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ZIP GUNS AND CRUDE CONVERSIONS—IDENTIFYING CHARACTERISTICS AND PROBLEMS

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This article deals with identification characteristics and problems which zip guns and crude conversions present to the investigator. In many areas, especially where commercial firearms are readily available to all those interested in possessing a gun, investigators will not encounter such weapons in a lifetime of work. Where weapons are regulated more strictly a zip gun may occasionally be examined. New York City, where gun ownership is highly controlled, has a very large number of zip guns produced many of which are seized by the police every week.

Numerous zip guns are produced by the curious youngster who perhaps being influenced by guns on television, but too young to be able to purchase a firearm, turns to his own resources. For such a person, concealability does not often motivate design. Many long arms are made by those experimenting with firecrackers and lengths of plumbing pipes. Where gang violence and armed crimes motivate youth, their efforts are directed towards manufacturing a concealable, efficient, deadly device with advantages over close combat weapons such as brass knuckles or knives. The gun, no matter how crude, offers long distance killing potential and in a gang fight or hold-up can inspire more fear.

Some zip guns are made by individuals working on their own while others arise from a group effort, often in a school metal workshop. The former tend to be very crude, unreliable, and usually more dangerous to the shooter than to his intended victim. Zip guns fabricated in school are still crude by commercial standards but show innovative skill and greater reliability. Better materials and closer tool tolerances make it possible to produce a much safer weapon.

Where blank-firing pistols and air guns have not been legislated out of the sporting goods stores their basic actions are often modified to fire live, bulleted loads. Usually, in these guns only a barrel suitable for .22 rimfire ammunition must be added, or an already existing barrel needs to be bored out to a greater diameter to accommodate live ammunition. Where multiple shot blank pistols are converted, the shooter possesses a relatively well-made large capacity weapon that outdoes the homemade gun in nearly every respect. Some disadvantages arise however, and these will be discussed later.

Not all zip guns are made by juvenile thrill-seekers. Large cities have their share of adults who also find difficulty in obtaining a firearm for whatever reason. They too build their own or purchase a basic action which can be modified to become a lethal weapon. While some adults use their guns in crimes such as hold-ups, others merely seem to be seeking a means of self-protection where legislation has precluded weapons ownership, policing is sporadic, and crimes against the person occur regularly.

Very little data has been compiled on the possibilities and problems of identification of these weapons. The trend to stricter firearms legislation can be expected to result in increasing construction of zip guns and their greater involvement in armed crimes. The investigator will be faced with identifying such weapons more regularly. Many variations are described in this paper to familiarize those who will be troubled by these unique weapons with the possibilities that may be encountered.

Zip Guns

Zip Gun is the name applied to a single-shot, crude, home-made firearm. Little care is taken to meet the esthetic values a connoisseur of fine guns appreciates. Since the design and workmanship are poor, these firearms impart a set of unusual markings to fired bullets and cartridge cases.

CONSTRUCTION OF ZIP GUNS

Any material that appeals to the maker can be used to build a zip gun. In those guns that use factory ammunition, a chamber (sometimes without a barrel), a hammer and a means of storing

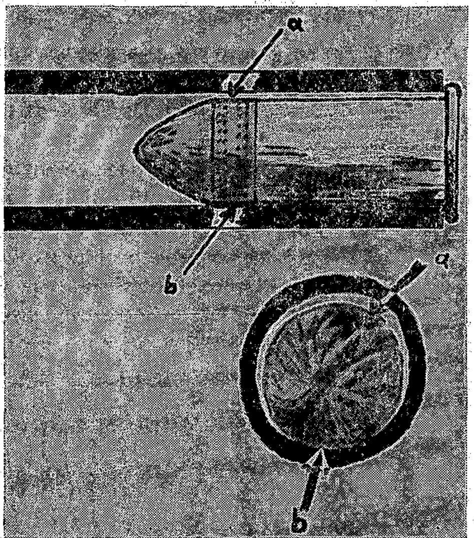


FIGURE 1
A space in the bore often surrounds the bearing surface of the undersize bullet and only the surface along the bottom of the projectile (b) is in contact with the bore.

energy to operate it, and a crude frame are all the parts required. When a firecracker supplies the energy, a breech cover may be added to protect the shooter from the back blast. Breech closures are almost always lacking in the cartridge-firing models. Gas leakage is not a serious enough problem to warrant the extra effort, as a substantial amount of the powder emerges unburned and pressure is relatively low as a result.

DESIGN IMPLICATIONS FOR CARTRIDGE IDENTIFICATION

The zip gun builder is aware that a chamber is needed for the cartridge. The lack of availability of precision tools precludes the reaming of chamber dimensions which will stop the expansion of the brass case walls past the breaking point. Thus, there is often a longitudinal split in the case wall indicating that the pressure was relieved as the gas broke through the side in addition to driving out the bullet. The most commonly available ammunition is some type of .22 rim fire cartridge containing very little powder. This requires a 16 inch gas tight barrel if complete powder combustion and optimum driving pressure are to be ensured. In the zip gun there is usually only a stump of a barrel, and frequently they are made with just a chamber to accomodate the shell, with the bullet protruding. In such weapons, whatever pressure is built up is partially dissipated through cracks in the side

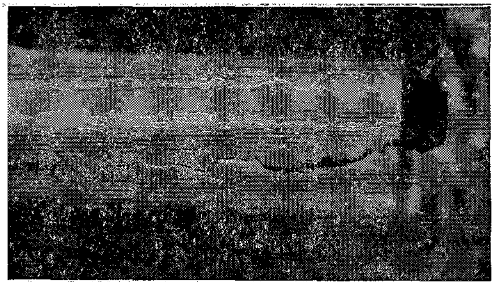


FIGURE 2
Cartridge case split by gas. Chamber diameter was oversized.

wall. Pressure is also lost as gas escapes around and ahead of the bullet due to the poor fit of cartridge in the bore (fig. 1). Depending on the amount of pressure developed the split may only be near the case mouth or, as in figure 2, may run right down to the rim. The same gun may not cause the cracks to appear to the same degree in consecutive shots. Often only a bulge will appear at some point on the case wall. The writer has seen one gun used in Toronto where the shooter tried to overcome poor case fit by wrapping the cartridge with cellophane tape. A little of the tape burned away, and the bulge was minimal.

The ignorance of the builder concerning firing pin design is evident in many zip guns. The pin should protrude a certain amount when hammer fall or striker movement is complete. It should be rounded at the striking face so that there is no sharp edge to cut through the rim metal. When these requirements are overlooked, the rim is often punctured, the firing pin leaving a jagged tear obvious to the naked eye. Here then is another point for gas leakage with its detrimental effect on bullet velocity, trajectory, and striking energy. However, this does not mean that a bullet so hampered cannot maim or kill, for it has in a number of cases. The investigator should suspect a zip gun if the cartridge case bears such unusual markings.

Where a barrel is used in addition to a chamber, the bullet will often have a skid mark on its bearing surface. Because zip gun bores are so often oversized, the cartridge is resting on the bottom of the bore as figure 1 shows. Although the base of the bullet is upset by gas pressure, and may be marked by the circumference of the bore, the bearing surface which lends itself to more accurate identification may only partially contact the bore because of the way it rests in the barrel. The part of the barrel that imprints on the bullet's bearing

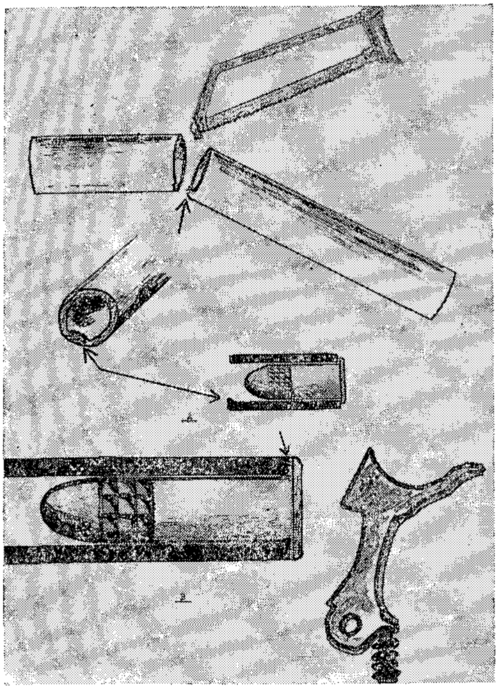


FIGURE 3
(A) Barrel tube. Arrows indicate a burr left as the result of a long tube being sawed part way, then broken. (B) Broken end used as the breech. The projections act as tiny firing pins. A flat cap pistol hammer may be used. Even a relatively light hammer blow to the back of the rim will cause the "firing pins" to crush the other side of the rim; the pin marks are useful for comparison purposes.

surface may change according to how the gun is canted. Canting causes the cartridge to assume a different position in the bore where the fit is loose. To keep within the definition of zip guns, we must exclude weapons that have had their barrels rifled and so rifling striae are not found in weapons of this class. In consequence, the bullet begins to tumble after travelling a short distance from the muzzle and will keyhole on striking the target.

Another type of mark may occur on a bullet fired through an oversized bore. This is a scoring of the surface as unburned powder grains are blown past the projectile at high speed. These markings always vary in appearance from bullet to bullet and can confuse identification efforts.

From time to time, two other classes of barrel impressions may be found on fired bullets. One is due to barrel materials and the other to improper tools to bore a barrel from bar stock. The first is a long jagged gouge on the bearing surface of the bullet. This may resemble rifling, but lacks pitch. A convenient source of .22 calibre barrels is the car radio telescoping antenna. The section usually selected is .25 calibre or $\frac{1}{4}$ inch inside diameter. For most purposes, a pistol is more desirable than a longarm since concealability is usually a requisite. To shorten the barrel, the builder may use a hacksaw if he has access to one, or a rough angular surface such as the corner of a brick building. The latter works well as antennas are made out of soft brass. When the tubing appears to be nearly cut through the bore, the builder often breaks off the piece that he intends to use in his gun. Then a jagged edge is left on each piece. Since this is thin-walled tubing, any metal which projects upward will cause slight occlusion of the bore. Figure 3 portrays this. Projections gouge the bearing surface of the bullet as it emerges from the muzzle. (In a commercial barrel "crowning" at the factory removes all such burrs.) Muzzle burrs also cause a deflection of the bullet off the bore axis opposite to the side of the muzzle that the projection is on. The amount of deflection depends upon the distance between the barrel and the target.

The second seldom-seen zip gun characteristic is a shaved or split appearance. This results when the builder cannot obtain proper tools to bore out a barrel from bar stock. Such barrels are usually longer than the average high speed drill bit. The bit normally available in a hardware store is neither the best quality nor of the necessary hardness to drill through up to eight inches of steel. It is also seldom over four inches in length and of this, nearly one inch is lost when the drill is locked in the chuck. Most bits, therefore, cannot bore through more than three inches and to drill a longer bore, the barrel must be turned around and started anew at the other end. If this were to be done on a lathe the bore would be true, but usually the only machinery available to the average builder is an electric hand drill and perhaps a vise. (The better-made weapons sometimes built in high school machine shops, are out of the class of crude firearms labeled zip guns. However, if they are very poorly finished, they may retain many of the characteristics that help to identify the cruder variety.) The usual bit diameters used are $\frac{7}{32}''$ or $\frac{13}{64}''$ and neither of these bores a hole exactly .22 calibre. The necessity of drilling from both ends of a barrel more than three inches in length at speeds low enough to drill steel accurately, and the lack of the proper metal-cutting lubricant contribute to two bores that meet off the axis of the barrel. Thus, as can be seen in figure 4, the meeting point is reduced in diameter and an edge similar to a plane blade is formed on each side of this point.

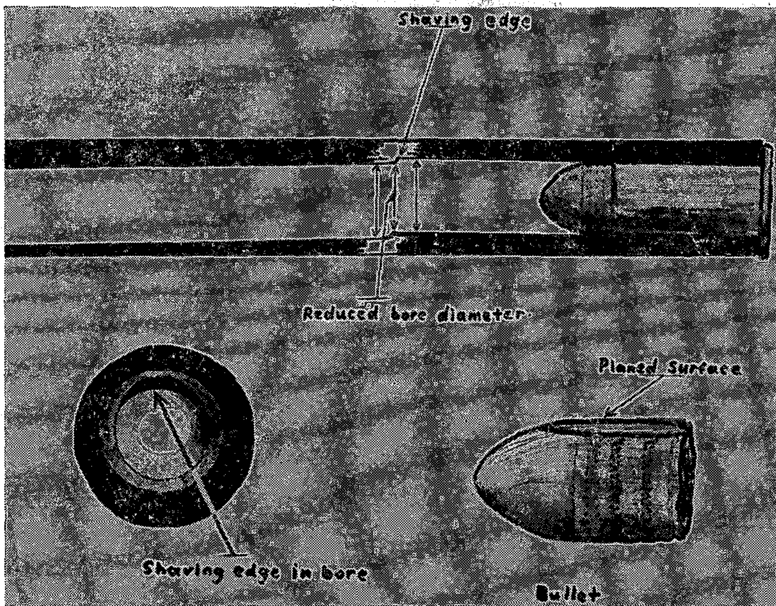


FIGURE 4

The planing action of a barrel poorly bored from both ends, meeting offcenter. Bore diameter is reduced at meeting point.

Whichever way the barrel may finally be mounted, the bullet will be shaved on one side as it passes through the bore.

Finally, regarding barrel materials, the writer has seen barrels made by boring a block of solid rubber to accept a .22 calibre cartridge. The cartridge is first slipped through the hole of a metal washer and then pushed bullet-first into the breech end of the block. The washer provides the hard surface necessary for good rimfire ignition. There is a difficulty in this system in that a cartridge must be pushed through a new washer for each shot. As the pressure expands the shell walls a bulge forms ahead of the washer and the two lock together. The expended shell and washer are then disposed of as a unit (fig. 5).

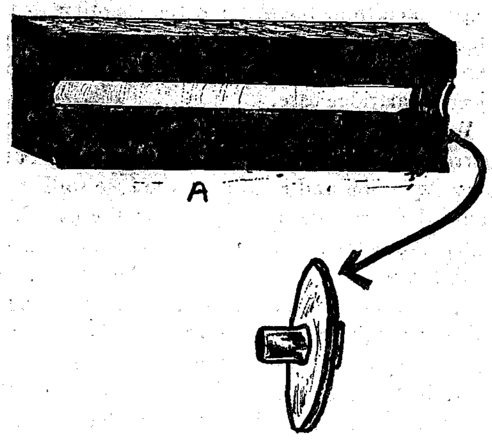


FIGURE 5

(A) Rubber barrel with washer. (B) Washer with fired cartridge case, now integral.

ASPECTS OF ZIP GUN SHOOTING INVESTIGATION

Tracing cartridge cases from a crime gun may not be too difficult in districts where juvenile delinquents form gangs. These districts in some cities are jealously guarded territory, and violence may break out between rival groups if territorial rights are infringed. In such scuffles zip guns may be carried along with other weapons. When shots are fired, a number of cartridge cases may be recovered from different weapons. This is an unusual situation for the investigator who is most often faced with identifying one particular gun using from one to three fired cases. Police may have to locate every weapon in the gang before a positive match can be made. Even then there is the difficulty of proving which shot from which gun (all of which may have been fired) actually caused an injury. The bullet alone may provide inconclusive evidence when compared with test shots from the other equally crude firearms.

When only one shot has been discharged, the task is considerably easier. However, since most zip guns are single shot weapons and several types do not eject when fired, a person who has fired a

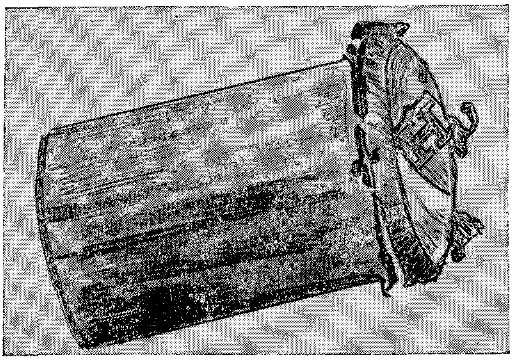


FIGURE 6
Incomplete separation of .22 Rim Fire case head, showing how it is still attached by "threads" of brass.

FIGURE 7
Ballooned head. Pressure forced the metal into the firing pin hole, which, in this case, was square.

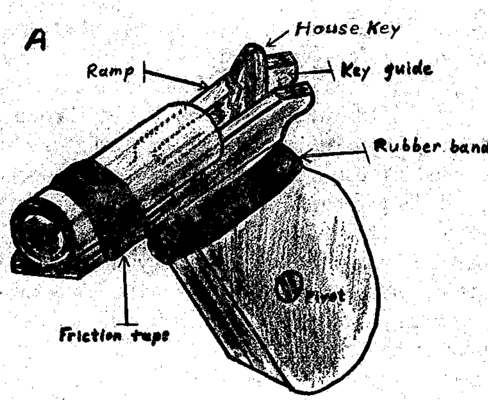
shot in a group scuffle and been pursued while fleeing, may feel that when he fled some distance from the scene of the shooting he has to reload for his own safety. At this point he will have to eject the spent shell from his weapon. Police on the beat in such areas come to know the group's movements and hangouts. They might be able to trace the steps taken from the scene of the shooting to the place where a suspect was apprehended and through such knowledge locate the spent and ejected cartridge case.

With rubber barreled zip guns and some metal barreled types that have a jagged chamber mouth, over expansion and rupture of the case walls may cause the cartridge case to lodge in the barrel. In an open-breeched gun the case head may separate as in figure 6, fly rearward out of the weapon and remain on the ground. Such separation can occur in some ammunition brands and not in others, or may only take place in a few rounds of an entire box of fifty. It depends on the age of the cartridges, the annealing treatment the cartridges have had in manufacture, and the type of metal used in cases. Many of the German cartridges made by R.W.S. are soft copper. The rimfire cartridges made in most other countries are of brass. An exception is the U.S.S.R. which manufactures shell casings from soft steel, which are a dull black with a domed rim and bear no headstamp. The case material is harder than brass and does not generally accept impressions of irregularities in firearm metal as readily as brass or copper. On the other hand, experiments with these cartridges in zip guns have shown that the steel is less resilient than brass and tends to cling tightly to the chamber walls. When tried in weapons that successfully eject brass cases most of the time, these shells stuck so tenaciously that they had to be driven out of the barrel from the muzzle. There was one weapon tested with these cartridges that functioned equally as well as with brass cased ammunition. This had a steel barrel with an exceptionally well-finished chamber. The other ones either had brass antenna barrels or crudely drilled steel ones that were rough inside to the naked eye.

At times, as is shown by figure 6, the case head exhibits incomplete separation and clings to the body of the shell by a few strands or threads of metal. In this example fragments were thrown to the sides, some lodging in the finger of the shooter and others embedding themselves in a board fence. Had the case head in fact separated, it might have blinded the shooter. In a zip gun shooting, the victim might be the shooter himself. Investigators should check with local doctors to see if they have treated a person for tiny jagged lacerations, or if they have removed minute metal splinters from the face or arms of a patient. Doctors recognize bullets as being connected with a shooting incident. They may not perceive the connection in the case of metal splinters, however. Occasionally, a particularly strong shell, which neither ejects nor yields to case head stress, is encountered. It has a rather strange appearance as if the head had ballooned; some stretching on the rim may also be present. The example shown in figure 7 was the result of a partially supported case head. Although the bolt face supported the perimeter of the head, the center of the shell was backed by an enlarged firing pin hole. The unsupported metal was forced back into this space under pressure, and if the bore had been any tighter, the brass would have ruptured into the shooter's face.

EJECTING FIREARMS

Ejecting zip guns are built in a peculiar way but function in a manner similar to the commercial semi-automatic pistol. The cartridge cases are usually physically battered and show unmistakeable class characterisitcs to an experienced investigator. Most of these weapons have both an open breech and a pivoting hammer. Some which have a reciprocating striker are frequently seized in New York City. The first group employing an easily-fashioned hammer most often are constructed around an ordinary housekey, because little effort is necessary to make an efficient weapon based on a key. The firing pin is already present, and the key has the general desirable shape of a hammer. The points are sharpened, with a file which impart individual characteristic marking to the case head. There is a ready-made hole for a pivot pin as well. In one model, the key slides in a vertical slot in the wood or metal frame. The upper surfaces of the frame are inclined with the higher end toward the rear. (See figure 8A.) In order to eject the case, pressure forces its head against the point(s) of the key, stretching a heavy rubber band as the key pivots. The shell slides up the inclined surfaces and jumps away from the gun. This system has been copied from the blank-ejection system found in the cheap single-shot German 'H.S.' starting pistol. The battering and scraping endured by the zip gun shell is similar to that often found on empty blank cartridges fired in the 'H.S.' pistol. Instead of a rubber band providing the driving force, a spring and plunger may be substituted. Figure 8B shows a key used in reverse to the way it has been described above. A hole has been punched in the shaft for the pivot pin and the handle has been filed to a point on one side to act as a firing pin.



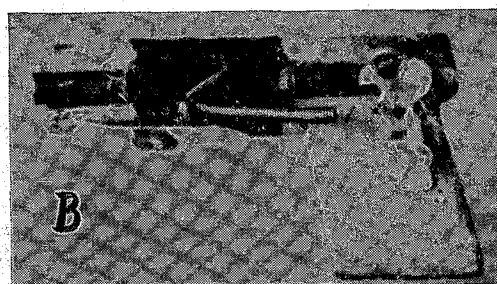


FIGURE 8
(A) An ejecting Zip Gun. The ramp is angled to eject the empty shell over the shooter's head or shoulders. (B) Zip Gun with key reversed from the way it is used in B. An extension spring *pulls* the hammer. (C) When the firing pin struck the rim the explosion jammed the case against the pin. As the case moved upward and to the rear the pin tore down through the metal to the center of the base.

IDENTIFICATION MARKS

In the ejection type as the hammer is cocked and the shell slides upward under pressure, when the firing pin strikes at the top of the head metal will be scraped vertically off the shell. If the pin strikes only at the bottom of the head as the shell is positioned in the chamber, no scrape striae will be produced. Very light battering or sliding marks will show if the ramps are wooden. They will be more distinct if the frame is made of metal harder than the shell casing.

Firing pin scrape marks will also be present in break-action zip guns, just as in a break-action shotgun that has a missing firing pin rebound spring. As the barrel is broken the shell is forced upwards and slides across the face of the firing pin. Often the shell will not eject because the pin is so sharp or jagged that it pierces the rim and holds the case in the chamber. The barrel cannot then be broken until the hammer is cocked. An example of a pierced rim is shown in figure 8C. Here the shell tried to rise up inclined guides and the pin tore through downward from its striking point on the rim before the case jammed in the gun. A good deal of the gas was discharged in the shooter's face. Another variation of firing pin marks may be produced if the key has some play in its movement around the pivot pin. The freedom to move from side to side or to twist at an angle on the pin may cause the firing pin to strike at varying sites or at different angles on the rim. This is similar to misaligned pin blows in cheap revolvers whose timing is poor or erratic from one chamber to the next. In fact it may require that the hammer be cocked and released smartly several times for the pin to strike at the precise spot to fire the round. Firing pin marks will appear to overlap in a weapon that has such play.

In some zip guns there are no guides for the key and no ramps to direct the moving shell. Upon discharging, the hammer recocks but the shell flies straight back toward the shooter's eye if he is sighting the firearm. The investigator should be extremely wary of firing such a gun, as he will not only receive a facefull of fragments if the case bursts, but a flying shell as well. Although the empty case is very light, its mouth and any portion that has burst are sharp and can lacerate the shooter.

To close this discussion of firing pin impressions, it is fitting to mention a situation where upon cursory examination they are apparently absent. In commercial firearms, the only possible way that a primer can be detonated without leaving a mark on it is through a 'cook-off'. This condition is seldom encountered except in sustained rapid fire typical of military shooting. When a barrel gets overheated, a freshly chambered cartridge can be set off by the intense heat. But it is hardly possible with a zip gun so some other answer must be sought. The only alternative is that of crushing the entire rim with a flat metal surface. A regular door bolt under pressure from a strong coil spring or a heavy rubber band can be set up to fire in this way. Figure 9 shows a double barreled gun of this type. If the empty cases are given close examination, it will be seen that the pattern on the bolt face has produced many minute impressions on the brass. Care should be taken not to dry fire a pistol of this type because the bolt will strike the barrel and become scored. If its individual characteristics were faint before dry firing, they may be obliterated for comparison purposes. Because all the energy in the moving bolt is not pinpointed on one section of the rim, misfires can be expected if the spring or elastic is not at full tension. When the energy is equally distributed around the rim it may merely loosen the priming compound on the first strike and render the cartridge useless. Such a dud may be removed and pocketed to be later connected with the gun by its impressions. Such cartridges should not be filed away without an examination of the rim, because they may be the only evidence linking the shooting with a shell found at the crime scene. The weapon may have disposed of in the meantime, and never be recovered for test firing and comparison.

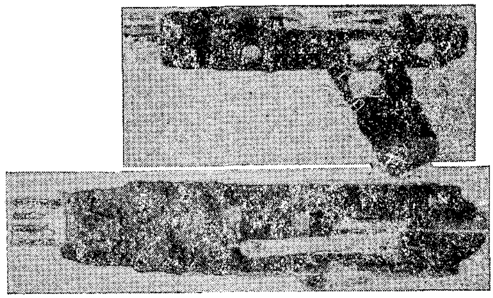


FIGURE 9
A side and top view of a double barreled Zip Gun. Barrels are made from car antenna, and the action is a door bolt with its face filed to two points. The barrels fire simultaneously. The barrels are held in place by nails, tape and "liquid steel" solder.
The rubber band is wrapped around the bolt handle and around a nail beside the chamber of the left barrel. It has been twisted three times for proper tension. The bolt is retracted and turned to the left to lock it. When the shooter wishes to fire, he pushes up on the bolt handle with the thumb of the hand holding the gun. This weapon was taken from a motorcycle gang member.

A similar weapon is portrayed in figure 10A. It has been turning up in large numbers in New York City. Construction is of a short piece of car radio antenna, a nail, a rubber band, and two pieces of friction tape. The nail makes a sliding fit in the tubing and the point is cut off. It may be reshaped to strike the edge of the cartridge base or be left flat and strike the entire rim and base. A slot the length of a .22 cartridge is filed across the middle of the tubing. The nail is inserted with the head protruding to the rear. A heavy rubber band is cut, and the ends are taped near the front of the tube. The loop of the elastic is passed around the nail head and taped to the shaft of the nail so that the nail can move far enough forward to strike the cartridge. To fire this weapon, one must simply insert a cartridge so that its rim rests against the tubing wall at the front of the slot. A backward

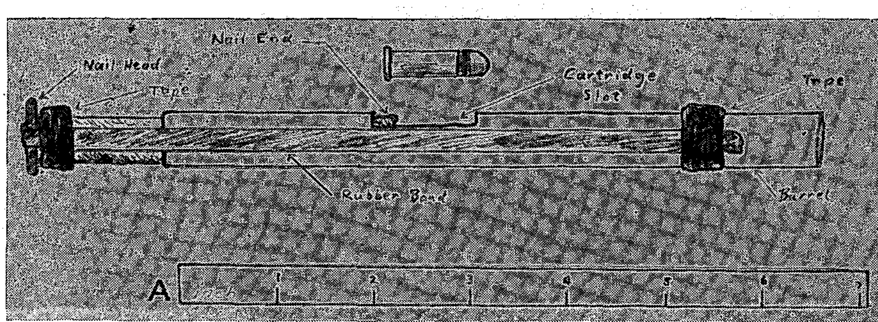


FIGURE 10
A. A Nail-type weapon. B. The effect produced by a roughly finished nail on a cartridge base.

pull on the nail head tightens the elastic, and releasing it allows it to slam home. The cartridge case often jams in the rear of the slot and takes impressions both of the nail and the tubing. At times the weapon may eject, but this usually depends on whether or not the gun is canted. Ejection may be described as the case dropping out of the slot onto the ground, as there is no provision for this function in the cycle. More often, the return motion of the nail will rechamber the shell or deform it against the chamber mouth. A long thin object is then required to push out the shell from the muzzle end. Figure 10B shows the effect of the nail face on a cartridge base.

Other weapons using a break action or those with a screw-on breech cap also have no means of extraction or ejection and are somewhat slow to use for more than one shot. They follow the pattern of the cheap 'nail-extraction' revolvers and the United States O.S.S. .45 "Liberator" pistol, in that a nail or rod must be carried on the person to push out the shell. If a metal rod narrower than the diameter of the shell is used, shiny scrape marks may be left inside the shell where the powder deposit has been disturbed. If an empty shell is all that is found, such scrape marks inside may provide a lead about the type of gun to seek. It is also difficult to headspace these guns to any degree of precision, and often this condition causes a ballooned rim or bulged shell walls near the rim. If the cartridge case is free to back up with a lot of force, the shell walls ahead of the rim may buckle and leave a casing with *two* rims as in figure 11! Greased bullets may heighten this effect.

FIGURE 11
A second "rim" on a Rim Fire case. The shell jumped back a short distance striking the poorly headspaced bolt. The shell walls buckled for the distance that they were unsupported.

NON-BULLETED LOADS

The cartridge-firing zip gun does not always fire a bulleted load. It may use a blank cartridge behind a load of shot pellets or split-shot lead fishing sinkers. A load of this nature would damage a well made weapon, because close tolerances plus the fast-burning blank powder result in shattering pressures. But in a poorly chambered and headspaced zip gun any excess pressure is either harmlessly bled off or the unsupported parts of the shell burst at weak points. The sections of a blank cartridge with the least strength are the crimped mouth and the metal where the shell wall has been die-stamped at 90° to manufacture the rim. The shooter often suffers from the back blast, and flare marks with embedded powder grains remain on his hands.

One type of cartridge may be used which is relatively unknown—the brass .22 rimfire shotshell. It is the same length as a *complete* .22 long rifle bulleted round, has a crimped mouth and contains from one hundred to one hundred and fifty pellets of number 12 shot. The actual count varies with the size of the individual pellets, which by company standards are supposed to be of .05 inch diameter and weigh 2,385 to the ounce. An overpowder wad protects the shot and may be made of either felt or cardboard 1/16th of an inch in thickness. Shotshells can usually be fired from zip guns, but there is a tendency for the case mouth to be blown off at the point where the crimp ends. Thus a ring of brass may be projected into a wall or be carried with the shot charge into the wound channel. Pressure is high with Winchester ammunition as a very fast-burning ball powder of fine diameter is loaded. Traces of this may be left in the barrel or fired into the wound if used at close proximity to the victim. The powder should not be confused with the lead shot as the former is about 5 times smaller in unburned form. Other ammunition companies load flake or disc powder of a type similar to that used in standard .22 bulleted rounds.

Firecracker-Powered Zip Guns

Despite the ban on large noise-making firecrackers in many areas, a lucrative bootleg trade is carried on in these devices. Around important national holidays, misuse of fireworks and accidents arising out of horseplay increase markedly. Boys are fascinated by the destructive potential of the big noisemakers; they tie several together to increase the force, make bombs from the gunpowder, use them in homemade rockets, shatter bottles with them, and use them in guns. The sizes vary with availability from one locality to another. Chinese "cannon" firecrackers range up to four inches in length and to half an inch in diameter. The most commonly sold size is two inches long with a diameter of 1/4 inch. The smallest, ladyfingers, are a tiny half inch in length and 1/8 inch in diameter. These last ones are usually unpredictable in performance when fired singly as they are made to be set off in strings of up to 500. When they are seperated the fuses are disturbed and often the cracker does not explode. But they do have sufficient force to propel a small diameter nail or a steel/osmium needle designed for the older 78 r.p.m. phonographs. This needle will be considered with an other type of firearm below.

The two by one-quarter inch Chinese (Macao, Hong Kong) firecracker has a pure gunpowder composition, and generally the outer paper is dyed red. The walls of the cracker are made of brown pasteboard. American manufacturers seem to prefer a flash composition in conjunction with the brusting charge of gunpowder. A certain proportion of metal dust is added to the black powder and the composition takes on a grayish tinge. American companies generally finish the outer surface with a gray dye and white wavy lines or some other pattern. Both types employ a paper fuse containing a fine black powder composition. Many of the American crackers burst with a white flame due to the metal powder content. The Chinese imports make a less spectacular flash in dark conditions, and the flame is generally a dull yellow with lots of sparks. Both varieties employ an inert clay obturator at the bottom and as packing around the entry point of the fuse. This is usually tightened into place by a ring crimp rolled around the ends of the cracker cardboard.

If properly confined in a tight barrel with a breech closure, firecrackers of this size can propel a number 3 or 4 shot pellet (.25 inch in diameter) with the muzzle velocity approaching that of the .22 rimfire cartridge. Wadding must be applied over the projectile to hold it tightly in place against the firecracker or the ball will roll out. A ramrod of some sort is necessary to push the wadding down into the barrel. Other "bullets" such as ball bearings and B.B. shot may also be used. It is often a matter of availability that determines what will be fired from these guns. The writer has seen live .22 ammunition fired from a firecracker gun at a brick wall and when the ammunition struck, it exploded with a dull noise. The maker of this particular weapon simply did not have the tools or the ingenuity to use this ammunition in the correct manner and so he constructed a firecracker operated zip gun to project live ammunition at hard objects.

Larger Firecrackers

The larger noisemaking fireworks, often called "cannon" crackers, produce a thunderous explosion rather than a sharp crack. When placed inside a pipe to project a ball or marble, the noise is reduced to a loud thud similar to mortar fire. These firecrackers are from two to four inches in length and usually have a diameter of a half inch. They have a pasteboard container colored red and are filled with a 4-f black gunpowder composition. A gun using these crackers retains a strong smell of burned powder that is unmistakeable. The smell should not be used as an accurate measure of how recently the weapon was fired because it can maintain its pungence for as long as two months. The clothes of the shooter worn above the waist also hold this odour for a day or two and may bear many fine fragments of the obturator sand, burned and unburned powder, and paper fibers. Brown paper fragments come from the inner layers of the cracker, only the outside portions being dyed red. A comparison can be made with fragments found inside the barrel and with any firecrackers seized provided that they are from the same lot.

Large firecrackers usually come with a looped double fuse and burning time may be increased from five seconds to nearly ten by pulling one end of the fuse out of the cracker. For the purpose of shooting, the user is often less concerned with the safety aspect of extending the burning time than with shortening the fuse to reduce the interval between lighting the fuse and detonation. The writer has seen several seized caches of fireworks set aside for use in a zip gun in which every cracker had had the fuse clipped to cut the burning time to about two seconds. In actuality, the burning period was even shorter because the fuse is paper rolled around a train of fine powder. Some of the powder leaks out of the open end if the fuse is mishandled or if the firecracker is carried in the pocket. At times all the powder is lost and the shot is a dud. The flame never reaches the main powder charge and the cracker is usually thrown away on the spot. Large pieces of the cracker may be thrown out at both ends of the gun, and they often continue to burn for about fifteen minutes. Confinement of a firecracker seems to lead to burning fragments far more often than setting one off in the open air. In the former case the heat of the burning powder is in longer contact with the paper and is not so readily dissipated.

Cannon crackers are most often used to propel large ball-bearings or glass marbles. At times an example is seen of "shot-shells" made from cannon crackers with B.B. shot taped to the base. Some shooters use aluminum foil and achieve a larger capacity with this material. Foil fragments found at the scene of a shooting can be matched, with some patience, to fragments found inside the gun barrel. In a weapon with a breech closure almost all the foil and most of the cracker will be found inside the barrel. The heat and pressure of the explosion force the foil tightly against the barrel walls, and if the investigator is careful, large fragments may be recovered intact for matching purposes. Using a cartridge of this nature a shooter can fire off several shots in rapid succession. In this event, matching fragments of foil to individual cartridges or to the residue found inside the barrel is decidedly more difficult. Most often though, a system similar to muzzle loading weapons is encountered. The firecracker is placed in a pipe, a missile is rolled down on top of it, and a wad of cloth or paper is rammed in to hold the projectile tightly against the firecracker. This wad may later be matched to the material it was torn from and still in the possession of the suspect. It is usually damaged very little beyond mild scorching because the wad lies ahead of the missile and therefore out of direct contact with the blast. This type of cartridge can be deadly as was seen in a recent case where ball-bearings were shot in Toronto. The bearings were fired at $\frac{3}{16}$th inch steel garage doors from a distance of 150 feet and pierced the metal. On these particular guns breech caps were used to direct all the pressure forward against the bearing. Where the breech is left unsealed, less spectacular results are achieved. Fragments of the firecracker will also be found behind the spot where the shooter was standing, and may be embedded in a wall or doorframe. Without a breech cover, the zip gun is like a military recoilless rifle in principle. The shooter must be careful to place the breech of the gun behind him by holding the rear of the weapon under his arm at hip level or over his shoulder. If the breech is open and is held ahead of his body, he is subject to severe burns and superficial lacerations on his face and neck. He will also be burned on the chest if he is only wearing light weight clothing. Figure 12 shows a weapon of this type with a variation having a breech shield to deflect the blast and noise to the sides of the barrel. Friction tape or metal hose clamps are used to bind the barrel to the wood mounting. Hockey sticks are sometimes used as a stock on long weapons.

Several other types of firecrackers are available in many areas of the United States, and when imported illegally, in Canada as well. These are commonly known as "ash cans" and "cherry bombs" among youngsters. The ash can is also called an "M-80" because of its similarity to a U.S. army hand grenade simulator with that model number. One manufacturer has gone so far as to label these with M-80 although most are either unmarked or

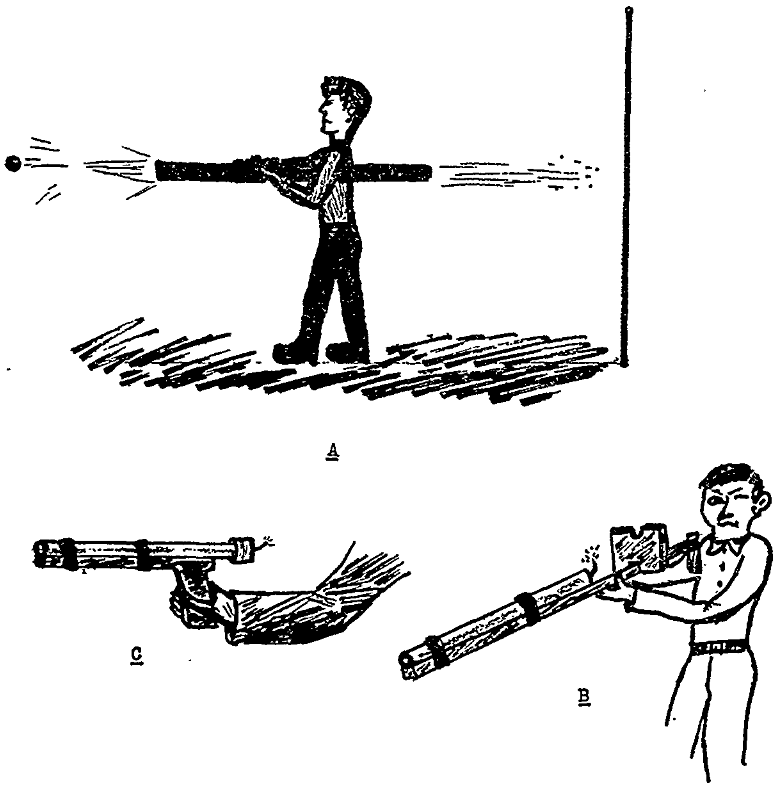


FIGURE 12
(A) A "recoilless rifle". Note that fragments are thrust to the rear, and may lodge in a wall or door. (B) A shielded breech. The fragments are thrown to the sides, and above the gun. (C) A pistol that has a screw-on breech cap with fuse hole.

are covered with the warning "Do Not Hold in Hand". The M-80 is about 1½ inches long and ½ inch in diameter. It is made of tough cardboard wound spirally, and the ends are filled with a colored ceramic material. The device is loaded with black powder mixed with a pyrotechnic flash charge of powdered metal; the powder appears to be gray and slightly lumpy. The fuse is an impregnated plastic type of cord and is red or green in color. It enters the side of the cylinder at the middle of the device. It is completely waterproof, and the writer has seen lit M-80s flushed down toilets with devastating effects on the plumbing. The metal powder content makes the charge a near-high explosive in its manner of ignition according to Lenz (2). Because the fuse is placed on the side of this firecracker, it is difficult to use in a narrow barrel and impossible to put into one that has a screw-on breech cap. The fuse is too short to project back past the end of the cracker and through a hole in the cap. If it is lit first and pushed into the barrel, there is not enough time to screw on the cap and still be able to aim the gun at a target. A break-action gun could overcome this, but the writer is unaware that this type of weapon has been used for this particular purpose. Because of the nature of the charge, sealing the breech could be expected to cause the chamber to burst, being fairly weak and thin plumbing pipe in most instances.

The cherry bomb yields the same difficulties. It is round and red with a short green fuse also made of plastic coated cord. The fuse is generally two inches long, and the device is approximately an inch in diameter, made of moulded cardboard. It is loaded with a similar compound to that used in the M-80 but has nearly double the charge. The writer has seen it destroy both open and closed breech weapons with a screw cap. It too can be placed in Lenz' list of high explosives (2).

The individual shooter has his preferences for firecracker brands, wad type (paper, tissues, plastic bags, foil, etc.) and projectile type. He usually sticks to what he finds best after a period of experimentation with different materials. A particularly successful innovation may serve as a pattern for other boys to follow when a group is involved. This can lead to problems when attempting to pin down a particular material to one person in the group, when several have been involved in an incident in which it is suspected a zip gun of this pattern was used. Material to be sought at the scene of a crime which can narrow down the number of possible shooters includes plastic fuse residue which may retain traces of color, and matches of any type. Refer to the description of types in Svensson's and Wendell's book (4), and for a detailed study of book match comparison methods see the article by Funk (5). Solution of a particular case is described in the *F.B.I. Law Enforcement Bulletin* (6).

Hand Cannons

From time to time an unusual black powder weapon is confiscated: It is a hand cannon and is often well made. It usually consists of a steel rod bored out most of its length, and a touch hole drilled through the wall at the breech end of the barrel. It may be mounted on a rough wooden stock or considerable care may be taken to mount it on a fitted metal frame with fancy grips. Instead of boring out bar stock the shooter may screw a threaded cap onto the outside of a piece of thick-walled pipe, or fit a plug into a piece of strong pipe by threading it in or pinning it into place. It is a two-handed gun because while one holds it the other touches a lighted match or glowing string to the flash vent. It is rather clumsy to use at night for this reason, and it is slower to load than any other gun described, for it uses two separate powder charges. Besides the main charge loaded into the bore behind the wad, a ball, and a second wad, another charge must be carefully poured into the flash hole and the depression around the hole. Accuracy is poor since it is impossible to aim carefully holding the weapon at arm's length and simultaneously touch the fire to the powder train on top of the barrel. From a distance of ten feet, penetration can be up to four inches in pine boards depending on the type of powder available (some shooters try to make their own and the quality is extremely poor), the powder load, degree of compression, type of wad, and the fit of the ball inside the bore. If the overpowder wad provides a poor seal then much of the powder gas will be lost around the ball. An investigator testing such a weapon may have to do considerable experimentation to duplicate the results obtained by the shooter in using the weapon in a crime. Care should be taken to use the original powder, if enough is available to retain a quantity on hand for court evidence. If possible to analyse the chemical contents of the powder, a duplicate sample can be compounded in the laboratory, and the original supply can be maintained as evidence.

If the bullets used in this type of gun are made of lead, they may bear the impressions of the ramrod used to seat them in the bore. These marks can be matched to the pattern on the surface of the rod as if they were any other toolmarks. If they have been deformed, they are not too useful because they are seldom very distinct in the first place. Smokeless powder is not suited for such a weapon as it cannot be tightly enough confined in a short, large-bored barrel to develop much thrust on the bullet. Most of this powder is unburned and is ejected with the ball. At close range, if the ball does cause a wound, then grains of smokeless powder will be found in the channel. It is simple enough to match this to the supply possessed by the suspect, and to unburned grains left inside the bore of his weapon. Pockets in the suspect's clothing may also yield grains of powder for comparison if he has pocketed the pistol barrel-downward.

A similar type of pistol that has been described by several writers because of the ingenuity used in its construction is the lockwork pistol that combines principles of the matchlock, wheelock, and the flintlock. Pressure on the trigger causes a wooden kitchen match to be pulled across an abrasive into the powder train. This requires an elaborate system of small springs which if properly adjusted, will provide consistent ignition. A section of a nail file, a piece of a lady's emery board or a fragment of sand paper provides the abrasive surface. A cigaret lighter flint may replace the match and more control can be obtained, but this requires adjustment of the flint as it wears away. Smokeless powder will not function properly in the bore, and it is difficult to light because of the retardant coatings. Homemade bullets for these weapons are often molded from solder. The caliber will be found to be unusual upon measurement, and there will be acid or resin flux within the solder that would not normally appear in bullet lead. Furthermore, the alloy could be comparable to solder found in the suspect's workshop, and a homemade mold that matched a recovered crime bullet could be useful evidence.

This article will be concluded in the March 1970 Issue.