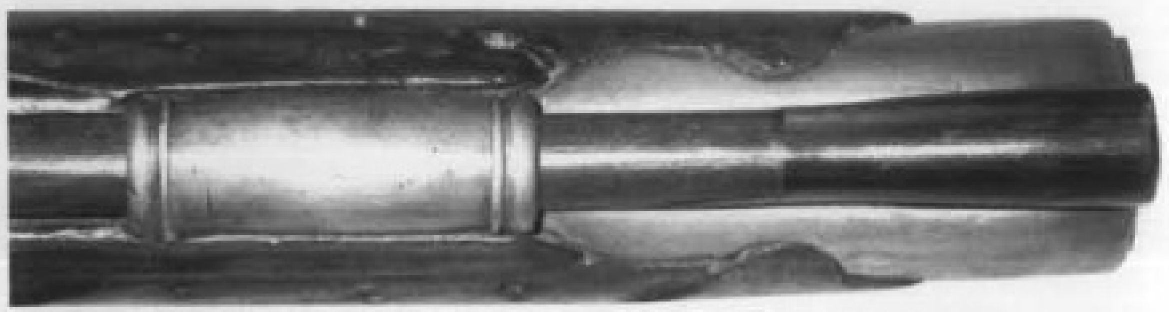




the ram rod runs down the centre line of the rifle and you can see from this view that it gets very close to the lock at the receiver end



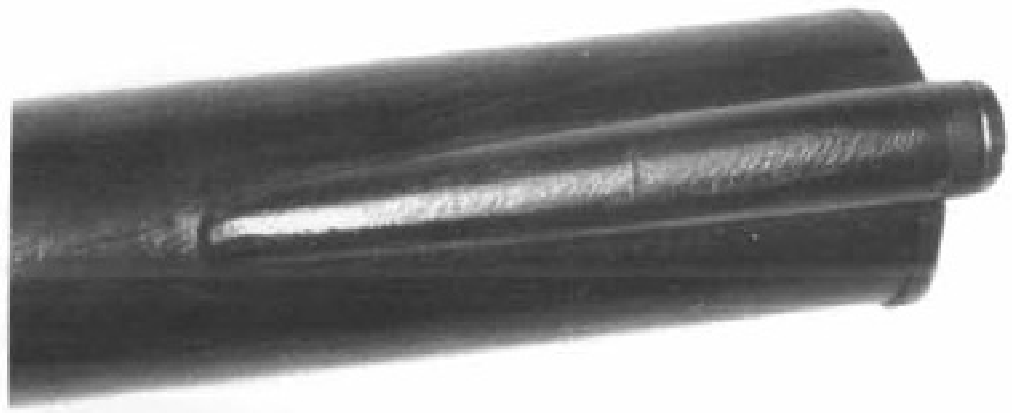
Although the ramrod appears to be superflous on a breechloader, it would have been essential in clearing balls stuck because of low air pressure.



Ram Rod

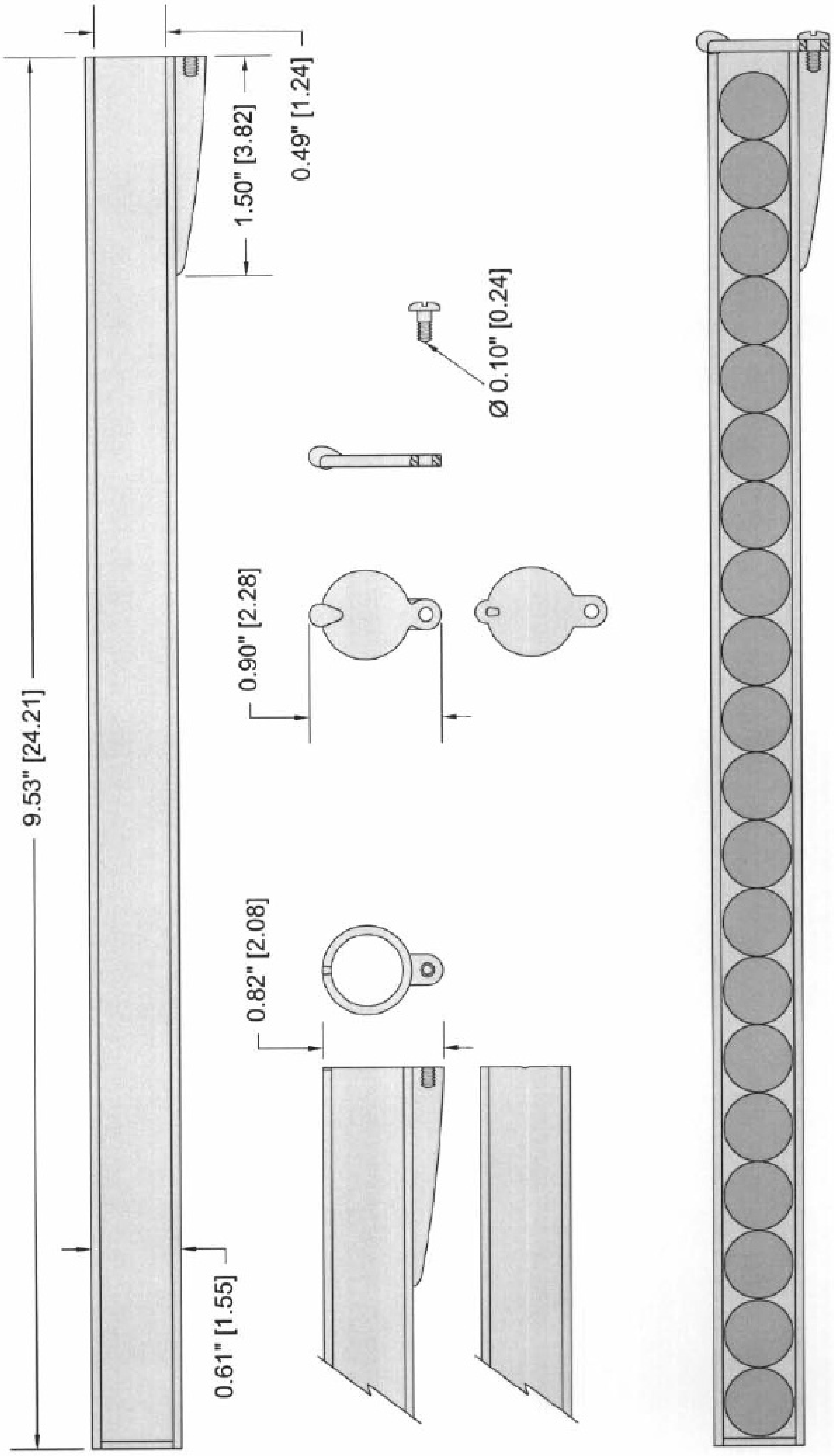
The magazine refill tube was intended to be used in action to quickly replenish the magazine. Each airgunner carried four as part of a standard issue kit, which also included two spare reservoirs.

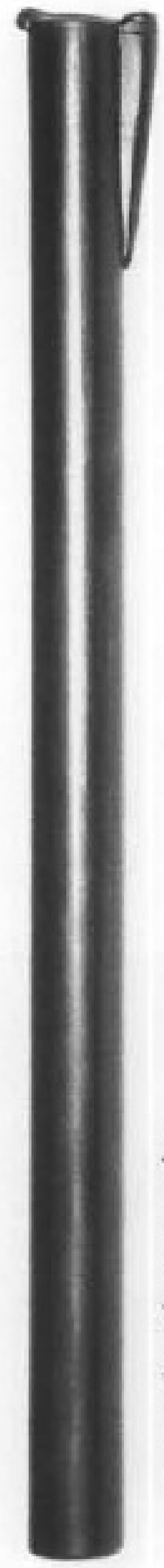
there is no spring on the cover plate, the plate has a small pip that slips into a cut out on the tube



reproduction made by Ernie Cowen

Magazine refill tube





reproduction made
by Ernie Cowen

Colin Currie about to fire a reproduction Girandoni

After all the work entailed in the research, the culminating experience was actually using a Girandoni Air Rifle. It was unbelievably satisfying, to effortlessly discharge ball after ball and watch them group closely on a target at 60yards.

Ernie Cowen with one of his reproduction Girandonis

These final photographs represent the end of a long voyage of discovery. A voyage that led to a greater understanding, and even greater respect for the ability and genius of Bartolomeo Girandoni.