### *SUU-13/A Canister Development*

Regardless of the specific Gyrojet or delay fuse type, a system for transporting and delivering the rockets in large numbers was required. The system MBA developed was a thin metal canister compatible with the existing SUU-13/A aircraft dispenser. The U.S. military used three types of submunitions dispensers in Vietnam; the SUU-7/A, the SUU-13/A, and the SUU-14/A. "SUU" stands for "Stores Suspension and Release Unit Universal." The SUU-13/A was a dispenser in the form of a rectangular box with rounded fairings at both ends. It ejected its submunitions straight down from 40 holes in the bottom of the box.

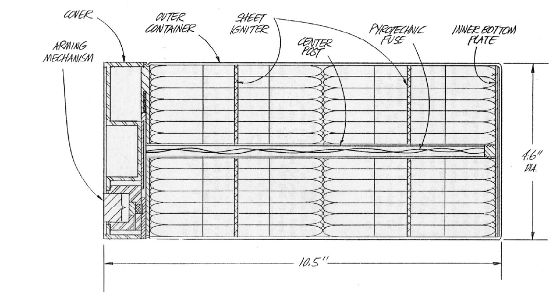



Fig. 9–28. *.30-caliber delay-fuse Gyrojet canister. MB-*

### *.30-Caliber Delay-Fuse Gyrojets*

This remainder of this chapter is about .30-caliber Gyrojets developed from 1963 to 1965 by MBA, initially as a company-financed in-house project. The concept was to use pyrotechnic delay fuses to fire volleys of up to 24,000 Gyrojets, which had been ejected from canisters dropped from low-flying aircraft in Vietnam. As the canisters filled with Gyrojets fell from the aircraft, a simultaneous ignition of all delay fuses was initiated by burning sheet igniters, which also over-pressurized the thin metal canisters, bursting them and scattering the Gyrojets into the air. The sheet igniters were lighted by devices that activated when the canisters were expelled from the aircraft dispenser. The Gyrojets fell to the ground with their fuses burning, and after a short delay, fired en masse.

In November 1981, after MBA had been acquired by Tracor, Inc. of Austin, Texas, Mainhardt recommended in an internal memo that consideration be given to reviving the project as a possible business area for Tracor/MBA San Ramon, an idea that Tracor management declined to pursue.

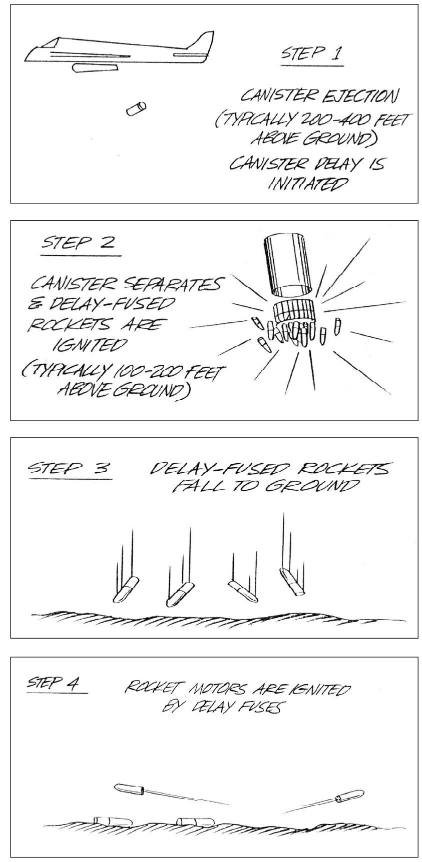



Fig. 9–7. *.30-caliber delay-fuse Gyrojet and canister functioning concept. MB-65.*

In January 1964, MBA submitted a proposal based on this concept to the U.S. Air Force Systems Command. The company's proposal was accepted, and contract number AF 08(635)-4211 was awarded to MBA by the Directorate of Armament Development, RTD, Weapons Division (ATWW), Eglin Air Force Base, Florida. The contract called for MBA to explore the feasibility of using small-caliber, delay-fuse Gyrojets delivered by low-flying aircraft as antipersonnel weapons in Vietnam. Enemy soldiers could sometimes protect themselves under cover from bullets fired from above, but the delay-fuse rounds would fire *horizontally* or even *up* from the ground. In July 1965, MBA published its Confidential final report on the project as document number MB-65/156, which was declassified in January 1973. The report was titled *Development and Demonstration of an Aircraft-Dispensed Antipersonnel Munition Using Delay-Fused Gyrojets.*

MBA used rolled cotton wicking in its first delay-fuse design. An empty .30-caliber nozzle primer pocket was filled with a primer mix, and a pyrotechnic fuse was positioned from the flash hole forward through the propellant grain's perforation to the Gyrojet's nose. A $BKNO_3$ igniter pellet was placed in the nose. When the primer mix was ignited by the burning cotton wicking delay fuse, it lit the internal fuse. The internal fuse transmitted fire to the igniter pellet, which then pressurized the case and ignited the Gyrojet's propellant grain.

The rolled cotton wicking, with sensitive pyrotechnic mixes applied at each end, was held in place against the cartridge nozzle and primer mix by a nichrome (alloy of 80 percent nickel and 20 percent chromium with a high melting point) heat-resistant wire loop inserted through the end of the fuse. The ends of the nichrome wire were secured in the case cannelure by a piece of waxed cord.

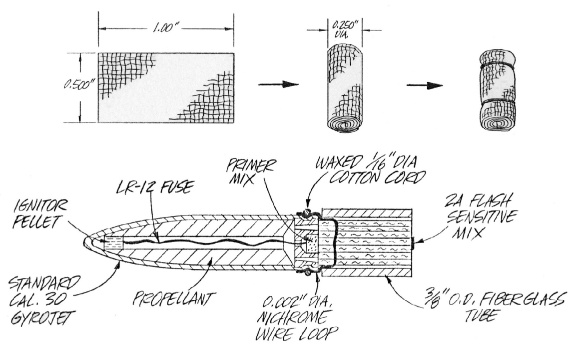



Fig. 9–8. *.30-caliber cotton wicking delay-fuse Gyrojet, first design. MB-65.*

The cotton-wicking delay fuse was ignited by a small pellet of flash mix, and was covered by a fiberglass tube to protect it against mechanical shock as the Gyrojet struck the ground. The tube also insulated the delay fuse, preventing it from transferring heat to the surface on which it was resting. Experiments showed that such a heat transfer away from a slowly burning fuse was the primary cause of premature fuse burnout and system failure.

As production of the delay-fuse cartridge increased, the cotton-wicking fuse was replaced with lengths of nitrocellulose-impregnated cotton cord, which was easier to produce than rolling and tying off sections of cotton wicking. Pieces of off-the-shelf cotton cord were simply cut to length and chemically treated.

Although burn rates of up to 20 minutes per inch were obtained with this fuse, reliability and reproducibility were poor and the correct mix of chemicals was elusive. The fuses would burn well enough under tightly controlled conditions, but they were too sensitive to temperature and humidity. Various oxidizers were used in the fuses in an attempt to decrease their sensitivity, but these efforts were unsuccessful. The fuses lay on the ground while they were burning, and heat loss from the fuse to the underlying ground they were in contact with was the major problem, in spite of the use of various fuse coverings such as waxed fiberglass cloth. One attempt to solve the heat transfer problem was made by using a finned standoff to prevent the fuse's contact with any surface, but this proved to be impractical.

In addition, the steel Gyrojet cases acted as heat sinks as the fuses burned. In an effort to solve this problem, tests of Gyrojets with their delay fuses attached by a nylon cup with a small section inserted into the primer pocket were conducted. The nylon cup served both as a means of fuse attachment and as an insulator.

Drop tests of 26 dummy Gyrojets with nylon cups and live delay fuses attached were conducted from a canister positioned under a balloon 150 feet above the ground. Nine fuses separated from their Gyrojets on ground impact, and 25 of the fuses burned out early. The obvious conclusion reached was that the delay fuses had to be more firmly attached and less sensitive to their environment.

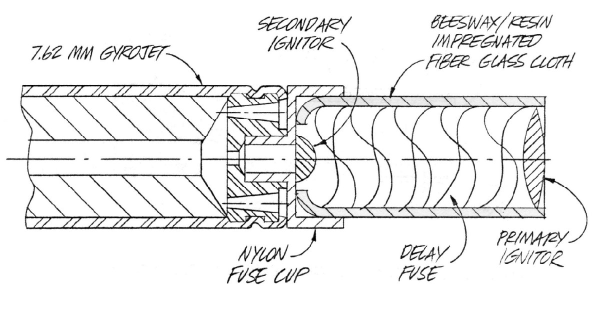



Fig. 9–9. *.30-caliber delay-fuse Gyrojet with nylon cup attachment. MB-65.*

All of the various delay fuses considered during the project had the same basic design criteria, which included an individual delay system that cost no more than a single Gyrojet. The delay fuse had to be fail-safe. It had to either ignite its Gyrojet or fail completely, so that after a period of time it absolutely would not fire the Gyrojet. Reliability had to remain high under adverse environmental conditions including shock, temperature, and humidity. Weight and volume also had to be kept to a minimum.

One company made its pyrotechnic delay fuse available to MBA for testing. Burn rates of 8 to 10 minutes per inch were obtained from this fuse. However, burn times and reliability were adversely affected when various coverings such as fiberglass tape, PVC, or latex were applied to the fuses to insulate them and prevent damage. In addition, the burning front of this fuse did not stay in contact with the unburned part of the fuse during severe ground impact conditions.

Another fuse was supplied by a second firm, but it proved to be unreliable in high humidity. Its burn rate was about 3 minutes per inch. Since it had no advantage over the first fuse, it was also rejected. Other concepts that were tested and rejected included a heat transfer delay fuse, an evaporative delay fuse, and a hypergolic delay system.

During this period, there were a number of mechanical delay fuses available that had been accepted by the military, including the XM218, which had a variable delay of zero to 90 minutes after ground impact. Its size and weight were compatible with the .30-caliber Gyrojets but its $1.50 cost was prohibitive. It would have had to ignite about 20 Gyrojets to be cost effective.

Chemical delay systems investigated included pyrotechnic, corrosion, electromechanical, and solvent action designs. Corrosion and solvent devices could extend delays to days, weeks, or months. Pyrotechnic delay fuses were an inexpensive solution and could provide delays of 20 minutes or less. They had excellent resistance to physical abuse, a smaller size, and required less maintenance than chemical or mechanical systems. Pyrotechnic fuses were able to withstand the severe mechanical shock of ground impact at falling velocities of 70 to 100 fps. They were able to withstand exposure to high velocity air streams of up to 600 fps when they were air launched. They functioned reliably in the hot, humid conditions typical of Southeast Asia. In addition, they were low in cost, small in size, and had no maintenance requirements. They were simple, with no moving parts, and easy to fabricate in the quantities required. The simultaneous ignition of large numbers of pyrotechnic fuses was relatively easy. They had long storage lives under proper conditions and their delay times could be varied by altering their composition or configuration.

Pyrotechnic fuses also had disadvantages. Their burn rate was somewhat temperature dependent, with variations as large as 25 percent. Great care had to be taken during material preparation since burn rates and reliability were sensitive to particle size, mixing, heat sinks, surface and volume (cracks, density, voids, etc.), venting, contact with atmospheric oxygen, and specific chemical composition.

Because the advantages of pyrotechnic fuses far outweighed their disadvantages, they were selected for the .30-caliber delay-fuse Gyrojet. Two specific pyrotechnic systems were developed; one with a delay time measured in minutes, and the other with a delay time measured in seconds. The longer delay time proved to be significantly more difficult to achieve than the shorter and it was ultimately rejected.

### *Mark I Development*

Once the decision to use a pyrotechnic delay fuse was made, and in anticipation of large quantities of Gyrojets being required for testing and subsequent large-scale production, MBA began development of a new Gyrojet design that would simplify manufacture and reduce costs. The .30-caliber rocket proved to be an effective size during early tests, and MBA had prior experience in the manufacture of this round using bullet jackets provided by Speer. However, while the .30-caliber was retained, the pointed spitzer-type bullet jacket with its good long-range accuracy was not required for the delay-fuse Gyrojet's shorter range. A bullet jacket with a blunter, more rounded ogive was selected, in part to increase space for a larger propellant grain to produce a higher velocity, and to reduce costs by reducing the number of steps required to manufacture it. The new case design was possibly just a .30-caliber draw piece taken from the manufacturing line prior to the spitzer ogive being formed. I have not been able to verify this, and Mainhardt did not remember.

The earlier spitzer-nose .30-caliber Gyrojet used a machined steel nozzle that was costly and extremely difficult to manufacture. It had a tiny 0.075-inch-diameter primer pocket with a step inside to index its copper or brass percussion primer. The bottom of the pocket was tapered, and had a flash hole with a 0.010-inch diameter. The nozzle also had four angled and tapered ports, each of which had to be individually drilled on a fixture using very expensive custom bits, which frequently broke. This nozzle was replaced in the delay-fuse Gyrojet by a simple stamped version. The new .30-caliber Gyrojet was called the Mark I and it was designed for high velocity.

The Mark I used an extruded double-base propellant grain with an outer diameter of 0.260 inch (6.6mm). Its longitudinal central perforation had a diameter of 0.125 inch (3.2mm) and a length of 0.920 inch (23.4mm). The grain *burned on all of its surfaces simultaneously*, unlike most other Gyrojet grains which burned only from the inside of the perforation.

At the start of the burn, gas flow from the outer grain surface went forward toward the nose then back through the perforation, in part because of the tight fit between the rear of the grain and the first cannelure rolled in the case. As the grain continued to burn, it probably broke into long segments due to the centrifugal force caused by the high spin rate. The burn time of the grain was about 0.035 second, during which time the Gyrojet accelerated to 1,800 fps, producing a loud supersonic crack.

Mark I cases were deep-drawn from cold-rolled steel cups in eight draws, and were annealed and plated with gilding metal after the second draw. The first Mark I case had an outside diameter of 0.308 inch (7.8mm) and uniform case walls .036 inch (0.9mm) thick. The inside of the case was a cylinder, with the same 0.272-inch (6.9mm) inside diameter from front to rear. This case was soon replaced with one that had a tapered inside diameter of 0.272 inch at the rear of the case to 0.268 inch (6.8mm) at the front where the ogive began. The taper made it easier to remove drawing tools between manufacturing steps, reducing breakage and cost. It also improved case concentricity.

Stress in the cases due to internal gas pressure created by burning propellant was approximately 13,500 psi. At their maximum velocity of 1,800 fps, the Gyrojets spun at 216,000 rpm, creating an additional hoop stress caused by centrifugal force of approximately 6,800 psi. Since the yield strength for the steel used was over 50,000 psi, the design that resulted in about 20,300 psi of total stress was considered by MBA to be conservative, with a large safety margin built in.

Figure 9–11. *.30-caliber Mark I Gyrojet with no delay fuse attached. Actual size.*

Nozzles were made from cold-rolled steel strips 0.050 inch thick. Thinner nozzles could not withstand the heat load. During manufacture, four ports (rectangular holes) were punched into a strip of rolled-steel sheet in a circular pattern 90 degrees apart. The tapered, wedge-shaped punches left angled tangs on the inside of the nozzle to deflect burning gases and cause the Gyrojet to spin. Nozzle discs, sized to fit the inside of the Gyrojet base, were then punched from the strip with the punching tool indexed on the ports in order to minimize thrust misalignment. A 0.034-inch hole was then drilled in the center of the nozzle to receive a 0.035-inch-diameter finishing nail, which was inserted from the inside of the nozzle.

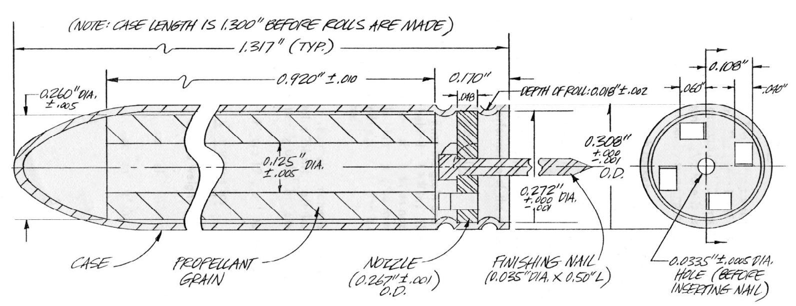



Fig. 9–10. *Mark I Gyrojet, without delay fuse installed. MB-65.*

Fig. 9–12. *Mark I nozzles, front and back. 3x actual size.*

This simple 0.50-inch-long finishing nail was used to attach the pyrotechnic delay fuse to the nozzle. Collectors sometimes mistake this nail protruding from the nozzle as some sort of electric primer terminal because no other primer is obvious in the loaded rocket without its delay fuse attached. Finally, the nozzle was covered inside and out, and especially in the ports, by dipping it in a liquid fire-transmitting compound (specific type unknown). This clear compound transmitted fire from the burning delay fuse through the ports, lighting the propellant grain igniter, which then pressurized the case and ignited the propellant grain itself.

The igniter, which was placed inside the propellant grain's central perforation, replaced the small igniter pellet in the earlier Gyrojet's nose. It was a liquid rocket ignition compound applied to a piece of flexible, porous paper such as a Kimwipe® or Kleenex® by spraying or dipping. The paper was about 1.0 inch long and 0.25 inch wide. After treatment and drying, it was rolled or folded lengthwise and inserted into the propellant grain's perforation. This method of second fire in Gyrojets was used extensively by MBA in other rockets, and it was very reliable.

To assemble a Gyrojet, a propellant grain with its igniter was inserted into a case. Then a cannelure 0.018 inch deep was rolled in the case behind the propellant grain to secure it and to provide a ring on which to position the nozzle. A nozzle with its finishing nail installed was then inserted into the case against the cannelure and a second cannelure was rolled in the case behind the nozzle to hold it in place.

The weight of the Mark I Gyrojet without a delay fuse attached was 60.2 grains (3.9 grams). The propellant weighed 14.7 grains, so the burnout weight of the Gyrojet was 45.5 grains. This resulted in a 45.5-grain "bullet" traveling at approximately 1,800 fps. This velocity was achieved in a distance of 20 feet, and it decreased to 900 fps in 160 yards. The rockets produced an average of 13 pounds of thrust, resulting in an initial thrust-to-weight ratio of 1,500 to one, i.e., the rocket produced a thrust 1,500 times its weight, but for just 0.035 second.

During testing of 200 Gyrojets of this design, no failures were observed at temperatures between -30 to +160 degrees F. One lot produced velocities of 1,780 fps. Storage for extended periods at temperatures up to 120 degrees F and in high humidity presented no reliability problems, and was a major factor in the design's adoption.

These Gyrojets were not accurate. They didn't need to be since they were intended to be scattered in large groups of up to 24,000 (40 canisters of 600 Gyrojets each) and fired in random directions. However, during testing, accuracy was measured by firing the Gyrojets from an 8-inch steel launch tube with a .310-inch inside diameter. As was typical during MBA testing of Gyrojets from launch fixtures, a 1-pound hold down weight was applied to restrain the Gyrojet after ignition until sufficient thrust had built up for a clean launch. The distance to the target was 32 feet. Five Gyrojets with nails installed were fired, and they all impacted inside a 28-inch-diameter circle. Three Gyrojets without nails were then fired and they impacted inside a 24-inch-diameter circle. Interestingly, the pattern formed was circular with all impacts being inside the 28-inch circle and zero impacts inside a concentric 20-inch circle. In other words, the pattern was like a doughnut, with no hits inside the hole.

### *Long-Delay Fuse Development*

The Mark I Gyrojet was used in the development of a long-delay fuse. The advantage of a long-delay fuse was that Gyrojets could be scattered on the ground in an area of enemy activity and remain in place for a relatively long period of time before firing. It was hoped that this delay might lull the enemy into a false sense of security as the aircraft that deployed the Gyrojets disappeared with no apparent danger. In time, the Gyrojets would fire, confusing the enemy with their supersonic cracks that sounded like small arms fire in an ambush, and simultaneously inflicting wounds in the process.

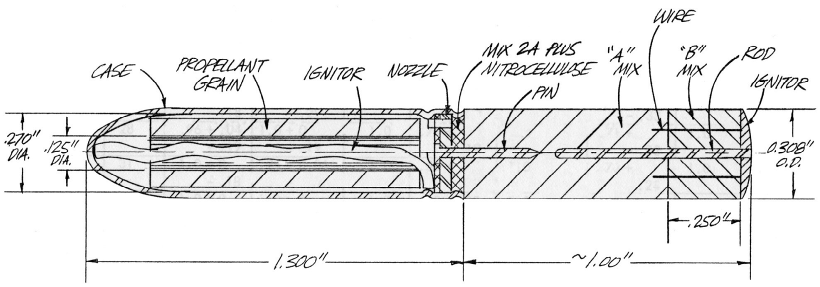



Fig. 9–13. *Mark I Gyrojet with long-delay fuse. MB-65.*

While it is beyond the scope of this book to delve too deeply into the complex chemical fuse mixtures tested, suffice to say that at least fourteen different mixtures of fuel, fuel binders, and oxidizers were tested with various results. MBA recognized the problems involved, and worked persistently to finally develop a slow-burning, organic-based pyrotechnic fuse that produced burn rates as slow as 20 to 30 minutes per inch under controlled laboratory conditions. The most challenging difficulty of this fuse's development was its poor reliability in adverse weather conditions. In general, fuses that burn quickly are much more reliable than those that burn slowly, and it proved to be very difficult for MBA to achieve and maintain long-delay reliability rates above 90 percent. The fuse mix eventually used was oxygen deficient and its minutes-long delay was achieved because it was continually on the verge of suffocation, just *"slowly struggling along on gasps of atmospheric oxygen."* The design also required that the fuse mixture be exposed to the atmosphere, not enclosed in any type of protective container or wrap.

### *Mark II Development*

Other significant problems were discovered with the Mark I Gyrojet fitted with the long-delay fuse. Live firing tests revealed that Mark I takeoff angles were generally higher than anticipated, considering the nearly horizontal orientation of most of the Gyrojets lying on the ground at ignition. Takeoff angles that were too high caused the Gyrojets to fly above their targets rather than impact them. By the time of these tests, MBA had already thoroughly investigated the .49-caliber Gyrojet used in the Model 137 pistol. That rocket had a spin rate 2.3 times that of the .30-caliber delay-fuse Mark I. Since the destabilizing forces created by contact with the ground during the initial stages of liftoff had a greater effect at lower spin rates, MBA decided to increase the spin of the .30-caliber delay-fuse Gyrojet to match that of the .49-caliber rocket. The new design was named the Mark II.

The increased spin rate was accomplished by drilling, not punching, the four nozzle ports at a steep 35-degree angle from the centerline of the rocket. This increased the spin rate from the 2.0 revolutions per foot of the Mark I to between 4.5 and 5.0 for the Mark II.

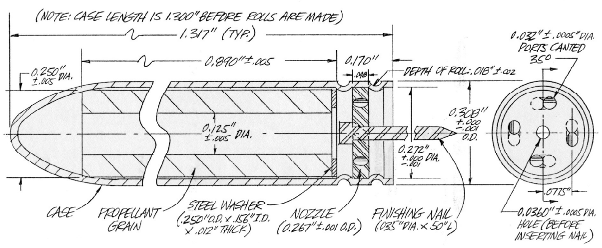



Fig. 9–14. *Mark II Gyrojet without delay fuse installed. MB-65.*

Compared to the Mark I, the Mark II used a slightly thinner and shorter propellant grain that weighed 12.9 grains, down from 14.7 grains. To compensate for the thinner grain without redesigning the Mark I case, a steel washer was inserted behind the grain to secure it against the first cannelure, which was rolled in the case to the same depth as the Mark I.

Fig. 9–15. *Mark II nozzle with no nail. 3x actual size.*

The Mark II used the same GMCS case as the Mark I. Stress in the Mark II case due to gas pressure was approximately 13,500 psi, the same as the Mark I. At its maximum velocity of 1,300 fps, the Mark II Gyrojet spun at 370,500 rpm (4.75 revolutions per foot), creating an additional hoop stress caused by centrifugal force of approximately 22,000 psi. This resulted in a total stress of 35,500 psi, which left just a 14,500 psi safety margin. The velocity of the Mark II was 500 fps less than the Mark I because more of the available thrust was used to spin the rocket and because the mass of the Mark II propellant grain was less than the Mark I. The Mark II propellant igniter was the same as the Mark I, and except for the addition of the steel washer, the assembly process was also the same.

The weight of the Mark II Gyrojet without a delay fuse attached was 63.3 grains (4.1 grams). The propellant weighed 12.9 grains, so the burnout weight of the Gyrojet was 50.4 grains. This resulted in a heavier 50.4-grain “bullet” traveling at a slower 1,300 fps compared to the Mark I’s 1,800 fps. This velocity was achieved in a distance of about 25 feet, and it decreased to half that in 160 yards. Mark II rockets produced an average of 11 pounds of thrust, down from the Mark I’s 14 pounds of thrust. The burn time of the Mark II rocket was 0.033 second, down slightly from the Mark I’s burn time of 0.035 second.

### *Short-Delay Fuse Development*

The Mark II Gyrojet was used to test a short-delay fuse after the long-delay version proved to be impractical. The short-delay (about 30 seconds per inch) fuse proved to be much easier to develop and it had excellent reliability.

The fuse mix eventually selected was 50 percent potassium permanganate and 50 percent polyester resin. It was ignited by a flash igniter pellet composed of 80 percent barium chromate, 10 percent potassium nitrate, 5 percent amorphous boron, and 5 percent nitrocellulose. The pellet and delay mix were contained in a 0.28-inch-diameter aluminum cup 0.55 inch long with 0.020-inch walls and a 0.10- inch hole in the center of the closed end. A flash mix was painted on the closed end, and served to transfer fire from a mass ignition system down to the pellet inside the aluminum cup. The clear flash mix was colored red so its presence could be more easily confirmed during visual inspections, a technique used in other Gyrojet production. The delay fuse was assembled by placing the igniter pellet in the bottom of the aluminum cup, and then pouring in the liquid fuse mix. Within about 15 minutes, the mix had cured enough so that a loaded Gyrojet’s nail could be inserted into the aluminum cup and mix. The nozzle itself had previously been treated with a compound to transfer fire from the delay fuse to the propellant grain igniter. After being attached to Gyrojets, some fuses were wrapped with 1.25 layers of fiberglass tape to protect them, while others were not.

Some Mark II Gyrojets with short-delay fuses were tested by dropping them 250 feet onto a concrete surface. This was a much more severe test than the Gyrojets would encounter when they fell through Southeast Asian jungle canopies onto the soft ground below. Even with a few failures caused by over-pressurization of the aluminum cup associated with ignition through the single 0.10-inch hole, reliability rates of over 96 percent were achieved and maintained.

At this point early in the development of the short-delay fuse, its fabrication was turned over to MBA production personnel. While this resulted in several design changes, it also produced delay-fuse Gyrojets at increased rates to meet testing requirements. Approximately 800 short-delay-fuse Gyrojets were soon produced as one lot and subjected to further tests.

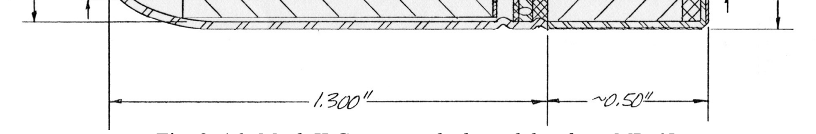



Fig. 9–16. *Mark II Gyrojet with short-delay fuse. MB-65.*

Fig. 9–17. *Mark II Gyrojet with short-delay fuse in aluminum cup. Actual size.*

Reliability continued to be high, with aluminum cup overpressurization as the major failure mode. MBA hoped to eliminate overpressurization by increasing the total port area at the arming end of the aluminum cup by switching from one 0.10-inch hole to three 0.065-inch holes, as shown below in Figure 9–18 (A).

*A.* *B.*

Fig. 9–18. *Mark II short-delay fuse cup ends. (A.) 3-hole cup with red igniter. The cartridge with this cup is shown above in Figure 9–17. (B.) 1-hole cup, from a test failure round. 3x actual size.*

Unfortunately, this change did not lessen the overpressurization problem, because the smaller holes tended to become plugged with the flash igniter and delay-mix byproducts of combustion. Eventually, the problem was reduced with the single 0.10-inch hole by reducing the amount of potassium nitrate in the flash igniter mix.

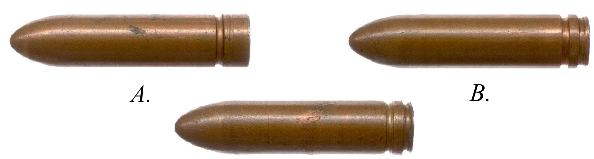
Additional testing of 380 Gyrojets, including some having delay fuses without the fiberglass tape wrap or other protection, showed the fuses to be about 97 percent reliable. Tests of the short-delay fuse installed on the Mark I Gyrojet were also conducted. During these tests, a few Mark I Gyrojet failures occurred which were caused by worn tooling that produced partially closed ports in the punched nozzles. Based on this series of tests, it was concluded that the short-delay-fuse .30-caliber Gyrojet could be manufactured by MBA production personnel to perform effectively, and with a high reliability.

Additional tests, including one to determine the effects of rough handling by placing 30 live Gyrojets in a Sieve Shaker for an hour, and another one to test the effects of storage in high heat (up to 160 degrees F) and humidity, caused no significant problems. Some Gyrojets were dropped into water after their delay fuses ignited, and their propellant grains ignited normally. These submarine Gyrojets achieved an underwater velocity of 200 fps in a distance of just 1 foot.

The result of the research and limited production experience was a short-delay fuse contained in an aluminum cup which functioned with high reliability. It was relatively insensitive to adverse environmental conditions, fail-safe, and simple and easy to fabricate. It was inexpensive, costing about the same to produce as the Gyrojet to which it was attached. Since the 0.50-inch, short-delay fuses were just half the length of the long-delay fuses, approximately 25 percent more Gyrojets with them could be packed in a container of a given size than Gyrojets with long-delay fuses.

### *Other Delay-Fuse .30-Caliber Gyrojets*

Three normal-length .30-caliber Gyrojets with Mark I and Mark II nozzles are shown below. These have no central nail holes in their nozzles because they were used by MBA to test methods of installing nozzles in Gyrojet cases or to test ballistics with live firing.



*A.* *B.*

*C.*

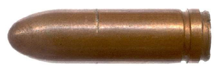
Fig. 9–19. *Normal length delay-fuse Gyrojets. (A.) Unfired, with a Mark I nozzle. Second cannelure is extremely light, and may be a manufacturing error. (B.) Fired, with a Mark II nozzle showing heat discoloration and eroded ports. The second cannelure is farther back on the case than normal. (C.) Fired, with Mark II nozzle showing heat discoloration and eroded ports. The second cannelure is so far back, it is barely on the case. Actual size.*

In addition to Mark I and Mark II Gyrojets that are 1.3 inches long without their delay fuses, shorter .30-caliber delay-fuse Gyrojets of the same basic design exist and are shown next in Figure 9–20.

*A.*

*B.*

*C.*



*D.*

*E.*

Fig. 9–20. *Short-delay-fuse Gyrojets. (A.) Loaded with blank nozzle disc shown with it. Nozzle-loading test. (B.) Empty case with only one cannelure. (C.) Mark I nozzle with no nail hole. Nozzle-loading test. (D.) Blank nozzle disc with the second cannelure almost off the case. Nozzle-loading test. (E.) Fired round, with remnants of red target-marking paint on nose, only one cannelure. Actual size.*

It is possible that these experimental cases were used to try various methods to place and secure nozzles in cases. Some of the cannelures, as in Figure 9-20 (*A*), are rolled very deeply. Presumedly, the only reason to assemble cartridges with blank nozzle discs would be to test the assembly techniques themselves.

A Mark I delay-fuse *dummy* Gyrojet is shown below in Figure 9–21. As was often the case, MBA used fired rounds in excellent condition to make dummy rounds for other testing, such as packaging. This corrosion-free dummy has a Mark I nozzle with nail intact, verified when curiosity got the best of me, and I carefully removed the fiberglass-tape-wrapped wooden dummy delay fuse to examine the nozzle.

Fig. 9–21. *Mark I dummy delay-fuse Gyrojet. Actual size.*

An unusual *turned*, not drawn, plain steel .30-caliber Gyrojet case has the same 0.308-inch outer diameter and 1.3-inch case length of the Mark I and Mark II cases. However, it has a small but distinct step cut inside the case, apparently for a nozzle. The case also has a shorter, more blunt ogive. Based on its dimensions, which are identical to the Mark I and II, it may be part of the delay-fuse Gyrojet development, but no information has been found to confirm this. It was acquired from Mainhardt, who couldn't remember any details about it.

Fig. 9–22. *Turned-steel .30-caliber Gyrojet empty case. Actual size.*

Two delay-fuse Gyrojets that failed during testing were found and recovered several days or weeks later. Both show evidence of the delay-fuse element burning out prematurely before reaching the nozzle. One round is heavily corroded and the other less so.

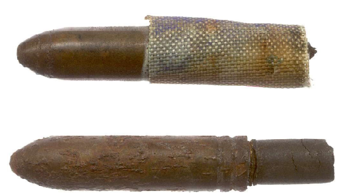


Fig. 9–23. *Recovered test-failure delay-fuse Gyrojets. Actual size.*

Fired and recovered rockets can be very instructive, even though some Gyrojet collectors are not particularly interested in fired examples of what they collect. Perhaps they should be, because regardless of what is said or written to have occurred, having an actual fired round in hand provides proof positive that a design was in fact flight tested. A close examination of the round can provide some indication of how the rocket actually performed or, as with the two specimens shown above in Figure 9–23, how they failed to perform.

For example, the five fired delay-fuse Gyrojets shown next in Figure 9–24 demonstrate that at least in *these* rounds, all of the nozzles were retained in their cases after severe impacts, indicating that the double-cannelure design worked. All of the nozzle ports show even and moderate ablation, so the steel used for the nozzles also seems to have worked well.