Ulf G. von Bremen[1] *and Lorne K. R. Blunt*[1]

Physical Comparison of Plastic Garbage Bags and Sandwich Bags

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ABSTRACT: Individual marks are located adjacent to machine-cut ends on garbage bags and sandwich bags. Class marks that change direction or width or both are present on many brands. The cut ends of plastic bags can successfully be related to each other. Visits were made to plants that manufacture both types of bags to observe the production methods and sequence. Consecutively made samples were collected and others purchased at retail outlets. All were compared with optical equipment and some with photographic techniques to enhance faint characteristics. Results obtained using the techniques described were presented in court.

KEYWORDS: criminalistics, plastic bags, comparative analyses, garbage bags, sandwich bags, polyethylene film, manufacturing process, individual characteristics, class characteristics, physical comparison, high contrast photography

A variety of foods and other products are sold in soft plastic bags. Once the contents have been consumed, the remains may be collected in other plastic bags—garbage bags. The ubiquitous nature of these products results in their occasional occurrence as evidence in criminal investigations. Sandwich bags are frequently encountered in drug cases and garbage bags have been used to contain stolen goods and parts of bodies. This research was prompted by a homicide in which the head of a family was accused of killing his wife and two small children. All three bodies were placed in garbage bags and transported to remote locations. This laboratory was asked to attempt to establish a relationship between these bags and others found in the suspect's home.

A literature search did not reveal any recent papers on the subject, but Swensson [*1*] includes a photograph of two garbage bags with corresponding "die lines." No conclusion is offered nor is there discussion of the individuality of the marks. The plastic bag industry publishes a useful guide [*2*] that describes various processing techniques for soft plastic containers and their manufacturing defects.

This paper explores the presence of class characteristics and individual marks in garbage bags and sandwich bags and their relationship to the manufacturing process.

Manufacturing Process of Plastic Bags

Two kinds of films are made, tubular film and flat film [*2*]. The two procedures differ from each other mainly in the die sections of the extruder and in the means of cooling the

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[1] Forensic analysts, Centre of Forensic Sciences, Toronto, Ontario, Canada.

film. The tubular film process is outlined here as it was observed at two plants (Union Carbide Limited and Canadian Industries Limited).

The clear or colored melted resin enters a circular die, is forced past a round mandrel, and shaped into a relative thick-walled continuous tube (Fig. 1). This tube is expanded to the desired diameter by air emitted from the mandrel. The air-dried film is drawn upward and flattened between rubber rollers or slats. Two folds that can be used as reference points during examination are formed at the sides here. From this point, production methods for garbage bags and sandwich bags take different routes.

For garbage bags two methods have been used.

In Method 1 a 66-cm (26-in.) wide tube is cut into 91-cm (36-in.) sections and each section sealed at the bottom to form one bag. These bags are made consecutively and therefore most of the class marks run from top to bottom.

In Method 2 an 183-cm (72-in.) wide flattened tube is halfed the long way and both halfs cut into sections 66-cm (26-in.) wide. The 66-cm (26-in.) end with the fold forms the bottom of the bag and the two 91-cm (36-in.) sides are sealed with a hot press (Fig. 2). Most of the class marks run from side to side, in the machine direction. Completed bags are folded and ten or more bags are placed in one retail package. There is the possibility that the continuity of the bags in one retail package may be broken. Bags may be removed for quality control or rejected for incorrect folds by an electric eye, but subsequently accepted by the operator.

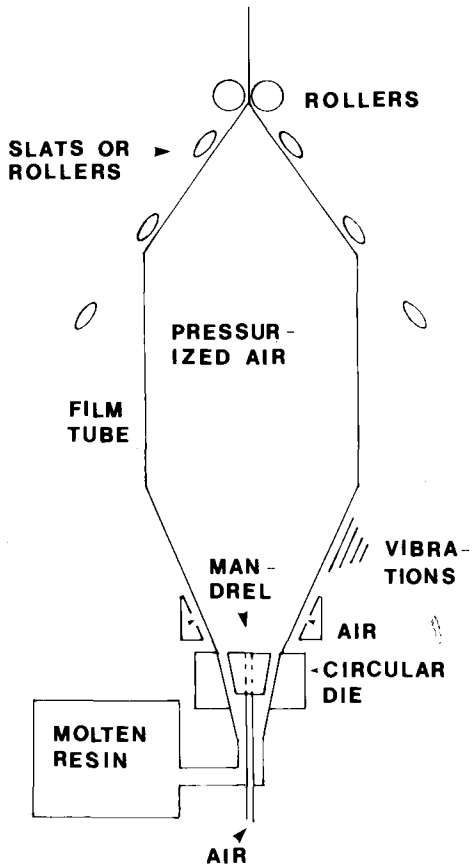

FIG. 1—*The tubular film production process.*

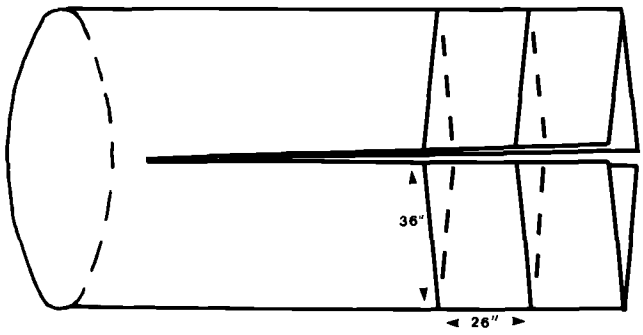

FIG. 2—*In one method garbage bags are made from a sectional film tube. 1 in. = 25.4 mm.*

In the production of sandwich bags the two folded edges of a 86-cm (34-in.) tube are cut off to produce two films 81-cm (32-in.) wide. Each film is further cut in half lengthwise, then folded to form the bag and sectioned. Consecutively made bags have common sealed sides (Fig. 3), and their class marks run from side to side. Sandwich bags made from a tube with a width equal to the width of the bag and sealed at the bottom also have been examined but their manufacturing process was not observed.

Materials and Methods

To determine the range of construction features and marks, ten packages of different brands of garbage bags were bought locally in food and variety stores. All of these contained ten separate bags in each package. Thirteen consecutively made garbage bags were obtained from one plant. They had been perforated but not separated. Three retail packages of consecutively made garbage were collected at each of the two plants by employees in the presence of one of the authors.

One package of five brands of sandwich bags were purchased at retail outlets. Two of

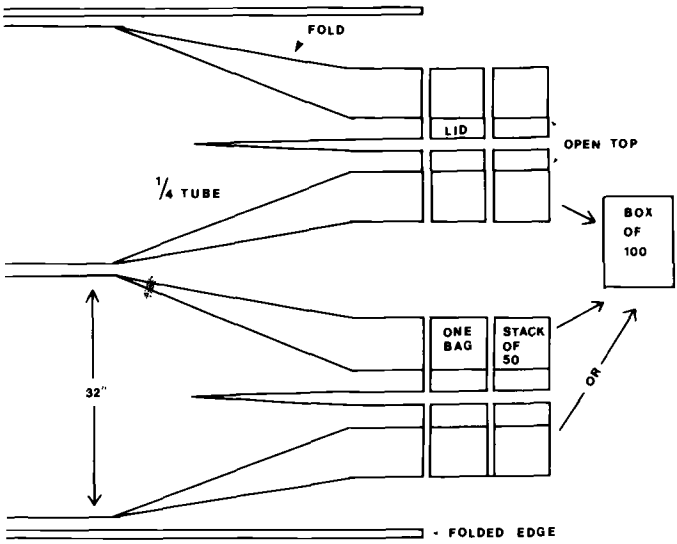

FIG. 3—*A quartered film tube is folded and cut to the size of a sandwich bag. 1 in. = 25.4 mm.*

these held individual bags whereas the others had unseparated bags on a roll. Two packages of consecutively made sandwich bags were obtained from one of the above plants.

In addition, various brands of both types have been examined since 1974 for case related reasons. All bags were examined visually and photographically. The garbage bags were examined visually with transmitted light from a light box in a dark room. A reading glass and a ×8 magnifier were sufficient to detect the smallest features.

The photography of garbage bags did not require any special equipment. They were photographed with a 4 × 5 view camera and transmitted light in a dark room. A light box where the tube to bag distance was 15-cm (6-in.) or more was best suited but an ordinary X-ray viewer could be used. Exposures were arrived at with a Sinar Six® meter that measures light at the film plane. Some were photographed with Plus-X® film, others with Contrast Process Pan® film to enhance the contrast. With black bags the exposures were 5 to 15 min long, therefore Tri-X® was more suitable. Many prints were made on paper grades 3 to 5 to increase contrast further.

The sandwich bags were examined and photographed with an X-ray viewer or a Wild-Leitz transmitted light stand. The stand has a dark field setting where the bulb is covered by a central disk. The background remained dark while the marks were highlighted from an oblique angle. A ×8 magnifier and a stereo microscope were used for examination. The photographs were made with Plus-X or Contrast Process Pan film, 4 by 5 in., and printed on paper grades 2 to 5. Most of the hairline marks (described below) were not visible to the unaided eye but were readily revealed with shadowgraphs, a photographic method [*3*]. Unlike shadowgraphs of sheet glass, the film to bag distance was kept from a few millimetres to approximately 3 cm for best resolution. Since the areas examined on sandwich bags were much smaller than on garbage bags, Polaroid High Contrast film, Type 51, 4 by 5 in. was well suited for actual size photographs and produced fast results.

Colored bands were also examined and photographed on a light box that had full spectrum tubes (Vita-Lites®). One 25.4- by 61-cm (10- by 24-in.) polarizer (Edmund Scientific, stock 71940) was used over the bags and a Hoya polarizer over the camera. The combination produced a neutral grey background. The film used was Vericolor type L, 4 by 5 in.

Results and Discussion

Class Characteristics

Color—Little, if any, variation in color was observed in garbage bags from one retail package from plants where only one line was used. Where extrusion and packaging of bags are done by two parallel lines, bags from each line may be fed alternately into one retail container. This accounts for the difference in color of bags from the same package.

Size—Variations in width and length of 0.6 cm or more with some consecutively made garbage bags were common. The diameter of the tube is controlled by pressurized air applied from the inside accounting for these variations. The lengths may vary because of slack in the chain driven operation. Little variation (1.5 mm) was observed in the length or width of sandwich bags but some variation in the length of the fold-over lid can be present since the locations of the folds are not as precisely controlled as the dimensions of the film.

Perforations—They are made by a blade with notches in the cutting edge. Garbage bags may have perforations at both ends, both sides, or not at all. Sandwich bags have them at the top and bottom; none have been examined with perforations on the sides. The location of the perforation closest to the edge of a bag may change. As two consecutively made bags share the same perforations, they provide a quick way to eliminate nonconsecutive bags.

Bags that do not have perforations may have a cut edge that is not absolutely straight. Slightly curving edges that change from bag to bag have been observed. This is because the flexible bags were not held perfectly flat when cut.

Construction—Construction (for example, location of seam or length of skirt or both) is directly related to the manufacturing sequence. The end of each bag, past the seam, is called the skirt and can be up to 2.5 cm in length.

Some sandwich bags have an "alligator" pattern added to them by a heated embossed roller. If the cut end of a bag is not parallel to the pattern, the angular relationship of the two is a class characteristic.

Code—Some brands of garbage bags have an embossed code near the edge of the open end that consisted of five numerals. They indicate, in order, factory or origin, last numeral of the year, finishing machine, and month.

Pigment Bands—To make a more appealing product or to protect garbage bags against weathering or both, dyes and pigments may be added to the liquid resin. Frequently they are poorly dispersed in the resin and form broad bands up to several centimetres wide in the film. These bands may run in the machine direction (Fig. 4) or at an angle to it since the mandrel rotates during the film forming process. Some of these bands were present in most bags from one retail package. Other bands changed width, faded away altogether, or shifted location relative to the folded edge of the bag. These are class characteristics that change and permit sorting of bags into approximate sequence or lots.

Hairline Marks—These are narrow straight lines 1 mm or less in width found in colored garbage bags (Fig. 4). They also appeared and disappeared or changed their relative location gradually. They probably result from irregularities or deposits on the inner lip of the circular die or the surface of the mandrel or both. These marks have been observed to spiral around the moving tube during manufacture like the stripes around a barber's pole.

Similar marks were also found on sandwich bags (Fig. 5) with some even crossing each other. Many of these could not be seen with the unaided eye but were revealed via shadowgraphs.

A bag missing from a sequence may not present a serious problem when the marks run at an angle to the fold but parallel to each other. They are still class marks but class marks that

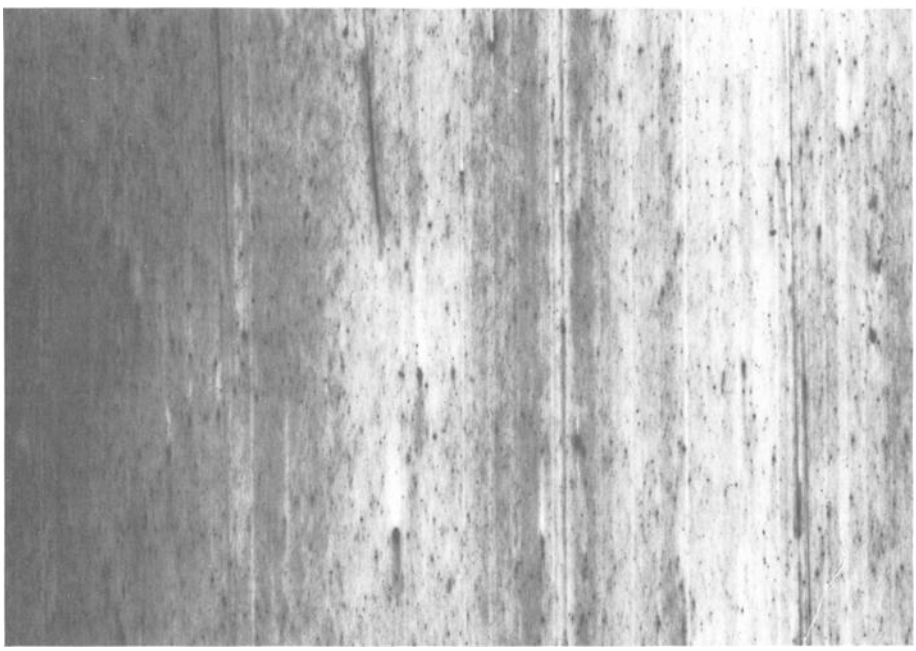

FIG. 4—*Pigment bands, streaks, and hairline marks in one colored garbage bag (actual size).*

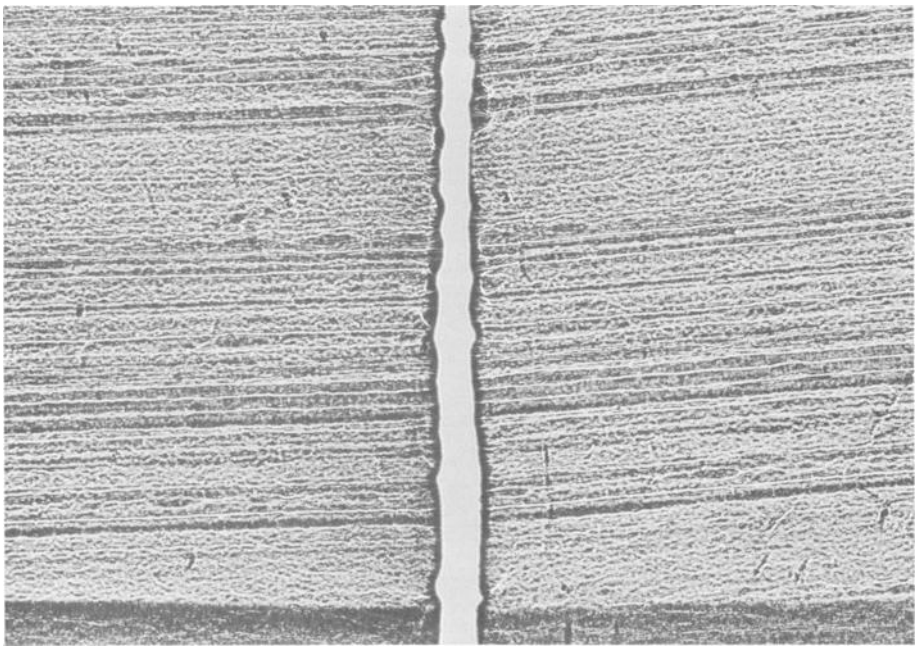

FIG. 5—*A shadowgraph of the edges of two sandwich bags showing an abundance of hairline marks at an angle from the edges (magnification ×2).*

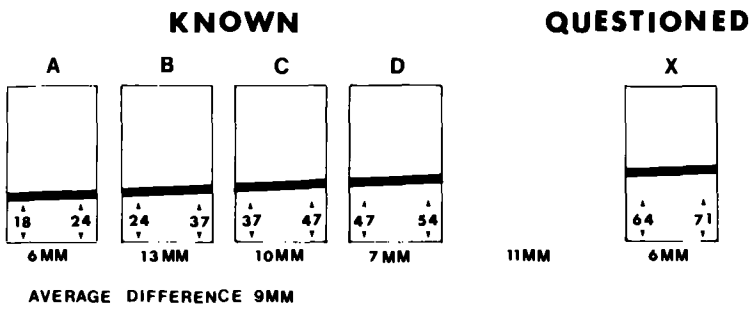

FIG. 6—*Determination of the possible number of bags missing from a sequence.*

change location. To determine the sequence of manufacture, a prominent mark can be selected and its position measured on both edges of all bags. The bags can then be sorted according to the slope of the mark (Fig. 6). The number of missing bags is arrived at by calculating the difference in the height of the mark in Bags D and X and comparing that figure to the average difference in height in Bags A to D. Great precision cannot be expected because the plastic is soft and stretchable and often has many creases.

Colored Bands—These bands are observed in transparent sandwich bags only when the bags are placed between crossed polarizers. They are represented by interference colors aligned parallel to the side of the bags. The interference colors are determined by the birefringence, the thickness, and the orientation of the plastic and therefore reflect changes in one or both of these properties. In some brands they are continuous through several bags, in others they taper off within the length of one bag.

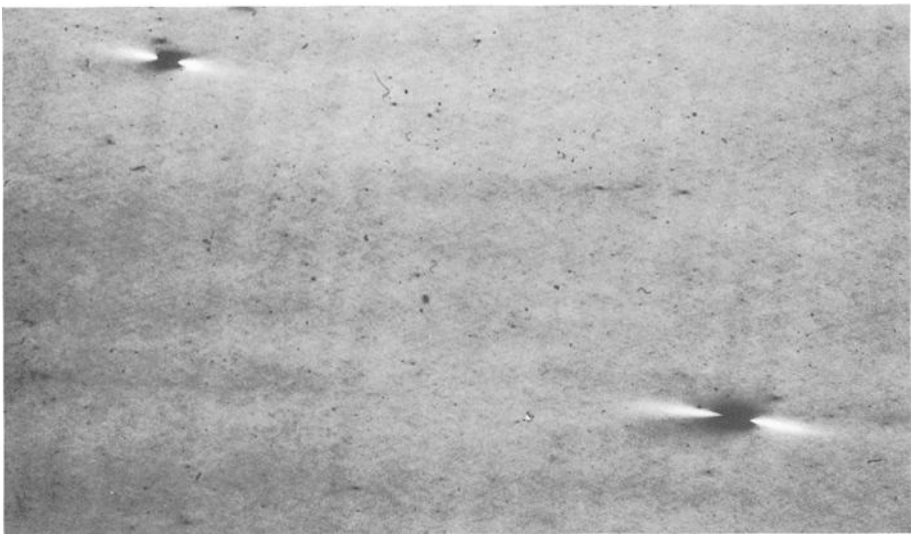

FIG. 7—*Fisheyes are concentrated pigment deposits whose distribution is a matter of chance (magnification* ×2*).*

Individual Characteristics in Garbage Bags

Fisheyes

These marks, so named by the industry [*2*], are dark spots with one or two light-colored tails (Fig. 7). The dark core may be only a millimetre or so in length but the overall length of a "fisheye" can extend over several centimetres. The size of the fisheyes varies and extensive observation suggests that their distribution results from chance. The dark spot consists of concentrated pigment that has not melted whereas the light-colored tails have little or no

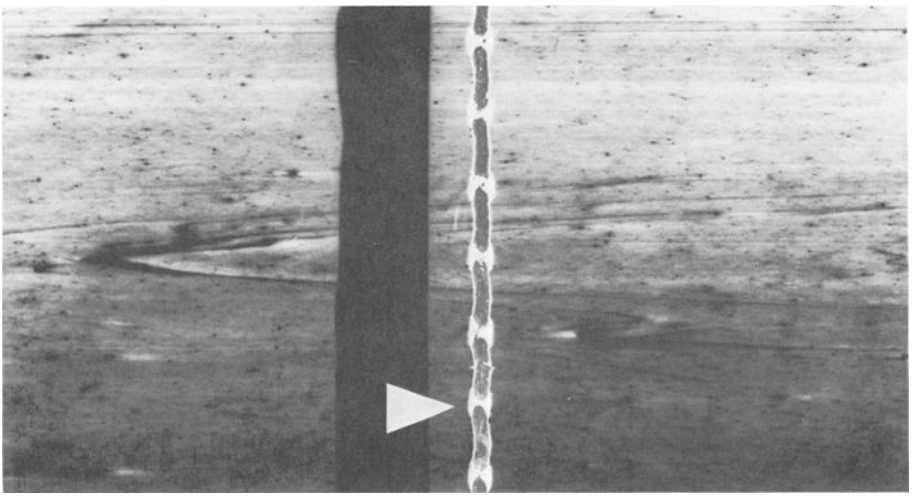

FIG. 8—*Two consecutively made garbage bags sharing one arrowhead adjacent to their perforated ends. The arrow indicates the gap between the two bags (actual size).*

pigment. The tails run parallel to the machine direction. Some of them can easily be overlooked because they are relatively faint and small. High constrast photomacrography with transmitted light however makes them obvious.

Arrowheads

These are dark lines meeting at an apex (Fig. 8) and pointing away from the mandrel during manufacturing. Their length varies and may extend over several centimetres. They are a

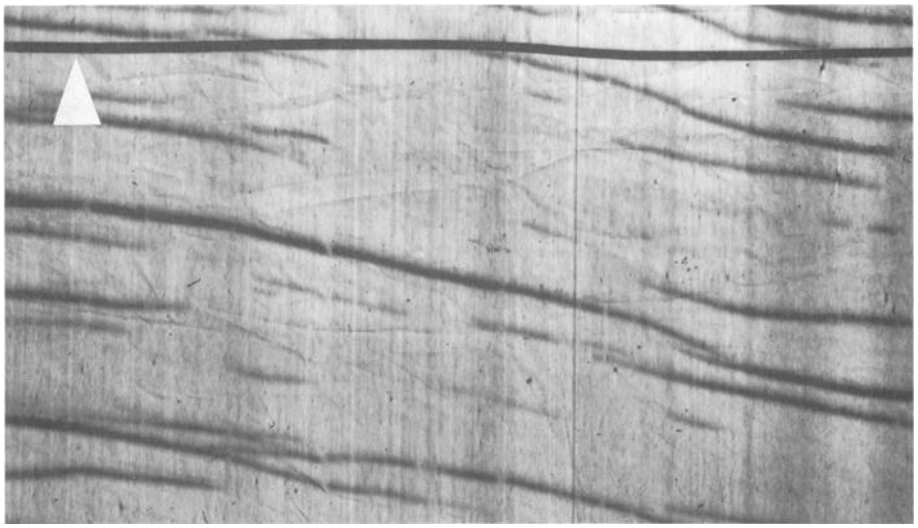

FIG 9—*Tigerstripes running across two consecutively made garbage bags. The black gap between the bags is shown by the arrow (3/4 actual size).*

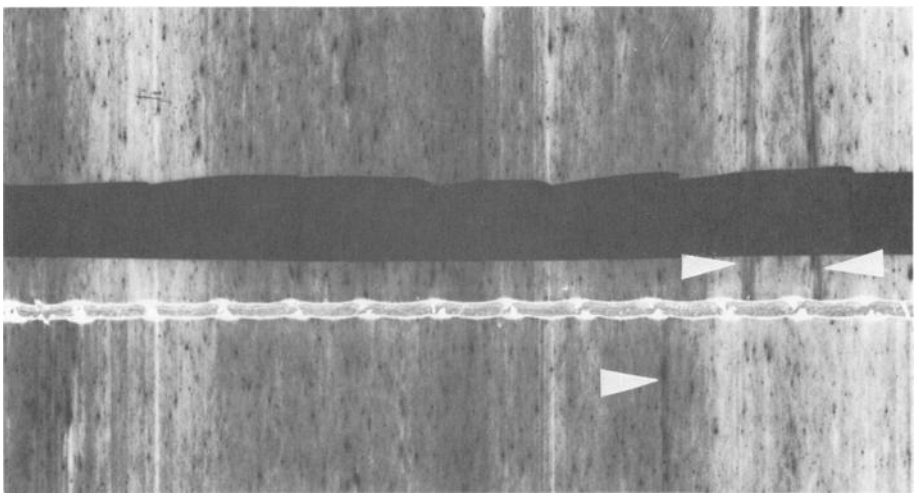

FIG. 10--*These two garbage bags were not sequentially made because the three dark marks do not correspond adjacent to the horizontal perforations (actual size).*

result of unmelted pigment or partly melted plastic scrap that has been recycled. When an apex is located at the cut edge of a bag or even a few centimetres away from the edge, it is possible to find the corresponding lines on the edge of a second bag. The lines on the second bag can be differentiated from other marks such as hairline marks by the angle at which they are converging towards the apex. In this work, "arrowheads" were not as frequently seen as fisheyes, but they varied in size and location at least as much as fisheyes.

Streaks

These are narrow short pigment marks similar in width to a single line in an arrowhead (Fig. 4). They too are formed by partly melted scrap or a poorly mixed colored resin batch. Their distribution appeared to be random in the film but they run more or less parallel to the machine direction.

Tigerstripes

These are pigment inclusions, usually a few millimetres wide, running at an angle to the machine direction (Fig. 9). They vary in length, have a wavy appearance and sometimes

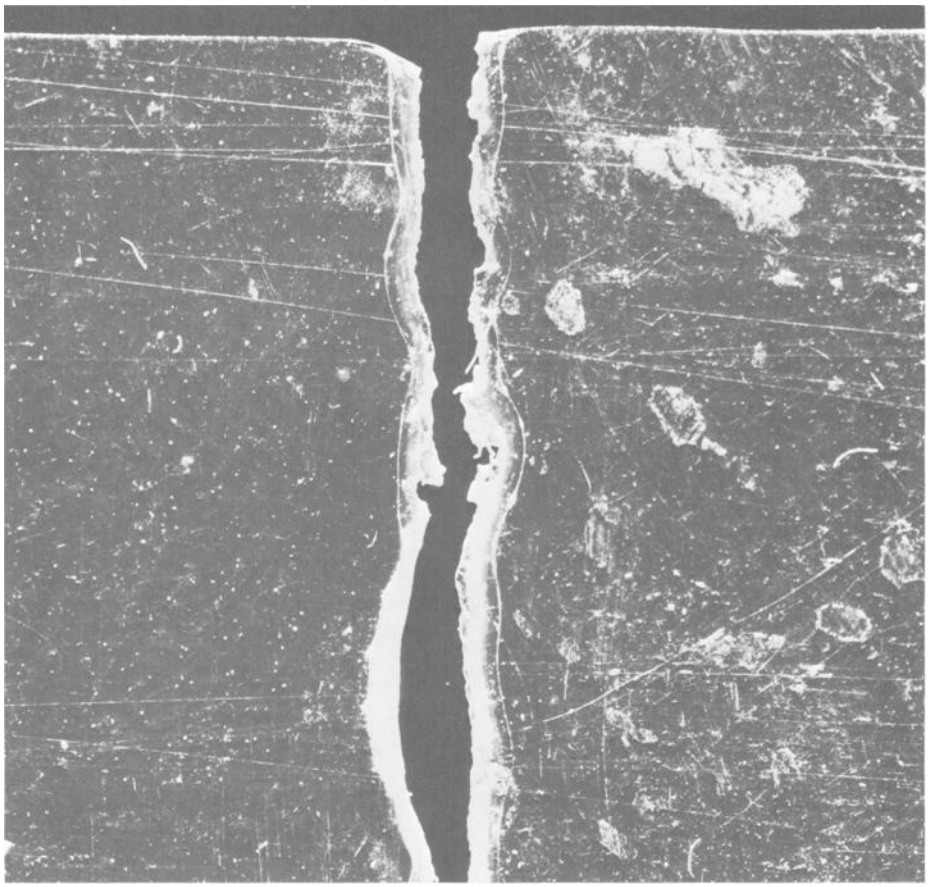

FIG. 11—*Two consecutive sandwich bags related by individual surface scratches (magnification ×10).*

cross each other. All of them are controlled by operator skill or the pressurized air above the mandrel that vibrates and stretches the film unevenly or both.

Many of the defects are not obvious in room light and must be examined with transmitted light and with a low power magnifier. Even then some individual marks are very difficult to see on some garbage bags. Enlarged high contrast photographs help greatly in the search for and comparison of these marks. To provide a jury with a perspective and to eliminate other questioned bags it can be useful to produce a photograph of nonmatching bags (Fig. 10).

Bags in which the marks run from side to side are more difficult to compare. To examine them, the seals have to be cut and some of the small marks like fisheyes may be damaged in the process.

Individual Characteristics in Sandwich Bags

Surface Scratches

These are fine colorless scratches similar in appearance to those found on old window glass (Fig. 11). Many were just a few centimetres long and ran at an angle from the edge of a bag. They were looked for initially on the lid of a bag because it consists of only a single layer of film. When that was not adequate, the sides of the bag were cut open.

Some of these marks are probably made by the stationary slats or rollers that flatten the tubular film above the mandrel. The slats observed had a considerable buildup of hardened plastic. It is likely that when the still soft film is pulled past them, some diagonal marks are formed by them. Since the film is still vibrating at this stage, it is subjected to a discontinuous contact with a changing slat surface. Any marks left by the many rollers along the line later on would have to be more or less parallel to the two sides of a bag and therefore would be class marks.

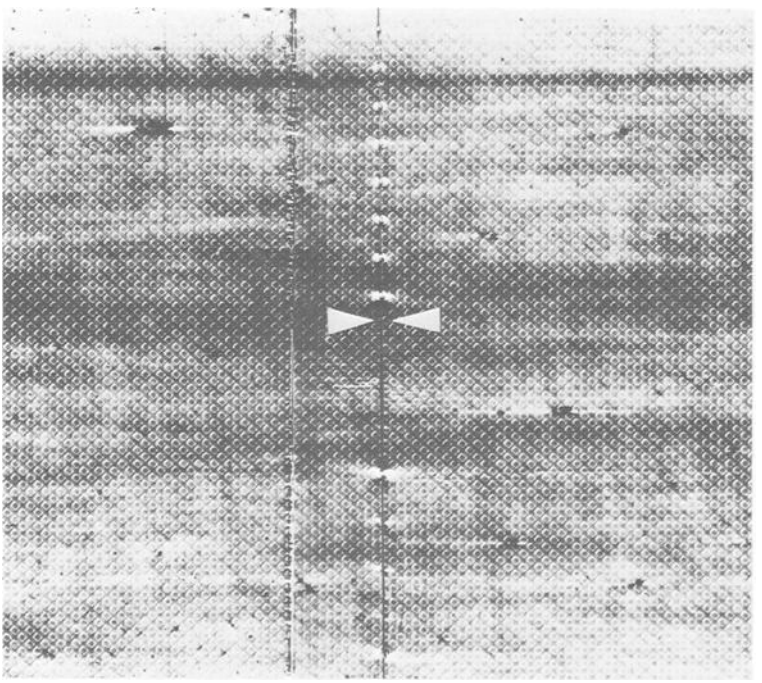

FIG. 12—*A freely changing pattern of intereference colors connecting two sandwich bags. The arrows point to the edges of the bags (80% of actual size).*

Colored Bands

Colored bands were mentioned earlier under the section Class Characteristics. However in some instances they were observed not as bands that gradually changed width or direction, but rather they consisted of a free flowing pattern that changed dramatically over just a few centimetres (Fig. 12). These undulating patterns were most impressive when a continuous roll of sandwich bags was scanned lengthwise between two large polarizing filters. Although only the making of tubular film was observed, some of the bags examined in case work had seals on both sides. Some of these must have been made from sheet film rather than tubular film. No marks were found on these that would contradict the findings on tubular film bags.

Conclusion

Knowledge of the manufacturing process permits the identification of the various marks observed on mass produced plastic bags. Class marks are differentiated from individual marks. A variety of individual marks are described whose size and distribution varies greatly. Sequentially made bags can be related to each other by marks present on their cut ends or sides.

When all class characteristics are consistent, and consecutive individual marks correspond on two bags, it can be concluded that they were originally one piece of plastic. That does not necessarily mean however that they originated from one retail package. Because the bags are not numbered, it is not known whether two bags are Nos. 9 and 10 from package A, or No. 10 from package A and No. 1 from package B.

References

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[3] von Bremen, U. G., "Shadowgraphs of Bulbs, Bottles, and Panes," *Journal of Forensic Sciences*, Vol. 20, No. 1, Jan. 1975, pp. 109-118.

Address requests for reprints or additional information to
Ulf G. von Bremen
Center of Forensic Sciences
25 Grosvenor St.
Toronto, Ontario, Canada M7A 2G8