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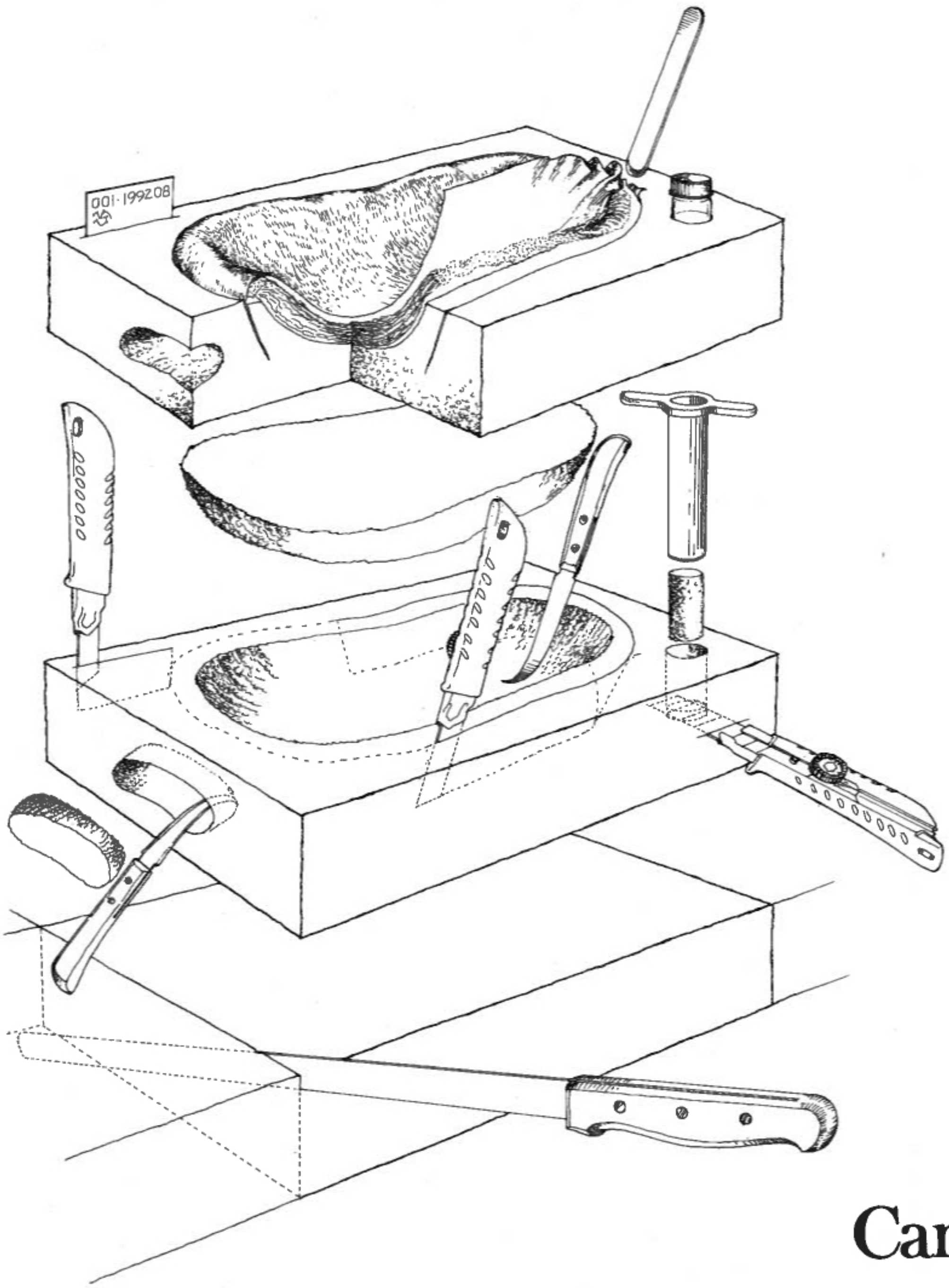
Technical Bulletin 14

# Working with Polyethylene Foam and Fluted Plastic Sheet




Canada

# Technical Bulletin No. 14

## Working with Polyethylene Foam and Fluted Plastic Sheet

**by Carl Schlichting**



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## CCI Technical Bulletins

Technical Bulletins are published at intervals by the Canadian Conservation Institute in Ottawa as a means of disseminating information on current techniques and principles of conservation of use to curators and conservators of Canada's cultural artifacts. The author welcomes comments.

## Author

*Carl Schlichting* worked in the Ethnology Section at the Canadian Conservation Institute from 1987 to 1992, where he specialized in the conservation of industrial collections and had a special interest in the mounting, storage, and handling of museum artifacts. He worked at the Royal British Columbia Museum and at the Alberta Culture Historic Sites Service before joining CCI. He holds a Fine Arts diploma in sculpture and a diploma in Museum Technology from Algonquin College (1982). He is a member of the Canadian Association of Professional Conservators, and is currently in private practice in Nelson, British Columbia.

## Abstract

In the past few years, polyethylene foams and fluted plastic sheet have become widely used in museums. This Technical Bulletin compiles a number of techniques and illustrates a series of approaches that have been developed for working with these materials in the context of the storage and support of museum objects. The many detailed illustrations clarify for the reader the fabrication methods described in the text. A wide variety of tools used for working these materials are discussed in the Appendices.

## Cover

Illustration by Carl Schlichting.

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## Introduction

Probably no two products have been more welcome or as widely used in museums as polyethylene foams and fluted plastic sheet. Plastic materials with the trade names Ethafoam, Micro-Foam, Cor-X, Coroplast, and Hi-Core are now generally used in museums. The increase in the variety of applications for which these materials are successfully used is the result of their stability, availability, affordability, and workability.

This Technical Bulletin compiles a number of techniques and illustrates a series of basic approaches that have been developed for working with polyethylene foams and fluted plastic sheet. The author hopes that this Technical Bulletin will also serve as a starting point for further developments in this field.

Because these materials lend themselves well to being worked by hand, the illustrations that follow focus on techniques that do not require power tools or workshop equipment. Nonetheless, power tools can greatly reduce the time required when preparing pre-cut stock, particularly when multiples are being made. However, in most applications, the fabrications are specific to each artifact support situation, and a practised hand can make short work of the job. Some of the processes described in the following pages require the use of appropriate safety equipment, such as face shields or safety goggles.

Due to the speed of technological change, certain parts of this Technical Bulletin may become outdated relatively quickly. Nevertheless, the basic techniques and approaches outlined will remain applicable. It is hoped that they will inspire readers to develop new and innovative techniques that suit their own needs. The basic challenge, however, remains finding ways to achieve what is required by the simplest means and involving the fewest fabrication steps.

## Materials

### Polyethylene Foams

Ethafoam is ideal for museum use because it contains only pure polyethylene that has been formed using various cell sizes and densities (Figures 1, 2, and 3). The product most commonly available is DuPont 220 Plank in thicknesses of 2.5 cm (1"), 5 cm (2"), and 10 cm (4"). (DuPont is among the largest and most easily accessible producers of these materials worldwide.) The planks are sold in 2.7 m (9') lengths. DuPont 221 Sheeting is sold by the roll in thicknesses of 3.2 mm (1/8"), 6 mm (¼"), 9.5 mm (3/8"), and 1.3 cm (½"). DuPont 220 is available in natural (white), blue, and black. DuPont 221 is only available in white. It is recommended that only white be used because the blue and pink products contain unstable additives that are not necessary or recommended for museum purposes. The black or grey pigmentation is, by contrast, stable because it is composed of carbon. Polyethylene has excellent stability characteristics and is easily formed using heat. However, it has a poor tolerance to ultraviolet (UV) radiation and has a poor affinity to adhesives.

Ethafoam's various industrial applications have resulted in some interesting products that can be used in museums. One of these is Backer Rod, which is a grey Ethafoam extruded in continuous rods with diameters ranging from 6 mm (¼") to 10 cm (4"). The 10 cm (4") diameter is available in various colours; however, use only the white for museum applications. The sizes under 5 cm (2") in diameter are sold by the foot, and larger diameters are sold in 1.8 m (6') lengths. A do-it-yourself pipe insulation, now carried by many hardware stores, is a darker grey Ethafoam formed into a split tube with a 3.8 cm (1½") or 5 cm (2") outside diameter. Household and gardening kneeling pads made of a rectangular extrusion are limited in length and shape, but may have some use either when cut into single tubes or when sectioned.

### Fluted Plastic Sheet

In Canada and the United States, fluted plastic sheet (also called polyflute sheet) is well known as Coroplast. In Europe, it is available under the trade name Cor-X. Polyflute sheet is a copolymer of approximately 90% food-grade polypropylene and 10% polyethylene. It is manufactured in a continuous extrusion process, which means that any length of sheet can be produced. The standard is 1.2 m x 2.5 m (47.2" x 98.4"). It should be noted that the sheets as supplied may not be square at the ends. When cutting a piece from the end, always use a square that is aligned with the flutes, which are parallel to each other.

The sheet is fluted, which accounts for the rigidity of the material. The flute membranes may not always stand perpendicular to the sheet surfaces, but this should not affect most applications. At the time of writing (1992), there are several thickness available: 2 mm (5/64"), 3.5 mm (9/64"), 4 mm (5/32"), 5 mm (13/64"), 6 mm (¼"), 8 mm (5/16"), 10 mm (25/64"), and 14.2 mm (9/16") (Figure 4). Densities can also be specified within these thicknesses. The more dense the sheet (i.e., the thicker the walls or the more resin weight per square area), the more rigid and tough it will be. Sheets 6 mm (¼") to 14.2 mm (9/16") thick are manufactured by Matra Plast Inc. under the trade name Hi-Core. The Hi-Core line of products also includes the "Hi-Tech Series", which are particularly rigid polyfluted sheets. This extra rigidity is achieved by adding inert fillers to the resins. However, the author has found that stocks of these more rigid products are not easy to find.

Polyfluted sheets 1.3 cm (½") and 4 mm (5/32") thick are available commercially in a wide range of colours. Coloured stock is safe to use and may be helpful for coding or for identification, but white seems to be the favourite among museum workers. The thicker products are not as readily available in different colours as are the thinner sheets, but rather are most commonly found in a translucent, natural resin colour or in white. There may be some concern that white will soil easily, but even if it does, polypropylene can be cleaned most effectively with an alcohol-dampened cloth, unless the sheet is heavily scuffed or deeply scratched. Also, white sheets used as trays, boxes, and shelf liners serve as an ideal background against which to see accumulated dust and evidence of pests.

Because of its stability, polyflute sheet is ideally suited to and is safe for use in any museum application: closed storage, open storage, or display environments. Tough, rigid, and lightweight, polyflute sheet is an ideal replacement for acidic-paper-based boards and for wood products. The 4 mm (5/32") sheet has already made major inroads into the container industry, and is now widely used in museums. If packaging firms continue to expand the variety and sizes of box patterns available, this product will likely become the most common container material in the museum field. With the recent introduction of products having a thickness of 6 mm (1/4") or more, it is quite probable that these will replace plywood and foam-core in the construction of artifact supports, shelving, and oversize storage containers.

## Cutting and Shaping Ethafoam

The cell walls that make up polyethylene foams are very thin and flexible, which can create potential difficulties when cutting them. Two types of cutting edges work well with these materials. The first type is a razor-sharp, finely honed, polished edge such as that found on new scalpels or on Olfa utility blades. These edges are difficult to keep extremely sharp. Therefore, either these tools must be kept specifically for cutting polyethylene foams and have the blades changed frequently, or the blades must be honed (which requires considerable skill). The razor edges are best used for cutting slits, for piercing, and for straight cuts through thin materials.

The other type of cutting edge that works well with polyethylene foams makes use of microscopic irregularities or "raggedness" to tear the cell structure, much like a butcher's knife cuts meat. This type of cutting edge requires a sawing or reciprocating action. A micro-ragged edge requires less frequent maintenance and is simpler to sharpen. A chef's sharpening steel creates the correct edge on a long slicer (Figure 5). With practice, the chef's steel can also be used on curved blades.

Cork borers, which are used for cutting round holes and plugs, are best sharpened with the tool designed for this purpose. Custom-shaped knives can be kept to the required micro-raggedness using a fine needle file.

It may be practical at times to cut complex profiles out of 10 cm (4") thick Ethafoam using a power band saw. Before cutting the desired form, clean the saw blade by running it through scrap foam until the cut in the foam is free of sawdust. When cutting thick foam planks, the cut surface may need to be dusted to remove the fine foam particles left by the blade.

Concave nests and other shapes can be quickly formed using heated, custom-made, curved blades (Figure 6). The cut is very smooth and fast, but a torch must be used to keep the blade temperature hot enough to burn off the residues. Any technique that burns plastics (i.e., that requires temperatures higher than those necessary for softening plastic) should only be practised when effective ventilation is available. An additional drawback to hot cutting is that it leaves a residue of semi-charred polymer, which will soil the foam surface if it is not cleaned regularly from the cutter. Mass production may warrant the construction of hot-wire cutters. However, these are difficult to use for making convex or concave shapes. In some situations, curved blades can also be used unheated.

Figure 7 illustrates the use of all of these tools.

## Cutting Polyflute Sheet

### Simple Cuts

Cutting polyflute sheet is similar to working with corrugated cardboard. The cuts usually follow straight lines either parallel to the channels or perpendicular across them. The cuts are either through the full depth of the sheet or else are far enough through to permit the rigid sheet to be bent.

It takes little effort to cut a standard 4 mm (5/32") sheet with an Olfa utility knife. A straight edge is not necessarily required for making cuts **along** the flutes because the channel itself will guide the blade (Figures 8 and 9). When cutting **across** the flutes, however, it is essential to work against a sturdy metal straight edge, scribing first (i.e., marking a line by cutting or scratching lightly), then cutting through in one or two passes. Whereas cutting outside curves can be easily done free-hand, tight inside curves are more difficult. Do not attempt to cut curves with an Olfa utility knife, because a twisting pressure may cause the segmented blade to snap. A band saw or fretsaw may be required to cut out complex profiles with inside and outside curves.

Heavier sheets 8 mm (5/16"), 10 mm (25/64"), or 14.2 mm (9/16") thick can also be cut with an Olfa utility knife. More passes with the knife will likely be required, depending on the strength of the cutter's hand. Always scribe the intended cut first, and **never** apply excessive pressure to an unguided blade. A knife cut leaves a clean finished edge.

### Power-Assisted Cuts

Cutting thicker sheets with a band saw will greatly speed up the process and is practical when making numerous cuts. However, the band saw does leave a rough and ragged burr that must be trimmed with a block plane. Table saws fitted with a fine-toothed, carbide-tip blade designed for plastics may also be used. A word of caution, however: table saw cuts should be made only by an experienced saw operator. Fluted sheets have a tendency to chip at the blade because the upper skin is not supported well. Also, the light weight and flexible nature of the sheet increase the risk of the saw binding on the material and causing dangerous kick backs.

## Shaping Polyflute Sheet

The fluted nature of this material allows for a number of interesting possibilities.

### Cutting Methods

Once either surface of a polyflute sheet is cut, the channels lose their rigid properties. When the sheet is bent, the uncut surface will act as a hinge. The bend can occur on the inside or outside surface of the finished product.

Cuts can be made along the length of the flute or across the grain, perpendicular to the flute orientation. When making a cross cut on standard 4 mm (5/32") sheet, it is not necessary to cut deeper than the top surface. The channel membranes will tear when the sheet is bent. Sheets with thicknesses of 10 mm (25/64") or 14.2 mm (9/16") require deeper cross cuts in order to break the membranes.

This process will create a smooth inside bend for a container, which is ideal for artifact storage (Figures 10 and 11). However, the exposed flute structure at the exterior corners of the container can be sharp and can catch on things.

An alternative method that creates smooth exterior and interior corners involves using a straight parting chisel (Figure 12). It is reasonably easy to remove the top surface along a flute with the chisel. It requires more skill, however, to create the required "V" kerf across the flute grain. Cut the cross grain in two passes, one side of the "V" in one direction and the other in the opposite direction, using a steel straight edge as a guide for the chisel. Be sure that the hand that holds the straight edge is always behind the chisel when making this type of cut. A mat cutter can also be used for making these cross cuts safely.

### Using Heat

The easiest and most effective way to create a corner bend in a sheet of polyflute is to use heat. When an area on one or both of the sheet's skin surfaces is softened with heat, the rigidity in that area is lost until the sheet is cool again. While soft, the sheet can be bent to any angle. A sharp corner can be made at any angle to the channel orientation, provided that a narrow, straight band is softened by heating prior to bending. Sheets with thicknesses of up to 6 mm (¼") can be shaped by softening only the inside surface. However, softening both surfaces will result in a stronger and straighter bend. Thicker sheets definitely require that both sides be softened before bending.

Electrically heated bending forms, typically used for acrylics, can be used to soften polyflute sheet. However, when creating short bends and custom sizes, it is faster to do the heating with a flame. The new generation of butane micro-torches are ideal tools for this work because of their small size, instant lighting features, and sharp, hot flame. However, it is better to use a regular propane torch to soften longer lengths because it has a larger flame.

When the flame is first applied to the polyflute sheet, the skin surface wrinkles and turns slightly yellow. As the flame is moved along the fold line, the wrinkled area behind the flame smooths out. Practice sweeping the flame along lines on scrap pieces of sheet to determine the correct distance and speed of the flame. The goal is to create a straight band of uniform softness approximately 1 cm (25/64") wide along the length of the intended bend. The straighter and more even the heated band, the more precise the corner will be. You may wish to use a pen to mark guide lines for the flame; the pen mark will disappear into the compressed corner. Another way to achieve a sharp, straight fold line is to pass the flame along a non-flammable straight edge before bending.

The intended fold must be held in position for a minimum of 5 to 10 seconds to allow the material to cool and set into the desired shape.

It is the author's opinion that softening is the best way to form polyflute sheet (Figure 13). Softening is simple and versatile, and is easier to learn than cutting methods.

## Adhesives and Fastenings

### Polyethylene Foams

Hot-melt adhesive is the most practical method of adhering foam to foam, paper to foam, fabric to foam, etc. A hot-glue gun, which has become a standard tool for this work, is most expedient and is easily mastered.

Use a small quantity of glue only where it is needed. As a rule, the adhesive should be applied where it will not be visible once the joint is finished. This is both for aesthetic reasons and so that the glue will not come into contact with the artifact material.

When molten glue is first extruded from the nozzle, it is so hot that it will melt the thin foam cell membranes. This can distort the surface of the material. To lower the temperature of the glue, quickly spread it in a thin layer over the surface. Wooden sticks are ideal for this purpose (Figures 13, 14, and 15). Thus, a thin hot-glue film will quickly cool to the required tack. The total time involved in applying the hot glue, spreading the film, and closing the open joint is short, which limits the size or length of joint to be attempted. Always apply the hot glue to the thicker material being adhered, spread it thinly, and then apply the thinner material to the thicker. In this way, thin, delicate foams, fabrics, and even fibres such as cotton wool, fibrefill, polyester batting, and felt can be adhered to larger foam forms.

It is important to note that once the joint is closed, the adhesive will cool slowly because of the insulating quality of the foams. For best results, maintain the required pressure for closing the joint for a minimum of 30 seconds.

Foam sections can also be heat welded together using hot air. However, this takes more time than hot-melt joins and is not practical when adhering thin micro-foams to larger stock or when welding large surfaces together.

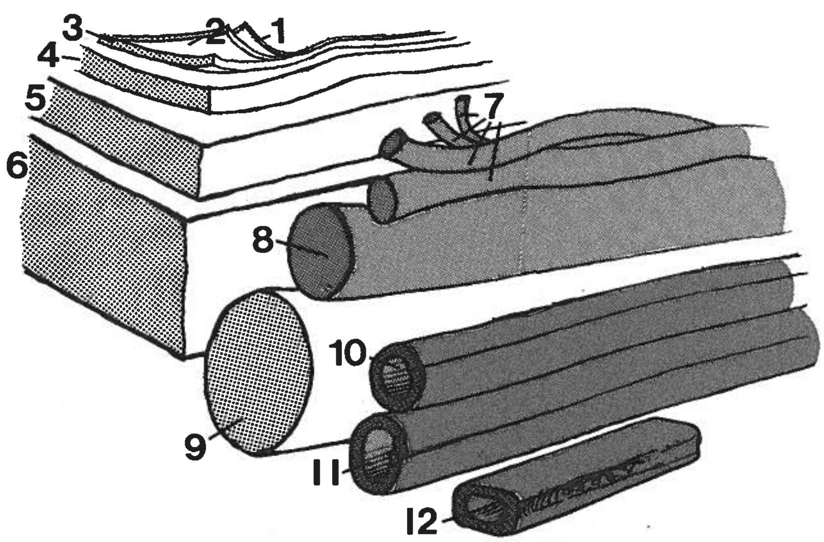
There are also many non-adhesive methods of attaching materials to foams. These include stitching, sewing, and tucking (Figures 16, 17, and 18).

**Polyflute Sheet**

Polypropylene, which makes up the bulk of polyflute sheet, has one regrettable characteristic: it has a poor affinity to adhesives. As a result, it is not easily adhered with adhesives alone. Commercial high-tack adhesives for polypropylene do exist and are becoming more common. However, they are difficult to find. Mechanical methods are currently the most reliable for fastening polypropylene. There are many types of fasteners available, and more options will become available as the commercial market develops. A few examples being used at the time of writing are illustrated in Figures 19 to 26.

## Figures

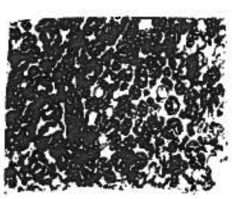
**Figure 1**




**Samples of polyethylene foam**

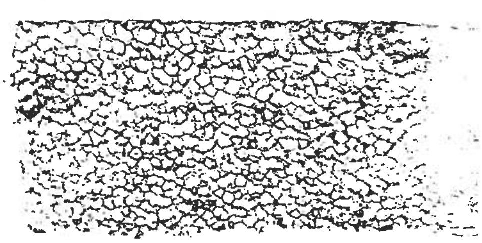
1. 3.2 mm (1/8") sheet (purchased by the roll)
2. 6 mm (¼") sheet (purchased by the roll)
3. 1.3 cm (½") sheet (purchased by the roll)
4. 2.5 cm (1") plank (sizes vary according to availability)
5. 5 cm (2") plank
6. 10 cm (4") plank
7. 6 mm (¼"), 1.3 cm (½"), 1.9 cm (3/4"), and 2.5 cm (1") rod (purchased by the foot or in rolls of 152.4 m [500'] to 304.8 m [1000']; other sizes may also be available)
8. 5 cm (2") rod (sometimes supplied only in 1.8 m [6'] lengths)
9. 10 cm (4") rod (1.8 m [6'] lengths available in white and in other colours)
10. 1.3 cm (½") inside diameter (ID) pipe insulation
11. 1.9 cm (3/4") inside diameter (ID) pipe insulation
12. segment cut from a kneeling pad

**Figure 2**



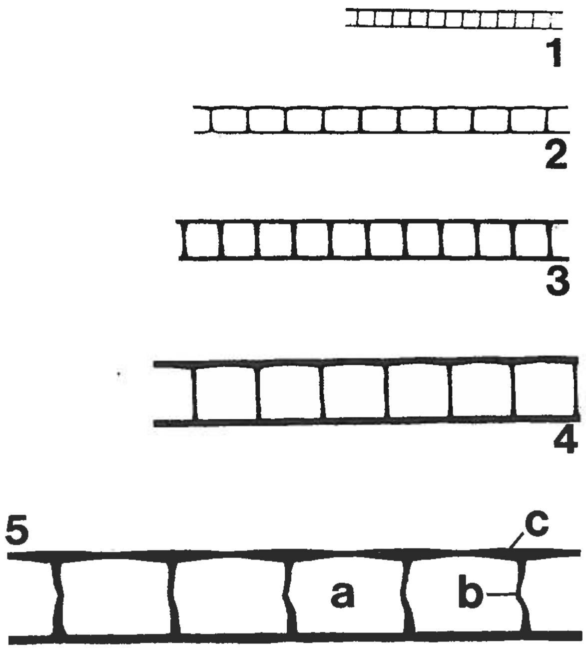
Print made from the factory skin found on the surface of most polyethylene foams. The exposed cell structures are closed or skinned over, resulting in a smooth texture.

**Figure 3**



Typical cell size and structure that is exposed when foam is cut. This surface can be re-skinned to be similar to the factory finish by blowing hot air on it or by passing a flame over the cut surface until the cells close. The exposed cells will shrink, causing a slight reduction in overall dimensions.

Figure 4



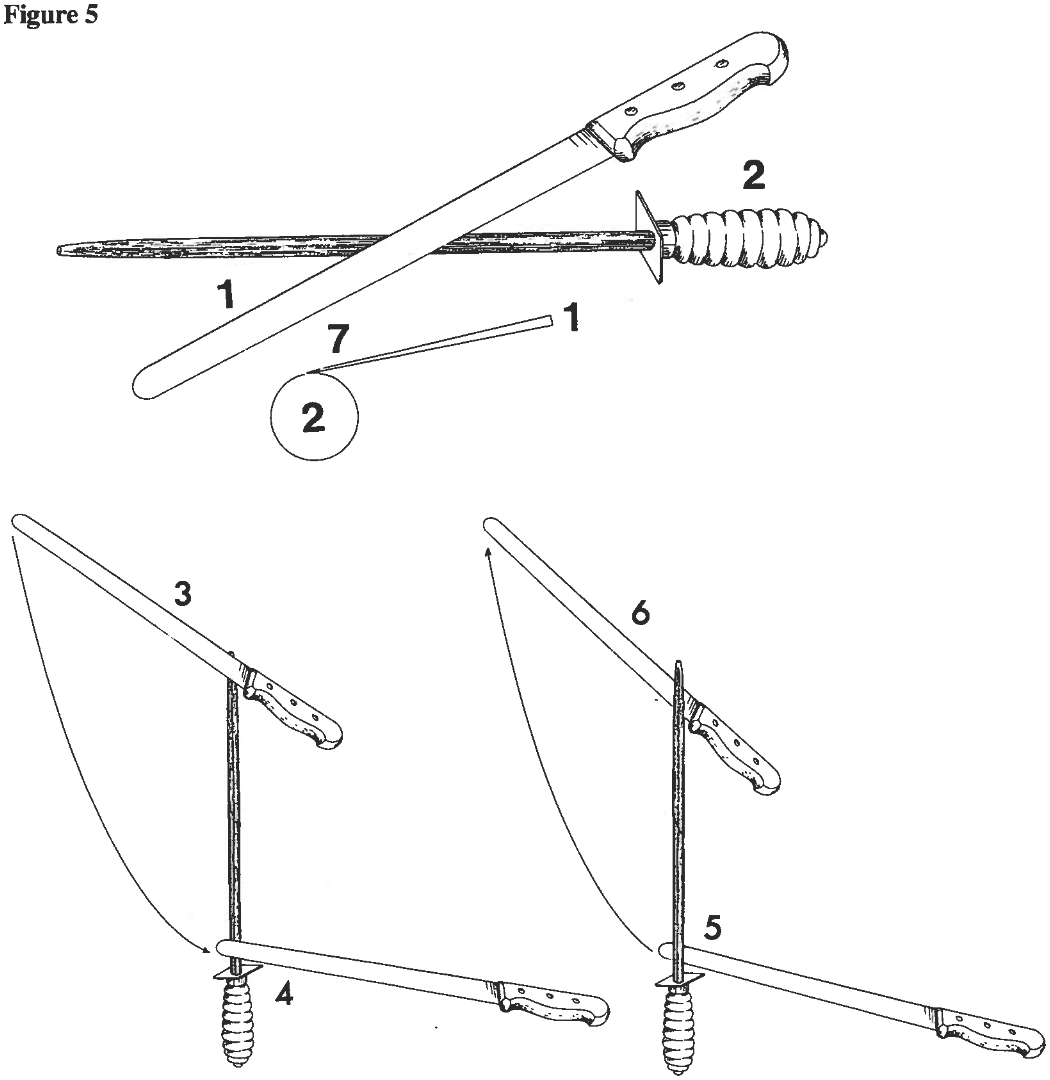

**Polyfluted sheet (prints of the end grain, actual size)**

1. 2 mm (5/64")
2. 4 mm (5/32") (most commonly available size)
3. 6 mm (¼")
4. 10 mm (25/64")
5. 14.2 mm (9/16")

*Polyflute Anatomy:*

a. channel
b. channel walls or membranes
c. outer skins (top and bottom of sheet)

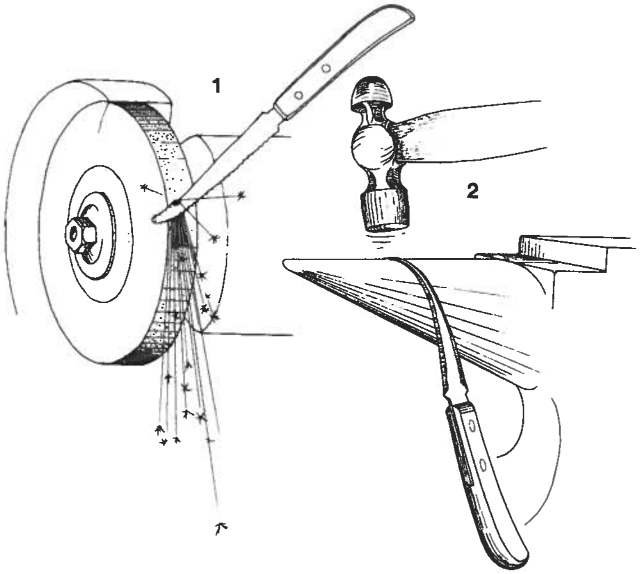
Figure 5




**Slicer use and maintenance**

- Keep the blade of the slicer knife (1) flat against the sharpening steel (2) while sharpening the knife.
- Beginning the stroke at the top (3), drag the knife edge in a downward, curving stroke against the steel until the tip reaches the bottom (4).
- Slip the blade tip under the steel and reverse the stroke (5).
- The heel of the slicer handle should hit the steel tip at the end of the stroke (6).
- Practice this until a quick, fluid motion is achieved. Remember to keep the blade flat against the steel (7). Note that the thinner the blade, the less drag will occur on the foam when cutting.

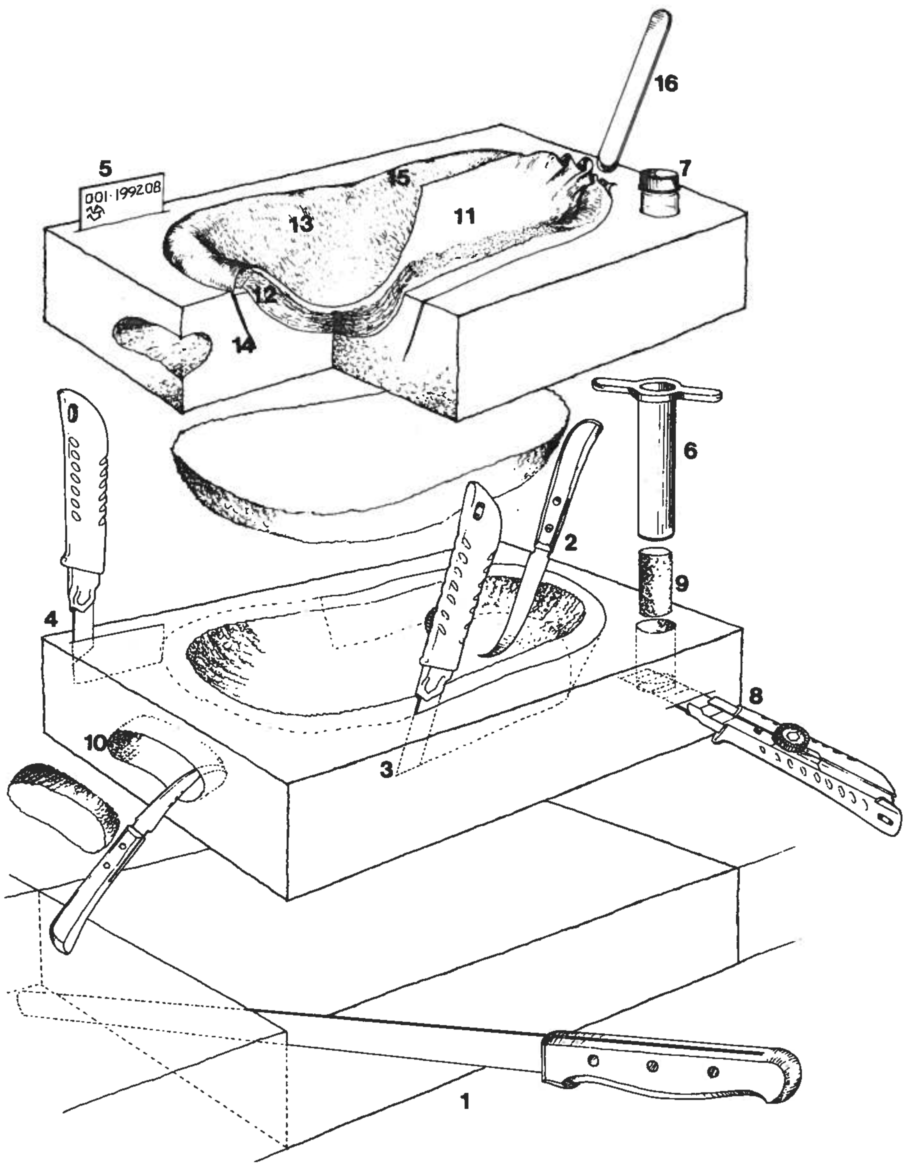
Figure 6




**A curved knife for carving polyethylene foams: customizing a grapefruit knife**

- Grind as illustrated (1), removing the factory serrations and creating a more distinct bevel.
- Increase the curve of the blade by hammering the blade over the horn of an anvil (2). Maintain a sharp edge by using a fine needle file.

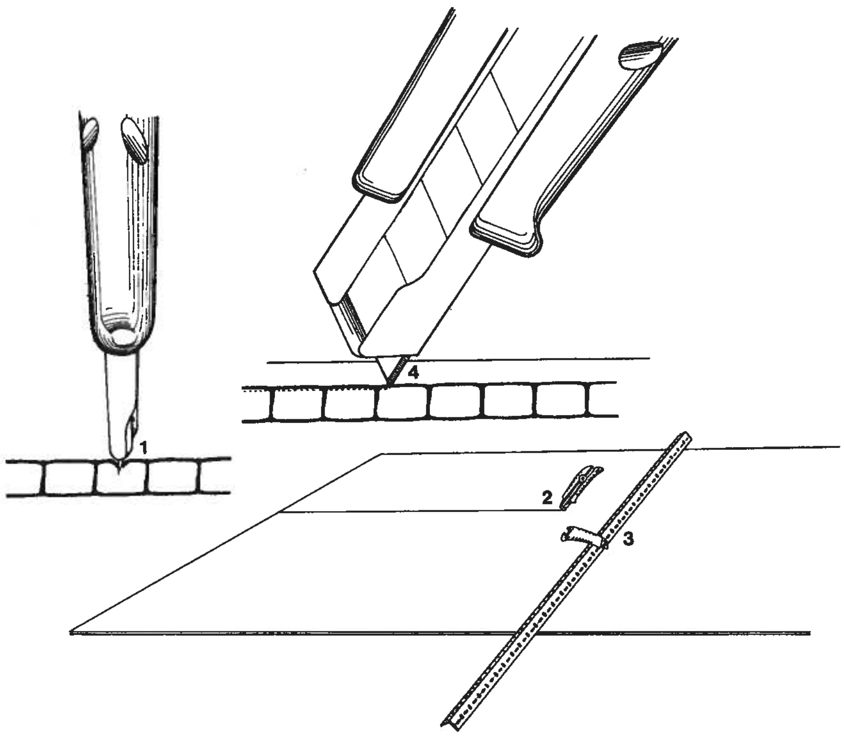
Figure 7




**Fabricating a padded artifact nest without using adhesives**

- Cut a block of the required size from a foam slab (1).
- Carve out a concave form that is slightly larger than what is required for the object (2).
- Cut a slit around the circumference of the concave form (3).
- A simple slit (4) creates a holder for an identification tag or card (5).
- Create a well using a cork borer (6) of a slightly smaller diameter than the intended container (7). Twist the borer while inserting.
- Create a flat bottom to the well (8).
- Remove the foam plug (9), and insert the container.
- Carve out handle holes using a curved knife (10). See Figure 6 for instructions on customizing and curving a knife blade.
- Lay padding into the concave form (11), leaving surplus over the lip to create a soft edge (12).
- Drape the fabric that is to be in contact with the object inside the form (13). Cut the fabric oversize to allow for surplus to be tucked into the slit (14).
- Tuck the fabric into the slit until the material draped in the nest is smooth and even (15). Use either a knife edge or a custom-shaped stick to push the fabric into the slit (16).
- The pinching effect of the narrow slit and the rough open cell structure will grip the covering fabric effectively. However, if rough handling and tugging action is anticipated, it will be necessary to adhere the slit closed with hot-melt glue.

Figure 8

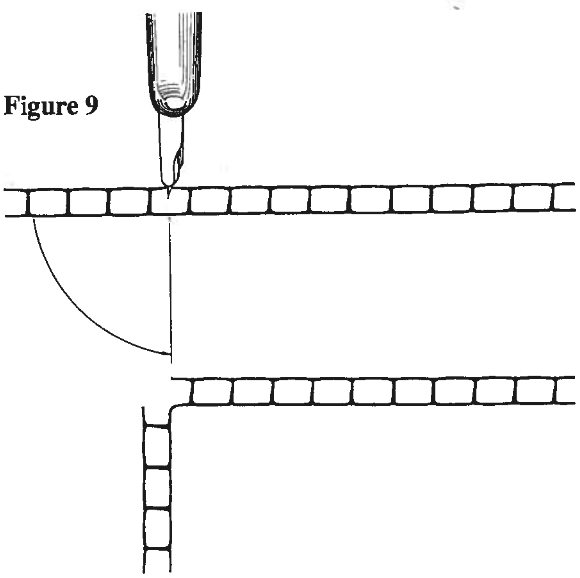



**Knife-cut bends**

The following instructions describe how to prepare a sheet that is to be bent into a tray box, a folio, etc.

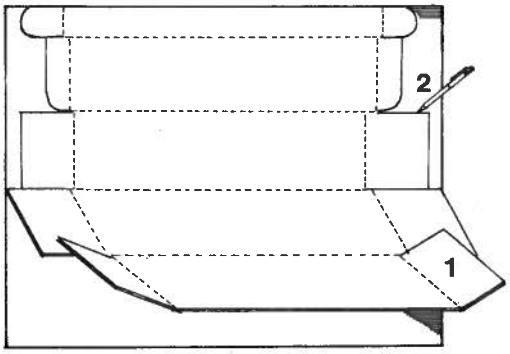
- When cutting along the channel lengths, adjust the blade depth to prevent cutting through the material completely (1). The thinner centre area of the flute skin results in a slight caving in of the surface, which guides the knife without the aid of a straight edge (2).
- When cutting across the channels, however, a straight edge is required. A Dexion perforated angle iron acts as a good straight edge (3) for making long, straight cuts.
- Making a bend across the channel requires only a very shallow cut (4). In fact, the upper skin need not even be cut through. This applies to sheets up to 5 mm (13/64") thick; thicker sheets will require deeper cuts. Figures 11a to 11e give instructions for constructing an oversize tray.

Figure 9



Simple right-angle inside bend. This is probably the most common technique for making a storage container.

Figure 10a

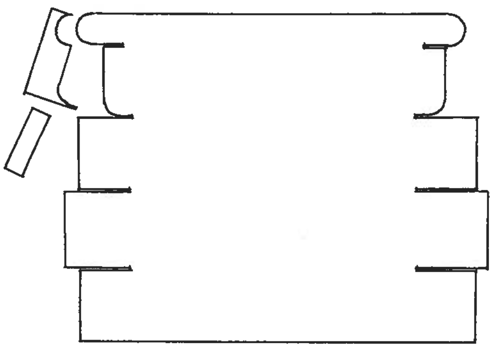



## Constructing a one-piece box and lid

### Develop pattern

- Develop a corrugated cardboard pattern (1), and trace it onto the polyfluted sheet (2) using a water-soluble or alcohol-soluble pen.

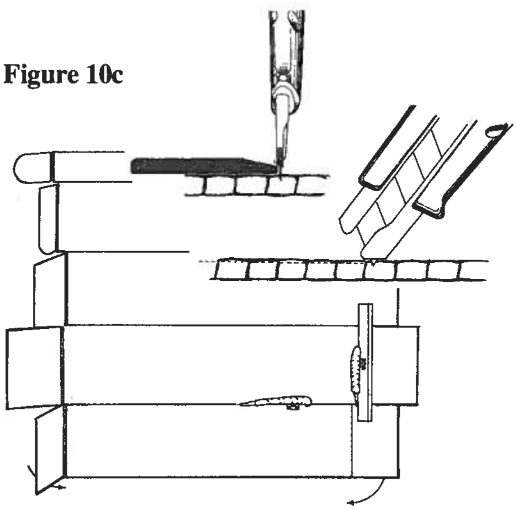
Figure 10b



### Trim

- Rough out the pattern as traced.

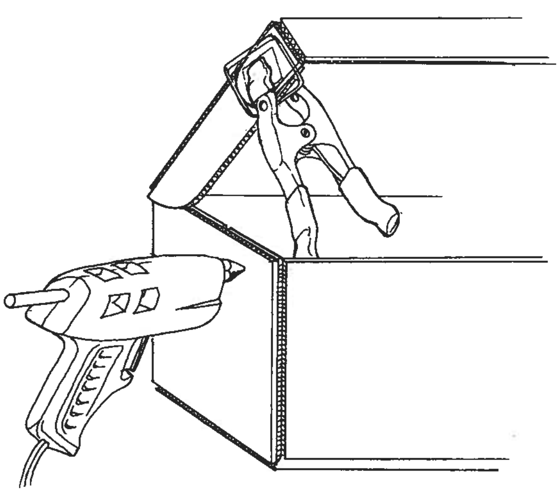
Figure 10c



### Cut to bend

- Cut the bend lines as illustrated. See Figures 8 and 9 for cutting and bending instructions.
- Turn the pattern over and bend the sides up.

Figure 10d



### Assemble

- Install the desired fasteners. See Figures 19 to 26 for examples and for instructions.

## Cutting and Fabricating an Oversize Tray

- Add two times the height of the tray wall to the length and width of the intended tray. The height of the tray wall must be based on flute widths.
- Cut the upper skin between two membranes (see Figure 11b) at lines Y.
- Scribe lines X all the way across both ends.
- Cut 3/4 of the way through the sheet (see Figure 11c) on lines X up to the point where they intersect with lines Y.
- Measure one sheet thickness over from the scribed lines X in the side wall areas, and mark lines Z. Cut through the sheet along lines Z. Also cut through the sheet along lines Y, but only from lines Z to the end of the sheet.
- Turn the sheet over and bend the corners (see Figure 11d).
- Soften the corners with a torch (see Figure 11e).
- Fasten the top of each corner with a screw or with another alternative, as illustrated in Figures 19 to 26.

**Figure 11a**

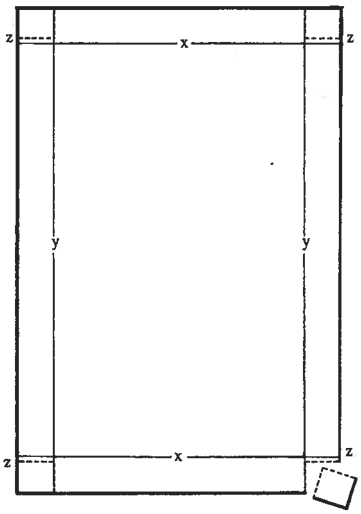
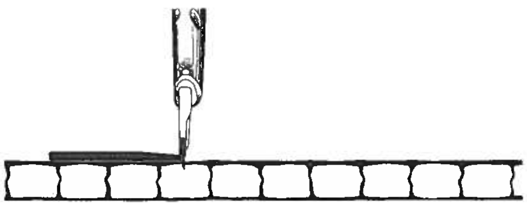
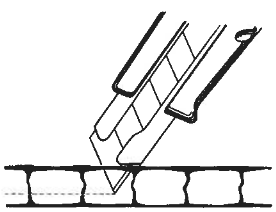



**Figure 11b**



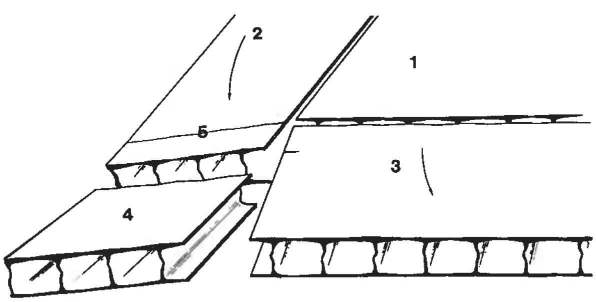
When cutting along the channels, set the blade at a shallow depth to prevent cutting both skins. Always use a straight edge when cutting thick sheet. Keep the blade perpendicular to the sheet. Remember to scribe first.

**Figure 11c**



To bend a corner across the grain of flutes, scribe along a straight edge and then cut 3/4 of the way through the sheet. Cut in passes until the blade reaches the preset depth.

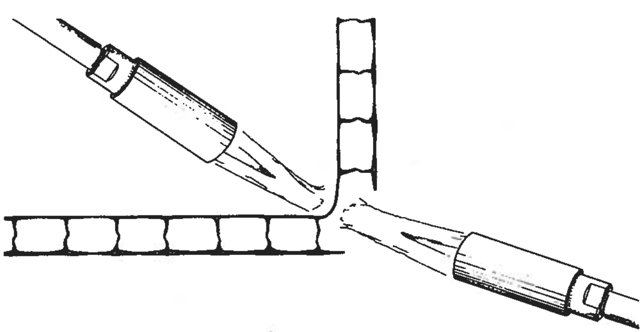
**Figure 11d**




View just as the bends are about to be made:

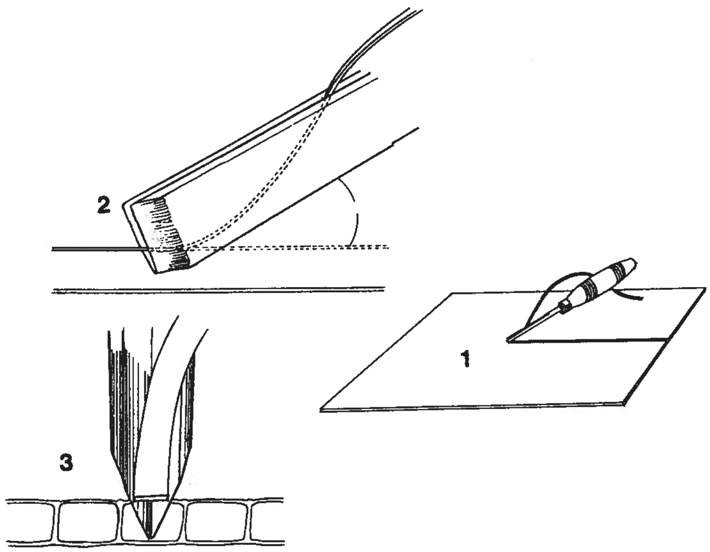
1. Underside of the container's base
2. Exterior side wall
3. Exterior end wall
4. Waste piece
5. Scribe line

**Figure 11e**



Corner bends made in thick material must be softened so that the bends will set into the desired configuration. Soften each bend from both sides. The plastic will have reached a softened state when the bending bruise (whitening at the bend) disappears and the bend is no longer under tension. Keep the torch moving in a sweeping action. Overheated or transparent patches will disappear once the plastic cools.

Figure 12a

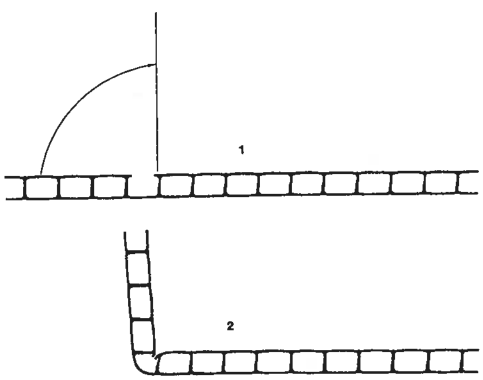



## Parting Chisel Bends

### Removing the top skin of a channel

With practice, the top skin of a channel can be removed quickly with one smooth pass using a sharp parting chisel held at the correct angle (1). Side view (2). End view (3).

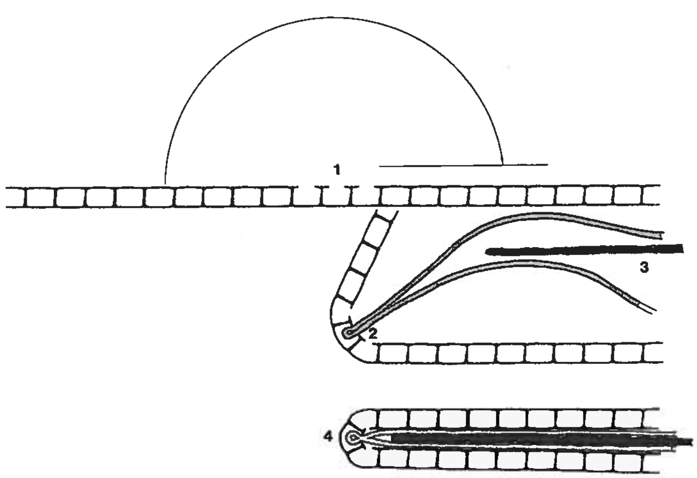
Figure 12b




### Simple corner

A single channel is opened (1) to create a simple 90° bend (2).

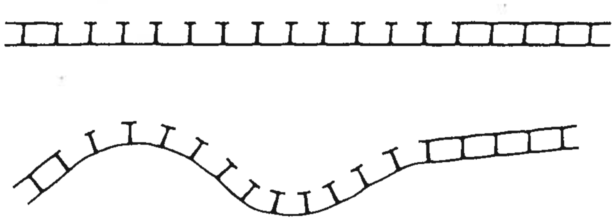
Figure 12c




### Folder bend

- Create a folder by opening 3 or 4 channels (1). The bend circumference will depend on the number of channels that have been removed and on the number of uncut channels between the ones that have been removed.
- Insert the crease of a folded interleaving foam or cloth padding (2).
- Insert an artifact suitable for flat padded storage (3).
- Close the folder (4) and secure it with some type of tie, i.e., twill tape, velcro, etc.

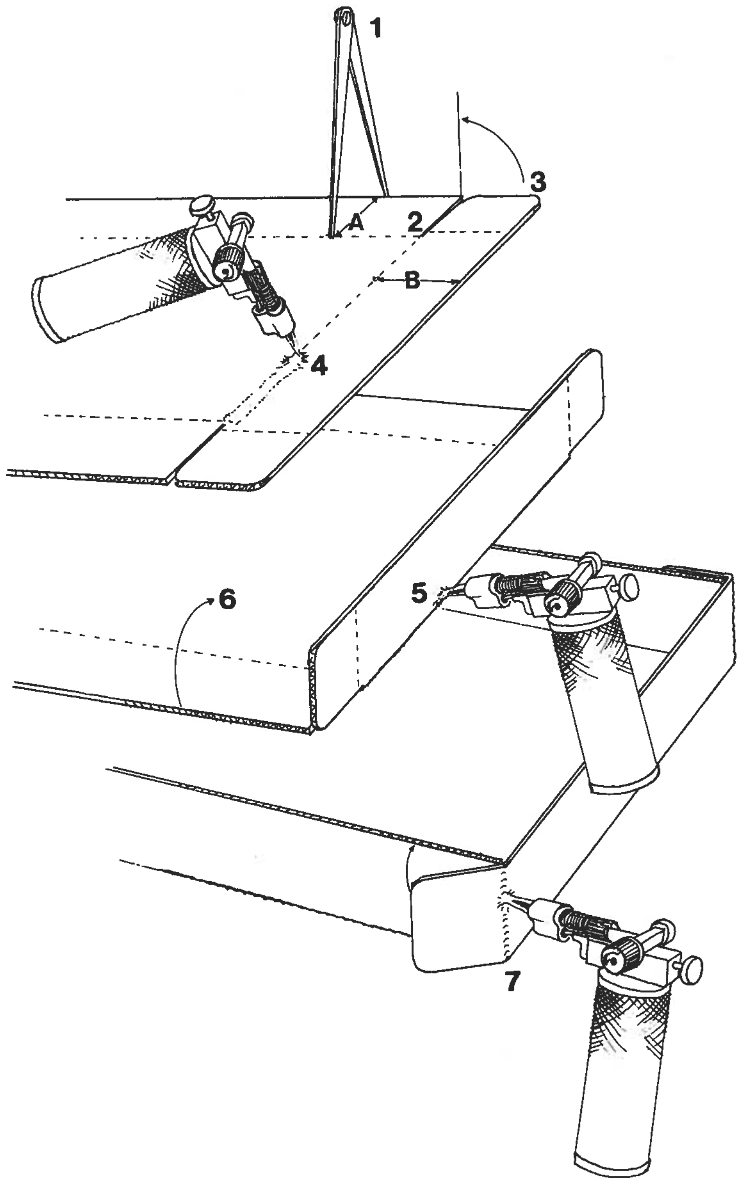
Figure 12d



### Multiple channel openings

Smooth concave or convex curves can be created by removing multiple channels in series. However, the curved form must be supported by some type of rigid backing shape (i.e., must be glued onto a corresponding profile).

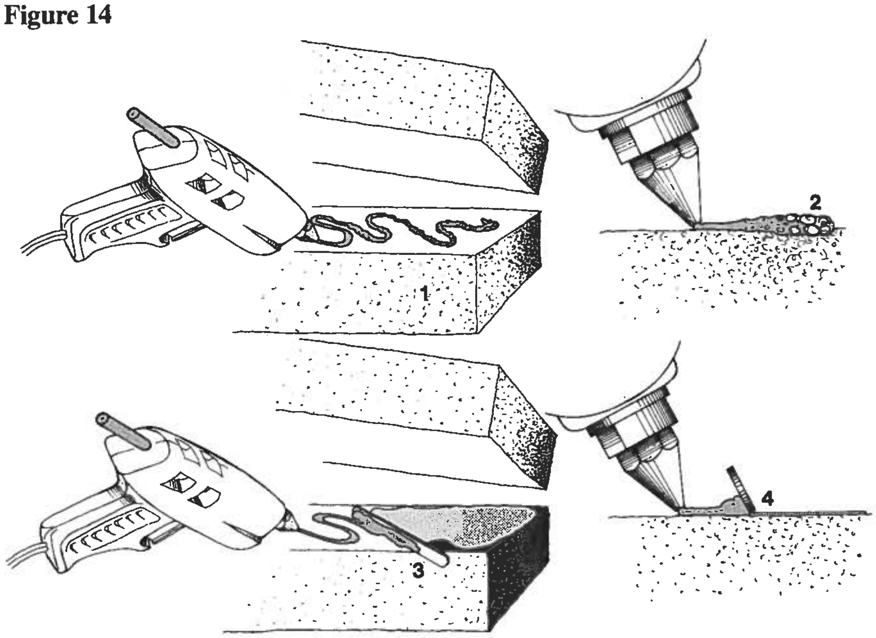
Figure 13




**Constructing a simple tray by heating and bending**

- With a divider (1), mark wall heights of equal sizes on a sheet of polyflute (i.e., A is the same as B).
- Cut corner flaps (2).
- Round the corners to remove sharp edges (3).
- Soften the first fold line by moving the micro flame along the sheet on what will be the inside of the tray (4). This should result in an even, softened band that is 1 cm (25/64") wide. Overheating will melt the top skin. Underheating will result in a bend that is not square, because too much tension will remain in the corner.
- Fold up the side and hold it square while heating and softening the outside surface of the bend (5). Once softened, the bend is relaxed and stands square on its own.
- Continue this process on all sides (6).
- Use heat to bend the corner flaps (7), and finish as desired.

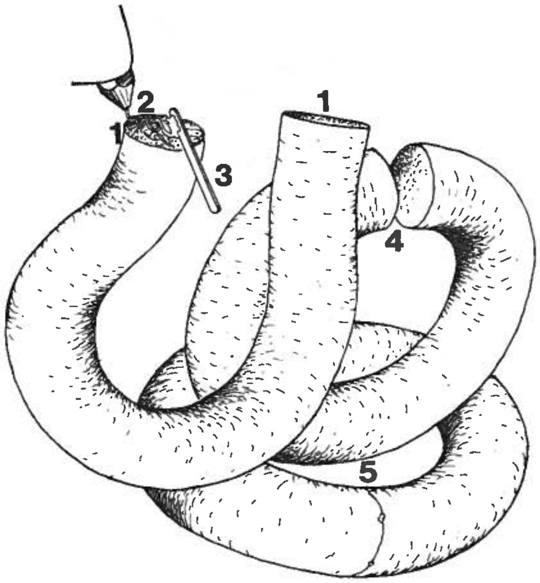
Figure 14




**Hot-melt adhesive on foam**

- A molten bead is hot enough to cause thermal degradation of polyethylene foams (1). Bubbles form, and the resin begins to melt down into the surface (2).
- Wooden sticks work well for spreading the molten resin (3).
- The thinned film cools quickly and does not affect the foam surface. However, the material to be attached must be put into position quickly while the adhesive film is still tacky (4). Maintain pressure on the joint until the adhesive is cool; due to the insulating effect of the foam, this may take 30 seconds or more.

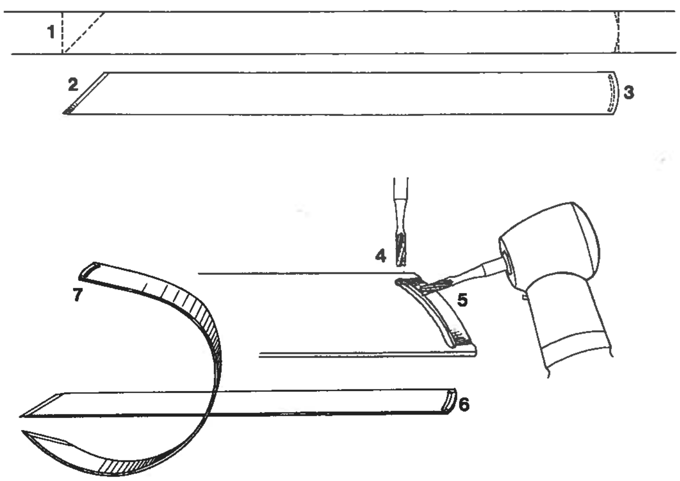
**Figure 15**




### Fabricating Ethafoam rod rings

- Slice both ends of the rod cleanly and squarely (1).
- Apply hot-melt resin to one end only (2). Apply enough resin so that when it is spread out the whole surface will be covered.
- Spread the resin immediately so that a thin layer covers the whole surface (3).
- Quickly join and align the two ends (4).
- Hold the joint securely until it is completely cool (5). Rods thicker than 2.5 cm (1") require a full minute to cool due to the insulating properties of the foam. When fabricating small-diameter rings, there is a great deal of tension on the joint so the adhesive must be cool to be strong. When creating several rings of the same diameter, set up a jig to hold each joint while it cools, and move on to making the next ring.

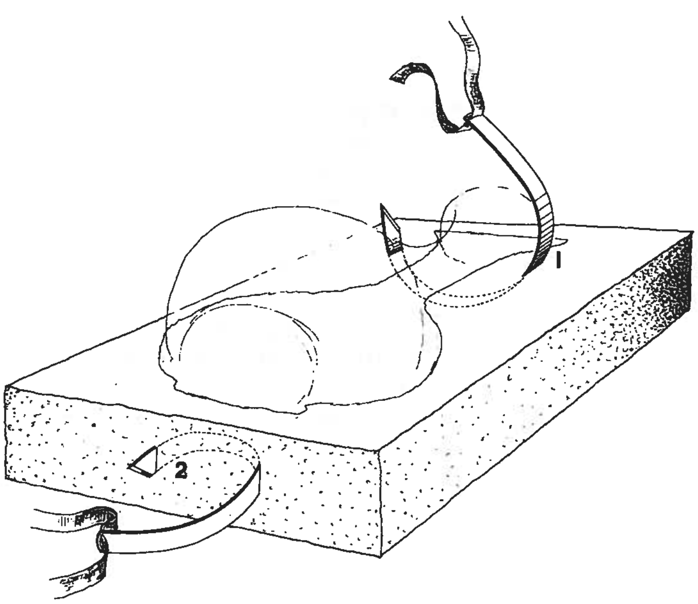
**Figure 16**




### Fabricating twill tape needles

- Cut two 23 cm (9") lengths of scrap 1.3 cm (½") steel strapping as indicated by the dotted lines (1). Cut the strapping by using a heavy pair of metal shears or by scribing deeply with a hard point and then bending back and forth until the strapping breaks.
- Sharpen the piercing end of the needle (2) by grinding a bevel along the edge.
- Round the opposite end of the needle (3).
- Grind out the eye of the needle as illustrated (4). This is best done using a high-speed dental drill with a carbide bur. A local dentist or jeweller may be able to help with this step if the required equipment is not easily available.
- Bevel behind the eye (5) to make the needle easier to insert. Remove any rough edges by rubbing the needle on a sharpening stone.
- Leave one needle straight (6).
- Bend the other needle into a curve by hand (7).

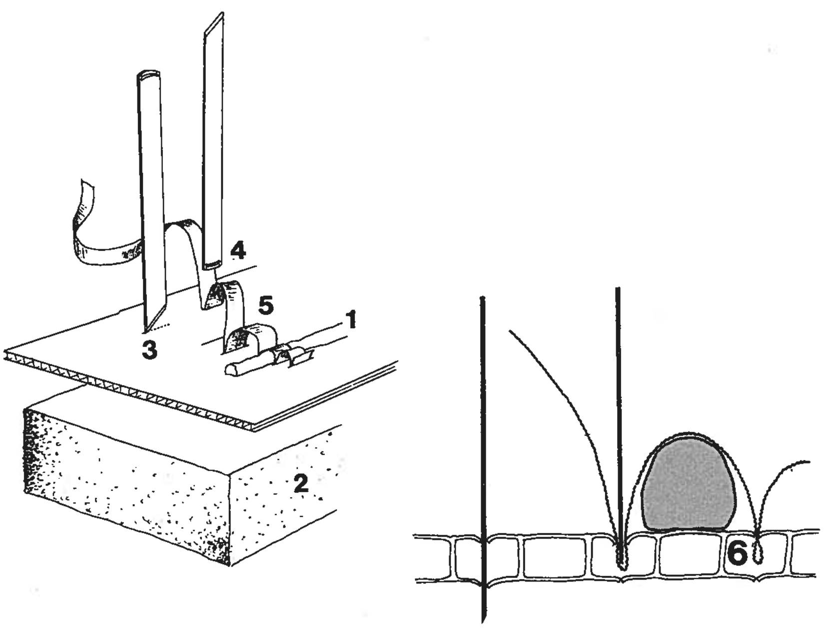
**Figure 17**




### Examples of a curved needle in use

- To anchor an object to a block of foam, thread twill tape through the foam (1), and tie the ends of the twill tape around the object.
- To create a handle in a block of foam, bend the needle into a sharp curve and then push it through the foam in a short arc (2). Pull the tape through, tie it into a knot, and pull the knot back into the foam, leaving a clean handle loop.

Figure 18



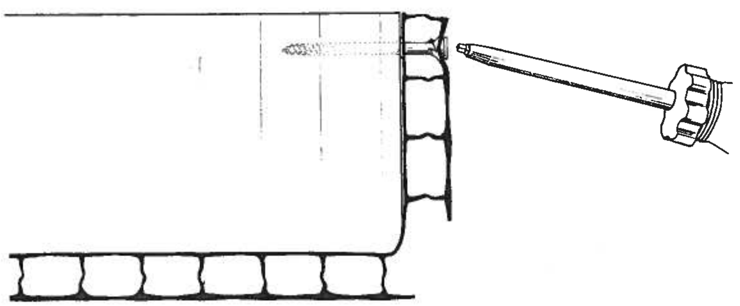

**Holders for multi-contact lightweight mounts**

Twill tape is an ideal material for holding a lightweight object against a mount. The following method does not require stitching through the base. Instead, fluted sheet membrane pinches the tape and holds it in place.

- Lay the artifact (1) on the sheet of polyflute.
- Protect the piercing tool by placing a foam block underneath the sheet (2).
- Pierce slits through both the upper and lower surfaces of the polyflute at the desired locations (3).
- Reverse the needle (4).
- Using the blunt end, push the tape into the slit until the tape is tight against the object (5).
- Remove the needle. The sides of the slit will grip the tape as it becomes taut (6).

## Fastening Alternatives When Constructing Trays and Boxes Made of Thick Polyflute Sheet – Figures 19-23

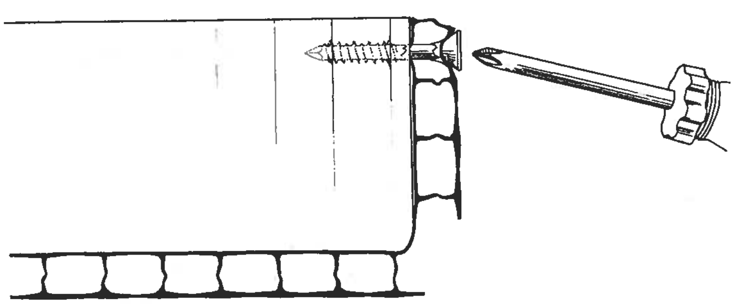
Figure 19



**Wood screw**

Probably the simplest and least expensive method for fastening polyflute sheet is to insert a wood screw that is long enough to penetrate at least two channel membranes. This type of fastener is sufficient for boxes with low strength requirements.

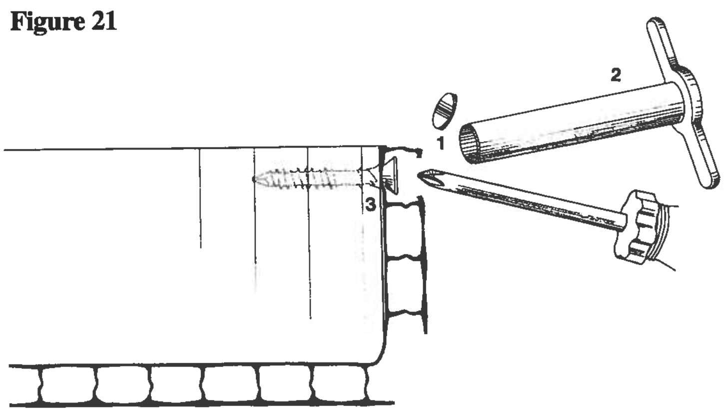
Figure 20



**Concrete screw**

Concrete screws are stronger fasteners than wood screws because they have larger thread flanges and a greater head size. However, the larger head may stick out too far from the tray wall. Turn the screw in further to make the head nearly flush with the surface.

Figure 21

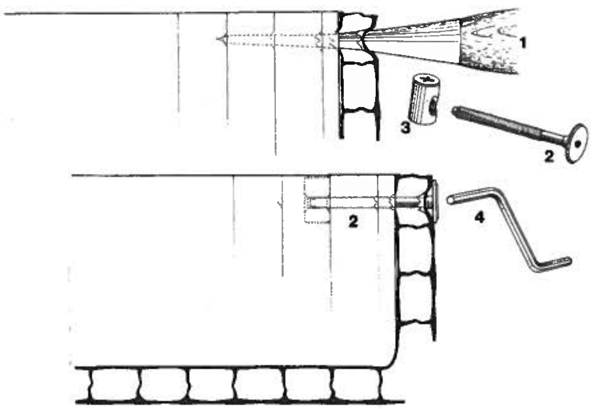



**Inset concrete screw (as an alternative to the exposed screw head)**

The large head of a concrete screw can be set into the inside portion of the channel by using the following procedure:

- Remove a plug the size of the screw head from the outside of the sheet at the point where the screw will be inserted (1).
- Cut out the plug by twisting back and forth with a cork borer of the appropriate size (2).
- Insert the concrete screw and turn it until it is snug (3).

Figure 22

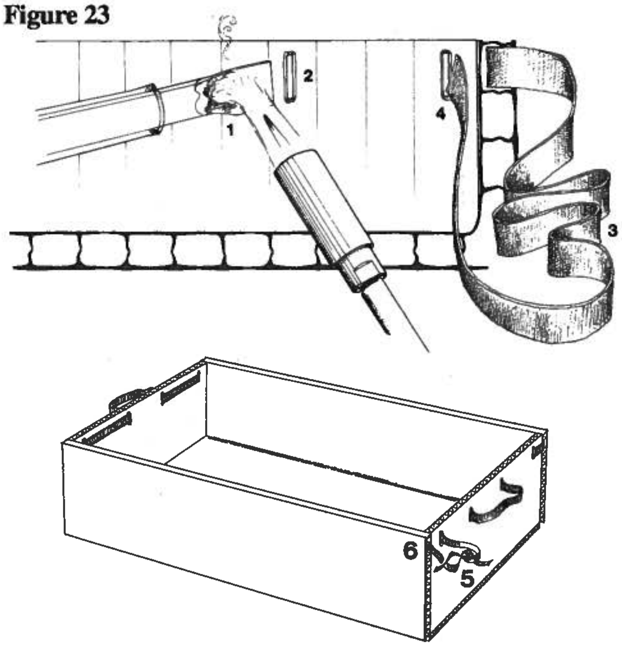


**Cross-dowel nut and bolt**

The strongest fastening method utilizes a cross-dowel nut and bolt. This fastener is recommended when fabricating boxes that require great strength and durability.

- Insert an awl (1) into the sheet at the desired location.
- Wedge a cross-dowel nut into the channel of the sheet, and insert a connector bolt (2) into the nut until the head makes contact with the nut (3).
- Tighten the bolt until the cross-dowel nut begins to distort the channel walls (4).

Figure 23



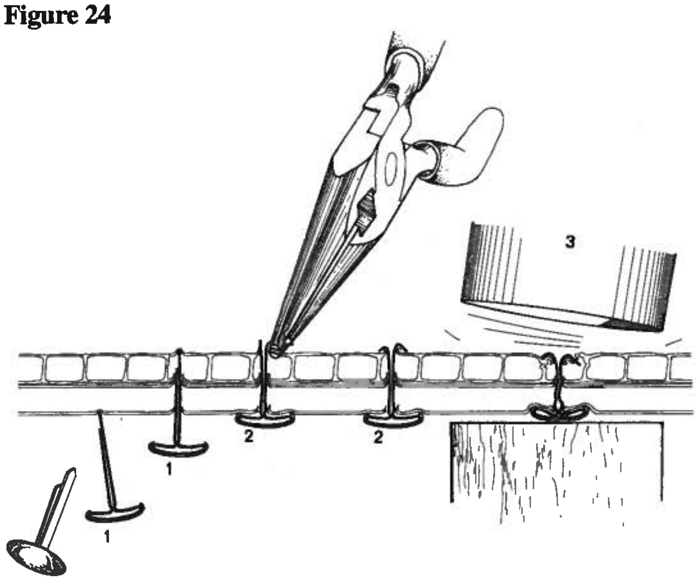
**Continuous webbing tie/handle system**

Nylon webbing is very durable and strong, and can be inserted through the channels of polyflute sheet to create both handles and a fastening system.

- Heat the irons that will be used to make the holes (1) until they are hot enough to burn off all residual plastic.
- Melt holes through both surfaces of the sheet (2). Clear the holes of residual melted plastic to make it easier to insert the webbing.
- Measure the length of webbing required (3) by running the webbing around the circumference of the container and then adding 30% to this length.
- Thread the webbing as illustrated (4).
- Tie the webbing at the corner (5).
- Manipulate the webbing until the knot disappears into the channel (6) and the handles are of equal length at both ends.

## Fastening Alternatives When Constructing Trays and Boxes Made of Thin Polyflute Sheet – Figures 24-26

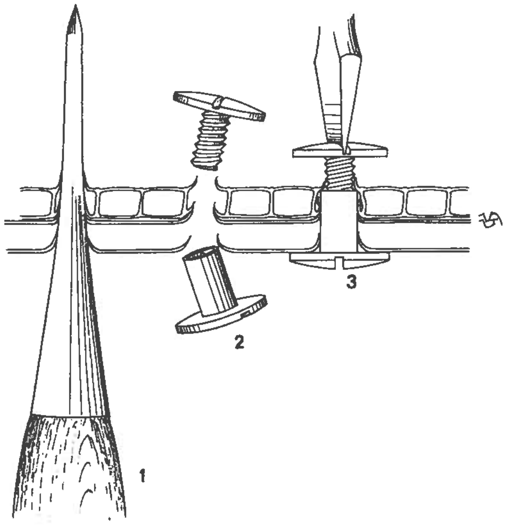
Figure 24



**Split brass rivet**

- Press a 1.3 cm (½") rivet into the polyflute sheet by hand (1). Pre-pierced holes may be required for rivets made of thinner brass stock. Avoid flimsy split pins because they are too weak and require pre-punched guide holes.
- Use pliers to bend the exposed tabs as illustrated (2).
- Give the bent tabs a sharp rap with a flat-head mallet (3). A block of wood held in a vice underneath the sheet will act as an anvil. The resultant fastener is secure and will not catch on any objects that slide past it.

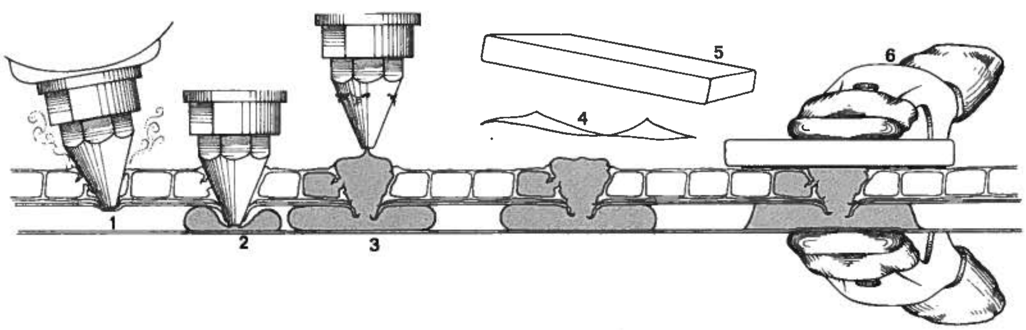
Figure 25

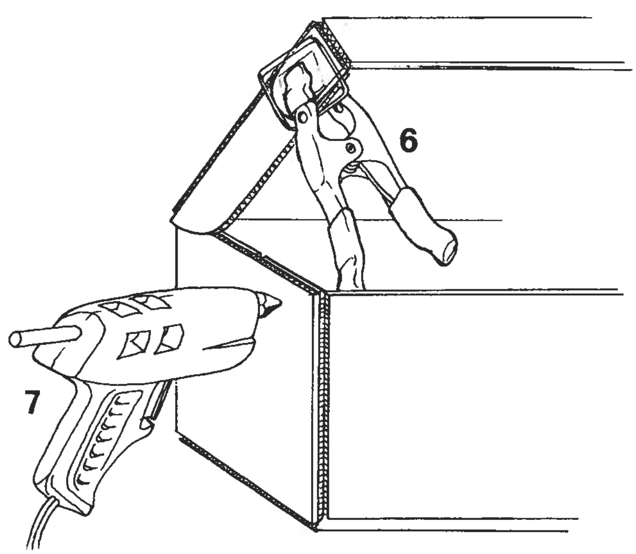



### Nylon adjust-a-lock

- Push an awl far enough into the polyflute sheet to create a pre-punched hole (1) large enough to insert the female rivet.
- Insert the female rivet (2).
- Screw in the male rivet (3).

Figure 26




### Flush hot-melt rivet

- Slowly insert the nozzle of a hot, clean hot-melt applicator into the sheet (1). Twist the nozzle back and forth to ensure that it perforates the skin of the lower channel.
- Once the skin of the lower channel is perforated, begin depressing the trigger so that molten resin begins to flow into the lower channel (2).
- Raise the nozzle out of the channel while the resin flows in (3). Leave surplus resin.
- Place a square of scrap silicon release paper over the button of molten resin (4).
- Place a block of plexiglass (or another rigid material) over the silicon release paper (5).
- Apply pressure to the joint using a hand spring clamp (6). Leave the clamp in place for a minimum of 15 minutes or until the resin core has reached room temperature. The release paper slides off once the resin has cooled, leaving a strong, flush fastening.
- Move on to the next rivet (7).

# Appendix I: Essential Tools

Assemble a set of tools to be used solely for working with polyethylene foam and fluted plastic sheet. Once the set is assembled, keep the tools together and apply some sort of very visible marking or colour band to each tool. This way, these tools can be spotted easily should one go astray. The more accessible the tools are, the more readily they will be used.

| Tool | Description | Uses | Approx. Cost (1992 $) | Suggested Retail Sources |
|---|---|---|---|---|
| Olfa utility knife | - 1.3 cm (½") snap-off blades (seven segments per blade)<br>- lockable blade position<br>- comfortable grip | - primary tool for hand cutting all Coroplasts, Ethafoams (up to 7.6 cm [3"] thick), micro-foams, matboard, Tyvek, and other sheet material<br>- The blades are surgically sharp, and the segments can snap and fly off when extended. Use the knife only for straight cuts. Do not apply any twisting or bending action to the blade. Always slip the exposed blade back into the handle when not in use. | 8-12 | hardware stores; stationary stores |
| Replacement blades for Olfa utility knife | - 10-blade pack | - as described above | 4 | hardware stores; stationary stores |
| Chef's slicer | - blade 30 cm (11.8") long for cutting meat (micro-raggedness tears the Ethafoam membranes, not unlike the edge on a butcher's knife)<br>- thin and flexible<br>- best sharpened with a chef's sharpening steel<br>- used with a sawing action | - cutting and carving thick Ethafoam and polystyrene blocks<br>- carving large, shallow concave shapes by bending the blade while sawing<br>- producing clean, straight cuts in thick foams that would normally require band sawing | 35 | professional kitchen supply stores |
| Chef's sharpening steel | - standard professional knife edge maintenance tool | - sharpening slicer and other curved knives | 20-40 | professional kitchen supply stores; restaurant supply stores; department stores |
| Hot-melt gun | - plug-in, workshop, or industrial-size unit is preferred<br>- trigger feed<br>- uses various resin refill sticks | - for adhering Ethafoam to Ethafoam<br>Microfoam to Ethafoam<br>Ethafoam to matboard<br>fabric to Ethafoam or to matboard<br>polystyrene to polystyrene<br>Coroplast to Coroplast, provided that the joint is mechanically assisted such as with a hot-melt rivet | 17-25 | Canadian Tire stores; craft stores; hardware stores |
| Glue sticks | - 20.3 cm (8") refills<br>- Canadian Tire Mastercraft (formerly Bostik) *<br>- 3M #3764 *<br>* These products were analyzed and were found to be primarily Ethylene/ vinyl acetate. See CCI's Analytical Research Services (ARS) Reports #2307 and #2309. | - as described above | 18 per case of 50 | Canadian Tire stores; hardware stores |

| Tool | Description | Uses | Approx. Cost (1992 $) | Suggested Retail Sources |
|---|---|---|---|---|
| Propane torch | a) - standard hardware variety or new, push-button, instant-lighting head for standard replaceable propane bottles<br>b) - new generation of butane micro-torches are a good alternative because of their sharp flame, quick lighting, and small size | - softening polyfluted sheet to form bends<br>- sealing ends of nylon webbing<br>- re-skinning Ethafoam open cell structure after cutting<br>- welding Ethafoam to Ethafoam by using flame spreader attachment<br>- heating irons used to pierce slots in Hi-Core | a) 25<br>b) 40 | Canadian Tire stores; hardware stores; suppliers of welding equipment; specialty craft stores |
| Short straight edge | - heavy steel ruler 61 cm (24") or 91.4 cm (36") long, 4.1 cm (1 5/8") wide, and 0.8 cm (5/16") thick<br>- one edge bevelled | - when cutting all straight lines, particularly across Coroplast flutes | 8-12 | art and graphic art supply stores; book binding supply stores |
| Medium straight edge | - 1 m (39.4") standard metal ruler<br>- rubber backing helps prevent slipping<br>- the heavier the better | - as described above | 10-20 | hardware stores |
| Long straight edge | - 2 m (78.7") length of Dexion perforated angle iron<br>- ideal ruler because it stays flat and straight<br>- working edge remains pressed to the material<br>- lightweight for its length | - when cutting pieces from large stock sheets | 10-20 | warehouse supply stores; used office furniture stores |
| Carpenter's square | - aluminum or steel flat square<br>- must be checked occasionally for squareness | - ensuring square cuts | 6-12 | hardware stores |
| Japanese garnish awl | - sharp point tapering rapidly to a thick shank | - pre-setting holes in Coroplast and Hi-Core for various kinds of rivets<br>- marking lines on plastic surfaces | 10 | cabinet maker supply stores |
| Divider | - pointed steel<br>- can be spring type | - marking repetitive measurements<br>- minimizing ruler measurements | 8-15 | machine tool supply stores |
| Alcohol-soluble marker | - test any of the large variety of pens available commercially | - marking points and lines prior to cutting | 1 | stationary or drafting supply stores |

# Appendix II: Tools Made or Altered in the Workshop

These tools are designed for specific fabrication techniques described in this Technical Bulletin, and are indispensable for their specific purposes. Some may have a commercially available equivalent. This list is by no means exhaustive. Each craftsperson will develop individual solutions to meet specific needs.

| Tool | Description | Uses | Approx. Cost (1992 $) | Suggested Retail Sources |
|---|---|---|---|---|
| Curved knife | - stainless steel grapefruit knife<br>- ground and curved to suit the need | - carving out nests and other concave depressions in Ethafoam | 5 | hardware stores; household department stores |
| Large plastic square | - 122 cm (48") sides<br>- large version of draughtsman's 45°/90° square<br>- Lexan or Plexiglas<br>- transparent and lightweight | - ensuring square cuts on larger pieces of Coroplast, etc. | 10-20 (off cuts) | suppliers of plastics; glass stores |
| Flat needles (curved and straight) | - sections of steel strapping 16 mm (5/8") wide used to secure shipping crates and pallets<br>- cut, shape, and sharpen as illustrated (see Figure 16)<br>- needle eye can only be ground with high-speed dental drill | - threading 1.3 cm (½") or wider twill tapes into or through Ethafoam<br>- piercing and tucking in twill loops (using a blunt rounded end) | 0 (salvaged) | warehouse garbage |
| Upholstery needles | - 15.2 cm (6") to 20.3 cm (8") round or three-sided steel needle with large eye | - piercing Coroplast and Ethafoam layer to draw through twill and other material for ties<br>- sewing blocks of Ethafoam together | 5 each | upholsterers; knitting supply stores; or make yourself |
| Piercing irons | - iron bar stock of various sizes with heat-resistant handle<br>- heat to near-glowing with propane torch<br>- use course steel wool to remove smouldering plastic from irons | - melting/piercing slot holes through Coroplast and Hi-Core to insert nylon webbing, handles, or pulls | 0 (scrap metal) | make yourself |
| Lacing needle | - Lexan 122 cm (48") long, 4 mm (5/32") wide, and 1.5 mm (1/16") thick<br>- eyelet drilled and carved at one end | - threading twill through standard 4 mm (5/32") polyflute sheet channels | 0 (off cuts) | make yourself |

# Appendix III: Additional Specialized Tools

These tools are for more specialized work. However, anyone doing ongoing work with support mounts will benefit from having these tools.

| Tool | Description | Uses | Approx. Cost (1992 $) | Suggested Retail Sources |
|---|---|---|---|---|
| Straight parting chisel ("V" chisel) | - 60°, 6 mm (¼") parting tool<br>- wood carving tool<br>- must be honed to a sharp and finely polished edge | - allowing polyflute sheet to be easily bent or curved to a desired shape by cutting a "V" groove across the Coroplast grain and along the flutes. This creates smooth outside bends for Coroplast boxes and trays because the cuts are on the inside. | 25 | cabinet maker supply houses |
| Needle-nose pliers | - standard tool | - crimping split brass rivets when fastening Coroplast | 10-15 | hardware stores |
| Pop-riveter | - standard tool | - inserting various types of pop rivets | 15 | Canadian Tire stores; hardware stores |
| Block plane | - standard tool | - removing power saw blade burr when cutting Hi-Core with table saw or band saw | 18-30 | hardware stores |
| Cork borer set | - set of 15 sharpened brass tubes used to cut lab stoppers and bungs<br>- outside diameters 4.8 mm to 23.8 mm (3/16" to 15/16") | - cutting finger holes or other holes in plastics<br>- cutting various round wells into Ethafoam (e.g., to hold containers)<br>- cutting foam cores to be used as padding points | 60 | laboratory equipment supply houses |
| Cork borer sharpener | - for sharpening cork borers described above | - maintaining sharp edges on cutting tubes | 50 | laboratory equipment supply houses |