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Resources And  
Insight For The  
Entrepreneurial  
Engineer

# Midnight Engineering

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Limited Run Parts  
Fabrication  
For Entrepreneurs

**Buying  
Machined  
Parts**



# The Machined Parts Business

**P**rojects undertaken by Midnight Engineers often require the business owner to be proficient at skills that, in a large company, would be handled by others or in many cases by a complete department. Most manufacturing companies, for example, have marketing, sales, engineering, production, accounting, shipping and receiving, human resources, and purchasing departments. These departments are usually staffed by people who have taken years to learn how to do their jobs efficiently and effectively.

A manufacturing entrepreneur, like myself, must perform all of these jobs. I wan't to talk a little about small business before I get into the specifics of buying machined parts. The do-it-all yourself requirement is a reality that can rudely awaken entrepreneurs that have mastered only one of the

**The best engineers are always interested in changes that are requested by the machine shop.**

pieces of this puzzle. Relief to this daunting task can often be found through association with other small businesses and high value suppliers. Other business owners often are an excellent source of advice, referrals, and business. The high value supplier is the one who supplies not only materials for your project but who often includes free design help, cost reduction tips, and advice that would otherwise have to be purchased from experts and consultants.

Although the range of businesses operated by midnight engineers is certainly wide, it has been my impression that most are either engineering consultants, software companies, or manufacturers of electronic products.

Engineering consultants usually do well when they are busy, but are limited by the fact that there are only so many hours per week that can be billed. An engineering consultant does not require many of the business skills such as purchasing and production, and needs only basic sales and marketing skills. Software companies can strike it rich when a product is a hit. This is especially true because of the low cost of sale of a software product. Software products, however, can be very high risk endeavors, particularly if a the target customer and market are not well known. A software developer needs the business skills that are found in large manufacturers. The

## Thomas R. Mathews, PE

product, like the consultant, however, is still intellectual property.

Manufacturer's of electronic products can have sales which are limited only by the popularity of the product. Manufacturing entrepreneurs seem to be saddled with the largest business skills requirements. As such, this often appears to be the hardest endeavor for the entrepreneur to bring to market. This entrepreneur must succeed at marketing, sales, engineering, production, accounting, shipping, receiving, human resources, and purchasing. Usually all of these items must be completed before the first dime is made! Most Midnight Engineers have mastered one of the most difficult parts of this puzzle, the engineering. They often figure out the rest by many hard knocks.

The marketing and sales portion of the puzzle is often particularly difficult. As a younger engineer, I once thought that this part of business was not very interesting and didn't seem to be too important. After all, all we have to do is design a good product and the world will come to the door... right? Business wisdom, learned the hard way, has driven home a point that is often hard to accept. That is, that engineering, production, accounting, shipping, receiving, human resources, and purchasing might as well all go home if sales and marketing cannot bring in customers. This too is true for the entrepreneur. Finding and maintaining customers is more important than any other business function! Once customers are found and their needs identified (or even better, a purchase order received), all

**I have run into many customers who know they need a machine shop to make a unique part but don't know how to specify exactly what they want.**

other skills can now come into play. Engineering can begin. Purchasing can start buying. Human resources can hire. Shipping can ship and accounting can count receivables and pay bills.



1. SAND OR SLIT ON CENTERLINE Z-LINES AS LAST MACHINING OPERATION, WIDTH NOT TO EXCEED  $\frac{3}{32}$  INCH

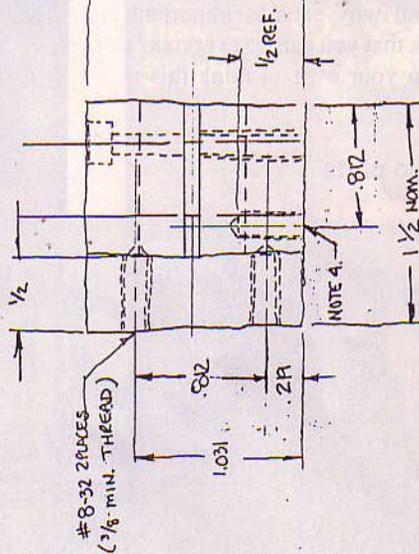
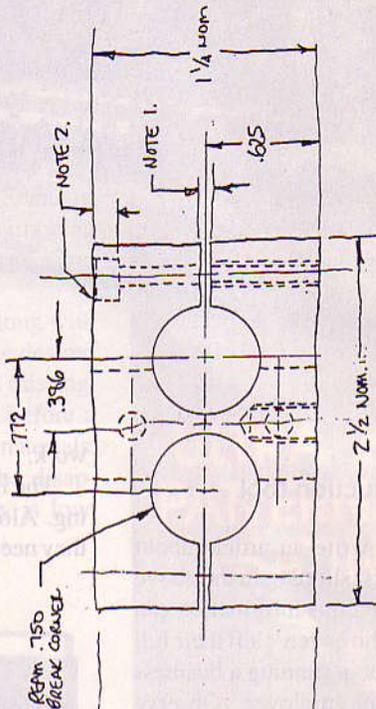
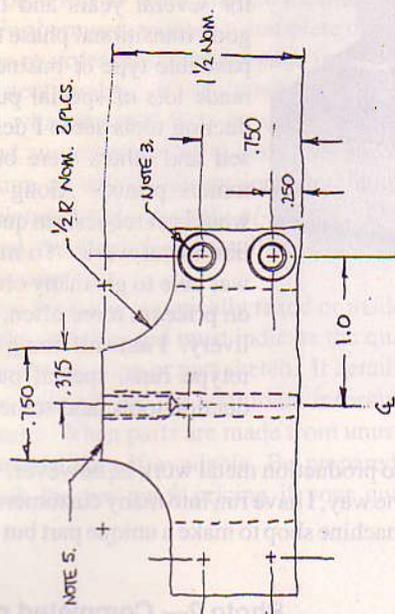
2. # 8 SOCKET HEAD CAP SCREW COUNTERBORE  $\frac{5}{16}$  DIA. COUNTERBORE DEPTH - FLUSH TO .010 BELOW

COUNTERSINK TOP JUST TO BREAK CORNER SLIGHTLY 4 PLACES

3. # 8-32 THREAD 4 PLACES ACT PREFERENCES USE OF SPIRAL POINTED G-2 TAP

4. DRILL #25 (.1495) AS DEEP AS NECESSARY TO ACHIEVE  $\frac{3}{8}$  LENGTH OF 10-24 THREAD AVOID DRILL BREAK-THRU INTO BORES.

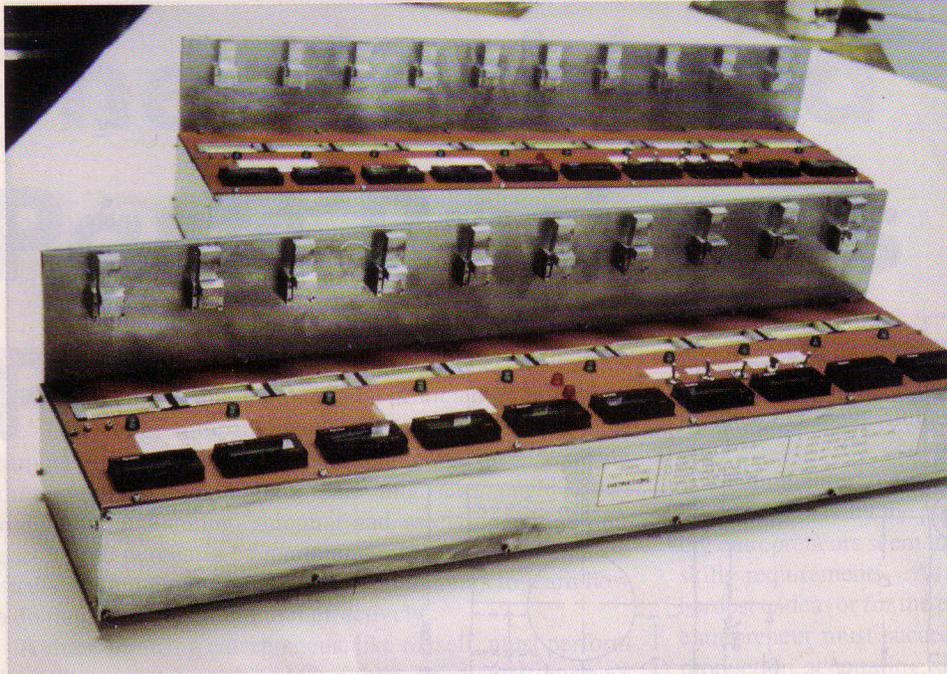
5. THIS  $\frac{3}{4} \times \frac{1}{4}$  SURFACE TO BE FACE MILLED TO ACHIEVE MATING SURFACE FLATNESS (CIRCULAR COLD SAWS FINISH OK)



MATERIAL: EXTRUDED 6061AL / MAX SUB. TOOLING PLATE  
 GENERAL NOTATIONS: EXTRUDED EXTERNAL FINISH OK IF SCRATCH FREE  
 CIRCULAR COLD SAWS FINISH OK  
 DO NOT GLASS BEAD  
 END MILLING OK FOR RADIUS PROFILE ONLY  
 FACE MILL CUT FOR ANY OTHER

sketch only - not to scale  
 VALVE CARTRIDGE 1ca. 15

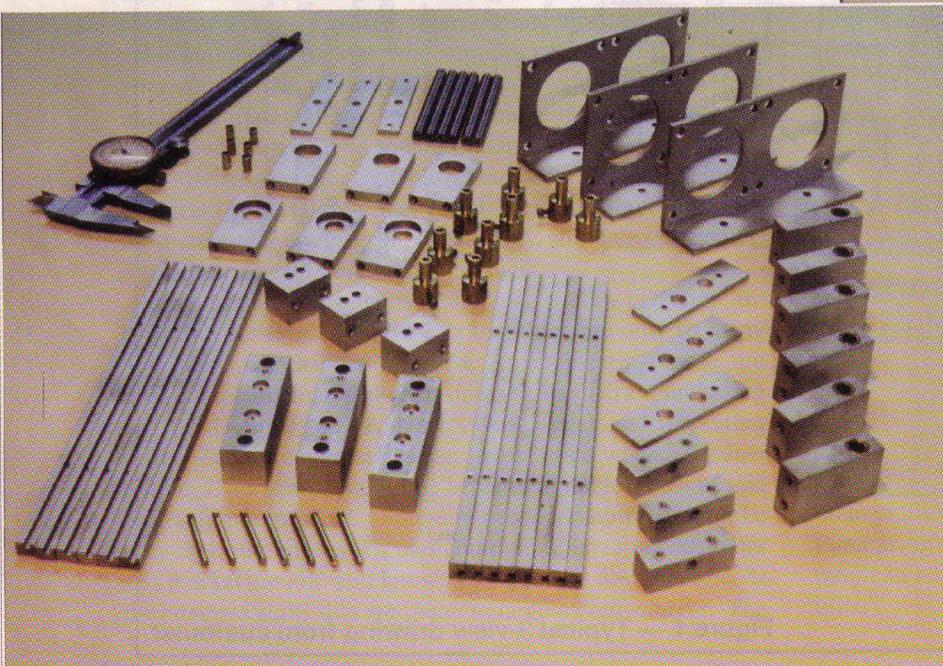
Figure 1 — Typical 3-view drawing from customer.



**Photo 1 — Custom production tool**

Bill Gates originally asked me to write an article about buying metal work. I couldn't resist first slipping in the above views about small businesses. I feel that this information can be especially useful to entrepreneurs who haven't left their full time jobs yet. The best information about running a business is available around you at your current employer. Observe how every department works and why each is important. When you're bold enough to think that you can do everyone's job, you are ready to start out on your own. I think this is

**Photo 3 — Typical machined parts**



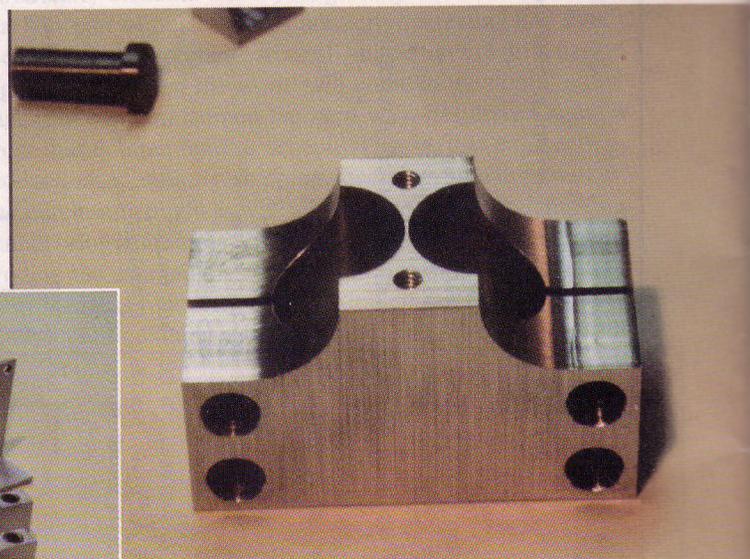
enough general rambling about running a business. A more specific topic that many entrepreneurs may have trouble with is how to specify and buy machined parts.

When I originally left my full time employer, I was planning to do consulting only. I have done this for several years and it is a very good transitional phase to more expandable type of business. I have made lots of special purpose production tools some I designed myself and others were built to customers prints. Along the way, I would get requests to quote production metal work. To my delight, I was able to get many orders simply on price or, more often, snappy delivery. I am still doing lots of prototype runs, special purpose production tools, and some consulting

work.

The lure to production metal work is, however, very tempting. Along the way, I have run into many customers who know they need a machine shop to make a unique part but don't know

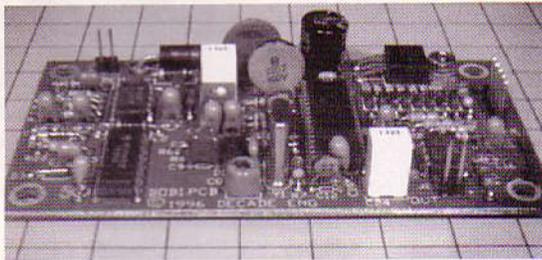
**Photo 2— Completed part**



how to specify exactly what they want. In many cases, I get hand drawings that are less than professional. This is usually not a problem. The key issue to specifying your part for a machine shop is that the drawing contains all of the information necessary for someone who doesn't know what the part is used for to fabricate it. This usually means that all dimensions are identified, typically in a three view drawing. Figure 1 is an example of a good three view drawing.

Many technical drafting books are available on this subject. We often receive drawings that need to be re-drawn before we can make the part. Mathews Engineering will usually do this with no charge. Customers sometimes don't understand the importance of a drawing that specifies all features. Drawings specify exactly what the customer wants. Additionally, a drawing documents what the machine shop has agreed to deliver. If parts don't fit, or are too big, the drawing is the customers only way to show that the machine shop has made an error. Furthermore, without a complete drawing, you will be unable to re-order parts or order parts from a second source with consistent quality. Your drawing should include notes explaining what material is to be used, plating or finishing desired, and any other special features not shown elsewhere. Also, be sure to specify dimensional tolerances. Standard industry tolerances are typically +/- 0.005". Once a drawing is completed, the machine shop will be able to quote price and delivery for your part.

A request for quote is typically faxed or mailed along with a copy of the drawing and must indicate the quantity desired and include the drawing or part sketch. If details are missing, most shops will ask for the additional information before a quote is made. When parts are made from unusual materials, include material data if available. Be prepared to be disappointed with the per piece pricing if your quantity is low.



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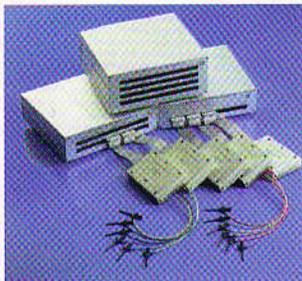
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Many shops will not bid on prototype quantity orders, especially from new or small customers. Due to high set up costs, per piece prices often will not be acceptable for profitable resale until quantities get above 100 pieces. Because of this, it is important to request a price quotation for your estimated production quantity when you are ordering prototypes. This makes it possible to prepare a cost of sale estimate for the production article. In many cases, customers who want to skip the prototype stage have sent us the remaining parts for their assembly and we have verified that the machined parts will work as designed. This can save time and money plus often gives us the opportunity to suggest improvements to the design.

A good part design often requires some knowledge of how the part will be made. We often help customers by working with them to redesign their parts so that they can be more easily manufactured. The best engineers are always interested in changes that are requested by the machine shop. Sometimes these changes are not possible, but when they are, the savings can be substantial. If you are not sure how your part will be made, the best solution is to call a machine shop and talk to the machinist. The variety of ways to manufacture things from metal is currently mind boggling. Most entrepreneurs will have to stay with traditional machining methods unless quantities are large. (Don't plan to use die casting if you only need 25 pieces per year!) Traditional machining includes milling, turning, threading, drilling, sawing, punching, bending, welding, etc. High volume machining usually requires automatic or CNC machines like the mill shown in photo 4. This type of machine can produce complex parts rapidly with consistent dimensional accuracy and quality.

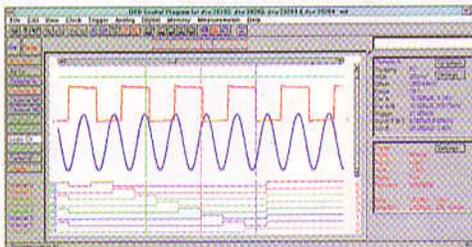
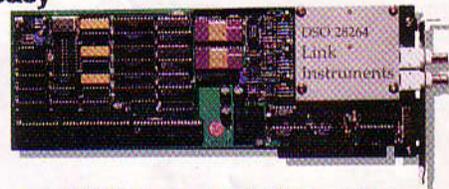
Many entrepreneurs are unsure how to specify the material to be used. The number of machinable materials available today staggers the mind. To make it even worse, each material usually has many different grades or alloys. Aluminum, for example, is available in hundreds of different alloys. When you are

# Serious Test Instruments



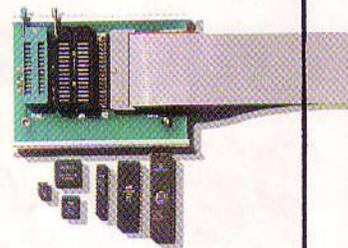
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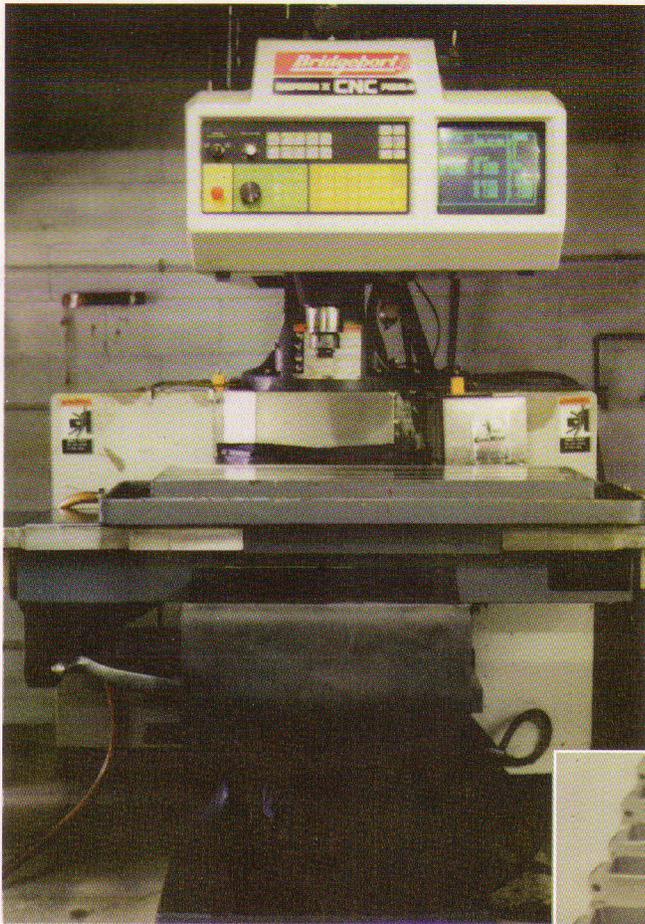
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**Photo 4 — CNC milling machine**

not certain which material to specify, call the machine shop and see what they suggest. Additionally, there are many materials handbooks available. Be advised that specification of exotic materials can adversely effect part cost. Some of the most common materials specified are:

\* **ALUMINUM** — Available in hundreds of grades the most common is probably 6061-T6. Aluminum is available in bar, rod, sheet, plate, extruded shapes, etc.

\* **COLD ROLLED STEEL** — CRS is available in rod, plate, bar, and other shapes. Typically low in cost and easily machined, this material, however, is subject to corrosion.

\* **STAINLESS STEEL** — Available in rod, sheet, bar, etc. This more expensive material is known for its resistance to corrosion. Stainless steel must be machined at lower feed rates and rapidly wears cutting tools. As a result, machine shops typically charge more for parts made from this material.

\* **TOOL STEELS** — A wide variety of tool steels are available for various applications. These steels are usually specified when low part wear or a cutting edge is required. Heat treatment is usually required.

\* **BRASS** — Available in rod, sheet, bar, etc. Brass has good machining properties and accepts many different types of plating.

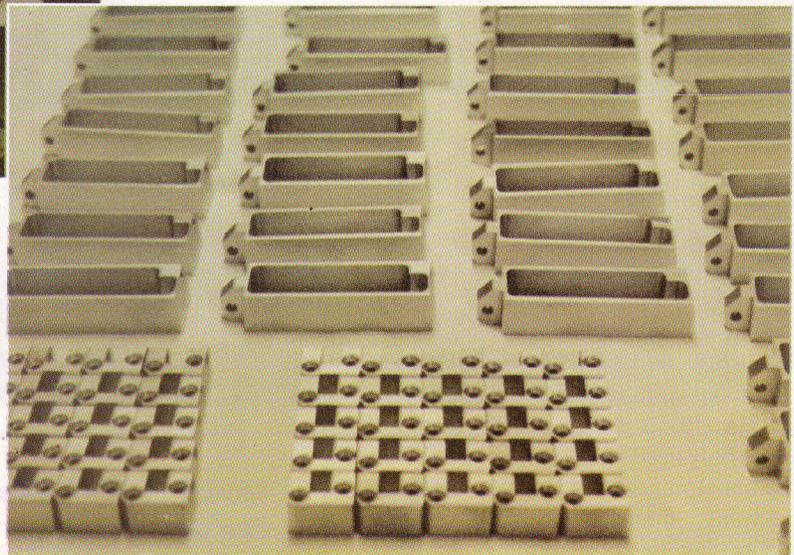
\* **PLASTICS** — Many different types of plastics can be machined. Common plastics processed by machine shops include: Delrin, ABS, Teflon, Polycarbonate, Phenolic, Nylon, and many more. Some machine shops may not machine plastics. Dimensional tolerances are typically degraded with plastics due to flexing during clamping and machining.

\* **CUSTOMER SUPPLIED MATERIALS** — Customers often drop ship materials to Mathews Engineering for machine work. This often includes standard electronics enclosures which need holes punched or other features machined.

Parts sometimes require special finishing after the machining operation is done. This can include plating, painting, heat treatment, insertion of PEM fasteners, bearings, etc.

Some machine shops will take care of plating details. Usually by sending your parts to a local plater. Many shops don't want to be involved in this step and you will likely have to take the machined parts to the plater yourself. This is

**Photo 5 — Production mill work**



because they don't want to be responsible if the plating company fails to deliver on time or if the quality of the plating is unacceptable. Lots of platings are available ranging from hot tin dips, nickel, chrome, silver, gold, etc. Small plating orders will typically encounter a \$100 minimum charge from most plating shops.

Painting operations are generally taken care of by local paint shops. I have worked with a local business that will perform most painting and screening operations. They typically use high durability epoxy based paints and can also screen print instrument panels.

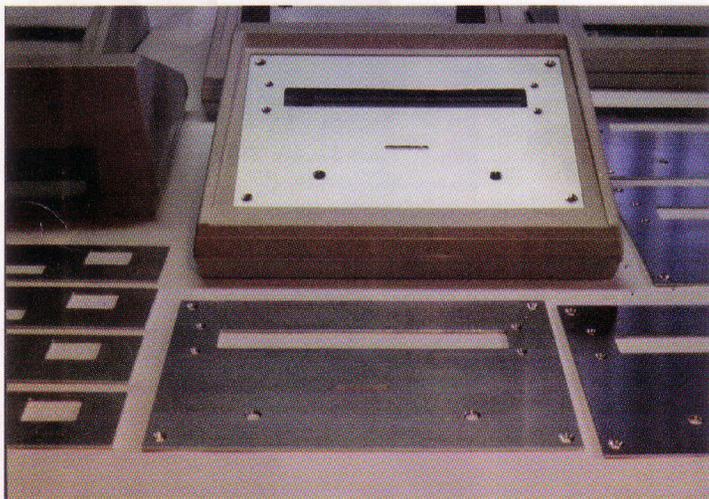
Parts requiring heat treatment are best when treated by professional heat treaters. Your local heat treater can be found in the yellow pages. Some machine shops will perform simple heat treating operations. High quality heat treating, however,



**Photo 6 — Machined plastic parts.**

usually requires a vacuum heat treating furnace. Most shops will not have this type of equipment which prevents corrosion from forming during the heat treatment process.

Running a small business can quickly become overwhelming. Entrepreneurs are required to possess many business skills. Often this can become overwhelming and this is when high value suppliers like machine shops can help with parts and services that could not be obtained in any other way. Developing a positive relationship with your machine shop can be very useful. Cost reducing advice and ideas are often



**Photo 7 - Modified enclosures**

free. Although many shops will not take care of secondary details like plating, they usually can refer customers to suppliers of these services.



Thomas Mathews may be reached at Mathews Engineering, 6125 East 10th St, Indianapolis, IN 46219-4610, 317-356-7692 or fax 317-352-1305.

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