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FIREARMS EVIDENCE—REPLICAS OF FIRED BULLETS

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The application of molding and casting techniques to evidence materials in the field of Criminalistics has received considerable attention over the years. Evidence requiring molding and casting procedures ranges from footprints in soil, teeth marks in remains of partially-eaten food, to tool marks, parts of the human body (including hair), indented writings, fingerprints, and various other specimens. Many of the problems presented by the reproduction of such specimens are peculiar to the field of Criminalistics, and while methods and materials applied in other fields have been successfully adapted to some of these problems, there are certain areas in which further work should be undertaken.

While a number of excellent papers dealing with this subject have appeared, it is unfortunate that there is as yet no single text in the field of Criminalistics devoted exclusively to the handling of molding and casting problems in relationship to physical evidence. In Criminalistics, particularly, one is not only concerned with duplicating the general shape and detail features of a specimen, but the light-reflecting quality of the final replica is frequently all-important. When one considers the great variety of materials handled by the Criminalist, and the problems they present from the molding and casting standpoint, it becomes apparent that there is still a fertile field for investigation along this line.

The object in making a replica of physical evidence is usually merely to permit its removal from the crime scene from which it would otherwise not be portable (tool marks, e.g.), or to permit the significant area of a specimen to be placed on the relatively small stage of the comparison microscope. In other instances (teeth marks in food), replicas are made as a means of permanently recording something which would otherwise be perishable. For the most part, such replicas are of value only to local laboratory personnel, though they may on occasion be introduced into court as exhibits.

There is one area in Criminalistics, however, in which replicas might serve an even more useful purpose—an area which seems not to have been covered—namely the reproduction of firearms evidence, with particular reference to fired bullets. Although it is not unlikely that efforts have been made in the past to duplicate fired bullets in replica form, this writer has noted no references to the subject in the literature available.

Replicas of fired bullets (and even cartridge cases) could serve a number of valuable functions. Replicas of evidence bullets would provide a permanent three-dimensional record of specimens involved in serious crimes, serving to lessen the problems which would attend any loss or damage to the original specimen. Such replicas might easily be distributed to other law-enforcement agencies for comparison against bullets or weapons recovered in those jurisdictions, and in this respect would serve far better than the usual descriptions commonly associated with the "Wanted" notices. They would also permit the laboratory to maintain on file an "evidence" specimen long after the original evidence had been introduced into court, or released to other authorities. Replicas of test bullets might be of value in cases involving recovered weapons in which many departments have an interest. Unnecessary test-firings of the weapon might be avoided by providing replicas of the first few tests for all preliminary comparisons; and the providing of such replicas, whether test or evidence, would not in any way break the "chain of possession" of the original specimens. Finally, replicas might be used merely for the "Specimen File," to indicate class characteristics of various arms. Exchange of such replicas would be more convenient in every way than the exchange of test-fired bullets. While dimensional characteristics of a replica might not duplicate exactly those of the original specimen (slight shrinkage must be expected), there is no reason why they could not serve for preliminary comparisons if the shrinkage factor is kept in mind.

Perhaps the greatest problem associated with the production of replicas, whether they be tool marks or bullets, is to obtain a final product which has light-reflecting qualities like that of the original. There has been no shortage of molding and casting materials—a wide variety of substances is available for use—but there are difficulties in attempting to locate materials which simulate an original when viewed under the comparison microscope.

During the past few months the writer has conducted a number of experiments with both tool marks and fired bullets, attempting to develop replicas which could be easily made from available materials, and which would at the same time simulate the surface quality of metals as viewed under the magnification and illumination normally associated with the comparison microscope. As a result of this research, a method and procedure has been developed which appears to meet quite well all major requirements of the problem. The final product resulting from application of this technique contains all the significant detail which is to be expected of any replica. Flaws in the replica are relatively rare (or if present, do no major harm), and comparison of the replica against the original shows an excellent correlation in all significant areas. The procedure involved in making the replicas is not a complex one, materials are simple, and dozens of replicas can be made in a relatively short time—all essentially alike. Finally, and most important, the problem of obtaining a suitable metallic surface on the final replica has been effectively solved.

The Molding Material

For the production of a mold, "RC-900" Silicone Rubber (Dow Corning) has proved entirely satisfactory. There are other silicone rubbers on the market which appear to be essentially the same as the RC-900 formulation, as well as certain dental compositions of rubbery character which might prove equally suitable. For those not yet familiar with RC-900, it is a very viscous (glue-like, in fact) white fluid to which a small amount of catalyst is added and thoroughly stirred in. Within 5 to 15 minutes, depending on the amount of catalyst added, the substance sets up into an opaque white rubbery mass. The silicone rubber resulting is quite flexible, fairly strong, and capable of recording extremely fine detail. With care in working it, air bubbles are not a serious problem. Although the liquid substance is very "sticky" and somewhat difficult to work with (it will not pour well at all), when it has once set up, it adheres to very few other surfaces.

One desirable feature of silicone rubber is that it may be mixed (before adding catalyst) with aluminum dust to give a semi-metallic-grey material. More important is the fact that fine aluminum powder, dusted on the surface of this hardened material, gives a very aluminum-like metallic appearance suiting it to direct comparison work.[1] Finally, and most important of all, is the fact that such aluminum powder may next be transferred to the casting material to give a finished replica, metallic in appearance, but without a "dusted on" type of metallic surface. Only aluminum powders have been tested, but presumably copper, bronze, brass, or any other fine metallic dust (fingerprint powders are quite suitable) could be used with equal success.

The Casting Material

There are various possibilities for casting media, some of which have been tried with success ranging from excellent to poor. For the most satisfactory all-round results, the material selected should probably be one which is quite liquid when poured, which sets up rapidly, which is rigid after setting, which introduces a minimum of potential defects (air bubbles, etc.), which will accept the metallic surface transfer, and which is easily released from the mold.

Materials tested by the writer included plaster of Paris, a fusible alloy (low melting point), silicone rubber, and wax compositions. Without going into detail, it may be stated that of these, none but the wax compositions met all the requirements set forth above.

As to the wax employed, three or four combinations were tested, none of which seems to have

[1] Tests show that "negative" tool mark replicas can be compared quite favorably with "positive" test tool marks on metal under the comparison microscope without the need for making "positives" from the silicone rubber. This is possible in many comparisons by the simple procedure of illuminating the "negative" with light from the "South," and the "positive" test mark with light from the "North." For preliminary work this eliminates the need to make positive casts from the original specimen.

significant advantage over the others. A high melting point is good for the final product (to resist heat of microscope lamps) but is also likely to damage the mold if too high. Satisfactory results were obtained with each of the following mixtures, poured in the molten state:

(a) Beeswax 4 parts, Carnauba Wax 6 parts
(b) Straight Carnauba Wax
(c) Carnauba Wax 8 parts, Paraffin 1 part Polyethylene scrap 3 parts

(All parts by weight, with sufficient fine aluminum dust stirred in to give a grey color.) These materials are heated until they are fluid but not "smoking hot." Stirring should not be done with wooden paddles lest vapor bubbles be created. The wax is poured into the mold, after which it cools within 5 or 10 minutes, and may be removed.

Making the Silicone Rubber Mold

Initial tests should be made using an undamaged bullet, lacking knurling rings or undercut surfaces. Using a .45 Automatic-fired bullet, the following procedure may be followed:

(1) Set the bullet nose up in the bottom of a small open-topped carboard box.

(2) Mix the silicone rubber in a paper drinking cup or similar container and pour it (with spatulation) into the box until the bullet is completely covered. A ¼-inch distance between the sides of the bullet and the container is more than adequate. Allow it to set up, remove the rubber from the container, and then the bullet from the mold.

(3) Alternately, the container may first be filled with the silicone rubber mixture, and the bullet, its base previously affixed to a strip of cardboard or wood, pushed into the box of rubber material. The specimen will then effectively hang nose down from the top of the box.

Microscope cover-slip boxes serve quite well as forms for the mold.

Prior to making this mold, it is essential that the specimen bullet be absolutely clean and free of grease and oil. Cleaning thoroughly in carbon tetrachloride enables one to obtain a good mold free of "sticky spots."

It should be noted that the manufacturer recommends 1 drop of catalyst per ten grams of silicone rubber. A drop is a rather indefinite quantity, and tests should be run on these materials for setting-time before attempt is made to use them in mold-making. The writer finds that a cubic inch of the liquid rubber, mixed with 6 to 8 droplets—or a single drop about the size of BB shot—provides just sufficient time for thorough but rapid stirring, "pouring," and perhaps 10 minutes' set-up time. If insufficient catalyst is added, hours or even days may be required for the substance to set. Should it not set up within an hour, one had best discard the mold and begin again. Also, if mixing is not thorough (after adding the catalyst), there will be soft viscous spots in the mold, making it unsuitable.

On removal of the bullet, the mold should be firm, clean and dry both inside and outside, and without soft spots or major air-bubble cavities visible.[2]

Preparing the Mold for Pouring the Cast

Prior to pouring molten wax into the mold, it is essential to coat the hollow of the mold with fine aluminum powder. This is best done with a tuft of cotton on the end of a swab-stick. The swab should be dipped in aluminum powder and then wiped around the inside of the mold until the inside of the latter is quite "silver" in appearance. It is essential that a good even coat of powder be put over the entire hollow of the mold, but excess powder must not adhere to the sides in lumps. Should excessive powder be used, it is likely to cause pits in the final cast, for it serves to separate the wax material from the silicone mold. Excess powder may be tapped out, or blown lightly out with a syringe. It is necessary to coat the mold even though the wax itself has aluminum powder in it, for otherwise the wax never obtains a true metallic appearance.[3]

Producing the Cast

Once the mold has been made and prepared as described above, pouring of the wax may begin.

[2] Vapors given off by RC-900 may be irritating to the eyes. Care should be used in handling it, with this in mind. It is also recommended that after molding, the specimen bullet be again cleaned thoroughly before it is returned to the file; there is a possibility that the RC-900 tends to oxidize some metals slightly.

[3] Molds which have set up slowly are inclined to accept and transfer the metallic dust better than those in which more catalyst has been used. Experiments also show that wax compositions to which rosin has been added are inclined to be a more silvery metallic in appearance than those made with straight wax formulations. Straight rosin and aluminum powder (no wax) casts are very sharp in detail, very metallic looking, and show no detectable shrinkage. They are, however, difficult to obtain free of air-bubble flaws. A true metallic appearance cannot be obtained with any of these materials if the metal powder is of the "flaky" variety; it must be a fine powder in which the particles are approximately of equal diameter in all directions.

Here, it is advisable to heat the wax until it is quite fluid; then permit it to cool down to the point where it appears to be getting thicker. At this point, the wax is poured from a beaker, pouring so that the liquid wax strikes squarely in the center of the mold at the bottom ("nose" of the bullet-hollow) without running down the sides. It must be poured in one steady stream. If poured too slowly, or in too cool a state, rings or other defects will form on the casting. When the wax is just at the right temperature, the mold fills up quickly and smoothly from the pouring stream, but at the top begins to become viscous as pouring is completed—the wax forming a "button" on top of the mold. Should the wax be too hot when poured, no such button is formed, and excess wax flows out over the surface of the rubber mold. Some shrinkage is to be expected and, as the cast cools, a depression will often be left in the top (corresponding to the base of the bullet).

If only one cast is to be poured, it may be cooled under water. If a number are to be made, it is best to let it cool in the air. When cool, the cast is removed from the mold by carefully pulling the silicone rubber mold outward from the center all around the cast (to release the wax), and gradually freeing the replica to the point where it may be "squeezed" out of the mold.

Should there be undercut surfaces on the original bullet, and hence projections in the mold, it may be necessary to cut the mold vertically down one side, about halfway through to the specimen (or cast), then breaking the side of the mold open along this cut in order to remove the bullet. This will cause a flaw on all casts made thereafter, but not one seriously interfering with the quality of the casts. Where undercut surfaces are involved, such a procedure is advisable.

On removing the finished wax replica from the mold, it will be found to have picked up all the aluminum powder from the inside of the latter, leaving the mold clean again. The bullet replica itself, then, will look quite like aluminum or lead, depending on the color of the original powder, and even at high magnifications will be found to look distinctly metallic.

Further reproductions require only that the mold be re-dusted with metal powder, and additional castings made. Dozens of casts can be made from the mold, in plaster, fusible alloys, waxes, and the like, without significant change in its quality.

Should it be desired to make silicone rubber casts, as well as molds, it is necessary to cut an air-vent in the bottom of the mold (nose of the bullet-hollow), for silicone rubber is not sufficiently fluid to fill the mold otherwise. The aluminum dust, previously applied to the mold, will be found to be a suitable release-agent (separating agent), preventing the mold and cast from becoming fused. Silicone rubber replica-bullets are interesting, but show no more detail than the wax replicas, and are considerably more troublesome to produce. They do have a distinct advantage, in showing even less air-bubble flaws than most casts, and, more important, show little or no detectable shrinkage. Being flexible, however, they present some disadvantages.

Replicas of fragmentary bullets, or bullets in damaged condition with undercut areas and the like, might not be suited to such molding and casting procedures. In some instances, however, by filling the voids with modeling clay before making the mold, reproduction of striated and significant areas might well be accomplished.

In some cases, where a bullet was distorted but not "curled back at the nose," thin-walled molds would be desirable. By making the mold in a short length of suitable metal tubing, the mold could be removed from the tubing between castings, allowing the mold to be stretched away from the cast more easily than would be possible with a thick-walled mold.

Bullet-replicas produced by the procedure described above are very light in weight, can be conveniently affixed to the stage and spindles of the comparison microscope, and provide a surface quality comparable to that of metal bullets. Their light-reflecting properties are often better than the original specimens. They are reasonably resistant to damage (provided care is used in handling them), and have a high enough softening point that they can be used with illumination sufficient for all ordinary visual and photographic requirements. Flaws on their surfaces are generally clearly recognized as casting defects, and they compare quite favorably with bullets from the weapon responsible for the original specimen. They compare essentially as well with other bullets from that weapon as does the original specimen.

Figure 1 illustrates the appearance of replica bullets, and the original specimen used for molding purposes. Also included are comparison-microscope photomicrographs of certain striated areas (figures 2 and 3). These photographs will illustrate

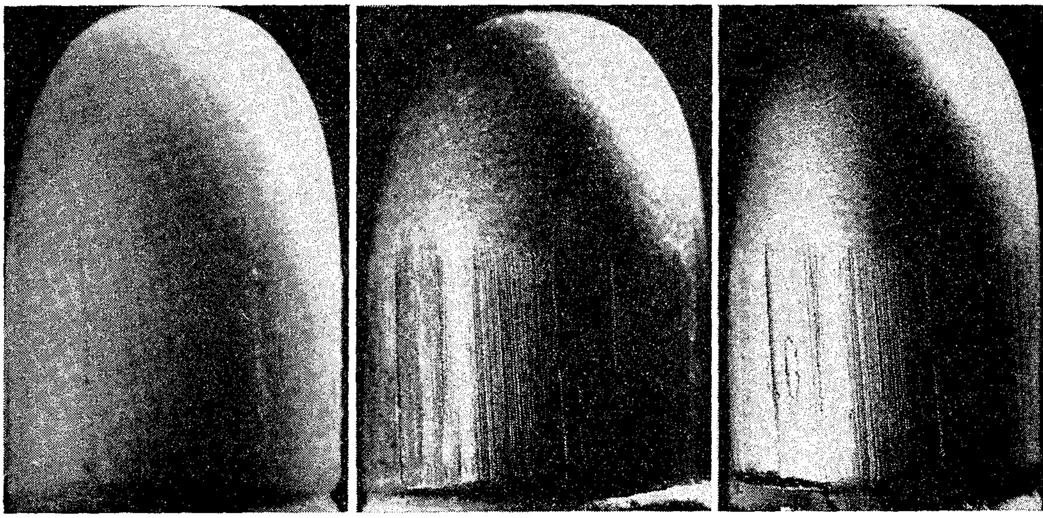

FIGURE 1

A .45 ACP fired test bullet (metal jacketed) is shown in the center with two replicas made from this same bullet on either side.

At the left is a plain wax replica made in a silicone rubber mold. Neither the wax nor the mold were treated with aluminum dust. The excellent detail present is extremely difficult to illuminate for examination.

At the right is a second replica in which the wax contains aluminum dust and the silicone mold was coated with aluminum dust before pouring the wax. Note the increased visibility of detail compared to the plain wax casting, and the similar detail compared to the original bullet. The mark in the middle of the lefthand land-impression of the replica is due to an air-pocket in the mold.

something of the general appearance of the replicas, and the relatively slight dimensional change which they have suffered by being cast in wax. All photographs were taken on 35 mm. Panatomic-X film.

While the production of replicas such as these is not something which could be done with all evidence bullets (considering the condition in which many are found), it is a procedure which seems to have definite practical value. It would in many cases simplify the problem of identification, particularly where distribution of specimens to other laboratories might aid in the solution of a crime, and is certainly a method with which the Criminalist should be familiar.

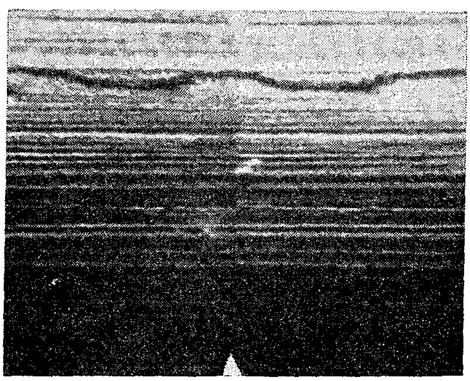

FIGURE 2

Comparison of detail on two .45 replicas shown by "side-by-side" alignment of matching areas. Repeated casting of replicas from a single mold does not significantly alter the detail within the mold.

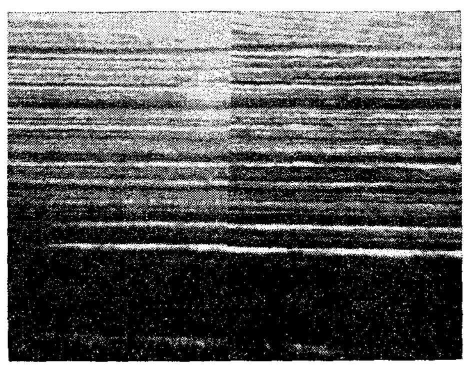

FIGURE 3

Comparison between replica (left) and the original bullet (right) with reference to a portion of a groove-impression area. Note particularly the "photogenic" quality of the replica and its metal-like appearance.