Investment Casting in Barrel Manufacture of the Thunder Five

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ABSTRACT

The Thunder Five is a 45 Colt/.410 bore revolver manufactured by investment casting at Munitions International Laboratories Incorporated (MILI) located in Tennessee. This article explains in detail the manufacturing process of the Thunder Five including the production of the rifling by investment casting.

The Thunder Five (figure 1) is a five shot revolver designed to fire the .410 bore shotshell and the 45 Colt cartridge. One distinctive feature of this revolver is that the lands in the rifling have a semi-circular profile and stop before the end of the barrel. This is a result of the rifling being placed in the barrel by an investment casting procedure (figure 8). The Thunder Five is manufactured by Munitions International Laboratories Inc. (MILI) in Piney Flats, Tennessee, and the specifications are as follows:

Caliber	.45 Colt/.410 bore
Action	Single and Double
Capacity	5
Overall Length	9 inches
Cylinder Length	3.2 inches
Barrel Length	2 inches
Finish	Phosphate
Safeties	Transfer bar; manual hammer block
GRC	8 right

The revolver was first produced in 1991 by Munitions International Laboratories Inc., then referred to as MIL Inc., and marketed as the Spectre Five. Shortly thereafter, its name was changed to the Thunder Five. In 1998, ownership of Munitions International Laboratories Inc. changed hands and the company became known as MILI. When MILI took over manufacturing the Thunder Five in July of 1998, the serial numbers started at 0001, and as of September 2004, the serial numbers were in the 2800's (1). Serial number information was not available for firearms produced by MIL, Inc.; therefore the 11,000 or more revolvers which have been sold throughout the U.S. may not have a continuous range of serial numbers. In addition, MILI has produced special order firearms which have been given serial numbers using alpha numeric combinations that do not fall in consecutive order with the rest of the serial numbers.

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Company Background

MILI is a small operation with five employees working in two buildings. One building is designated for making the steel parts using the investment casting process and the other building is used for the assembly of the revolvers. Besides the Thunder Five, MILI has produced firearm parts under contract with several different companies including Ruger, Smith & Wesson, Charter Arms, and Walther. In the past MILI also produced firearm frames that included barrels with investment cast rifling to include North American Arms .22 mini-revolvers, of which they produced approximately 4000, and the Autauga .32 Auto pistol, of which they produced approximately 5000 (1). No further information about these two firearms was available from the MILI employees (1). In 2004, MILI was in the process of designing an automatic

Figure 1: Thunder Five

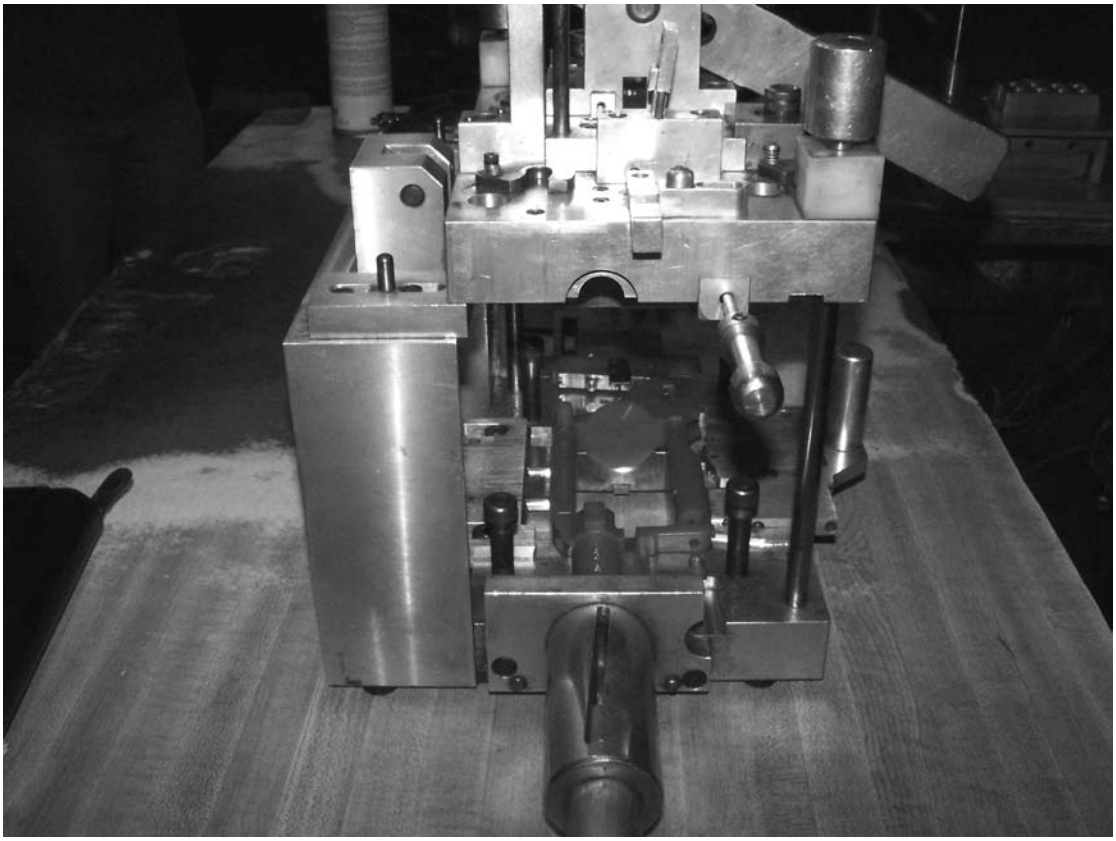
shotgun which has been demonstrated to multiple branches of the military. This shotgun, the AA-12, is a select fire, gas operated, 12 gauge shotgun which fires from an open bolt and is manufactured primarily using investment cast stainless steel parts.

Manufacturing Process

The Thunder Five is made predominately using investment casting. There are many other manufacturers, such as Sturm, Ruger and Company Incorporated, Winchester Repeating Arms Company, Colt Firearms Company, and Bauer Firearms Corporation who use investment casting for making firearm components (2). The investment casting process used by MILI, however, is unique because the casting process produces a rifled barrel. The rifling is not produced by a cutting or swaging method. There are other companies that manufacture barrels using investment casting, but no other manufacturers have been found that also produce the rifling during the investment casting process (2, 4).

In general, investment casting is a process in which wax is injected into a die forming a wax pattern, which is then attached to a tree or sprue. The tree is then dipped into a ceramic slurry and coated with sand to form a ceramic shell. After the wax is melted out, the ceramic shell is used as a mold to form the finished steel parts (2, 4). "The specific techniques utilized by different producers vary slightly but the principles shown are universal within the industry" (Chenow, pp. 64).

The manufacturing process of the Thunder Five starts out with the making of the wax model, using a mold (figure 2) consisting of two halves, the top of which slides down to meet with the bottom half with several pieces placed in the appropriate slots for the mold to function correctly. One of these pieces has eight pins attached to it which, when inserted into the mold, creates the holes in the frame through which the internal mechanisms are later attached. The part of the mold which creates the rifling in the barrel is a cylindrical steel insert with the negative image of the lands and grooves cut into it (figure 2). This piece is slid into the side of the mold, and when the mold is opened after the wax has been inserted, this mandrel is rotated and pulled out at the same time so that the rifling in the wax model will not get damaged. The cost of this particular mold was approximately $15,000 and it is the



Fugure 2: Mold

only mold that has been used to make the main frame of the Thunder Five (1).

The wax model of the frame is made by first spraying the mold with a specially formulated wax-release spray which makes removing the wax pieces easier. The mold is then closed and all of the attachments are set in place. The molten wax is forced through a nozzle into the mold for a pre-determined amount of time during which the mold is filled. The mold is then allowed to sit until the wax is cool. Once the wax has cooled sufficiently the mold is opened and the wax model is removed. The wax model is placed on a special metal cooling block the purpose of which is to ensure the cylinder window will retain the correct dimensions (figure 3). When the wax parts are completely cool they are mounted onto wax trees. The wax trees are also made using molds, just like the

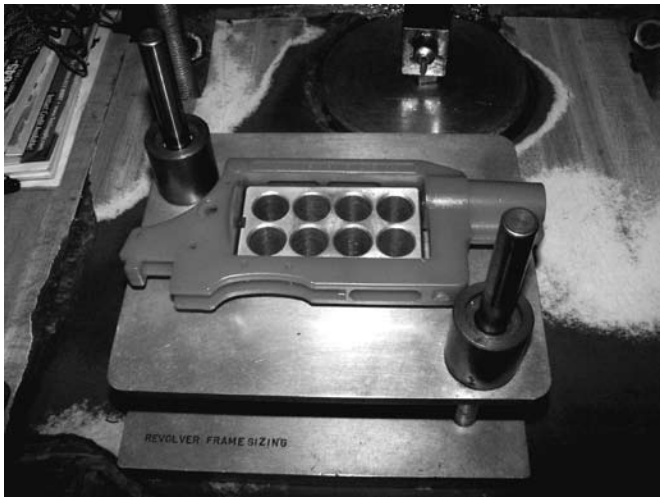


Figure 3: Cooling Block

other parts, and start out as long, narrow, tube-like structures that are squared off to create four sides. The trees are made completely out of wax with the exception of the metal hanger that is inserted through the top of the tree for the purpose of hanging the trees on racks. During the mounting process, only one type of part is mounted onto each tree and the size of the part determines how many parts will be mounted per tree. Only two frames can be mounted onto one tree, but there can be as many as forty parts mounted on a tree. The mounting process is very simple. A thin, metal spatula is heated for a few seconds using a basic heat source, such as an iron or hot plate, and then the hot spatula is placed against the wax tree to melt a small section of the wax. The wax part to be attached to the tree is placed on the section of melted wax and allowed to cool (figure 4) (1).

After the wax trees have been completed, the next step is to create a ceramic coating over the wax. The ceramic coating

Figure 4: Mounting Parts

is made by hand-dipping each tree into a slurry made from a mixture of silica components. Then each tree is coated with sand. There are two different types of slurries and two different types of sand used in this process. For the first step, the trees are dipped into a slurry mixture for 16-18 seconds and then, while they are still wet, coated with very fine zircon sand. The bucket of sand has a pedal attached to the base which, when pressed, sends compressed air up through the sand, blowing it onto the tree. After the trees have gone through the first step of the coating process they are hung on racks to dry (figure 5). The drying process takes about twelve hours and the trees must be completely dry before they can move on to the next step (1).

The second step is similar to the first step. The process repeats with the trees being dipped into the slurry mixture and then coated with sand, however this zircon sand is much coarser than what was used in the first step. During the second step

Figure 5: Trees Drying

the trees are dipped more than once. The size of the part mounted on the tree determines how many times the tree will be dipped, ranging from four to six times. The entire process entails the tree being dipped into the slurry, coated with sand, hung to dry for twelve hours, and these steps are repeated as many times as necessary until the tree is fully coated. After the ceramic coating has dried, the trees are put into a furnace to melt the wax and allow it to flow out of the ceramic mold. This leaves only the ceramic coating which will be used as a mold to form the steel parts of the Thunder Five. The molds rest on racks to dry for several days, or even weeks, before the steel is poured (1).

When the steel is ready to be poured, the ceramic trees are placed in a furnace which is heated up to 1800 degrees F. After heating the trees in the furnace, they are placed, one at a time, into a metal bin and the steel is poured into the molds. Typically only virgin steel is used, but occasionally the steel might be reused once. The factory generally pours steel once a week. On that day they can do 26 runs, or steel melts, at three to four trees per run (1).
When the steel has cooled, the ceramic coating is broken off leaving only the steel tree with its attached parts. At this point, the trees go into the saw room where the steel parts are broken off of the tree. The parts are cleaned, inspected, and any remaining ceramic is burned off using a caustic soda. The parts are then sent to an outside source for machining where four steps are completed. The first step is to cut off the gates, which are the areas where the parts were attached to the tree. The second step is to broach the cylinder gap, which is cast to be smaller than the final specifications, so the cylinder will fit. The third step is to heat-treat the breech face and lastly, the holes in the parts are drilled and tapped to create screw threads (1).

After all the machining is complete, the parts are sent back to MILI where they are sandblasted and the frame is serialized. The serial number of the Thunder Five is cut into the left side of the frame using a Computer Numerically Controlled (CNC) machine rather than roll stamped. After serializing, all of the parts are degreased and parkerized (1). The Parkerizing process creates a phosphate coating which turns the parts a dark grey/black color and gives the firearm a matte, rust-resistant finish (3). The firearm is then ready to be assembled. Several of the Thunder Five's components, including the cylinder, yoke, and firing pin, are machined by other companies (1).

Preliminary Examination of Test Fired Bullets

The primary concern for the firearms examiner is the fact that the rifling in the Thunder Five is produced by investment casting. Without any further research, there is no way to know whether or not rifling produced by this manufacturing process yields individual characteristics that will allow a firearm to be uniquely associated with a bullet fired through the barrel. It is possible that because each barrel is made by the same mold that similar microscopic features will be imparted to each barrel and on bullets fired through different barrels. It is also possible, and very probable, that the individual silicate grains could form a unique surface pattern on each ceramic mold which would then be imparted onto the final piece. The finishing processes applied to the steel frame might also help create a more unique surface inside the barrel.

During the tour at MILI, we were able to obtain several test fired specimens from two different Thunder Five revolvers, neither of which were new. The ammunition used for test firing consisted of 20 Speer brand cartridges with 250 grain jacketed hollow point bullets and 25 Remington brand cartridges with 250 grain lead round nose bullets, for each revolver. We were also able to obtain eight Thunder Five barrels from frames which had failed the quality assurance and quality control procedures in the rear portion of the frame. At our request, the finishing processes were completed on these eight barrels so that the barrels can be used to slug lead bullets through and be cast with Mikrosil to examine whether each barrel has individual characteristics.

In general, test fired bullets from the Thunder Five have poorly defined rifling. Several have deformities such as inconsistent land impressions, where one side of the bullet has light impressions and on the other side the impressions are so deep that some of the metal has been forced past the base of the bullet (figure 6). Although the rifling in the barrel has a right-hand twist, some of the test fired specimens have rifling which appears to be straight or even twisting slightly to the left. This uneven rifling most likely occurs because the bullet is not uniformly engaging the rifling due to the short barrel length and long cylinder length. The Thunder Five has an approximately 3.2 inch long cylinder in order to fit the .410 bore shotshell, the caliber of its original design. The rifling was added later to reduce the likelihood of the Thunder Five being classified as a sawed-off shotgun (1); therefore, when a 45 Colt cartridge is fired in this cylinder the bullet has approximately 1.6 inches of cylinder to travel through before it engages with the forcing cone (figure 7). During the bullet's travel down the cylinder, it may deviate from its axis so it enters the forcing cone at an angle instead of straight on. Additionally, the short barrel length does not allow the bullet much time to engage with the rifling and begin twisting uniformly.

Only a preliminary examination of the test fires has been conducted so far and further study will have to be performed

Figure 6: Test Fired Bullets

Figure 7: 45 Colt cartridge compared to Thunder Five cylinder

to conclude whether or not investment cast rifling produces unique markings inside each barrel.

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References

(1) Factory tour with Jerry Baber, owner of Munitions International Laboratories Inc., and Bill Mitchel, Piney Flats, TN, September 28-29, 2004.

(2) Chenow, Richard, and Lemmer, John, "The Use of Investment Casting in the Manufacture of Firearm Components," AFTE Journal, Vol. 26, No. 1, Jan. 1994, pp. 64-76.

(3) The Sporting Arms and Ammunition Manufacturer's Institute, http://www.saami.org/glossary/index.cfm., Accessed December 30, 2005 [online].

(4) Ruger Investment Casting, http:www.ruger-firearms.com/Casting/Tech-Process.html, Accessed January 12, 2006 [online].

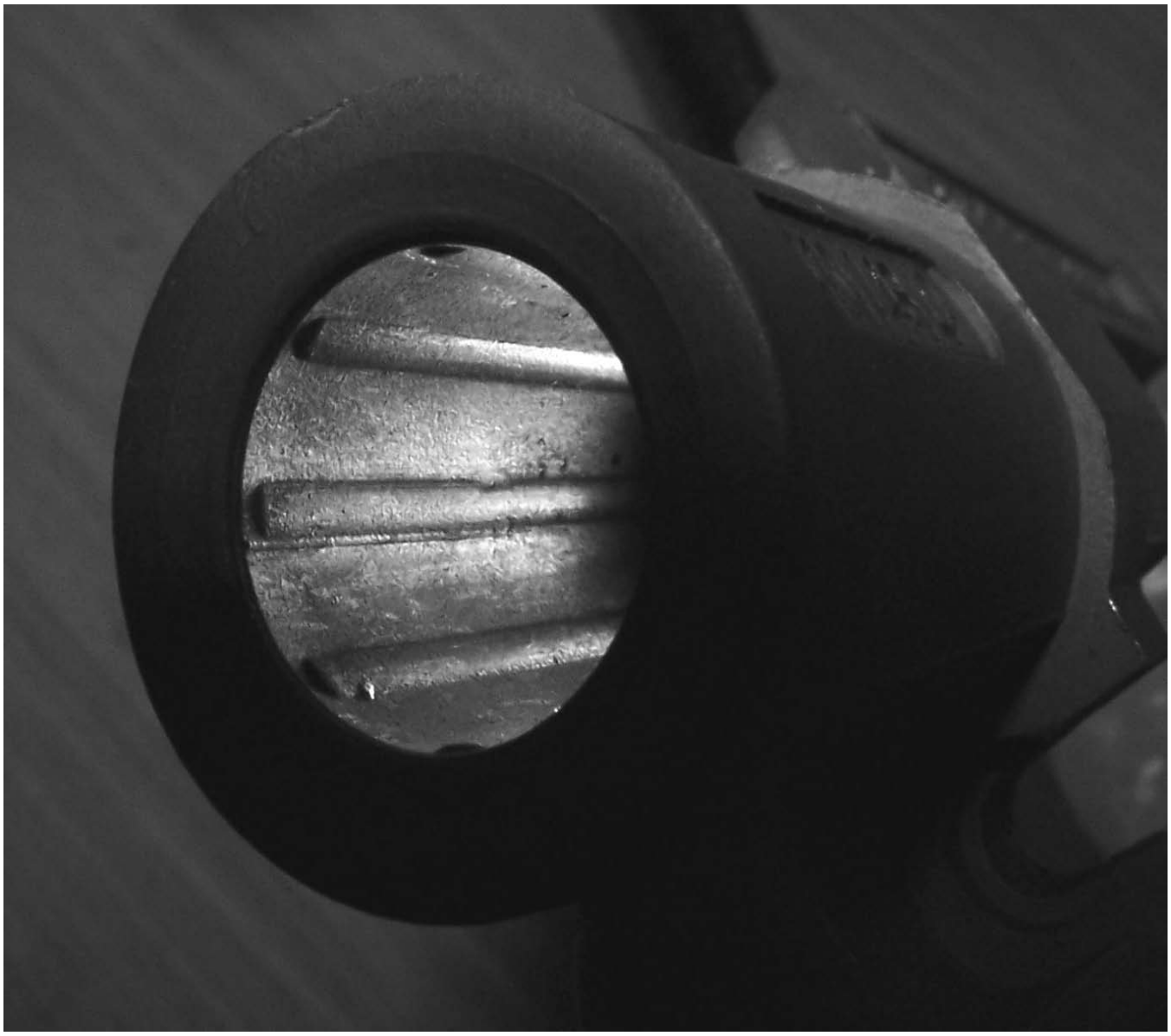

Figure 8: Rifling of the Thunder Five