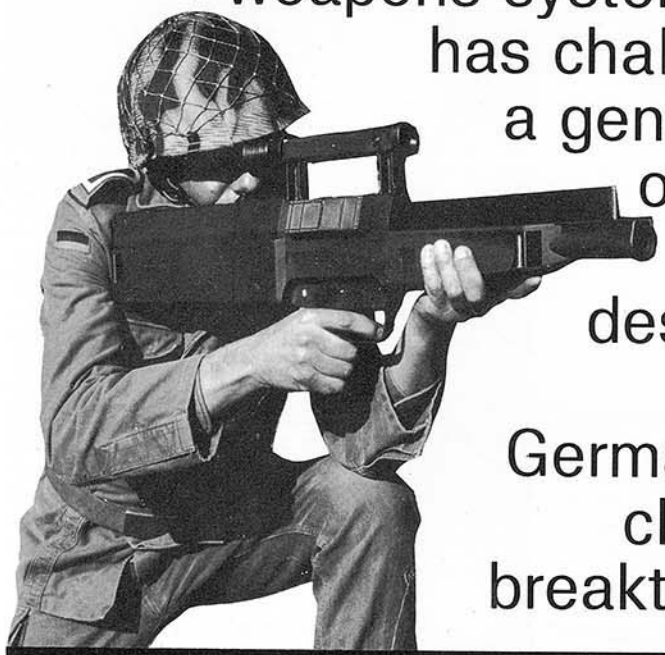
Overcoming the problems inherent in developing caseless ammunition and a weapons system for it has challenged a generation of small arms designers. Now a German firm claims a breakthrough.



THE HECKLER & KOCH G11

BY CHARLES R. FAGG

It is sometimes supposed that the adoption of a new and satisfactory military rifle such as the U.S. M16 or the German G3 signals an indefinite cessation of efforts to develop a replacement.

That is not the case.

In fact, any country that chooses to develop its own military weapons must commence immediately to search for a replacement that exceeds the performance of the current model. The search sometimes seems fruitless because the concepts involved cannot be implemented within the limits of contemporary technology. Advancements of the general technology lead to constant reexamination of promising weapons concepts previously abandoned. Two such concepts are caseless ammunition for rapid-fire guns, which has its roots in the muzzleloading era, and the delivery of multiple projectiles to improve hit probability on fleeting targets, a concept as old as shotguns.

The most commonly discussed advantages of caseless ammunition are lower cost, lower weight, and reduced use of copper, a critical material. In a cartridge such as the 5.56 mm, the potential weight saving is about 40%. Cost saving is less easily estimated because it depends upon the processes developed for manufacture of the caseless ammunition. Certainly, in time of war, it is desirable to reduce the use of critical materials.

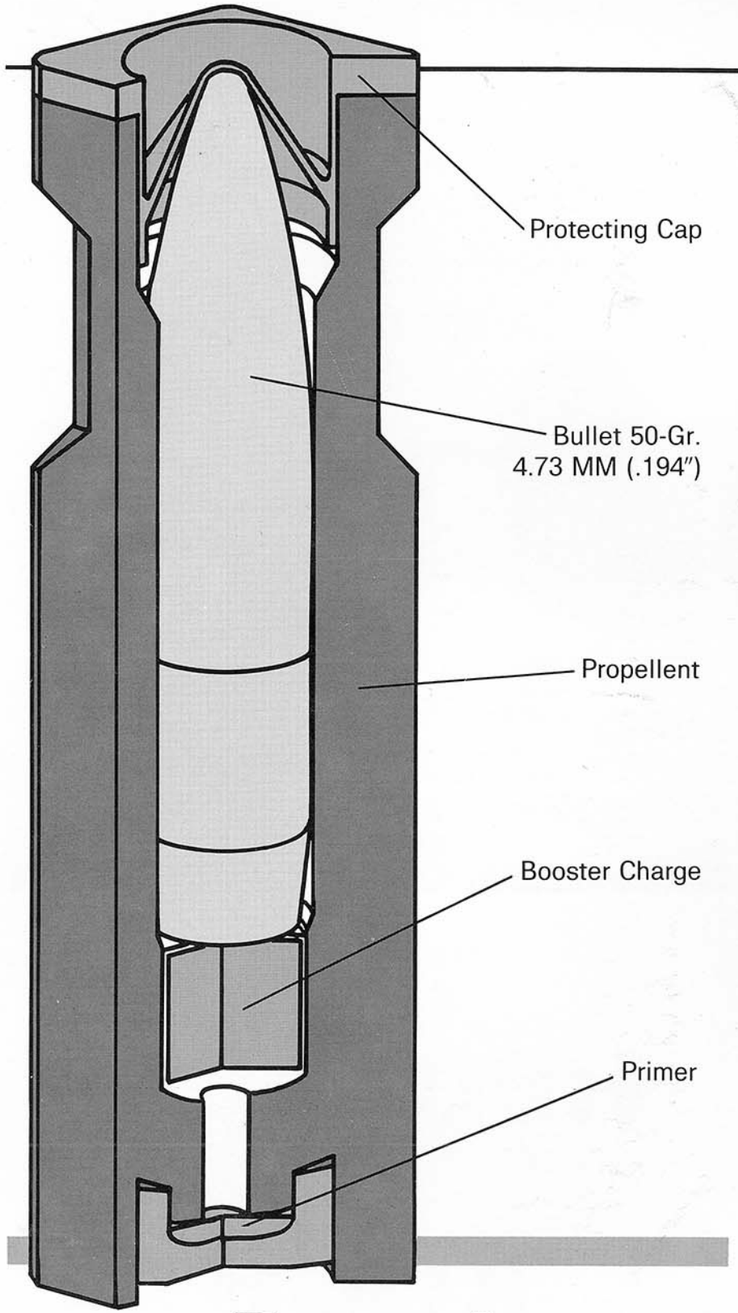
Dispensing with the cartridge case is not simple, however, because the case performs several vital functions. Its most important function is sealing the gun's breech. Without this sealing action, all the clever variations of breechloading gun mechanisms, as we currently know them, could not exist.

Other important functions of the cartridge case include the securing of the other components into a strong, waterproof package, and the removal of heat that would otherwise be absorbed by the walls of the chamber and contribute to heating of the barrel.

The second concept, delivery of militarily effective multiple projectiles to the target at practical rifle ranges, is at least equally complicated. After World War II, and during the Korean War, several U.S. studies sought to define more specifically the conditions and results of infantry combat. Though of course there were exceptions, it was found that infantry riflemen rarely engaged a target at ranges greater than about 400 meters.

Though this finding has been attacked many times by those who take justifiable pride in long-range marksmanship, the fact remains that the long-range capabil-

DIGITIZED FOR YOUR REVIEW AT WWW.SMALLARMSOFTHEWORLD.COM SAW



Part I: The Cartridge



Will HK's caseless 4.73x33 mm cartridge join the NATO-standard 7.62 and 5.56 mm rounds in the field? Trials are underway.

ity of the M1 rifle was very seldom used in combat. A second finding was that a small-caliber rifle, with its greater supply of ammunition, would be more effective than the .30-'06 and the 7.62 mm NATO at the actual ranges of engagement. A third finding was that the stress of battle, and the short exposure time of the target, produced aiming errors which reduced the probability of a hit to very low levels at ranges beyond about 300 yds.

One important study of combat, done by the Operations Research Office (ORO) and titled "Operational Requirements for Infantry Hand Weapon," was published in 1952. It showed that, in terrain such as that of Korea, the hit probability of the M1 rifle in the hands of the typical infantry rifleman declined rapidly as the range increased and approached zero at about 300 yds. The study also indicated that, in the terrain of Normandy during World War II, the hit probability of the typical infantry rifleman approached zero at a range of about 400 yds. The ORO report contained the following significant statement: "To improve the hit effectiveness . . . the adoption of a pattern-dispersion principle in the hand weapon could partly compensate for human aiming errors and thereby significantly increase the hits at ranges up to 300 yards."

These findings have profoundly affected the architecture of small-arms research in the United States for almost 40 years. While it is fairly simple to deliver a pattern of projectiles at a target, it is not a simple matter to deliver *lethal* projectiles, to a range of 400 yds., in a pattern dense enough to produce high hit probabilities on man-size targets. The difficulty is increased when it is required that the projectiles must be delivered by a shoulder-fired weapon of reasonable weight, and with a tolerable recoil impulse.

A government project called SALVO was initiated to investigate various ways of achieving these goals, and was actively pursued from about 1953 until 1960. These investigations included the use of multi-barrelled guns, the firing of multiple projectiles from a single cartridge, and controlled bursts of automatic fire, using conventional bullets as well as small steel darts called "flechettes."

While it became evident that considerable improvement in hit probability was possible, it also became evident that actually achieving the goals in a practical and reliable weapon system was very difficult. One of the most difficult tasks is the delivery of multiple projectiles in a pattern sufficiently small to be effective at the longer ranges of interest. The most promising approach appeared to be the serial firing of three projectiles, in a rapid automatic burst, at one pull of the trigger. The problem of firing three-round bursts is not mechanically difficult (it is accomplished by the M16A2, for example), but the control of the dispersion pattern is much more difficult, and that subject requires further discussion.

When a round of ammunition is fired, the force of recoil acts rearward, along the center-line of the bore. Since the center-line of the bore is usually above the center of gravity of the gun, and above the center of resistance offered by the shoulder, the gun not only moves rearward, but at the same time, the muzzle tends to rotate upward or "climb."

This effect is compounded by the behavior of the human body under the influence of recoil. In the standing position, the body tends to rotate, both backward and horizontally, about points above the hips. This rotation contributes to the muzzle climb, and simultaneously (for right-handed shooters) swings the muzzle toward the right. The amount of movement is directly proportional to the recoil impulse. The usual result in automatic fire from shoulder weapons is that far too much movement takes place between rounds, so that the dispersion pattern spreads widely upward and to the right for right-handed shooters, or upward and to the left for left-handed shooters. For these reasons, automatic fire from the standing position, using the current conventional assault rifles, is relatively ineffective against individual targets except at very close range.

4.73x33 MM Caseless Cartridge

Bullet weight: 51.5 grs.
Muzzle vel.: 3051 f.p.s.
ICAO Std. Atmos.
Sight Above Bore: 4.7″
C7=.175

Range (meters)	Rem. vel. (f.p.s.)	Rem. energy (ft.-lbs.)	Momen-tum (lb.-secs.)	Drop (ins.)	Eleva-tion (m.o.a.)	Time of flight (sec.)	Max. ord. (ins.)	Max. high (ins.)	10 m.p.h. wind (ins.)
0	3051	1064	0.70	0.0	0.0	0.000	0.0	−4.7	0.00
100	2752	866	0.63	2.4	6.5	0.113	0.6	−1.3	0.95
200	2466	696	0.56	10.3	6.9	0.239	2.8	0.9	4.30
300	2198	553	0.50	25.1	9.1	0.380	7.0	5.1	10.14
400	1949	434	0.45	48.5	12.2	0.538	14.1	12.2	19.05
500	1715	336	0.39	83.0	16.0	0.718	25.1	23.2	31.80
600	1494	255	0.34	132.8	21.0	0.926	41.7	39.8	49.44

There are several conventional ways to reduce the size of this pattern. One is to employ a so-called "straight-line" stock and thus reduce the distance from the center-line of the bore to the center of gravity of the weapon. Another is to reduce the recoil impulse of the ammunition, and thus decrease the disturbance of the weapon between shots. A third is to increase the cyclic rate of fire, thus reducing the time interval between shots, and thereby decreasing the movement of the gun between shots. A fourth is to employ devices such as muzzle brakes and compensators to divert propellent gases and thus both reduce recoil impulse and provide counter-thrust to oppose the muzzle climb.

Weapons incorporating all of these measures were developed in the U. S. during the 1960s under a program named SPIW, which is the acronym for the "Special Purpose Individual Weapon." To reduce the recoil impulse of the ammunition, the SPIW fired small steel darts, flechettes which weighed only about 10 grs. each, from a .22-cal. smoothbore barrel and employed a discarding sabot roughly comparable to the sabot used in Remington .30-'06 and .30-30 Accelerator ammunition. The total mass of the projectile and the sabot which drove it was about 16.5 grs. The SPIW fired at an extremely high cyclic rate. The stocks first used were of radical straight-line design to reduce the distance between the center-line of the bore and the center of gravity, but this design was later changed to improve pointability of the weapon.

After much experimentation, it was found that the SPIW weapons did, indeed, demonstrate the predicted improvement in hit probabilities, but they were not sufficiently reliable for use in a field environment. Efforts to achieve acceptable reliability failed, at least partly because they attempted to produce very high cyclic rates with relatively conventional mechanisms. For example, the maximum bolt velocity of the M14 rifle or the M16 rifle is approximately 18 f.p.s., whereas the cyclic rates of some of the SPIW candidates required bolt velocities in excess of 50 f.p.s.

With the adoption of the M16 rifle in the United States, the SPIW concept was relegated to a relatively low level of continuing development. In West Germany, at about the same time, the government established criteria for a new military rifle. The German requirements were similar to those that had shaped the SPIW program, but were somewhat less restrictive. The basic guidelines were as follows:

1. Significant increase in hit probability

5.56 MM NATO SS109 Cartridge

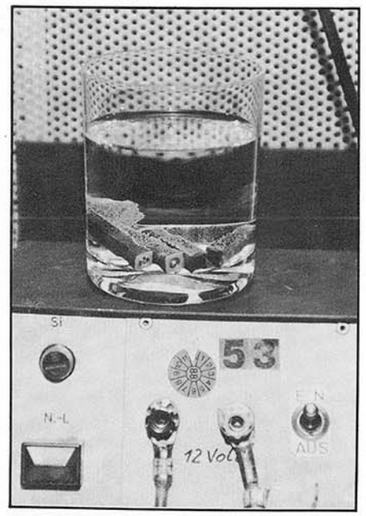
Bullet weight: 62 grs.
Muzzle vel.: 3050 f.p.s.
ICAO Std. Atmos.
Sight Above Bore: 4.7″
C7=.165

Range (meters)	Rem. vel. (f.p.s.)	Rem. energy (ft.-lbs.)	Momen-tum (lb.-secs.)	Drop (ins.)	Eleva-tion (m.o.a.)	Time of flight (sec.)	Max. ord. (ins.)	Max. high (ins.)	10 m.p.h. wind (ins.)
0	3050	1281	0.84	0.0	0.0	0.000	0.0	−4.7	0.00
100	2733	1028	0.75	2.4	6.5	0.113	0.6	−1.3	1.02
200	2432	814	0.67	10.4	6.9	0.241	2.8	0.9	4.54
300	2151	637	0.59	25.5	9.2	0.385	7.2	5.3	10.90
400	1890	492	0.52	49.5	12.4	0.547	14.5	12.6	20.48
500	1645	373	0.45	85.6	16.5	0.734	26.2	24.3	34.47
600	1414	275	0.39	137.2	21.6	0.948	43.7	41.8	53.31

2. Magazine capacity of at least 50 rounds
3. Distinctly reduced weight
4. Total length not to exceed 30″
5. High reliability
6. Reduced training requirements
7. Simplified maintenance

Study contracts to determine means of meeting these goals were awarded in 1970 to three German firms, including Heckler & Koch (HK). A contract was awarded to HK in 1974 for development of the new rifle. Recently, I was privileged to examine and fire the new HK G11 rifle and its caseless 4.73x33 mm ammunition during a visit to Germany. I was able to discuss the revolutionary HK G11 system with the engineers who conceived and developed it. The system combines both the caseless-cartridge concept and the concept of firing a pattern of controlled dispersion to increase hit probability. So far as I know, the new rifle and associated ammunition embody the most advanced concepts thus far attempted in the small-arms field.

Unlike their predecessors in the pursuit of caseless-firing guns, the engineers at HK did not choose the caseless round with the object of saving weight, cost or even materials. These are all desirable collateral benefits, but they were not in their mainstream of planning. They recognized from the beginning that one of the prerequisites for firing a three-round burst small enough to achieve the desired hit probability would be an extremely high cyclic rate of fire and a very low recoil impulse.



Caseless rounds were immersed in water four hours and then fired in a demonstration witnessed by the author in Germany.

If sufficiently high rates of fire were to be attained, every effort must be made to utilize time efficiently. Since the extraction and ejection processes are not required when firing caseless ammunition, and since magazine friction can be reduced to levels lower than is possible with cased ammunition, it was concluded that the highest probability of success lay in the use of caseless ammunition. This entailed a considerable risk. No small arms using caseless ammunition had ever been very successful since the days of muzzleloaders. Nevertheless, a caseless round was considered to be the necessary means to the end of firing three-round bursts reliably at the required high cyclic rate.

It was decided that the caseless ammunition should be of "telescoped" configuration, having the projectile contained inside the propellent charge and not protruding at the front of the cartridge. This appears to have been a very sound decision. The short overall length of the cartridge reduces the time necessary to feed it into the chamber, and it better secures the bullet during the high accelerations associated with feeding. This is particularly important in caseless ammunition, which does not have the benefit of a strong metal case to hold the various parts of the cartridge together.

The need for minimum recoil impulse was addressed by designing the entire round around a bullet of the minimum weight that could retain adequate penetration and lethality at all the required ranges of engagement. This dictated a bullet of small diameter and reasonably high sectional density.

The 4.73 mm bullet is of relatively conventional construction, with a lead core and a jacket of gilding-metal-clad steel. The nominal weight is 50 grs., but the bullets that I weighed were quite uniform at a weight of 51.5 grs. The bullets that I measured were .194″ in diameter and about .896″ long. Measurements made on an optical comparator showed that the ogive is approximately

About the Author

AN *American Rifleman* contributing editor and professional engineer, the author is a graduate of the University of Texas. His 25-year government career included assignments with the U.S. Army Weapons Command and U.S. Army Weapons Laboratory, Rock Island Arsenal. His work there involved the M16 rifle and Special Purpose Individual Weapon (SPIW) program. Since retirement from federal service, his career has included stints with Diemaco, Inc., Kitchener, Ontario, where his work involved the Canadian C1, C2 and C3 rifles, and on the faculty of the College of Engineering at the University of Arkansas at Fayetteville. A full-time small arms engineering consultant since 1986, the author is a smallbore rifle Master and a Life Member of the NRA.



.450″ in axial length, and has a variable radius approximately equivalent to a tangent ogive of seven calibers. The bullet has a 6° boattail about .078″ long. Calculations of the drag coefficient based on the comparator measurements of the bullet agree very well with the drag coefficient implied by exterior-ballistic data provided by the engineers at HK.

The accompanying tables summarize the exterior ballistics of the 4.73x33 mm HK cartridge and the current 5.56 mm NATO SS109 round using identical sight-above-bore-lines.

The unusually high mounting of the G11's sight above the bore (about 4.7″) increases the apparent flatness of the trajectory. With the rifle zeroed at 260 meters, the bullet path is within about 3″ of the line of sight at all ranges from 25 meters to very nearly 300 meters. The engineers at HK reported that penetration of one side of a German steel helmet (a NATO test criterion) has been achieved at 600 meters. Based on a published muzzle velocity of 3051 f.p.s., and a propellent weight of about 30 grs., the calculated recoil impulse is approximately 1.2 lb.-sec. For comparison, the recoil impulse of the 5.56 mm M193 round with its 55 gr. bullet at about 3200 f.p.s. is approximately 1.27 lb.-sec.

Since the ammunition has no cartridge case to act as a barrier and heat-sink between the propellent and the hot chamber walls, the problem of "cook-off" obviously demanded special attention. I was therefore particularly interested in the characteristics of the propellent, a product of the German firm of Dynamit-Nobel. The engineers at HK report that this propellent contains no nitrocellulose, but is based on materials more commonly associated with explosives than with gun propellents. It has an ignition temperature higher by about 180°F than that of nitrocellulose-based propellents, thus permitting the caseless system to meet the West German army's requirement that the rifle be capable of firing at least 100 rounds rapidly without a cook-off.

The propellent is reportedly granulated in the same manner as extruded-grain propellents, and the grains are then coated with a material which is said to serve both as a deterrent to retard early burning, and as a plasticizer or an adhesive to bond the grains together during formation of the finished cartridge. The current manufacturing process entails pressing the coated propellent into suitably shaped blocks, cutting the blocks to length, and drilling longitudinal holes to contain the bullet, a small booster charge, and the combustible primer. This process appears to be not well suited to mass production, but if it is not, then a more satisfactory mass-production process will probably be developed.

Another obvious area of concern about caseless ammunition is its ability to survive exposure to wet conditions, and then to function normally when fired. To demonstrate for me that this problem had been solved, HK engineers placed several rounds in a glass container under about 4″ of water, where they were left for about four hours. The cartridges were then taken to the test range, removed from the water, loaded while wet directly into a pressure-test barrel and fired. The cartridges fired normally. The pressures recorded were very slightly less than those of dry cartridges fired for comparison, probably because of the water carried into the chamber by the wet ammunition.

The location of the bullet in the telescoped round is such that, if the main propellent charge began to burn before the bullet had moved into the bore, much of the gas would escape down the bore ahead of the bullet. To drive the bullet into the bore before the main propellent charge begins to burn, a small booster charge is located in a central cavity between the primer and the bullet. This booster charge, which is encapsulated in thin metal foil, undoubtedly serves also to fracture the main charge into individual grains, which will then burn similarly to the grains in a conventional granulated charge. The ignition of the main propellent charge is much slower than that of conventional propellents, and its interior-ballistic performance appears to be somewhat different. If all the combustible components of the caseless cartridge are counted as propellent, then the specific energy imparted to the projectile is only about 35 ft.-lbs./gr., whereas the comparable figure for the 5.56 mm M193 cartridge loaded with conventional propellent is about 47 ft.-lbs./gr.

The ammunition is packaged in 15-round plastic "loading units" comparable in function to the "stripper clips" used with conventional ammunition. These units are made waterproof and dust-proof by sealing with an adhesive plastic tape. When this tape is stripped away, the open end of the loading unit is placed over the mouth of the magazine and firmly pressed home, thus inserting the 15 rounds into the 50-round magazine. The capacity of the magazine will reportedly be reduced later to 45 rounds, so as to accept the contents of exactly three of the 15-round loading units, which the West German army reportedly prefers over any other size.

The G11 rifle is no less revolutionary than the caseless ammunition that it fires. The details of the rifle, and its firing performance, will be described in Part II of this article next month. ■

REPRINTED BY PERMISSION OF AMERICAN RIFLEMAN MAGAZINE

HK®

In a world of compromise, some don't.

Heckler & Koch, Inc
21480 Pacific Blvd.
Sterling, VA 22021
Tel: (703) 450-1900

THE HECKLER & KOCH G11

Part II: The Rifle

BY CHARLES R. FAGG

THE new Heckler & Koch G11 rifle is no less revolutionary than is the caseless ammunition that it fires (see May, p. 30). It is difficult to know where to begin the description of such a rifle. Perhaps I should begin with a description of the outer appearance, which is distinctly ugly to those who appreciate the aesthetics of fine walnut and well polished deep-blue steel. It resembles nothing more than a dull-black plastic box, about 30″ long, 5″ high and 3″ thick, to which is attached amidships a pistol grip on the bottom, and an optical sight on the top. Beneath this ugly facade, however, is one of the cleverest gun mechanisms that I have ever seen.

The outer shell of synthetic material reinforced with carbon fiber acts as a stock. The center-line of the barrel passes approximately through the center of the butt (as it should to minimize muzzle climb), and the sight is elevated above the bore similarly to that of the M16 rifle. The rifle I examined and fired had a fixed 1X (non-magnifying) optical sight with a wide field of view and a well defined circular reticle. The engineers at HK reported that the final rifle configuration would allow the mounting of other sighting devices, such as a specialized night sight or a magnifying scope.

The pistol grip is located just below the center of gravity, and the magazine is located immediately above the barrel. The longest dimension of the magazine is parallel to the barrel, thus avoiding the normal projection associated with large-capacity box magazines. The cartridges in the magazine lie perpendicular to the barrel, rather than parallel to it in the manner of conventional magazines. Two 50-round magazines are in place at once on the rifle, one being in position to feed the cartridges and the other in a storage position. When a magazine is removed from the rifle, a small spring-loaded door automatically closes the magazine opening, indicating the importance that the designers have attached to preventing the entry of foreign material that might contaminate the mechanism.

An unusual feature of the magazine is a window about an inch in diameter, located near the floorplate, through which the magazine spring can be seen. One coil of the magazine spring is colored, so that the view through the window gives an approximate indication of the amount of ammunition remaining. A selector lever is located near the pistol grip on the left side of the rifle and allows selection of safe, semi-automatic, three-round burst, or automatic fire. To charge or to unload the weapon, a rotatable charging handle is located on the left side, a few inches behind the pistol grip. Since there is no ejection process associated with the firing of caseless ammunition, there is no ejection port. For unloading, there is a small hole about 1/2″ in diameter in the bottom of the stock beneath the charging handle. Except during the unloading process, this unloading port is tightly closed to prevent entry of foreign material which might contaminate the mechanism.

Upon picking up the rifle for closer examination, I was most aware of the thickness of the weapon, which measures nearly 3″ from side to side. Having become accustomed long ago to firearms with conventional stocks, I do not find any weapon with a pistol-type grip very comfortable in my hands, though I have now worked with such weapons for almost 25 years. However, where the design requires that the center-line of the bore pass nearly through the center of the butt, a pistol-type grip is a necessity.

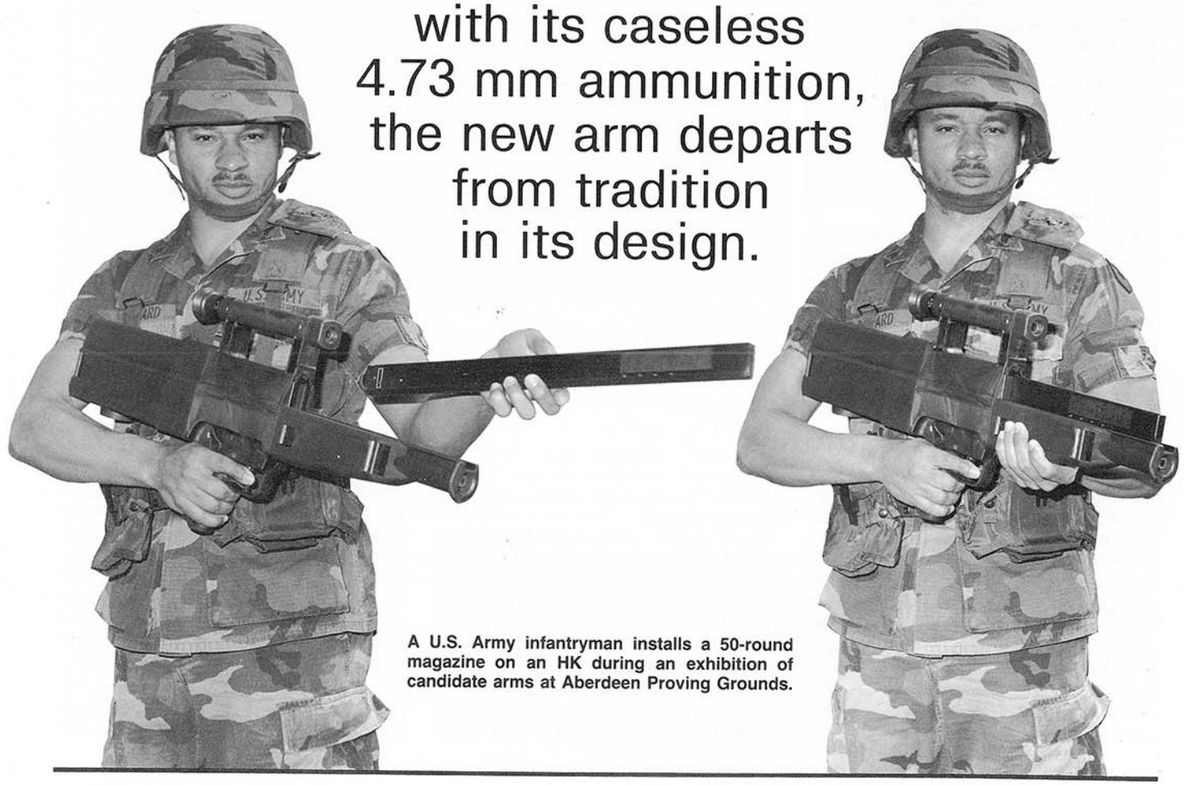
Removing the box-like stock to expose the gun mechanism reveals a bit of especially clever thinking by the HK engineers. Though their plans had incorporated all the conventional design principles to minimize burst-fire dispersion, ammunition powerful enough to meet the required criteria for penetration and lethality at the longest ranges of interest still produced too much recoil disturbance. An approach was required which would reduce still further the disturbing effects of recoil on the rifle and human body during firing of three-round bursts. It was decided that a mechanism should be devised to transfer the recoil impulse to the stock and shoulder over a period of time longer than the duration of a three-round burst, and thus to delay the greater part of the recoil disturbance until the last of the three rounds had been fired.

This was, then, the approach that they took. The barrel and action of the G11 are spring-mounted and free to recoil longitudinally within the stock. This recoil movement is not to be confused with the recoiling movements that take place within the mechanism of recoil-operated guns, such as the short-recoil Browning machine gun or the long-recoil Browning-type autoloading shotgun. None of the recoil movement in the G11 rifle is utilized to drive the mechanism, which is itself gas-operated. In semi-automatic fire, the time required for complete transfer of the recoil impulse from the gun mechanism to the stock and shoulder is about 140 milliseconds, or 1/7th of a second. This is about a hundred times the time required for the cartridge to produce the recoil impulse. The result is that the sensation of recoil is greatly reduced in the firing of single rounds.

In the burst-fire mode, the time interval required for this transfer is somewhat less, because the gun mechanism travels faster within the stock under the influence of the combined recoil from three rounds. Nevertheless, under burst-fire conditions the transfer of the recoil to the shoulder requires about 120 milliseconds. At the cyclic rate of more than 2,000 rounds per minute, the time required for a three-round burst is about 55 milliseconds. The result is that the major part of the recoil impulse is delayed until after the last bullet of the burst has left the barrel. Then, and only then, is the full force of the recoil transferred to the stock and rifleman's body. Though the calculated recoil impulse of the three-round burst is approximately 3.7 lb.-secs., or somewhat greater than the recoil impulse of one round of 7.62 NATO ammunition, its disturbing effect on dispersion is greatly reduced.

This unique spring-mounted mechanism serves another purpose as well. The cyclic rate of fire during the firing of three-round bursts, which is more than 2,000 rounds per minute, would be far too high for firing bursts in the full-automatic mode by trigger manipulation. When a round is fired in the full-automatic mode, the mechanism reloads at its usual high cyclic rate, in about 27 milliseconds,

Capable of fully-automatic, burst- and semi-automatic fire with its caseless 4.73 mm ammunition, the new arm departs from tradition in its design.



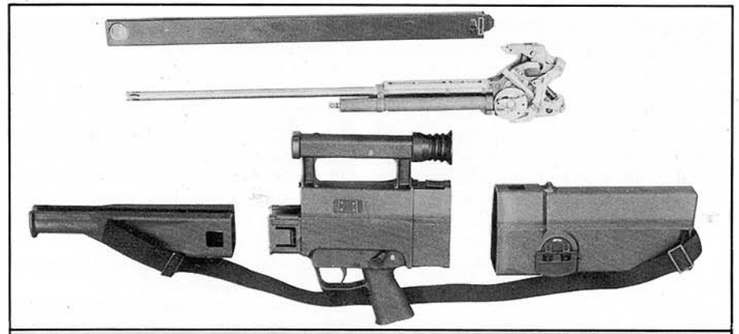
A U.S. Army infantryman installs a 50-round magazine on an HK during an exhibition of candidate arms at Aberdeen Proving Grounds.

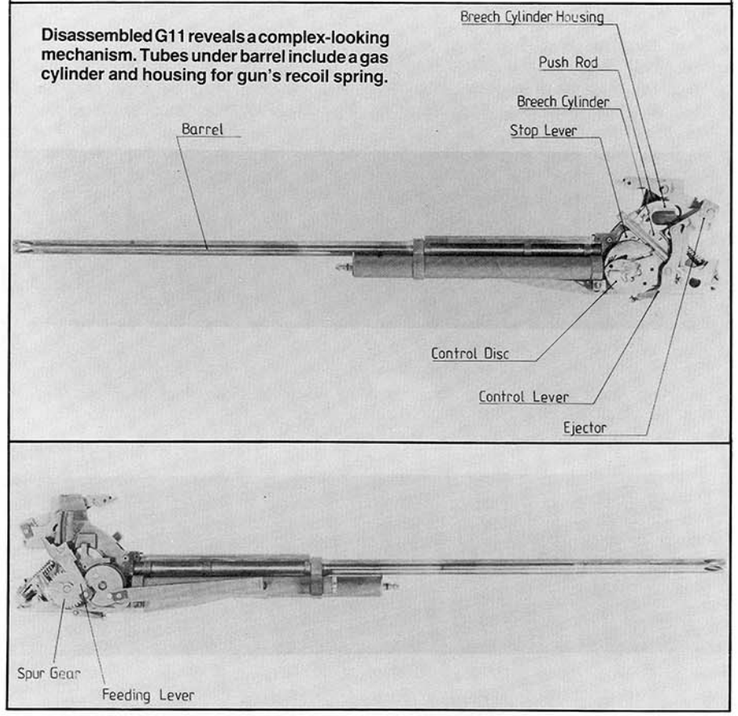
while the spring-mounted barrel and breech mechanism begin to recoil together within the stock. The next round is not fired immediately upon completion of the reloading cycle, however, but its firing is delayed until the spring-mounted mechanism has completed its recoil within the stock and returned to battery, which requires about 140 milliseconds. The spring-mounting of the mechanism thus serves as a very effective rate-reducer, so the gun fires at a comfortable and controllable cyclic rate of about 450 rounds per minute in the full-automatic mode.

To facilitate the high cyclic rate for three-round bursts, the HK engineers have again departed from the conventional. The gun mechanism has no reciprocating breechblock and no locking mechanism. To the rear of the barrel is attached an enlarged section which I shall call a receiver. This receiver has a large hole through it from side to side, with the center of the hole on the extended center-line of the bore. This hole is approximately 1.3″ in diameter. The so-called "breech cylinder" is fitted into this hole, and is so arranged as to rotate about a horizontal axis perpendicular to the barrel, rather than parallel to the barrel in the manner of a conventional revolver cylinder. Into this breech cylinder, perpendicular to the axis of rotation, is fitted a separate piece which contains the chamber. In the firing position, this breech cylinder is rotated so as to align the chamber with the bore. When the breech cylinder is rotated 90° from the firing position, the chamber is perpendicular to the bore, and is then in position to receive a cartridge from the magazine.

Viewed from the left side, the cylinder beneath and parallel to the barrel is the recoil-spring housing. The recoil spring is used to return the entire mechanism to the forward position in the stock, and it plays no other part in the functioning of the mechanism. Viewed from the right side, the gas cylinder is located alongside the recoil-spring housing, and a rod connects the gas piston with a wheel which is, in turn, geared to the "spur gear."

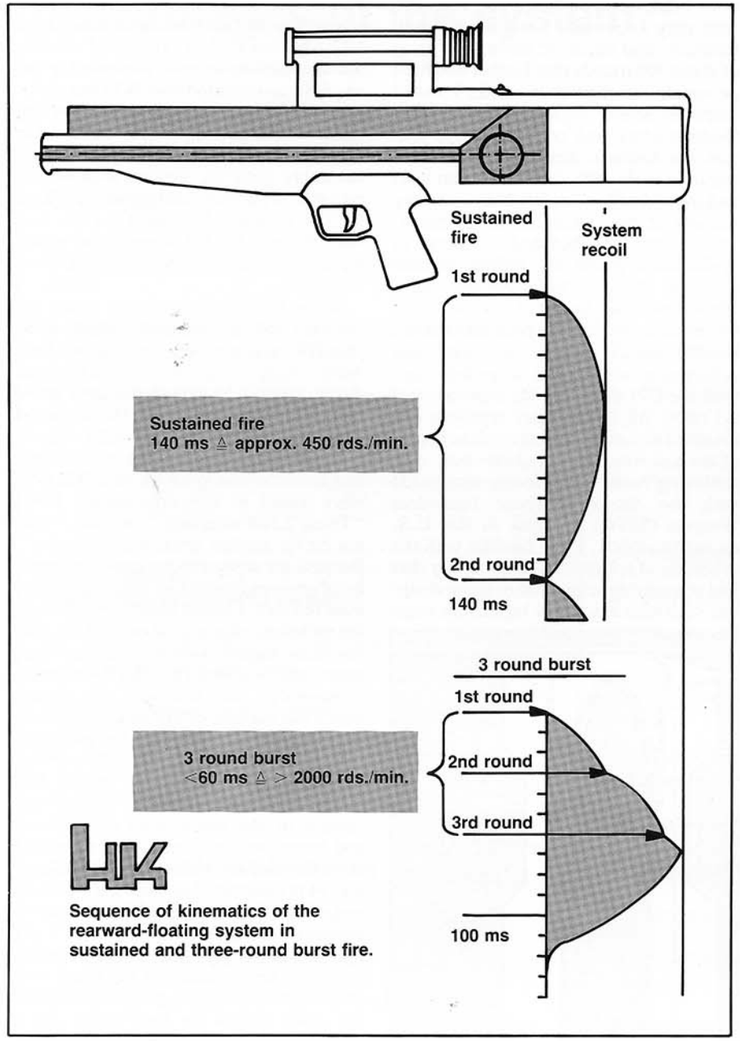
When a shot is fired, the connecting rod rotates the small wheel to which it is attached, and thus the spur gear, through one complete revolution. During this rotation, a cam on one of the wheels engages and rotates the breech cylinder through 90° into the loading position. The breech cylinder pauses briefly in this position, the feeding lever travels through its downward stroke, stripping a round from the magazine and inserting it into the chamber. After this action is complete, another cam rotates the breech cylinder through 90°, returning it to the firing position. This is the action illustrated at far right. Because the masses involved are relatively small, the accelerations and velocities of the various parts can be quite high without involving excessive forces.





Disassembled G11 reveals a complex-looking mechanism. Tubes under barrel include a gas cylinder and housing for gun's recoil spring.

Since sealing of the breech has long been considered a problem with caseless ammunition, I asked Tilo Moller, HK's chief engineer, what form of seal was used. He informed me that they had found that no special seal was necessary in this design. When I later inspected the internal parts of the gun, I found that the obturation depends only upon a close fit between the receiver and the chamber which is carried by the breech cylinder. Since the peak pressure may be as high as about 58,000 p.s.i., I expected to see some gas erosion of the ends of the chamber, but I could see no evidence of it in the used cylinders I inspected. Current chamber life was typically 2,500 to 3,500 rounds, I was told, but chambers were being replaced after 1,500 rounds to insure that the obturation would not fail unexpectedly and thus cause damage to other parts of the weapon. I was also informed that a new chamber design would be completed by mid-1989, and it was expected to have a life more nearly approaching the engineers' goal of 6,000 rounds.

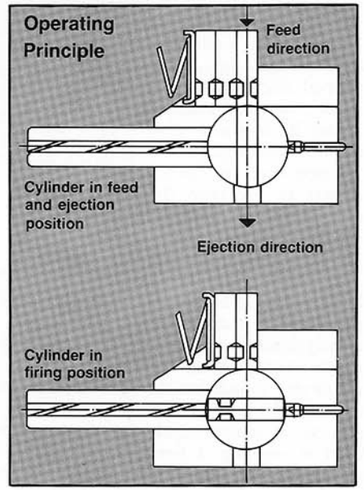


Sequence of kinematics of the rearward-floating system in sustained and three-round burst fire.

After being briefed and having the opportunity to examine the gun, I was invited to firing demonstrations, one at the HK indoor range, and another on the following day on an outdoor range some distance from the factory. On the indoor range I found that the rifle shot quite well. With a barrel and mechanism that move inside the stock, and a sighting system mounted on the stock itself, I did not expect the small groups that were fired in the semi-automatic mode. The best group had an extreme spread just over 2 minutes of angle (m.o.a.), and it was fired by an HK gunner. My own semi-automatic group was less impressive at just over 3 m.o.a.

The trigger was the most unusual feature that I noticed when shooting the rifle from a bench. The travel was very long, and it had no sensation of release. One simply pulled the trigger until something happened. While it was not the trigger action that most trained riflemen expect, it was undoubtedly safe, and it was not a serious obstacle to accurate shooting. I shot the weapon in the automatic mode only from the bench, but it appeared to be quite controllable. My 10-shot automatic group had an extreme spread of just over 27 m.o.a. Specific information on the dispersion pattern obtained in three-round bursts is currently classified, and though I was allowed to fire some three-round bursts at targets on the indoor range, we did not measure the resulting dispersion patterns. Based on my past experience with other weapons firing three-round bursts, my subjective impression is that the groups obtained with the G11 were surprisingly small, though I am unable to say how nearly the dispersion approaches that desired for maximum hit probabilities in combat.

The next day, after a delightful early morning ride through the German countryside, we arrived at an outdoor range which was equipped with firing points, stationary knockdown targets, and a moving target. All the targets were in the form of camouflaged, life-size silhouettes. Both the targets and the firing points were situated in an enormous expanse of mud. My hosts informed me that they had installed the targets at some expense, but that the mud was free, the gift of a mild, wet winter. The day was overcast, and a wind of about 15 miles an hour reminded me that, though the winter had been mild, it was not yet over. Except for the mud, I was adequately dressed. Quickly assessing the situation, my hosts provided me a pair of overshoes. They were a one-size-fits-all type which would have been only slightly large for Ronald McDonald, but I accepted them with genuine gratitude. For the next half hour I made my way about in the treacherous mud trying not to fall or to remind anyone of Charlie Chaplin. Finally, I realized that I was the only person present who could even remember Char-



Cartridges are fed into a chamber at right angle to bore line. Chamber (lower sketch) is then rotated into its firing position.

lie Chaplin, and just tried not to fall.

Since time and the number of rounds that could be fired were both limited, and because I knew that the three-round-burst mode placed the most rigorous demands on the mechanism, I elected to fire entirely in three-round bursts. Provision was made to shoot from any position, but I felt that I could best assess the performance of the G11 in three-round bursts by shooting from the standing position. The targets were grouped in a random array, offering no appearance of order. The range varied from about 50 yds. for the nearest targets to a little over 300 yds. for the most distant. A moving target crossed the area at about 100 yds.

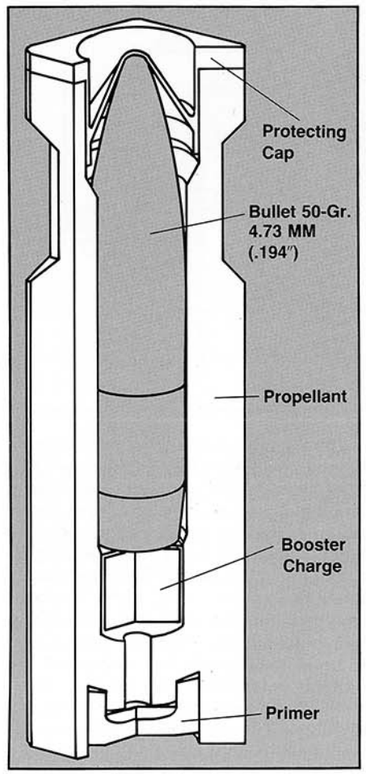
Before actually firing, I tried the G11 at the shoulder to determine the general feel of the rifle and the appearance of the target in the sight. The current sight is similar to the non-magnifying optical sight found on the Austrian AUG. The clear image, large field of view, and well-defined circular black reticle allow the shooter to acquire the target quickly and center it. In short, it is a sight which inspires confidence.

I first fired on several of the nearer targets to ascertain the effect of the recoil. I then decided to engage a series of targets as rapidly as I could, allowing an absolute minimum of time for sighting. The relatively slow transfer of recoil impulse to the body resulted in no discomfort, but it did move my body sufficiently to require a brief interval to regain my shooting position. There was no timing device to indicate the interval, but I estimate the time at slightly less than a second. Probably another second was used in sighting. I found that I could engage five targets successfully in approximately 10 seconds out to a range of about 200 yds. To engage targets successfully at longer range required a longer aiming time. As was expected, the burst pattern reduced the requirement for precise lead estimates and allowed me to engage the moving target quickly and effectively.

In the three-round-burst mode, one gets the impression that a great deal of activity is occurring within the G11's stock. This activity is accompanied by the sounds of a quietly busy mechanism instead of the sounds of impacting metal surfaces and vibrating springs that are common in more conventional gun mechanisms. After about 250 rounds of firing, I asked that the weapon be field stripped so I could see how much fouling was in the mechanism. Surprisingly little had accumulated, indicating that the propellent burns very cleanly.

Of course I was not visiting HK to conduct or participate in a full-scale test of the G11 rifle. I was a guest, allowed to examine and shoot HK's latest creation. I did, however, keep score, as I'm sure they knew that I would. No malfunctions had occurred during the firing of about 300 rounds that I either had fired personally or had witnessed. I asked Engineer Moller what testing the West German army had conducted. He said that the German army evaluation had begun in early 1988, and that troop tests had now been completed by infantry schools at five locations in Germany. These tests had included the firing of approximately 200,000 rounds of ammunition through 50 prototype rifles. Moller said these tests had included firing by recruits who had no prior experience in rifle marksmanship, and they had achieved notably higher hit probabilities with the G11 than with the conventional G3 rifles. All five infantry organizations involved in the tests had favored adoption of the new rifle, the HK spokesman said.

Having been quite closely associated with the Special Purpose Individual Weapon (SPIW) program in the U.S. during the 1960s, I was familiar with the problems of reliability and durability that had attended development of those weapons with their extremely high cyclic rates of fire. I was therefore interested in the malfunction rate the G11 experienced during its user tests to date. HK's Moller was obviously pleased to report that the rate of the malfunctions attributed to the G11 rifle was 0.15 per thousand rounds, and the malfunction rate attributed to the caseless ammunition was 0.30 per thousand rounds, for a system malfunction rate of 0.45 per thousand rounds. He noted that these rates compared quite favorably with the system malfunction rate of 0.30 per thousand rounds recorded for the standard German G3 rifles and the 7.62 mm NATO ammunition which were fired for comparison in the same user tests.



The 4.73x33 mm G11 caseless cartridge with its bullet weighing about 50 grs. yields 3051 f.p.s. muzzle velocity (see May, p. 30).

When I asked about future plans for the G11 rifle in Germany, Moller said that HK engineers are working on three minor changes requested by the German Army, and that he expected to have these completed within the year. He predicted that the German Army would initiate procurement during the first half of 1990, and that the first pilot lot of 2,000 G11 rifles would be delivered during 1991. "These 2,000 weapons," he said, "will not be for further tests, but for issue." Because the answer to the question would be of obvious interest to *American Rifleman* readers, I asked Moller whether all the technical information on the G11 rifle has been shared with the U.S. government, and he assured me that it has been.

Inevitably, the final test that determines the success or failure of a military weapon system is its record of performance after widespread deployment in the hands of troops. Some of the factors that determine the outcome are within the control of the engineering developers, and some are not. The history of small-arms development abounds with examples of prophecies that were not fulfilled, and of prophets chagrined because their prognostications were premature. I do not intend to join the ranks of such prophets. Let it suffice to say that I was truly impressed by the progress that HK has made toward the long-sought goals of fielding a practical infantry rifle that embodies both the concepts of caseless ammunition and of tightly controlled burst-fire dispersion.

The trip home was relaxed and unhurried. We were treated to one of the most magnificent scenes that I have ever had the privilege of viewing, southern Greenland in mid-winter. I had time to rest a little, and to reflect on what I had seen and heard at HK. In the arms room at HK, I had seen 13 generations of prototype weapons that were direct ancestors of the present G11, dating back to the first studies in 1970. Realizing that the G11 was the culmination of almost 20 years of intensive development, I knew that there was no way to do justice to an effort of that magnitude in the space available here. ■

Advantages of the system

G 11 Rifle

High hit probability in all firing positions and modes of fire

- Mounted (rearward floating) weapon system with extremely low and delayed recoil
- Extremely high rate of fire in the burst fire mode
- Low rate of fire in the sustained fire mode
- Quick target engagement and binocular battlefield observation

Sealed receiver
Integrated high-capacity magazine

- Full functional capability under adverse environmental conditions
- No impediment to the shooter from propellant gases
- Simplified maintenance training
- Increased combat capability

Rotating chamber, no linear moving bolt

- Short weapon length with maximum barrel length
- Short and straight line cartridge feeding
- Minimum mechanical strain on fed cartridge
- Minimum stress on components even in high rate of fire

Optimized ergonomic design

- Quick readiness to fire
- Left or right hand shooting
- Ideal center of gravity (located near the grip)
- Smooth exterior shape
- Minimum overall dimensions

Caseless ammunition

No cartridge case

- No ejection port on the weapon
- No consumption of expensive metals
- No signature of ejected cases
- No impediment to the near-by shooter
- No disposal of spent cases

Low cartridge weight, small cartridge dimensions

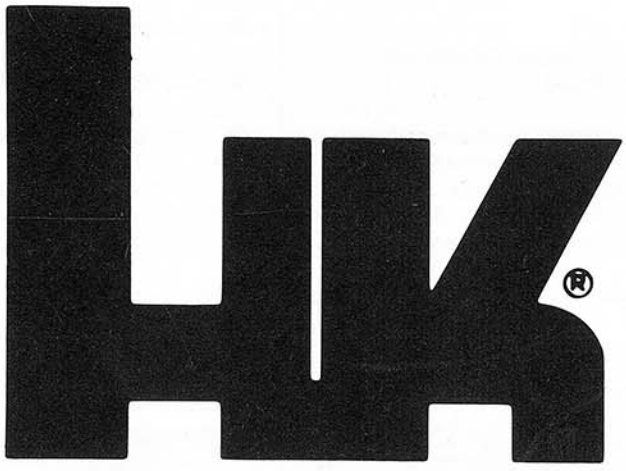
- More ammunition portability by the shooter
- Higher ammunition capacity in the weapon
- Simplified supply and logistics

Small caliber with high sectional density of the bullet result even at extreme ranges in:

- Flat trajectory
- High penetration power
- Good stability
- Minimum cross wind sensitivity

High ammunition dependability

- High mechanical strength of the cartridge
- Reloading directly from packing units
- Fully automated ammunition production
- Mechanical ignition



In a world of compromise, some don't.

HECKLER & KOCH, INC.
21480 Pacific Boulevard
Sterling, Virginia 22170-8903 U.S.A.
TEL. (703) 450-1900 TELEFAX (703) 450-8160
TELEX 7109550846