Model 710
Concepts for High Margin and Ease of Manufacture.

Presented:

Investment and Extruded Tube Receivers Based on a Common Barrel, Bolt, and Fire Control Configuration

CONFIDENTIAL

83

Prepared By:
Derek Watkins

Date:
1/12/98

Mode 710 Team:

Project Manager:	Will James
Advisor:	Jim Ronkainen
Technical Lead:	Derek Watkins

PLAINTIFF'S EXHIBIT 324

EXHIBIT 17

Table of Contents

CONFIDENTIAL 83

I. Introduction

In mid 1997 the foundation was laid for what would eventually become the Remington Sportsman Model 710 project. Remington's marketing department conveyed they wanted a bolt action rifle to be positioned as an economy priced centerfire rifle. Offering only the basic features and low manufacturing cost being the major goal. The following is marketing's specification list for the Sportsman Model 710:

- Bolt action - short & long action (including magnums)
- Standard barrels lengths (22" - 24")
- Synthetic stock with recoil pad & swivel studs
- Wood stock may be added in the future based on investment & stock cost
- Floor-plate or detachable box magazine (lowest cost)
- Reasonable bolt action grade trigger (comparable to competitive products)
- Inexpensive metal finish (uniform without turn rings)
- Inexpensive adjustable sights optional
- Accepts after-market scope bases (bases not included with gun)
- MSP $229 (non-magnum synthetic)
- NSP $188 (non-magnum synthetic)
- Target Margin 45% (non-magnum synthetic)
- Target manufacturing cost $103 (non-magnum synthetic)"

Presented in this document are two concept bolt action rifles which meet and, in many cases, exceed these criteria. During the evolution of these concepts it was important to define a backbone upon which any number of bolt action products could grow. This backbone was derived from the three components of a bolt action rifle which rarely, if ever, deviate in function from rifle to rifle: the fire control, the bolt, and the barrel. In theory, the configuration of the three components described in this document render the receiver nothing more than a tube upon which to hang the fire control and locate the barrel. All strength and safety issues are being addressed by the bolt and barrel interaction. An enormous array of options is then available with respect to styling, function, and marketing target audience.

The primary difference between the two rifle concepts is the method in which the receiver (the most machining intensive component of Remington's M700) is made. Concept one is built around an investment cast receiver, while concept two is founded on an extruded tube receiver. Implementation of either receiver type would be a first for Remington. They also have the potential to: reduce inventory, accommodate a build to order, environment, and implement proprietary new technology which could definitively placing Remington at the top of the bolt action market.

II. Preliminary Modern Manufacturing Methods Research Results

Remington Arms Co. Inc. has contracted with the Institute of Advanced Manufacturing Sciences, Inc. to conduct a technical search for cost-effective candidate processes for agile manufacturing of firearm components, as they apply to the M710 program. The preliminary report was submitted December 12, 1997. The areas of high speed machining, forging, semi-solid forming, and assembly technologies look particularly interesting. The report gave overviews of several machining processes, but was not specific enough to draw any conclusions. The final report is due the first week of February 1998.

III. Receivers

A. Investment Cast

The primary manufacturing goals for the M710 receiver are low cost and to include as many features as possible without incurring extra cost. The investment cast receiver shown in Figures 1, 2, and 3 was designed with such criteria in mind. The near net shape parts which investment casting renders eliminates many of the preliminary shaping cuts currently done on the M700 receiver. It also adds the ability to use the mold for casting receivers from alternate materials as they become available.

The flat panel design of the receiver (such as seen in many contemporary shotgun receivers) was chosen to increase receiver stiffness, utilize cheaper two piece stocks, and inclusion of a rigid magazine guidance system. The flat panel receiver design has been utilized very rarely in bolt action rifles. This unique shape provides receiver stiffness which can not be found in conventional cylindrical designs. With the receiver's dimensions stretching the full height of the gun, the conventional single piece stock can be replaced with a less capital intensive two piece stock. For plastic stocks, the molds are much smaller, i.e. much easier to handle and requiring smaller less expensive presses in which to operate. For comparison, the Remington M100 synthetic butt stock costs $3.20, while the fore end is $2.96, for a total of $6.16. The single piece M700 ADL synthetic stock costs $7.69, for a difference of $1.53. A savings of $153,000 a year if 100,000 units are sold. Similarly, two piece stock wood blanks tend to be cheaper than their single piece counter parts. This is due to the fact the frequency of knots is lower the smaller the section of wood, i.e. less rejected blanks. The two piece stock also supplies the opportunity for a part reduction. The recoil lug found in the M700, and other conventional bolt action rifles is rendered obsolete. Finally, the flat panel receiver and two piece stock design provides a unique cosmetic look which would be very distinguishable on the shelf of any gun store.

As seen in Figure 3, the investment cast receiver allows for a potentially less expensive approach to attaching the barrel to the receiver. The threading operations on the barrel and the receiver are eliminated. The barrel is instead attached via the clamping action of the cross screws. This method of barrel attachment has been practiced for many years by Sauer, and is thought to be reliable and accurate. This also facilitates barrel interchangeability, with respect to a group of calibers supported by the bolt supplied with the gun. A significant step towards the cost-effective build to order method of manufacturing not presently incorporated in the gun industry.

B. Extruded Tube Design

When compared as a whole, conventional bolt action receivers are essentially steel cylinders with some geometry cared out the length of the [illegible]. The bolt and barrel designs exhibited in sections V and VI eliminate the need for the bolt key broaching operation. This turns the receiver into a thick walled tube. This tube can be readily obtained from a process known as extrusion. Extruded blanks (seamless blanks) have recently been adapted in Remington's process for making shotgun barrels. Adapting this extruded blank approach to receiver design, coupled with high speed machining, could easily make receiver production more cost effective. The receiver shown in Figures 4 and 5 show one such possible receiver.

Elimination of the broaching operation in the receiver should have a substantial impact on the financials of this concept rifle. Broaching tools have a lead time of 16 weeks and are approximately $3,000 apiece. Replacing this operation with a drill and reaming operation should reduce tool cost and increase through put. Figure 6 depicts how the interior geometry of an extruded tube receiver could be obtained by a step drill and ream operation.

Cosmetically this receiver design is very conventional (modeled after the Remington M788) and should be palatable to the traditionalist. This cylindrical design facilitates the use of a single piece stock, but also requires the integration of a recoil lug. Using the approach of embedding the recoil lug in the stock, and implementation of bedding compound as adhesive could provide the customer with the impression each barreled action is custom fit. The use of bedding compound in Remington M700 rifles was proven to reduce five shot group size by .3 inches (with a 90% confidence interval) in the 30-06 caliber. The receivers mating cut for the recoil lug can be seen in Figure 5.

Barrel attachment for this design will also be more conventional. External threads on the barrel and internal threads in the receiver will be required. In addition, these threads will also have to be timed. This is due the nature the mating system between the bolt and barrel described in the subsequent sections. This method of attachment is very prevalent in the gun community and should be readily accepted.

IV. Fire Control

A. Evolution of the 6-Bar and 4X4 Fire controls

The first component in the backbone of these two concept rifles is the fire control. The M710's fire control is the evolutionary sibling of the linkage fire controls developed in the M700 improvements program. The 6-Bar and 4X4 were prototype linkage fire controls developed on the principals of reduced tolerance sensitivity, ease of manufacture, and superior performance. The 4x4 showed the most potential for success after having a dry cycle life in excess of 100,000 cycles, passing all SAAMI safety standards, and being comprised mainly of stamped and powder metal parts. It should also be noted that these results were obtained from preliminary testing, not the engineering evaluation test, nor design acceptance test.

The reasoning behind a linked fire control being considered is mainly the inherent advantages associated with such a mechanism. By eliminating the contact surfaces between the sear and the trigger, and replacing them with a toggle system, one disperses with such issues as surface quality and perpendicularity. Connecting the trigger to the sear via a series of links also ensures that if the trigger is forward, the sear is up. Last but not least, the feel and crispness of the prototyped, linked, fire controls is superior to the production fire control of the Remington Model 700. Often thought to be the best production fire control on the market today.

The 4X4 and 6-Bar both have limitations though. The intricate nature of the 6-Bar's parts make it sensitive to assembly procedures. It also suffers from the highest part count of the linked fire controls (including the M710). While, with the 4X4's simplified parts and streamlined design, tolerance issues have been identified with the safety and system return. The M710 fire control addresses all these issues, while adding features and reducing the part count even further. Addition of a bolt lock, tolerance insensitive safety, and the elimination of two pin joints with a single slider joint are just a few examples. Renderings of the M710 fire control can be seen in Figures 7 and 8.

One of the most unique aspects of the M710 fire control is its inclusion of a tolerance insensitive system return. First conceived by David Findlay for use in conventional fire controls, and later adapted for use in linked fire controls by the author, a system return mechanically resets the fire control to the cocked position every time the bolt is cycled. The safety system also performs the same task every time it is cycled. Couple these things with only .010 inch of the trigger to fire the mechanism, and an expected cycle life of 100,000 plus rounds, the M710 fire control has the potential to be the best performing mechanical fire control the bolt action market has ever seen. For a detailed explanation of the workings of linkage fire controls and the M710 fire control see Appendix A. Note, all expectations and predictions as they apply the M710 fire control are based on data obtained from 6-Bar and 4X4 testing; dynamic and kinimatic analysis of modeled M710 parts; and the authors knowledge and expertise in the subject matter.

83

B. Trigger Housing

The vast difference in the receivers of the two concepts for the Sportsman M710 poses interesting possibilities in how to package its fire control. The investment cast receiver of concept one lends itself to a trigger assembly incorporating a trigger guard. Not unlike the synthetic and aluminum trigger housings used in the Remington 870 and 1187 shotguns. More readily known as the common fire control. This type of housing has the advantage of being modular, which makes disassembling the gun for cleaning and general maintenance much easier. Unfortunately, this concept has not yet been modeled and a rendering is unavailable.

Figure 7, depicts a viable candidate for the extruded receiver's trigger housing. This type of housing consists of one MIM or die-cast side plate, which retains all the parts (Figure 7), and a simple stamped counterpart acting as a cover. This is the most common style of trigger housing used in bolt action rifles. The Remington Model 700 uses a very similar type.

C. Safety

The safety shown in Figures 7 and 8 is a three-position tang safety. The first position is the fire position; the state in which the firearm can be discharged and the bolt cycled. The second position is the safe position, the firearm will not discharge but the bolt can be cycled. The third position is the safe and bolt lock position. In this position the safety mechanism of position two is engaged, and the bolt is rendered immobile. This type of safety has features not presently available in the Remington M700, and could be construed as an improvement over that rifle.

There are two possible safety configurations for the common fire control style housing. The first is the tang safety just described. The second is a cross bolt style safety synonymous with the common fire control and the more recent Remington 597. This cross bolt approach requires fewer parts and would be easier to assemble than its tang safety counter part. To the authors best knowledge, the cross bolt is not presently used in any conventional bolt action rifles on the market today. This poses certain risks with respect to acceptance by the gun community. Aesthetic issues would also have to be addressed. The cross bolt design is not applicable to the trigger housing in Figures 7 and 8.

D. Tolerances

One of the biggest obstacles facing manufacturing during the building of a product is the tolerances associated with each part. The M710 fire control is designed to make those tolerances as large as possible. This is achieved by strategic placement of pivot locations and the use of set screws in key locations. Each pivot is optimized for performance and sensitivity during the graphical and kenematic analysis phase of design.

Set screws were placed in the trigger, toggler, and firing pin head to address tolerances associated with distance past toggle, safety engagement, and contact area between the sear and firing pin head. In this respect the M710 fire control should be more robust than the Remington M700's.

E. Status

The M710 fire control has entered the final stages of preliminary design. All the parts have been modeled and are presently being detailed. Extensive kinematic analysis has been completed on Working Model and confirmation of the kinematic results has begun on Adams. The M710 fire control has been designed to operate on a Remington M700 slave housing. This fire control assembly will attach to and function in a Remington M700, but is not in any way a retro-fitable design. This approach to the design was taken to expedite testing, which should start in February 1998.

V. Bolt Assembly

A. Unidiameter Bolt

The proposed bolt assembly for the M710 utilizes a unidiameter approach to the external geometry. The entire assembly, minus the handle, has the same outside diameter. This can best be seen in Figure 10. The main advantage of this is the elimination of the broaching operation needed to cut the bolt key. The bolt key can then be constructed by a drill and ream operation. This should be less costly and possibly be faster than broaching. Bolts of similar design are currently implemented in a few high end European bolt actions.

B. Integration of the Bolt Handle and Bolt Body

More cost effective ways of producing a bolt handle has long since been a goal of Remington manufacturing. The recent evolutionary advancements in investment casting and drop forging technologies may aid in attaining this goal. By combining the bolt handle and bolt body as a single casting or forging, it may be possible to eliminate a brazing operation and reduce the total part count. Part porosity and surface finish would be issues of concern in these processes.

C. Three Lugs

Incorporating the locking system into the barrel places size constraints on the bolts' lugs. In the Remington M700 the bolt's lugs are approximately the same diameter as the barrel. In the concept bolts' case, this can not be true. The bolt's lug diameter must be small enough to enter act with the barrels locking system, but also be strong enough to hand the high proof pressures of today's magnum shells, see Figures 6 and 13. To accomplish this a three lug system has been designed. This maximizes the locking surface area, while minimizing head diameter. The 60° bolt throw is an added benefit. It alleviates any chance of interaction between the bolt and the scope during cycling.

83

D. Field Strippable

This concept bolt also includes a first for Remington – it is fully field strippable. Very similar in function to the Sako IV and the Styr Safe Bolt, this concept bolt's firing pin assembly can be removed by twisting the bolt plug clockwise 90 degrees, with respect to the bolt body. Unlike the competition, the bolt plug and firing pin assembly will remain in tact. Allowing easy cleaning and reassembly. A patent search is underway and the risk factor is presently considered low.

E. Reduction in Part Complexity & Tolerance Sensitivity

Several parts in the concept bolt have been reduced in complexity, and optimized for tolerance insensitivity. The firing pin head is a perfect example. As shown in Figure 11, this firing pin head is a simple powder metal part with two holes (one of which is threaded). The tail of the firing pin head acts as a cocking indicator, but also the locking mechanism which keeps the bolt plug from turning as the bolt is opened and closed. The large diameter hole locates the firing pin in the bolt plug, while the threaded hole contains the contact pin. This technique of single-part-multi-functionality is key to product robustness and part count minimization.

The contact pin has four roles: it serves as the contact surface between the sear and the firing pin head; it retains the firing pin in the firing pin head; it retains the contact bushing; and it takes up all the tolerances in the system return. This is a simple screw machine part. It absorbs the most punishment in the bolt assembly, and can easily be made from alloys designed for such a task.

The contact bushing is also a multifunction part. Retained by the contact pin, the bushing rolls on the bolt cam cut. This rolling action should increase bolt life significantly, while reducing bolt lift forces at the same time. It should also be noted, during the 4X4 fire control testing, nickel teflon coating the contact surface on the firing pin head improve M700 bolt life during dry cycling as well.

F. Firing Pin and Lock-Time

The concept bolt body has a larger diameter than the Remington M700's bolt body. This allows for a larger diameter spring to be used with the firing pin. A spring's diameter has a dramatic effect on the energy to load ratio of a spring. The larger the diameter, the greater the energy for a specified load. What this means is: primer indents can be kept in SAAMI speck with lower cocking forces on the spring, i.e. lower bolt lift forces. This coupled with the contact bushing should cancel out any adverse effects in bolt lift forces the 60° bolt throw may have.

Lock-time should also be positively affected by these changes. To keep the spring from buckling in the bolt body, the firing pin has a star shaped cross section, see Figure 6. This star shape also adds mass to the pin. Mass was the variable found to have the most effect on primer indent in the M700 improvements program. The higher energy spring coupled with the more massive firing pin should reduce the travel distance needed to supply adequate primer indent, therefore, reducing lock time.

Manufacture of a complex shape such as the firing pin could be preformed by a relatively new process - micro-forging. An interesting process, which over the past few years has become very competitive and capable of producing small parts with very tight tolerances. Few secondary machining steps, if any, are needed with this process.

VI. Barrel

A. Locking System

The last vertebrae in the back bone of these concept rifles is the barrel. The barrel ties the whole system together by incorporating the lugs. This is not an unheard of system in the gun industry, but is generally expensive to process. The barrel designs shown in Figure 12 could possibly sercomvent this deterrent. Incorporating the lugs into a barrel is generally done by boring a pocket in the barrel to accommodate the bolt's lugs, and then pot broaching the key way for the bolt. The designs shown would be created by the same initial boring operation, but an end mill operation is used to cut the key ways in the barrel. Figure 13 shows a bolt and barrel in the locked position. Note, the only difference between barrel designs in Figure 12 is the external threads. The cutaway barrel on the right does not need threads because of the clamp design incorporated into the investment cast receiver.

B. Three Rings of Steel

Both concept rifles incorporate the three rings of steel found in the Remington M700. Figure 13 shows a barrel and bolt in the locked position. The three rings of steel surrounding the base of the shell are easily seen. The ability of the bolt head to obturate in case of over pressure, and prevent the shooter from exposure to harmful gasses has proven itself in Remington M700 testing.

83

C. 5R Rifling

Rifling consisting of five lands and five grooves (5R) is the rifling configuration of this barrel design. The Russians have used this rifling pattern in their sniper rifles for years. Remington most recently implemented it in its 597 rimfire line, with very good results.

D. Alternate Configurations

The lugs being incorporated into the barrel also has the added benefit of begin able to accommodate black powder and slug versions. A black powder version of the concept rifles could be accomplished with only a change in the bolt head and installation of a breach plug and a nipple in the barrel. Alterations to the receiver, such as those seen in the Remington M700 muzzle loader receiver, would not be needed. A 12-gauge slug gun would also be possible, but some issues around the extractor and the size of the lugs need further investigation. The key to either alternate configuration is to design the receiver big enough to accept the outside barrel diameter.

VII. Magazine

Basically three options exist for the magazine clip of the M710: add use the Remington M700 clip, design an all synthetic clip, or create a new stamped version. The main deciding factor is what's the desired customer's perceived value. For an economical firearm a synthetic clip is probably fine, for a high-end firearm resistance would probably be meet. In any case, the only novelty associated with the conceptualized M710 clip is the possible use of a rear spacer. This would allow the receiver to accept a range of caibers with one clip. The only change necessary would be the type of spacer. This would reduce the number of magazine boxes require to support a line of firearms.

VIII. Summary

What has been described is two bolt action rifles which can be tailored for a custom fit in the bolt action market. The investment cast receiver, two piece stock, synthetic trigger guard/housing, clampable barrel, and synthetic clip combination should be a good high margin rifle with customer economics targeted. The extruded tube receiver, one piece synthetic or wood stock, conventional trigger housing, taped barrel, and a metal clip configuration should preform equally as well as a high margin bolt action, but also give the customer the added sense of value associated with high end rifles.

The areas for possible cost savings are many. For the investment cast receiver version they are as follows: the receiver should require less machining than the M700 receiver; decreased tolerance sensitivity in several areas; two piece stock; elimination of barrel threading operation; elimination of the recoil lug; elimination of the receiver broaching operation; and elimination of the bolt handle brazing operation. For the extruded tube receive concept rifle the cost benefits are as follows: the receiver should require less machining than the M700 receiver; decreased tolerance sensitivity in several areas; elimination of the broaching operation in the receiver; and elimination of the bolt handle brazing operation.

The important thing to note in both concepts, the design of the over all gun is such that performance should be equal to better than the Remington Model M700. Another fact is the receiver dimensions are set up to accommodate ultra magnum and 12-gauge slug shells. These facts coupled with the ease of conversion blackpowder make either of the concept bolt actions rifles viable candidates to become the Remington Sportsman M710.

IX. Alternate Method of Execution

If one evaluated the two concept rifles in the configurations described in the summary, a distinct difference in value would most likely be evident. This would probably be based on how people view synthetics and the cosmetic differences between the firearms, not on the performance of the firearms (they are expected to be equal). Due to the fact the concept rifles have a very high number of interchangeable parts, the unique opportunity two produce two bolt action rifles with minimum capital investment exists. The introduction date of the Sportsman M710 corresponding with the year 2000 also encourages this opportunity. Introducing the investment cast receiver concept rifle as the economically priced Sportsman M710 makes sense. While introducing the extruded receiver design as a technologically advanced high-end gun is equally logical. Both guns would have high margins, exaggerated by the reduced manufacturing power needed to produce two products sharing a common backbone of parts. This backbone approach to gun manufacturing not only allows for two distinct products, but also an entire family of calibers (centerfire, black powder, and shot shell). This approach to new product design has never been implemented in Remington.

83

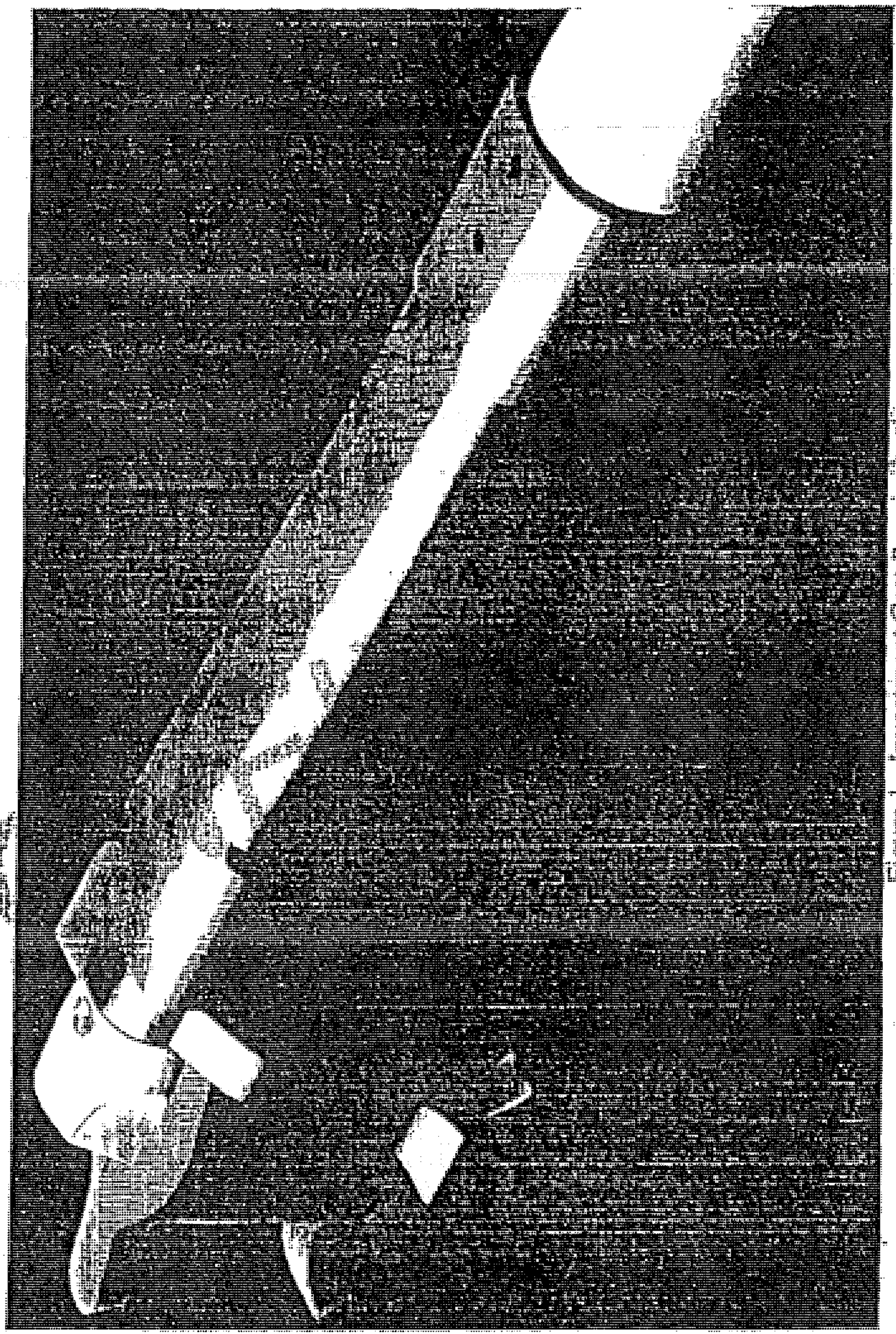

Figure 1. Investment Cast Receiver Isometric View

83

ET00400

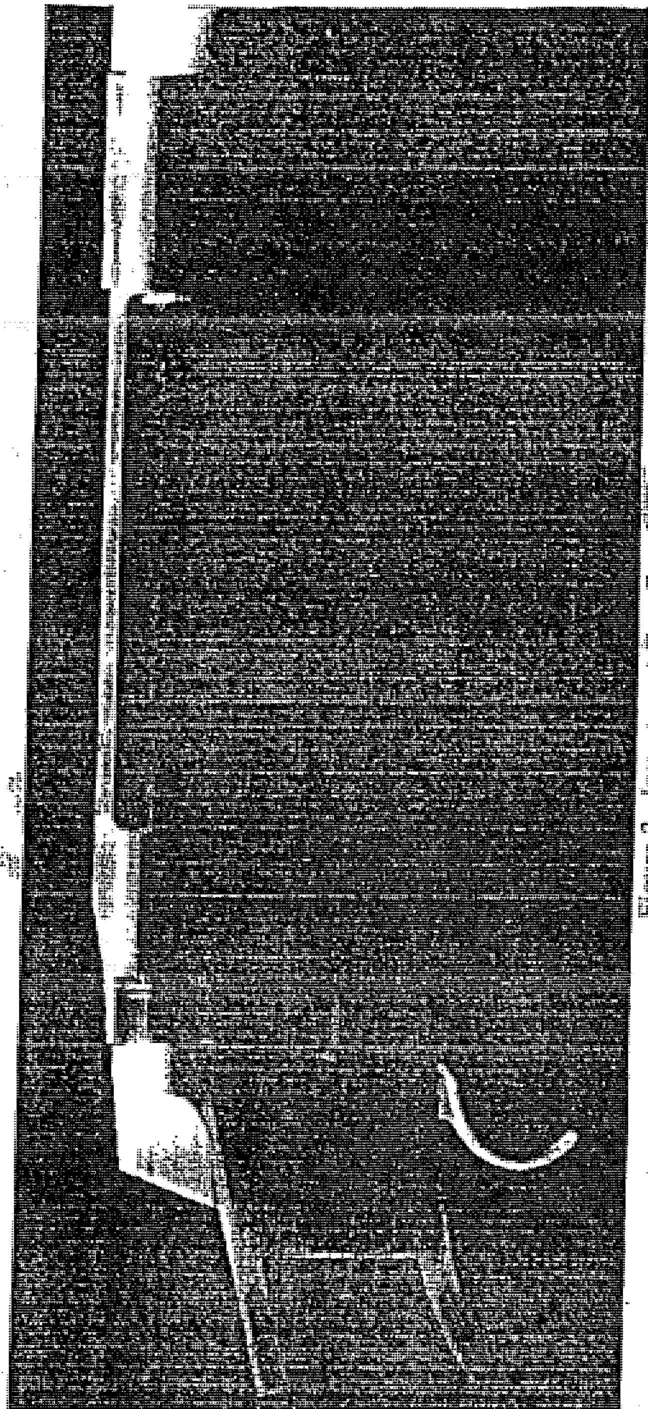

Figure 2. Investment Cast Receiver
Side View

ET00401

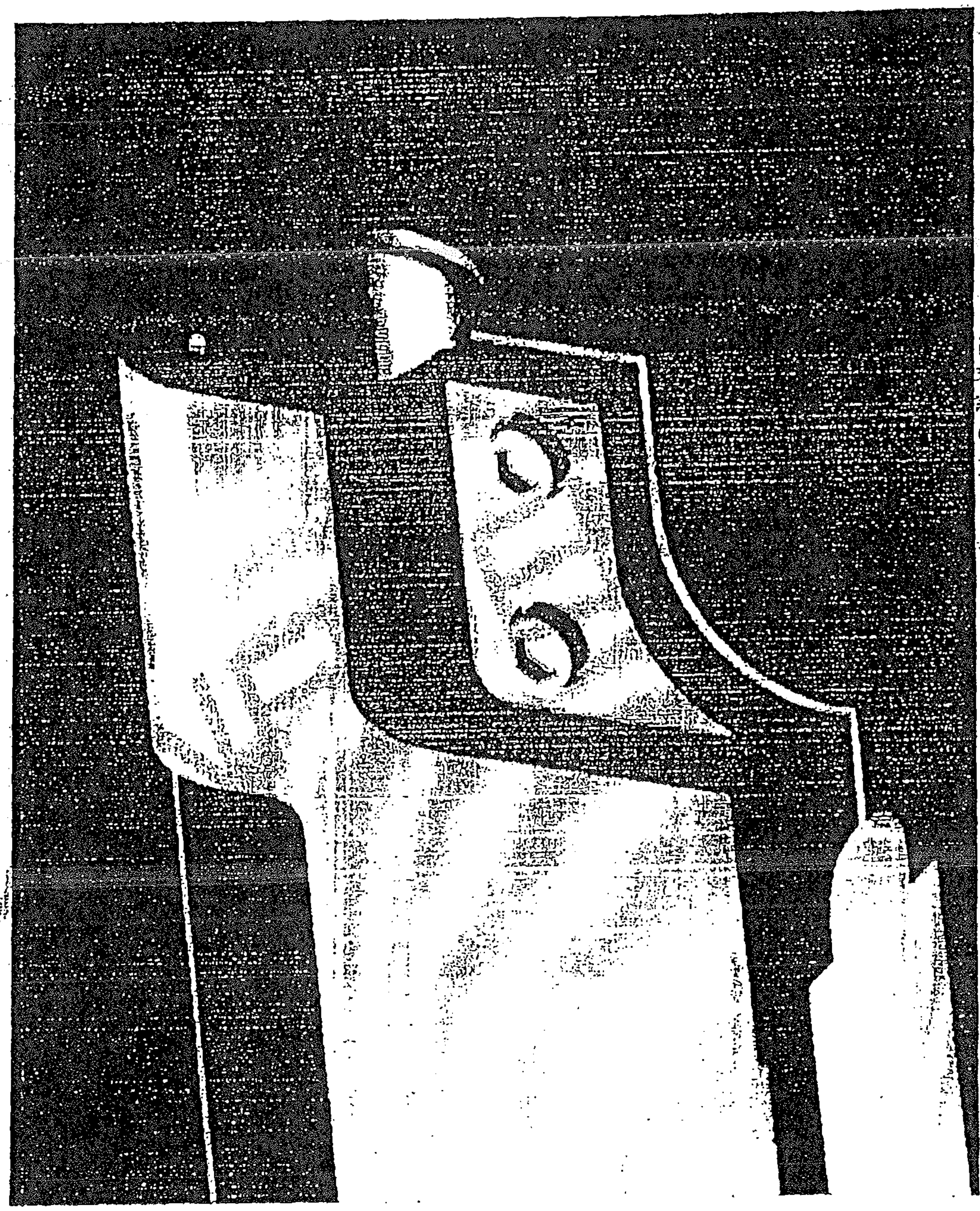

Figure 3. Investment Cast Receiver with Barrel Clamp

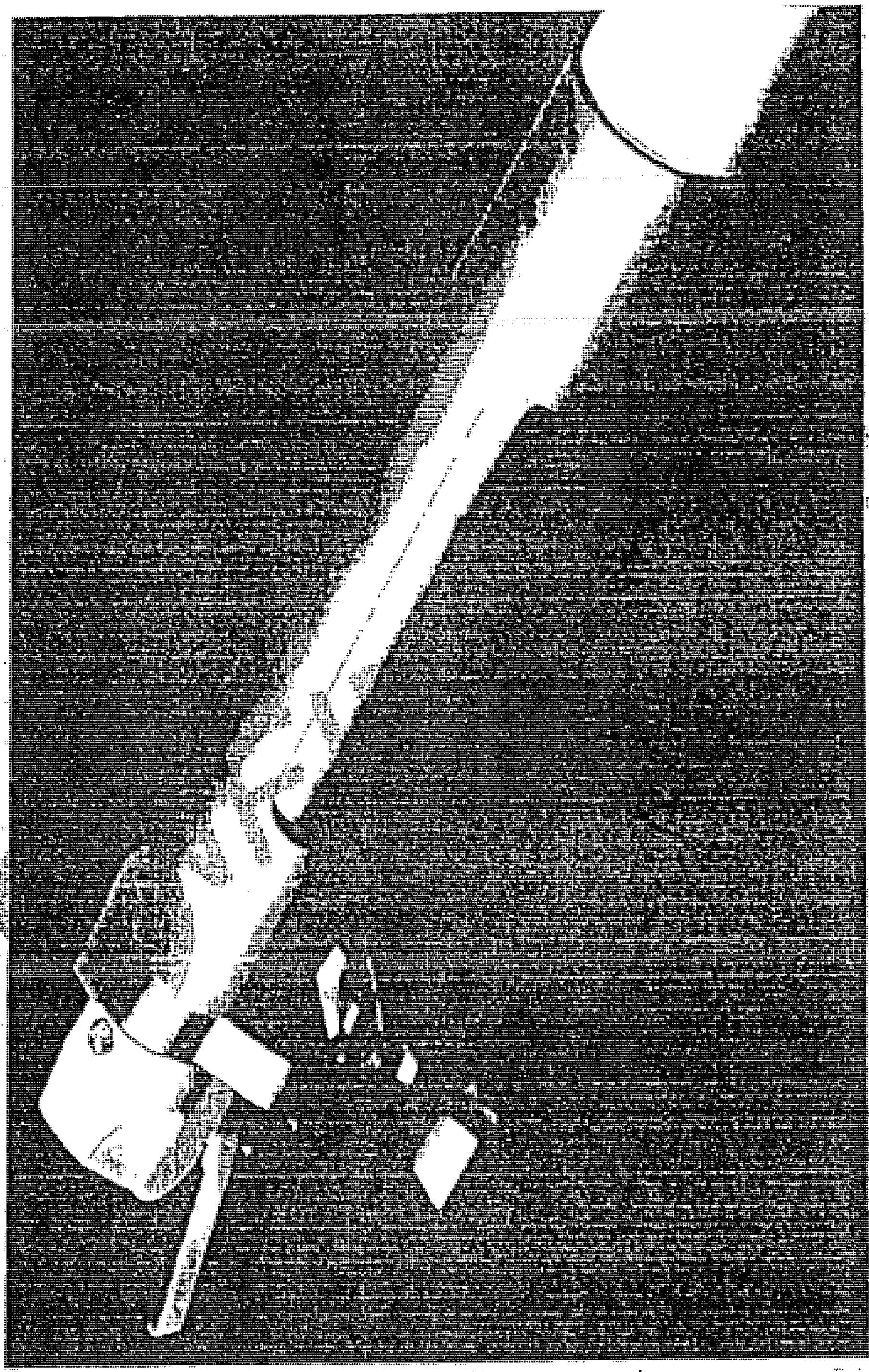

Figure 4. Extruded Tube Receiver
Isometric View

83

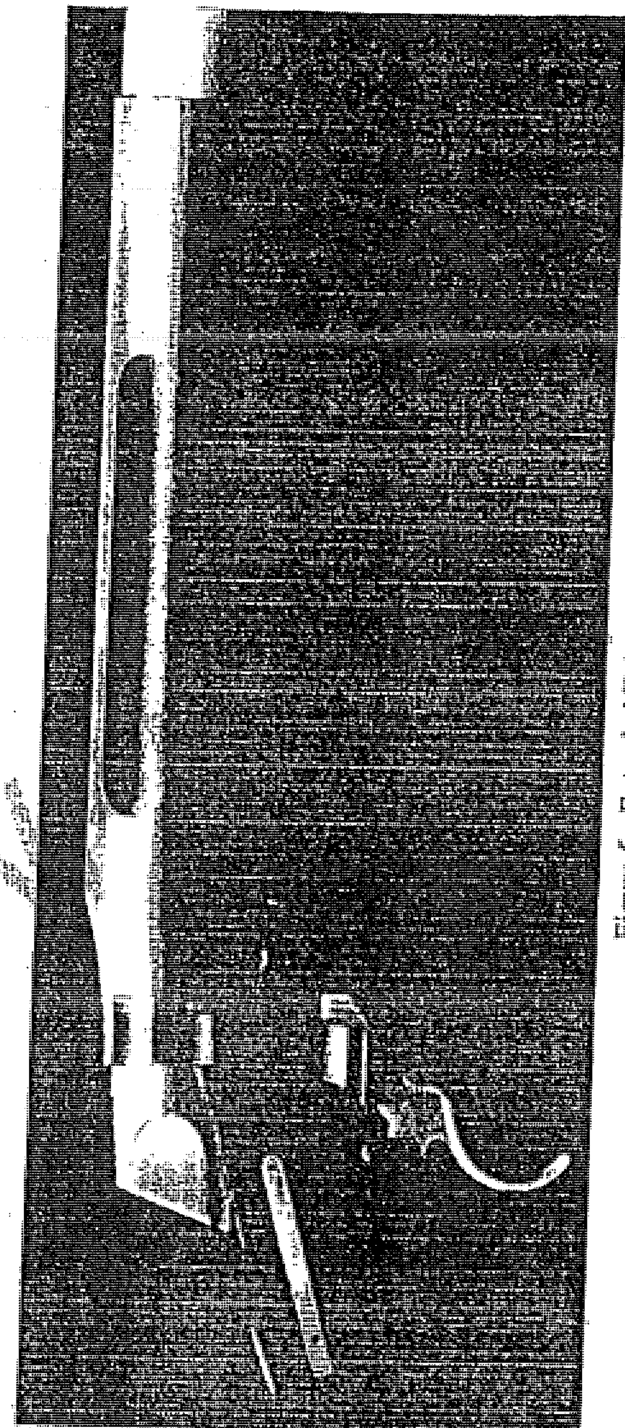

Figure 5. Extruded Tube Receiver
Side View

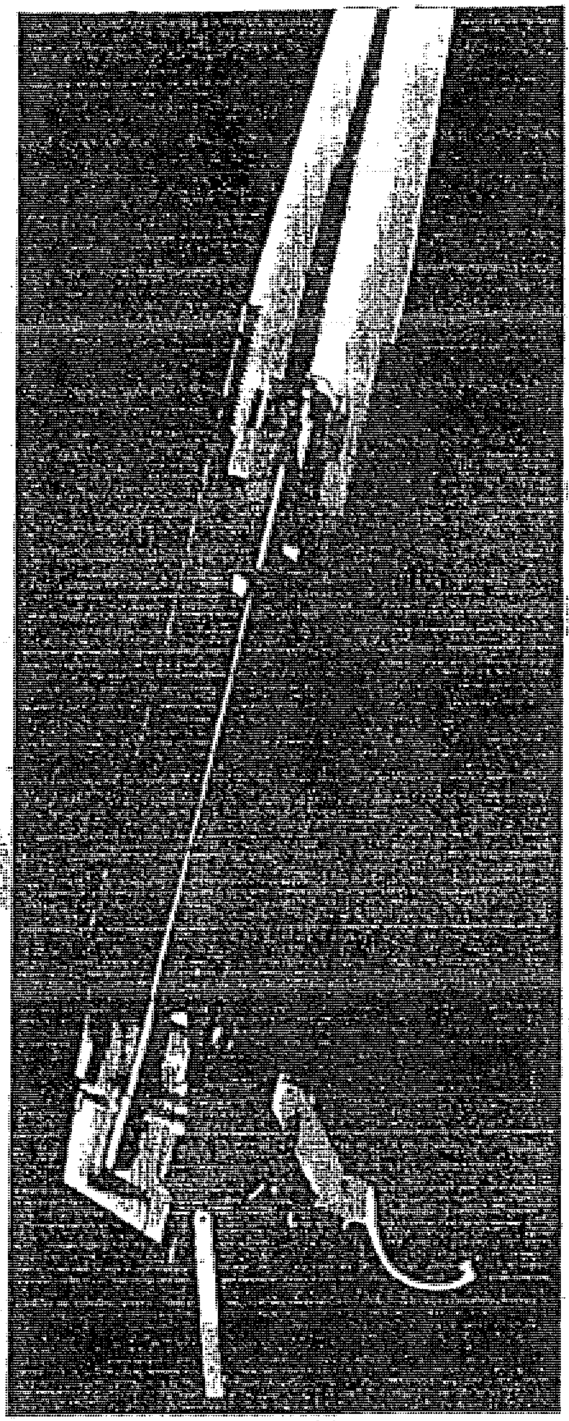

Figure 6. Cutaway of the Extruded Tube Assembly

83

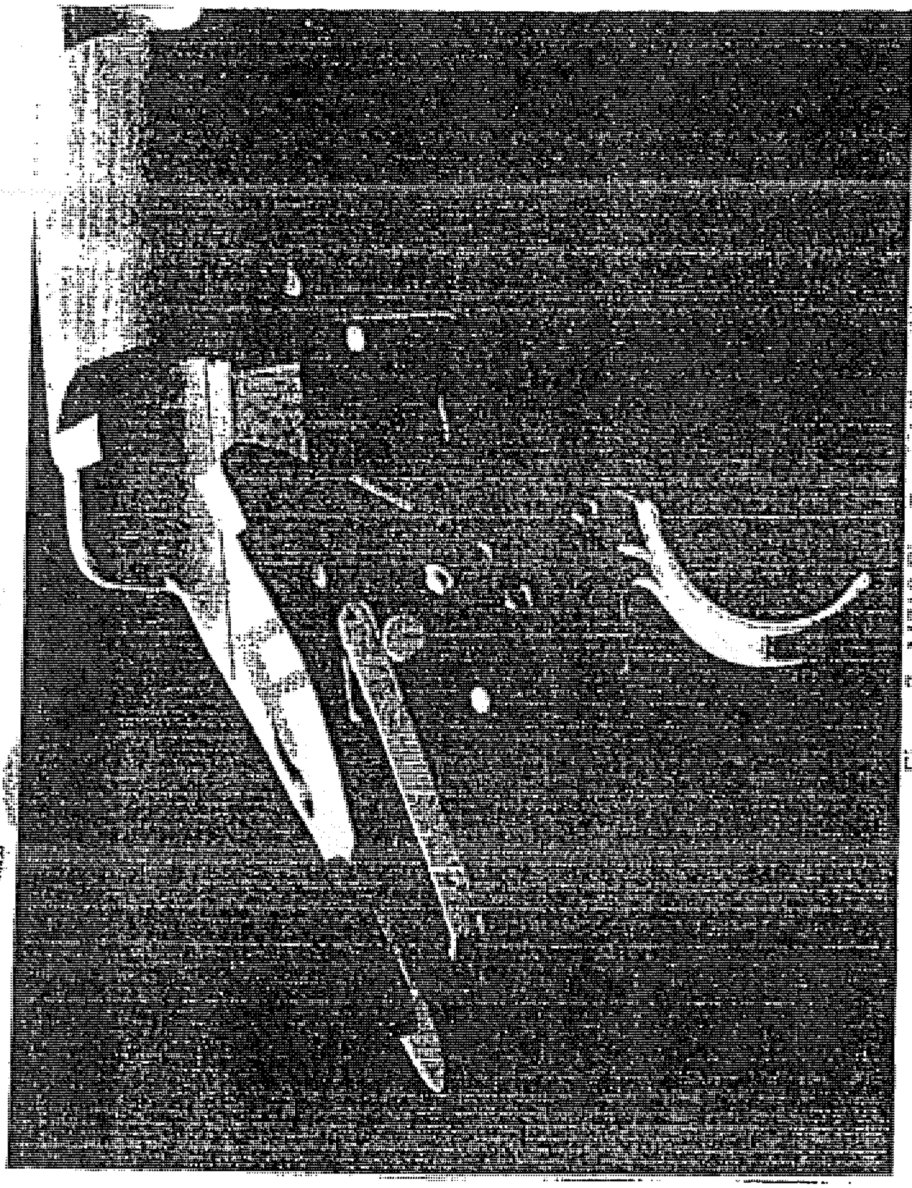

Figure 7. M710 Fire Control

83

ET00406

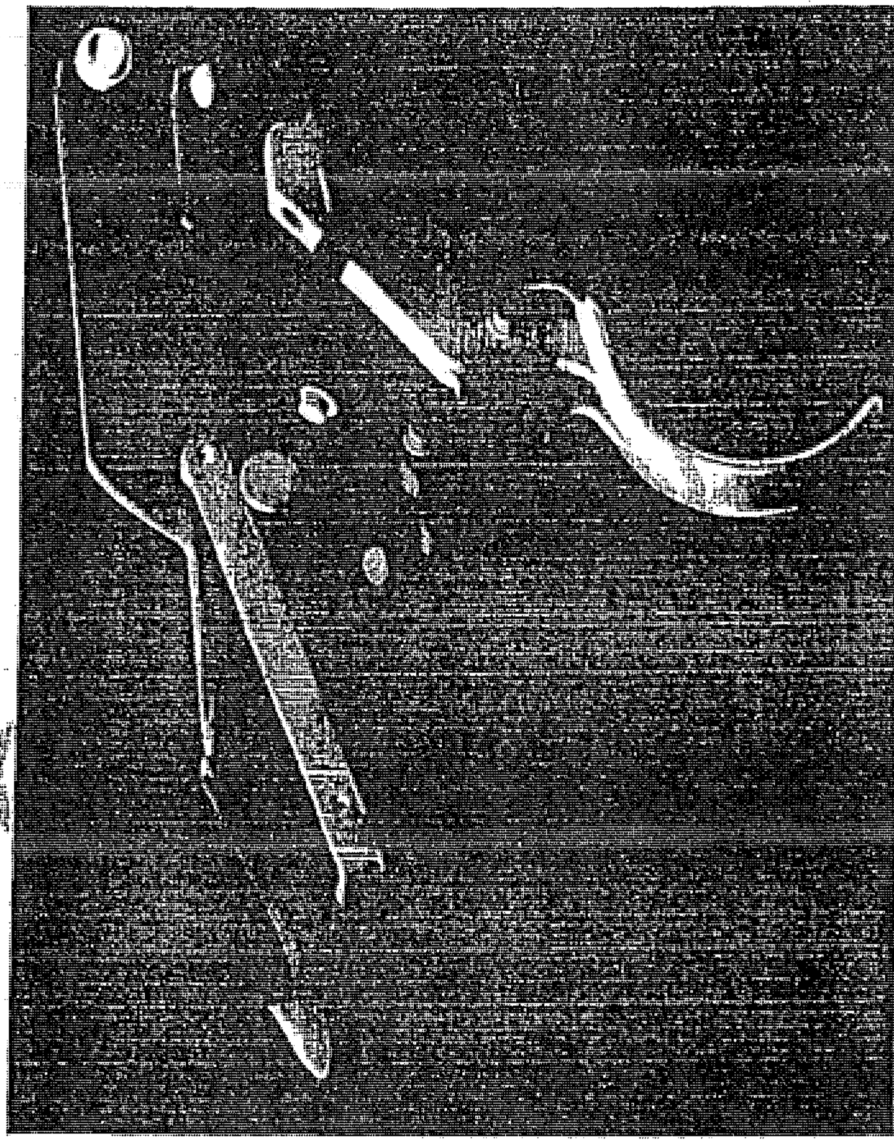

Figure 8. M710 Fire Control Cutaway

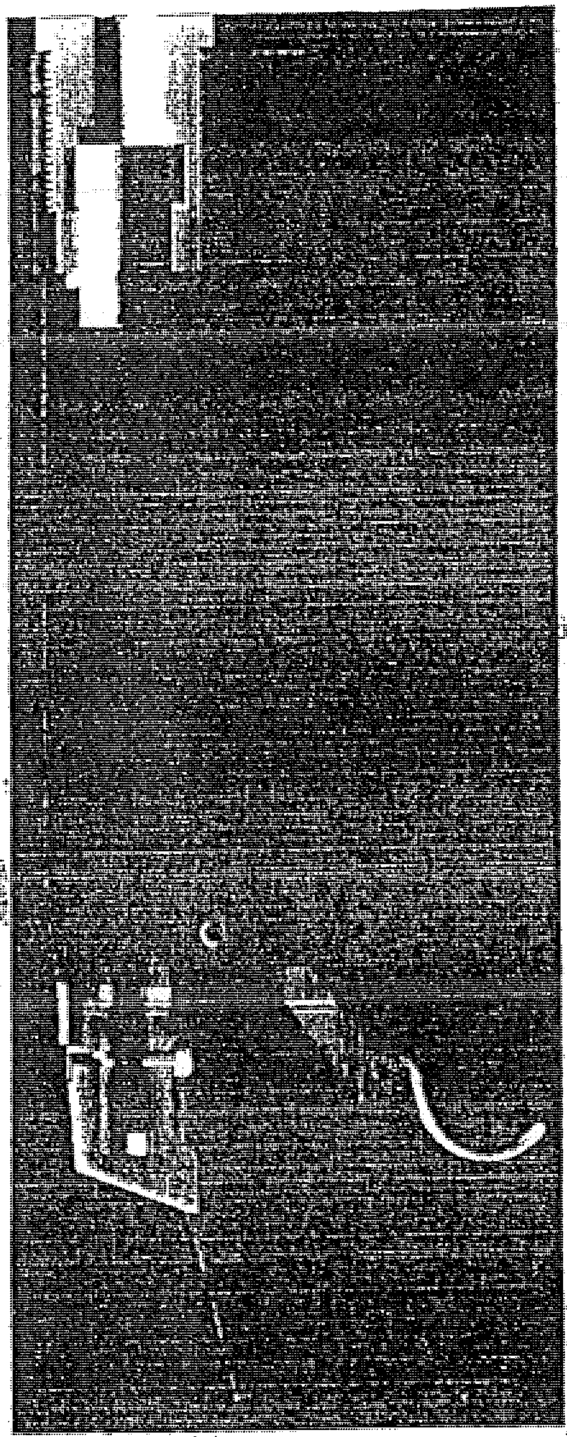

Figure 9. Investment Cast Receiver Cutaway

83

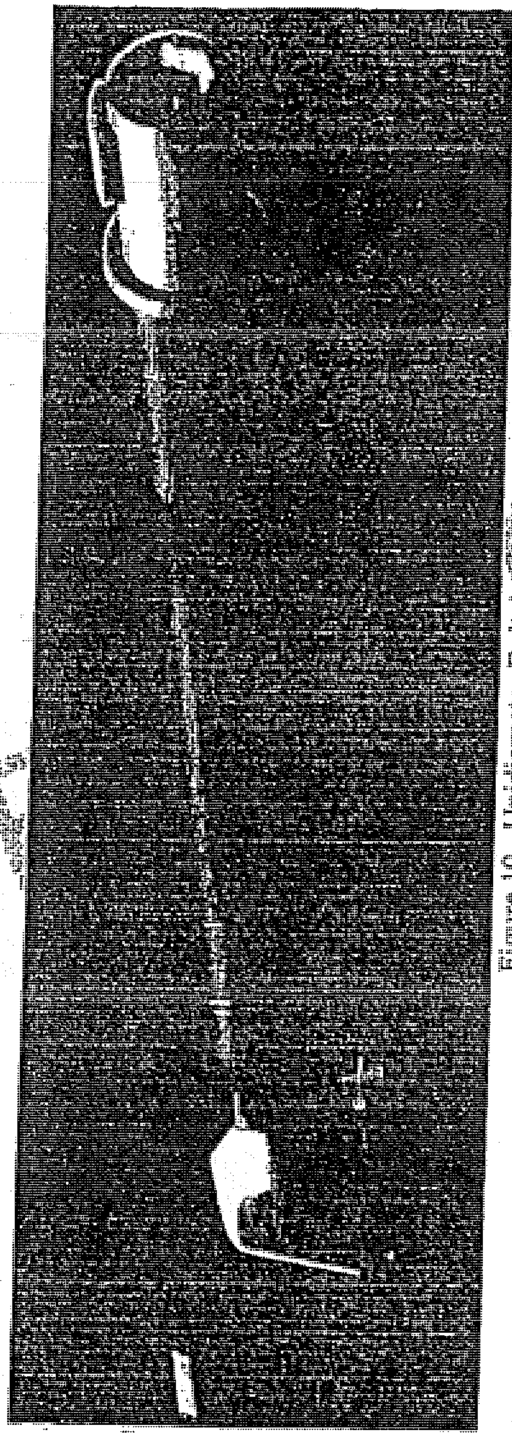

Figure 10. Unidiameter Bolt Assembly

83

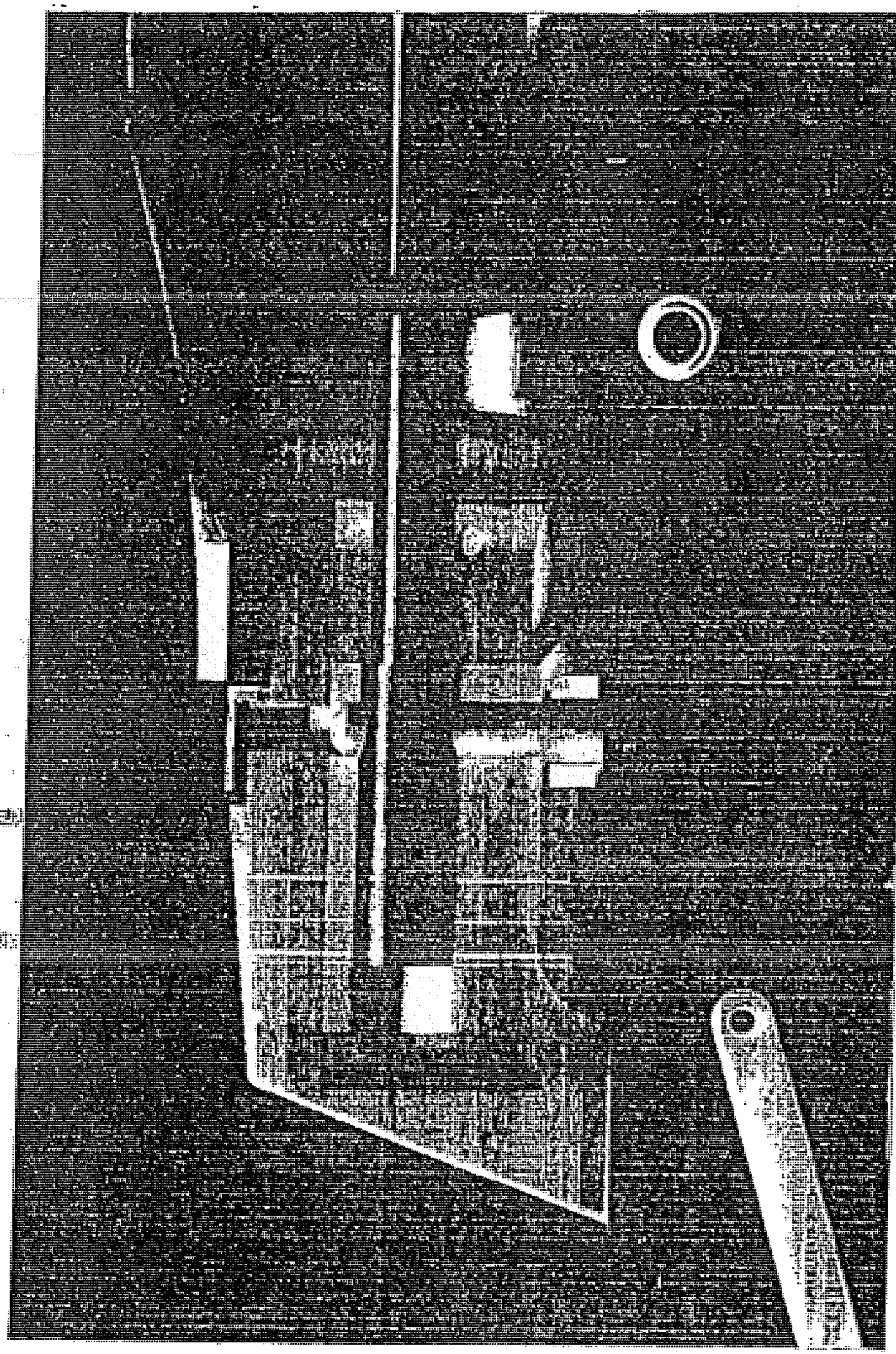

Figure 11. Firing Pin Head Assembly

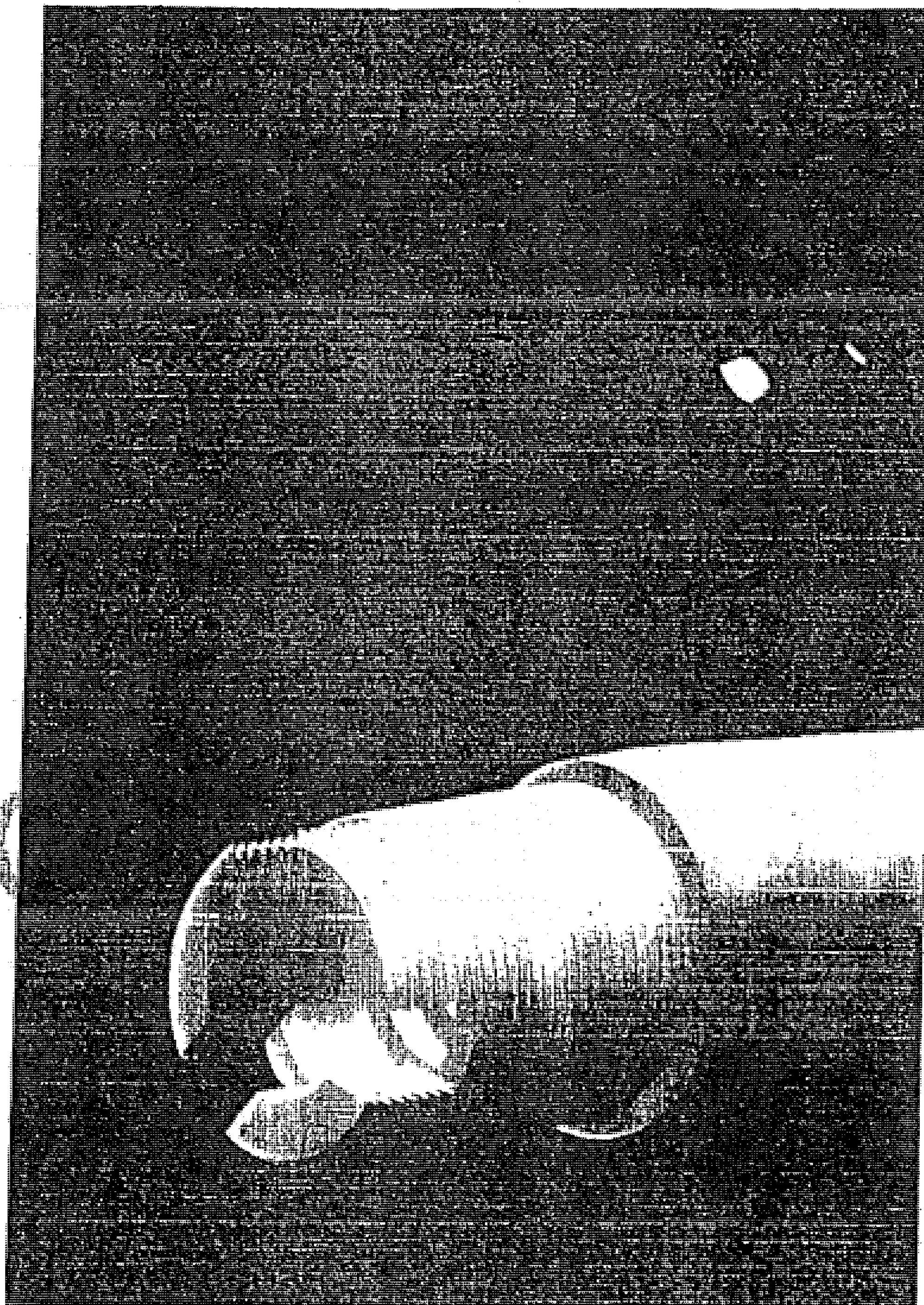

Figure 12. Three Lug Barrel Design

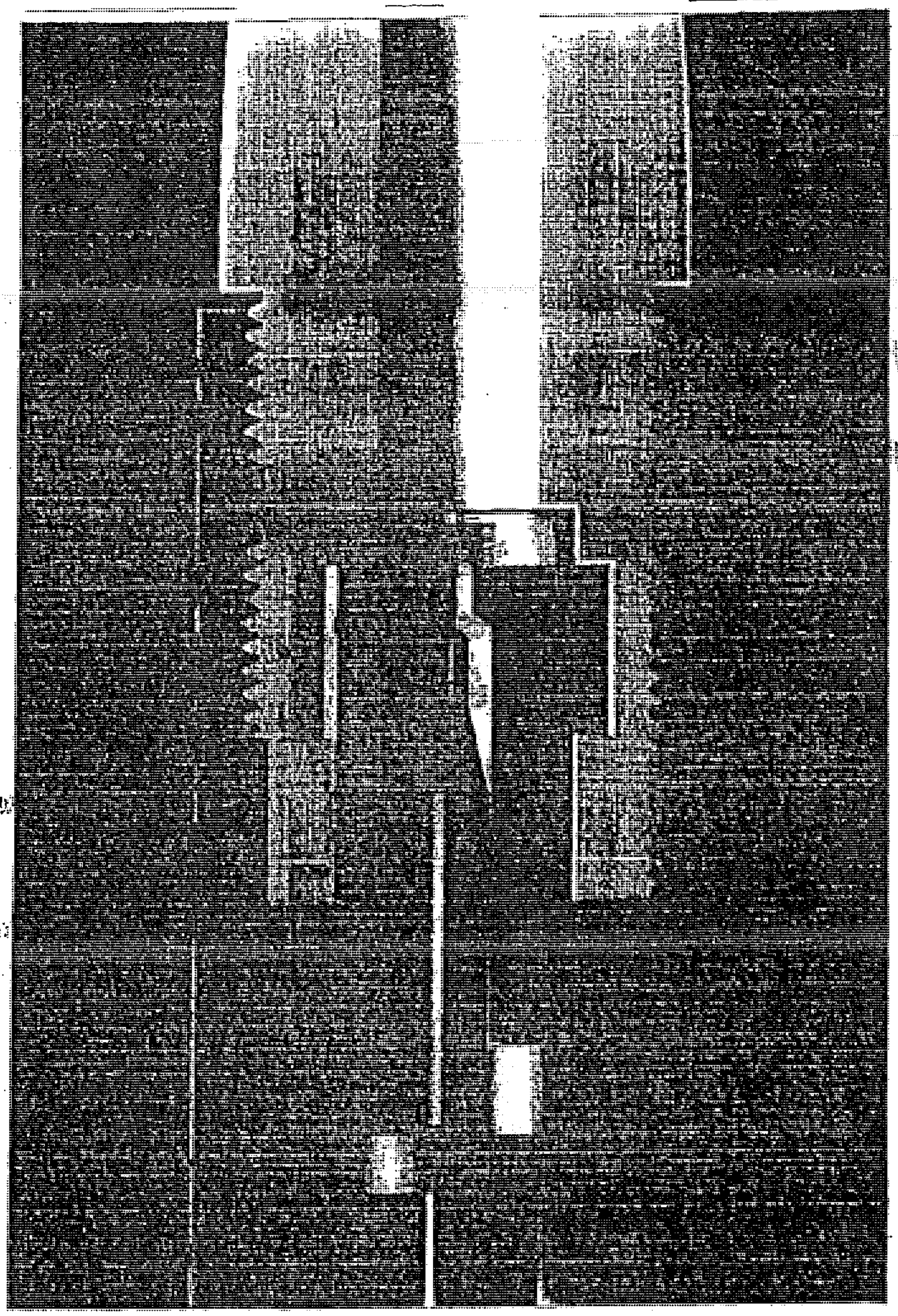

Figure 13. Bolt Head and Threaded Barrel Assembly

ET00412