

Fluted and Annular Grooved Barrel Chambers in Firearms

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ABSTRACT: The identification of suspect firearms by fluted and annular grooved barrel chamber markings on fired cartridge cases is described.

KEYWORDS: forensic science, criminalistics, firearms identification, cartridge case identification, fluted and annular grooved barrel chambers

What Is a Barrel Chamber Flute?

Barrel chamber flutes are longitudinal grooves cut in the chamber of a firearm that allow propellant gases to surround the fired cartridge case thereby equalizing internal and external gas pressures, which facilitate extraction or bolt operation in a delayed blow-back firearm design. (Note:) In the Heckler & Koch HK-4 semiautomatic pistol caliber .380 (Fig. 1) there is a longitudinal flute barrel chamber design that is intended to retard case extraction rather than to facilitate case extraction.

The flutes in this design are dimensioned so the case metal forced into wide, closed-end grooves must be forced back out of the flutes as the case moves to the rear. No gas flows between the case and chamber walls.

In all other designs the flutes in addition to channeling propellant gases, are dimensioned such that any expanded case metal will slip out of the open-end grooves as the case moves rearward.

Factors Affecting the Identification Value of Flutes

Flutes are found in the chambers of some semi and full automatic pistols, semi and full automatic rifles, submachine guns and machine guns. They vary in number (2 to 18), shape, length and width, and leave corresponding impressions on a fired cartridge case. The forensic firearms examiner can often determine the type, model, and caliber of the suspect firearm through examination of the flute impressions on the fired cartridge case. Similarly, some weapons can be eliminated as possible suspects.

Flute patterns are most often identifiable as swellings of fired cartridge case metal; however, a few are identifiable only as patterns of pronounced firearm discharge residue on the spent cartridge case. The latter have to be handled carefully to avoid disturbing the residue pattern through poor handling or rubbing.

The length of the flute impressions on fired cartridge cases

varies. On some cartridges the flutes are found only in the cartridge neck and shoulder area. Examples are the Russian Tokarev 1938 and 1940 rifles (Fig. 2), People's Republic of China (PRC) Model 1980 pistol (Fig. 3) and PRC Type 64 Submachine gun (Fig. 4).

With the exception of the Italian Machine Guns Fiat 38 and Breda 30 the flutes do not cover the whole length of the cartridge case. There is always a fluteless area at the rear end of the cartridge case to seal the chamber and prevent the propellant gases from entering the receiver.

Test fired cartridges will very seldom show the perfect impression of all flutes; but it is less important since the number and width of the flutes are of great significance. It is possible to get excellent flute impressions by using factory pressure test cartridges; however, these are not always available.

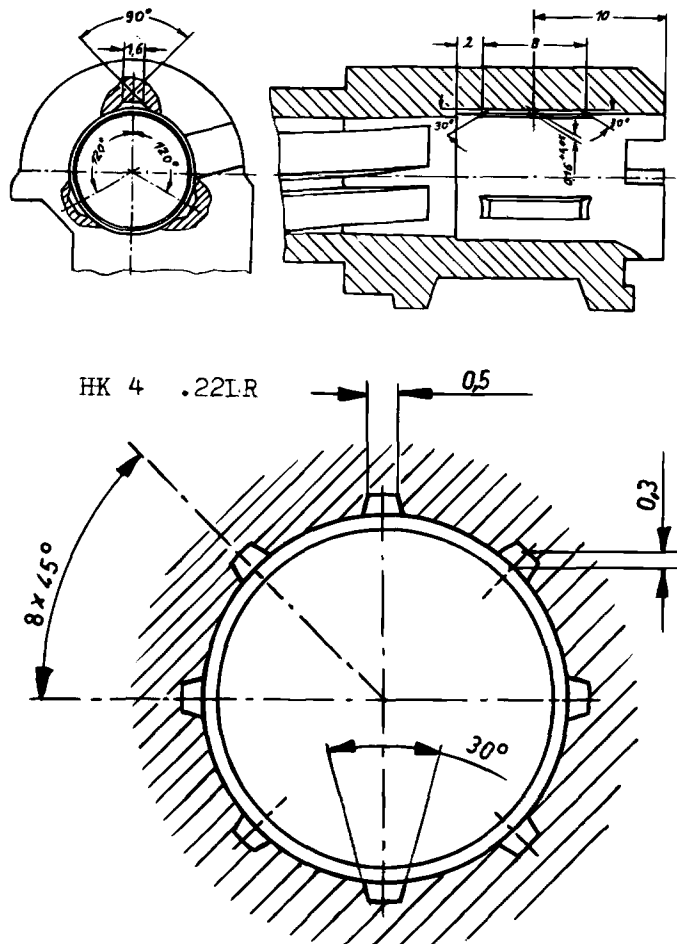


FIG. 1—HK 4 pistol, H&K Germany, Cal. .380, 3 retarding flutes; Cal. .22LR, 8 flutes.

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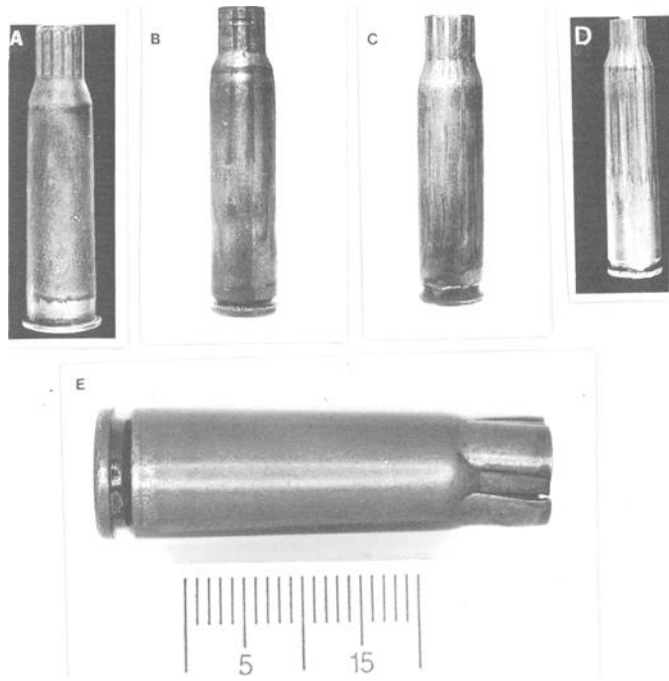


FIG. 2—Flute impressions on cartridge cases. A) Tokarev Model SVT 1938 & 1940 s.a. rifles, Russia, Cal 7.62 × 54 mm R, 14 flutes; B) PE 57, Swiss, Cal 7.5 × 55.5 mm, 8 flutes in 4 pairs; C) G 3 Heckler & Koch, Germany, Cal .308, 12 flutes; D) H&K 33, Cal .223, 18 flutes; E) Russian cartridge 7.62 × 39 mm fired in RPG rocket launcher training device. It bears 4 very deep impressions of the rifling 4-R.

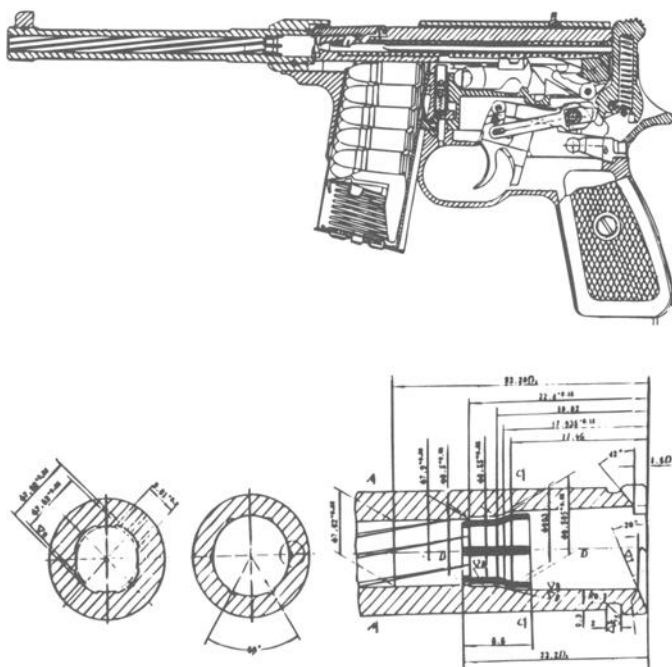


FIG. 3—Mode! 80, full auto pistol, PRC, Cal 7.62 × 25 mm b.n., 6 flutes.

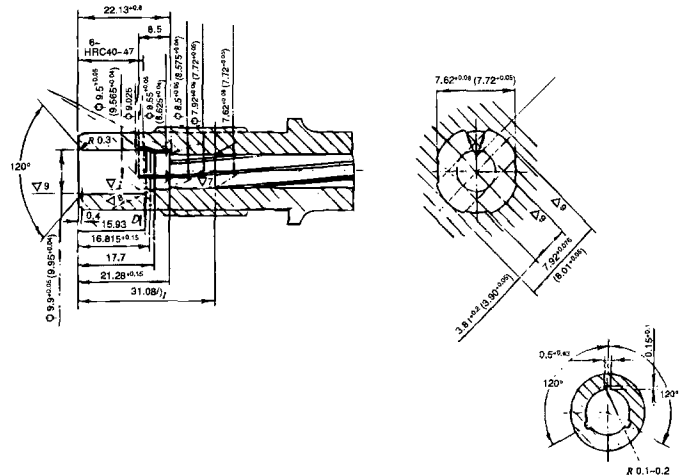


FIG. 4—Type 64, silent submachine gun, PRC, Cal 7.62 × 25 mm b.n., 3 flutes.

The factors affecting the quality of flute impressions are as follows: a) the hardness and thickness of the cartridge case (some manufacturers use harder brass than others); b) type and pressure of propellant; c) size and condition of the chamber; and d) depth and shape of the flutes.

Some same-caliber weapons have the same number of flutes. For example, the German Heckler & Koch semi-auto rifle Model 300 Cal 22 WMR 16 flutes; and the American Grendel Pistol (Fig. 5) and Model P-30 Cal 22 WMR 16 flutes. In this case, an accurate identification (of the type of weapon involved) can be made by distinguishing the flute patterns of the Model 300 semi-auto rifle, which produce pronounced expansion of the cartridge case from those of the Model P30, which are pronounced only by powder residue impressions.

Other examples can be more difficult. These include the German Heckler & Koch Model 43 (M88)SEATO Cal .223 16 flutes; the French FAMAS military assault rifle (Fig. 6A) Cal .223 16 flutes; and the Spanish AMELI LMG (US designation MG 82) (Fig. 7)



FIG. 5—Grendel pistol, USA, Cal .22 WMR, 16 flutes.

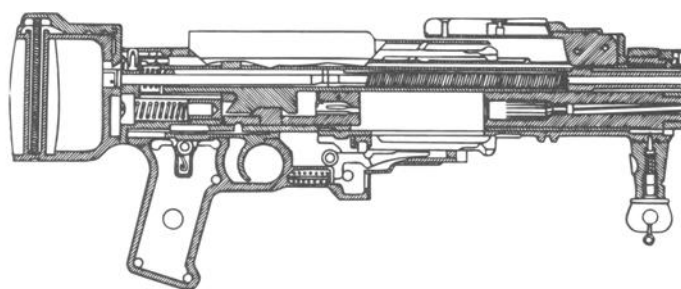
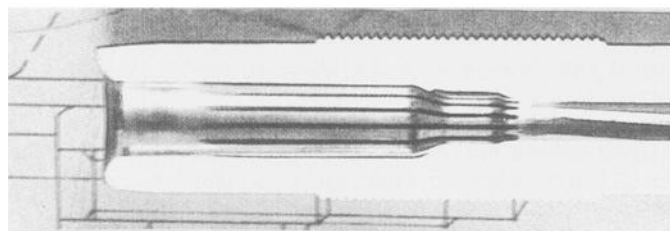


FIG. 6—FAMAS military assault rifle and Shkas aircraft machine gun. A) Famas, Barrel cross section, France, Cal .223, 16 flutes; B) Shkas Aircraft MG, Russia, Cal 7.62 × 54 mm R, number of flutes unknown.

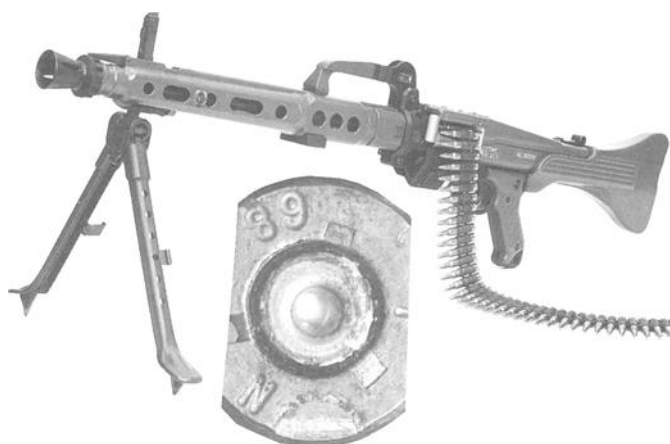


FIG. 7—Cetme Spam LMG (Ameli or MG 82), Spain, Cal .223, 16 flutes.

Cal .223 16 flutes. In these weapons, the cartridge case identification has to be supported by the following: firing pin, breech block face, ejector, extractor, and ejection port markings.

What Is an Annular Grooved Barrel Chamber?

Annular and helical grooves are cut in barrel chambers to permit propellant gases to expand the walls of the fired case into these grooves, thereby causing resistance to extraction or case projection of the bolt.

Factors Affecting the Identification Value of Annular or Helical Grooved Barrel Chambers

Annular or helical barrel chambers are generally found in lower pressure, straight cased, cartridge weapons. The basic factors affecting identification are generally the same as those with fluted chamber barrels.

However, case markings tend to be obliterated by the extraction or case projection process. Initial radial expansion or residual patterns are overrun by longitudinal scrape striations. Nevertheless, the location and the number of distinctive expansion marks can usually be determined by close examination.

Examples include the following semiautomatic pistols: the American Kimball Cal 7.62 × 33 (Fig. 8); the American Hi-Standard T-3 9 mm Para (Fig. 9); the PRC Type 1964 7.65 × 17

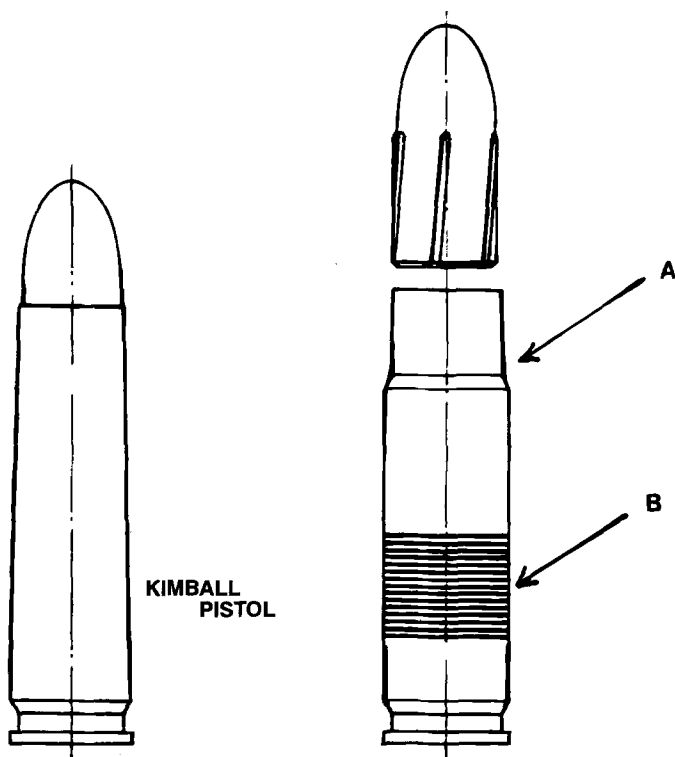


FIG. 8—Kimball pistol, USA, Cal .30 CAR (7.62 × 33 mm); Arrow A) shows fire-formed shoulder; and Arrow B) shows 14 shallow annular grooves.



FIG. 9—Hi-Standard Model T-3 pistol, USA, Cal 9 mm Para, one retarding annular groove.

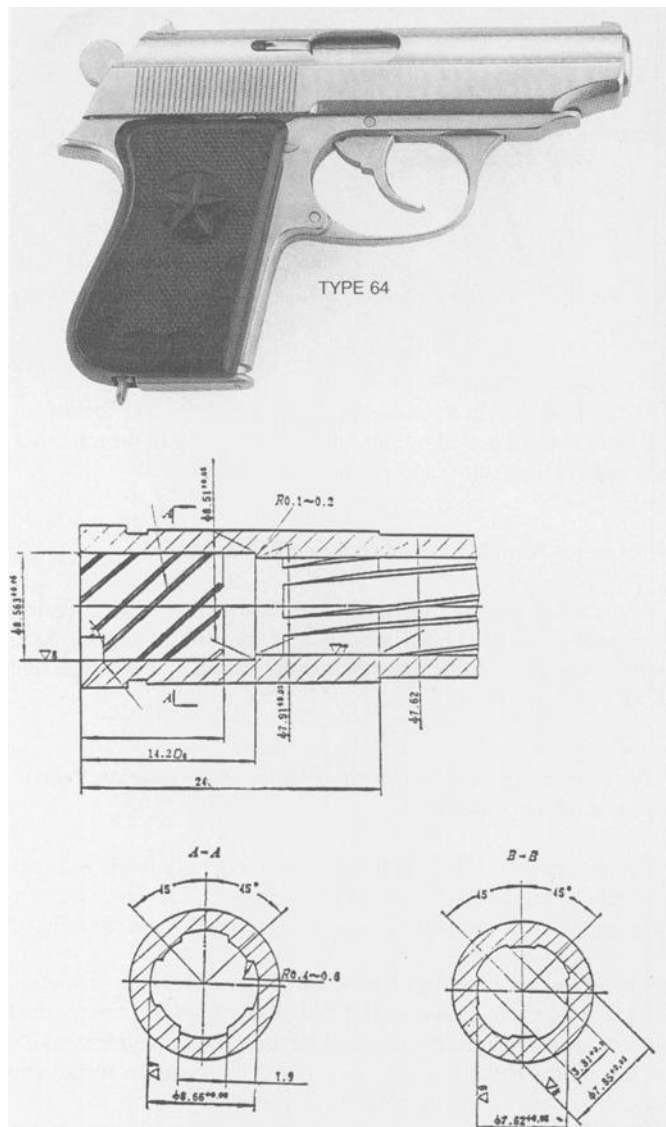


FIG. 10—Type 64 pistol, PRC, Cal 7.62 mm, rimless, 4 retarding helical grooves.

mm (rimless) (Fig. 10); and the PRC Type 1977 7.65 × 17 mm (rimless) (Fig. 11).

Fluted and Annular or Helical Grooved Barrel Chambers in Pistols

There are two types of machine patterns found in semiautomatic pistol barrel chambers. Flutes to assist initial extraction and retarding annular and helical grooves.

Flutes to Assist Initial Extraction and Accelerate Slide Operation

These are found in the German H&K P-7 pistol (Fig. 12); and its variations, for example, P7M8, P7M13, P7M13SD, P7M8ST, the German H&K P9S and H&K 4 in Cal 22 LR, the Italian Benelli Model B-76, the PRC Model 1980 (Chinese copy of Mauser Mod. 712 (1932) (semi and full automatic), and the USA Grendel P-30 and Auto Mag II (Fig. 13) pistols.

Retarding Annular and Helical Grooves

Their purpose is to slow down the opening of the slide to enable the use of a relatively light slide and recoil spring, thus a lighter firearm. Retarding flutes are found in several American experimental pistols.

There is an annular groove in the HI-Standard Model T-3 experimental pistol in the forward part of the chamber. The re-sizing effort required for the cartridge case ejection retards the movement of the case and slide, and allows the use of blow-back rather than locked action.

The Kimball experimental pistol chamber has 14 rather shallow annular grooves, the impression of which is found on the fired cartridge case. In addition, the fired cartridge case expands into an enlargement cut in the front of the barrel chamber and creates the appearance of a bottleneck cartridge.

Only one mass-produced semiautomatic pistol using an annular groove flute is encountered in the USA. It is the PRC Model 77 (1977-DA) Caliber 7.62 × 17 mm rimless onehand cocking pistol, which has an annular groove in the chamber. Firing results in a bulge in the cartridge case measuring approximately 8.58–8.59 mm in diameter. The re-sizing of this bulge in the process of extraction slows down the slide.

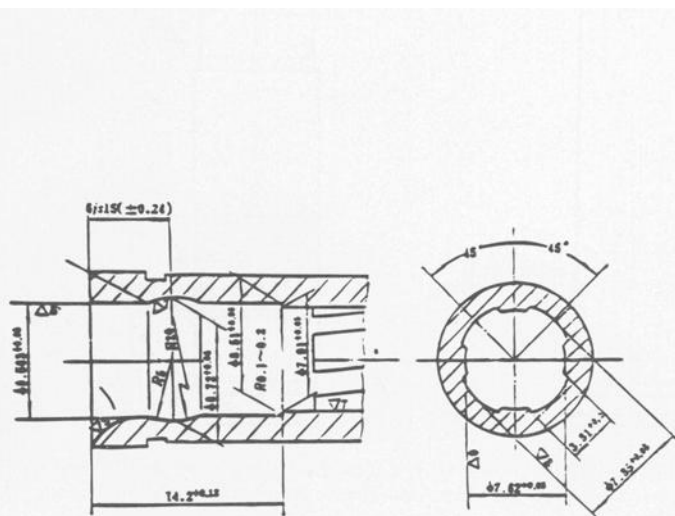


FIG. 11—Type 77, Onehand pistol, PRC, Cal 7.62 mm, rimless, 1 retarding annular groove.

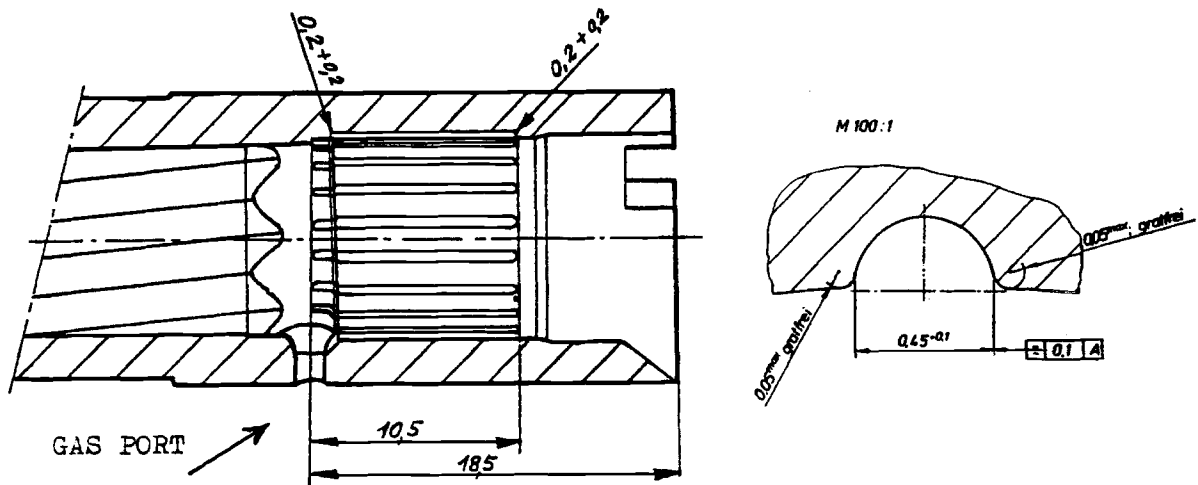
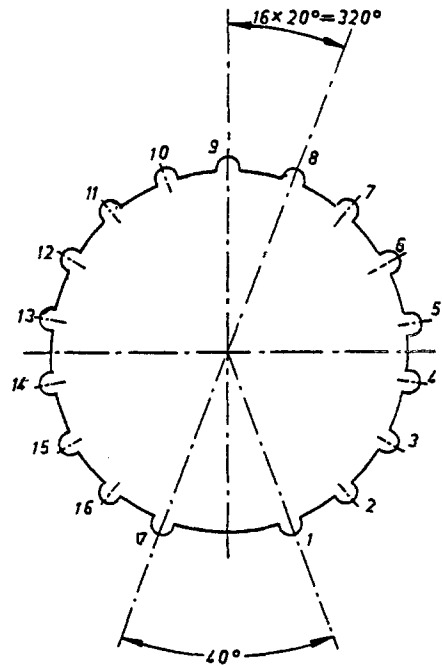
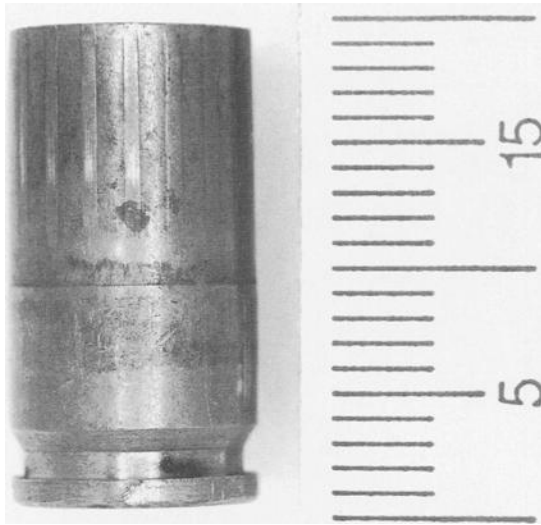


FIG. 12—P 7 pistol, H&K Germany, Cal 9 mm Para, 17 flutes.

The PRC Model 64 (1964-DA) Caliber 7.65×17 mm rimless is the only pistol manufactured anywhere using four helical flutes. These are very shallow and appear as small swellings on the fired cartridge case and are very difficult to identify.

Fluted Barrel Chambers in Semi and Full Automatic Rifles

The first mass-produced military semiautomatic rifles known to have chamber flutes were the gas operated, locked-breech, Soviet

Tokarev Models 1938 and 1940. Both have flutes in the chamber neck area to assist initial extraction.

Most semi and full auto rifles using fluted chambers were produced after WWII and these were delayed, blow-back operated design. They depended upon fired case projection under residual pressure to permit the case to act as a piston to overcome a mechanically delayed bolt operating system. Without the barrel chamber flutes (or lubrication), the cartridge case would not move with sufficient force to move the bolt without the case being torn in two. This would occur because the front section of the case tends to adhere more tightly to the chamber walls than the thicker rear section. In all blow-back and delayed blow-back systems, the cartridge cases are projected from the chamber by propellant gases. The extractor is used only to hold the fired cartridge case in its place in the bolt face for ejection. The leader in this field was the German Heckler & Koch Company, which has produced the rifles shown in Tables 1 and 2.

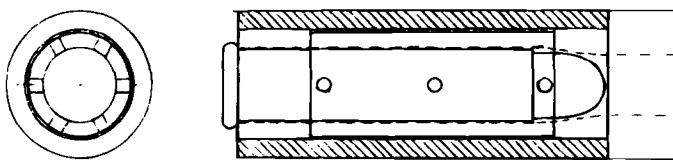


FIG. 13—Auto Mag II, USA, Cal .22 WMR, 12 round retarding impressions.

“STAR” SUBMACHINE GUN MODEL Z-70 Cal. 9 mm. PARABELLUM (Luger)

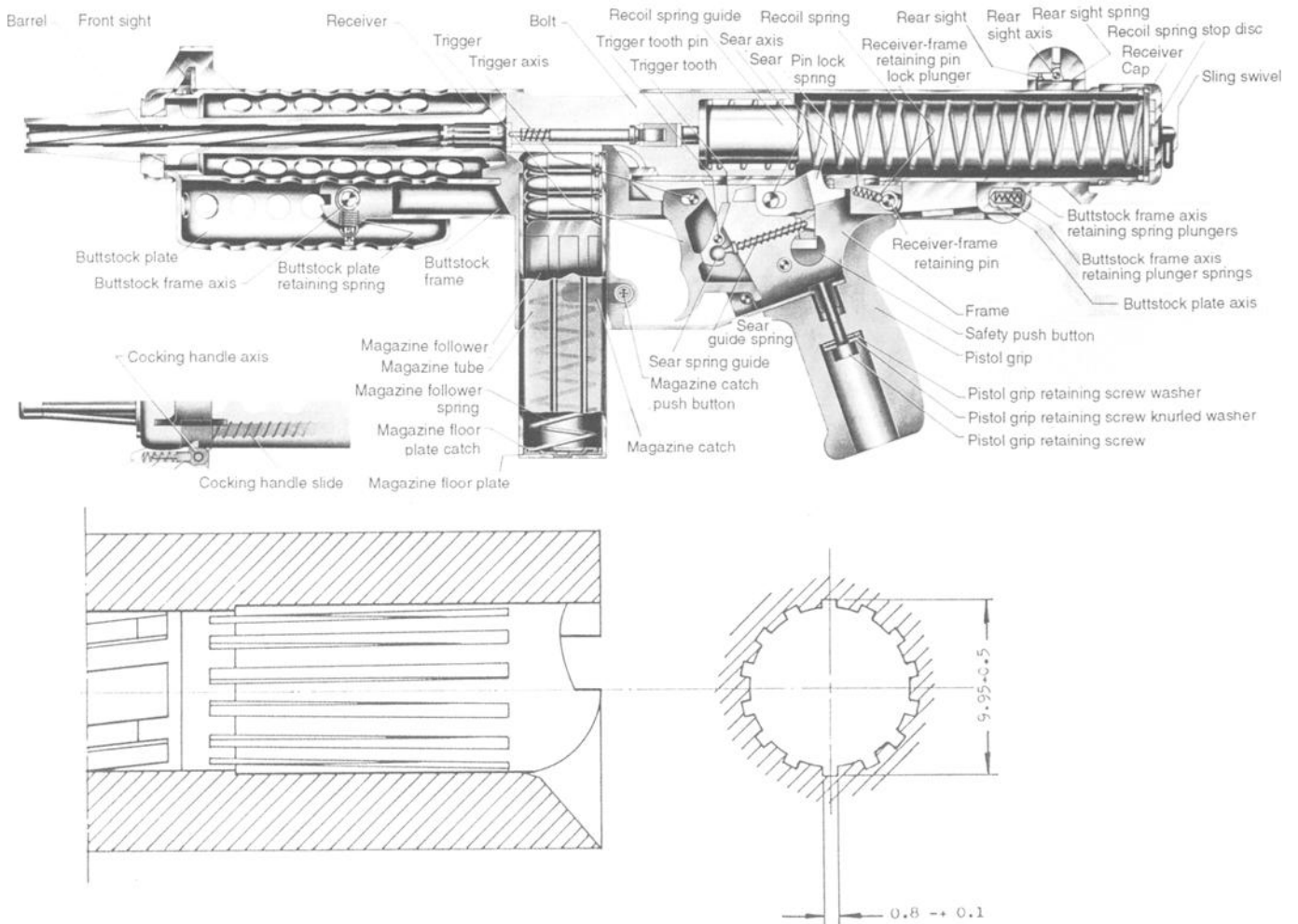


FIG. 14—Star Model Z-70 submachine gun, Spain, Cal 9 mm Para, either 14 or 10 flutes.

TABLE 1—Rifles produced by the German Heckler and Koch company.

Rifles Cal 7.62 × 51 mm: G3 (Fig. 2); G3 A1 to A4; G3E G3k GR 7 G3/SG1; G3SG1L; PSG1 MSG 90; MSG 90E HK 91 A1 to A5; SR9 HK 41	Semi and full auto Standard models Short barrel Optical sight only Rifles for snipers Semi auto only Semi auto only—German version
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NOTE—All of these rifles have 12-flute barrel chambers.

TABLE 2—Rifles produced by the German Heckler and Koch company.

Rifles Cal 5.56 × 51 mm: HK 33 (Fig. 2); HK 33E1 HK 33k; HK 33kE; HK 33kE1 HK 33/SG1 GR 3 HK 93 A1 to A5 HK 43 HK 53; HK 53 E1 HK G41; HK 41k	Semi and full auto Standard models Short barrel Sniper Optical sights only Semi-auto only Semi auto only—German version Short barrel and short receiver Housing modified { Barrel 450 mm short barrel
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NOTE—All of these rifles have 18-flute barrel chambers.

TABLE 3—Pistols fluted and annular grooved chambers.

Country	Model	Cal	No. of Flutes	Remarks
Germany	H&K P7	9 mm Para	17	The first 479 pistols were marked "PSP." The production of the P7 started 1 May, 1979. Approximately 79,700 pistols were made. The flutes in the P7 barrel are 20° apart ($16 \times 20 = 320$). At 6 o'clock there is 40 gap between the flutes due to the gas port in the barrel. The flute width is $0.45 + 0.1$ mm, and the flutes end 9.5 mm from the bottom of the cartridge case.
	P7 M8	9 mm Para	17	M8 indicates 8 shot magazine.
	P7 M13	9 mm Para .40 S&W	17	M13 indicates 13 shot magazine. Flute width 0.45 mm.
	P7 M13S	9 mm Para	17	13 shot magazine, with lever safety.
	P7 M13SD	9 mm Para	17	Barrel threaded for silencer.
	P7 M8 ST	9 mm Para	17	Weapon and magazine of stainless steel.
	P7 M10	.40 S&W	17	10 shot magazine. Production start 1977. Flute width 0.45 mm.
	P9S	9 mm Para	18	The flutes are 20° apart. Produced since 1968.
	HK4	.380	3	Retarding longitudinal grooves in HK4 were used only since Oct/68. The earlier production only had a smooth chamber.
	PRC	HK4	.22 LR	8
Type 1964		7.65 × 17 mm 7.62 mm rimless	4	Helical retarding flutes in the chamber. They cover the whole chamber. Difficult to identify. Flute impressions have expansion form or bulges. Flute width 1.9 mm, depth 0.75 mm.
Type 1977 Onehand		7.65 × 17 mm 7.62 mm rimless	1	1 retarding annular groove in the chamber. Expansion of the fired cartridge case measures approximately 8.58–8.59 mm.
USA	Type 80 (1980) Full Auto Auto Mag II	7.62 × 25 mm bottle necked .22WMR	6 12	Flutes are located on the neck and shoulder area of the fired cartridge case. Re-designed copy of Mauser full auto M 712 (1932) pistol. 18 equally spaced holes in the chamber. (3 sets of 6 each), but only 12 of them leave round impressions on the fired cartridge case.
	Grendel P-30	.22WMR	16	The flutes on the fired cartridge case are pronounced in powder residues only. H&K rifle Mod 300 also has 16 flutes but these produce metal expansion.
	Kimball (Exper)	7.26 × 33 mm US CAR	14	14 thinly pronounced shallow annular grooves found on the lower half of the fired cartridge case. An enlargement in the chamber fire-forms a shoulder on the fire cartridge, creating a false impression of a bottle-necked cartridge.
Italy	Hi-Standard T-3 exper.	9 mm Para	1	One retarding annular groove.
	Benelli B-76	9 mm Para	12	Very shallow barrel chamber flute impressions. Some fired cartridge cases show hardly any evidence of flutes.
	Tanfoglio TA 90	9 mm Para	6	6 spiral grooves in the barrel chamber—reported by E. Thompson Forensic Science Laboratory, Indianapolis, IN.

TABLE 4—Semi and full automatic rifles fluted barrel chambers.

Country	Model	Cal	No. of Flutes	Remarks
Germany	H&K 300	.22 WMR	16	This rifle is not produced any more.
	HK G 3	.308 NATO	12	Flute width 0.54 + 0.53 mm. Flutes end 13 mm from the bottom of the cartridge case.
	H&K 43, M88 (SEATO)	7.62 × 51 mm .223	16	Sold by Interarms.
	HK 33k, HK 33	5.56 × 45 mm .223	18	Flute width 0.37 + 0.17 mm. Flutes end 13 mm from the end of the cartridge case.
	G 41, G 41k			Called ORION SR9 in the USA. Trigger group and thumbhole buttstock and forearm made from Kevlar reinforced fiberglass.
	H&K SR9	.308	12	Flute impressions found only on the neck and shoulder area of the fired cartridge case.
USSR	Tokarev	7.62 × 54 mm R	14	
Switzerland	SVT 1938 and 1940			
	SG 510-4	.308 NATO	8	
	SG 510	7.62 × 51 mm 7.5 × 55 mm	8	
	SIG AMT	1911 ctge .308 NATO	16	Semi auto only, commercial model. No grenade launcher ribs on the barrel. Equally spaced flute impressions.
	PE 57 (SF)	7.5 × 55.5 mm	8	Flutes form 4 groups of 2. Double shoulder fire-formed on fired cartridge case.
Spain	Stgw. 57	7.52 × 55.5 mm	8	Paired by 2, double shoulder.
	CETME M-58	.308 NATO	16	
		7.62 × 51 mm		
France	FAMAS	7.92 × 40 mm		
		5.56 × 45 mm	16	Semi and full auto for the French army; semi auto only for the civilian market.
		.223		

NOTE—List of H&K made rifles Cal .308 and .223 is found in Tables 1 & 2.

TABLE 5—Submachine gun fluted barrel chambers.

Country	Model	Cal	No. of Flutes	Remarks		
Germany	H&K MP 5	9 mm Para	12	Flute width 0.6–0.2 mm. Flutes end 8.5–0.7 mm from the bottom of the cartridge case. 12 flutes used up to 1989.		
	<div style="display: inline-block; vertical-align: middle; font-size: 2em;">{</div> MP 5	9 mm Para	16	After 1989, the number of flutes was changed to 16. Flute width 0.4 + 0.2 mm. Flutes end 8.5–0.7 mm from the bottom of the cartridge case.		
		*MP5 K to MP5 K A5	9 mm Para	16	Short barrel, short receiver, no shoulder stock.	
		MP5 SD to MP5 SD6	9 mm Para	16	With silencer.	
		MP5N, MP5 KN, MP5 N1	9 mm Para	16	US Navy.	
		SP89 SP89 A1	9 mm Para	16	US civilian market.	
		MP5 A2/10	10 mm	16	US Government.	
		MP5 A2/40	.40 S&W	16	Flute width 0.4 + 0.2 mm.	
		*HK 94 to HK 94 A3K	9 mm Para	16	Semi-auto—in USA called rifle.	
		HK 94 Long	9 mm Para	16	Longer barrel—in USA called rifle.	
		Spain	STAR Z-45	9 mm Para	14	Flute width 0.8 + 0.1 mm.
			9 mm BB			
				STAR Z-62	9 mm Para	14
			9 mm BB			
STAR Z-70	9 mm Para			14	0.8 + 0.1 mm.	
9 mm Para						
	STAR Z-70B	9 mm Para	10			
9 mm Para						
	STAR Z-84	9 mm Para	14	0.8 + 0.1 mm. Developed for the Spanish Guardia Civil.		
PRC	Type 64	9 mm Para	14	0.8 + 0.1 mm.		
		7.62 × 25 mm	3	Silent weapon. Very narrow flutes found in the neck and shoulder area of the fired cartridge case. Flute width 0.5 mm.		
Russian Commonwealth of States	KLIN	9 × 18 M (modernized Makarov ctge)	?	Designed by Dr. Ing. M.E. Dragunov in Izhevski Mechanitschesky Zavod. Reportedly chamber with screw-type flutes.		

*Weapons produced before 1989 have 12 barrel flutes.

TABLE 6—Machine gun fluted barrel chambers.

Country	Model	Cal	No. of Flutes	Remarks
USSR	Shkas	7.62 × 54 R special aircraft ctge	?	Obsolete.
Italy	Breda 30	7 × 57 mm	2	Made for Costa Rica.
	Fiat 28	7 × 57 mm	2	Flutes extended over the whole length of the cartridge case.
Switzerland	MG 710-1	7.5 × 55.5 mm	12	
	MG 710-2	7.5 × 55.5 mm	12	
	MG 710-3	7.62 × 51 mm	12	
France	AAT Mle 52	.308 NATO 7.5 mm French M 1929 ctge.	16	
Spain	CETME SPAM (Ameli)	.223	16	Same number of flutes as AAT Mle 52, but different calibre.
Germany	HECKLER & KOCH HK 11	7.62 × 51 mm	12	All H&K machine guns are convertible from belt to magazine feeding.
	HK11 A1 to A3/2		12	
	HK11 E		12	
	HK 21 to HK 21E		12	
	G 8	.308 NATO	12	Magazine and belt for } German border police. Magazine only
	G 8 A1		12	
	HK 13; HK 13E; HK13 E1; HK 23E	5.56 × 45 mm .223	18 18	

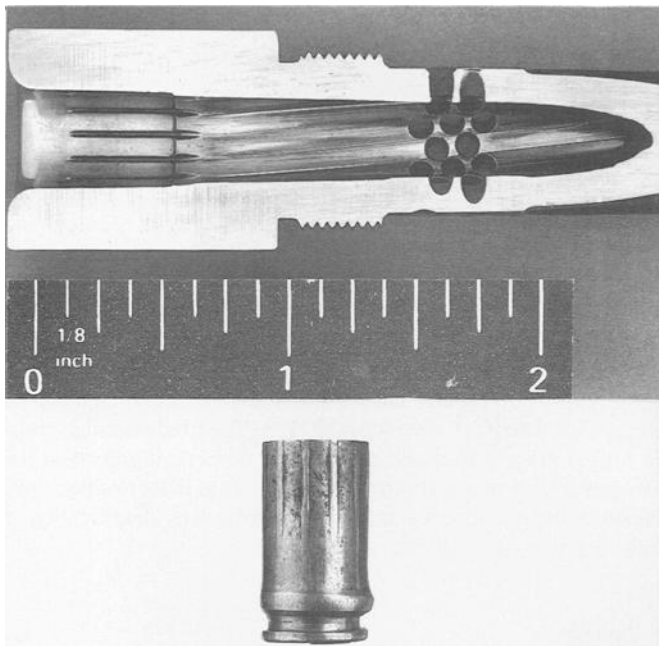


FIG. 15—Barrel cross section of H&K silent MP 5 submachine gun showing the chamber flutes and the silencer gas release ports. These guns had straight magazines and therefore required a deep feed ramp. The cartridge case shown was overloaded, using a very soft brass cartridge case. This resulted in explosion and fire in the chamber, very pronounced expansion of the case wall into the flutes, "set up" (bulge) of the fired cartridge case and subsequent stoppage.

The Swiss produced the SG 510-4, SIG-AMT, PE 57 (SF) (Fig. 2) and Stgw 57. Spain produced the CETME M-58 assault rifle and the French produced the bull-pup FAMAS assault rifle.

Fluted Barrel Chambers in Submachine Guns

The design and characteristics of pistol caliber submachine gun fluted barrel chambers follow the same principles as those employed in pistol design. The first post WWII submachine gun with a fluted chamber to assist initial extraction and case projection was the Spanish STAR Model Z-45. Its chamber has 14 flutes. This was the beginning of the developmental line of the STAR submachine guns Models Z-62, Z-70, Z-70B and Z-84 (Fig. 14).

All of these submachine guns use the same rifling specifications and have barrel chambers with 14 characteristic flutes of the same dimensions. However some Star Z-70 models have been produced with only 10 flutes and the same rifling specifications.

The German Heckler & Koch Company produced the MP-5 submachine gun (Fig. 15) in many variations, some with silencer, and having barrel chambers with 12 and 16 flutes in Calibers 9 mm Para, 10 mm and .40 S&W.

The PRC silent submachine gun Model 1964 is the only known weapon ever manufactured with three flutes located in the barrel chamber neck and shoulder area. The cartridge used in this weapon is bottle-necked with a special heavy bullet.

There is no known application of annular or helical barrel chamber grooves to retard case extraction in production guns.

Fluted Chambers in Machine Guns

Machine gun fluted barrel chamber designs follow the same principles as those of semi and full automatic rifles. The first

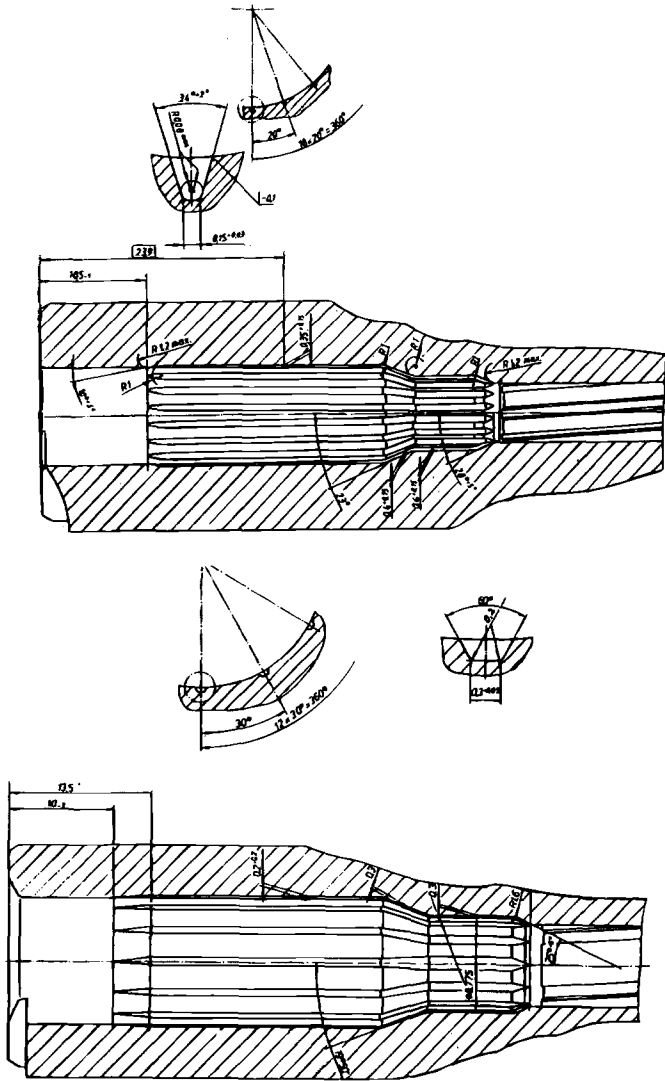


FIG. 16—1) H&K, LMG Model 23, Germany, 18 flutes; 2) H&K, LMG Model HK 21, Germany, Cal .308, 12 flutes.

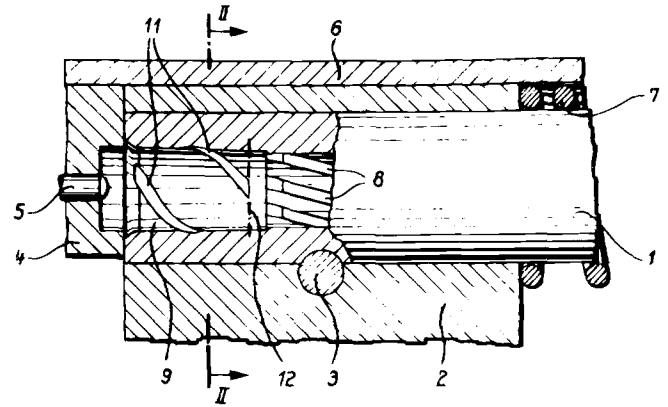


Fig. 1

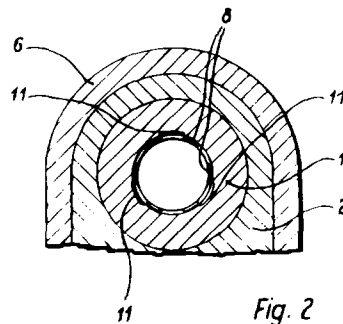


Fig. 2

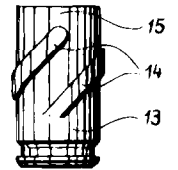


Fig. 3

FIG. 17—German Patent 1921319 was granted to H&K designers Tilo Moller and Helmut Weldle on June 8, 1972. It covers a unique 3-chamber screwlike design using 3 retarding helical grooves. This design was intended to achieve reduced recoil of a powerful cartridge through the screw action in the course of ejection. It was never used in mass production of the VP 70 by H&K and the problem of reducing recoil was solved by deepening of the rifling grooves; however, at some expense of bullet velocity. NOTE: In the Commonwealth of Russian States, Dr. Ing. Ewgeni F. Dragunow spent several years of development on a Compact submachine gun called Klin, suitable for police use and chambered for the improved Makarov cartridge. This weapon is produced by Izhewski Mechanicheskii Zavod in Tula and reportedly uses screw type flutes in its chamber.

countries to use fluted chambers in machine guns before WWII were Italy and Russia.²

The Italian LMG Fiat 28 is the only known machine gun ever manufactured with a barrel chamber having just two flutes. They are located at the 3 and 9 o'clock areas of the chamber and are unusual in length as they extend from the neck of the chamber all the way to the end of same.

In 1933, the Russians developed the Shkas Aircraft machine gun with fluted barrel chambers (Fig. 6B).

The first post WWII machine guns with fluted barrel chambers were the Swiss MG 710-3 (12 flutes), followed by the French AAT Model Mle 52 (16 flutes). H&K in Germany developed the HK 11 to A3/2, HK 11E, HK 21 (Fig. 16) to HK 21E, HK G-8, HK G8A1 chambered for the .308 NATO cartridge (12 flutes) and the HK 13, HK 13E, HK 13 E1 and HK 23 E (Fig. 16) in Caliber 5.56 × 45 mm (.223) (18 flutes).

²Figure 18 shows Patent No. 8943 AD 1915 of June 19, 1916 issued to Giovanni Angelli of Corso Dante Vo. 30, Turin, Italy covered two types of barrel flutes—flutes to help initial extraction and case projection, and an annular groove for retarding.

The latest post WWII machine gun with a fluted chamber is the Spanish Ameli (16 flutes) in Cal. 223. The fired cartridge cases are fully extracted from the chamber by propellant gases and the extractor is only used to hold the cartridge case in its position until ejected. A large semi-circular ejection mark makes identification of fired cartridge cases easier.

Conclusion

This paper contains most but not all of the firearms that have fluted barrel chambers. More research is required to establish a complete file of standards on such firearms. It should contain a picture of the weapon, a drawing of the barrel chamber and breech block face showing the location of all identification and accidental markings, rifling specifications and serial numbering systems.

Any additional information on firearms with fluted barrel chambers is always welcomed and greatly appreciated by the author.

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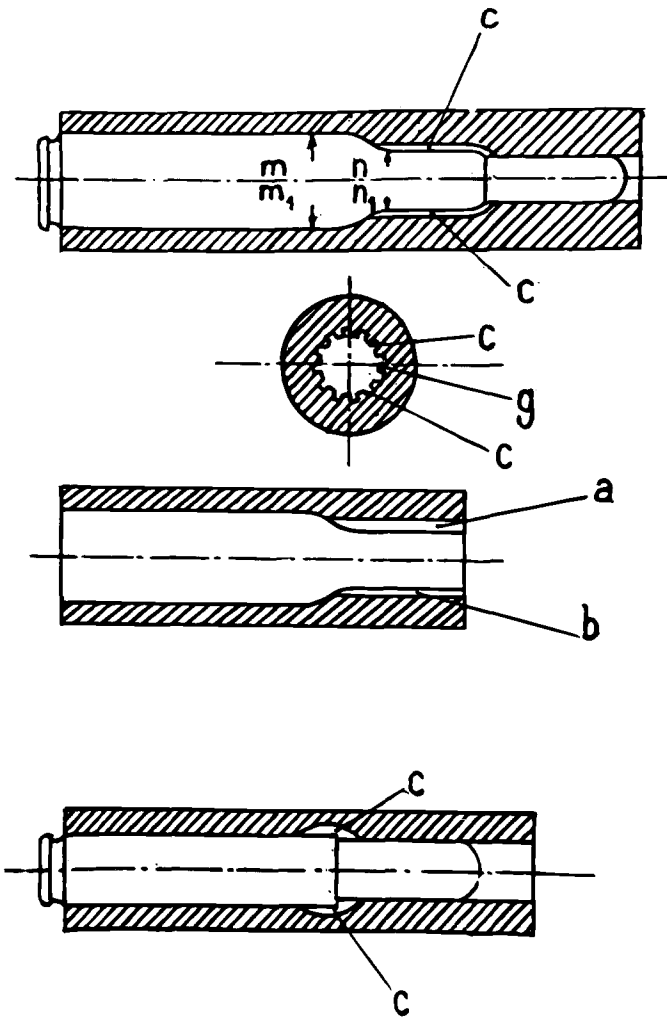


FIG. 18—Shows Patent No. 8943 AD 1915 of June 19, 1916 issued to Giovanni Angeli of Corso Dante Vo. 30. Turin, Italy covered 2 types of flutes: Fig. 18 top and center flutes aiding initial extraction. Figure 18 bottom shows retarding groove to slow extraction and case ejection.