DUPLICATION OF PARTS IN WOOD OR PLASTIC

We have put together a complete library of books on gun work and tool making into one file on a CD. This is the most complete volume covering information that is no longer available.
H. Hoffman

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PREFACE

This book is for beginners as well as experience craftsman, who need to find information to make duplicate parts or objects for selling at the maximum price.

The methods discussed in this book are basic instructions that you will need to make duplicate objects, whether in wood or plastics.

In my other books, many other processes are discussed that will help craftsman to start their own business. Much of the information given has c from over 35 years experience in the related fields.

After mastering the basic skill, you will be able to learn and master many as you progress deeper into the process of making duplicated objects.

All of my books are directed for the person who needs to make additional info and with a little time will be able to start his or hers own business.

I am constantly changing and improving my own craft, skills and finding ways to produce a quality product. I strive for a better and higher quality on each one I make. If you do this also, you will be able to continually improve your product.

I want to thank all of the following Corporations for the help and information in this book. Without there help most of the information would not be available.

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DUPLICATION OF PARTS IN WOOD OR PLASTIC

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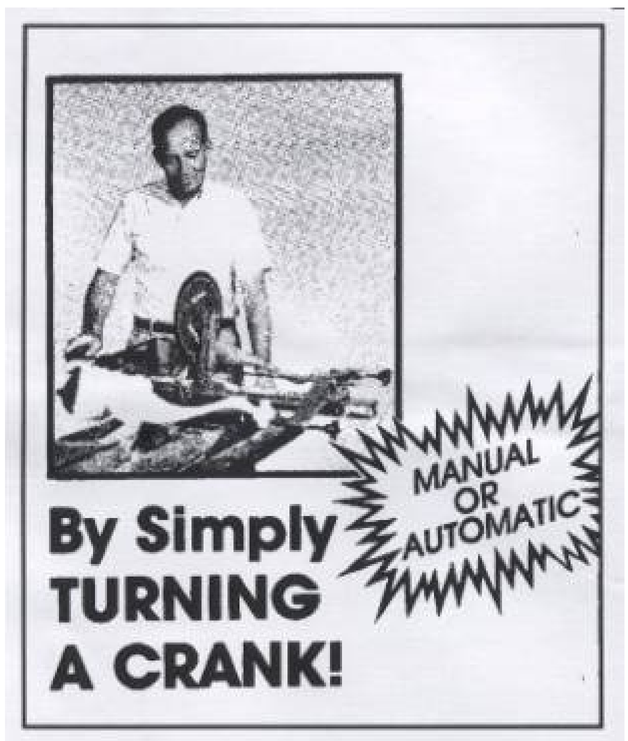
CHAPTER 1 - DUPLICATION OF PARTS IN WOOD & PLASTICS

BY Harold Hoffman

ROTO CARVER

Please Note - If you are interested in making Gun Stocks. Check out the Roto Carver. I have used it for a number of years with excellent results.

The Roto Carver is a add on for a table saw, and will do a good job of duplicating a gunstock. It may be the most economical way for the gunsmith to make stocks. It will do no inletting but will serve the purpose of shaping the stock.



1 FREE CENTER: The free center attaches to the model and work piece in seconds with a hammer blow.

2 FOLLOWER WHEEL: A rubber tire prevents damage to the model, which rotates against the follower wheel camming the work piece into the saw blade.

3 LEAD SCREW: The lead screw coupled to the crank feeds the carriage laterally as the model and work piece revolve.

4 CARRIAGE FEED RELEASE: A quarter turn of a lever splits the feed nut from contact with

the lead screw releasing the carriage for quick lateral movement by hand gliding easily on nylon bearings. A quarter turn of the lever reengage s the lead screw for additional cuts.

5 TAILSTOCK ADJUSTMENTS:

Tailstock adjusts along carriage to accommodate work size using Total Tool.

If your hobby is creating beautiful wood objects . . .
you will discover the pleasure of expanding your hobby into the world of wood carving. This is a surprise bonus by making your saw do work together with ROTO/CARVE®, heretofore an unexpected capacity. Many rewarding hours await the person who wishes to transfer from any master beautiful carvings into wood. Although in shape the same, yet each carving is an original with its own grain pattern and type of wood. Even skilled wood carvers oftentimes wish to reproduce their own originals. What does an orchestra do with a Beethoven symphony? It reproduces music as close to the composer's interpretation as possible but yet different; — so too the wood carving.

6 ADJUSTABLE CENTERS: Dead centers are easily adjusted and quickly locked with hand knobs and wing nut locks.

7 NYLON SLIDER BEARINGS: Sixteen nylon bearings support the carriage as is glides back and forth. Nylon bearings will last indefinitely and require no lubrication.

8 COUNTERBALANCE: When model is heavier than work piece, a heavy elastic band counter-balance maintains proper contact of the model to the follower wheel.

9 DRIVE LUGS: Lugs are screwed to the model and work piece. The lugs fit into drive slots in the sprockets, which turn the synchronized model and work piece on the free centers.

10 SPROCKET DRIVE MECHANISM: A small sprocket coupled to the crank drives the two large sprockets to which the model and work piece are coupled through roller chain.

Two and two-thirds turns of the crank produces one revolution of the model and work piece while traversing about 1/8" laterally. The chain needs only occasional lubrication with heavy use.

11 ROLLER BEARINGS: Six roller bearings are used in the drive mechanism to insure smooth, friction-free operation and lasting precision.

12 SAW BLADE: It is very important that the saw blade have a wide set and be sharp, if a normal blade is used.

13 CRANK: The crank operates much like a pencil sharpener and just about as easily. Easier yet with MOTOR DRIVE.

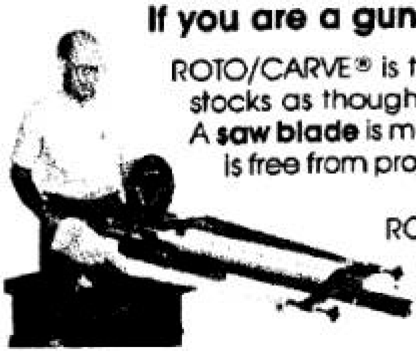
14' ' TOTAL TOOL' ': There is no need to buy wrenches or gauges; one tool provided with the machine tucked away in the end of the carriage does it all:

WOOD CONTOUR SHAPER

1 Q. Will IT ATTACH TO ANY TABLE SAW?

A. Yes. The base supports are 13" on centers. The saw should have a 1 0" or 1 2" capacity, Radial arm saws are not adaptable to ROTO/CARVE.

If you are a gunsmith . . .



ROTO/CARVE® is the most perfect tool to reproduce gun stocks as though it were created for this purpose alone. A **saw blade** is most efficient when the item to be shaped is free from projecting parts like legs of a horse. Such an item is the gunstock and the power of ROTO/CARVE® at its best. Quickly remove wood down to the original's shape. Fast! Accurate! Simple!

2Q. WHAT SHAPES ARE OPTIMUM?

A. Shapes carved in 360 degrees such as a gunstock or duck decoy free from projecting parts.

3 Q. HOW EASY IS 1T TO' ' SETUP?'

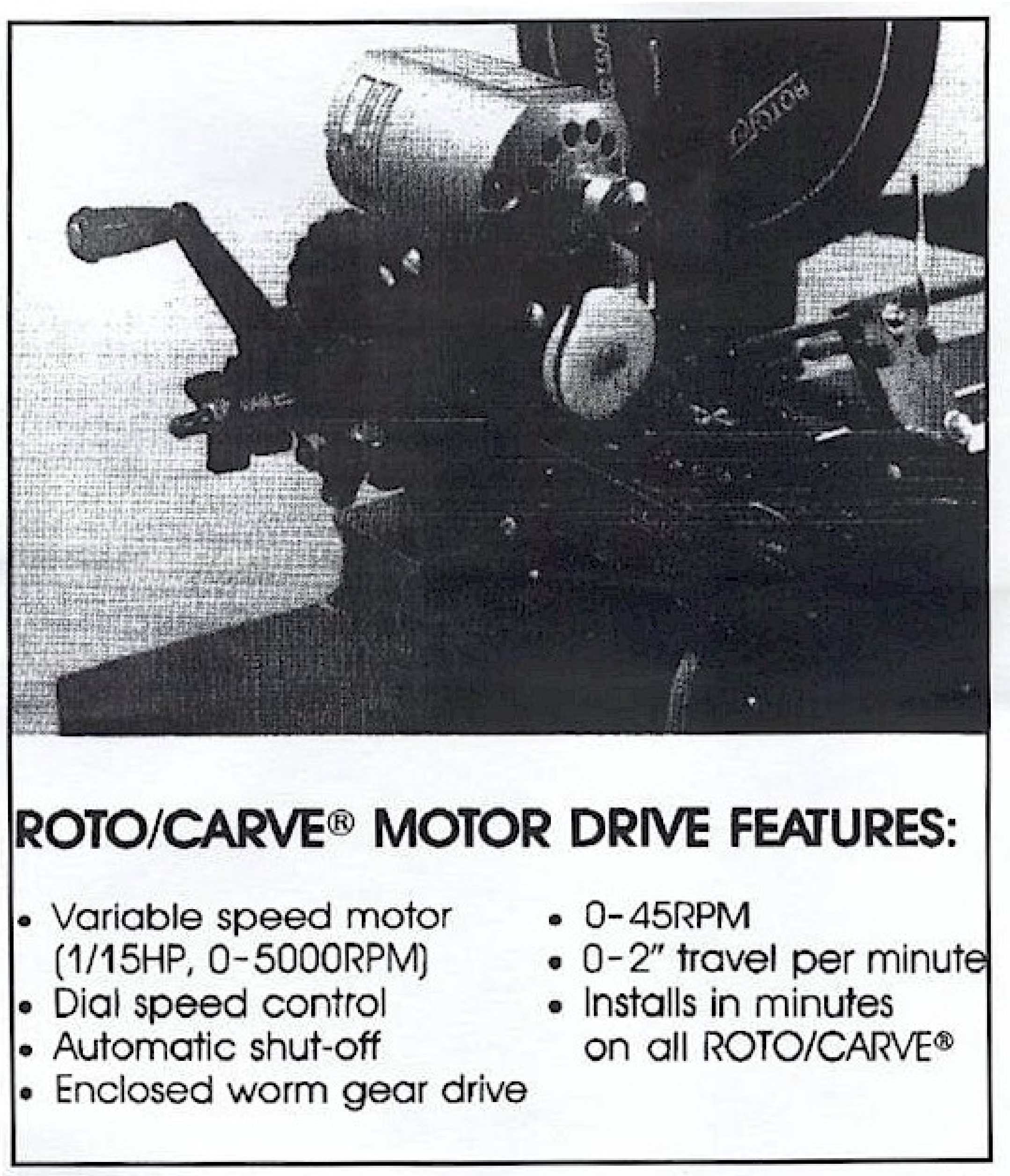
A. Special pains have been taken to make positioning of the original model simple to do and the holding device easy to adapt to any rigid material such as ceramics, plaster of paris, plastic, clay, metal or wood. Positioning of the work piece is even simpler than the model. The Operator' s Manual explains these procedures in detail. Of course, no written word beats experience; the second time around it' s a breeze.

4Q. IS IT EASY TO OPERATE?

A. Can you operate a pencil sharpener? It is almost that easy because the same type of crank rotates the model and work piece at the same time as they travel horizontally; three turns of the crank to one of the work piece.

5Q. WHAT CONTROLS THE SIZE OF THE WORK-PIECE?

A. The blade elevation determines the depth of cut. This is the only variable other than speed of feed. The contour of the model is always in contact with the follower wheel guiding the work piece as its slave into the saw blade in an ever-constant position. When the blade is at its maximum height as originally calibrated, the work piece will carve to a one to one replica of the model.



6 Q. WHAT CAN IREPRODUCE?

A. Any object to be reproduced in 360 degrees within the capacity of the machine. Examples of these objects are gunstocks, duck decoys, birds, table legs, figurines, wooden shoes, patterns, totem poles, fish, etc.

7Q. WHAT BLADE SIZE?

A. The blade must match the wheel follower diameter or 10'. For you folks with a 12" blade, replace it with a 10" blade - no problem. For best results use SHAPER BLADE.

8Q. HOW MUCH HAND FINISHING IS REQUIRED?

A. The sculptured work piece will show contour marks around its periphery about 1/64," deep. A cushioned drum sander works especially well.

9 Q. HOW QUICKLY CAN if BE MOUNTED?

A. We furnish the template for two 1/4" holes in your table, drill and tap with bits we provide and you' re in business in about ten minutes. Remount takes only a few seconds.

10 Q. WHY A SAWING CONTOUR SHAPER RATHER THAN A ROUTER TYPE?

A. A saw blade is simply much more productive than a routing cutter. Also pressure on the model is much less.

11 Q. WILL IT CARVE DETAILS?

A. ROTO/CARVE will cut all outside contours subject to limitations of blade radius. ' ' Carved in details may be added later with normal carving techniques.

12 Q. HOW IS IT BEST USED FOR MAXIMUM EFFICIENCY?

A. Prepare the work piece by band sawing away excess material. One customer who makes full size duck decoys band saws two views allowing ROTO/ CARVE' ' to complete its job in 6 minutes and in one pass.

FINISHING

The reproduced, carving, although to shape, will need to be finished by using, whatever tool is necessary to clean corners and smooth roughened areas. You may wish to carve features that the model did not contain. After the piece has been' ' cleaned' ' to its final shape, begin the finish sanding operation and watch the beauty of your carving start to emerge. Apply a coat of TUNG oil or equal and rub in thoroughly. Painting or rose maling with' ' see thru' ' wood grain is a very attractive technique. The beauty of your finished piece will give you a pride of satisfaction known only to people who have created an object of unusual value - and a desire to start the next carving tomorrow!

Included with the machine is Harald Petersen' s Duckling' ' as a starter piece in maple stock.

This is a fun project to help you become acquainted with your ROTO/CARVE?

For More Information contact-ROTO CARVE

6509 Indian Hills Rd.

Mpls., MN 55439

DUPLICATION OF WOOD PARTS

DUAL VERTICAL TRACER

This type of tracer is used for making duplicate objects from a master pattern of wood, plaster, or metal, and is used to shape flat objects in relief, table legs, statues.

The main requirement in duplicating objects is to have an accurate pattern, and from this pattern the duplicate part can be made larger or smaller by changing the length of the stylist. Shorting the stylist produces a smaller object, while lengthening it will produce a larger part.

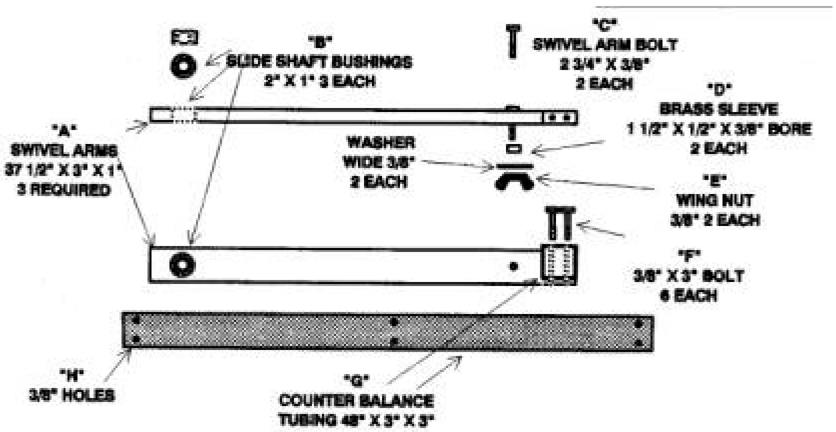


FIG 2 SWIVEL ARMS

The duplicator is not hard to make, and the plans call for the construction of metal. Wood, aluminum, plastic also can also be used for a smaller machine. Many of the metal parts can be found in the local hardware store, as well in a metal scrap yard.

The size can be reduced or enlarged for whatever needs that you need, as there are no restrictions. As an example the size could be reduced and using a Dermal Tool Cutter, Pistol grips could be made from any available patterns.

Figure 1 shows the top view of the dual tracer, which is very simple in its construction. The slide shaft G' ' slides through the support bushings K' ' ,and on this shaft the Router or Dremal Tool' ' J' ' is mounted. What controls the Router is the Stylist' ' I' ' with the Stylist point that is the same shape and size of the Router cutter.

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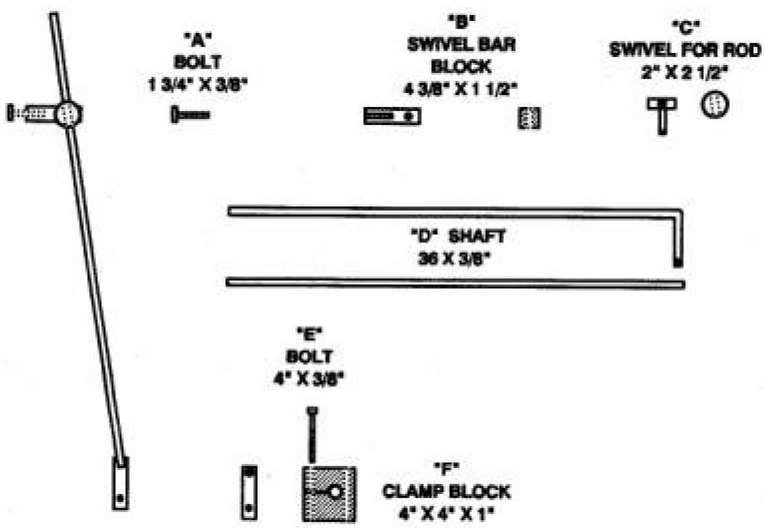


FIG. 3 CLAMP BLOCK FOR SLIDE SHAFT

Figure 1 shows the top view of the dual tracer, which is very simple in its construction. The slide shaft "G" slides through the support bushings K' ', and on this shaft the Router or Dremal Tool' ' J' ' is mounted. What controls the Router is the Stylist' ' I' ' with the Stylist point that is the same shape and size of the Router Cutter.

The Router and stylist as they are moved are controlled by the swivel arms' ' 0' ' and the side arm

Both the support arm and side arm are hinged and will move up & down as well as forward and backward. Its movement can trace the shape of the pattern closely to the duplicated part.

The slide shaft' ' ' can be rotated 360°, once the angle is set it is locked at this angle by tightening the clamp' ' H' '. This clamp does not interfere with the movement of the shaft as the leveler rod ' F' ' is free to slide. The clamp will help to eliminate an accident if the hand slips from the controller knob.

There is a 3-inch square steel tubing mounted on the backside of the support arms to help balance the Router and slide shaft. Weight can be added to this to balance it so that the Router has very little weight. I use lead to add the necessary weight and slip the lead inside the tubing.

There are two bases ' ' L' ' for attaching the pattern and the object to be traced. These rotate together and are connected by pulleys ' ' M' and a ' ' V' ' belt. As the master pattern is rotated, the other is rotated the same amount.

If the pattern is flat like Pistol Grips, the Router and stylist are rotated to point down, and then clamped with the slide shaft clamp' ' H'

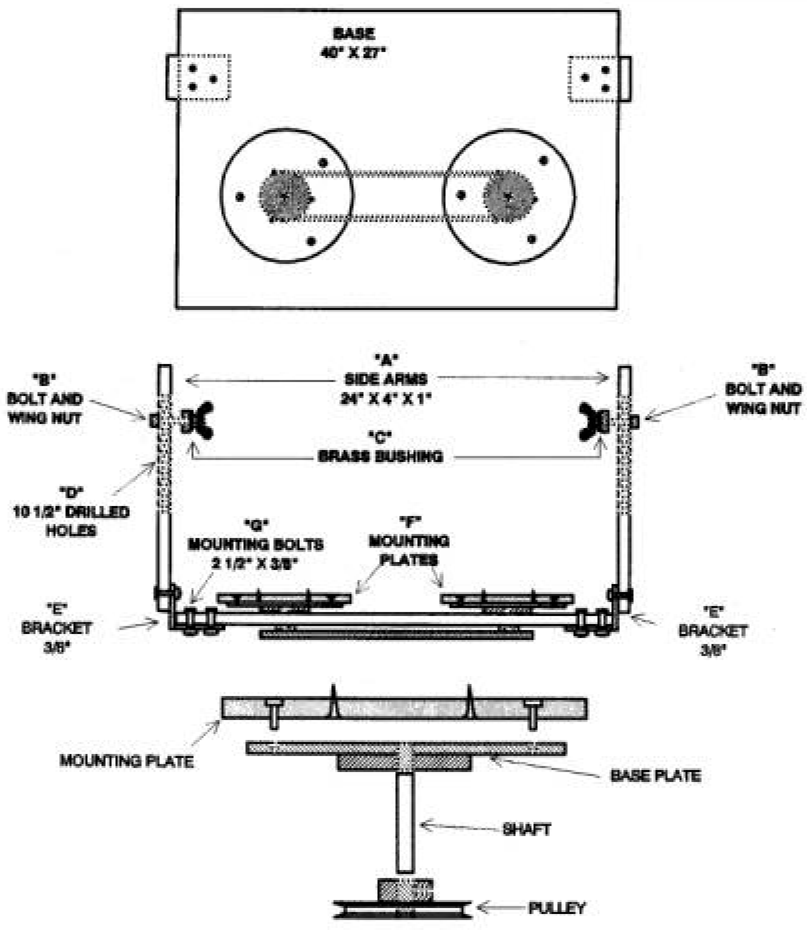


FIG. 4 BASE AND SIDE ARMS

The slide shaft' ' G' ' is a ground shaft, and the bushings are brass or steel bushed with Nylon or Teflon for easy sliding. The fit of these bushings need to be close, otherwise you may experience chattering or grabbing of the Router bit.

Figure 2 shows the side construction of the swivel arms, with the slide shaft bushing ' ' B' ' in place. The arms are cut out to accept the tubing and it bolted in place. If the tracer is scaled down the center arm can be left out. It is used to make the tracer more rigid and reduce any vibration in use.

The swivel arms is are mounted to the side arm with 1/2" bolts' ' G' ' and a brass sleeve which is a bearing against the side arms and swivel arms.

The slide shaft bushings are spot welded in place while the shaft is in place to keep the alignment. If you have a way to drill and ream the holes for the bushings they could be held in place with setscrews. To assure that the bushings would be in alignment, the fit would have to be very close so tipping would not occur.

Figure 3 shows the drawing for the clamp block and slide shaft. This unit is needed to hold the Router at the angle that you want, and if not used it tip one way or the other and cause possible injury if it was running. The swivel for the shaft' ' D' ' is held in place by a washer and Cotter Pin so it won't work out from the hole. The clamp ' ' F' ' is split to the Shaft hole and a 3/8" bolt is used clamp it to the shaft.

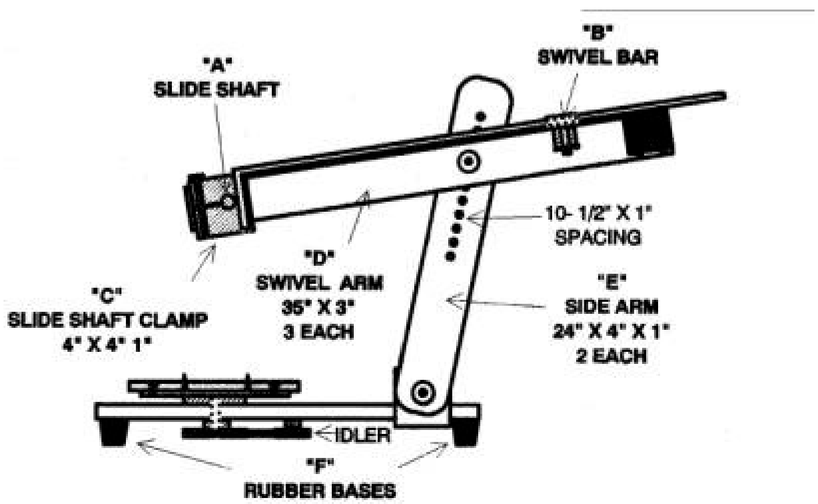


FIG. 5 SIDE VIEW OF DUPLICATER

Figure 4 shows the front view of the tracer. The side arms will swivel, thus they will allow the Router will be allowed to move forward and backward as well up and down. There are 10 holes drilled on each Side Arm

A' ' that will allow you to raise or lower the swivel arms to duplicate different heights of patterns. Figure 5 will show you the side view of this arrangement and how it is used.

The Mounting Plates' ' F' ' are shown as well as the pulleys as they are set up. The break down of this assembly is shown and most of the parts can be purchase at a hardware store. The mounting plate is removable and the pattern and part block are fastened to this. In the drawing it shows 3 wood screws, but about any combination can be used to mount the pattern and pattern block. Once mounted the mounting plate is then screwed back on the base plate.

The base plate has a setscrew to hold the drive shaft once it's inserted. It would be best to mount a bearing or bushing in the base for accurate and easy rotation of the part. This is optional, as you could use a reamed hole to accomplish this, but there would be faster wear on the shaft. The shaft is 1/2" by the length that you need as the parts and pulleys you use will vary in thickness.

The belt will need to be on the pulleys when you slip the pulleys in place, or you can make up an idler pulley to adjust the tension of the belt. Once mounted the base plate should be rigid with no side play, as side play will cause the parts to vary from one to another.

Figure 5 shows the side view of the Duplicator, and the side arm. By adjusting the Swivel arm up or down you can duplicate just about any size pattern. This view shows the rubber mounts, as well as the idler gear for tightening the belt. About any shape of pattern can be used with the duplicator, as the Router and stylist can be changed in a minute to cut a slightly different angle.

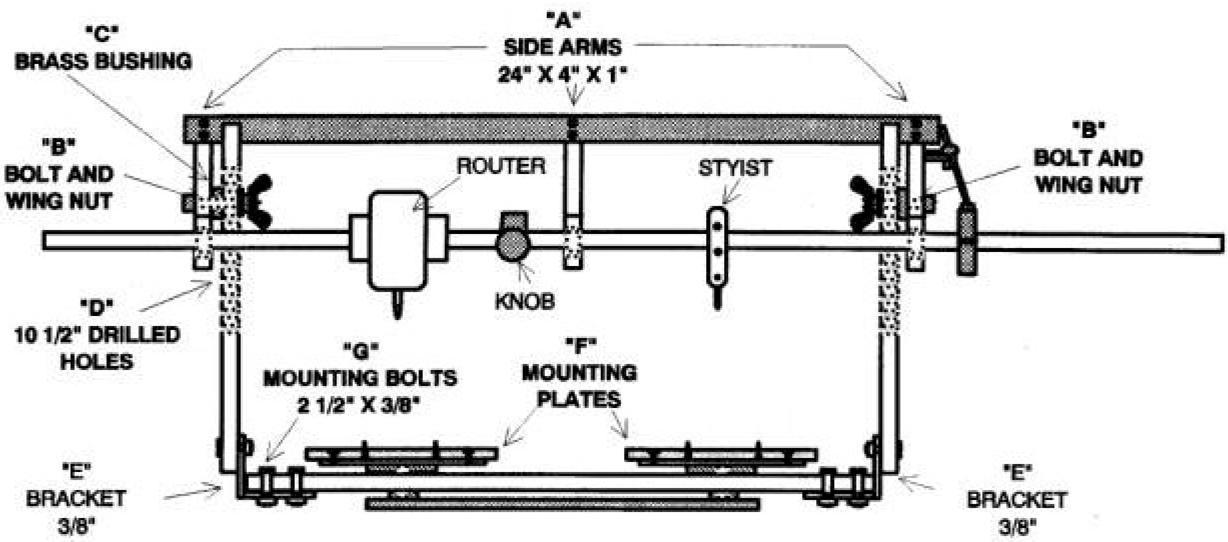


FIG. 6 FRONT VIEW OF TRACER

Figure 6 is the front view of the same Duplicator showing how the swivel arms are mounted to the side arms. Take note of the brass bushing' ' C' ' as these can provide a little friction to the movement of the swivel arms. The wing nuts can be tighten to about any tension that is needed.

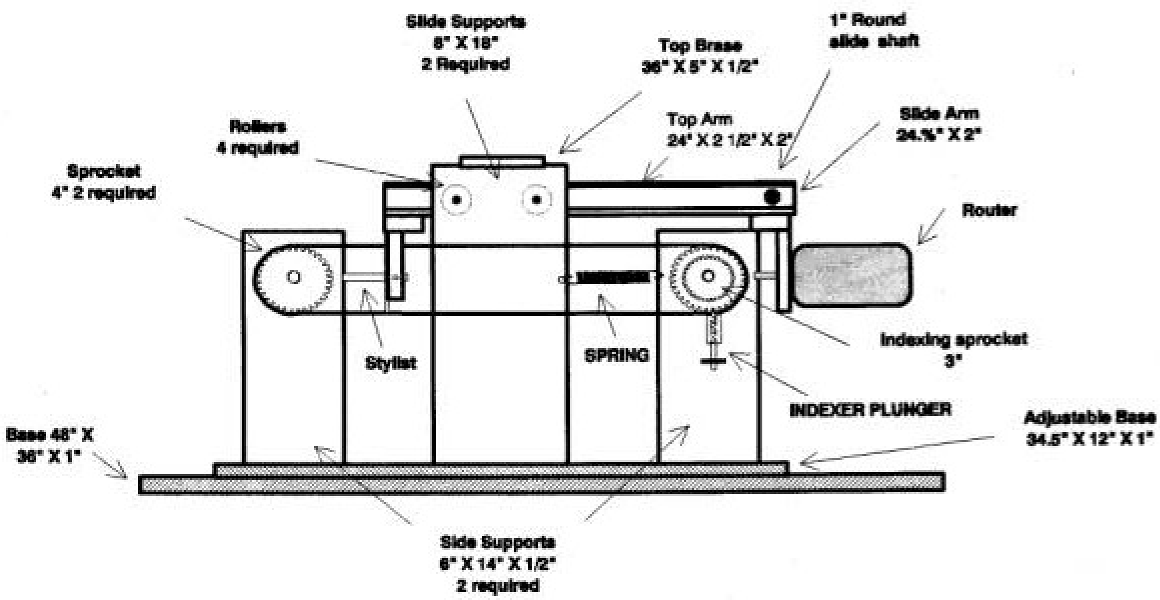


FIG. 1 STOCK DUPICATOR

This view also shows the Router and stylist in the downward position for duplicating plaques, grips, signs, or any other flat object. Just to the right of the Router is a knob that is used for control of the shaft and Router. In use you hold on to the knob and the stylist to guide the stylist along the shape of the pattern.

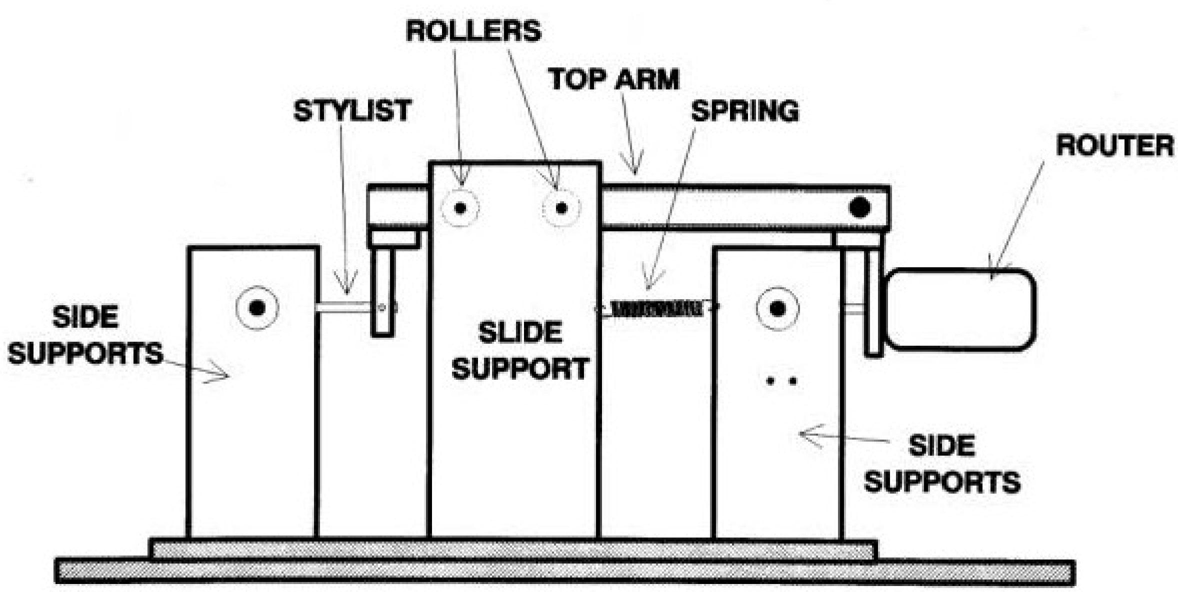


FIG. 2 LEFT SIDE OF STOCK TRACER

Figure 7 shows the slide shaft parts. If you can' t find a Router' ' A' ' or Dremal Tool that has a side mount attachment one can be made by bending thin sheet metal around the Router and clamping it to the base. Each type of Router will require a slightly different type of clamp.

The knob' ' B' ' can be found in some Automotive stores and they are steering wheel knobs. Inmost cases they can be clamped on the shaft and used as is. The stylist' ' C' ' is made from 3/8" or 1/2" stock depending on the size of the unit that you are making. The stylist point is usually 1/4" and shaped on the end to match the shape and size of the Router cutter.

Figure 8 shows the slide shaft bushing that the sliding shaft slides through. The drawing shows it made from brass, which is fine if the holes in the swivel arms are bored true. Setscrews can be used to clamp them in place, but if the holes are sloppy they need to be made of steel so they can be spot welded in place while the shaft is in place.

USING THE DUPLICATOR

Mount the pattern in place on the rotating base using wood or metal screws. Mount the block of wood to the other table with two or more screws, as it must not move after starting the cut. Extend the stylist about a third farther than the Router cutter (assuming that you are making a part the same size as the pattern). Angle the Router to the proper angle and clamp the slide shaft clamp.

Double check that you have the point of the stylist and the Router cutter the same distance apart as the centers of the base, and if not adjust them. Move the slide shaft back and forth to get the feel of how it works.

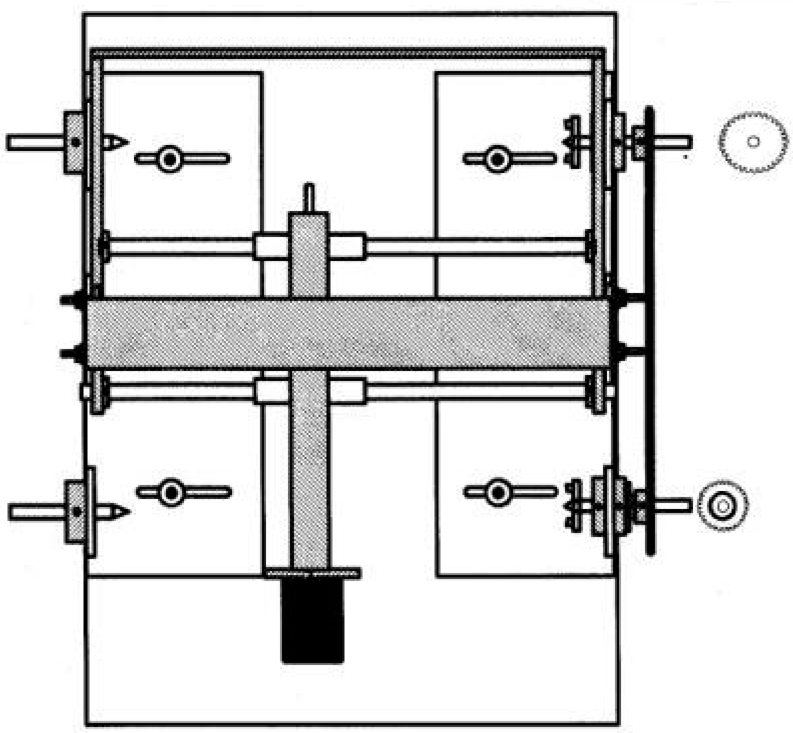


FIG 3 TOP VIEW WITH ROUTER SLIDE

When you feel ready turn on the Router, and just touching the stylist on the pattern start rotating the table base. By having the stylist extended farther the Router cutter will start to rough out the part. When all the edges are rough out, set the stylist in to just a little longer than the Router cutter. Make another pass all over the part and then reset the stylist to the correct length and carefully go over the entire pattern.

The part will then be completed to the size that you want, but be careful and go slow so that the cutter will not tear the wood. By changing the shape and size of the Router cutter small sharp corners can also be duplicated.

DUPLICATION OF PARTS IN WOOD OR PLASTIC

There many possibilities of this duplicator as it will do all types of 3 Dimensional works.

CHAPTER 2 - STOCK DUPLICATOR

The stock duplicator is similar to the other duplicator with the exception that the pattern and part are mounted different. Figure 1 shows the side view of the duplicator, and the main difference is that the slide arms are fixed in the sense that it an only move forward and back.

There is a sprocket and chain that connects the pattern and part centers, which allows the pattern and part to be rotated together. This allows for easy automation and with a little extra work, it will trace and duplicate stock automatically. The top or slide arm can be a track from garage doors, or aluminum channel. The rollers has to be machined from brass or nylon and needs to be bearing mounted. There are springs on both sides that help keep pressure on the pattern as the stock is cut. The stylist is what controls the cutter and it sets against the pattern and regulates the cutting of the Router cutter. When starting the stylist always extends about 1/3 rd farther out than the cutter on the Router. This will cause the stock to be cut oversize, but will also remove the extra stock from the wood stock. Figure 2 shows the other side of the Duplicator.

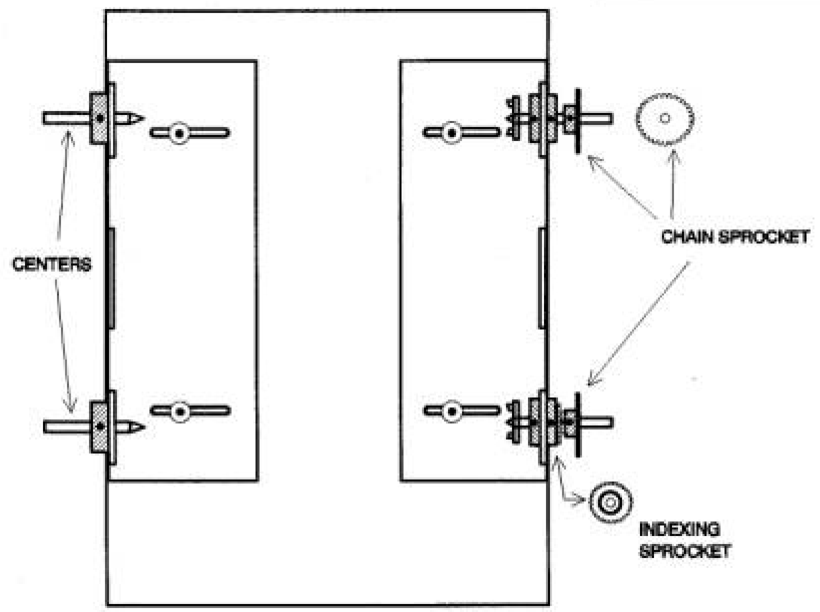


FIG. 4 TOP TOP VIEW BASE AND CENTERS

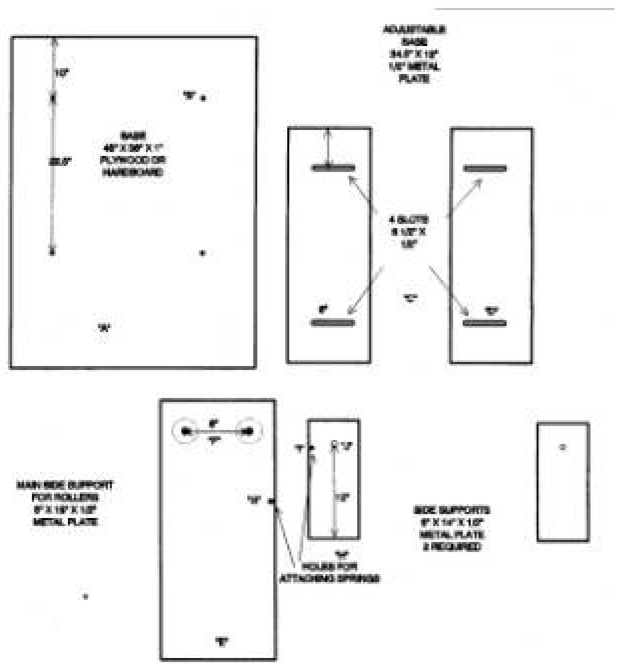


FIG. 5 PARTS FOR BASE AND SUPPORTS

Figure 3 shows the top view of the duplicator, showing how the two centers are connected together by the chain and sprocket. It shows how the Router and Stylist slide are connected together. Figure 4 is the same view but without the chain, and you will notice that there is a smaller sprocket that is the indexing sprocket.

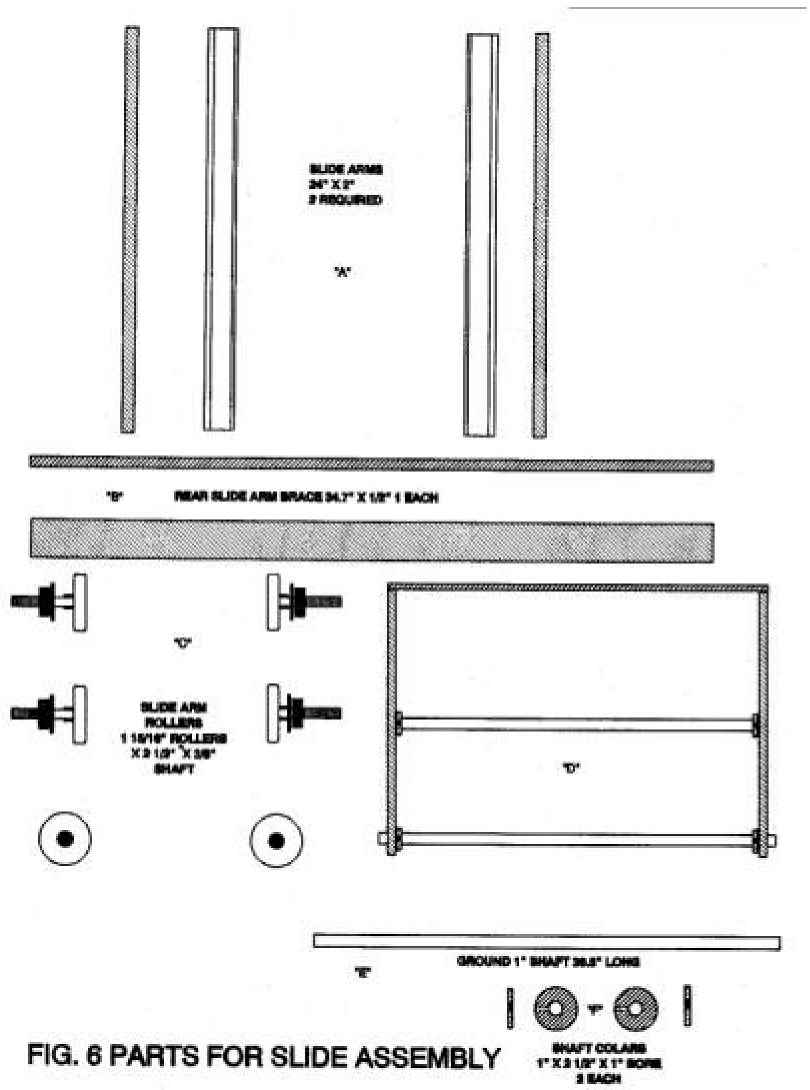


FIG. 6 PARTS FOR SLIDE ASSEMBLY

Figure 5 is the break down of the parts that are needed to make the Duplicator. The slide arms' ' A' can he made from a door track.

The top and rear slide arm brace "B" are usually made of steel flat bar stock and welded in place for support. The slide arm rollers should be bearing mounted for long life and accurate use. These can also be found at hardware or lumber stores. For accurate use the rollers should be machined to be a close fit inside the track.

The ground shaft and the way it is installed are shown in "D" and "E". The shaft collars can be attached to the slide arms either by welding or with screws. If you are using screws to attach them you must be sure to countersink the heads so that they do not interfere with the rollers.

Figure 7 shows the slide arms "A" attached with the slide shaft and Router/stylist slide in place. The top arm "B" and "C" show how the slide shaft bushings are mounted. It is very important that everything is in perfect alignment when assembling or there may be binding when in use. The drawings, "D" , " E" "F", "G" and "H" show the rest of the component parts that are needed to finish the Router and Slide Arm assembly.

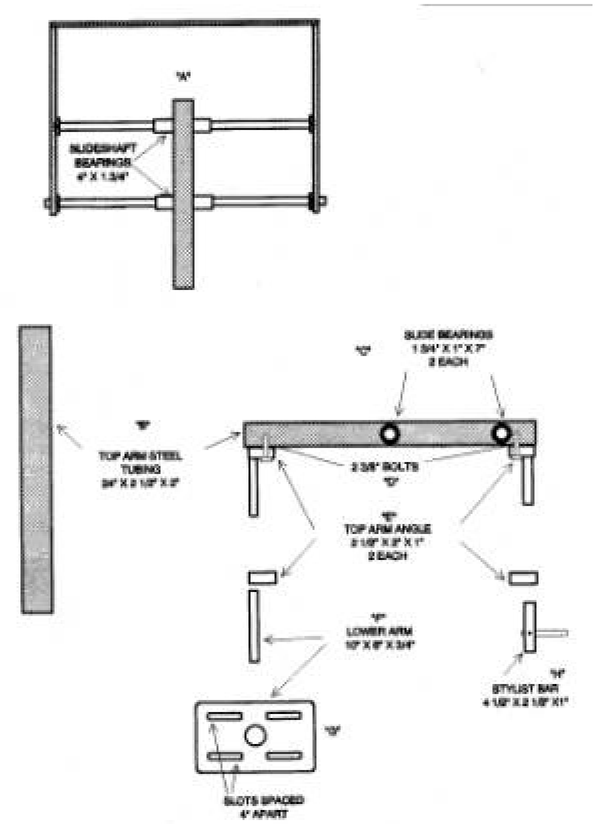


FIG. 7 ROUTER AND STYLIST ASSEMBLY

Figure 8 is the other parts that are needed for centering the stock and pattern in the duplicator. The Indexing assembly "H" is what locks the stock and pattern in place while doing the duplicating is being done. Most of the parts can be made in the shop, but in some cases might be found in some wood working catalogs.

Figure 9 is the finished duplicator but with a lead screw shaft such as is found on a lathe. When this is added the feed can be made automatic and it will shut down when the Router has reached its preset length.

There is a half nut such as is used on the carnage of the lathe for engaging and disengaging the feed.

You will notice also that there are two stop switches that are used to shut down the feed motor. The feed motor is a gear reduction motor that is reversible by using a switch. The speed reducer motor is belt driven and is attached to the pulley on the lead screw.

Figure 10 is the same drawing with the pattern and stock in place. In use it is like using a wood turning lathe with the exception that the stock does not rotate, except one notch at a time. The pattern and stock blank are inserted in the duplicator and clamped in place. The stylist is extended out about 1/4 farther than the Router cutter for the first pass. In roughing out the stock a large Router and a stylist the same size are used.

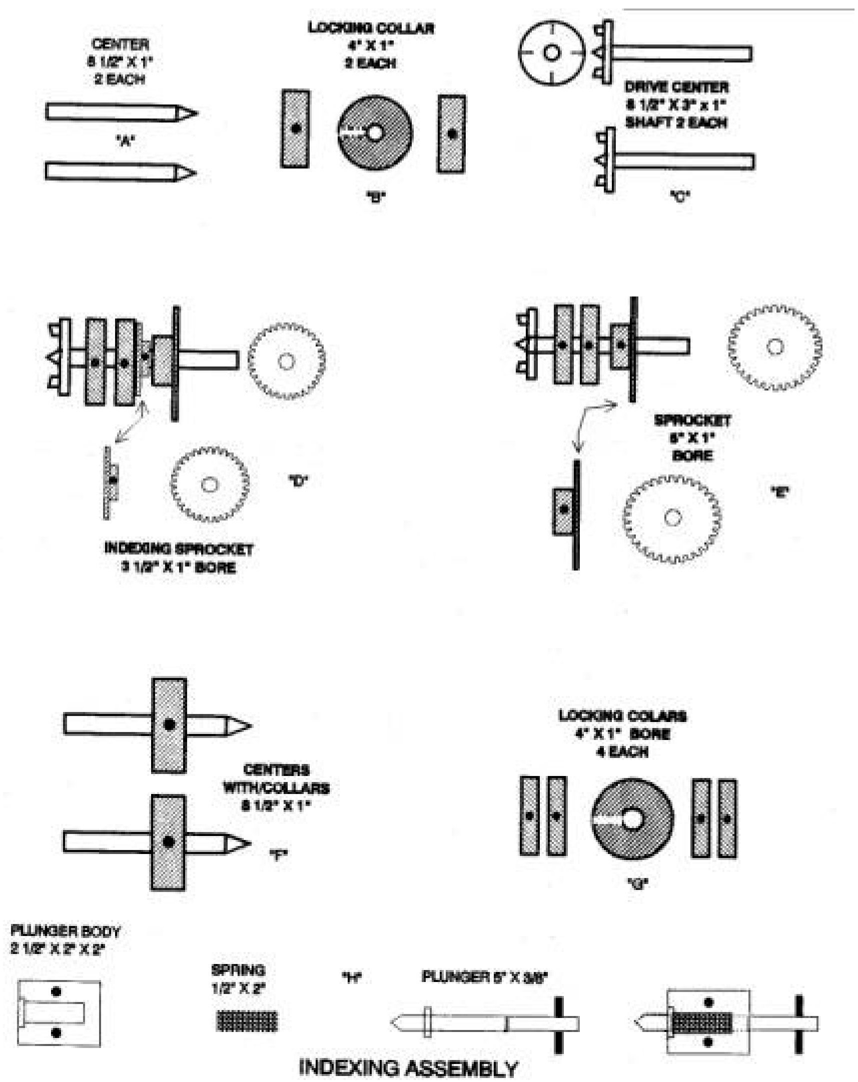


FIG. 8 CENTER PARTS ASSEMBLY

It is important that the stylist tip and the cutter tip are the same shape and size when using. You will need to make a stylist for each type and size of cutter you use. In use it is a simple operation, but it will take some time to get use to its use. I would recommend that you have a speed reducer such as a light dimmer attached to the Router to save on tools on harder woods.

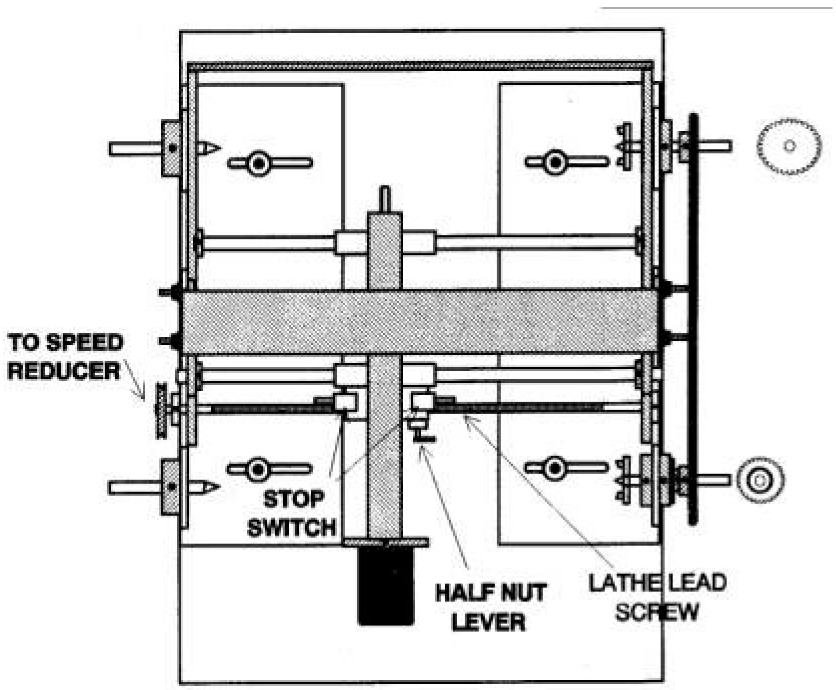


FIG 9 TOP VIEW WITH ROUTER SLIDE
WITH AUTO FEED

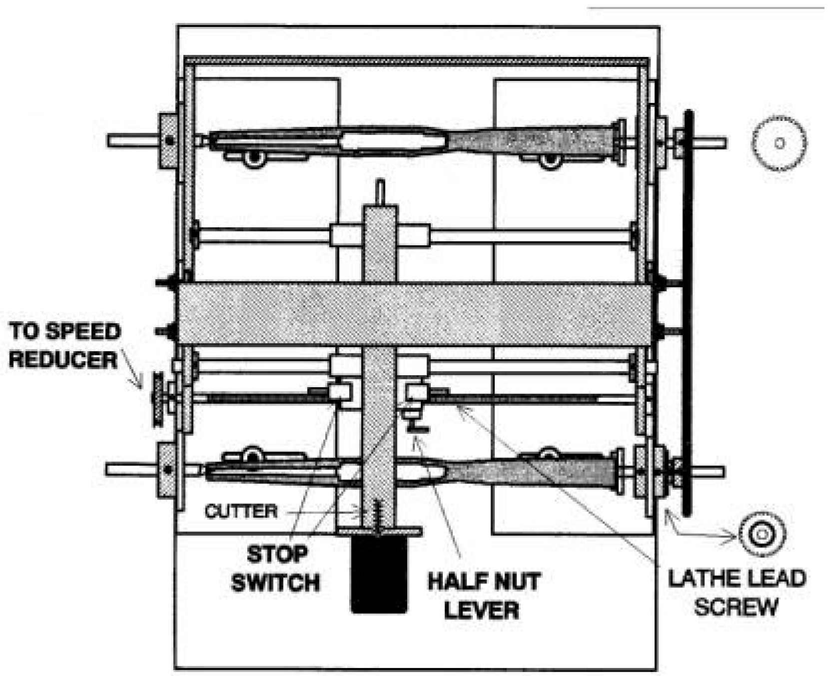
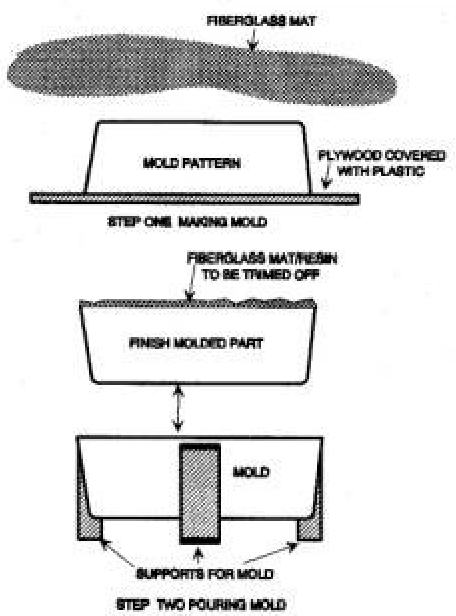


FIG 10 TOP VIEW WITH ROUTER SLIDE
WITH AUTO FEED

CHAPTER 3 - MIXING RESINS

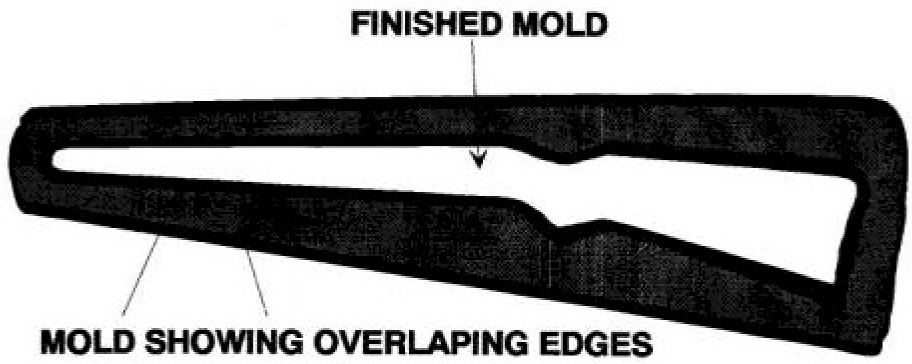
In the workshop where the contact molding process is used, the temperature must never be allowed to drop below 600 F., in fact 65° or 700 is safer. This temperature must be held for at least one hour before laying-up starts, and should continue for about four hours after ending work.



MAKING MOLD WITH RESIN AND FIBERGLASS MAT

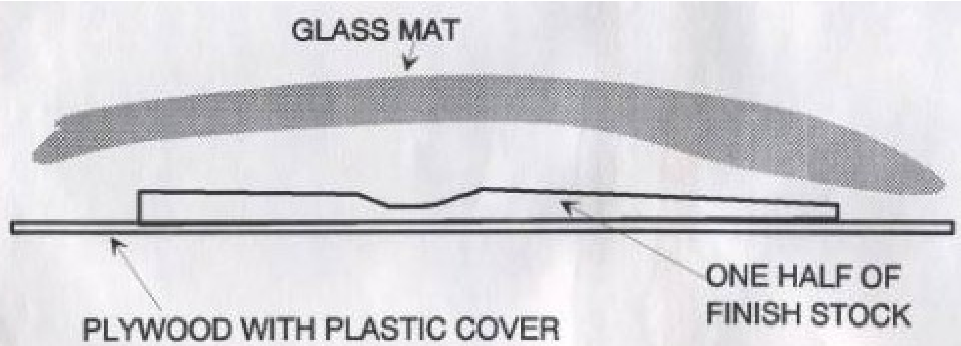
Polyester resins have proved most suitable for bonding parts but epoxide and phenolic resins are also occasionally used in glass fiber work. In the same way, although glass fiber has become the most popular material for reinforcing the resin.

It is certainly the most suitable for parts work, other materials are also used, nylon cloth and asbestos fiber having some useful applications. Resins without reinforcement are brittle, and have a tensile strength less than a reinforced laminate.



TOP VIEW OF A STOCK MOLD

Glass fiber is available as cloth (woven rovings); scrim (coarse cloth of very open weave); tape (1 in., 2 in., and in. wide) and chopped strand mat. The latter is almost universally used for parts molds, the gauge weighing about 1 1/2 oz. per square foot being the ideal in most instances. Chopped strand mat is formed from 2 in. lengths of fiber bonded together in a random crisscrossed manner, and is normally supplied in rolls 36 in. wide. When impregnated with resin, this produces a layer about a2 in. thick. Cloth and mat are normally in rolls i6 in. wide.



FIRST STEP IN MAKING A MOLD

Before any resin can be applied to the mat it must be mixed in an accurate manner to incorporate the following ingredients.

(I) Polyester resin.

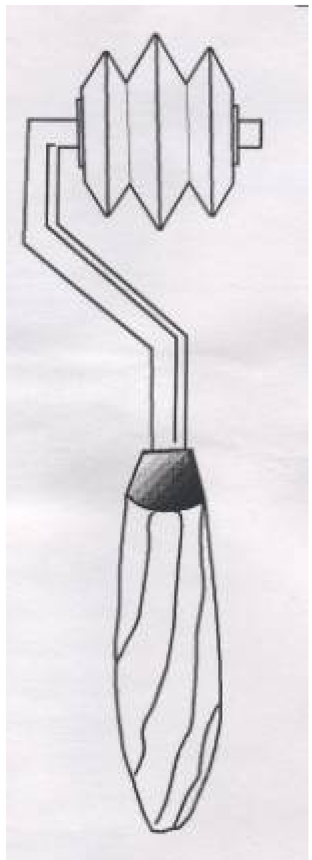
(2) Catalyst.

(3) Accelerator.

(4) Thixotropic paste or agent.

(5) Fifier.

(6) Polyester pigment paste.

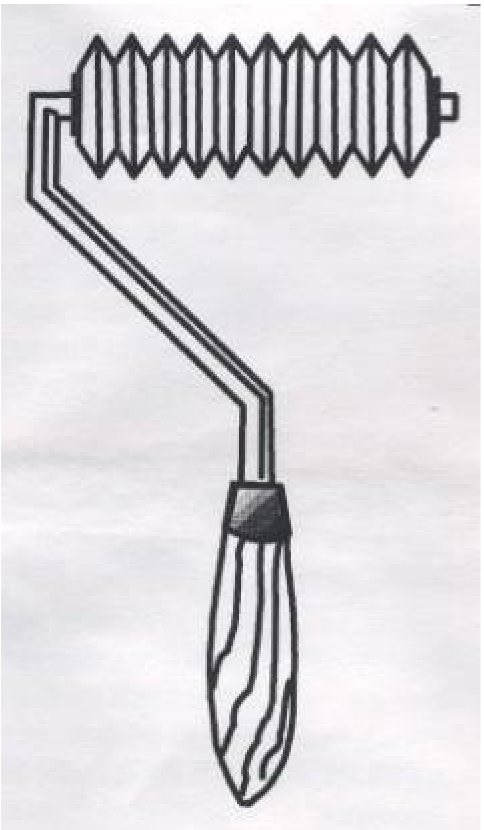


RESIN ROLLER

The catalyst is essential to activate the resin and cause it to set hard, but when this process must occur without applying external heat. The accelerator must also be added; Catalysts and accelerators must never be mixed directly together, for an explosion might then occur. First the catalyst is dissolved in a small quantity of resin that is then stirred into the remainder of the resin, using 4 parts catalyst to 100 parts of resin by weight, or as recommended by the resin supplier.

This mixture can be stored for about 30 hr. Just before use, 4 parts of accelerator should be added, or whatever quantity is recommended by the resin supplier, stirring the resin vigorously al] the time. This mixture will set in 40 min. or so depending on the ambient temperature and the actual quantity of catalyst and accelerator that has been used.

Ingredient (4) must always be added when working on the vertical sides, for it prevents the resin from draining downwards before setting occurs. The Thixotropic agent is similar to the polyester resin, and when used, it replaces part of the resin for mixing purposes. Thus for a gel coat (the initial layer of resin on the mold, not reinforced with glass fiber), the 100 parts of resin quoted above would become 60 parts of polyester resin to 40 parts of Thixotropic agent. For the resin used to impregnate the chopped strand mat a minimum of Thixotropic agent should be used, a ratio of 85 to 15 usually proving adequate.



WIDE RESIN ROLLER

Item (5) above is the filler (such as chalk), which may be mixed with, resins, giving an opaque laminate and sometimes lowering costs slightly. Trouble may be experienced in getting powdered fifiers evenly dispersed throughout the resin, but some manufacturers supply the filler in a paste form specially prepared to mix readily and ensure the best results. About 10 per cent filler maybe added for the gel coat, 20 per cent for impregnating the glass mat, while for making molds 40 per cent is permissible, all measured by weight.

PIGMENT PASTES

A range of Pigment Pastes, including white and black, is available, the colors being ground into resin to ensure easy mixing. They may be added at any stage of the preparation, but the exact quantities of white and other colors blended into a pastel shade should be weighed, in case more has to be mixed later to match up. About 1 oz. of pigment paste to 1 lb. resin is usually sufficient to obtain opacity.

Constituent (I) above can be obtained in three viscosities; High, Medium, and Low. Medium is generally preferred for gel coats where a thick even layer is needed, but low is best for impregnating the mat at minimum temperatures. When a large amount of fifier has been added, while a medium is better for this job in hot weather. If a large quantity of Tow Viscosity is ordered with a small quantity of High, any desired viscosity can then be mixed.

It proves cheaper to mix one's own resin in the manner just described, but material can be purchased from the suppliers of repair kits that merely needs the addition of the correct amount of catalyst before starting work, the resin having its accelerator, Thixotropic agent, and filler included. It must be stressed that delamination of the fiber mats can occur in a part even a long time after building if the resins have not been correctly mixed. Each particle of filler and pigment should be surrounded by resin, so make certain of this by stirring the mixture vigorously with a paddle, attached to an electric drill. This will form a vortex on the surface, and all additives should be poured into this vortex, continuing the stirring for at least two minutes afterwards, moving the paddle into all parts of a large container.

Because of the risk of failure due to the faulty dispersal of fifiers, many firms producing glass fiber molds omit chalk fifiers completely. Most people use flexible containers for holding mixed resins; hardened material can then be loosened from the inside by merely distorting the container. However, for amateur work, a supply of large clean fruit cans will suffice, and they can be thrown away after use. Oil is the anathema to resins, so avoid empty oil drums unless carefully cleaned and then boiled out with detergent and water.

ADHESIVES

When you are working with plastics or fiberglass, you will need to bond two sides together if you make half molds. In most types of plastics that are used in heat forming, all that is needed is to flatten the edges that are to be joined, apply the cement and join together.

Adhesives are a useful class of plastic's materials, having their origin in the naturally occurring resins and animal glues many hundreds of years ago. However the technology has advanced rapidly in recent years with the development of the new synthetic adhesives in the 1930's and the increasing knowledge of their important property of adhesion.

The firsts of the synthetic adhesives were the phenolics. They are now somewhat old fashioned, though not out-dated, for they possess desirable properties such as thermal resistance, moisture resistance and high bonding strengths. Besides they are the lowest priced of the thermoset resins. The ailcyds, ureas and some of the cellulose's have relatively long histories, but still compete with many of the more modern adhesive resins.

There are a great number of types of adhesives for different purposes. Some produce a strong rigid bond for high structural strengths, while others are known as flexible adhesives for improved shock or vibration resistance. Others are pressure-sensitive adhesives for ready application, perhaps of a temporary nature.

SELECTIONS OF ADHESIVE

The main problem facing the user is that of proper selections of the correct type of adhesive for a specific application. Although there are many commercial adhesives on the market today, often the problem may be one of adhesive formulation rather than a mere selection of an available product. Many of the newer synthetic materials do not bond together easily with any of the existing adhesives and therefore a new type of adhesive must be devised.

Adhesives may be classified either according to their uses or their chemical structure. Both systems are of importance to the user, but one expert in adhesive technology readily recognizes the interrelationship between the chemical nature of the adhesive and the possible applications it will satisfy. Two broad classes are desirable even within the chemical structure classification, to differentiate between the rigid or thermoset adhesives and the flexible or thermoplastic adhesives. The following listing of adhesives attempts to do this:

RIGID RESIN ADHESIVES

Phenolics Alkyds and polyesters

Ureas and melamine's Polyurethane's

Epoxies Furanes

Sfficone resins

FLEXIBLE RESIN ADHESIVES

Vinyl acetals Acrylic resins

Vinyl acetate Isobutene resins

Vinyl alcohol Cellulose acetate

Vinyl chloride copolymers Cellulose nitrate

Vinyl ethers Methyl cellulose

Vinylidene copolymers Carboxylmethyl cellulose

Styrene resins Ethyl cellulose

Polyaxmdes Hydroxyethyl cellulose

Sificone elastomers Rubber-based adhesives

PROTEIN ADHESIVES

Adhesives are available in several forms

(1) As powders that may be melted or dissolved in various solvents

(2) As solutions of film forming resinous materials

(3) As dispersions of polymeric substances such as latices

(4) As meltable stocks such as films or rods

(5) As two-component packages of resin compounds and curing agents.

The use of adhesives for metal-to-metal attachment has been steadily increasing, replacing some of the older more time-consuming metal fasteners. Epoxy adhesives have become important materials for this application. They may also be used to cement almost any material to another and have successfully been used in place of solder in repairing metal parts under the trade name of Liquid Solder. An application for adhesives that has gained considerable prominence in recent years has been their use in cementing plastic parts together such as plastic pipe and plastic toys. Practically every type of plastic requires a specific adhesive for bonding it to itself or to another material.

METAL TO WOOD

In bonding metal-to-wood it is recommended that two adhesives be employed. One applied to the metal surface and the other to the wood surface. The two adhesives must be compatible with each other, and when the two-glued parts are placed together, application of pressure and heat produces a strong permanent bond. Metal-clad plywood is made in this way. The phenolics, ureas, vinyl acetate and casein are the more common adhesives for use with wood and paper.

Phenolics are sometimes applied as a solution by a spreader before uniting the parts. Powders also can be applied to the pre-heated surfaces to be joined. In some of the better grade plywood's and veneers, the adhesive is applied as a film in a sandwich-type construction. In any case, heat and pressure are required to set or cure the phenolic adhesive, thus making a water-resistant strong and rigid bond. The resorcinol types of phenolics are particularly good for bonding wood products, such as marine veneers and weatherproof plywood's.

The contact cements are usually a rubber-base adhesive in a solvent solution. These are applied to the two surfaces to be joined and allowed to dry before pressing them together to form a tight flexible bond. This method has been widely adapted by the packaging equipment people for a highly mechanized, fast-operating automatic sealing process. Lately the hot-melt adhesives have also been gaining favor in the packaging field.

They are applied hot from rollers or contact brushes and the applied areas are immediately pressed together to give an instantaneous bonding upon chffling of the cemented area. This newer method is particularly adaptable for attaching lithographic printed wrappings to cardboard such as cigarette cartons. It does away with the hazardous fumes of the solvents in the contact cement.

Many of the plastics materials are self-sealing by merely applying heat to the surfaces to be united, thus eliminating the need of any exterior adhesive. Heat-sealing and heat bonding of plastics have become almost commonplace in packaging with plastic film and the joining of plastic pipe. Vinyl, polyethylene, polystyrene and nylon films are readily heat-sealed, this operation is sometimes facilitated by the application of a small amount of solvent on the surfaces to be sealed and then applying heat and pressure, followed by cooling.

Nylon can be bonded to itself by moistening the parts to be joined with an alcoholic solution of a phenolic compound such as cresol, and pressing the parts together with or without the application of heat. Likewise methyl methacrylate plastic sheet, tube, rod and other parts can be cemented together very easily by moistening the edges or surfaces to be attached with a thin film of a chlorinated solvent, such as perchloroethylene. Then pressing them together long enough to let the solvent evaporate and the joint set to a rigid strong bond.

New and improved adhesives are constantly being sought for high-temperature applications.

The plastics that perform well as adhesives at elevated temperatures are the phenolics, epoxies, silicones, fluorohydrocarbons, and some of the newer inorganic polymers such as the phosphorus, nitrogen and boron compounds. Claims have been made that these inorganic adhesives are stable up to 800º F and show shear strengths approaching 300 psi at room temperature. Among the newer developments are the phenolic-epoxy resins and the sioxy-phenolic, which as the names imply, are co-condensation products of phenolic polymers with epoxy and Sfficone compounds respectively.

CHAPTER 4 - COMPOUNDING

Not many resins are useful in their original form; further mixing of other ingredients is required to make them more flexible, or more the case may call for. The purpose of mixing the basic resins with materials is to improve and enhance the properties of the resin making them more useful for a variety of applications. The process that the final plastics mixture is made is known as compounding.

This consists of a method whereby the ingredients are intimately mixed together into as nearly as homogeneous mass as is possible. However, this represents a difficult problem because of the viscous nature of both the materials and of the other ingredients involved. The wide range of mixes from slurries, pastes, doughy consistencies and the like, requiring methods of mixing which include dispersion, kneading, masticating and similar mixing operations, makes this one of the most complicated processes in the plastics industry.

The factors that contribute to the ultimate properties of the compounds are many, depending upon the type of plastic in question most important factors are.

(1) Type of basic resin.

(2) Type of plastic compound.

(3) Type and amounts of other ingredients.

(4) Degree of homogeneity of the mixture.

The basic resin may vary considerably as to chemical constitution, molecular weight and configuration, and particle type of plastics compound may range from an adhesive or coating to a molding powder.

The latter may vary as well, depending on whether it is to be used for extrusion or compression molding. There are a large number of secondary plastics materials that may be incorporated with the plastics resin in the mixture. These include liquids such as plasticizers or solvents, solids such as fillers or pigments, and miscellaneous ingredients such as stabilizers, dyestuffs, lubricants, etc. Finally, the uniformity of the mix contributes greatly to the properties of the plastic, for usually the more homogeneous, the better the properties, or at least the more uniform the properties will be.

Some of the plastics mixes are quite simple in composition, containing 90 to 95 per cent of the basic resin with only small amounts of additives. Such is the case with clear plastics films. Other plastics are quite complicated with a dozen or more ingredients mixed with as little as 20 to 30 per cent of the basic resin. These are referred to as the "fified plastics" from which many of the molded articles are formed.

The major secondary plastics materials or ingredients compounded with the basic resins, are:

(1) Fifiers: Inorganic, organic, cellulose, metallic, etc.

(2) Plasticizers: esters, amides, resins, solvents, etc.

(3) Colorants: pigments, dyestuffs, etc.

(4) Miscellaneous: stabilizers, hardeners, catalysts, etc.

FILLERS

There are a great variety of fifiers of all sorts, inorganic, organic, mineral, natural and synthetic. These are more commonly employed with the thermosetting resins such as the phenolics, ureas and melamines, although there are some fified thermoplastics as well. Where large amounts of fifiers are used, they are commonly referred to as extenders, because they increase the bulkiness and likewise decrease the cost of the plastic.

However, the properties of the resulting extended plastic often suffer somewhat, thus limiting their use to less critical applications. In normal usage, fifiers impart to plastics specific mechanical, physical, and electrical properties such as strength characteristics, hardness, and density and dielectric strength. Fifiers increase the resistance of the plastic to one or more of the various service conditions. The amount of fifier is usually between 10 and 50 per cent of the weight of the plastics mix. Some of the common fillers and their function is listed below:

FOR BULK:

Wood flour sisal-jute

Sawdust purified cellulose

Wood pulp mica-rock

FOR REINFORCEMENT:

Glass fibers cotton fabric

Asbestos fibers paper

Cellule sic fibers synthetic fibers

FOR HARDNESS:

Inorganic pigments powdered metals

Mineral powders graphite

Metallic oxides sifica

FOR APPEARANCE:

Colored pigments powdered metals

Dyestuffs phosphorescent minerals

Carbon blacks woven fabrics

One of the most widely used fillers, especially for the thermo setting plastics is wood flour, which consists of a finely ground powder of one or more of the hardwoods or sometimes of nutshells. Such fillers may be designated as walnut wood flour, apricot wood flour, coconut shell flour, etc. The main advantages of the wood flours are their availability, cheapness, light weight, increased strength due to their fibrous nature, and ease of compounding, being easily wet by the resin.

Next to the wood flours in importance are the mineral fillers. These again are varied and comprise a large number of natural minerals as well as the refined minerals and inorganic pigments. Almost every conceivable type of rock has been used in powder form and represents a fairly inexpensive and easily available filler.

The more expensive are the refined metal oxides, sulfates and other inorganic pigments that impart both color and hardness to the plastic. The purer forms of silica, such as mica and quartz also provide good heat and electrical insulation. Inmost instances, however, the inorganic and mineral fillers result in increased brittleness of the plastic when used in substantial amounts. Asbestos, a mineral fiber, combines the advantages of an inorganic fifier with those of a fiber; good strength and heat resistance are imparted to the plastic.

In the proper selection of a fifier for a plastics composition intended for a specific application, there are several factors that require consideration before a choice may be made.

These are:

(a) Cost, availability and uniformity.

(b) Compatibility or wet ability with the resin.

(C) Moisture absorption characteristics.

(d) Physical properties, i.e., density, hardness, etc.

(e) Thermal stability to mold temperatures.

(f) Resistance to chemical agents.

(g) Abrasion characteristics.

(h) Effect on plastic flow characteristics.

PLASTICIZERS

In order for a plastics material to exhibit flexibility, resiliency and melt flow, it must be "plasticized," either within itself or by the addition of an added substance that is known as a plasticizer. Without this, it would not be possible to make plastics sheeting, tubing, film and other flexible forms of plastics.

The theory of plasticization is concerned with the internal movement of the molecular chains of the polymers so that they are free to move with respect to one another, with a minimum of entanglement or internal friction. The plasticizer therefore acts as an internal lubricant, overcoming the attractive forces between the chains and separating them to prevent intermeshing. The higher the temperature, the greater is the penetration of the plasticizer in between the chains, and consequently the melt flow or moldabiity is greater.

Most of the plasticizers are liquids, although a few are solids that melt at the compounding temperatures. All must exhibit good compatibility with the resin. They are usually colorless, odorless, and have low vapor pressure and good thermal stability. Added to the basic resin with or without other ingredients, the plasticizer imparts increased flexibility, impact resistance, resiliency, moldabiity and softness. At the same time it decreases strength characteristics, heat resistance, dimensional stability and solvent resistance.

Most of the plasticizers are esters of dibasic acids such as phthalic, adipic, sebacic, maleic, succinic, etc. Some of the more common is dibutyl and dioctyl phthalates, dthexyl sebacate, dilauryl adipate, diamyl maleate and 2-ethyihexyl succinate. In addition to the simple esters, there are many mixed esters such as acetyl tributyl citrate, butyl phthalyl butyl glycolate, dibutyl phenyl phosphate and butoxyethyl stearate. Among the plasticizer resins are the low molecular weight polyesters such as polyethylene adipate. Other plasticizer resins include the terpene resins or esters of abietic acid, as well as the phenolics and polyamides.

COLORANTS

Color is a very important characteristic of plastics. Colorants make possible a great variety of colored materials varying from pastels to deep hues besides the varicolors and marblelike shades. There are two types of colorants used in plastics and these are the same as used in textiles, namely, dyes and pigments. The essential difference between them is one of solubility.

The dyes are fairly soluble in the plastics composition, while the pigments, being insoluble, are dispersed throughout the plastics mass. The matter of compatibility or solubility of the colorant in the plastics mixture is an important consideration in the proper selection of the dye or pigment. Almost of equal importance is the color stability, a factor that requires that the dyestuff or pigment be stable to the molding temperature and the exposure conditions of light, moisture and air expected in the end use.

Other considerations include such requirements as strength, electrical properties, specific gravity, clarity, and resistance to migration (bleeding) in the finished plastic. A great variety of final effects must be considered when coloring the darker phenolic resins that need bright pigments to hide them. The lighter colored ureas and melamines call for pastel shades to take advantage of their attractive translucence and glass-like transparency, typical is the acrylics requiring soluble dyes that will not dim their clarity.

Although dyes on textiles generally fade more readily than pigments printed on the textile, the dyed plastics often hold their color much better against fading than the pigmented plastics. This is attributed to the greater depth of color imparted with the dyes; they may fade at the surface but the deeper placed undamaged dye will show through and obscure the faded dye on the surface. The opaque pigmented plastics that are light sensitive fade on the surface and obscure the unchanged pigment color beneath.

Just the opposite to light stability, the dyes have a much lower thermal stability than the pigments, particularly the inorganic pigments. Some of the synthetic inorganic pigments are even translucent and permit a deep gloss effect with brilliancy of hue.

Since the dyes are soluble, they are transparent and give the brightest colors of all, being used mainly in the clear plastics.

The dyes are much more sensitive to the temperatures of molding and to use conditions and may easily become discolored under the higher heats. With some of the newer heat resistant plastics that require higher temperatures for molding and longer mold cycles with the larger plastics articles. The problem of thermal stability of organic dyes and pigments becomes most serious. With molding temperatures of 400 to 600º F not uncommon for some of the newer plastic materials, there are few organic colorants and a great number of the inorganic pigments that can withstand this heat without yellowing or browning to some extent.

One of the recent developments has been the color concentrates, which are furnished with the natural plastics molding compounds. This enables the molder to color his plastics by mixing some of the color with the molding powder in a blender, or by adding it directly in the hopper of an extruder press. This is particularly useful in wire coverings where a large variation in color is desirable, especially for identification in coaxial cables such as used in telephone communications.

For hardness, reactants are added such as paralormaldehyde or hexamethylenetetranilne (hexa) for the phenolics, ureas and melamines, or the epoxy resin hardeners such as the amines or anhydrides. Even monomeric styrene added to the polyester plastics mix may be regarded as a hardener in the formation of the styrenated alkyd plastics. Lastly, a mold lubricant is an essential ingredient for most molding powders, acting as a pasting compound for the release of the plastic part from the mold. Most of these molding lubricants are the metallic soaps such as zinc, aluminum and calcium stearates, or waxes such as carnauba, or more recently the sificone oils.

METHODS OF COMPOUNDING

The essential problem in compounding is that of completely mixing the ingredients that go into the plastics mix. Since most of the materials are solids and viscous liquids, their intermixing is one of the most difficult operations known. To accomplish a complete blending of these substances, the mixing operation requires a manipulation of the mass under conditions of minimum viscosity so that a fairly homogeneous mixture, which is uniform in composition and structure results. The mixing actions involved in this type of operation consist of smearing, folding, stretching, wiping, compressing and low speed shearing. It is somewhat similar to the mixing of dough or the working of clay, with the added complication of a sticky tacky mass to be handled.

The order of addition of the plastics ingredients is most important, maintaining as liquid a mix as possible at the beginning and progressing stepwise to the final stiff plastic mixture. The completeness of the mixing is limited by the toughest and most viscous ingredient, which supplies a supporting structure and folds about the other ingredients as the mixing proceeds. The more mobile of the materials are locked up inside the tough viscous doughy envelope.

In other instances, extensive exposure of the mixing surfaces produces a drying or hardening effect that causes striations or strata formation. To overcome these difficulties, it is well to employ mixers with small clearances between the mixing arms and the body of the mixer so that the viscous bubbles or envelopes are broken up between the rotating members and the adjacent surfaces. As mentioned previously, the use of heat is highly desirable to soften the mixture and decrease tackiness so that the strata formation can be broken up during the mixing.

After a complete blending of the plastic ingredients has transformed the mixture into a fairly homogeneous plastics mass, there remains the task of converting it into a granular molding powder, suitable for remelting and molding into a plastics article. In some instances such as extrusion or calendering, the taffylike mixture can be transferred directly to the extrusion machine and extruded into various continuous shapes.

MOLD DESIGN

An important part of any plastics molding job is the mold itself. It is the heart of the operation, for it defines the size and shape of the molded article. If the product is not right, the first place to look for the cause of the trouble is the mold. Molds are usually made of steel to withstand the pressures used in the molding operations. Other metals and even plaster, rubber, or wooden molds can be used for some molding jobs, especially for special types of plastics materials or short runs.

THERMOSETTING PLASTICS

Molds have been used in place of metal molds for molding some of the thermoplastic compounds.

In the design of molds for plastics, molding techniques, mechanics, tool design, heat control and economics enter into the problem. If the method is restricted to compression molding, there are eight important considerations to be given to the mold design.

(1) Type of plastics material in order to determine the bulk factor and mold shrinkage.

(2) Size of press to be used, especially the size of the platens and the maximum opening between them; (3) molding pressure to be used with the plastics material.

(4) Parting line on the part to determine the dividing point between the two halves of the mold.

(5) Size and shape of the part, for this will determine the number of cavities per mold.

(6) Inclusion of any metal inserts requiring provisions for puffing side core pins and unscrewing threaded pins.

(7) Heat requirements for proper spacing of hot oil or steam coils, or electrical resistance wires for fast and uniform heating of the mold.

(8) Ejector assembly for removing the molded part easily from the mold.

Economy in mold making may become extravagance in the production of molded parts. A well-designed, durable mold is essential for any successful molding operation. The length of the run, the rate of production, and the accuracy of the detail and dimensions of the part, are some of the major factors to be considered in the selection of a suitable mold. Because of the specialized nature of mold making, a large number of mold and die makers have been established throughout the industry for producing the molds and dies for the plastics molders.

However, in the larger plastics companies, one of the more important departments is a well-equipped and manned mold and die shop. This requires specialized machines for the hobbing, milling and routing of the massive blocks of steel into the shape of the molds, furnaces for the hardening of the molds, and electroplating baths for the chrome plating of the molds.

All of these machining operations utilize well-trained and experienced tool and die makers. Special steels are needed for the molds, and steel companies produce a variety of steels for this purpose. For many of the molds, a general-purpose hot-rolled machine steel can be used. It is easy to machine and can be readily surface hardened by carburizing.

Softer steels are available for hobbing, which is a method of making mold cavities by pressing a very hard steel core of proper shape into the softer steel. This is a convenient way of quickly duplicating molds to speed up production. Chromium plating of molds provides not only smoother surfaces, but also corrosion resistance and thus prevents deterioration of the mold on long runs.

Hard chromium plating is made electrolytically by deposition directly onto the hardened steel surfaces of the mold. In general practice, a deposit of 0.3-to 0.5-mil thickness is sufficient. Where excessively corrosive molding compounds are to be used, a stainless steel mold is recommended. It will stand up well for runs of a year or two, whereas the usual mold will have to be replaced every six months or so, due to pitting.

In a large plastics molding plant, duplicating machines are standard equipment in the mold-making department. Using the patterns or models, which are clamped to one side of the machine and a tracer is moved over the surface of the pattern. This movement starts a cutter spindle that cuts a duplicate shape in a block of steel on the other side of the machine. Some hand finishing is usually required, but for routine work this operation saves a great deal of the toolmakers' time.

There are three types of molds used for compression molding: the positive, the semi positive, and the flash mold. A typical positive type mold with guide pins to align the two halves in position. With this type of mold, the correct amount of charge of molding powder must be carefully measured out so that a-hen melted and compressed, until it just fills the cavity. The plunger or male part of the mold fits closely in the cavity part of the mold and the full pressure is exerted on the piece. There is no escape for any excess material. In the case of the semi positive mold, the plunger is seated with a shoulder landing that prevents full pressures being exerted on the material.

A clearance of a .001 or .003 is provided as an escape opening when the plunger is fully seated. In the flash mold, the excess material is pushed out of the mold cavity when the male plunger is inserted. This results in a fin of plastics material at the parting line between the two parts of the mold, which must be trimmed off the molded part. It is wasted material in the case of thermosetting plastics and cannot he used again, as is true of the thermoplastics.

The flush type mold is frequently used to avoid excessive wear on a close fitting plunger.

CHAPTER 5 - MOLD CONSTRUCTION

Parts molds made from plastics reinforced with glass fiber are now so widely accepted that little need be said of their advantages over wood and metal construction. This modern material is unaffected by rot. It can possess a strength/weight ratio equivalent to steel, the weather will not affect it. The material does not have the stiffness of wood or metal (of equal weight), but this matter can be rectified by correct design. Incorporating ribs inside a big mold; ensuring that the skin of a small part is well curved everywhere. By adopting sandwich construction, where the space between two skins is fitted with a light cellular material.

Glass fiber parts are often cheaper than wood or metal where mass-produced to standard designs, but the cost of one-off molds is usually higher than for conventional methods. The amateur is nearly always concerned only with one-off molds, and it proves almost impossible to produce a good glass fiber parts as cheaply as using other methods of manufacture. It must be remembered that whereas a mistake in cutting a piece of wood might cost a few cents, an error in the mixing or application of resins might cost several dollars.

Because it can be mass produced almost as cheaply as in wood or other material, the amateur requiring a plastic parts is advised to purchase the pattern or part from one of the makers, and complete all the remaining work (which is often largely of wood) using his own labor. Molding a glass fiber parts is in many ways as intriguing as working with wood, and even if the cost proves higher than anticipated, some amateurs will prefer to do all their own work. For these individuals, and for those desiring to make their own parts, the necessary information will be given.

As the materials used consist of thin mats composed of hair like filaments of drawn-out glass and a liquid resin. One must start with a mold representing the shape of the mold, to which the correct number of layers of mat and resin can be applied. When the resin has cured, the new shell can be lifted from the mold, the latter then being discarded.

MOLDS

Many different methods are used in factories for producing moldings and castings of glass fiber, some being automatic, with rapid curing in hot ovens. The simplest system of all, often called the wet lay-up process, is almost universally used for making smaller parts. Everything has to be done by hand, the success of the product depending largely on the care taken by the workers. Only one mold is used for this wet lay-up process, so only one side of the shell will have a fine smooth surface identical to the face of the mold. The other side may be fairly rough, just as left by the final layer of resin, covering the last layer of mat.

For all parts the outside of the mold must be the perfect side, thus a female mold is essential. Laying-up over a male could would result in a very fine interior (perhaps rarely seen after completion) and rough topsides and bottom. The removal of a finished shell is easier from a female mold because the laminate contracts slightly with hardening and curing, releasing the contact with a female mold, but creating a firmer grip on to a male mold.

The first major problem now arises. A male mold is fairly easy to make, using a number of wooden frames cut to the shape of the body plan sections on the lines drawing. Fitting thin laths of wood between these frames, and then covering right over with about a 1 in. layer of plaster or a single skin of 3-mm. Plywood. A female mold of similar construction is extremely difficult to make. The attaining of a female plaster surface true and smooth enough for the outside of a parts mold is very nearly impossible.

The usual method for arriving at a suitable female mold is to make first a plaster male mockup as mentioned above, rubbing this down and adding more plaster until the surface is absolutely perfect. Then a glass fiber shell is formed over this mold in exactly the same way as for a proper mold, but making the skin 1/2 or 2/3 the thickness. On lifting this female mold from the mockup, it is rested into a prepared framework of timber to increase its rigidity and maintain the true shape. The molding of the final parts can now commence.

MAKING THE MOLD IN BRIEF

1. Apply a gel coat of polyester resin to the wood mold; A gel coat is a thin outer layer of resin applied to the mold. Follow the manufacturer's specifications for mixing the proper amount of hardener (catalyst) with the resin,

2. Allow the gel coat to "set" so that the fibers of the glass mat will not penetrate, it when applied.

3. Place a layer of glass mat on the wood mold and saturate it with resin.

4. Cut a piece of plywood to fit on top and around the handles of the wood mold,

5. Place this plywood on top of the lay-up, draw the edges of the lay-up over the top of the plywood and tack them in place.

6. Cut a second piece of plywood to fit over the first piece and fasten it in place with screws, thereby holding the lay-up edges in place.

7. Clamp the entire assembly until cure is completed.

8. After the glass fiber reinforced plastics mold has cured, remove it from the wood mold and apply a gel coat to the exposed plywood edges.

9. Wet-sand the entire mold, using successively finer grades of abrasive paper, until the surface is smooth. This type of mold is widely employed in industry, and may be used indefinitely as long as the release agents are renewed for each molding.

The reason for the high cost of one-off molds now becomes apparent, both mockup and female mold being expendable. The cost of material may work out higher than for a plaster mockup, but the hours of labor are reduced.

The only means whereby the mockup stage can be eliminated is by laying-up the female glass fiber mold over the out side of an existing mold of the desired shape and size. Unless the copied part happens to be a new part, it may not have a surface smooth enough to use. Little can be done to improve the surface of a female mold, and although a small amount of grinding and polishing is possible to the outside of the final parts shell, this is restricted to only the most insignificant blemishes. One could almost say that better workmanship is demanded in making the female mold than in laying-up the actual mold.

The important male mockup is fashioned in the following manner. Upside-down erection is adopted for all sizes of molds as a rule, making plaster work much simpler. Bevels should be applied properly to all the templates, either before or after erection, and faking-in to check the bevels must be carried out in the usual way.

In the majority of parts there is a flat transom, conveniently raked in the correct direction to allow the female mold to be lifted off. Always remember that no sharp corners are permissible in glass fiber parts, a radius of 1/2 in. being the very minimum. Therefore the edges of the transom must be carefully radius.

The outer surface of the plaster being shown as a dotted line. Cleats must be nailed to each side of each template, so that lengths of standard plasterers' laths can be tacked from cleat to cleat about 1 in. below the template edges. Expanded metal lathing is in many ways simpler to use than wooden laths, for this can be attached readily to a number of 14-gauge steel wires stretched tightly from stem to stern, passing through holes in the templates. Alternatively, fewer laths covered with hessian may be used.

Keen's cement or Sirapite is most frequently used to cover the laths, but is not suitable for the outermost layer, being difficult to rub down smoothly. Therefore, the final 1/8 in. or 3 in. should be composed of plaster of paris or a cellulose fifier such as Polyfilla. Both of which can be rubbed to a very fine smoothness, and will take wafer-thin additional layers of the same material should slight indentations need building up.

As soon as the plaster is brought up flush with the templates, and the correct curvature has been checked by means of thin patterns held across the templates from front to back. The surface should be roughened just before hardening by stroking with a wire brush or painter's graining comb. This provides a good key for the final skim coat of plaster of paris.

To make the skim coat exactly 1/8 in. above the templates, lengths of annealed copper or soft iron wire should be stretched round the periphery of each template, held by a staple at the ends. The skim coat can be slightly thicker than 1/8 in. to allow for rubbing down all aver, and before this coat hardens, the wires should be unstapled and pulled away, leaving grooves in the surface. The next day, these grooves can be filled flush with new plaster, and will not show after smoothing down.

Check everywhere with long splines to discover any serious humps, marking these with a pencified circle, and rasping down with a surface form tool followed by coarse garnet paper over a cork block. Then look for any serious hollows, mark them, and build up with more plaster after scratching the old surface to form a key. Any small waves in the resultant surface can usually be spotted by working at night with a single inspection lamp, held to throw its light at a tangent to the curves. Finer wet or dry glass paper should now be used with water ending with an overall rub using very fine paper, grade 0. Note that in the range made by Oakey's, glass paper of grade 0 is equivalent to garnet paper of grade 4/0 and carborundum paper of grade 150. For glass paper of grade M2, the equivalents are grade 1/2 and grade 60.

A fiberglass component, for whatever use, is made in a three-stage process. First the pattern is built, next the mold is made, and from this the final product is fabricated.

As the pattern has to be full size and a replica of the final product it may be costly. It has to be made at least moderately rugged, so that the mold can be made from it without risk of distortion. The finish on the pattern is reproduced on the mold, which in turn comes out on the product. It is essential to get the same grade of smooth finish without undulations on the pattern as is needed on the part to be made from it. When the mold has been made the pattern is seldom of any further use, which is sad and bad for anyone trying to keep costs down.

Making the pattern for any type of part follows the same procedure. Instead of wood it is usual to use hardboard or plywood with a super-smooth surface. One of the modern plastic high-gloss laminates on the plywood such as Formica is particularly useful here because it needs no surface treatment. It is flat, smooth, and free from microscopic indent or protrusion so a mold made of it comes out with the lovely finish that is the dream of all fiberglass fabricators.

Once the pattern is complete the mold is made without immediately, otherwise seams and butts start to open because of drying out or cooling or warping. The mold might be described as the reverse of the pattern. The mold follows exactly all the contours of the pattern, its inner surface is the same size and of the same proportions as the outside of the pattern. It is made by coating the pattern with fiberglass cloth, then soaking this in a resin that hardens in a few hours.

When the resin has set and bound the fiberglass into a continuous solid shape the pattern is extracted. This is possible because before starting the mold a 'parting agent has been applied to the smooth surface of the pattern to prevent the mold from sticking. Sometimes the parting agent is less than fully efficient.

Making a pattern for a fiberglass mold is a straightforward job because the pattern is the same size and shape as the final object. The pattern must have a perfectly smooth surface so the clever thing to do is to use materials that have this characteristic.

Sometimes it is a good idea to use smooth sheets of fiberglass for the pattern, sometimes solid wood carefully planed and faired is the answer.

Edges should be very well rounded otherwise the fiberglass cloth will not lie close when it is wetted down with the resin. It is no bad thing to aim for a minimum radius of 11/2 inches on all components. This is achieved by having thick wood at the corners and edges, and planning away the wood to give a soft curve, as shown in the right hand sketch.

A typical way of building up the right wood thickness is shown on the left.

Each part should be made a neat fit and all joins should be fified with a bedding compound that takes up any tiny gaps, Screw heads are sunk deeply in the wood, then covered over with plastic wood or a fifier that is compatible with the fiber glassing resins. Alter the screw hole has been filled it must be leveled off perfectly.

The mold is used repeatedly, perhaps several hundred times. To make it able to stand up to so much usage it is reinforced. The stiffening is often of wood glassed in, partly in the form of external frames, partly external stringers. This stiffening is to keep the mold the exact shape of the original pattern and to make it able to cope with the inevitable humping and heaving, first to get the original pattern out, and later to get the finished product out.

MAKING A COVER

At least a rough sketch is needed first. From this an accurate plan to scale should be drawn, though this is sometimes omitted. Details like strengthening and clearances should be indicated. If making a cover for a container, there must be a gap at each side and each end of about 1/2 inch so that there is not the slightest risk that the cover will come off.

If a cover was being made, the outside surface is the one that would show, so a female mold is used, since this will have a smooth surface. This surface finish will be transferred faithfully to the outside of the part being made. As we are following through the making of a cover, we need a male mold, which has a smooth outside surface. On this we make our tray, which needs to be smooth on its top, inside face.

Before making the mold some builders like to mock up a template from cardboard. This is a good idea if the part has to fit into an awkward recess where the mold is curved and the space tapers in every direction. A template takes such a short time to make that it is worth it if there is any doubt or if the person is just starting. Even a three-dimensional template, made up from cardboard and tape, will not take more than a few minutes to assemble.

It is seldom a good idea to make up a plan or a template from the basic drawings, not least because the latter are so often out of date, were never followed accurately or were planning on selling the finish product.

Molds should be as simple as possible. This is to keep down their costs and the time it will take to fabricate a part if there are many changes of angle, or many recesses and many edges. A mold, regardless of what the finished object is, should have no sharp edges because fiberglass will not easily conform to the shape when wet. The wet glass cloth cannot be molded easily into sharp cut interior angles, certainly not if they are less than 135 degrees. So all edges and recesses should be made with big radius, an absolute minimum of 1/4 inch is a good working basis.

Molds are made so far as is possible like simple boxes, often with diagonal stiffening. This is put on the outside of a female mold and the inside of a male one. The material used for the mold can be anything that is sufficiently rigid and easily worked. It should have a smooth, glossy surface where the fiberglass is to be applied, so Formica covered plywood is sometimes used. However, the surface can be given the necessary smoothness and polish later, so the cheapest plywood may be used. Sometimes hardboard is used, provided it is totally non-porous and will not soak up fluids. Another favorite material is fiberglass sheet, because it is smooth-faced, strong, and easy enough to cut with a jigsaw or band saw or hacksaw, easy to bond together. It is not affected by changes in moisture and temperature, and perhaps its only defect is its cost.

Molds are made with slightly beveled sides so that whatever is made in them comes away easily. Suppose the mold is for a cover, the sides of the tray will all slope outwards at the top. This slope can be as much as 100 off the vertical since this makes no difference to the operation of the tray, but it makes the job of removing the tray off the mold easier. It also reduces the interior angle where the sides meet the bottom. This edge becomes easier to glass round and there is less chance that it will be too rich in resin, and as a result too short of glass cloth. If it does have this defect it is likely to be brittle and have hollows with thin layers of resin over. These 'pop' leaving bubbles that allow moisture to get at the fiberglass.

GOOD FIBERGLASS MOLDING

Whether making a simple cover, or building a complete mold, the same principles are followed. The total mold is made with sides, which 'lie in' at the bottom, so that the finished product is easy to remove from the mold. All edges, whether interior angles like the one along the root of the bottom flange or external like the ones round the top, are made boldly rounded to avoid resin richness and ensure the glass cloth lies well.

The sloping ends ensure that objects will not snag on them, the shape is far from rectangular. Interior angles need filling with a solid or malleable material so that when the fiberglass goes in, it forms round a gentle curve. Some people use a mixture of 50 per cent Cascanilte glue and 50 per cent Polyffila made into a firm putty by the addition of water. It is worked in with the thumb and when hard is smoothed and made regular by the application of glass-paper, and well feathered out at all edges.

Wood or plastic strip moldings are also used for filling interior angles; these can be bought from joiner's suppliers and some lumber yards.

Outside edges are faked away with a plane or Surform to the biggest possible radius. All crevices are sealed and if plywood is being used it is treated with a wood sealer like a two-pack polyurethane paint. The aim is to get a smooth finish entirely free from all blemishes.

CHAPTER 6 - RELEASE AGENTS

Before beginning to make anything in a mold a release agent is applied all over. It is normally in two parts and must be put on systematically starting at one end and working to the opposite end. To make sure that not even a few square inches have been missed it is probably best to work over the whole mold three times, carefully polishing in the final waxy release agent component by hand.

Parting the shell from a mold can be helped by pouring water between them, but proper release agents must be used. For flat surfaces, a sheet of cellophane can be used to form a reliable release agent, but this might wrinkle on a curved surface and cause irreparable defects. For parts molds, we must use a special type of wax polish that is rubbed on, or certain special liquids that may be sprayed or brushed over the mold and allowed to dry.

Wax is nearly always rubbed on to a plaster mockup, as the plaster is very absorbent to most liquids. However, a better finish is imparted to the female mold if the mockup is given two coats of white emulsion wall paint before waxing, thus filling the pores. The builder's glue product Bonacyefe is also suitable for this job.

Use paraffin wax direct on the mockup, according to the suppliers' instructions, and not allowing surplus wax to cake on the surface. Some domestic waxes contain harmful ingredients, and should be avoided. Over the wax, two coatings of a suitable Polyvinyl Alcohol Solution release agent should be sprayed or thinly brushed, drying almost immediately. This elaborate three-coat process is essential to avoid having to break up the mockup to release the mold, and even then the mold may prove defective.

Exactly the same process is advisable when preparing the female mold surface for laying-up the final parts shell, for although a glass fiber mold is quite flexible when removed from its supporting framework, any adhesion is bound to ruin either the mold or the shell.

Some of the sprayed release agent will be left on the final shell after removal from the mold, but can be washed off with warm water. A glass fiber female mold is quite the best link between mockup and mold, but one can make a female mold from plaster, breaking up the male mockup from inside it when hardening has completed.

As mentioned, a good jig or framework is needed to support the flimsy glass fiber mold, and this wooden structure should be built on to the mold while it rests over the mockup, thus ensuring it will not distort the mold later. Jig frames are best, spaced about 2 ft. apart though this does depend upon the thickness of the glass fiber skin. All the frames must be joined by stiff stringers or else arranged to be cleated to a level floor, so that no distortion will occur when the assembly is lifted from the mockup and inverted ready for use.

LAYING-UP

Polyester resin is a thermosetting plastic, When activated with a hardener (catalyst), and applied to glass cloth or mat; it impregnates the material and hardens, giving the completed form considerable strength and rigidity. The resin gives permanent shape to the glass fibers as well as providing a hard, strong surface finish.

The hardening takes place at room temperature, although it may be speeded up by the application of dry heat. The method of glass fiber, polyester resin laminating presented here makes use of contact molding in which the reinforcement (glass mat) is placed by hand against the mold surface and saturated with resin. The material is allowed to harden without external application of pressure. Boat hulls, automobile bodies, machinery housings, planter boxes and many other commercial products are made by curing polyester resin and glass fiber lay-ups under heat and pressure.

Chopped strand mat weighing 1 1/2 oz. per square foot is the best gauge for most mold work. Mat of 2 oz. gauge should never be used, but 1 oz. is available and is the easiest of all to handle and impregnate, though it makes more work in needing one or more extra layers to make up the required thickness.

Using 1 1/2 mat, molds up to 8 ft. in length generally need two layers of mat, making a skin thickness of 3/16 in. To calculate approximately how much material you will need, it may be reckoned that 1 sq. ft. of skin 1/8 in. thick weighs 1 lb. The ratio by weight of resin to glass fiber is about 2 1/2 to 1 as a rule, thus one can work out the weights of materials needed by measuring the surface area of the mold.

Before mixing any resin it is best to cut out the panels of mat to fit neatly into the mold. Templates of very thin paper can first be shaped; ignoring wrinkles and securing them into the mold with adhesive tape until all the panels along one side are properly tailored with joints overlapped about 1 in. Then remove the templates, numbering them if necessary, and use them as patterns to cut the glass fiber mat for both sides of the mold.

The joints for the second layer of mat must not coincide with those of the first layer, so make up a second set of paper patterns to suit. You might manage to cut the mat direct, eliminating patterns, but chopped strand mat can be damaged by handling, such as required by trial-and-error shaping inside the mold. For very small molds it might be possible to cut the mat in one section for each side.

The interior surface of the female mold should be polished with metal polish or one of the cutting compounds used for cellulose enamels, then the double release agent maybe applied as for the mockup. Small defects in the surface of the mold can often be eradicated by filling with one of the polyester putties obtainable from suppliers, and grinding down flush afterwards.

The gel coat of resin that is intended to produce a fine outer surface mold is brushed all over the mold at the rate of about 6 oz. per square yard to form a layer between .005 in. and .01 in. The correct amount of Thixotropic agent is essential, for any drainage from the topsides may ruin the whole shell by causing wrinkles. Too thick a gel coat may result in cracking.

Very special equipment is necessary for applying resins by spray, and no attempt should be made to modify a paint sprayer for this duty. Some firms prefer to reinforce the gel coat by placing a special glass fiber tissue surfacing mat .012 in. in thickness on to the inside of the gel coat. This mat also helps to prevent drainage of the gel coat from the topsides.

MOLDING THE PART IN BRIEF

1. Apply a coat of wax, two coats of polyvinyl alcohol, and a final wax coat to the mold to form the release agent.

2. Mix a gel coat and ad the coloring agent, mixing thoroughly and apply it over the release agent.

3. Apply two layers of glass mat, saturating each with catalyzed resin by dabbing with a brush.

4. Place Saran wrap over the flat bottom of the lay-up and roll out air bubbles with a roller or with your hand.

5. Peel off the Saran wrap and dab down the fibers over the entire surface including the edges.

8. Allow the lay-up to cure, and then remove the hardened laminate, by using compressed air around the edges (water for larger molds) in addition to prying gently with the fingers.

7. Mark the laminate for trimming.

8. Trim the marked laminate on the band saw, then sand it to smooth the edges,

The laying-up of a mold is best done as one continuous process, for you must not allow more than 48 hr. to elapse between layers, and better results are ensured if this interval is considerably shorter. There must be no lull after placing the gel coat. When this gels (becomes touch dry) the first coating of ordinary resin mixture must be brushed on, over the area to be covered by the forward most panel of mat on one side of the mold. The mat is laid carefully into place, with an inch or so left protruding above the edge, and stippled all over with a brush or special roller, until the resin works right out through the glass fiber.

Laying up a component in a mold starts off with the gel coat. This is a clear resin for items that are hidden or unimportant because clear gel is cheaper and less porous. Anything like a shower tray or a cover for a life raft will be on view, so it will be colored to suit its job and the surroundings. The gel coat is applied smoothly and not too copiously as it must not 'run' or form 'curtains' like paint put on too thickly.

It is left till it is just tacky, then a coat of resin applied, the first pieces of glass cloth applied, more resin and so on, till the correct thickness has been built up. Stiffeners are laid in place and strips of wetted cloth laid over them, there should be at least two, and for parts like a part that has to stand up to such stresses, three layers of 2 oz chopped strand mat are a minimum.

The new component is left in a warm dry atmosphere to harden. The time this takes depends on the resin and mix used, so here the resin maker's guidance is needed. If in doubt, leave it for a week. To get it off the mold, pry the edge apart with care. The new part will have been made too big so that lithe edge is damaged while being taken off the mold it does not matter. However, the damage must not extend beyond the surplus edge, so once separation is started it should be encouraged slowly and with care.

Slow softwood wedges are favorite tools: a couple of men, one pulling the mold down and the other pulling the component up often does the trick. It is usual for the first item off a mold to be difficult to extract and all sub sequent ones to be easy. It may help, if a part will not come out, to distort the mold diagonally a little, by apply wooding forces from opposite corners in plan and elevation.

Once off the mold the new component is trimmed all round the edge with a saber-saw (using a fine tooth blade, as recommended on the packet of blades) or a hacksaw. The cut edge is then smoothed with a file, and where it has to be watertight it is coated with resin.

This impregnation process should be completed in less than 1/4 hr., for the resin might start to gel soon after that. If the gel stage is not attained within 1 hr., you have made a mistake in mixing the resin, or else the temperature is too low, and the mold may be a failure. Resin gels and hardens more quickly in bulk (such as in the container) than in thin layers such as impregnated glass fiber.

If you have someone to help, you might be able to impregnate two or three molds at a time. The stippling process should never be skimped. All the air trapped between the tiny glass fibers must be forced to the surface, and failure to accomplish this could result in a porous part. Impregnation is far more difficult using woven glass cloth instead of chopped strand mat, for the air must be worked out to the edges of each panel. Should insufficient resin have been applied over the gel coat to completely wet the mat, more resin must be spread over the mat as soon as stippling is finished. A stiff brush tends to break up the mat, so a soft brush is best to apply the resin, followed with a special roller.

Having impregnated one layer of mat, any hollows, such as a narrow ridge, can be fified up with resin and scrap pieces of chopped strand. Also at this stage, all wood and metal inserts that may be required for attaching other internal fittings should be glued into position so that the subsequent layers of mat will encase them.

All these inserts should be of very large area, with grooves or holes in the surface to improve adhesion. Where ribs must be incorporated to stiffen a large mold with a thin skin, the cores for these should be glued in place now. Cores made from metal pressings, wood, plastics tubing, and even hemp rope, has been used with success.

Having made sure that the surface so far has no protruding pieces of hardened fiber, the necessary number of extra layers of resin and mat are now installed. Before laying the final one, a neater job may result if any additional thickness is applied first.

SUMMARY

1. Apply a coat of mold release wax to the piece of plate glass upon which the lay-up of the place mat will be made. Polish with a soft cloth.

2. Brush or spray on a light coat of mold release solution.

3. Mix the hardener (catalyst) with the polyester resin according to the manufacture's directions.

4. Brush a coat of the mixed resin over the waxed surface of the plate glass,

5. Place the printed cotton cloth (finished side Down) upon the coat of resin and coat it with more resin,

6, Place a layer of glass mat on top of the cotton cloth,

7. Dab the glass mat with the brush until all fibers are saturated.

CHAPTER 7 - THERMOPLASTICS

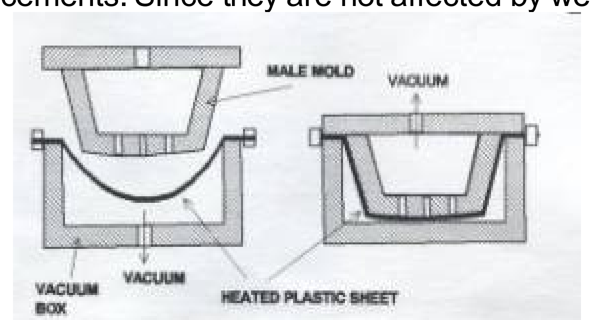
Thermoplastics are plastics that can be reprocessed. With the application of heat they will soften and can then be molded into different products. If the product is defective, it can be granulated and molded again.

ACETALS

Acetals plastics are called engineering plastics because they have a high degree of strength. They are noted for their toughness and dimensional stability. A plastic that has good dimensional stability does not change size easily over a wide temperature range; Acetals are used as a replacement for die-cast metal parts. Acetals have a low coefficient of friction. A plastic that has a low coefficient of friction is slippery. They have excellent abrasion resistance. Abrasion resistance is the ability of a plastic to withstand the action of rubbing or scraping. Acetals products include gears, pulleys, cams, and bearings.

ACRYLICS

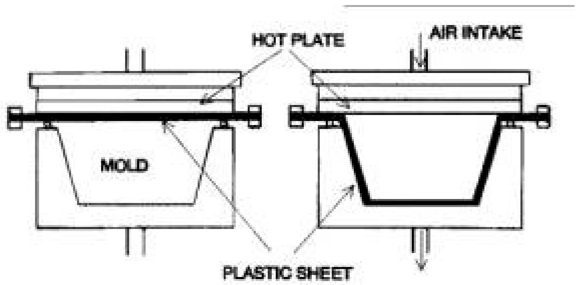
Acrylics have exceptional clarity and light transmission properties. Weathering does not affect their properties. Acrylics are rather strong plastics. They are used as window glass replacements. Since they are not affected by weathering, acrylics find many uses as outdoor signs.



VACUUM SNAP BACK FORMING

CELLULOSES

Cellulose acetate butyrate is noted for its toughness, transparency, and resistance to weathering. Butyrate is used for steering wheels, tool handles, and signs. Ethyl cellulose is a very tough plastic and finds uses as edge moldings on cabinets. Ethyl cellulose maintains its toughness and dimensional stability over a wide temperature range. Cellulose propionate has good shock resistance and hardness. Screwdriver handles, pens, and toothbrush handles are made from cellulose propionate.



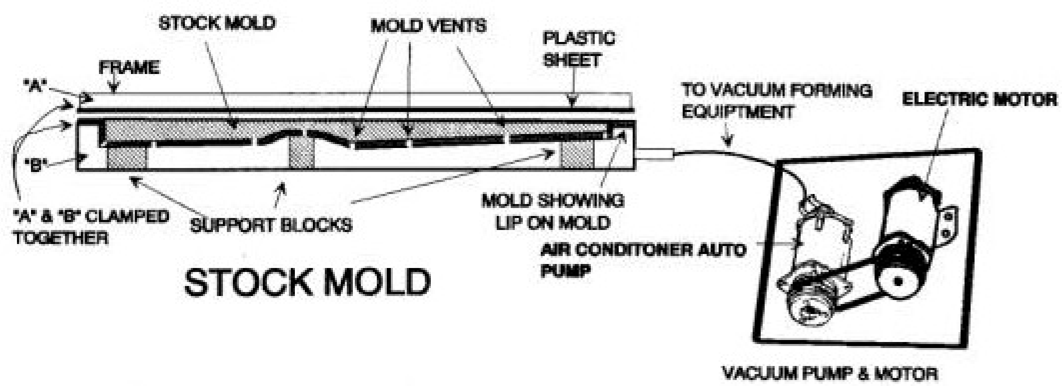
PRESSURE FORMING USING AIR PRESSURE

ETHYL-VT NYL-ACETATE

Ethyl-vinyl-acetate is a copolymer similar to rubber. Ethyl-vinyl-acetate is has a low-temperature flexibility is the most outstanding property of EVA. It is used for refrigerator gaskets, squeeze bulbs, pool liners, and inflatable toys,

FLUOROCARBONS

There are four types of Fluorocarbons and they are not affected by chemicals and are almost friction-less. Fluorocarbons are used for bearings, valve seats, lab ware, and "nonstick" frying pans.



LONOMER

Lonomer is a very tough, resilient, clear plastic. Lonomer is not affected by oils or greases. It is used for skin packaging, bottles, closures, and wire insulation.

NYLON

Nylon was first developed as an engineering plastic because of its outstanding properties. It is tough, resilient, and has tremendous strength. Nylon has a very low coefficient of friction and is used for bearings. Other uses include cams, gears, fishing line, and brush bristles.

PHENOXY

Phenoxy is another engineering plastic that has outstanding rigidity and hardness. Phenoxyis strong and tough. It is used to mold precision parts for computers. Uses for phenoxy include bottles, drug containers, and appliance housings.

POLYCARBONATES

Polycarbonates are another engineering plastic that has tremendous strength and is almost impossible to break. Polycarbonate is used as a glass replacement in high crime areas; It will even stop a small caliber bullet.

Polycarbonate is used for unbreakable bottles, power tool housings, air-conditioner housings, and coffee pots.

POLYOLEFINS

The Polyolefins include polyethylene, polypropylene, and polyallomer. Polyethylene, is strong and flexible. It is very resistant to breakage. Polyethylene is used for ice cube trays, squeezable bottles, plastic bags, and refrigerator containers. It can be made either flexible or stiff. Polypropylene has an outstanding flex life and is used for flexible hinges. Its electrical properties are outstanding.

Polypropylene is used for electrical insulation. Other uses include pipes and fittings, car battery boxes, house wares, and toys.

Polyallomer combines many of the better properties of polyethylene and polypropylene. It has much better flex life for hinges than polypropylene. Polyallomer can be colored and processed more easily than polyethylene.

POLYPHENYLENE OXIDE

In another engineering plastic, Polyphenylene oxide was introduced. It has outstanding physical and electrical properties over a wide temperature range. Electrical uses include switches, printed circuits, and capacitors. It is ideal for sterilizable medical and surgical Instruments. Polvnhenvlene oxide is being used to replace brass in plumbing applications.

POLYSULPHONE

Another engineering plastic Polysulphone was introduced. Polysulphone has the highest use temperature of any thermoplastic. Because of this property, it is used for many parts in automotive engine compartments. It has excellent electrical properties at temperatures of up to 350°F (178°C). Polysuiphone is used for electrical insulation, switches, and circuit breakers exposed to high temperatures.

POLYSTYRENE

Styrene is one of the least expensive plastics. Because of this, it is used for disposable products such as forks, knives, spoons, water glasses, and packaging trays.

Styrene has very low strength. Many polystyrenes have rubber added to increase their strength. SDN (styreneacrylonitrile) is a styrene copolymer. It performs better than polystyrene to scratch and chemical resistance. It has better stiffness and a higher use temperature. ABS (acrylonitrile-butadiene-styrene) is the strongest styrene copolymer. ABS has outstanding impact strength and overall toughness. It is used for molding refrigerator door liners, luggage, football helmets, and telephones.

POLYURETHANE

Polyurethane has exceptional ranges of flexibility, toughness, resilience, and abrasion resistance. Urethanes are used for solid tires, rollers, and bumpers on industrial equipment. They are also used in varnishes and paints. Flexible urethane foams find many uses as padding under rugs, sponges, mattresses, and padded dashboard panels in cars. Rigid urethane foams are used for refrigerator and freezer insulation. Rigid urethane is used to duplicate intricate woodcarvings on furniture.

VINYLS

There are several different kinds of vinyls. All of them have excellent electrical properties. They are very tough and strong. Vinyls can be made rigid or very flexible. Polyvinyl acetate is used for white glue and paints. Polyvinyl alcohol is used as a water-soluble mold release in fiberglass work; It is also used as a water-soluble film for packaging soaps, detergents, and dyes. Polyvinyl chloride is the most important vinyl. It can be made rigid or flexible.

FORMING THERMOPLASTICS

Many different types of objects can be made by blowing Thermoplastics. Rifle, shotgun stock, as well many other type of objects can be made by blow molding. The disadvantage of blow molding is a finished pattern has to be made. This is time consuming unless you use a finished part. For more information, Making Art Casting In The Shop goes into detail on how to make patterns or molds.

Thermoplastic items can be made from parts that are blown, or formed with air pressure. Only simple equipment is required to make small items, however the equipment can be enlarged to accommodate about any size object. It can be easily constructed from plywood, toggle clamps, some rubber gasket material, and a piece of sheet metal.

MAKING A PLASTIC FORMER

The plywood base upon which the toggle clamps are mounted is the permanent part of the equipment, and is made of 1/2" or 3/4" plywood. In the center of the base is an opening leading from a source of constant air pressure and at least ten pounds of pressure is necessary. A sheet of rubber gasket material, with a hole at the center to allow the compressed air to pass through, is placed upon the base. This gasket forms an airtight seal between the plastic and the base as the plastic is blown.

A shut-off valve controls the flow of air, which is purchased from your local hardware store. The air inlet is covered by a piece of sheet metal 1/8" thick, raised above the hole by small washers and screws. This is a deflector and prevents the incoming rush of cold air from cooling the plastic unevenly as blowing takes place. The shaped die is held in place by the toggle clamps, is removable. The size and shape of the hole in this part determines the size and outline of the formed plastic.

Molds can also be made from plastics, aluminum to give a definite shape and size for the part you want. Since plastic stretches and thins out as it is blown, a piece 1/8" thick is necessary to blow a hemisphere six inches in diameter. If larger dimensions are required, then the thickness of plastic must be increased accordingly.

To use the pressure forming equipment it is necessary to cut the plastic so that at least a one-inch margin is allowed around the opening in the die through which the material is to be blown. For a die eight inches in diameter, an ten-inch square piece of plastic 1/8" thick is needed. Open the toggle clamps, remove the die, and regulate the air pressure to ten pounds.

Use a small oven and heat the plastic until it is rubber like, or with a heat lamp or heating element, then remove it from the oven and center the piece over the air inlet. Center the die over the plastic and clamp it in place. Then open the shut-off valve and allow the air to exert pressure under the plastic, thus blowing it up through the hole to form the desired shape. Close the valve.

When the blown part has cooled, it is removed and the excess material cut off. If a two-part pattern is made, they can be sanded flat on a belt sander and cemented together. Use a cement that will dissolve the plastic, some types of plastic pipe solvent will melt some plastics.

To test out the solvent, put a drop of it on the plastic and let it set for 30 seconds. Wipe it off with a rag, and if it leaves a slight depression it will work for cementing the two pieces together. If it wipes off clean it is not the right type, and you might check with sign makers to find a different type of solvent. When dried, sand and buff to finish the edge and the part is completed.

CHAPTER 8 - FORMING AND DRAWING OF PLASTIC SHEETS.

With this method many types of objects can be made for mass production. The main disadvantage is that making the mold can be time consuming and expensive. Many of the molds can be cast from aluminum.

Most forming and drawing operations requires that the plastic material first be heated to a suitable temperature. The press operations used for sheet metals can be applied also in many cases to plastic sheets. These include blanking, stretch forming, forming, and drawing with suitable dies. Thermoplastic sheets can be readily formed and drawn.

Two other processes that can be used, with vacuum forming and vacuum drawing. Blowing is also used to produce bottles and other hollow articles. Two plastic sheets can be clamped together by the two halves of a die, and air can be blown into the space between them, expanding them to take the form of the die cavity.

At the edges of the die cavity, the plastic sheets are fused together, and the excess material is pinched off. Another method of blowing using suitable lengths of extruded plastic tubing with one end closed. These may be placed into a split die, blown to a desired shape, and ejected when properly cooled.

Expanded plastics may be made by;

(1) Whipping gas into a resin by mechanical agitation.

(2) Incorporating a gas or liquid that expands upon reducing pressure or raising temperature.

(3) Releasing a gas throughout a resin by the breakdown of a chemical material. The resulting plastic is cellular, or foam like, containing many small bubbles of gas. The material is impermeable and extremely light. It has a low thermal conductivity, high strength-weight ratio, and negligible water absorption.

DESIGN OF PLASTIC PARTS

Many of the design rules for molded plastic parts are similar to those, which apply for die-castings, permanent-mold castings, and sand castings. Some of the design rules for plastic-molded parts may be given as follows:

1. Allow for shrinkage after molding.

2. Specify dimensional tolerances only as close as actually necessary tolerance's closer than 0.0005 inch, the usual commercial limit generally increases costs.

3. Allow at least the minimum draft of 1/2 to 1 degree to facilitate removal of parts from the mold.

4. Avoid undercuts. These will require cores or split cavity molds.

5. Locate the mold parting in one plane, if possible.

6. Locate holes at right angles to part surfaces. Oblique holes add to mold costs.

7. Avoid long cored holes, especially if not in the direction of mold closing. It is necessary to provide support for sufficiently long core pins not in the direction of mold closing.

8. Design projections to have circular sections. Irregularly shaped holes are generally more expensive to obtain in the mold.

Many types of objects can be made by vacuum forming, and I have found much time is saved by using the following methods. A simple vacuum forming setup is shown below, but it can be altered in size to form many different items such as gunstocks.

The equipment is constructed from 1/8" and 3/4" plywood, 1" dowel, 3/8" pipe, a pipe T, a winged stud, a pipe flange, metal window screen, sheet steel, fastener, hinges, rubber gasket material, and a heat lamp.

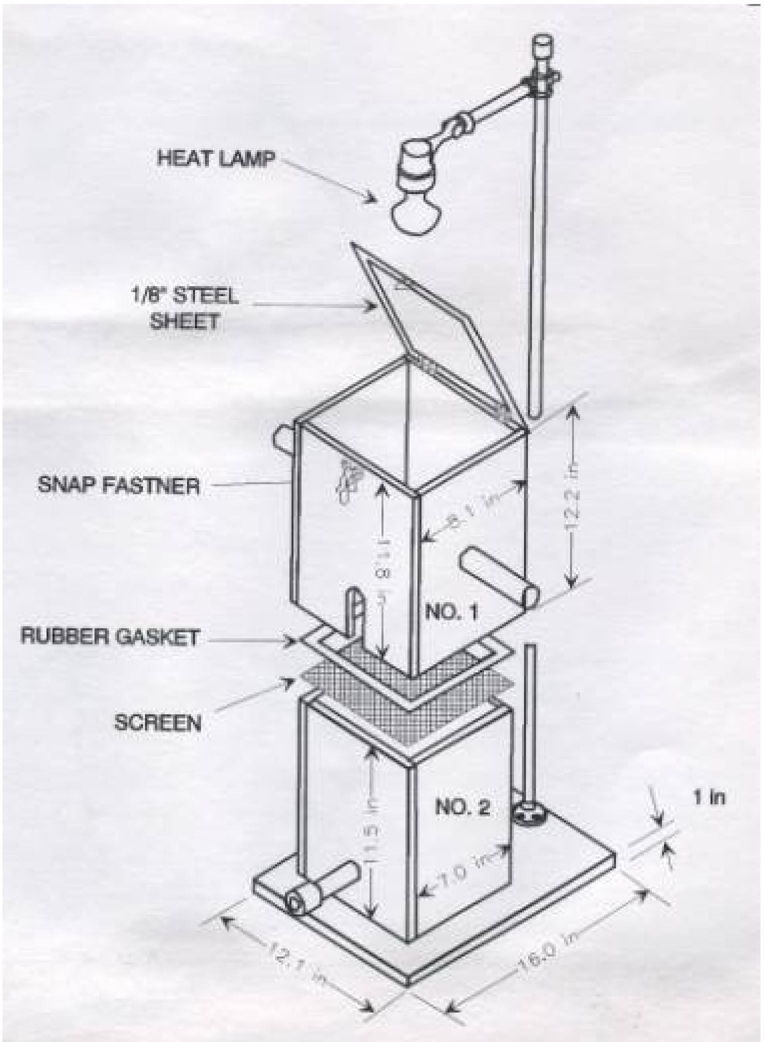
Locate holes at right angles to part surfaces. Oblique holes add to mold costs.

Avoid long cored holes, especially if not in the direction of mold closing. It is necessary to provide support for sufficiently long core pins not in the direction of mold closing.

Design projections to have circular sections. Irregularly shaped holes are generally more expensive to obtain in the mold.

CHAPTER 9 - MAKING A VACUUM MOLDER

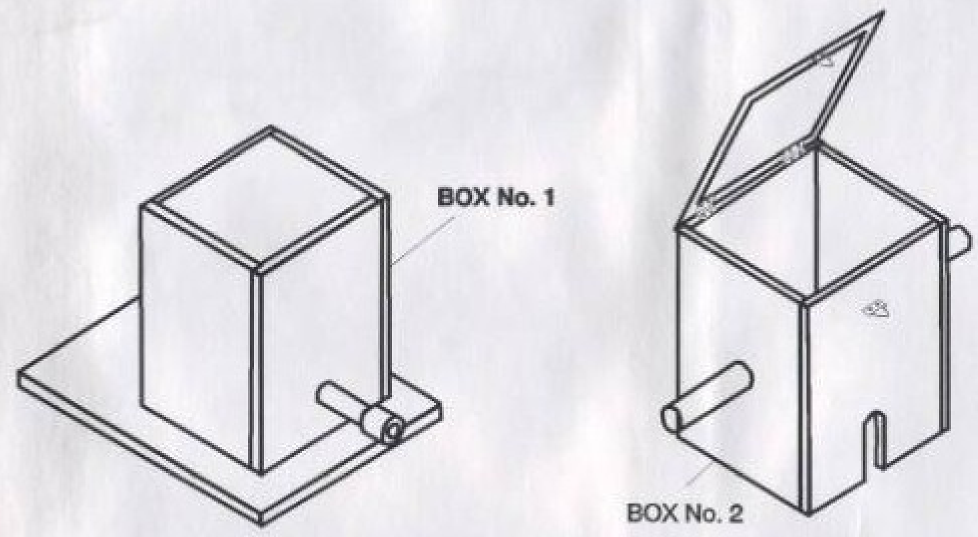
1. Make the base, which is usually made of 1/2" or 3/4" plywood.



2. Cut the pieces for part No. 1.

3. Now drill a hole in one side in which to thread a piece of pipe. This pipe will lead to a source of vacuum, and an ordinary shop vacuum cleaner will generate sufficient suction but I prefer a vacuum pump made from a air conditioning pump from a automobile.

4. Assemble the four sides of part No. 1 with airtight joints using a good wood glue, such as Elmer's glue. Then seal and fasten this assembly to the base with wood screws.



BOXES 1 & 2 USED IN VACUUM FORMING

5. Cut a piece of metal window screen to fit the top of part No. 1 and tack it in place.

6. Cut a rubber gasket to fit around the top edge of part No. 1 and cement it in place.

7. Next, cut the pieces for part No. 2.

8. Cut out one side to fit down over the pipe in part No. 1.

9. Drill the holes halfway through the two opposite sides to take the dowel handles. Fasten the handles in place with glue and wood screws.

10. Assemble the four sides of part No. 2 with airtight joints, and with just enough clearance to slip down over part No. 1.

11. Lay out and cut a piece of sheet steel to frame the top of part No. 2, which should be at least 1/8" thick.

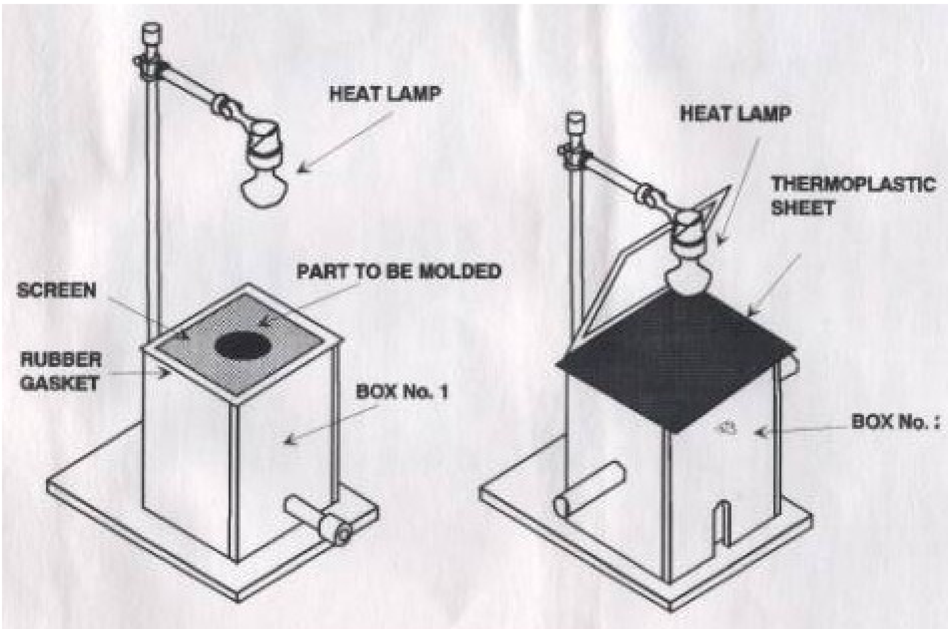
12. Fasten the metal frame in place with hinges and a suitable fastener, which can be purchased at any hardware store.

13. Drill and tap threads in the pipe to take the winged stud. This will allow the heat lamp to be adjusted to the proper height above the plastic for efficient heating.

14. Assemble the pipe lamp support parts, align the heat lamp directly over part No. 2 and fasten the pipe flange to the base to complete the equipment.

USING THE VACUUM FORMING EQUIPMENT

1. Select the pattern which to form the .010 thickness thermoplastic. This thickness of thermoplastic material (cellulose acetate) can be drawn with very fine detail, and without thinning out much, over a pattern not more than 3/8" in thickness. The model may be any type of pattern that you make, or copy, if it is rigid enough to support the plastic sheet as it is heated and vacuum drawn.



READY TO VACUUM FORM

2. Place the model on the window screen, part No. 1.

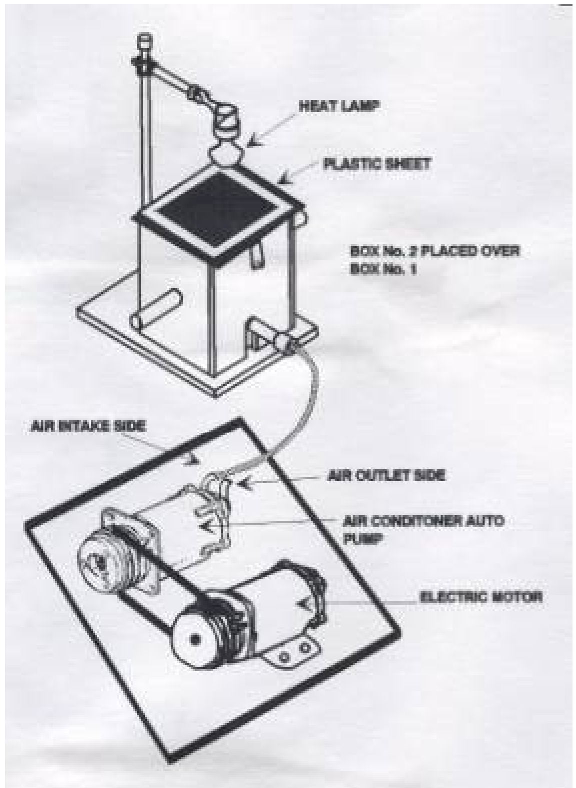
3. Clamp a sheet of plastic under the metal frame of part No. 2.

4. Slip part No. 2 over part No. 1, but do not touch the model with the plastic.

5. Adjust the height of the heat lamp above the plastic. Experiment until the heat lamp causes the plastic to change from a glossy to a dull appearance and sag slightly in a matter of seconds.

6. At the very moment that the plastic is hot, lower part No. 2 over part No. 1 and turn on the vacuum.

7. The formed plastic part maybe immediately removed and used.



VACUUM FORMING PART

CHAPTER 10 - FOAM

FOAMED PLASTICS

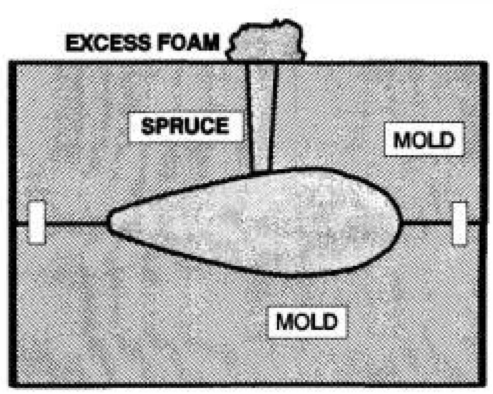
Foam can be used to fill stocks, etc., to give added weight to the object. In practice they are easy to use, and usually few problems are encountered when the manufacture's instructions are followed.

Foamed plastics are made by adding a gas to a plastic resin. The gas gives the resin a certain cell structure. Common plastics that are foamed include phenolic, silicone, acetate, urethane, polystyrene, and polyethylene.

Foamed plastic was developed by Dr. Leo Baekeland, and his early experiments in developing phenolic led to a phenolic foam. Many foams were developed during World War II as a result of the need for a material to float munitions to a beachhead. There was also a need for a structural material for building aircraft.

Foams can be classified as either physical or chemical. In a physical foam, there is only a physical change. A hydrocarbon is added to the plastic resin as it is being made, causing it to foam. Most thermoplastics, such as polystyrene, polyethylene, and acetate, are physical foams.

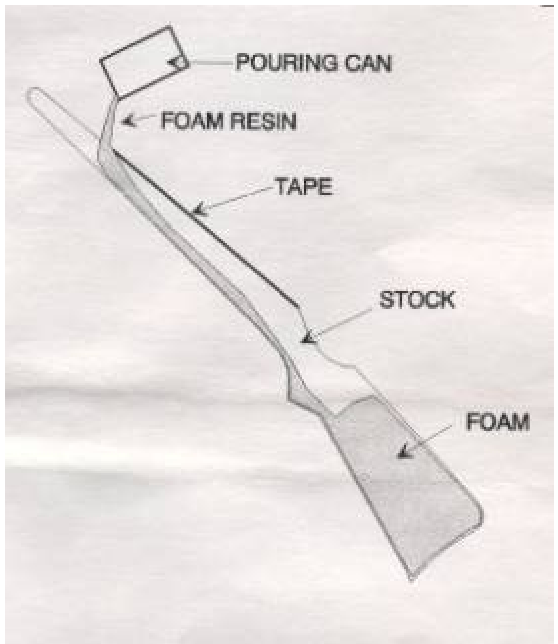
In a chemical foam, a chemical reaction takes place. Thermosets are generally chemical foams. Epoxy, silicone, and polyurethane are chemical foams. They are usually a two-component system. Component A and component B must be mixed together to cause the foaming.



MOLD FOR POURING FOAM

Chemical and physical foams can also be classified as open or closed cell. Foams with an open cell structure are usually flexible and will absorb water. The small cells are interconnecting. A closed cell foam will not absorb water.

Each cell is enclosed with air or a gas. Generally, closed cell foams are rigid. Density is an important factor in selecting a foam. Density is the weight per unit volume of a substance expressed in pounds per cubic foot. A 2-pound per cubic foot density foam is very light. A 25-pound per cubic foot foam is very heavy. The lower the density, the better the insulating and flotation qualities. A high-density foam is usually stiff and has good structural properties.



POURING FOAM IN THE STOCK

Polyurethane foams are produced by the reaction of a poiyoi, isocyanate, and a blowing agent. The polyol can be a polyester or a polyether resin. Carbon dioxide, which is generated by the chemical reaction, is the blowing agent generally used for flexible foams. Freon gas is usually used for rigid foams; Densities for urethanes can vary from 1 to 70 pounds per cubic foot.

Rigid urethanes are closed cell foams and are excellent insulators against heat and cold. They are the best insulators known to man. Most rigid urethanes have a k factor of about .12. Fiberglass insulation has a k factor of about .28. The k factor is the ability of a material to insulate against heat or cold. The lower the k factor, the better the insulating ability of a material.

Many refrigerators and freezers use rigid urethane foam as an insulating material. Since it is a closed cell foam, it can be used for flotation products. It also has found wide acceptance as a wood substitute. Many pieces of furniture have fronts foamed from rigid urethane foam; The foam can be stained and finished to match wood.

The advantage of urethanes is that they do not warp and split as wood can. They are cheaper because the doors can be duplicated in a mold. This eliminates expensive machining operations. Urethane foam is also less expensive than wood. A flexible mold is made from a wood master. The flexible mold duplicates exactly the grain of the wood. The rigid urethane is then foamed in the mold. The molded part is then removed and finished to look like wood.

Flexible or rigid urethane foams can be mixed by hand and cast into a closed mold. The ratio of components A mold release must be used to keep the foam from sticking to the mold. Commercially, a dispensing machine is used to mix the components; The foam can also be sprayed in place. Polyurethane's cure by the heat generated by the chemical reaction.

USING FOAM

A little mixed foam/resin goes a long way. Read the instructions on how to mix the resin for the foam. The warmer the resin the faster it starts to expand, which is less normally than 30 seconds. What this means is that when you start to mix the two parts together, have everything ready.

On the gunstock that is shown in the drawing, tape the top of the barrel and action channel up to the last 2 inches. Mix and stir a small amount of the foam together very fast, and pour it into the small opening of stock. In a moment the foam will start to expand, and if you have mixed too much it will foam out of the stock and get all over everything. If you do not pour enough a little more can be added, or the space can be fitted with a compounded plastic mixture when you fit the barrel/action.

This is the better way to do it, as you will be able to fit any type of barrel/action to the existing stock.