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Ballistic Studies and Lethal Potential of Tear Gas Pen Guns Firing Fixed Metallic Ammunition

Contemporary conventional tear gas pen guns that expel a mist or vapor of chloroacetophenone (CN) or orthochlorobenzalmalononitrile (CS) are simple, inexpensive devices designed for noninjurious self-protection. These pen guns are not presently classified as firearms by Federal statutes if they have not been modified to accommodate fixed metallic cartridges or shotgun shells [*1*]. Victims as well as persons firing pen guns, however, have sustained serious injuries, including permanent blindness, from the intentional or accidental discharge of these devices at close range [*2-5*]. Injurious components include the wadding and, especially, the incompletely vaporized powder of the chemical agent. Nonlethal and lethal wounds caused by firing conventional threaded tear gas cartridges reloaded to simulate miniature shotgun shells have been described [*6*]. Suicide, homicide, and nonlethal accidental injury caused by illegal older model and foreign-made pen guns firing fixed metallic ammunition have also been reported [*7*]. Recently a law enforcement officer wounded another officer by accidentally discharging a caliber .38 bullet from a pen gun seized during a routine stop and search. Even more recently a bizarre fatal injury occurred while a man was test-firing a caliber .45 cartridge from a tear gas pen gun. Recoil from the discharge propelled the pen gun backward, out of the operator's hand, through his eye, and into the center of his brain.

Many pen guns are designed to resemble ballpoint or fountain pens (Fig. 1), mechanical pencils (Fig. 2), air gages for tires, billy clubs, or other devices [*8,9*]. Some are so deceptive or otherwise concealable that they could easily circumvent security measures at airports, political events, and other locations.

The potential and increased incidence of converting deceptive, concealable tear gas pen guns into operable firearms by various modifications of either the muzzle or the barrel to accommodate fixed metallic ammunition is the basis for this study. This report describes the ballistic characteristics, lethal potential, and other hazards of a variety of tear gas pen guns firing revolver or pistol cartridges of calibers .22, .25, .32,

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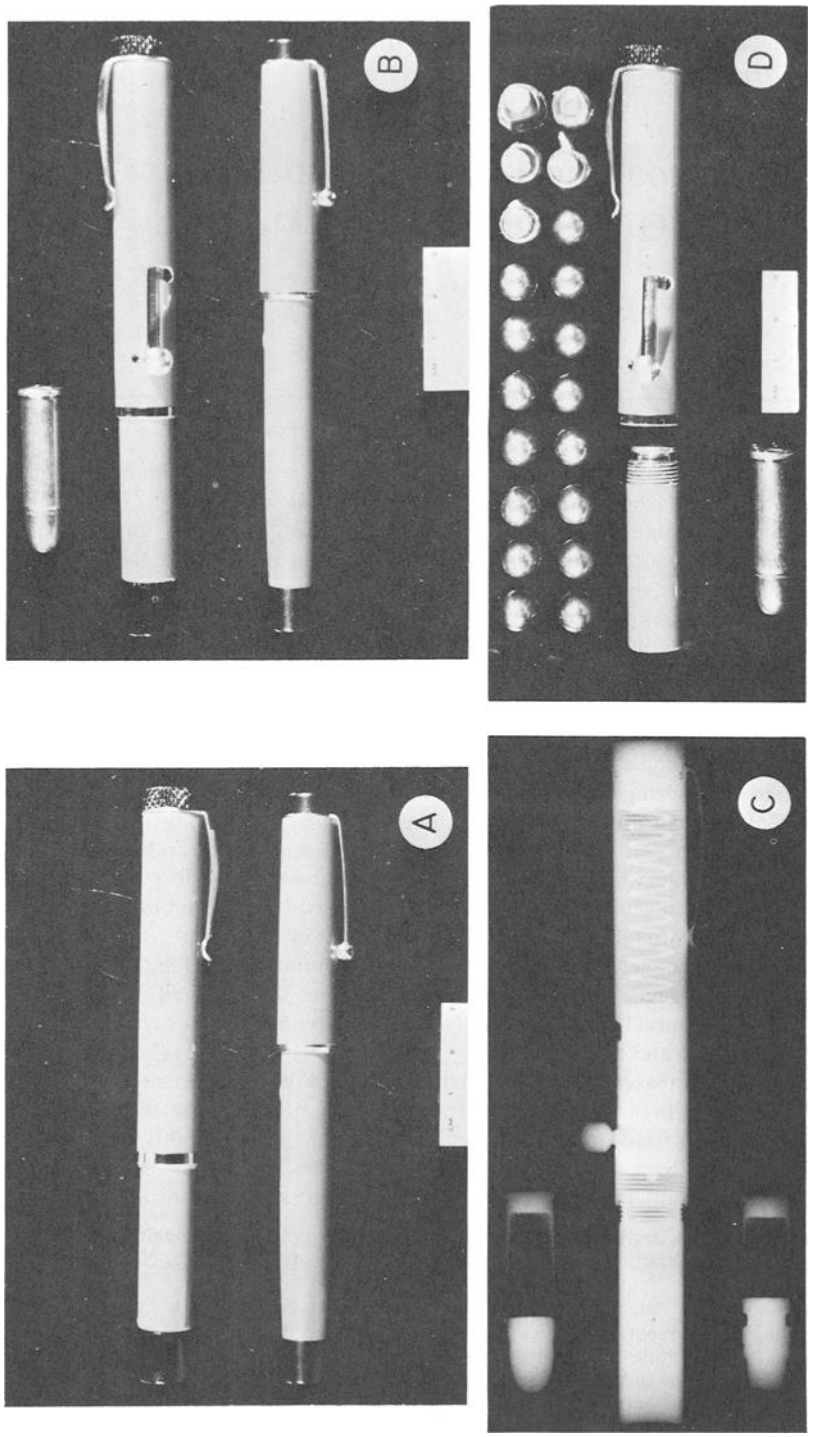

FIG. 1—(a) *Pen Gun CDE* (top), *designed to resemble a fountain pen* (below) (*AFIP Neg. 74-4852-4*). (b) *Pen gun* (top) *showing safety notch, firing slot, thumbpiece, and caliber .38 cartridge that fits inside the threaded barrel* (*AFIP Neg. 74-4852-1*). (c) *Roentgenogram of caliber .38 Pen Gun CDE showing the threaded barrel* (left), *firing pin* (middle), *and spring* (right), *as well as two caliber .38 cartridges* (*AFIP Neg. 74-5285-3*). (d) *Caliber .38 Pen Gun CDE showing a cartridge in the threaded barrel along with bullets from some of the numerous cartridges fired from this pen gun* (*AFIP Neg. 74-4852-5*).

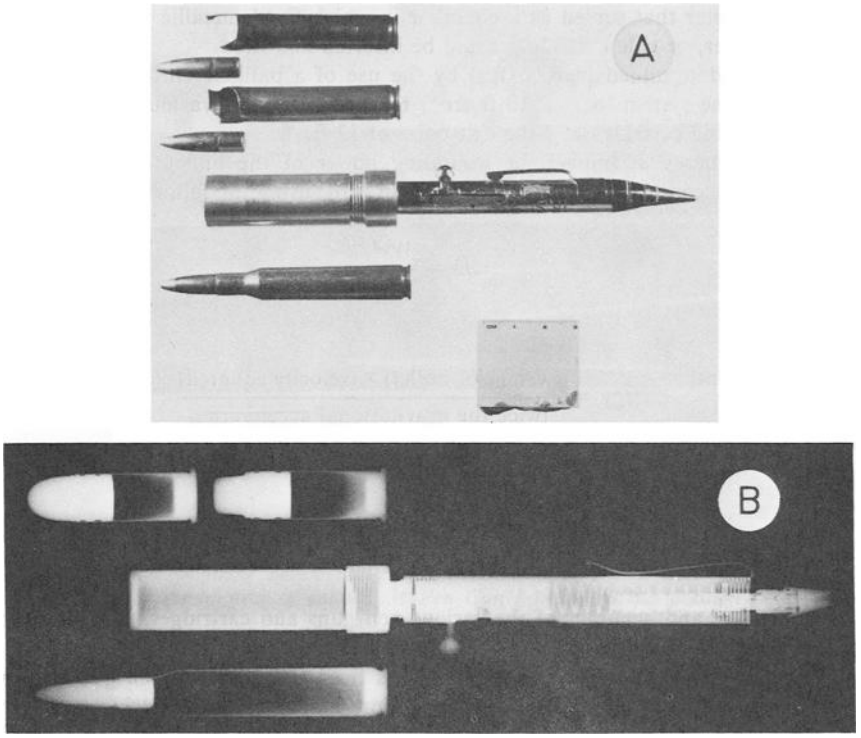

FIG. 2—(a) *Pen Gun F, designed to resemble a mechanical pencil, is shown with a new aluminum barrel and caliber .270 rifle cartridges (AFIP Neg. 74-4852-3).* (b) *Roentgenogram of Pen Gun F with original brass barrel* (left), *firing pin* (middle), *and spring* (right) *and also with three calibers of cartridges fired from this device: .44 Special, .44 magnum, and .270 (AFIP Neg. 74-5285-4).*

.38, .44 Special, and .44 magnum, as well as rifle cartridges of caliber .270. Ballistic and tool mark characteristics of fired bullets, cartridge casings, and firing pin impressions are also described.

Materials and Methods

Agents from the Bureau of Alcohol, Tobacco, and Firearms, Department of the Treasury, have acquired a large assortment of tear gas weapons, pen guns, and illegal devices from local law enforcement agencies throughout the United States. From this collection, a group of ten illegal pen guns capable of chambering caliber .22 through caliber .44 magnum pistol or revolver cartridges, as well as caliber .270 rifle cartridges, were selected for test-firing and further study. Simple modifications were made in the muzzle or barrel of several of the pen guns. In two additional pen guns, the barrels were replaced after several test firings.

Each of the ten pen guns consisted of a metallic cylinder of variable length and diameter that housed a spring-loaded metal rod (Figs. 1 and 2). The tip of the metal rod acted as a firing pin when released. The open end of each cylinder was threaded to accept either interchangeable threaded tear gas cartridges or an additional threaded

cylinder or adapter that served as a chamber in which fixed metallic tear gas cartridges or pistol, revolver, or rifle cartridges could be inserted and fired.

Velocity was determined in ft/s (fps) by the use of a ballistic chronograph[4] with the entry point of the system located 10 ft from the muzzle of the various pen guns or the tip of a protruding cartridge and the exit point at 12 ft.

The kinetic energy at impact, or wounding power of the bullet, was calculated in foot-pounds in accordance with a previous report [*10*], using the following equation:

$$E = \frac{Wv^2}{2g}$$

or

$$\text{energy} = \frac{(\text{weight of bullet}) \times (\text{velocity squared})}{\text{twice the gravitational acceleration}}$$

or

$$\text{ft} \cdot \text{lb} = \frac{(\text{weight in grains}) \times (\text{velocity in fps})^2}{448{,}000}$$

Data on range and accuracy of the various pen guns and cartridges were obtained by use of standard human silhouette combat targets[5] at ranges of fire at 50 and/or 30 ft.

The exterior ballistic characteristics of bullets fired from various pen guns also were observed by means of high speed, motion picture photography. Cartridges of various calibers were fired from pen guns located 6 in. from optically clear gelatin blocks (20% gelatin[6] at 10°C) and photographed with a high speed camera[7] loaded with black and white reversal film, at a speed of 8000 frames/s.

Ballistic and tool mark characteristics of recovered bullets, cartridge casings, and firing pin impressions were examined and photographed with a comparison microscope[8] for photomicrographs.

Cartridges were discharged by either of two remotely controlled firing devices, one which was used in a previous study [*4*], or a slightly larger device constructed for this study (Fig. 3). The new device is described in detail elsewhere [*8*]. The remote control devices are fired by means of a cord that, when pulled by the operator from his position of safety, releases the catch holding the firing pin of the pen gun in its cocked position. The caliber .25 and three caliber .22 pen guns were also test-fired by hand. The remote control devices were used for all pen guns during studies of velocity, accuracy, range, and gelatin block penetration.

Results

All ten pen guns when received were capable of firing without modification a particular caliber of pistol, revolver, or rifle cartridge, depending on the diameter of the barrel. The caliber .25 Pen Gun H (see alphabetical identification of pen guns in Tables

[4] ECI Computing Chronograph, Model 4001, Electronic Counters, Inc., Englewood, N.J.

[5] The National Target Company, Rockville, Md.

[6] Pharmagel A, Kind and Knox Gelatin Company, Sioux City, Ia.

[7] Hycam® (high speed camera), Redlake Corp., Santa Clara, Calif.

[8] Dual Stage Comparison Microscope with Polaroid camera, American Optical Co., Instrument Division, Buffalo, N.Y.

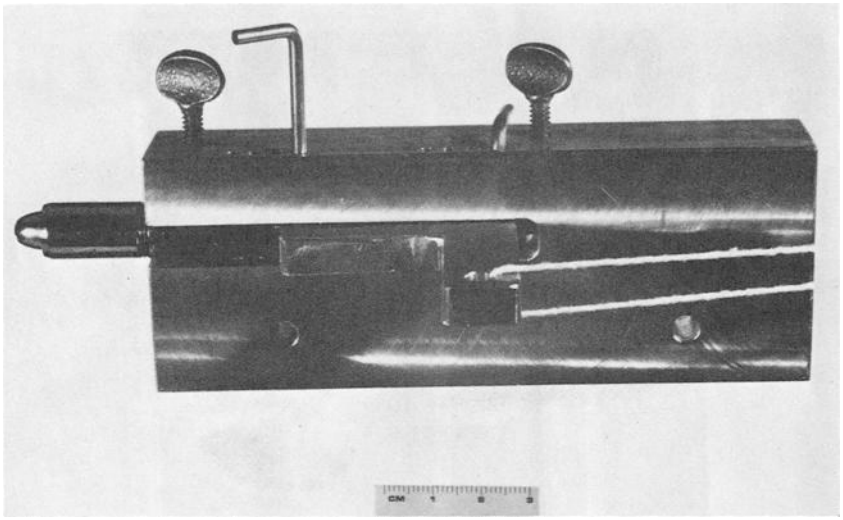

FIG. 3—*Remote control firing device made of aluminum alloy shown here with the catch mechanism holding the thumbpiece of caliber .38 Pen Gun I in its cocked position (AFIP Neg. 74-3884-1).*

1, 2, and 3), designed for threaded tear gas cartridges, was received with a homemade threaded adapter that served as a barrel to accommodate caliber .25 pistol ammunition. All nine other pen guns were designed by the manufacturer with a barrel to accommodate metallic tear gas cartridges or fixed metallic revolver cartridges or both.

In order to facilitate passage of the bullets and to sustain multiple discharges, the narrow muzzles of caliber .38 Pen Guns A and I were trimmed, and a diaphragm or shoulder in the muzzle was bored out of the barrel of caliber .38 Pen Gun CDE shown in Fig. 1. The original barrels and breeches of caliber .44 Pen Guns F and G each split and/or fragmented along with a cartridge (Fig. 4) after several firings and were replaced with new barrels and breeches made of aluminum alloy (Fig. 2). Except for the original barrels and breeches of these two caliber .44 pen guns (which also fired the caliber .270 rifle cartridges), the pen guns withstood many discharges of cartridges without significant damage (Fig. 1*d*). Even the mechanical pencil on the end of caliber .44 Pen Gun F (Figs. 2 and 4) continued to write well.

The average velocity and range of velocity of bullets fired from the pen guns of various calibers are compared to the manufacturer's stated muzzle velocity of the ammunition in Table 1. The impact kinetic energy of the bullets is also given in Table 1.

The range and accuracy of bullets fired from these pen guns via remote control devices are shown in Table 2. The target shown in Fig. 5 demonstrates the alarming lethal accuracy of pen guns firing revolver cartridges at ranges up to 50 ft. The target score would have been much higher in this case if the pen gun had been aimed slightly lower. Targets from this study illustrating much higher scores with caliber .22 and .25 pen guns and cartridges have been included in other reports [*8, 9*].

Table 3 gives the penetration or perforation of bullets fired into gelatin blocks from tear gas pen guns. The trajectory of these bullets as determined by high speed, motion picture photography is also given in Table 3.

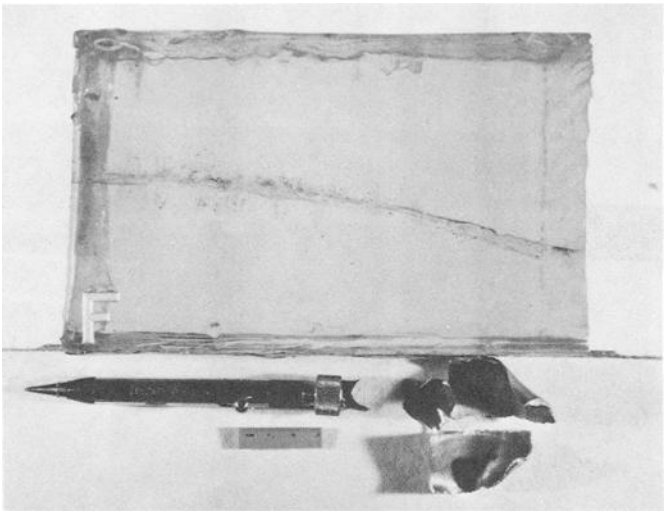

FIG. 4—*One-half-length (7.5-in.) gelatin block perforated by caliber .44 Special bullet fired from Pen Gun F. Note fragmentation of barrel and cartridge* (below) *and bullet track through gelatin block* (above) (*AFIP Neg. 74-5077-9*).

Still photographs of the gelatin blocks were also taken to demonstrate penetration or perforation and the track of the bullet. Figure 6 depicts the track of a caliber .38 wad-cutter-type bullet penetrating a gelatin block after being fired from Pen Gun CDE (Fig. 1). The composite of selected frames of high speed movies (Fig. 7) shows the bullet from a caliber .44 Special cartridge fired from Pen Gun F (Figs. 2*b* and 4). The cloud of gas and burning and unburned gun powder that precede the bullet in the first frame (Fig. 7) left a moderate amount of flake powder on the face of the block (Fig. 8). Cavitation produced in the gelatin block and the tumbling trajectory of the bullet are seen in the last three frames of Fig. 7.

Only bullets fired from the rifled caliber .22 Pen Gun J had suitable marks for comparison and identification. The remainder of the pen guns had smooth bores that did not leave suitable marks on the bullets. All cartridge cases, however, had prominent identifying marks from firing pin impressions and, in addition, breech face marks acceptable for comparison were present on some of the cartridges (Figs. 9 and 10).

Discussion

Contrary to the belief held by some concerning lack of durability of pen guns firing fixed metallic cartridges [*11*], the pen guns in this study were capable of multiple discharges (Fig. 1*d*) with astonishing accuracy and range (Table 2). Lethal accuracy was achieved at 50 ft (maximum distance in our range), in spite of the tumbling trajectory of most of the bullets, demonstrated by high speed motion pictures (Table 3 and Fig. 7). Shorter ranges of fire and better sighting could have improved the accuracy of these pen guns, but we feel that the results listed in Table 2 are remarkable and alarming.

The velocity of bullets fired from the pen guns was, as expected, lower than that stated by the manufacturer for bullets fired from properly designed weapons (Table 1). Factors apparently responsible for the slower velocity include lack of rifling and the loose fit of cartridges in the barrel. The loose fit, or in a few instances the actual protrusion of

TABLE 1—*Velocity of bullets fired from pen guns of various caliber.*

Cartridge and Manufacturer	Bullet Weight, [a] grains	Pen Gun [b] and Number of Firings	Kinetic Energy, ft · lb	Average Velocity, [c] ft/s	Velocity Range, ft/s	Manufacturer's Stated Muzzle Velocity, ft/s
.44 magnum, Remington	240	F/G, 6	213	630	577-688	1470
.270 Winchester-Western	130	F/G, 1	8	166	...	3140
.38 Special, Remington	158	A, 6	29	286	260-308	855
.38 Special, Remington	158	CDE, 11	95	520	461-593	855
.38 Special, Remington	158	I, 9	23	256	242-267	855
.32 S&W, Remington	88	B, 3	17	292	290-294	680
.25 automatic, Remington	50	H, 3	36	568	556-576	810
.22 short, Remington	29	J, 3	51	889	845-917	1125
.22 long rifle, Winchester-Western	40	J, 1	81	955	...	1285
.22 short, Remington	29	K, 3	46	847	839-859	1125

[a] Style of bullets: All were lead except .270 Winchester had a silver-tipped expanding bullet; .38 Specials were lead semi-wad-cutters, and .25 automatic cartridges were metal jacketed.

[b] Letter indicates pen gun identified in photographs and X-ray films. Only Pen Gun J had a rifled barrel.

[c] Entry point of chronograph system located 10 ft from muzzle of pen guns and exit point at 12 ft.

TABLE 2—*Range and accuracy of bullets fired from pen guns of various calibers.*

Cartridge and Manufacturer	Bullet Weight, [a] grains	Pen Gun [b] and Number of Firings	Distance, ft	Location of Hits on Targets [c]
.44 magnum, Remington	240	F/G, 4	50	K5-3, K2-1
.270 Winchester-Western	130	F/G, 2	50, 30	K5-1, K4-1
.38 Special, Remington	158	CDE, 4	50	K5-1, miss-3 (near head and shoulder
.32 S&W, Remington	80	B, 2	50, 30	miss-2 (near left elbow)
.25 automatic, Remington	50	H, 10	50	K5-5, K4-2, K3-1, miss-2 (near left shoulder and upper arm)
.22 short, Remington	29	J, 3	50	K5-3
.22 short, Remington	29	K, 3	50	K5-2, K4-1

[a] Style of bullets: All were lead except .270 Winchester had silver tips; .38 Specials were lead semi-wad-cutters, and .25 automatics were metal jacketed.

[b] Letter indicates pen gun identified in photographs and X-rays.

[c] Standard Human Silhouette Combat Target, The National Target Company, Rockville, Md.

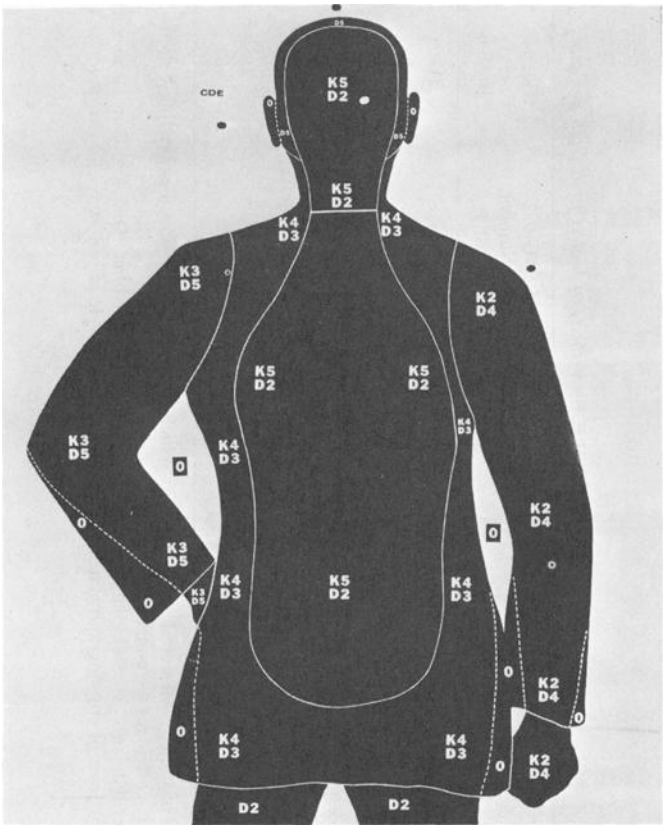

FIG. 5—*Combat target fired from 50 ft with caliber .38 Pen Gun CDE. Note bullet holes in and near head and above left shoulder (AFIP Neg. 74-5076-12).*

TABLE 3—*Penetration or perforation of gelatin blocks by bullets of various calibers fired from pen guns.*

Caliber and Manufacturer of Cartridge	Weight, grains, and Type of Bullet	Pen Gun [a]	Penetration or Perforation of Blocks, [b] in.	Remarks and High Speed Motion Photography Observations
.44 magnum, Remington	240 lead	G	2.50	muzzle fragmented; bullet tumbled in flight, penetrated block sideways, and came to rest in a base-first position; no powder residues
.44 Special, Remington	246 lead	F	7.50+ [c]	breech cracked and threads sheared; bullet tumbled in flight and entered, perforated, and exited block sideways; moderate amount of flake powder on face of block and in bullet track
.38 Special, Remington	158 lead (ball powder)	A	7.50+ [c]	muzzle tip split open at anterior 1 cm; bullet flared on posterior edge but maintained nose-first trajectory in flight and through block; heavy amount of ball powder on face of block and in bullet track
.38 Special, Winchester-Western	158 wad-cutter	C	5.75	a lead ring was sheared off bullet by diaphragm in muzzle; bullet entered block nose first but then turned and penetrated sideways and came to rest in base-first position; no powder residues
.38 Special, Winchester-Western	158 wad-cutter	D	7.50+ [c]	a lead ring was sheared off bullet by diaphragm in muzzle; bullet entered block partially sideways and perforated and exited sideways; heavy amount of flake powder on face of block
.38 Special, Winchester-Western	158 wad-cutter	E	8.75	a lead ring was sheared off bullet by diaphragm in muzzle; bullet tumbled in flight and penetrated block and came to rest in a base-first position; slight amount of flake powder on face of block
.32 S&W, Remington	88 lead	B	2.75	bullet tumbled in flight, penetrated block sideways, and came to rest in a base-first position; moderate amount of flake powder on face of block
.25 automatic, Remington	50 metal jacket	H	7.00	bullet tumbled in flight, penetrated block sideways, and came to rest in a base-first position; slight amount of flake powder on face of block
.22 short, Remington	29 lead	J	9.50	rifled barrel; bullet maintained stable, nose-first trajectory in flight and in entry and penetration of gelatin block; moderate amount of flake powder on face of block and a few flakes in bullet track
.22 short, Remington	29 lead	K	10.25	unrifled barrel; bullet entered and penetrated block sideways and came to rest in a base-first position; moderate amount of flake powder on face of block and a few flakes in bullet track

[a] Letter indicates pen gun identified in photographs or X-ray films or both.
[b] Gelatin blocks were 15.0 by 4.5 by 4.5 in., weighed 14.2 lb, and were located 6 in. from the muzzle of the pen guns.
[c] For Pen Guns A, D, and F, only half (7.5 in.) the length of a gelatin block was available, and the bullets perforated the entire half.

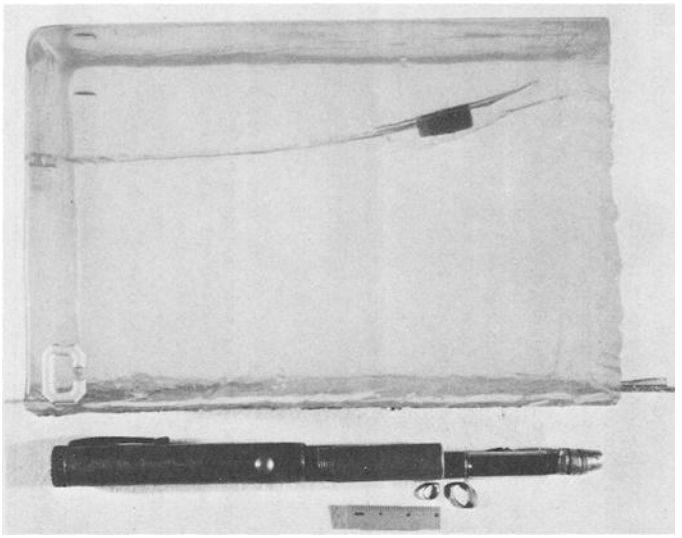

FIG. 6—*One-half-length (7.5-in.) gelatin block penetrated 5.7 in. by a caliber .38 wad-cutter bullet fired from Pen Gun C. Note lead rings sheared from bullets by diaphragm in muzzle of pen gun and the base-first position of the bullet in the gelatin block (AFIP Neg. 74-4267-6).*

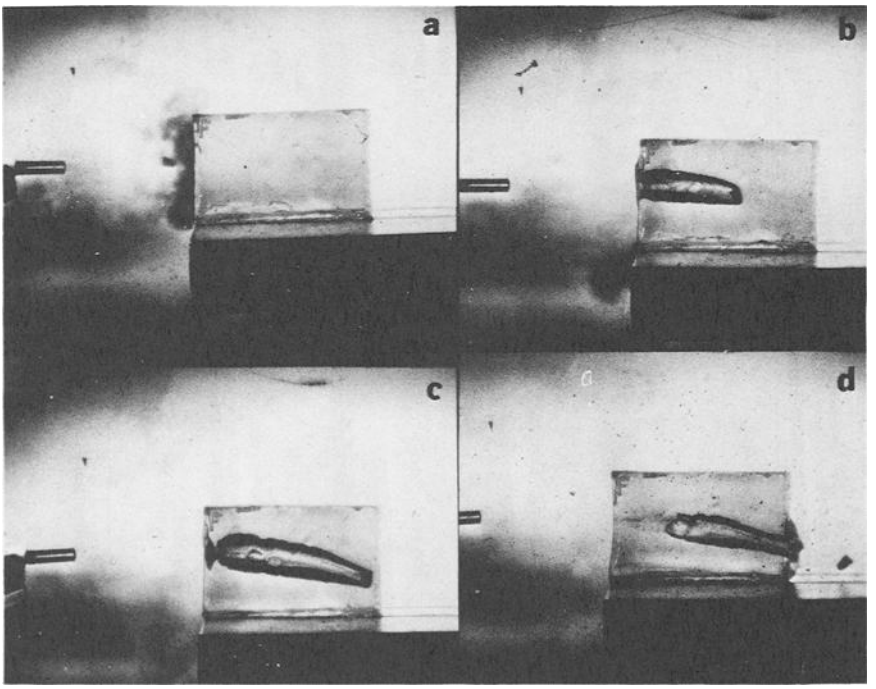

FIG. 7—*Composite of selected frames from high speed movies, exposed at a rate of 8000 frames/s, showing a cloud of gas and gunpowder preceding the caliber .44 Special bullet in Frame* (a) *and the perforation and cavitation produced by the tumbling bullet in Frames* b, c, *and* d *(AFIP Neg. 74-6131-1).*

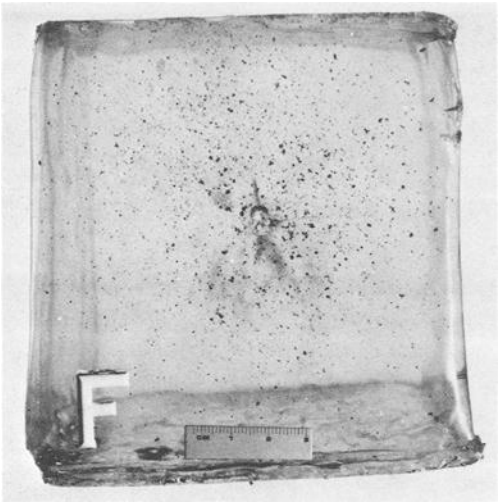

FIG. 8—*Moderate amount of flake gunpowder on face of gelatin block seen in Fig. 7 following discharge of caliber .44 Special cartridge from Pen Gun F at distance of 6 in. (AFIP Neg. 74-5077-8).*

the cartridge from the barrel, allowed the gas from the gunpowder to escape around the bullet instead of propelling it forward. The lower velocities and kinetic energies of the bullets in Table 1 correlate exactly with cartridges that protruded from the barrel of caliber .32 Pen Gun B, caliber .38 Pen Guns A and I, and Pen Guns F and G when firing caliber .270 rifle cartridges.

The "casualty criterion" of a missile is the kinetic energy or wounding power necessary to cause a human casualty or put a person out of combat [*10*]. The casualty criterion used by different countries in the past varies as follows: France, 29 ft · lb; Switzerland, 46 ft · lb; United States and Germany, 59 ft · lb; and Russia, 184 ft · lb [*10*]. In three instances in this study (Table 1), the bullets at 10 ft from the muzzle of the pen guns did not reach the minimum casualty criterion of 29 ft · lb. These weapons, however, could still produce either severe or lethal injuries at ranges up to 10 ft or more, depending on numerous physical, anatomic, and physiologic factors [*10*]. Pen guns are likely to be used at ranges closer than 10 ft and especially at contact, where the bullets would have even greater accuracy and kinetic energy.

In addition to homicides, suicides, and accidental injuries caused by pen guns firing fixed metallic cartridges [*7*], these weapons possess other potential hazards or dangers to the person firing such a device or to persons near by. These hazards or dangers include explosive fragmentation of the barrel or cartridge or both (Fig. 4) and the recoil of the pen gun, converting it into a lethal missile when firing larger caliber cartridges.

All tear gas pen guns are potentially hazardous to intended victims as well as users, even when used as designed for tear gas cartridges [*2-5*]. The potential for simple conversion of many pen guns to operable firearms is alarming because of their surprising firepower and concealability. As with many exotic and homemade weapons such as the stove bolt gun described recently [*12*], most pen guns do not have rifled barrels, and therefore bullets fired from them cannot be matched to the weapon.

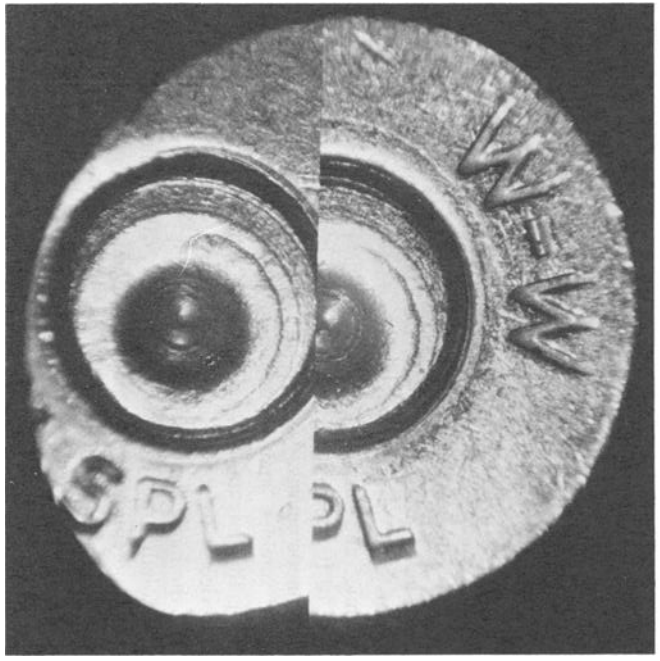

FIG. 9—*Comparison photomicrograph of firing pin impression and breech face marks in two caliber .44 Special cartridge cases following discharge from Pen Gun F (original magnification ×4, AFIP Neg. 74-6606-1).*

FIG. 10—*Photomicrograph of two caliber .44 Special cartridge cases following discharge from Pen Gun F showing comparison of firing pin impressions and breech face marks suitable for positive identification (original magnification ×4, AFIP Neg. 74-6606-8).*

Summary

Illegal older model and foreign-made tear gas pen guns as well as illicitly manufactured pen guns were used to fire revolver or pistol cartridges of calibers .22, .25, .32, .38, .44 Special, and .44 magnum, as well as rifle cartridges of caliber .270. Velocity, range of accuracy, impact kinetic energy, and gelatin block penetrability of bullets fired from the various cartridges are presented. The characteristics of recovered bullets, cartridge casings, and firing pin impressions are described, and the hazards of these weapons to users and potential victims are discussed.

Acknowledgments

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References

[*1*] 18 USC 921 (a) (3).
[*2*] Levine, R. A. and Stahl, C. J., "Eye Injury Caused by Tear Gas Weapons," *American Journal of Ophthalmology,* Vol. 65, 1968, pp. 497-508.
[*3*] Stahl, C. J., Young, B. C., Brown, R. J., and Ainsworth, C. A., III, "Forensic Aspects of Tear-Gas Pen Guns," *Journal of Forensic Sciences,* JFSCA, Vol. 13, 1968, pp. 442-469.
[*4*] Ayers, K. M. and Stahl, C. J., "Ballistic Characteristics and Wounding Effects of a Tear Gas Pen Gun Loaded with Ortho-Chlorobenzalmalononitrile," *Journal of Forensic Sciences,* JFSCA, Vol. 17, 1972, pp. 292-297.
[*5*] Ayers, K. M. and Stahl, C. J., "Experimental Injuries of the Eye Caused by a Tear Gas Pen Gun Loaded with Ortho-Chlorobenzalmalononitrile," *Journal of Forensic Sciences,* JFSCA, Vol. 17, 1972, pp. 547-554.
[*6*] Jones, S. R., Besant-Matthews, P. E., Williams, F. J., and Stahl, C. J., "Injury Potential of a Reloaded Tear Gas Pen Gun," *Journal of Forensic Sciences,* JFSCA, Vol. 19, 1974, pp. 812-819.
[*7*] Stahl, C. J. and Davis, J. H., "Missile Wounds Caused by Tear Gas Pen Gun," *American Journal of Clinical Pathology,* Vol. 52, 1969, pp. 270-276.
[*8*] Harriman, J. J., Jones, S. R., and Stahl, C. J., "Firearms Examination of Tear Gas Pen Guns," to be published.
[*9*] Stahl, C. J., Harriman, J. J., and Jones, S. R., "Tear Gas Pen Guns: Hazards to Arresting Officers," to be published.
[*10*] Finck, P. A., "Ballistic and Forensic Pathology Aspects of Missile Wounds. Conversion between Anglo-American and Metric-System Units," *Military Medicine,* Vol. 130, 1965, pp. 545-569.
[*11*] "Dangerous Gadget," *FBI Law Enforcement Bulletin,* Vol. 35, 1966, p. 23.
[*12*] Butler, D. J., "5/8" × 4" Stove Bolt Zip," *Association of Firearm and Tool Mark Examiners Journal,* Vol. 6, No. 2, April 1974, pp. 5-7.

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