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DETAILS REPRODUCED BY METAL CASTING

Lauren J. Goin

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Oftentimes the laboratory investigator is confronted with the necessity of reproducing for comparison purposes the fine surface details and irregularities found on certain kinds of physical evidence. Usually the most satisfactory method is to photograph them. However, the nature of some kinds of evidence prevents one from obtaining worthwhile results with the use of the camera. Such an example presented itself recently in connection with the investigation of a fatal automobile accident. Glass fragments were submitted for examination consisting of several pieces of glass from the scene of the accident and a sample of glass from the damaged sealed beam headlight of the suspect's automobile. In each instance some of the fragments had one mirrored surface.

Occasionally it is possible to actually fit together the broken edges of two glass fragments and thus show that they were from the same source. Such a conclusion is, of course, based on the fact that there are numerous irregularities present on the fractured surface of one piece that have complementary irregularities present on the other. In the case mentioned particular attention was directed to one pair of fragments which appeared to "fit" together, but the fractured surface in common between the two was straight with almost no contour irregularity. On the fractured surface of each fragment there was observed many small striations running at right angles to the long axis of the fragment.

Thus the irregularities were seen not to be gross ones, but microscopic in size. These lines, commonly called "hackles," run in the direction of the fracture and result from a particular force, causing a sudden rupture of the glass. The hackles are generally at right angles to the rib or conchoidal fracture lines. It was expected that these striations would provide an excellent basis for comparison. The utilization of this fine detail in comparing glass fragments is not unknown and cases are reported by Spence,[1] and by O'Hara and Osterburg.[2]

1. Police J. *22*:4, 293-5, Oct.-Dec. 1949.
2. O'Hara and Osterburg, An Introduction to Criminalistics, The Macmillan Co., N. Y., 1949, pp. 243-4.

Figure 1.
Photograph of glass fracture surface.

The problem presented was one of reproducing these lines photographically so they could be compared and the comparison presented in court. An attempt was made first to photograph the fractured surfaces using carefully controlled illumination, including oblique and polarized light, without success due to reflection from the glass surface, refraction from within the fragment which was aided by the mirrored surface on one side of the fragment, and a difference in depth of the surface of the glass because of slight conchoidal fracture lines which were present. Figure 1 shows the results of this attempt.

It became apparent that a means of reproducing the fine striae on the glass surface would be necessary in order to record such detail photographically. Several casting methods such as moulage, paraffin, Plaster of Paris, and sulfur, were considered (though not tried) and discarded as not providing the fineness of detail nor opacity that was considered satisfactory. Wood's metal (Bi, 50%, Pb, 25%, Sn, 12.5%, Cd, 12.5%) was selected as the casting medium because of its low melting point (72° C) and its opacity. Its use as a casting medium has been previously used elsewhere.[3] The former application was to reproduce the more gross features of headlight lenses for the purpose of obtaining accurate measurements of the curvature of the many lens surfaces of different radii found on the inner surface of headlight lenses. The method devised for the present purpose stated in earlier paragraphs is, as far as is known, an untried one and is to be discussed in detail.

Experimental

The method consists of spraying the low melting point alloy directly on the object to be cast. A spraying device was constructed as follows. A brass casting pot resembling a dipper, having an inside diameter of approximately one and one-sixteenth inches and an approximate volume of fifteen cubic centimeters was used in conjunction with and fitted to

3. Scientific Crime Detection Laboratory, Northwestern University School of Law, unpublished material.

an electric soldering iron. An especially constructed pot cover of non-inflammable material (transite) and a spraying nozzle of copper tubing with brass orifices was made and a compressed air tube attached to it. An air regulator was placed in the compressed air line for the purpose of providing a uniform, controlled air pressure to the nozzles.

Casts of the glass fragments were made in the following manner. The Wood's metal was allowed to become molten in the pot, and the temperature of the metal increased to approximately 370° C. with the aid of a hand torch flame. Compressed air was applied to the nozzle up to a pressure of twenty-five pounds. The fragment being cast was held by crucible tongs so that the surface to be cast was directly in front of the nozzle and approximately one and one-half inches away. The flame from the torch was placed so that it warmed the fragment, yet was heating the pot. The glass fragment was kept near the flame as the initial layer of metal was sprayed on the surface to be reproduced. It was found that the metal cools quite rapidly otherwise and presents an undesirably grainy or crystalline surface to the cast. After the initial layer had been deposited the torch flame was removed, and the air pressure increased to forty pounds. This resulted in a spray containing droplets of larger size. The cast was then built up to increase its strength and rigidity. The metal was not allowed to be deposited excessively on the sides of the fragment immediately adjacent to the fractured surface. With the use of reasonable care, no difficulty was encountered in removing the cast from the glass after the metal had cooled.

In order to evaluate the use of Wood's metal as a reproducing medium, it is necessary to know the thermal characteristics of behavior of the metal. Also, it is necessary to know whether or not the cast is an accurate replica of the object being cast. To answer these questions a test plate was prepared by scribing two lines at right angles to the long axis of a microscope slide and about one and one-half inches apart. This test plate was then cast as described above. Measurements were then made of both the test plate and its cast so as to determine the amount of linear distortion of the cast due to cooling and the thermal characteristics of the metal.

In order to conduct these measurements a special heating stage was constructed (See Figure 2). A Chromel A wire on mica heating element was sandwiched between a sheet of non-inflammable material (transite) and a copper bar, 2″ x 4″ x 7/16″. The bar was so constructed that the cast was secured to the stage at the point of one scribe mark by means of a screw. A hole was drilled in the side of the bar

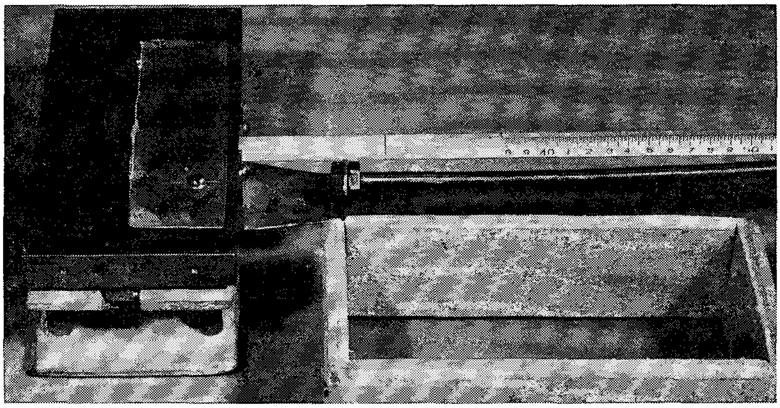

Figure 2.
Heating stage used in making measurements. Cast of test plate is shown secured to the copper bar.

and as close to the top surface as possible to receive the thermometer, A convenient support was adopted for supporting the free end of the thermometer. The heating stage was secured to the stage of a toolmaker's microscope which allowed movements of 0.0001 inches to be read directly with an estimation of plus or minus 0.00003 inches. A variac was used to provide a continuously variable voltage and subsequent heat.

The measurements were made by mechanically advancing the stage of the microscope so as to cause the standard plate or cast to move beneath the objective. The distances were read directly on the calibrated microscope drum. Thus, the distances between the scribe marks on the test plate and that between the reproduction of the scribe marks on the cast were measured. The values, when compared, give the linear distortion of the cast. The thermal characteristics of the metal were determined by gradually heating the cast of the test plate and measuring the distance between the reproduced scribe marks as the temperature increased.

Readings were taken every other degree to 65° C. and every degree from 65° to 70° C. Readings were taken approximately every five degrees during the cooling period.

Certain measurements were also made of the casts of the glass fragments using the toolmakers microscope as a measuring microscope again. These measurements were fragment width, striation width, striation length, and number of striae present in each case. Each glass fragment cast was photographed without difficulty, using slightly oblique lighting.

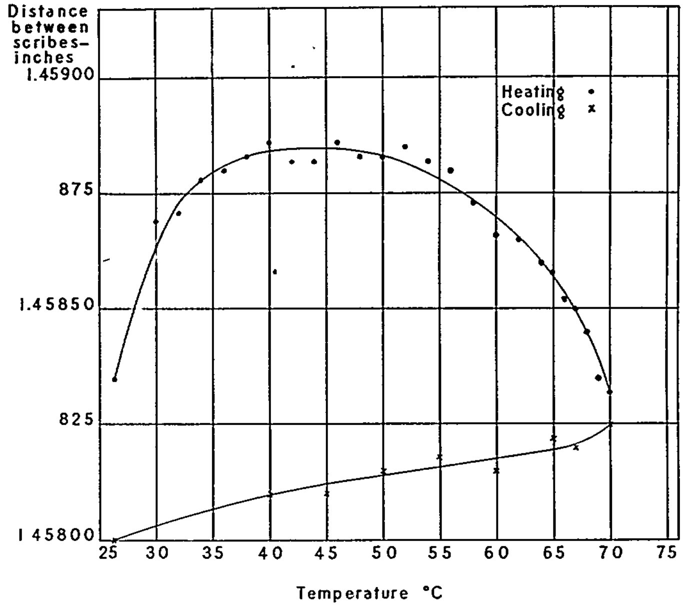

Figure 3.
Thermal characteristics of Wood's metal cast.

Results

The results of the study made to determine the heating and cooling behavior of Wood's metal are presented graphically in Figure 3. It can be seen that as the metal heats there is an initial expansion which gradually levels off and then undergoes contraction as it nears the liquid state. Upon cooling there is further contraction, the rate of which diminishes as the temperature drops. Thus, the molten metal contracts as it solidifies, and in solidifying, forms a faithful reproduction of the detail desired.

The investigation to determine the difference in length between the scribe marks of the object being cast and the cast revealed that this difference was but 1 x 10^{-5} inches. This figure is well within the reading error (extent of estimation) or 3 x 10^{-5} inches. The difference between the glass fragments and their casts was determined to be 6.9 x 10^{-6} inches. Also, well within the reading error, using the method of casting described, casts of the fractured surface of the glass fragments were obtained which presented a negative of all fine surface irregularities without a crystalline or grainy surface. A photographic reproduction of this fine detail then became relatively simple in contrast to the earlier difficulties.

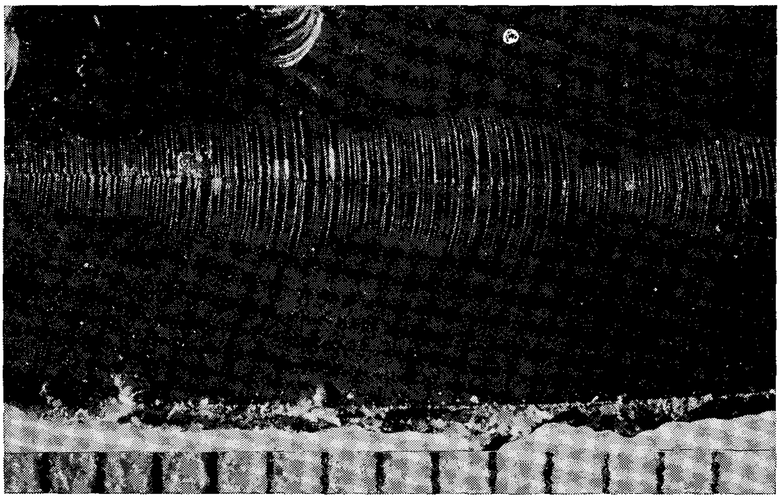

Figure 4.
An abutment of photographs of each cast of glass fragments involved in fatal automobile accident. One negative reversed to show match.

Figure 4 shows an abutment of the casts made from the two glass fragments to show the match. The hackles can be readily seen in each case.

Photographic enlargements were made on transparent material (Translite, Eastman Kodak Co.) which allowed the superposition of the details present on one fragment's fractured surface over the other. It was seen that the striations on one were cancelled out by the other and were, therefore, at one time a single piece.

SUMMARY

A method is described for the reproduction of fine surface detail by spray casting with Wood's metal. Certain thermal properties of the alloy are presented as they bear on the practicability of the metal as a casting medium.

The method is described as it was applied to the study and comparison of striations and surface irregularities on the fractured surface of glass fragments coming from a headlight lens of an automobile.