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PLASTIC REPLICAS IN FIREARMS AND TOOL MARK IDENTIFICATIONS

ALFRED A. BIASOTTI

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Various casting methods have been proposed to facilitate the recovery and comparison of identifying individual characteristics as an aid to firearms and tool mark identification. Moulage, plaster, plasticine (3, 5), *Faxfilm* (2, 6), wax, thermoplastics (3), and electroplating (8) are some of the better known methods which have been proposed. Of these methods, most have met with little or limited success due to the rather involved time-consuming techniques which too often give unsatisfactory results. The limited range of application of many of these methods is often due to difficulties inherent in the method which cannot be eliminated, e.g., plaster and plasticine will not reproduce fine detail, plasticine and wax are too unstable to heat and pressure, etc. It was inevitable that with the rapid development of plastics in recent years that improved casting techniques would be developed. The legal question of admissibility of replicas should offer no serious obstacle when it can be conclusively demonstrated that the technique used will give accurate and reproducible results.

In 1938, Moritz proposed a technique utilizing cellulose acetate with an acetone or amyl-acetate vehicle for the reproduction and comparison of the individual characteristics on bullets, cartridge cases, and breech faces (4). The advantages cited by Moritz were that the flexible, translucent cast produced by this method could be flattened and viewed by transillumination thus reducing or obviating the difficulties inherent in the direct observation of curved or inaccessible surfaces by reflected illumination.

A commercial adaptation of the technique described by Moritz, distributed under the trade name *Faxfilm*,¹ has since been developed for studying the quality of finish on machined metal parts. The use of *Faxfilm* in law enforcement work has been reported, but literature on its practical application is meager (6). Cowles and Dodge have reported the successful application of *Faxfilm* to tool mark recovery and comparison and have pointed out its limitations when applied to deep impressions or to painted surfaces (2). The author's experience with *Faxfilm* has indicated that while it may be quite satisfactory for relatively small, flat, smooth, and unpainted surfaces,

¹ The Brush Development Company, 3405 Perkins Avenue, Cleveland 14, Ohio.

it falls far short of being satisfactory for the usual casting problem encountered in firearms and tool mark identification. Some of the principle difficulties encountered are: (a) the elimination of air bubbles, (b) shrinkage due to the evaporation of the solvent, (c) warping, and (d) the effect of the solvent on painted surfaces. Most of these difficulties are aggravated as the irregularity of the surface and the area covered increases. Such difficulties are of major importance when the ultimate purpose of such replicas would be to make a detailed microscopic comparison of two casts in order to ascertain their identity or to clearly preserve and demonstrate such an identity. The definite advantage offered by a flat, translucent cast together with the difficulties inherent in the practical application of *Faxfilm* led to a search for other plastics better suited to the casting problems encountered in firearms and tool mark identification.

Sheets of vinyl thermoplastic, varying in thickness from 0.030 to 0.125" (depending on the depth of the mark), were used to form replicas of the entire bearing surface of fired bullets by the application of heat (100 to 125° C.) and pressure (3). An infrared lamp or electric hot plate were used for heating. These replicas were flattened and viewed by transillumination as either a positive or negative image. Accurate, reproducible replicas, free from air bubbles, shrinkage, and warping were obtained. However, the necessity of applying heat and pressure simultaneously, which may not be a serious disadvantage in the laboratory, makes this method rather impractical to use at the crime scene in the recovery of tool marks.

Further investigation into the wide range of plastics commercially available led to a study of the thermoplastics distributed under the trade name *Dip-Pak*² (1). The commercial use of this product is that of forming an easily removable protective coating for newly finished metal parts and tools. Of the several variations of this product supplied for study, *Dip-Pak* No. 661 (cellulose acetate butyrate) which is a clear, non oil exuding type, was found to be the most satisfactory. This plastic is applied in liquid state (150 to 170° C.) simply by dipping the object being cast or by pouring the liquified plastic onto the object. Using this plastic eliminates the need for pressure, but the heat necessary for melting is still a problem outside of the laboratory. The heat required to melt this plastic is not, however, a deterrent to its application to painted surfaces since it can be applied in small quantities without injury to painted surfaces as the heat is usually rapidly dissipated in the object being cast. If an evenly heated melting pot is not used, localized over-heating and consequent decomposition of the plastic may be encountered. Various, specially designed, melting pots are available from the distributor. This material can be remelted and reused as often as desired. An added advantage of *Dip-Pak* is that it forms a tough, slightly elastic film which is a desirable characteristic when casting deep irregular impressions. By dipping, a replica of the entire bearing surface of a bullet can be made which can be easily slit, trimmed, mounted between two glass slides (figure 1) and used directly in the manner of a photographic negative for projection viewing or forming a photographic print; or such a replica can be viewed with a microscope by transillumination for optimum resolution (figure 2). A similar procedure can be used for preparing replicas of the markings on cartridge cases. The improved resolution of

² Fidelity Chemical Products Corporation, 470 Frelinghuysen Avenue, Newark, New Jersey.

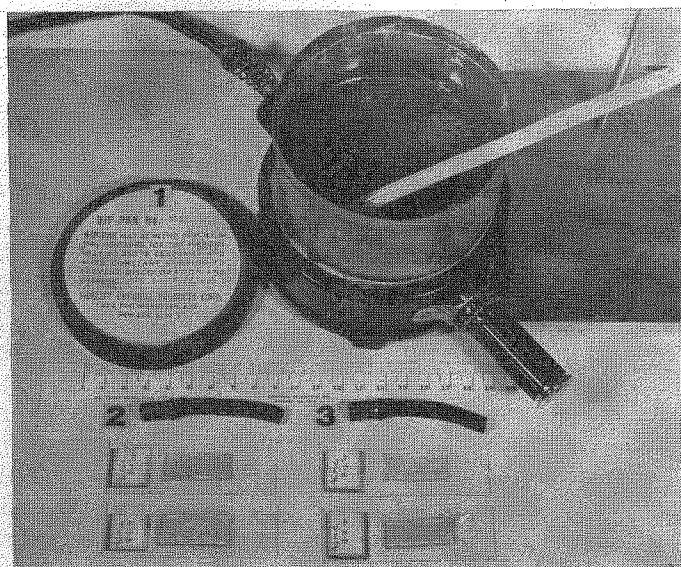


Figure 1

The procedure in preparing *Dip-Pak* replicas: (1) *Dip-Pak* being melted directly in sample can on an electric hot plate. A thermometer immersed in the plastic is necessary for temperature control (special even temperatures melting pots are available from the manufacturer); (2) and (3) Two .38 Special caliber metal cased bullets with rubber tubing over nose of bullet to act as a handle for dipping. Below, duplicate casts of each bullet which have been trimmed and mounted on glass slides.

a plastic cast viewed by transillumination over a direct photomicrograph made by reflected illumination is demonstrated by comparing figures 2 and 3. The reproducibility of such casts is shown by the photomicrograph of duplicate casts (figure 2). Care must be taken to maintain uniform thickness and composition of the casts being compared otherwise a change in the refractive properties of the plastic will produce a change in the magnification observed in different casts. Dipping the test and questioned specimens at the same time obviates this problem. By preparing several casts of each individual specimen, the reproducibility can be readily demonstrated. The simplest means of mounting is to place the trimmed replica between two glass slides and fasten the ends with cellulose tape. Cellulose tape can also be placed directly over the back of the replica leaving an excess border around the edges of the replica which will hold it flat on the slide. However, this plastic will, after a few days contact, cause the adhesive coating on the tape to become very soft and should not be disturbed. Fresh cellulose tape can be used to remove the adhesive which may stick to the replica if it is necessary to remove the old tape used for mounting. This plastic, after being held flat by cellulose tape for a long time, will then remain flat without any support.

A relatively new group of thermosetting plastics, the *Plastisols* (7, 9), have more recently been explored by the author and were found to offer some desirable improvements over the plastics previously discussed. The particular *Plastisol* used, developed in cooperation with Mr. J. W. Britton of the Castor Engineering Company, Carnegie,

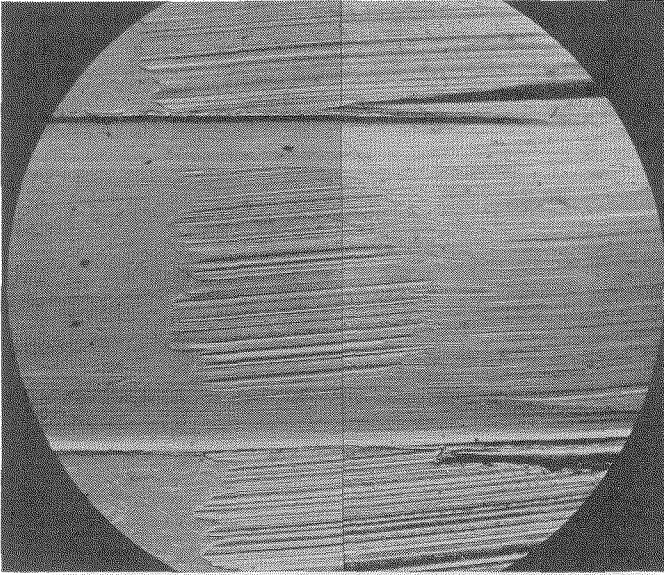


Figure 2

Comparison photomicrograph 23 \times (transillumination). Duplicate *Dip-Pak* 661 replicas of same bullet and land mark as shown on right in Figure 3.

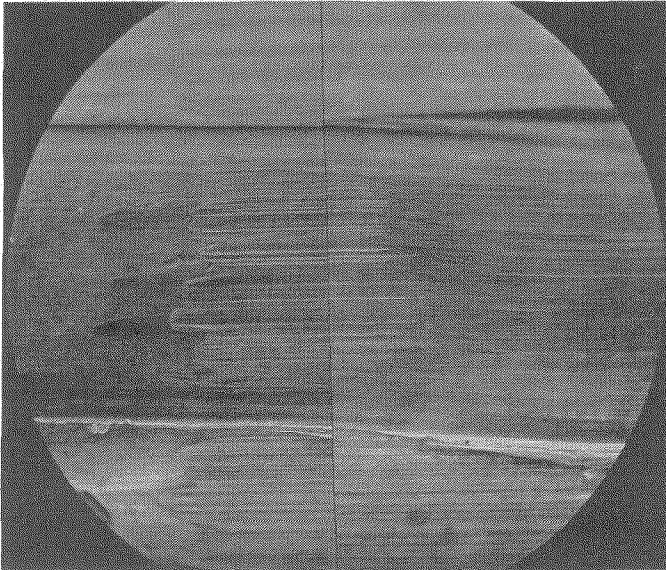


Figure 3

Comparison photomicrograph 23 \times (actual bullets by reflected illumination). The two .38 Special test bullets from Figure 1 are shown in matched position.

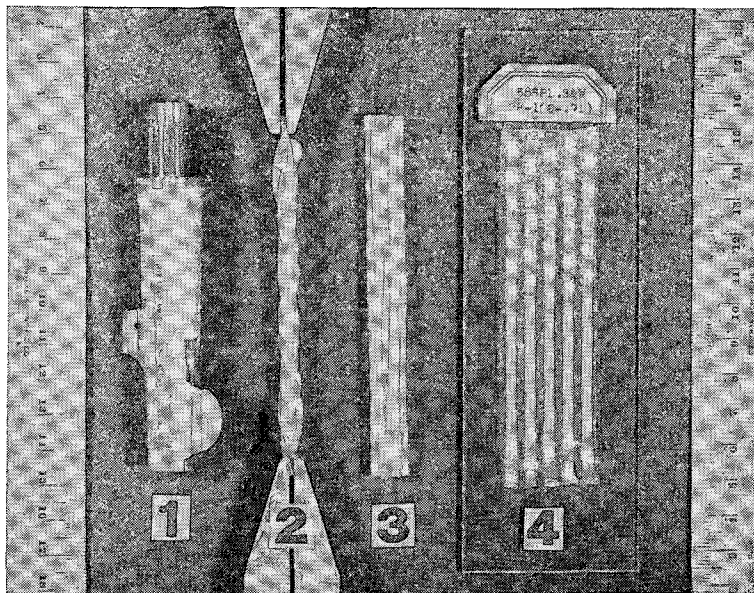


Figure 4

Plastisol as it is used to cast the interior surface of a gun barrel: (1) The barrel should be removed from the gun to facilitate handling; (2) a cured cast, twisted between two clamps, to demonstrate the flexibility necessary for easy removal; (3) the whole cast before it is slit for mounting; (4) a cast which has been slit along one land mark and laid flat on a glass plate for viewing.

Pennsylvania, has been designated C-191. This formula consists of Vinylite QYNV resin 50%, dioctylphthalate plasticizer 49%, and epoxy heat stabilizer 1%. This mixture is a viscous, milky white, liquid or paste formed by the dispersion of finely powdered resin in a suitable plasticizer. Heating (curing) this mixture to 160° C. causes the plasticizer to diffuse throughout the resin particles resulting in a clear, tough, coherent plasticized mass. Since there is no solvent and no polymerization occurs, there is virtually no decrease in volume (9). This mixture is applied at room temperature by either dipping or pouring it onto either a cool or preheated object and then cured in a 160° C. oven for 10 or 15 minutes. The transition from milky white to clear indicates the material is cured; a yellow color in the cured cast indicates overheating. Curing offers no problem since the temperature and time can easily be controlled and the progress of the curing checked in an ordinary oven. Preheating the object or increasing the resin content can be used to control the thickness of the cast; e.g., the higher the temperature or the higher the resin content, the thicker will be the cast. However, it was found that preheating the object over 100° C. produced air bubbles, and increasing the resin content decreased the elasticity and produced uneven film thickness due to uneven drainage. Increasing the plasticizer content will decrease the viscosity and increase the elasticity, but will also decrease the hardness and tensile strength.

Plastisol C-191 was found to be a suitable compromise formula which gave a clear, tough, slightly elastic film. The versatility of *Plastisol* will allow the formula and

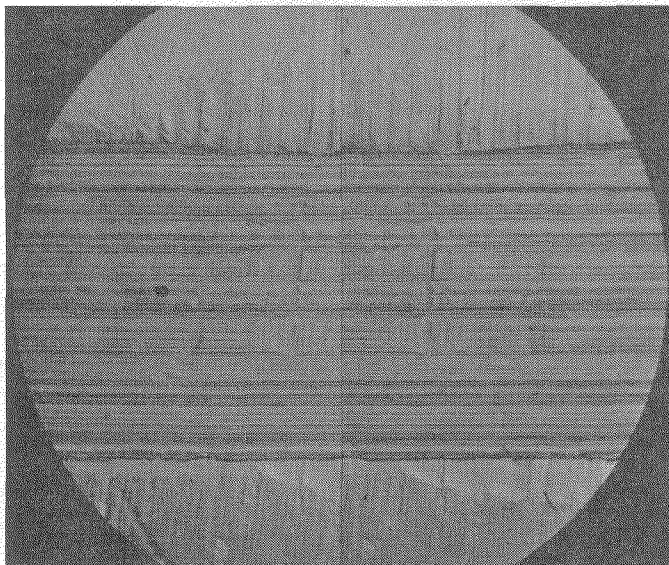


Figure 5

Comparison photomicrograph $23\times$ (transillumination). Duplicate *Plastisol* C-191 replicas of a groove in a 38 S & W caliber barrel. Adjacent areas (not matched) are shown to allow comparison of the same area on both casts. This barrel was rifled with a "hook type" cutter, not lapped, and has been fired and abused prior to making these replicas.

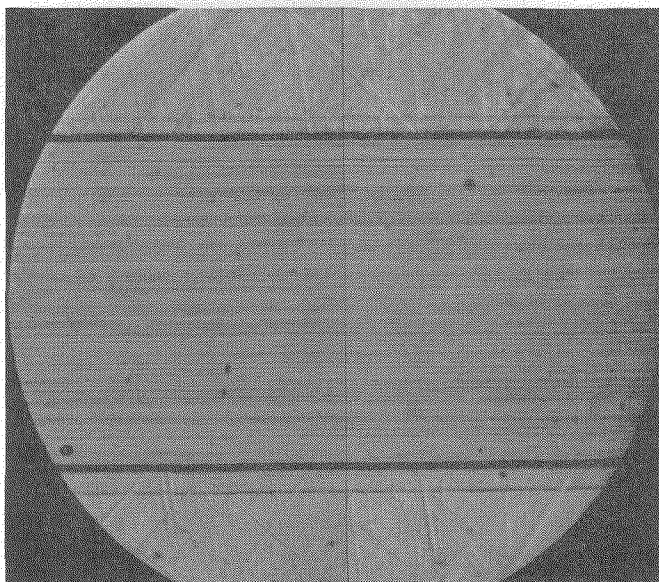


Figure 6

Comparison photomicrograph $23\times$ (transillumination). Duplicate *Plastisol* C-191 replicas of the .38 Special caliber barrel shown in Figure 4 in match position. This is the first barrel cut with a freshly ground "broach-type" cutter and has not been lapped or fired.

means of application to be adjusted to individual requirements. Various means of mechanical manipulation can be used to obtain uniform film thickness when uneven drainage is present, but a simpler solution to this problem was found. A uniform film of any desired thickness can be obtained by applying several coats and alternating the direction of drainage.

Plastisol C-191 is currently being used to cast, in one piece, the entire interior surface of revolver barrels without altering the barrel. Due to the elastic quality of cured C-191, casts 0.020 to 0.040" thick can easily be pulled out of the barrel in one piece, slit along one of the land marks, and laid flat on a glass or plastic plate for direct viewing or projection (figures 4, 5, and 6). Several different mounting procedures can be used depending on the use to which the cast is to be put. Laying the cast between two pieces of plate glass is satisfactory for visual microscope examination. However, for projection and photomicrography, it is desirable to eliminate different areas of transparency due to contact and non-contact with glass. The ideal method is to mount the outside surface of the cast on a glass plate using Canada Balsam and having nothing in contact with the replica surface. Lens tissue wet with xylene can be used to remove the excess Balsam without affecting the plastic (*Plastisol* will swell on soaking in xylene but will not dissolve). In order to insure adequate and uniform thickness, these casts were formed by applying two coats. The first coat was formed by filling, draining, and curing the barrel from one end, and then repeating the procedure from the other end. The barrel must, of course, be held as vertical as possible during these steps.

The above technique is being applied to the study of consecutively rifled barrels to ascertain the extent to which the individual characteristics of the rifling cutter may be reproduced in more than one barrel. The results of this study, not yet complete, will be reported at a later time. Another possible application of this technique, first suggested by an engineer of one of the larger gun companies, is that it could be used to provide a periodic and permanent record of the changes (e.g., wear, erosion, rust, fouling) occurring in a barrel during a series of tests and under various conditions.

The use of the *Plastisols* retains the one disadvantage of requiring heat which for practical reasons will probably limit its use to the laboratory. The use of *Plastisol* rather than *Dip-Pak* is preferred for casting bullets, cartridge cases, barrels, and other inaccessible surfaces because of its greater versatility and ease of application.

The study of *Plastisol* led to the realization that a related family of plastics, the *Plastigels*, could provide a simple and accurate means of recovering tool marks at the scene which could be routinely applied by non-technical personnel. Plaster, moulage, *Faxfilm* have all proved to be far from satisfactory for routine recovery of tool marks, especially when in the hands of non-technical personnel. The addition of a gelling agent (Bentone 34) to the free-flowing *Plastisol* converts it to a *Plastigel* which has a putty-like consistency. The most important property of the *Plastigels* is that the gel structure persists even at the temperature necessary for fusion (curing) (5). Work thus far has shown that *Plastigel* can be simply pressed into a tool mark, removed and taken to the laboratory for curing. The reproduction of detail is for all practical purposes as good as that obtained with *Plastisol*. Since work on

the application of *Plastigels* to tool mark recovery is still in its preliminary stage, further discussion should be reserved until more complete information is available.

SUMMARY

Two new plastics, *Dip-Pak* and the *Plastisols* were found to offer definite improvements both in ease of application and resolution of detail over casting methods previously proposed. However, because of the heat necessary for curing at the time of making the replica, these new plastics will probably be limited to laboratory use. The new family of *Plastigels* seem destined to fulfill the need for a simple, accurate means for routine tool mark recovery.

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