HIPERTOUCH® Trigger Family

Cam-Over Toggle Engine™ (COTE)

Introduction

Terry Bender, HIPERFIRE's founder, and CEO was designing a 50-BMG semi-auto rifle. At first, he ran aground, trying to increase the 50-cal. hammer strike using Eugene Stoner's AR-15® (Armalite Rifle) semi-auto styled trigger mechanism. It was a convenient starting point, but the hammer needed to be taller to reach the firing pin, heavier to touch off the 12.7X99 NATO cartridge and lock up had to be as fast as the MIL-spec AR15. The early result was a trigger with a 10-12 lb. pull, which was an obstacle in the way of achieving an easily controlled trigger break for 50-cal. long-range accuracy. Finding a satisfying solution was difficult, but through inspiration, Mr. Bender imagined a "toggle spring."

The "toggle spring" idea, among other 50-BMG design features, was presented to some potential startup equity investors in January of 2011. They were immediately attracted to the "weird-looking trigger." Once explained, the light bulb above their heads turned ON, and they asked whether it could be scaled down for today's AR15/10 platform. Mr. Bender answered, "Yes." Within a week of that presentation, Mr. Bender organized HIGH PERFORMANCE FIREARMS LLC d.b.a. HIPERFIRE, and filed the first trigger patent application. That 50-cal. trigger morphed into HIPERFIRE's HIPERTOUCH® trigger. The rest is history.

This first HIPERTECH (HI-gh PER-formance TECH-nology) white paper explains the early genesis of the "weird-looking trigger" and how it works.

The information provided is accurate to the best of HIPERFIRE's knowledge. Any experimental data presented has been collected and analyzed using commercially available test instruments, software, and products, subject to the application of the scientific method and engineering knowhow, so that anyone familiar with the art could reproduce and verify the results. The interpretation of that data is not necessarily definitive, but of HIPERFIRE's considered opinion.

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(651) 762-2800

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The hammer spring forces of the early 50 cal. had to be high to ensure reliable ignition of the 12.7x99 NATO round. Therefore, the only way remaining to reduce the pull weight was to reduce the sear friction component of pull weight somehow. Friction was the enemy. However, how could it be tamed?

The early 50-cal. trigger design looked like that shown in Figure 1. The hammer spring system provided the hammer fall characteristics desired, but the trigger pull was still too heavy. You may have seen similar hammer spring mechanisms like this in other firearms. Mr. Bender learned of some of those arrangements only after the fact. He had no background in firearm design at the time and only a very casual familiarity with the AR15 and of some handguns he owned. He was not a gun "geek." In his engineer's mind, he was looking at a blank sheet of paper, and he had to draw "outside the box" to be successful.

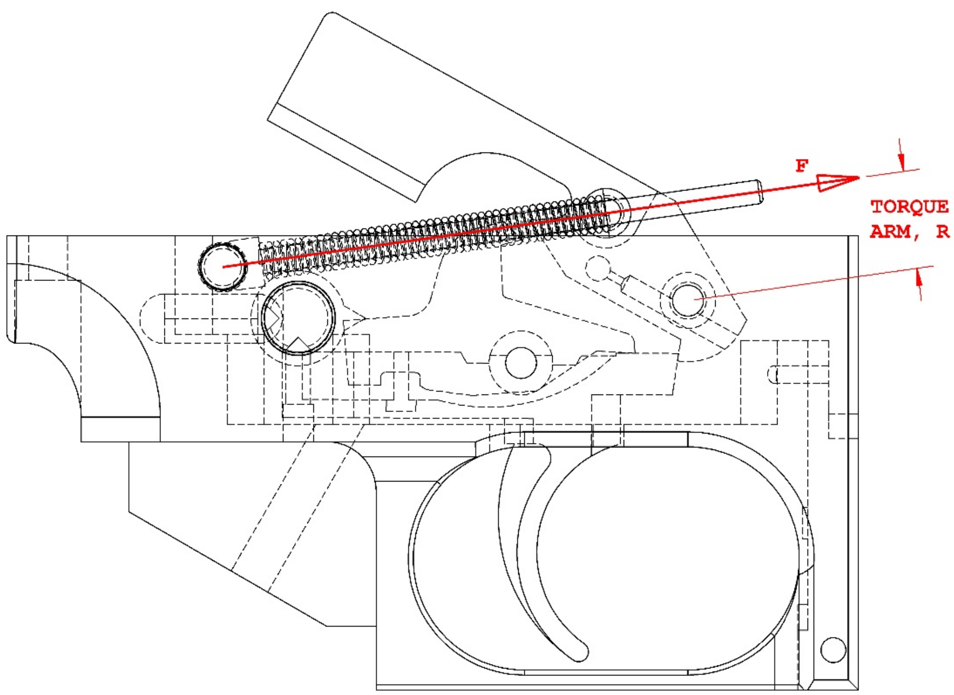

Figure 1. An early embodiment of the 50-BMG rifle fire-control group that included a MIL-spec trigger and disconnector, a tall custom hammer, and a pair of hammer springs as shown. It included no conventional torsion hammer spring. Note the compression springs' force vector.

Figure 1 shows a hammer spring force vector, **F**, and the **Torque Arm, R**. The torque on the hammer that resists cocking and causes the hammer to fall upon trigger break is related by the equation **T = FR**. If the force is in-lbs. and the torque arm is measured in inches, then the torque has units of in-lbs.

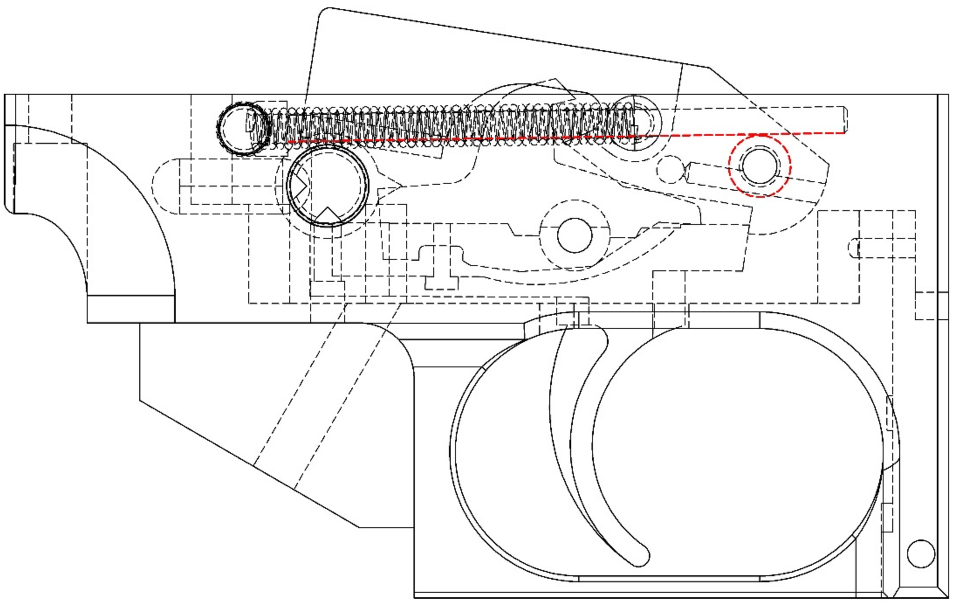

Figure 2. The lowest potential trigger pull weight was determined by how small R could be made. That value was limited by the spring rods' contact shown in red with the hammer pivot bosses.

When the hammer falls after the trigger break from the initial position shown, the torque arm increases in length, so that even when the spring compression force drops as the spring elongates, the torque may still increase causing the hammer to hit very hard. The initial position of the hammer as caught by the trigger at the contacting sears determines the initial length of the hammer **Torque Arm, R**, the initial torque on the hammer, and most importantly, the contacting force of the hammer sear on the trigger powered by the springs. That force governs the sear friction and ultimately determines the pull weight of the trigger. So, to reduce the pull weight of the trigger as much as possible, **R** (from Figure 1) should be as small as possible to make the sear friction component of pull weight small to s satisfactory limit. However, Houston, we have a problem.

Figure 2 shows the spring rods contacting the hammer pivot, which limited how small the **`Torque Arm, R`**, could be, or limited how small the sear friction could be made.

Given the hammer rotation range limited by the available clearance between the spring rods and the hammer, it was found that with any single fixed value for **`R`**, the pull weight could vary significantly from spring pair to pair, notwithstanding that the pull weight was too high in any case. The springs were manufactured to within the tightest tolerances possible, but that did not control the pull weight variation to be within a small enough tolerance to be practical or attractive to 50-cal. shooters. There appeared to be little hope that this problem could be remedied until…

Mr. Bender saw that the spring rod and hammer interference could be eliminated by reversing the orientation of the spring rods. So, the fixed rod ends would now pivot off the hammer, and the sliding rod ends through the receiver pin. Now **`R`** could be reduced even further to reduce trigger pull weight, but this created a potential problem. In an extreme case, **`R`** could go to zero and even past zero, when the semi-auto bolt pushed the hammer into over-cock forcing the springs' line of action to "go over center." Center is defined as the line joining the hammer pivot with the spring rods' sliding pivot in the receiver. The working assumption is that the hammerhead was redesigned to prevent collision with the springs or the safety selector. If over-cock or over-rotation occurred, the hammer would be captured by the springs, preventing it from falling at all. So, this "outside the box" spring action wasn't going to work! However, this very difficulty resulted in a breakthrough and more hope.

Think about it. Why not cause the springs to go over-center, a lot, and use the conventional dual hammer torsion spring to bias hammer rotation against the other two springs? In other words, prevent hammer capture by the dual compression springs. That was an "outside the box" inspiration. It turned out that not only is the pull weight much lower, but the tolerances for that weight could be tighter. So the required 50-cal. hammer fall energy was not compromised — the best of both worlds.

The unconventional springs became an over-center mechanism resembling the toggle effect found in wall mounted light switches, electrical toggle switches, the ubiquitous VICE-GRIP®, and other toggle clamp devices. The application to a trigger was novel. HIPERFIRE calls this design concept the Cam-

Over Toggle Engine™ (COTE) because it generates other beneficial, quantitative, and demonstrably sound effects discussed in following HIPERTECH articles. What happened next?

As a novel concept, at least to Mr. Bender, the toggle spring system looked like what is shown in Figures 3 through 5, embodiments from the first patent application. The investors at that 2011 meeting saw with this design concept, the "weird-looking trigger" that drew their attention. Figure 3 shows the toggle springs over-center. Figure 4 shows the toggle springs on-center. Figure 4 shows the hammer in its fallen position.

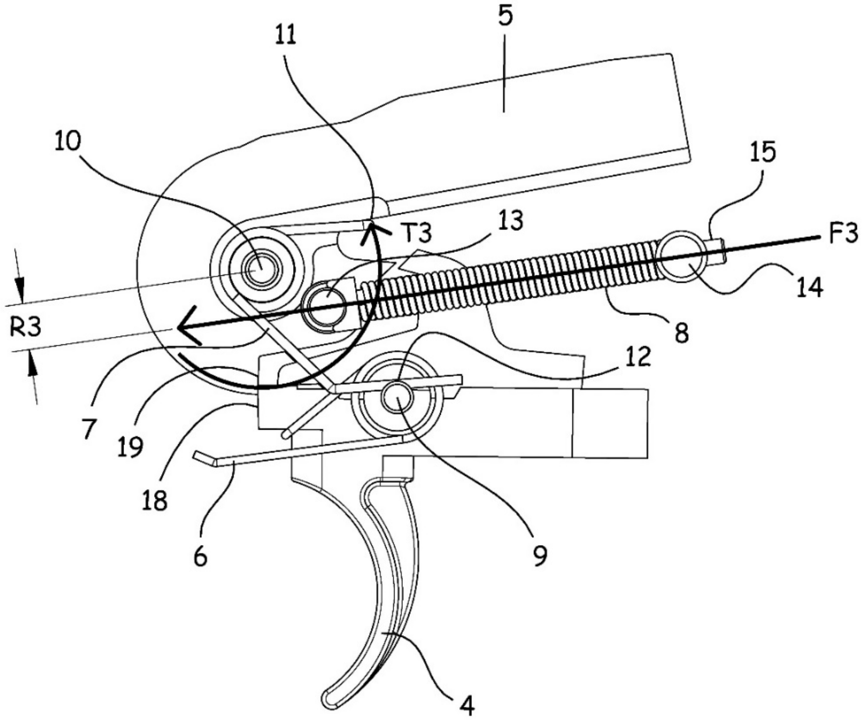

Figure 3. Cam-Over Toggle Engine as drawn in the first trigger patent application. Here, the line of action of the toggle springs is shown over-center when the hammer is fully cocked and ready to drop.

Now we can explain how it works, what it does.

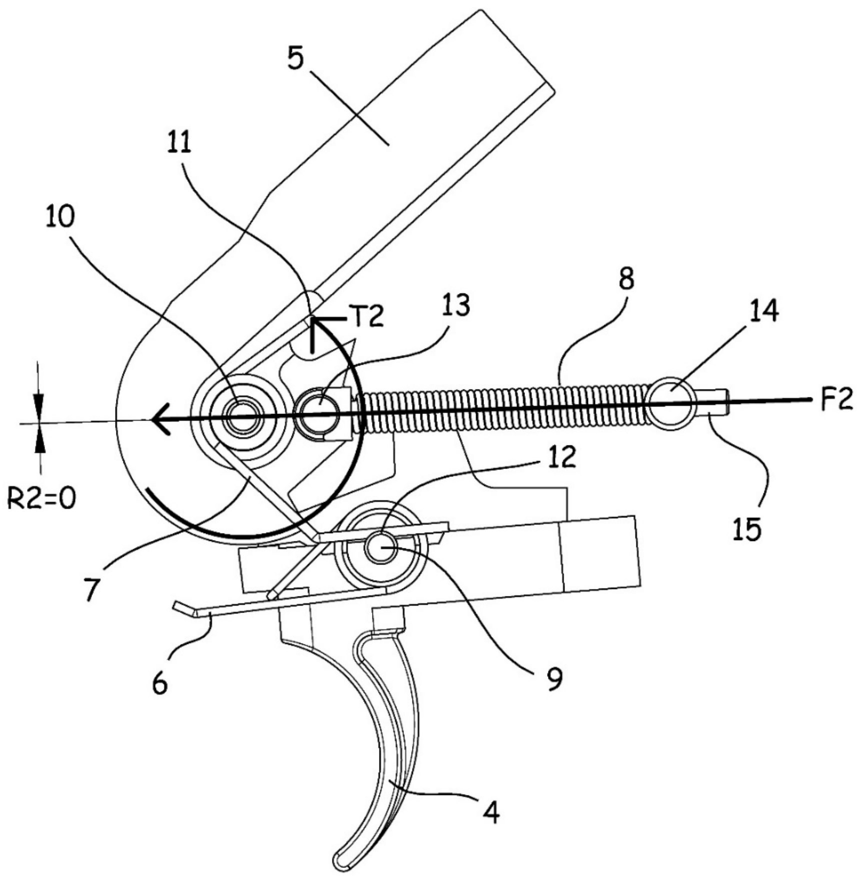

Figure 4. Cam-Over Toggle Engine with the line of action of the toggle springs on-center when the hammer has either fallen or is cocked half-way.

The toggle spring forces' line of action is the vector labeled **F3**. R3 is the moment or torque arm. Note its dimension. T = FR defines the hammer torque. Also noted is the torque applied to the hammer by the presence of the conventional hammer torsion spring labeled **T3**. Note that the two different torques, **FR** and **T3**, point in opposite rotational directions. The first is shown clockwise (CW), while the second is shown counter-clockwise (CCW) respectively. When the toggle springs are over-center, they are said to be "antagonistic" with the hammer torsion spring, in other words, the forces were subtractive. What this does is reduce the force of the hammer sear on the trigger. The torque generated by the toggle springs subtracts from the torque generated by the hammer spring. As long as the initial torque supplied by the torsion spring is greater than the initial torque generated by the toggle springs, the hammer cannot be captured by the

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toggle springs, only by the trigger sear. When the trigger breaks, the hammer always falls. Adding the hammer torsion spring back in, compared to the design of Figure 2, biases rotation of the hammer to begin falling and significantly lowers the sear friction and pull weight without compromising the 50-cal. trigger's hammer fall. Mr. Bender could only wonder at it.

In Figure 4, the toggle springs' force line of action, labeled **F2**, is on-center with the hammer pivot axis. In this position, it contributes zero torque to hammer rotation. However, it adds some rotational friction (higher impingement force) at the hammer pivot axis and hammer, toggle spring, pivot axis, which contributes a negligibly small counter-rotational frictional torque that is so small as to be ignored.

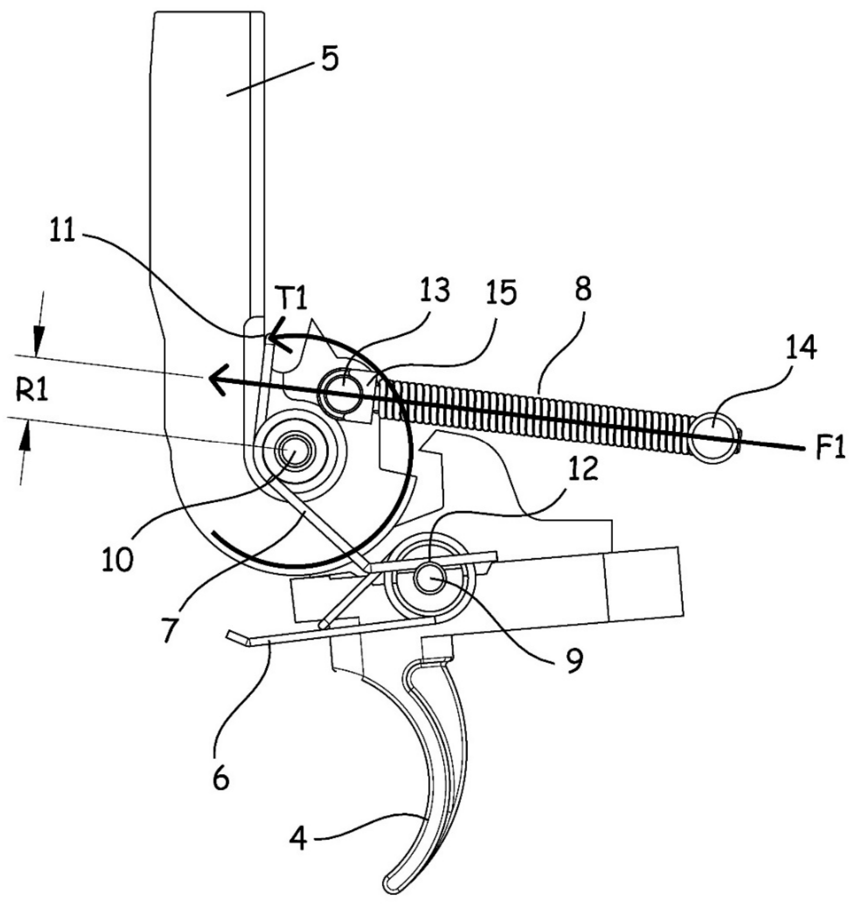

Figure 5. Cam-Over Toggle Engine with the line of action of the toggle springs above-center when the hammer has fallen against the firing pin.

Figure 5 shows the hammer fallen. In this orientation, the torques of the toggle springs and torsional hammer spring are going in the same rotational direction, CCW. They are said to be “cooperating,” or the resultant forces are additive.

Conclusion

The "weird-looking trigger's" Cam-Over Toggle Engine, or COTE, exhibits this fantastic property in stark contrast to every other trigger known. Trigger pull weight decreases, and hammer fall energy is maintained:

1. When the hammer is cocked, the total applied force causing hammer fall is at a minimum because the toggle springs unload the sear, reducing pull weight substantially; and
2. when the hammer falls, the total applied force is at a maximum.

When the hammer is manually cocked, one can feel that the initial force required to start cocking is very high. As the hammer lies down, or as the toggle springs go over-center, that force drops off dramatically. This new feeling is like drawing a compound archery bow. To best describe this new hammer spring convention and feel, we called it the Cam-Over Toggle Engine (COTE) because this engine generates positive outcomes beyond lower pull weight, hammer cock, and hammer fall benefits. Some of these results were known intuitively by Mr. Bender at the instant he received the inspiration. He discovered others later. Subsequent HIPERTECH articles discuss these and other real benefits. See **Appendix A** for a feature comparison chart of HIPERFIRE’s and many other’s aftermarket trigger upgrades.

Thus began the life of what would become the HIPERTOUCH (HI-gh PER-formance TOUCH) trigger for the ubiquitous AR15/10 rifle. The 50-cal. rifle’s trigger pull weight came down from a 10-12 lb. range into a 6-7 lb. range with the design concept of Figures 3-5. However, that weight had already been achieved by Eugene Stoner 60 years ago. It was a far cry from what Mr. Bender wanted and needed. If it was to become Everyman’s trigger, it required more inspiration. That is the topic of the next white paper, HIPERTECH Bulletin #2.

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Appendix A Green Means Column Feature Criteria Satisfied

AR15/AR10 Trigger	Single-Stage	2-Stage	Drop-In Single-Stage	Cam-Over Toggle Engine
HIPERTECH Bulletin				1
MIL-SPEC Semi-Auto				
MIL-SPEC Full-Suto				
EDT Sharp Shooter				
EDT Heavy Gunner				
EDT Designated Marksman				
HIPERTOUCH Genesis				
HIPERTOUCH Elite				
HIPERTOUCH Reflex				
HIPERTOUCH Competition				
HIPERTOUCH Eclipse				
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