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A Study of Handcuff Improvements

James E. Harris

Product Performance Engineering Division
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Contents

FOREWORD

The Law Enforcement Standards Laboratory (LESL) of the National Bureau of Standards (NBS) furnishes technical support to the National Institute of Justice (NIJ) program to strengthen law enforcement and criminal justice in the United States. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

LESL is: (1) Subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guides and technical reports.

This document covers research on law enforcement equipment conducted by LESL under the sponsorship of NIJ. Additional documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

Technical comments and suggestions concerning this document are invited from all interested parties. They may be addressed to the author or to the Law Enforcement Standards Laboratory, National Bureau of Standards, Washington, DC 20234.

Lawrence K. Eliason, Chief
Law Enforcement Standards Laboratory

A Study of Handcuff Improvements

James E. Harris
Product Performance Engineering Division
Center for Consumer Product Technology
National Bureau of Standards
Washington, DC 20234

SUMMARY

Designs for improving the security of present day ratchet and pawl metallic handcuffs are presented. Two methods utilizing a new lock feature were developed that significantly improve the lock. The National Bureau of Standards has applied for a patent on these innovations. In addition, several other potential handcuff improvements are discussed in this report.

INTRODUCTION

The use of a metallic handcuff as a temporary restraint of individuals is an everyday occurrence. However, since the present handcuff was introduced two developments have occurred. First, some individuals have obtained an alarming level of skill in defeating the design, and second, the user population has requested more security from the device than it presently provides.

In order to determine the present metallic handcuff problems and to explore possible solutions to the identified problems, meetings were held with manufacturers, distributors, instructors, users, and other knowledgeable persons. Among the persons consulted were the instructors and armory experts at the Federal Bureau of Investigation Academy and members of the International Association of Chiefs of Police. In addition, a large manufacturer of law enforcement equipment was visited to observe their handcuff manufacturing process. Further information was obtained by examining handcuffs that had failed in various ways.

Users of handcuffs have reported that most of the available handcuffs are in need of improved lock security (pick resistance), and increased strength for swivels, chain links, rivets and pivots. The primary objective of this project was to investigate improvements to existing handcuff designs that could be accomplished with minor modifications to existing tooling and manufacturing processes. In addition, the procedures presently used in the application of handcuffs should not be significantly increased in complexity.

A handcuff is a temporary restraining device. Its purpose is to contain a person for a short duration and under proper surveillance. However, arresting officers may sometimes be preoccupied with other matters or otherwise unable to maintain proper surveillance. Under these abnormal conditions, it is

desirable that metallic handcuffs continue to provide a reasonable level of security.

DESCRIPTION OF OPERATION, STANDARD HANDCUFFS

The operation of an ordinary handcuff can be understood by referring to figure 1 in conjunction with the following description. When open, the ratchet pivotes freely about the ratchet pivot toward the main body of the handcuff until the teeth of the ratchet engage the teeth of the pawl. Further ratchet movement will cause the spring-loaded pawl to cam up away from the ratchet each time the teeth on the ratchet move over the teeth on the pawl. When the ratchet motion stops, the pawl is forced against the ratchet locking the teeth together. This is the primary locking means. The motion of the ratchet may be continued to a desired amount of closure about an object (a wrist). If there is no object present to prevent continued motion, the ratchet motion may be continued until the ratchet completely passes the pawl. The shapes of the ratchet and pawl teeth, when engaged, and the spring action are such that the ratchet motion is possible in one direction only. In order to open the handcuff when the teeth are engaged, the pawl must be disengaged (against the pawl spring force) from the ratchet teeth. That is the function of the key when unlocking the primary lock. Notice that the pawl is able to move against the pawl spring force only when

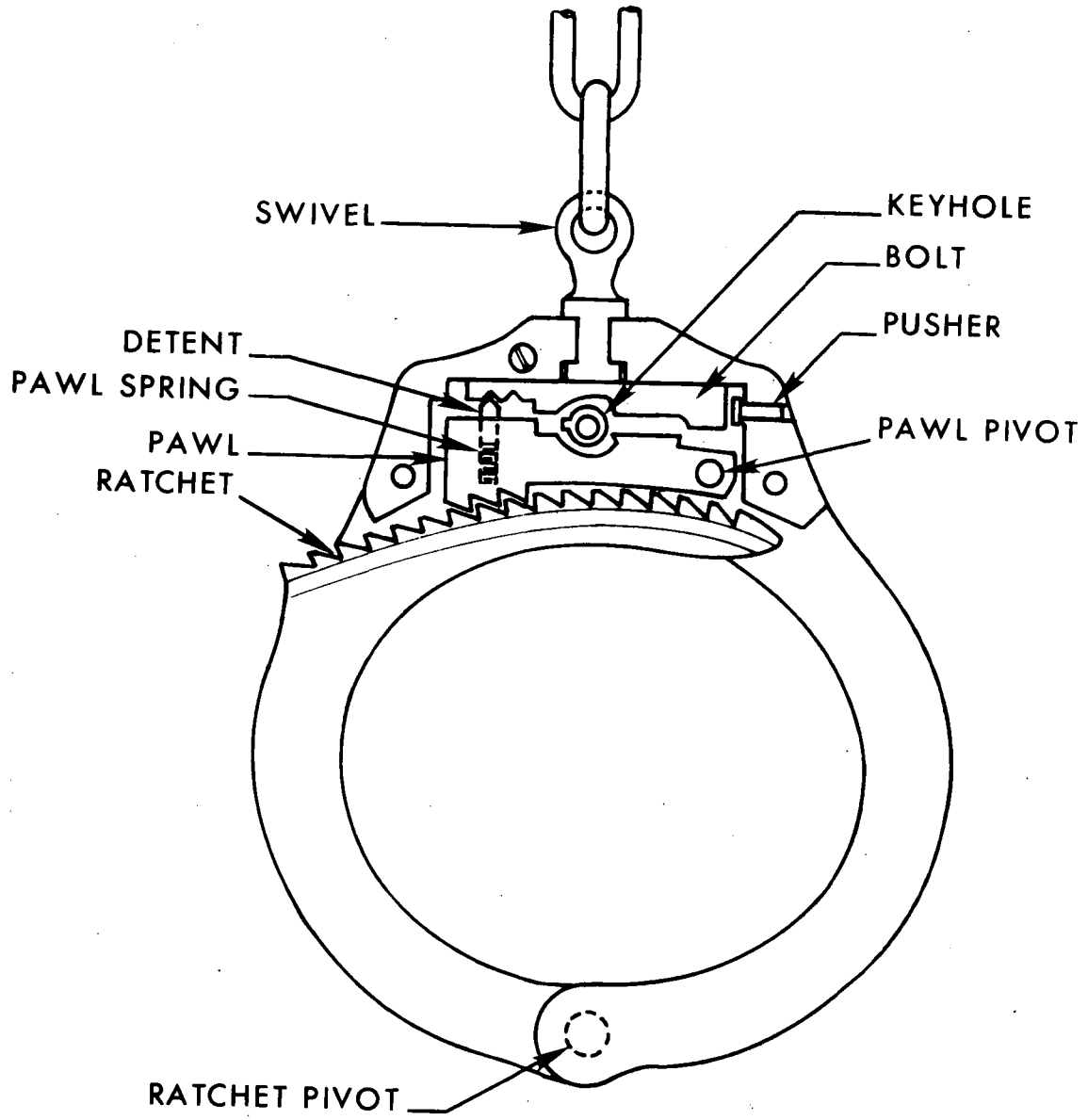

Figure 1. Partial cross section of a typical handcuff with the double lock bolt in the inactive position.

the double lock bolt is set to the inactive position (fig. 1 shows the double lock inactive). When the handcuff is closed to the desired position, the rear tip of the key is then inserted into the pusher hole to engage and press upon the pusher, moving the double lock bolt to the active position as shown in figure 2. With the bolt in this position, the pawl is not able to cam sufficiently to enable the ratchet and pawl teeth to disengage because of the interference between the bolt and the pawl. Accordingly, the ratchet cannot be closed further, nor can it be opened. The hancuff is then said to be double locked. No method has been discovered to enable a double locked handcuff to be opened without first moving the bolt to the inactive position unless some parts are physically distorted or cut.

To open a double locked handcuff, the double lock bolt must be moved away from the pawl as shown in figure 2 (key turns clockwise). Only after this is done can the tang of the key or a picking tool lift the pawl (against the pawl spring force) away from the ratchet (key turns counterclockwise). In this position, the teeth of the pawl and ratchet are no longer engaged and the ratchet is free to swing in either direction. It should be observed that the function of the pawl spring is two-fold: to retain the pawl against the ratchet to effect the primary locking, and to provide a detent that maintains the double lock bolt in either the active or inactive position. In most handcuffs a properly directed sharp impact of the handcuff against a hard

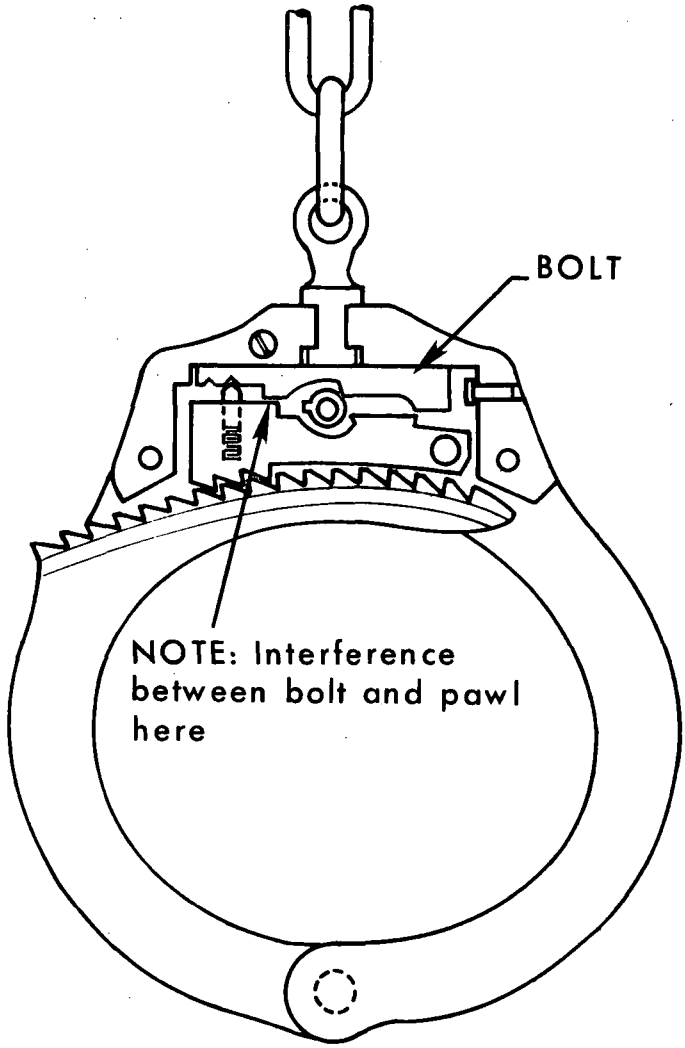

Figure 2. Partial cross section of a typical handcuff with the double lock bolt in the active position.

object can defeat the detent function of the pawl spring and cause the bolt to move. It is also a simple matter for a skilled person to move the double lock bolt to the inactive position with a paper clip or similar implement. If the double lock bolt moves to the inactive position, it is then possible to open the lock with a picking tool such as a bent paper clip wire, or with a thin shim that may be inserted between the pawl and ratchet to separate the teeth. If the double lock bolt moves to the active position, the handcuff must be "unlocked" prior to its use. In either case, the ability to move the double lock bolt by a means other than the key is undesirable.

DESCRIPTION OF OPERATION, MODIFIED HANDCUFFS

The modified (improved lock) handcuffs that were developed during this study operate on the same principle as the standard handcuff with the following additions. The improved handcuff has means to automatically lock the bolt in the active position. Locking of the bolt in the active position is called triple locking. Refer to figure 3 to follow the operation of the triple locking feature. When the double lock bolt is moved fully to the active position, the pawl spring now forces the corner of the bolt against the housing wall, so that movement to the inactive position is prevented by a ledge inside the handcuff housing. Once the double lock bolt is active, it can only be moved to the

inactive position by unseating it from the ledge so that the corner of the bolt will clear the corner of the ledge. It can be seen that the bolt must be unseated prior to and during lateral motion when the bolt moves to the inactive position. As before, the lateral motion of the bolt is caused by the tang of the key or the picking tool.

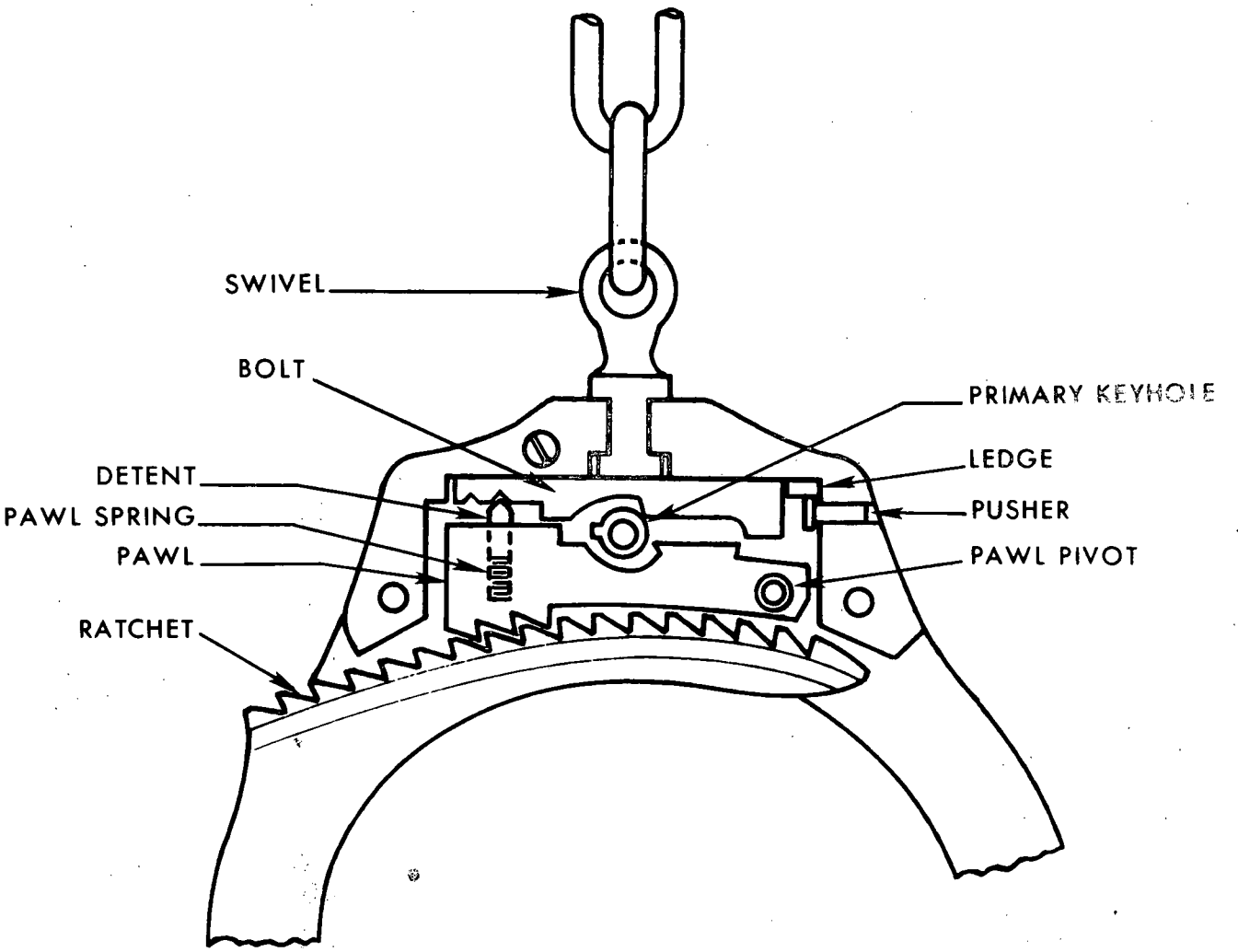

Figure 3. Cross section of a modified handcuff with the double lock bolt active and held in place by a locking ledge.

Two methods have been developed to unseat the bolt under normal operation. One method of unseating the bolt is by the use of a second key which is inserted through a new secondary keyhole located on the opposite side of the handcuff from the standard or primary keyhole as shown in figure 4. Rotation of the second key causes the tang to move the bolt downward and away (unseating) from the ledge. The standard or primary key is inserted through its keyhole and this second key is rotated so that the tang of the key moves the bolt to the inactive position. Both keys or two picking tools must be operated simultaneously to unlock the handcuff and since they are from the opposite sides of the handcuff the skill required is high. This results in a difficult feat for a handcuffed person to perform, which improves the security features of the lock. A second method of unseating the bolt is to use a hollow swivel with a concentric protruding pin that serves as a push rod when the chain link within the eye of the swivel is grasped and pressed upon the tip of the protruding pin as shown in figure 5. The pin transmits a force that presses the bolt downward and away (unseating) from the ledge. The key must then be inserted and rotated so that the tang of the key moves the double lock bolt to the inactive position. The action of grasping and pressing of the chain link against the pin to unseat the bolt must be done simultaneously with the turning of the key. These operations are difficult to perform by a handcuffed person because they require a high degree of manual dexterity. The security of the handcuff lock is thereby improved.

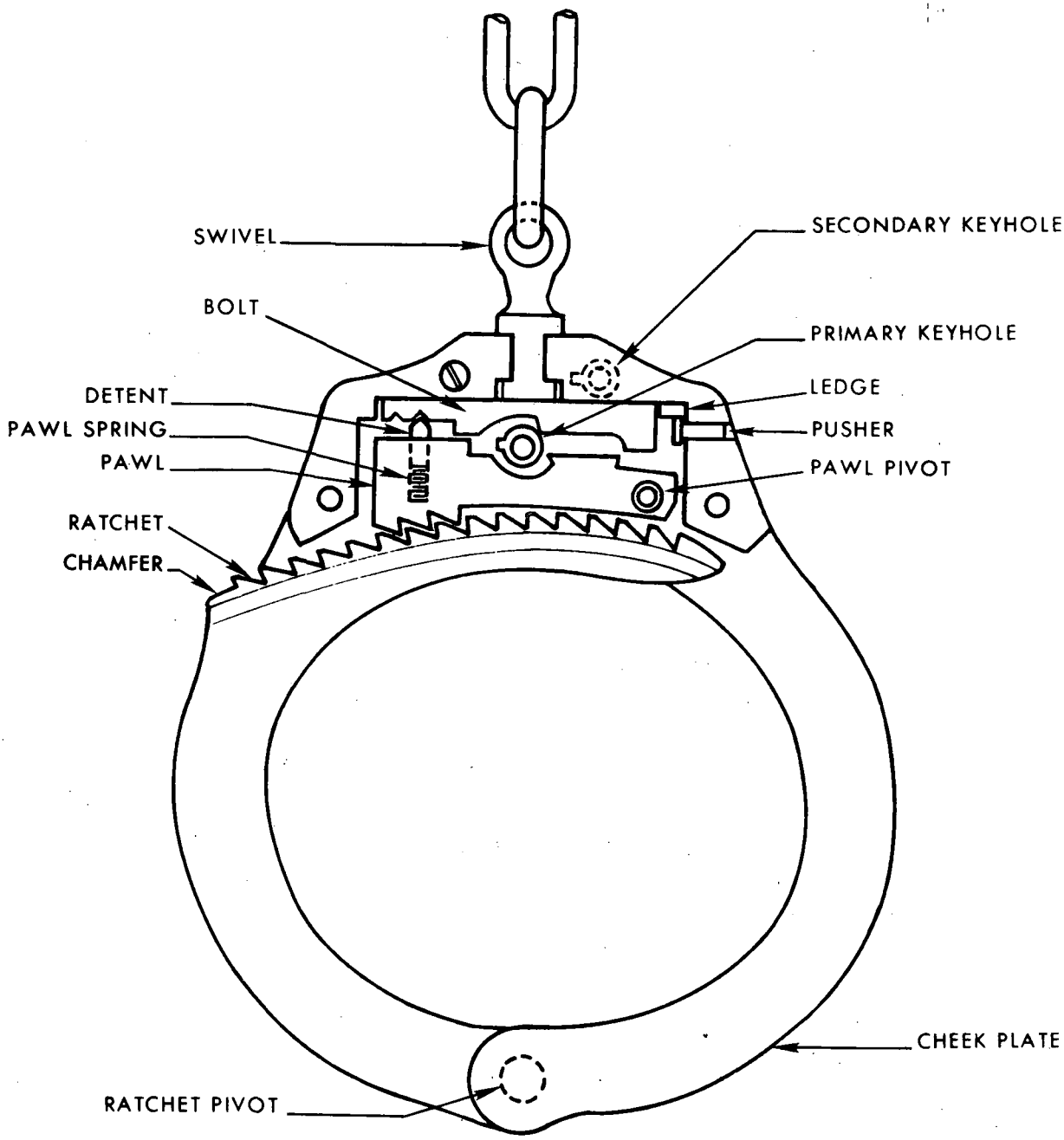

Figure 4. Partial cross section of a modified handcuff showing the secondary keyhold for unseating the double lock bolt and the chamfer of the last tooth of rachet.

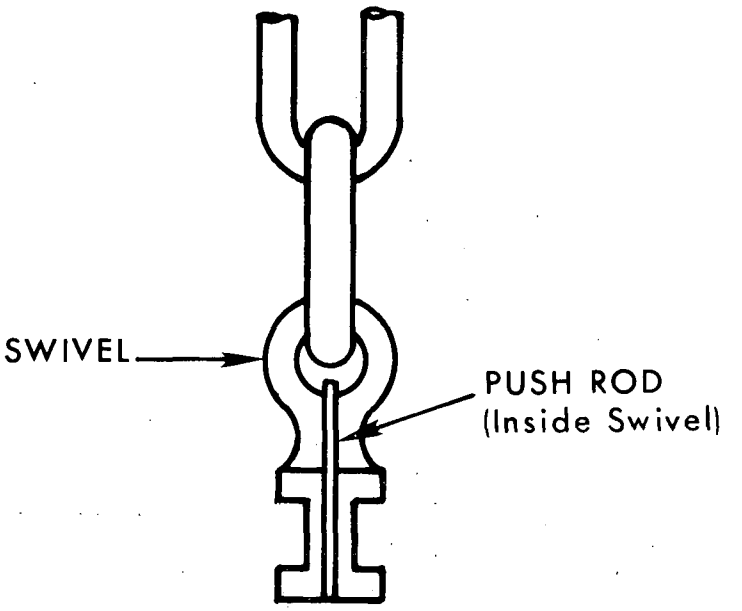

Figure 5. Alternate method of unseating an active double lock bolt.

An additional improvement for the locking of the handcuff was developed that automatically double locks (and consequently could triple lock) the handcuff when applied about a wrist or other object. Refer to figures 6 and 7. When the handcuff is applied and closed about a wrist, the pressure of the double/triple lock lever against the wrist will cause counterclockwise rotation of the lever. This rotation will move the other end of the lever to the left where it will engage the pusher, which has been lengthened to protrude from the body of the handcuff, and press upon it thereby moving the double lock bolt to the active position. The handcuff will then be multiple locked. This action is automatic when the handcuff is properly applied. By proper

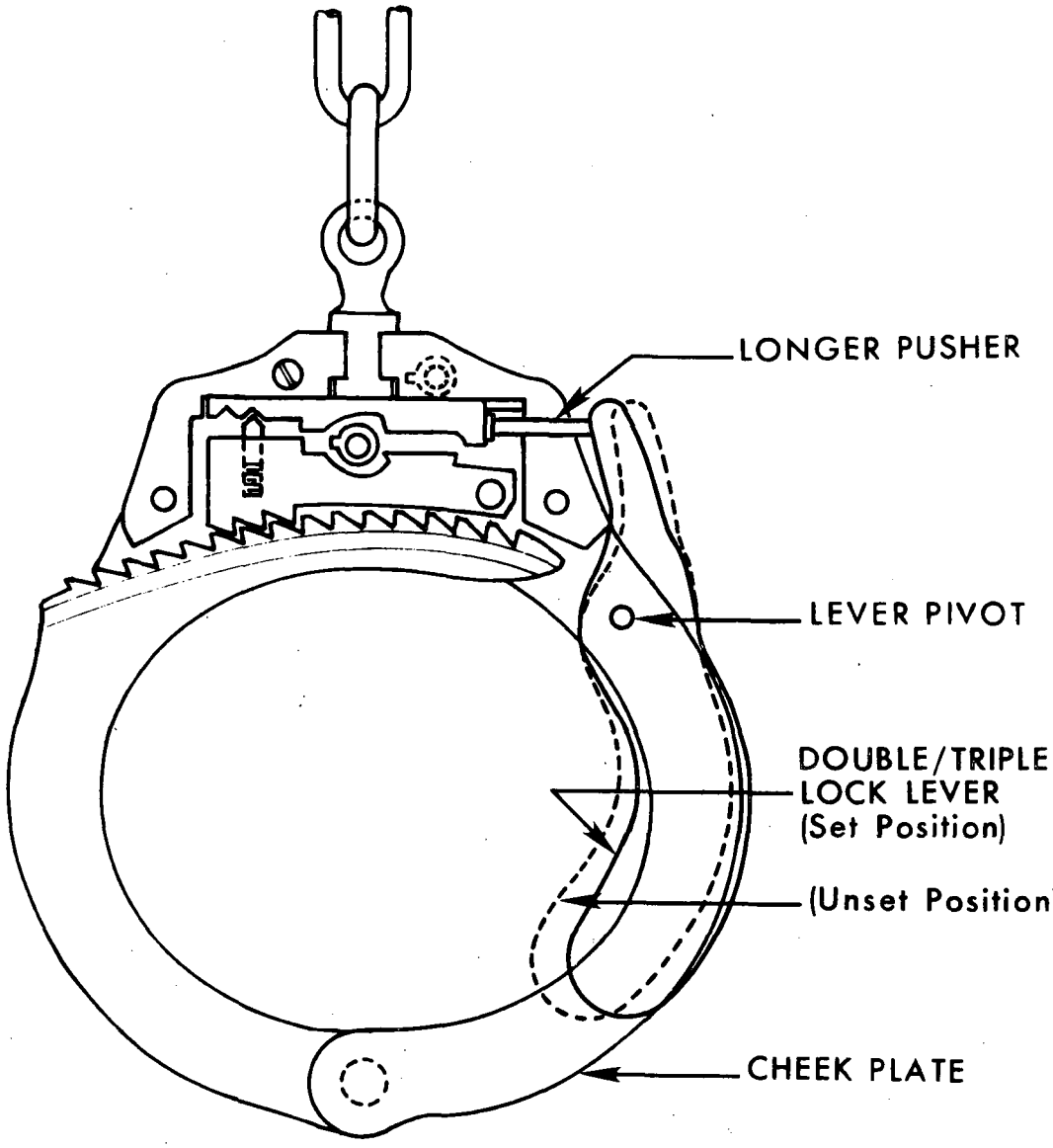

Figure 6. Partial cross section of improved handcuff with the double lock bolt inactive.

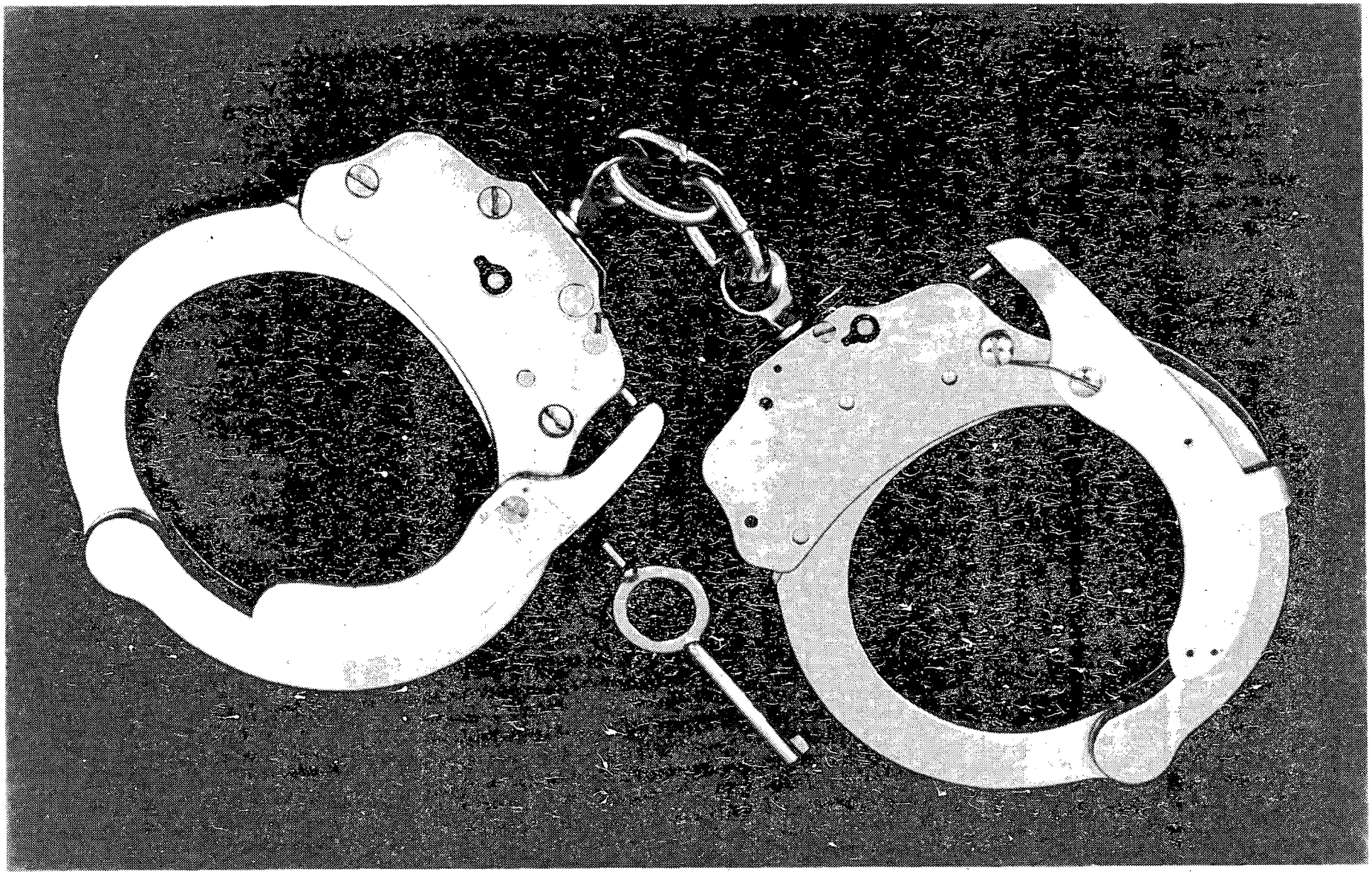

Figure 7. Photograph of the demonstration model of the improved handcuff.

design of the geometry of the lever and its pivot, it will be impossible to apply excessive squeezing pressure to the wrist because the lever will activate the double lock and prevent further closure of the handcuff. Officers will not need to use the key to activate the double lock, a maneuver that is difficult to do in the dark or with a hostile individual. Also, officers will not forget to activate the double lock since this improvement causes automatic multiple locking. If combined with the previous improvement, triple locking is effected automatically when the double lock is activated.

The improvement of automatically triple locking makes it very unlikely that any directed shock would be able to unseat and unlock the bolt. In order to accomplish this, one shock would be required to unseat the bolt and while the bolt was unseated against the pawl spring force, a second shock at a right angle to the first would be required to move the bolt to the inactive position. It is very unlikely that anyone would be skillful enough to apply such shocks in the proper direction, intensity and sequence even if they knew how these shocks were required. Finally, it is doubtful if a single shock could replace the two right-angled components because of the internal friction of the sliding bolt against the ledge.

ALTERNATE RESTRAINING DEVICES

The improvements cited in this report are generally applicable to other handcuff-like restraints. Some of these restraints are leg irons, belly chains, leg chains, transportation belts, and hobbles. Since there is sufficient variation in the design, each product would require a detailed examination to determine the aptness of any of these changes.

RESULTS

Modified handcuffs were given to various engineers, technicians, law enforcement personnel, instructors and administrators with variable knowledge of handcuffs to see if they could open them. They tried with and without the keys. No one was able to open the hollow swivel type in a reasonable time period, even when not applied to a wrist. The double keyhole type was opened by only a few (with some difficulty) as the second keyhole gave a somewhat obvious clue as to its method of operation, whereas, with the hollow swivel, the clue was well hidden. There was a general consensus that either type would be very difficult to pick by a handcuffed subject. A number of those who evaluated the double-key type believed that there would be some objection to the use of two keys to open the handcuffs, although it was admitted there was high security due to the requirement of two keys used simultaneously.

OTHER POTENTIAL HANDCUFF IMPROVEMENTS

During this investigation a number of possible handcuff modifications, other than to the lock, were identified. These modifications eliminate structural weaknesses or simplify operational procedures and are enumerated below:

1. Use a single chain link instead of the present two or more. With two chain links, it is possible to interlock the handcuff swivels allowing the individual to stress the swivels to failure. The use of a proper sized single chain link would preclude interlocking the swivels.

2. Add a back edge chamfer to and reduce the slope of the last ratchet tooth to facilitate finding (in the dark) the last ratchet tooth so that the handcuffs can be stowed in this position (see fig. 4). When this last tooth is engaged it will take less time and force to apply handcuffs to a subject reducing the chance for wrist injury or claims of wrist injury by the subject.

3. Add coined "match-up" marks to the ratchets and housings. This will facilitate finding and stowing of the handcuffs at the last tooth for the reasons cited in the preceding paragraph. Such marks would make it easy to visually check if the handcuffs were so stowed.

4. Use a single, heavier cheek plate to eliminate the present gap between the two existing cheek plates. When handcuffs are applied to an individual the gap between the cheek plates is readily accessible and almost any available prying tool may be engaged in the gap. Even the ratchet of the other handcuff may be inserted into the gap and a large mechanical advantage may be brought to bear upon the cheek plates and rivets. If a single and necessarily stronger cheek plate is used, this gap would not exist and the ability to pry cheek plates apart would be eliminated. This design change would also require a design change in the ratchet pivot point. A possible benefit of such a change is that there could be an opportunity to combine several parts into a single part.

5. Use a longer pusher that protrudes a small distance from the housing when the bolt is in the inactive position such that the pusher may push the bolt to the active position without the use of a key tip. Present handcuffs use a short pusher that does not extend to the housing's external surface thereby requiring the use of the key tip or other pin-like object to activate the double lock. This present arrangement makes it relatively difficult for an officer to activate the double lock once an individual is handcuffed. This becomes an important problem if the individual is hostile or it is dark, when it would be difficult to get the key out, find the pusher hole, engage the pusher and press upon the pusher to activate

the double lock. This improvement is automatically incorporated with the proposed automatic double/triple lock feature as that feature requires the use of a longer pusher and the double lock is automatically activated when the handcuffs are properly applied. The longer pusher improvement is listed separately since it may be incorporated independently of the automatic double/triple lock feature. It is important that the length of the pusher be increased only by the minimum amount required, so that the double lock will not inadvertently or maliciously be activated.

6. Use bags made of canvas, rubber or leather with ties to cover the person's handcuffed hands thereby depriving him of the effective use of his fingers. Under some circumstances a handcuffed individual may be able to overpower an arresting officer and take the officer's weapon and use this weapon to effect an escape. Anytime that a handcuffed person has the use of his fingers he should be viewed as a potential escapee and still very dangerous. When each handcuffed hand is inside a separate secure bag of stiff material the use of the fingers is significantly impaired. Since officers presently carry a considerable amount of special purpose equipment on their person these bags could be carried in a convenient place in the squad cars for ready use to enhance the security of handcuffs after the handcuffs are applied to the individual.

CONCLUSION

Modifications and test results have shown that with fairly easily implemented changes it is possible to significantly increase the security of handcuffs.

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Designs for improving the security of present day ratchet and pawl metallic handcuffs are presented. Two methods utilizing a new lock feature were developed that significantly improve the lock. In addition, several other potential handcuff improvements are discussed in this report.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Handcuff; lock security

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