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The Manufacture, Examination, and Identification of Die Cut Corrugated Boxes

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ABSTRACT: Corrugated boxes are often used as containers for the delivery of bombs or may otherwise be part of the evidence in an investigation. For that reason, forensic examinations may be necessary to compare a corrugated box with its manufacturing source or with other boxes. The methods of manufacturing steel rule box dies, which are used to cut boxes from corrugated stock, result in some important physical characteristics that can assist in the examinations of those items. Dies, which are produced for flat bed platen presses for cutting and folding corrugated boxes, may develop characteristics that can be used to positively associate boxes with a die or with one another.

KEYWORDS: forensic science, criminalistics die, box, corrugated containers

Background

In 1989, two individuals were violently killed in two different cities when they innocently opened two mail bomb packages sent to them through the US mail. Within days, two other similar mail bomb packages were intercepted in two other cities before their addressees could open them. The disarming of these two bombs allowed for a thorough examination of their contents, the method of construction, and the materials used, including the corrugated box containers.

Forensic examinations of the four mail bombs with one another necessitated numerous document examinations, including those involving handwriting, hand printing, typewriting, stamps, torn and cut edges, rubber stamps impressions, letter folding machines, photocopiers, and watermarks. Document examination also included the intercomparison of the corrugated boxes used to house the bombs as well as forensic support to link those boxes to a suspect.

Reference materials that would assist in the examination of the corrugated boxes were limited. It was, therefore, necessary to acquire additional information from the box industry relevant to the construction and features of corrugated boxes that would be useful in this type of examination.

The Box Industry

The box industry has estimated that approximately 90% of the manufactured goods in this country are stored or shipped in corrugated containers (1). The Fiber Box Association has estimated that more than 25 billion corrugated boxes are produced annually (2).

An important part of the manufacturing process involves the die-making and flat platen die-cut process. To obtain information about this process, people in the box making industry were consulted to discuss and observe both die making and box making within the box factory. [Personal contact with representatives of the Mack Chicago Corporation, Chicago, IL (1990), and personal contact with representatives of the Die Tec A Schawk Company, Des Plaines, IL (1990)].

Corrugated board is made by softening a corrugated medium with steam, and then, forming flutes or arches by pressing it between meshed corrugating rolls that fit together like huge gears. Glue is applied to the peaks of the flutes that are then pressed against a linerboard. To cover the other side of the flutes, a similar process takes place, first applying glue to the peaks of the opposite sides of the flutes followed by covering with linerboard. A simplified schematic is shown in Fig. 1.

The size of the fluting is rated as A, B, C, or E depending on the height of the flute and the number of flutes per foot. The fluting provides strength and rigidity and also serves as a cushion (Fig. 2). Corrugated medium can be single, double, or triple corrugation.

The corrugated material can then be used to produce boxes. The size, shape, and configurations of those boxes are numerous and serve a variety of needs. A couple of the more commonly used box types include the "regular slotted container" and the "tuck folder" that are illustrated in Fig. 3 in both their folded and unfolded configuration.

Predominant Methods of Corrugated Box Making

To produce a box, the corrugated cardboard stock must first be cut into an unfolded box. Two predominant methods of cutting the corrugated stock involve the use of either (1) a flat platen die cutter, or (2) a rotary die cutter. The general mechanisms for producing these cuts are illustrated in Fig. 4.

The flat platen die process utilizes a flat die cutter that is mounted on a flat platen press. It functions much like a cookie cutter. This method permits the use of complicated cutting patterns and produces great accuracy.

A second process, known as the rotary die process, uses a rotary die cutter that is shaped to fit around a curved drum and rotates as it cuts. The two main advantages of the rotary process are that it is quicker, and provides increased production.

The remaining discussion is concerned with the way in which the flat dies are produced, and how they are utilized on a flat platen die cutter. This will demonstrate how features, which are

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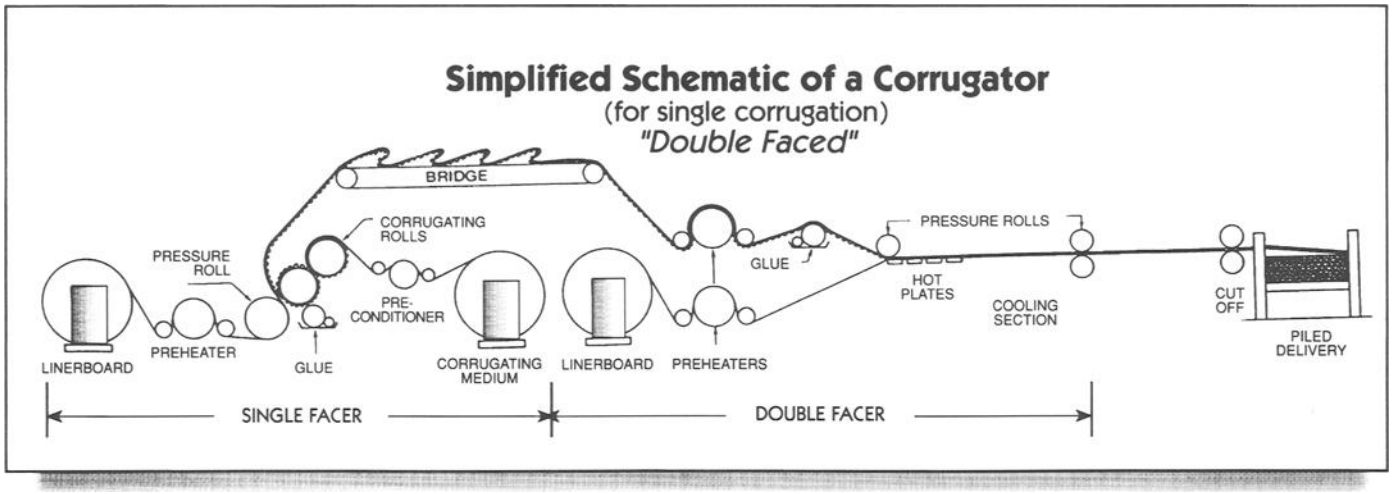

FIG. 1—*Simplified diagram of how single corrugated material is formed.*

Types and dimensions of flutes in general use in the corrugated industry

	Flutes per linear foot	Approximate Height
A flute	33 ± 3	3/16 inch
B flute	47 ± 3	3/32 inch
C flute	39 ± 3	9/64 inch
E flute	90 ± 4	3/64 inch

FIG. 2—*Type of fluting used in the corrugated industry.*

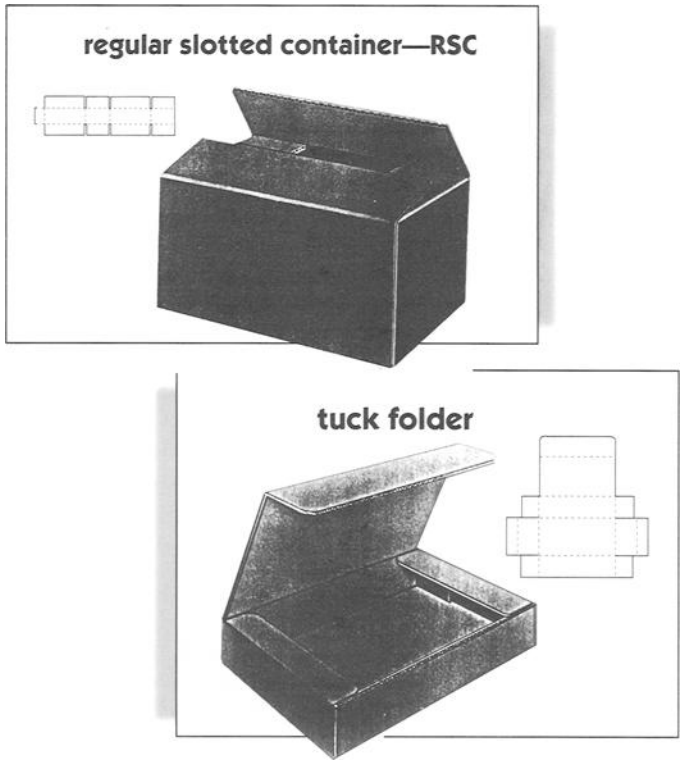

FIG. 3—*Two commonly used boxes. The small diagram depicts their shape before they are folded into a box.*

characteristic of that equipment and process, have potential value in a forensic comparison.

The Flat Platen Die Cut Process

In the flat platen die cut process, the flat die is mounted on a press in an inverted position. Figure 5 depicts a flat platen die press with the die mounted in that position. A single piece of corrugated material is placed beneath the die on the press. As the press closes, it forces the sharp flat die through the corrugated cardboard much like a cookie cutter.

The flat platen die contains flat pieces of both dull and sharpened steel rule. The steel rule is shaped into the specific dimensions of the box as it is mounted on its edge in a groove on a flat piece of plywood. The sharpened pieces of steel rule can have either a straight edge or a serrated edge as illustrated in Fig. 6. The sharp steel rule is placed on the die where it is intended to cut through the corrugated material. Other pieces of steel rule have blunt unsharpened edges. These pieces do not cut the corrugated material, but only serve to crease or "break the memory" of the corrugated material in areas where the box will be folded.

To manufacture a flat die, the specific design, special features, and size of the box must first be determined. The design can be chosen from one of the more commonly used shapes and sizes, or can be a totally custom designed box for a specific purpose. Either through the assistance of a computer or through the transfer of a drawing, the specific pattern of the die is then applied to a piece of plywood. A special, band-saw type cutter is then used to cut out a narrow groove in the plywood in the areas where the steel rule will be inserted. A skilled die-maker, with the assistance of special tools, then bends and cuts pieces of the sharpened steel rule so they will fit into those grooves with their sharpened edge protruding. The precise characteristics of the various angles and contours of each bend of the steel rule will vary with the skill, habits, tools, and efforts of the craftsman. For that reason, when manufacturing two dies of the same pattern, differences will result in the specific dimensions and contours of the finished die, including the features of each bend, joint, and intersection of the pieces

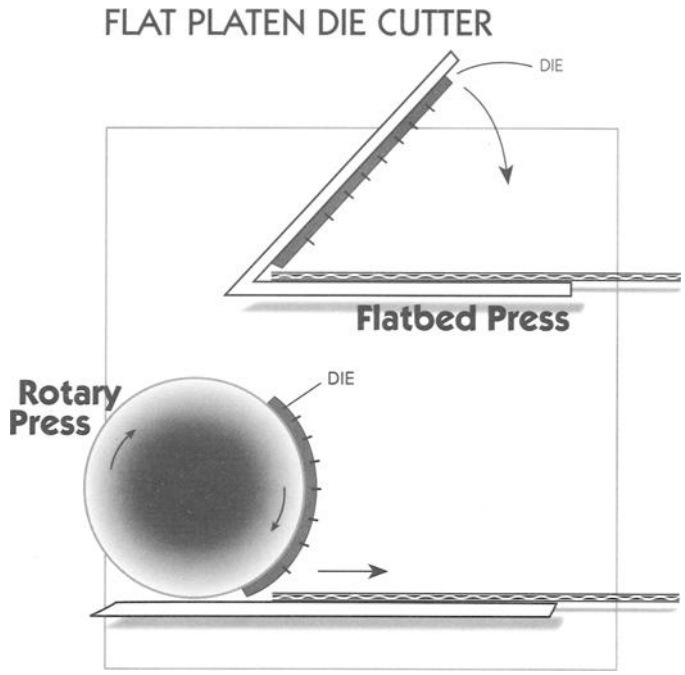

FIG. 4—*The general mechanisms for a flat platen die cutter and a rotary press cutter.*

of steel rule. Figure 7 illustrates some of the variable ways in which these joints can occur. The areas indicated by the larger arrows in Fig. 8 depict how two single turns in the steel rule in one die vary, and are reflected in the cut box.

To prevent the cut portion of the cardboard from sticking within the die, the edges of the sharpened steel rule are nicked by the

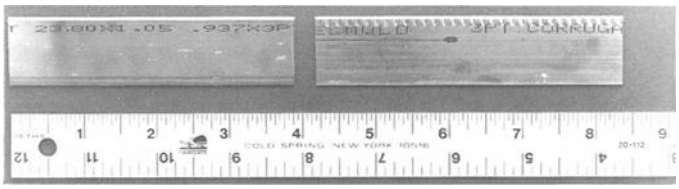

FIG. 6—*Two types of sharpened die rule, one having a straight edge, the other having a serrated edge. The cuts are distinguishable.*

die maker at numerous points, resulting in a gap in the cutting edge. Where those gaps exist, the corrugated medium will not be cut, and a small piece of the corrugated medium will remain. These small uncut areas are illustrated by the small arrow in Fig. 8 and above all five arrows in Fig. 9. These uncut areas serve to keep the cut-out box connected to the scrap material, thus, allowing the operator to remove both the cut and the uncut cardboard waste simultaneously from the press. The box can easily be punched away from the waste material after removal from the flat platen press. The small areas of uncut cardboard, which represent the nicked areas in the die, are easily observed on the finished box. It is noted that these nicks are not needed, nor are they present in a rotary die because the curvature of the die and rotary motion automatically separate the box from the waste. The number of nicks applied and the exact position in which the die maker places each is done randomly. The location of the nicks on the steel rule will vary immensely between dies depending on the design of the box and the personal choice of the different die makers. Although the precise dimensions and shape features of the die are essentially unique, the presence and positioning of these nicks add tremendous individuality to each die and allow for the positive identification of a corrugated box as having been cut by a particular die. Additional

FIG. 5—*A flat platen die cutter.*

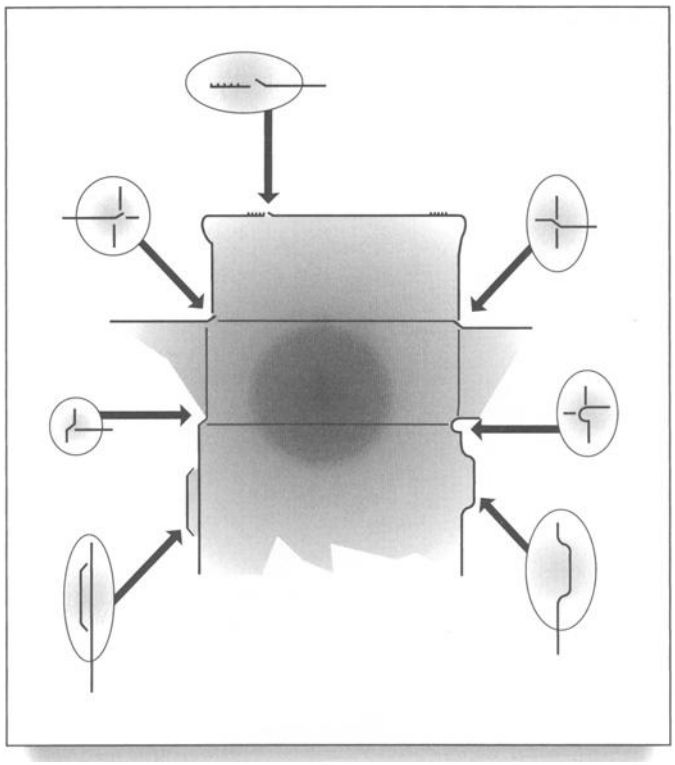

FIG. 7—*There are many intricate turns and joints that must be hand-made by the die cutter when manufacturing a die to cut boxes. The diemaker's choice of which to use and the variations between similar ones contribute to the uniqueness of each die.*

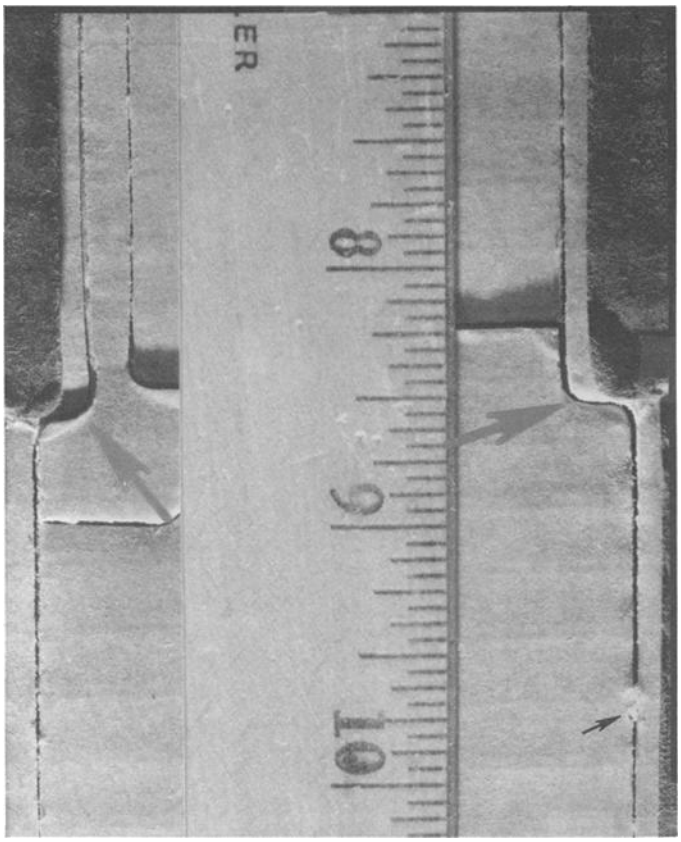

FIG. 8—*The two large arrows are an example of how similar turns in one die vary slightly. The smaller arrow points to an uncut portion of corrugated material as a result of an intentionally placed nick on the sharpened edge of the die.*

variations to a die could include the addition of nicks at the box factory after the die was made, as well as defects due to damage or wear.

An example of a needed repair to the steel rule in a die is depicted along the edge adjacent to the angled arrow in Fig. 9. The steel rule has broken at this point, and the two broken edges have become misaligned, resulting in a slight bend in the cut.

On many dies, individual perforated numbers are also added. These are illustrated adjacent to the arrow in Fig(s). 10 and 12. The *exact* relative position of these individually placed perforated numbers will vary, although, when used, they are generally placed in the central area of the box bottom. They will punch a perforated number into the inner liner of the corrugated medium. The perforated numbers normally denote the style of the box, although a manufacturer may occasionally use these numbers for other reasons. In the case of an 1184 box, the style number 1184 represents the approximate box size of 11 by 8 by 4 in. The 1184 box is a very common size tuck-and-fold box used to mail periodicals and standard sized published materials.

The die illustrated in Fig. 12 is actually a die that will cut out *two* 1184 boxes nested against one another in opposite directions. A die of this type is known as a two-up die because it will cut out two boxes at one time. Figure 11 illustrates a piece of corrugated board which has been cut into two 1184 tuck-and-fold boxes by the die in Fig. 12. The scrap material has not yet been removed. Figure 10 depicts a closer view of a portion of the die in Fig. 12, including the 1184 perforated number. It also depicts several small gray blocks of foam that are positioned around the die to help eject the corrugated material from the die after it is cut.

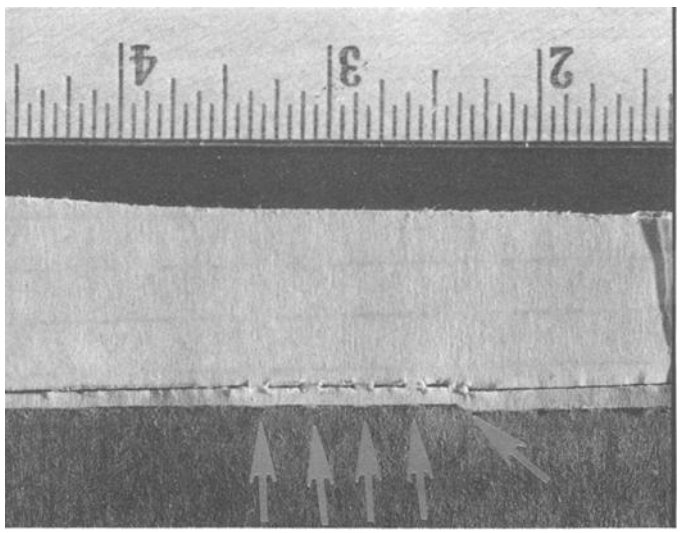

FIG. 9—*Five nicked areas leave five uncut portions of corrugated material. The edge at the tip of the angled arrow reflects a portion of the die rule that has broken and become misaligned.*

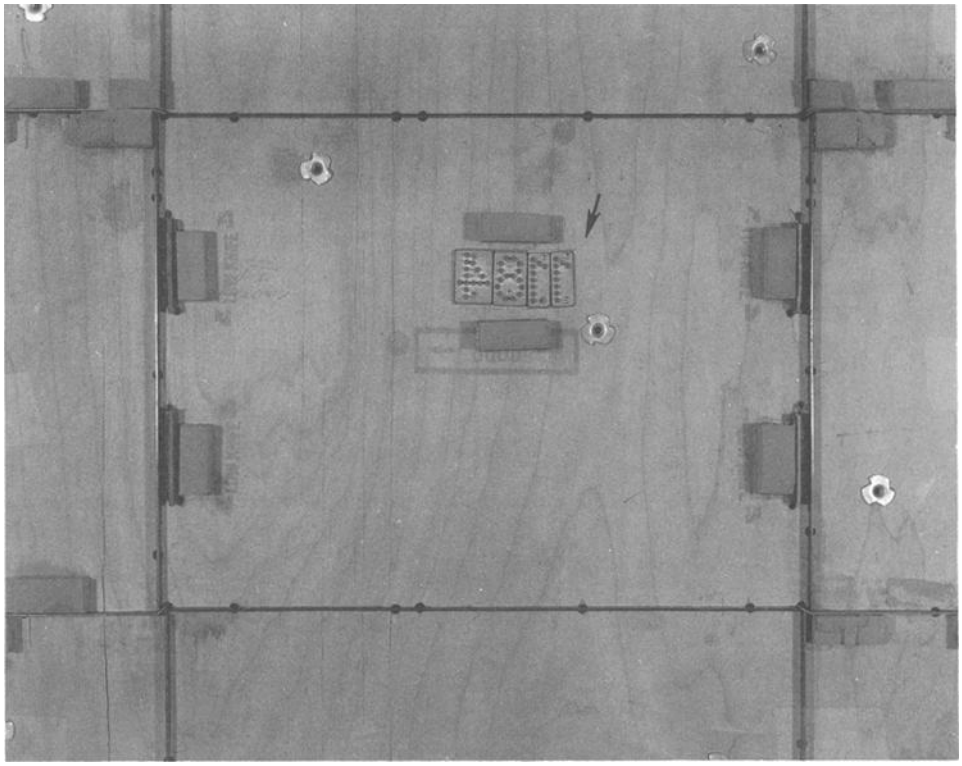

FIG. 10—*A close-up view of the perforated 1184 number in the die pictured in Fig. 12.*

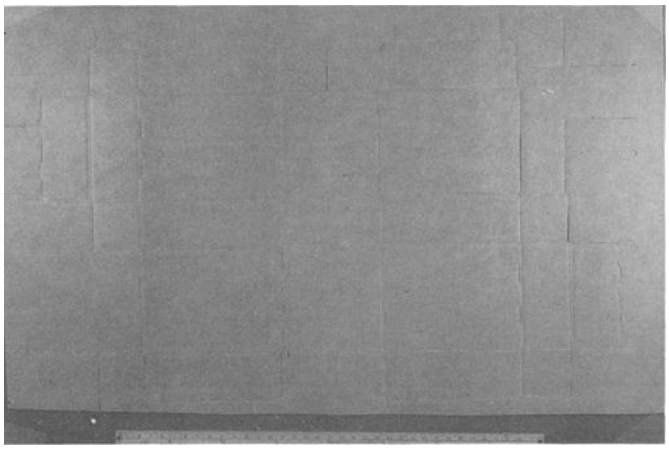

FIG. 11—*A sheet of corrugated material that has been cut by the die in Fig. 12, but which has not had the waste material removed.*

In the investigative search for the source of the 1184 tuck-and-fold boxes utilized in the mail bombs, a diagram was prepared based on information from one of the undetonated bomb boxes. That diagram is depicted in Fig. 13. The search was in its early stages when the actual die was located, based on information from a cooperating witness. The description of the die in the diagram was based solely upon the characteristics observed in the bomb box, all of which turned out to be accurate later. Some of these are as follows:

(a) The short flap in the drawing with the angled edge is indicative of a die made to cut two boxes nested side-by-side, as in a two-up die.
(b) The observance of an angled radius made by two pieces of steel rule along the edges of the tabs on one side, as opposed to a curved radius made by a single piece of steel rule on the other side, also represents the intersection of two nested side-by-side boxes.
(c) The specific contours and size features of the curved corners and friction lock bulges (see Fig. 13), as well as the position and existence of the nicks in various random positions along the steel rule, and the needed repair in the form of an offset break in the steel rule on the leading edge of the flap, all contributed to the die's uniqueness, and were represented in the bomb boxes, as well as other boxes cut by that particular die.

In the particular die used to cut the 1184 bomb box in this case, there was also the existence of an 1184 perforated number. In the case of one of the mail bombs, the bottom of the box had been obscured by an extra layer of corrugated medium that had been added by the suspect and glued over the original bottom. Over a period of days, the added bottom was soaked and removed to expose the original bottom of the bomb box. On the original bottom, a portion of the top layer of paper liner had been cut out,

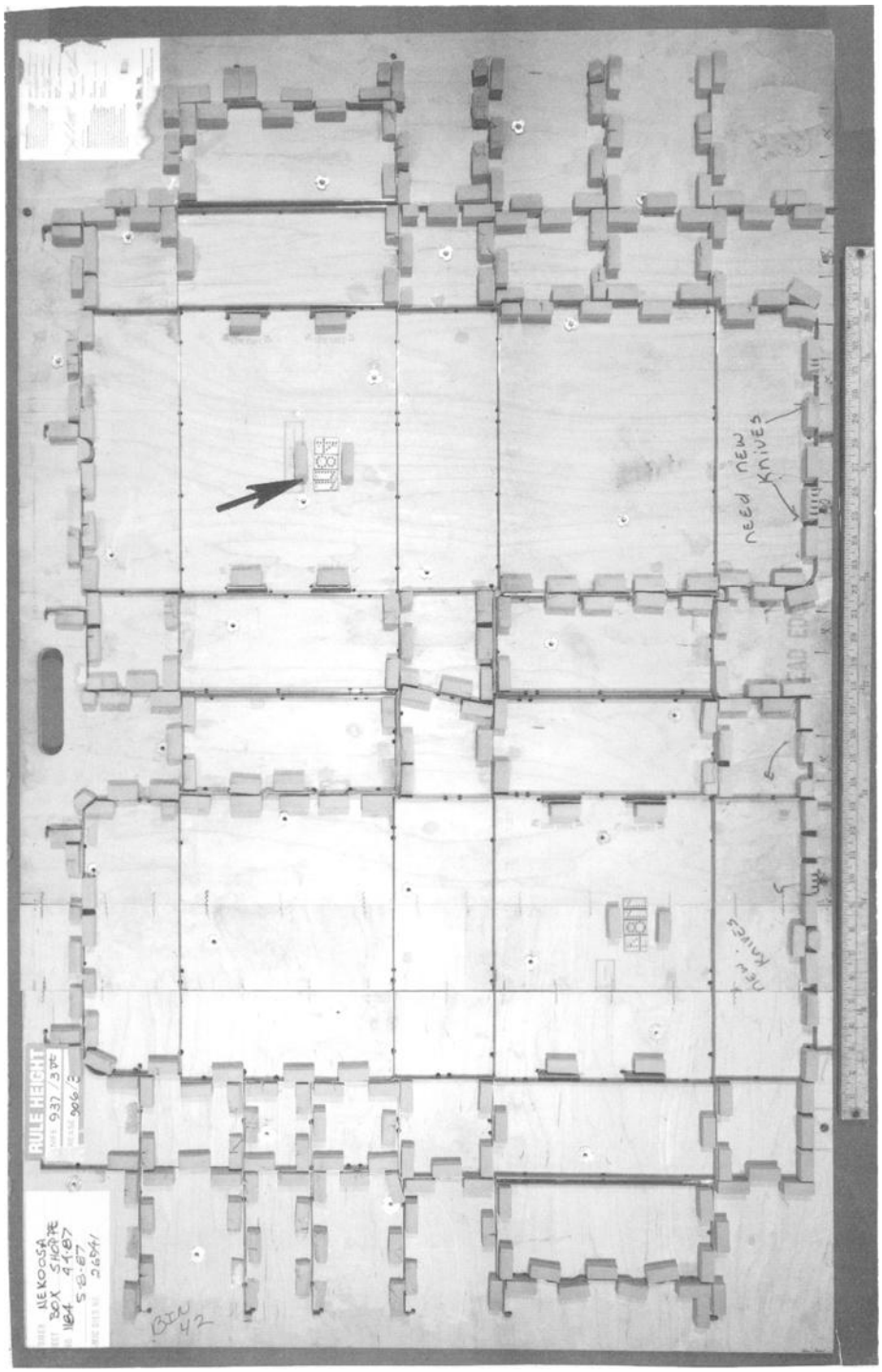

FIG. 12—*A two-up die used to cut two 1184 tuck-and-fold boxes. The arrow is pointing to one of the two 1184 perforated numbers.*

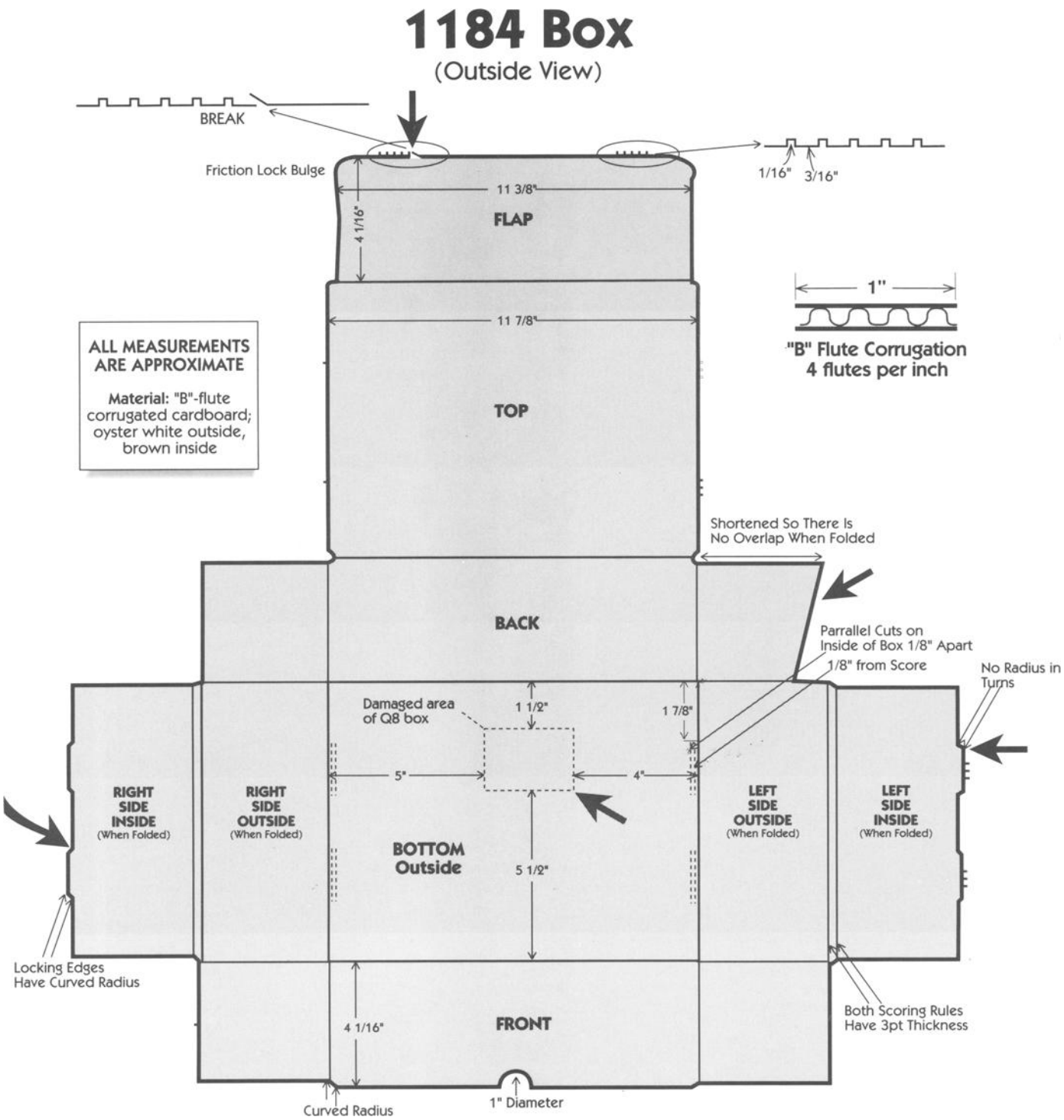

FIG. 13—*A diagram that was prepared for the investigative search for the box used in the bombing.*

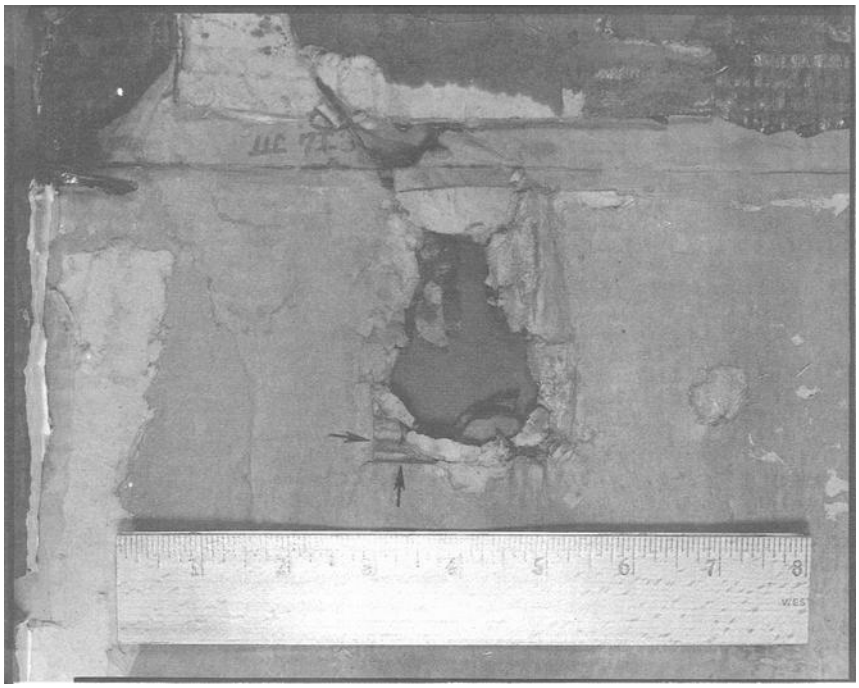

FIG. 14—*The arrows point to the cut areas of linerboard at the point where the 1184 number was intentionally removed.*

as evidenced by the remaining marks from a knife or scalpel, some of which are adjacent to the arrows in Fig. 14. The suspect had intentionally removed the top layer of linerboard, which contained the 1184 perforated number from the original box bottom. The drawing of the box in Fig. 13 depicted this area with a dotted rectangular line. When the 1184 die was located, the precise location of the die's 1184 perforated number corresponded with the area of the bomb box that had been removed.

Summary

In conclusion, the method in which some dies are manufactured, particularly those which are utilized on a flat platen press, results in dies that are unique. In turn, those dies, as they cut corrugated material into boxes on a flat bed platen press, transfer those unique characteristics to the corrugated box medium. These features can be compared to confirm the manufacturing origin of boxes, and can also be used in the comparison with other boxes in possession of, or available to a suspect.

References

(1) The Wiley Encyclopedia of Packaging Technology, John Wiley & Sons, New York, NY, 1986;66.
(2) Fiber Box Handbook, Fiber Box Association, Rolling Meadows, IL, 1989.

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