This is the FAQ for rec.crafts.metalworking. It is in several pieces
to keep the overall size of each part below the limits imposed by
some news systems. This is part 1 of 11.

Generally, units below are United States dollars, degrees Fahrenheit,
and all the other silly backwards units we Americans still use. Sorry.

The questions being answered in part 1:

The questions being answered in part 2:

The questions being answered in part 3:

The questions being answered in part 4:

The questions being answered in part 5:

The questions being answered in part 6:

The questions being answered in part 7

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0. Where is this FAQ kept, and where are archives of the newsgroup?

    This FAQ is also available via anonymous ftp to plains.uwyo.edu,
    in the METAL directory. I also hope to someday get it posted to
    news.answers and into rtfm.mit.edu, which is where many groups'
    FAQs are kept.

    I also keep an "informal" archive of the newsgroup on plains.uwyo.edu,
    also in the METAL directory. It's informal in that I only update it
    from time to time, not continuously.

    Plains.uwyo.edu is usually down early Sunday and Monday
    mornings, so if ftp fails then, just try it again later.

1. The original rec.crafts.metalworking charter.

    A tiny bit of history: there existed a group trial.rec.metalworking,
    but few sites pick up the "trial" feed. Also, the trial method of
    group creation sort of died of neglect, so this group
    (rec.crafts.metalworking) was created to take its place and become
    an official wide-spread group.

    Charter

    Charter -- REC.CRAFTS.METALWORKING

    The USENET newsgroup, rec.crafts.metalworking, is a newsgroup which
    discusses various aspects of working with metal, such as (but not
    limited to):

      machining, as on a lathe, milling machine, grinder, etc.;
      numerical control of such machines;
      welding, whether by gas, arc, mig, tig, thermite, or other methods;
      Metal joining, whether welding, brazing, soldering, riveting,
        screwing, folding, etc. (this section was added during the discussion)
      casting various metals by various methods;

hardening/tempering various metals;
blacksmithing/forging;
spinning and hammer work;
sheet metal work;
jewelry-making;
purchasing and/or reconditioning metalworking tools and machinery;
interesting projects;
books on metal technologies and history;

Example areas of interest:

knife/sword making;
automotive repair;
steam engine (model/scale, though full-sized discussions are welcome!);
art work, such as bronze castings and sculptures;
gunsmithing;
toolmaking, such as for woodworking, further metalworking, etc.;

While the bulk of the discussion will probably be directed towards small-scale "home" shops, industrial/production discussions are also quite welcome.

2. Network resources (other lists, vendors, etc.)

There are several other metalworking-related resources on the Internet, such as mailing lists and WWW pages. Here are a few we are aware of.

So the first one I list isn't even metalworking related!
A handy reference available in most libraries is the Thomas Register, which lists many manufacturers and sellers of "stuff".
They currently have an on-line presence on the World Wide Web:
http://www.thomasregister.com

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http://tbr.state.tn.us/~wgray/
Metal Web News "A Virtual Newsletter for the Online Metal Enthusiasts"

An effort by William Gray and others to present a metalworking newsletter. Contributions are welcome.

Machine Design (a Penton publication) has some nice web pages that discuss a range of topics such as fastening (glues, clapms, etc.) and many other topics. http://www.penton.com/md, under "Basics of Design Engineering" for example.

Two newsgroups related to crafts such as metalworking:
alt.binaries.pictures crafts
alt.binaries.pictures crafts.d
The first is where people should post binaries such as blueprints, photos of projects/equipment, and so on. The second is for disucssion of what's posted.

CAD software and related goodies are available via:
http://www.mecheng.asme.org

A CAM (Computer Aided Manufacturing) mailing list was created in mid-May 1996. Here is part of their announcement:

A new mailing list for the discussion of any CAM related software, hardware, questions, procedures, methods, terminology, etc. has been created and is now in operation. Topics could include, for example, software such as Camax, Mastercam, CimLinc, Cisigraph, SurfCam, etc, or subjects such as G-godes, APT source, different cutting methods and styles, or even actual CNC related topics.

To subscribe to this list, send mail to "majordomo@umcc.umich.edu" with:

subscribe cam

in the body of the mail by itself. The subject of the mail is ignored. This will subscribe you to the per message version of the list. This means that for every message the list receives, you will receive one piece of mail. If there are 10 submissions to the list in one day, you get 10 pieces of mail.

There is also a digest version available. To subscribe to the digest version, send mail to "majordomo@umcc.umich.edu" with:

subscribe cam-digest

There's a CNC newsgroup: alt.machines.cnc

Gardner Publications, publisher of the magazines Modern Machine Shop, Production, and Products Finishing, has a web page:

http://www.gardnerweb.com/

Metal casting:

- http://ourworld.compuserve.com/homepages/brnzcaster
- http://soho.ios.com/~jfisch
- http://www.teg.co.uk/teg/hoben/index.html

If you are interested in clocks/watches, there is a CLOCKS mailing list. Send mail to listserv@listserv.syr.edu, containing the command "SUBSCRIBE CLOCKS your name".

There is also a clock presence on the World Wide Web (WWW):
http://glen-ellyn.iit.edu/~clocks/clocks/clocks.html

A similar newsgroup is alt.horology.

Steam Engines: http://mindlink.net/Ron_Stewart/livsteam.html
http://www.bendigo.net.au/~jstein/livestm.html
http:////edge.edge.net/~vrbass/steamfaq.htm

On the scientific side, there's sci.engr.metallurgy.

There is also a Usenet newsgroup rec.woodworking that may be of interest to people who read rec.crafts.metalworking.

WWW (World-Wide-Web) users may be interested in Enrique Vega's efforts which he calls ArtMetal. This includes a mailing list and a Home Page of:

http://wuarchive.wustl.edu/edu/arts/metal/ArtMetal.html

Enrique can be reached at evega@artmetal.pdial.interpath.net.

See also the Prince Edward Island Crafts Council (Canadian):

http://www.crafts-council.pe.ca

A crafts fair guide is at:

http://www.teleport.com/~paulec/FAIRGUIDE/CRAFTLST.HTML

A Usenet newsgroup was created around March of 1994, called rec.crafts.jewelry. Some of the questions on rec.crafts.metalworking have been jewelry related, such as casting small pieces; these might be more appropriate on the new group, or at least you might get more answers!

A newsgroup called rec.knives was created in September 1995.

A mailing list for knifemakers was created in early 1995:

Such a list is now available, and may be joined by sending mail to majordomo@basis.com containing a line "subscribe knife-list". Following is the announce text for the list:

The purpose of this mail list is to be a forum where knife makers and bladesmiths discus technical, artistic, political, and business ideas related to the field of custom and handmade cutlery.

Knife fighting techniques and martial arts are not part of the discussion, except where it relates to an actual knife design.

In short, this mailing list is for knife makers, sword makers, bladesmiths, and serious collectors of custom and handmade cutlery.

An older mailing list for knifemakers, collectors, and people interested in edged-weaponry martial arts and techniques is the EDGE mailing list. Requests to be added to this list should be sent to:

EDGE-owner@HICOM.LUT.AC.UK

Submissions to the list itself should be sent to:

EDGE@hicom.lut.ac.uk

Topics on this list have ranged across topics like discussions of the types of steels used in knives, and why select one over another; the qualities and selection of different types of pocket tools [such as the Gerber Multi-Plier, the Leatherman, the SOG Toolclip, etc.]; current sales on knives from mail-order or discount-house sources; why Japanese swords are made the way they are/were, and how to take care of such a sword; selecting modern reproduction swords for martial-arts purposes; and many other edged-weapon and edged-tool subjects. However, lately (April 1995) it has been heard that the list is largely dead and unresponsive.

Silversmithing (commercial): http://www.gold.net/users/dy93/.

The "industry", whatever that may be, has a WWW home page as well as a Telnet address, respectively:

http://www.industry.net
industry.net

Then there's the manufacturer's Information Network:

http://mfginfo.com/home.htm

Metal finishing (electroplating, anodizing, galvanizing, etc.):

http://www.finishing.com
http://www.peganet.com/dalmar/dalmarhm.html

METAL Machining and Fabrication:

http://www.mmf.com/metal

Used Equipment Network (UEN), WWW or Telnet respectively:

http://www.hsix.com
buyused.hsix.com

The Global Recycling Network deals with used machines and tools:

http://grn.com/grn/

Book sellers:

Powell's Technical Books (new and used) can be reached at http://www.technical.powells.portland.or.us, or you can

get more info by sending blank e-mail to
ping@technical.powells.portland.or.us. More info in the vendor list.

Amazon.com claims one million titles, at http://www.amazon.com.

Book Stacks Unlimited can be reached via telnet to books.com,
or (216) 861-0469, or http://melville.books.com/scripts/main.exe?
or http://www.books.com.

3. What are some good books and/or video tapes on metalworking?

Note that this is not a complete list. If you are looking for books on anodizing, there is a separate FAQ section that deals with that topic and lists several books.

- How to Run a Lathe

  This book is available from South Bend distributors, such as Blue Ridge, and/or Lindsay. It was originally printed in 1914 and last updated in 1966, I believe.

- Advanced Machine Work by Robert H. Smith (1925). This book is not as "advanced" as the title might indicate, but assumes that you are not a total beginner. Available from Lindsay Publications (Cat. No 4236, $27.50, hardcover).

- Machine Tool Operation, Vol. 1 & 2, by Henry Burghardt, Aaron Axelrod & James Anderson. These books were for many years the standard text in trade schools and technical colleges. Volume one covers the basics: safety, measuring, bench work, drill press, lathe and forge. Volume two covers: shaper, planer, milling machine, grinding, hydraulics, band saw, metallurgy, and cutting fluids. Your best source for these is a used book store or a technical school library. They overlap much of "Advanced Machine Work", but neither is a complete substitute for the other.

- Materials Handbook by George S. Brady (McGraw-Hill Book Co.) "An encyclopedia for purchasing managers, engineers, executives, and foremen". Essentially, it gives an "executive summary" of virtually every material that is valuable in commerce. For instance, there is a two-page entry for "Die Steels". It is not aimed at the scientist or engineer; it is aimed at the person who needs to quickly understand the important characteristics and economics of industrial materials without involvement in details. It does cover a lot of non-metal materials as well.

- Machine-Tool Work, by William P Turner and Halsey F Owen. 1932 and 1945 (hence no ISBN number). Some libraries may still have a copy, though you're probably out of luck for a purchase.

  Moderately good text, very good diagrams and pictures, especially of huge special-purpose machines like railroad wheel grinders. Suffers a bit from age, and seems intended for large industrial shops, but a good read if you find it.

- Machine Shop Theory and Practice, by Albert M Wagener and Harlan R Arthur. 1941 (hence no ISBN number). Some libraries may still have a copy, though you're probably out of luck for a purchase.

  Fairly good text, more specific techniques than the Turner/Owen book.

Suffers a bit from age, but still a nice instructional book.

- Lathe Operations, by Richard R. Kibbe.
  1985, ISBN 0-471-89023-5.
  Adapted from materials originally prepared by the Engineering Industry Training Board of Great Britain. Also in the same series: Milling Machine Operations, and Grinding Machine Operations.

  A step-by-step text with about 2 photos and lots of simple but usually-clear drawings. Shows how to do most any common lathe operation (and a few uncommon ones) in as few words as possible.

  Check page 90 for what seems to be a man with two right hands.

- Machine Tool Practices, by Kibbe,Neely, Meyer and White.
  It's the first year machine shop text used by some community colleges.

- The Making of Tools, by Alexander G Weygers
  Prentice Hall Press, 1973, ISBN 0-671-60924-6.
  A modern book about doing things the old way. How the artist/craftsperson can design, make, sharpen and temper tools. May be available from Centaur Forge.

- Machinery's Handbook.
  A standard reference book for machinists, available from most distributors of machines or tools.

- Clockmaking & Modelmaking; tools and techniques
  by W.R. Smith

  Mr. Smith has published other books on clockmaking, but this one covers more than just clocks, and is thus of interest to more than just clock-makers. This is a collection of articles from the British Horological Journal, Timecraft, Model Engineer, and Horological Times. The articles have been updated and expanded for inclusion in this 112-page coil-bound book.

  For a complete review, see HSM Jan/Feb 1992, page 14.

  Available from Gateway Clocks (see names/addresses section), $35 post-paid within USA (overseas buyers add $5 for postage).

- Elmer's Engines, by Elmer Verberg,
  available from Modeltec magazine.
  Has many very nice, and fairly easy to build stationary steam engines.

- Model Locomotive and Marine Boilers
  [Argus Press, 1988, ISBN 0-85242-923-1]

  by Martin Evans (well known in the Model Engineering field, at least in Great Britain)

- Model Boilers & Boilermaking
  by K.N.Harris, published 1971

  Possibly available from Argus.

- The Shop Wisdom of Frank McLean,
  available from Village Press.

  Lots of good ideas, and common sense approaches, and the few pages

about inspecting used machines is worth its weight in gold for first time buyers.

- THE MACHINIST'S BEDSIDE READER
  Guy Lautard
  2570 Rosebery Avenue
  West Vancouver, B.C., Canada V7V 2Z9

  (Some of Guy's books are also available from other suppliers, such as MSC)

  Contains: Working drawings and detailed instructions for making 15 useful and practical machinists tools and lathe accessories; dozens of hints, tips and tricks to help get things done faster, easier and better in your shop; a collection of 2 dozen machine shop anecdotes; 2 highly readable machinists short stories.
  Projects include: a sharpening jig for drill from 1/8 to #60, a swiveling base for a 2" Wilton vise, a graduated handwheel for the lathe leadscrew.....and many more

  THE MACHINIST'S SECOND BEDSIDE READER
  Similar in format to the first book; projects include: a small pantograph engraving machine, a tool maker's block, poor man's jig borer and a kerosene-burning blowtorch..... also a short story titled "The Bullseye Mixture" which details the method for carbon pack color casehardening.

  THE MACHINIST'S THIRD BEDSIDE READER
  Some of the projects/info: color casehardening, a co-ax indicator, a collet chuck system, a deluxe overhaul of a keyless drill chuck, sharpening tools, sandblasting, setting up work on a faceplate, taper turning, knurling flat surfaces, and more.

  "A Treatise on Oiling Machine Tools"
  Very small (25 pages), very costly ($7.95), and not much useful information according to Tom Walter. One useful warning is to not use way oils in a milling machine's centralized oiling system, as some of them contain wax which will clog the system.

  Other books and plans by Lautard (not a complete list):
  "Hey Tim, I gotta tell ya....' a mini Bedside Reader"
  "3.75 Inch Diameter Ungeared Rotary Table"
  "Universal Sleeve Clamp".

  Lautard's targeted readership seems to be the home machinist. I'm sure that much of what he has to say may be "old hat" to a skilled machinist with many years experience. I confess that I am a rank amateur in machine shop practice (my only professional experience was as a part-time helper in a gunsmith shop where the machine I got to know best was the polishing wheel). The flyer I quote from is available from Lautard at the address I gave with my last posting.

  [reviews and typing courtesy of Michael Gordon, except for the description of the third bedside reader. JK]

  It has also been reported that Guy sells an index of some sort, either of all projects or all articles, in the back issues of Model Engineer. However, the index is reportedly hard to use. See the description of Model Engineer magazine.

- Machine Tool Reconditioning, by Connelly

Covers reconditioning of machine tools, including figuring out what's off on lathes and such. Also a good section on scraping (i.e. removing small areas of metal by scraping, such as making a plate very flat). Mostly deals with reconditioning ways, and does not spend much time on mechanical problems such as worn nuts or gears.

- The Surface Treatment and Finishing of Aluminum and its Alloys, Edited by S. Wernick, R. Pinner, and P.G. Sheasby. Published 1987 by ASM International, Metals Park, Ohio. 2 volumes.

  Mentioned in sci.materials in response to a "how do I anodize aluminum?" question.

- Electroplating for the Amateur, by L. Warburton.
  Model & Allied Publications.
  Available via Argus.

- The Electroplater's Handbook, by C.W. Ammen
  TAB books.
  ISBN 0-8306-0410-3 (hardbound), ISBN 0-8306-0310-7 (paperback)

- Metal Finishing - Guidebook and Directory
  Metals and Plastics Publications, Inc
  One University Plaza
  Hackensack, NJ 07601

  Mentioned as a good reference for electroplating.

- Machine Tool Practices, fourth edition, John Wiley and Sons.

  Covers a lot of ground and is the first-year book at DeAnza College.

- Machine Shop Practice, second editions, volumes 1 and 2
  by K.H. Moltrecht. Published by Industrial Press, Inc.
  ISBN ISBN 0-8311-1126-7 and ISBN 0-8311-1132-1 (vol 1, vol 2)

  Preface: "It is written for the beginner, as well as for the more advanced craftsman, technician, and manufacturing engineers." "...designed for use in the classroom or for home study,..." (about $20 each)

- The Home Machinist's Handbook, by Doug Briney (c)1983,
  $17.95 [TAB Books] ISBN 0-8306-1573-3 (paperback)

  Basic... Reading prints, measurements, hand tools, bench tools, the lathe & operation, the milling machine & operation. Projects using the Sherline machine system.

- Machinists' Ready Reference, 7th edition (c)1989 [Prakken Publications, Inc], Compiled by Clarence Weigartner, ISBN 0-911168-74-5,
  7th edition: $12.50/$10.00(schools), new 8th edition: $14.50

  Pocket sized (4.5" x 6"). Good student guide to math, drills, tapers, threads, milling/turning speeds, gears, weights & reading shop prints. Sort of a "poor man's Machinery's Handbook".

- How To Work Sheet Metal, by Herbert Dyer
  Available from Power Model Supply. Highly recommended by Guy Lautard in his Machinist's Bedside Reader.

- The New Science of Strong Materials, 1968 (1st ed.), 1976 (2nd ed.), 1984 (Penguin paperback). J.E. Gordon, Princeton University Press.

  (review courtesy of Bob Powell):
  This wonderful 280 page paperback lucidly covers the realm of materials science and engineering, in lay terms rather than textbook theory, but with enough depth and detail to satisfy an engineer in a different discipline.

  Explains, along the way, the physical and chemical nature of wood, and the nature and evolution of all common glue types, plastics, composites from straw-clay brick to fiberglass to kevlar, through iron and steel and alloy metals. Elasticity and the theory of strength and toughness, with basic beam theory developed from first principles. Cracks, defects and crack propagation (why glass bends then shatters), hardening and tempering, and to boot, the best explanation I've seen of all the classic iron and steel making processes.

  For the wood-inclined, a whole chapter on timber and cellulose from the molecular level up through the evolution of the structural design of wooden ships and (wood) airplanes, with insight into wood drying and wood rot. Dedicates a chapter alone to the evolution of wood glue and the operation and properties of each type.

- The Starrett Book for Student Machinists (c)1941, 1975 & 1982 [160 pages] Catalog #1700 @ $8.50.

  Drawing, fits, bench work, how to measure, cutting speed/fluids, drilling, lathe operations, grinding, sawing, toolmaking, geometry, mechanics, & reference tables. Good information, well worth the price. It covers screw cutting, via the lathe, better than most. Be sure to get the FREE Starrett information, "single copy mailed to individual craftsmen." Decimal Equivalent Card (pocket size 3" x 5"); The Starrett Story (36 pages 4-5/8" x 6-7/8"); The Tools and Rules for Precision Measuring, Bulletin #1211 (80 pages 5-1/4" x 7-5/8")

- Watch Making, by George Daniels.

- De Re Metallica (Georgius Agricola, 1556) translated by Herbert Hoover
- Pirotechnia (Vannoccio Biringuccio, 1540) translated by Smith & Gnudi

  These two are Dover reprints, and were state-of-the art from renaissance through perhaps 1850 or so. The first is on mining, and the second on metalworking. An interesting historical look at how things were done in earlier times, and why they thought it worked.

- Computational Geometry for Design and Manufacture,
  Copyright 1979, I.D.Faux, M.J. Pratt.
  Ellis Horwood Publishers, a division of John Wiley & Sons.
  ISBN 0-85312-114-1

  Very good overall text on surfaces and design. Was recommended as a way of learning strange jargon used in CNC machining of surfaces, such as loft, nurbs, and coons.

- Computer Numerical Control: Essentials in Programming and Networking by Lin. Delmar Publishers, Inc. 3 Columbia Circle, P. O. Box 15015, Albany, NY 12212-5015. (800-347-7707)

(recommended by Jerry Kimberlin)
This is a textbook for a 2 semester course. It assumes you know nothing and takes you through the whole thing including G, N, APT...2D, 3D, CNC networking, the math, etc. I don't remember the exact price but it is over $50 and less than $70.

- The New Edge of the Anvil, by Jack Andrews

Not only is it a great intro to blacksmithing, but it also has the most wonderfully brief description of metallurgy and heat treating. It is available from Skipjack Press direct at:
637 Drexel Ave.
Drexel Hill , PA 19026
or e-mail andrews@hslc.org

The following suggested books pertain to jewelry-making, per Sherry Lem.

The Complete Metalsmith ISBN 0-87192-240-1, $14.98
Tim McCreight
Davis Publications, Inc.
Worcester, MA, 1991
Excellent, easy to follow techniques for beginning to intermediate levels, this is the revised edition which is much improved over the original.

Contemporary Jewelry,
Philip Morton
Holt, Rinehart & Winston
NY, 1970, 1976
Interesting design philosophy, techniques.

Design and Creation of Jewelry,
Robert vonNeumann
Chilton
Radnor, PA, 1961, 1972

Form Emphasis for Metalsmiths,
Heikki Seppa
Kent State University Press
Kent, OH 1978
Perhaps THE book on anticlastic raising/forming, though difficult to teach yourself from the pictures and instructions.

Jewelry Concepts and Technology ISBN 0-385-04185-3, $100.00
Oppi Untracht
Doubleday & Company
Garden City, NY, 1982, 1985
Most comprehensive guide on jewelry making techniques, also contains gemological data, info on setting up a workshop. Also, his "Metal Techniques for Craftsmen" $75.00 is a somewhat abridged version.

Jewelry: Contemporary Design and Technique,
Chuck Evans
Davis Publications
Worcester, MA, 1983
Especially good sections on mixed metals (mokume gane, etc.).

Jewelry Making and Design,
Augustus F. Rose and Antonio Cirino

Dover Publications, Inc.
NY, 1949, 1967
Decidedly English flavor, very inexpensively priced.

Jewelry Making Manual,
Sylvia Wicks
Brymorgen Press
Cape Elizabeth, ME, 1986
Beautiful color photos, good technique instructions.

Jewelry Manufacture and Repair,
Charles Jarvis
Bonanza, NY, 1978

Metal Sculpture - New Forms New Techniques,
John Lynch
The Viking Press
NY, NY
Basic art metal techniques.

Another book, suggested by Marc Kerr:

"Silversmithing" by Finegold $35.00. This is an excellent book if you are really after smithing and not jewelry making. It has very good descriptions of the smithing process and walks you through a few projects like a bowl, box with hinge and others.

How about video tapes?

- New Life Video Productions

Several tapes with Rudy Kouhoupt, frequent author in HSM and other magazines. Titles such as:
"Fundamentals of Machine Lathe Operation"
"Fundamentals of Milling Machine Operations"
"How to Cut Spur Gears"
"How to Cut Screw Threads"
"Building a Sterling Hot Air Engine"
Price varies from tape to tape. Production qualities seem poor (based on viewing the first title), such as poor and inconsistent audio, including a radio playing in the background. But you can safely ignore this and concentrate on what Rudy is trying to show you. Seems reasonably priced for the material covered. The material is quite good for the beginner ("I just got a vertical mill; how do I use it?"), or perhaps even the advanced beginner. These are probably tapes you will watch once or twice, so it would be nice if you could rent instead of purchase them! Most of them seem to focus on making a simple but useful project while presenting the material.

- Bailey Craftsman Supply

"Greensand Casting Techniques" from David Gingery's workshop. HSM seemed to like it. Others include a second volume of the above, Basic Metal Lathe Operation (2 vol), Basic Milling Machine Operation.

- Darrell Markewitz, Wareham Forge

"A 3 hour instructional VIDEO - $25.00 each (includes postage)"

"This video contains a wealth of information, including what to look for in used tools, building a home shop, and demonstrations of a number of basic forming techniques."

PART 1 - TOOLS: forges; lighting a fire; coal
anvils; hammers; vises; safety

PART 2 - TECHNIQUES: 'S' hooks; tent peg; fire poker
twists; toasting fork; home forge

the WAREHAM FORGE
Hamlet of Wareham - RR #2
Proton Stn Ont, CDN - N0C 1L0
(519) 923-9219, wareham.forge@headwaters.com

- Quality Street Productions

The Fourth Annual NAMES Expo (1993)

- Starrett

Tools and Rules for Precision Measuring

- Colonial Williamsburg
P.O. Box C
Williamsburg, VA 23187

Tapes are also available from:

KVC Entertainment
P.O. Box 40276
Indianapolis, IN 46240-0276

CW produces several tapes on blacksmithing, silversmithing, gunsmithing, and so on. They show the "old time" way of doing things, but are reported to be excellent.

- Tim McCreight:
Complete Metalsmithing

Apparently Tim has a book *and* video by this title. Sandy Grossmann sez:

"He takes you step by step through a couple of projects. When *he* does it, it sure looks simple! He gives some great shortcuts, and his examples are instructive."

"I especially liked his sections on riveting and on using a rolling mill. Very useful. The entire video is oriented toward jewelry, but he also does a sterling silver box. You can get the video mailorder from River Gems and Findings (phone 1-800-545-6566) or from TSI (I think). Last time I checked it was about $40."

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 10 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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99. Names and addresses of publishers and suppliers.

Note also that a potential source of manufacturers/suppliers is the Thomas Register, found in most public libraries, or now on-line:

http://www.thomasregister.com/

-- Special entry: Not a company or anything, but for more info on crafts supplies, send e-mail to info@crafts-council.pe.ca and put "WANTED:" at the beginning of the subject line. This is a non-profit service of PEI Crafts Council in Charlottetown, Price Edward Island, Canada. They maintain a list of crafts suppliers and can answer questions like "give me a list of ceramics suppliers East of the Mississippi" or "who sells ConeArt kilns?" (per a post 9-Nov-1993)

- ah-ha! Design Group, Inc.
  Box 14519
  Minneapolis, MN 55414
  (800) 473-7650, (612) 641-1797, (612) 641-8681 (FAX)
  e-mail ahha@gdic.com

  In the UK, distributed by Eagland Machine Tool, 01420-23830, fax 23804.

  CNC conversion kits for large and small machines. Free catalog.

- Aircraft Spruce & Specialty Company
  Fullerton, CA
  (800) 824-1930

  400-page catalog costs $5, but they pay $4.10 to mail it to you (at 1994 postage rates). Airplane kits (real ones), as well as parts and raw material such as aluminum stock, composites, epoxies, foam, and spruce. This is not as complete or as universal as McMaster-Carr, but it has a number of things you won't find elsewhere.

- Alley Supply Company
  P.O. Box 848
  Gardnerville, NV 89410
  (702) 782-3800

  Deals in Jet lathes and accessories.

- Allied Devices Corporation
  2365 Milburn Ave
  P.O. Box 502
  Baldwin, New York 11510
  (516) 223-9100, (516) 223-9172 (FAX)

  "Standard Precision Mechanical Components" such as small gears. Reputedly not cheap, but Small Parts Inc isn't either.

- American Watchmakers-Clockmakers Institute (AWI)
  P.O. Box 11011
  Cincinnati, OH 45211
  (513) 661-3838, (513) 661-3131 (FAX)

  Membership is around $45 or so per year. They have an excellent

magazine, Horological Times. Their orientation is more towards watch/clock repair. They offer many courses along those lines. The "Project Extended" courses are given in Cincinnati, but they have many other courses (around 5 days) given around the country. They have at least 100 videotapes on various aspects of lathe work and clock repair.

- Jim Anderson
  1642 Hillridge
  Ann Arbor MI 48103

  There were a few Craftsman lathes that were apparently *not* made by Clausing or their predecessors, called AA Products. Jim has a catalog of sorts; send an 8 1/2 x 11 self-addressed-stamped-envelope with 2 stamps. Include the model number in the request and he will send a copy of the manual, a list of customers, and a list of parts sources.

- ARE, Inc.
  Box 8
  Greensboro Bend, VT 05842
  (800)736-4273, (802)533-7007, (802)533-7008 fax

  Tools for jewelry-making, perhaps more. Catalog is $4.

- Argus Books
  P.O. Box 35 Wolsey House
  Wolsey Road, Hemel Hempstead
  Herts HP2 4SS England
  Telephone: Hemel Hempstead (0442)66551

  Former publishers of Model Engineer, in England. ME is now published by a sister company, Nexus. However, Argus still has interesting books that are described elsewhere in this FAQ, and may still be a source for back issues of ME.

  The US distributor for some of the Argus/Nexus publications is:
  Wise Owl Worldwide Services
  4314 West 238th Street
  Torrance, CA 90505-4509
  (310) 375-6258, (310) 375-0548 (FAX)

- Armstrong Tool & Supply Co, Inc.
  31747 W Eight Mile
  Livonia, MI 48152
  (800) 446-9694

  Full range of hand tools & Sherline Products. Catalog $2.00

- Bailey Craftsman Supply
  P.O. Box 276
  Fulton, MO 65251-0276
  (314) 642-5998

  Shop videos, Books, EMCO Maier & Sherline Products

- W.M. Berg, Inc.
  499 Ocean Avenue
  East Rockaway, NY 11518
  (516) 596-1700, (516) 599-3274 (FAX), (516) 599-5010 customer service

Very similar to Stock Drive Products (q.v.). Separate catalogs for metric vs. english parts. They undoubtedly have a few items that Stock Drive does not carry, and vice-versa.

- Blades & Stuff
  1019 E. Palmer Ave.
  Glendale, CA 91205

  Catalog $5

- Blue Ridge Machinery and Tools, Inc.
  PO Box 536
  2806 Putnam Avenue
  Hurricane, WV 25516
  800-872-6500, (304) 562-3538 in WV, (304) 562-5311 (fax)
  Credit cards, COD's up to $200
  M,W,F 9-5 EST, Tu,Th 9-9 EST

  Lathes, milling machines, presses, brakes, from puny to industrial.
  Accessories and parts for popular machines from Myford, South Bend, Atlas, Sherline, Emco-Maier, etc.
  Hand tools and books of interest to hobbyists and professionals.
  Woodworking power tools
  Steel, brass, aluminum, tool steel in small quantities.

  110 page free catalog

- J. C. Boegeman
  1464 S. Warner Dr.
  Apache Junction, AZ 85220
  (602) 982-8436

  Discontinued parts for Atlas, Craftsman, Clausing lathes.
  Quadrants, reverse gear boxes, lead screws, half-nuts, spindles, steady rests, and so on. No catalog, so call.

- Borel and Frei
  712 S. Olive St., Suite 318
  Los Angeles, CA 90014
  (800)654-9591 (national), (800)252-9392 (CA), (213)689-7007, (213)488-0485 fax

  They also have a Kansas City office:

  Jules Tools (Jules Borel & Co.)
  1110 Grand Ave.
  Kansas City, MO 64106
  (800)776-6858 orders, (800)776-6865 customer service, (816)421-6110, (800)776-6862 fax

  Jewelers' tools: main 172-page catalog "T" is color, slick paper, no prices (separate price list is enclosed). Also catalog "J" for jewelry, "H" for horological (watchmaking) supplies, and "F" of jewelry findings. Specialty tool catalog "T<year>S" is 50 pages B&W and does have prices.

- Boston Gear
  14 Hayward St.
  Quincy Ma. 02171
  (617) 328-3300

They have nearly any gear iminaginable, IN STOCK. Their prices are lower than you might imagine, and delivery is good.

- Bourget Bros.
  Lapidary and Jeweler's Supplies
  1636 11th St.
  Santa Monica, CA 90404
  (800)828-3024

- Brownells
  Route 2 Box 1
  200 South Front Street
  Montezuma, Iowa, 50171
  (515) 623-5401, (515) 623-3896 (FAX)

  Brownells is a fine firm that specializes in gunsmithing, though a lot of their merchandise is great for general-purpose metalworking, such as steel, brass, and nickel silver.
  Catalog is $4.00, refundable with first order of $40 or more (but if you can convince them you are a dealer, then it is free).
  They have lower prices for gun dealers, "enciphered" in the catalog in a manner similar to the following --
  Item: Foo Bar Grips an9xx20dd Price: $19.95
  means list price is $19.95, dealer price is $9.20. However, in recent catalogs they have changed the coding on some items.
  While some people have apparently convinced them they are a dealer, the usual requirement seems to be an FFL (Federal Firearms License) before they sell for the dealer price.

- Bryant Laboratory
  1101 Fifth St.
  Berkeley, CA 94710
  (510) 526-3141, (800) 367-3141

  They sell chemicals used in patination, and have recipes as well.

- Camden Miniature Steam Services
  Barrow Farm
  Rode
  Bath BA3 6PS
  U.K.
  Tel: (44) 01373 850151
  Fax: (44) 01373 850516 (drop the first zero if outside the UK)

  Have a 56-page list of their books and videos (British PAL 625/50hz) available at no cost. Engineering books and videos; rail, road and sea transportation from the USA, UK and France; mining, wireless and electrical subjects etc.

- Campbell Tools, Inc.
  2100-H Selma Rd.
  Springfield, OH 45505
  (513) 322-8562

  A machine supplier attuned to the hobbyist metalworker. They carry Sherline, Emco, Jet, and other machines. Also books, hardware, raw materials, etc. Highly recommended by one net reader. Catalog is $1

- Cardinal Engineering Inc
  RR #1, Box 163

Cameron, IL 61423
(309) 342-7474, (309) 342-3182 (FAX)

Supplier of various metals, but they also can supply CNC mills and/or kits to convert existing milling machines. Also some CNC lathe work. Several articles in recent years in HSM regarding CNC conversions were written by the folks at Cardinal. Catalog is $2. Also some books, and plans from a company called Wood-Met.

- Castings
PO Box 915001
Longwood, FL 32791
(407) 869-6565

Equipment and materials sized for chess pieces, etc., made in pewter. Probably other, related stuff as well.

- Caswell Electroplating in Miniature
(315) 597-5140

Reportedly has all kinds of small to medium plating supplies and is very helpful.

- Centaur Forge Ltd.
P.O. Box 340
117 N. Spring Street
Burlington, WI 53105-0340
(414) 763-9175, (414) 763-8350 (FAX)

Publications concentrate on forging, blacksmithing, though all aspects of metalworking are covered. A good, well-organized collection. They also publish a magazine, Anvil.

Centaur Forge is the source for blacksmithing supplies from tongs to furnaces. Also a source of horse shoeing supplies.

- Century Spring Corporation
800-237-5225, (213) 749-3802 (FAX)

A Los Angeles company, they sell a wide range of both extension and compression springs, and also some more specialized springs like disk springs and rubber-tube springs. Their catalog is free and lists springs sorted by diameter, length, wire diameter,and material, and list number of coils, solid height, and calculated spring rate.

The catalog does not include prices, but prices are reasonable, but there is a $25 minimum order.

- Clausing Industrial Inc.
Service Center
P.O. Box 877
Goshen, Indiana 46527-0877
(219) 533-0371, (219) 533-0403 (FAX)

Long ago, Sears sold Craftsman lathes that are still popular. These were actually made by Atlas, which was later bought by Clausing. Clausing apparently still has parts and manuals for the Craftsman/Atlas lathes, and will provide a free catalog.

- Coles Power Models, Inc

P.O. Box 788
839 E. Front Street
Ventura, CA 93002
(805) 643-7065

Castings, books, supplies, accessories. For trains, stationary steam, gasoline engines. The catalog costs $4.

- T. E. Conklin Brass & Copper Co.
  345 Hudson St.
  NY. NY 10014
  800-225-5510

  They have every size of hex brass in 12' lengths from 1/8" to 7/16" by 1/32" increments, and then it goes up to 3" hex by 1/16" with some odd sizes thrown in such as 23/32. They got it in round, square, flat, gauge, strip, dimension plate, wire, rectangular rod, pipe, round tube, square tube, rectangular tube, angle, channel. They state that small orders are important.

  This is not only brass, but bronze, copper, monel, muntz, nickel silver, etc., in several alloys. I would doubt they have every alloy in every size. Ask for the Conklin Index. For locals the phone is 212-691-5100.

  (however, it is reported that a minimum first order is $100, and subsequently $50)

- Condar Co.
  10500 Industrial Drive
  Garrettsville, OH 44231
  (216) 527-4343

  They sell a pyrometer (high-temp thermometer) for gas forges and such, Unit 9-85 which comes with a 6-foot 2200-degree probe for $60. They also have a high temp probe (3000 degrees; Unit 14S4-1, $17). Probably lots of other related items, but this came up in discussion on low-cost pyrometers around 3/25/93.

- Conquest Industries
  Santa Fe Springs, CA.
  (310) 906-1111, (310) 906-1112 (FAX)

  Apparently casting supplies. They have a free video tape and info packet on casting metal in rubber molds. The rubber can take heat up to 840F for zinc alloys.

- Cowell's Small Machine Tools Ltd
  The Manor Workshop
  Church Road
  Little Bentley
  Colchester
  Essex
  CO7 8SE
  UK
  tel +44 1206 251792

  Cowells sells two main products: a small lathe (88mm swing, 200mm between centers) and a small milling machine (200mm by 50mm bed). Also vertical blade jig-saws. Somewhat similar to Sherlines, these are described as being a bit better in quality and considerably more powerful. Cost is roughly double that of a Sherline.

Their USA connection:

Cowells USA
Post Office Box 843
Richmond, KY 40476-0843
(606) 624-9269, (606) 625-1191 (FAX)

There is also a book, "Cowells 90 Lathe" by A. Smith.

- Craft Books
  4 Maple Street
  Chester, CT 06412
  (203) 526-9887

  At the very least, books on patinizing such as The Coloring, Bronzing and Patinization of Metals.

- Cyberlabs: see US Cyberlabs

- Dalmar
  (941) 275-6540, (941) 275-1731 (FAX)
  http://www.peganet.com/dalmar/dalmarhm.html
  dalmar@peganet.com

  Manufacturer of electroplating equipment.

- Darex Corporation
  220 Hersey Street
  Box 277
  Ashland, OR 97520
  (503) 488-2224, (503) 488-2229 (FAX)
  http://www.darex.com

  Precision drill and end-mill sharpening equipment. Some of their complete systems are very expensive and intended for large production shops (around $2000). They also sell fixtures for use with existing grinders (about $250) and sharpeners for taps, reamers, and countersinks.

- Diamond Pacific Tool Corporation
  25647 West Mail Street
  Barstow, CA 92311-9702
  (800) 253-2954, (619) 255-1030

  A complete selection of diamond cutting bits, saws, powders and compounds. Free catalog.

- Dillsburg Aeroplane Works
  (717) 432-4589

  Source for aluminum, steel, tubing, bar, sheets, etc.
  Advertises that they supply: machine shop, race car, airplane building, etc. These people are nice and helpful. They have shipped orders same day with no errors.

- Eastwood Company
  (800) 345-1178

  Metal fabrication equipment, welding supplies, etc. Reportedly, the prices are rather high.

- EMCO Maier (Consumer Products Division)
  2757 Scioto Parkway
  Columbus, OH 43221-2134
  (800) 521-8289, (614) 771-5990 FAX

  Makers (importer?) of the Unimat and Unimat PC lathes, small mills, and such. They will/do sell direct, you can get a discount (5-15%) by dealing with Campbell or Blue Ridge on a package. Good customer service and parts department.

- Enco Manufacturing Co.
  13 stocking locations, main site in Chicago, IL (addresses not handy now)
  800-860-3400 (24 hr orders, automatically routes to closest location)
  800-860-3500 (fax, also auto routes)
  Credit cards, COD's up to $500, discount for pre-pay by check
  $25 minimum order
  Customer service & Chicago showroom M-F 7-midnight CST,
  Sa 8-4 CST, Su 9-4 CST

  Lathes, milling machines, etc, from small to large NC machines.
  Hand tools, cutting tools, storage cabinets, shop supplies
  Maker (not just distributer) of turret bed lathes.

  However, many net folks have reported that quality and service are between awful and terrible (this author included), and that Enco should be avoided. This is not a unanimous opinion, but close.

  230 page catalog (as of 1994)

- Far West Materials
  405 Woodland Ave.
  Walla Walla, WA 99362
  (509) 522-0556, (509) 525-7326 (FAX)
  http://ns.bmi.net/farwest, e-mail farwest@bmi.net

  "Specializing in Foundry, Sculpture, & Molding materials"

- Gateway Clocks
  7936 Camberly Drive
  Powell, TN 37849

  Gateway Clocks is apparently a one-man business, in the person of W. R. Smith, author of several clockmaking books and one on clockmaking and model-making (see earlier section in the FAQ). Gateway also sells all of John Wilding's books, and John Wilding (in England) sells all of Smith's books, through a reciprocal agreement.

- General Factory Supplies Co., Inc.
  Cincinnati, Ohio
  Dayton, Ohio
  http://www.virtual-adventures.com/gfs/

  A stocking wholesale distributor of industrial supplies. No experience with them.

- Gesswein
  255 Hancock Ave.
  Bridgeport, CT 06605
  (800)243-4466, (203)366-5400, (203)366-3953 fax
  e-mail: gessweinco@aol.com

Jewelry-making tools, perhaps more. On the 800 number, there is a voice mail system, and if you just want a catalog you have to wait for the last prompt when they let you speak for a longer period without being cut off.

- Glendo Corporation
  900 Overlander Road
  P.O. Box 1153
  Emporia, KS 66801
  (800) 835-3519, (316) 343-1084, (316) 343-9640 (FAX)

  Their Accu-Finish line of "advanced sharpening equipment" includes grinders and fixtures for lathe cutting bits and similar tools. Also, most affordable for the home shop, the Grind-R-Table for use with existing grinders. They often run ads in the magazines, or you can call for information.

- Grainger
  http://www.grainger.com
  feedback@grainger.com

  Wholesale supplier of industrial and commercial equipment and supplies, with branches in all 50 states of the USA, and Puerto Rico. Their web site includes a "terms of access" page that had to be written by a team of lawyers working overtime!

- Grand Tool Supply Corp.
  U.S. Highway 46 & Huyler St.
  Teterboro, NJ 07608
  (800) 922-0512, (201) 288-7090 FAX

  "80,000 inch/metric cutting tools, measuring instruments & equipment for the machine shop." $50 min/order, free catalog.

- Griegers
  Pasadena, CA
  (800) 423-4181

  Lost wax casting supplies for jewelry making. Silver solder and flux, gold solder, nickel silver, etc. Free catalog on request. Apparently not what you'd call low prices, but they do have a good selection.

- Grizzly Imports, Inc.

  West of Mississippi:
  P.O. Box 2069
  Bellingham, WA 98227
  (800) 541-5537, (800) 225-0021 (FAX)

  East of Mississippi:
  2406 Reach Road
  Williamsport, PA 17701
  (800) 523-4777, (800) 438-5901 (FAX)

  Imports a wide range of power tools and accessories. Metal lathes, milling machines, as well as lots of woodworking tools. They also sell a belt sander called the "Knife Belt Sander/Buffer." Among the importers of Taiwan-made tools, Grizzly seems to rank fairly well compared with Enco or Harbor Freight, though some consider Jet

to be a bit better (at higher cost).

- H & H Foundry Machine Company
  PO Box 605
  Manor, PA 15665
  (412) 863-3251

  They will accept small one-off cast iron jobs (and probably other work as well, just don't know their full scope). They seem to do good work and are reasonably priced, according to D. E. Johnson who wrote an article in HSM about building a hefty milling machine attachment for a lathe. The pattern for that project is "on file" with them and can be requested.

- Harbor Freight Tools
  3491 Mission Oaks Blvd.
  Camarillo, CA 93011-6010
  800 423 2567

  They mostly sell cheap tools. Usually cheap = inexpensive, sometimes cheap = junky. All (or most all) imported. They are best for items which have a lot of metal in them and for which fine/precision is not your main objective. They have really great buys on anvils, cold chisel sets, screwdriver sets, tinsnips, crowbars, ... and free shipping (other than a $2.95 handling fee) for orders over $50.

- Neil Hemingway
  30 Links View
  Half Acre
  Rochdale
  Lancashire OL11 4DD
  England
  +44 01706 45404
  http://www.fotec.co.uk/mehs/hemingway/index.html

  Neil has many lathe accessories and kits, many for Myford lathes, and George Thomas kits from Model Engineering. You might enclose a couple of international reply coupons when asking him for a catalog.

- M. B. Herman
  9308 N.W. 60th Street
  Tamarac, FL 33321
  (305) 722-0061

  Mentioned as another source of parts for Craftsman/Atlas lathes.

- High Quality Tools, Inc.
  1327 E. 289th St.
  Wickliffe, OH 44092
  (216) 944-0144, (216) 585-2265 (FAX)

  Replacement parts for Bridgeport milling machines. Reputedly the quality is excellent. They have a catalog with exploded views of all assemblies. Cheaper than Bridgeport. See also Lee's and J.R. Machine.

- Hobby Hangar
  1862 Petersburg Road
  P.O. Box 417
  Hebron, Kentucky 41048
  (606) 334-4331, (606) 334-4333 (FAX)

http://www.cforc.com/hangar/

"Serving All Your Hobby Needs." Also "The exclusive United States importer of Minicraft Precision Power Tools."

- Industrial Pipe and Steel Co.
  9936 E. Rush Street
  South El Monte, CA 91733
  800-423-4981, 818-443-9467, 818-579-4602 (fax)
  Credit cards, COD's
  M-F 7:30-4:30 PST, Sa 7:30-1 PST

  Cutting tools, hand tools, air tools, lathes, milling machines, you name it. Shop supplies, tool and die maker supplies, you name it. Metal of all sorts, you name it. New and used press die sets. Surplus rounds and plates. Buy by the foot, buy by the pound. Most of their metal stock is not listed in the catalog(s). Call and ask what they've got. Definitely oriented toward professional users, not hobbyists. Full line distributors for most instrument makers, Starrett, Mitutoyo, etc. Quality ranges from ultra-classy, great deals, garbage-at-any-price import.

  Small catalog several times a year, 200 page catalog once or twice a year, and a 750 page full-line catalog once every five years. They came out with a full-line catalog in 92. Get one if you can.

- ISCAR
  http://www.iscar.com

  ISCAR manufactures metal cutting tools for industry. "Iscar is a full-source supplier producing a complete range of innovative turning, milling and drilling tool lines. Its cutting inserts are composed of advanced, proprietary cutting materials including coated and uncoated carbides, cermets, silicon nitrides, sub-micron compositions, and CVD and PVD (chemical and physical vapor deposition) layers."

  I don't believe ISCAR sells retail, but instead are carried by distributors such as MSC and others (see web pages).

- Jax Chemical
  (718) 347-0057

  Patina solutions and chemicals. Available from some jewelry supply houses.

- Jet Equipment & Tools
  http://www.jettools.com
  jet@jettools.com

  Jet sells lathes, milling machines, etcetera. Usually they do not sell directly to a customer, preferring to go through distributors such as Alley Supply, Campbell Tools, and others. Their home page includes a list of distributors. The general consensus suggests Jet is somewhat higher in quality and price than Grizzley's products.

- Johnson Atelier Sculpture/Casting Supplies
  50 Princeton-Hightstown Road
  Suite L
  Princeton Junction, NJ 08550
  (800) 732-7203 (orders or technical assistance), (609) 936-7206 (FAX)

Aimed at the metalcaster and sculptor. Clays, modeling tools, shellcasting kits, plasters, various kits for making life casts, waxes, pyrometers, sandcasting/foundry tools, foundry metal ingots/plate/rod (SiBronze, 85-5-5-5, aluminum, copper), patina solutions and raw chemicals to make your own, safety equipment, etc. Looks like they target the school foundry and small art studio market.

- Lee's Machinery
  4089 N. Ridge Road
  Perry OH 44081
  (216) 259-2222

  Bridgeport and South Bend parts, new and used. The owner, Lee Zinn, does used machinery rebuilding of all kinds and has many new and used parts and accessories (chucks etc.). Will also make parts if unavailable, or parts that are better than original if needed (e.g. South Bend back gears like to break). See also High Quality Tools and J.R. Machine.

(continued in next part)
This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 11 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

(continued from previous part)

- J. Malcolm Wild (Clocks)
  12 Norton Green Close
  Sheffield S8 8BP England
  Telephone: 0742 745693

  Supplies and accessories for clockmaking.

- The Jeweler's Loupe 1625 Crenshaw Blvd.
  Torrance, CA 90501
  (310)320-7005

- J.R. Machine
  Houston, Texas
  (800) 332-5361

  Make replacement parts for Bridgeport machines, at a lower cost than from Bridgeport. Catalog available.

- Kitts Industrial Tools
  22384 Grand River Avenue
  Detroit, MI 48219
  800-521-6579, 313-538-2585 in MI, 313-538-6499 (fax)
  Credit cards, COD's
  $25 minimum order
  M-Sa 9-5 EST

  Cutting tools, hand tools, air tools, supplies
  Quality ranges from ultra-classy, great deals, garbage-at-any-price import.

150 page catalog, but you have to mail a $2 check (won't accept phone orders for catalogs!).

- Klockit
  P.O. Box 636
  Lake Geneva, WI 53147
  (800) KLOCKIT (i.e. (800) 556-2548)

  Books, kits, plans, tools, parts for clocks and watches.

- The Knight Foundry
  P.O. Box 158
  81 Eureka St.
  Sutter Creek, CA 95685
  (209) 267-5543 Foundry, (209) 267-1449 Tourism & Education

  This outfit has been casting iron since 1873, and preserves old machinery and methods as a sort of living history museum. They also operate a machine shop entirely from a water-powered line shaft! They are doing serious commmercial work, including grey iron castings to 4000 lb. for industrial and architectural applications. They do a lot of reproductions and one-offs for steam and gas engine nuts. They also run a pattern shop.

  The proprietor is Ed Arata, a very approachable fellow who apparently runs the place with the help of Friends of Knight Foundry, a non-profit with historical/educational goals.

  (as of around January 1996, their future seems uncertain; contact them for current status and capabilities)

- Laguna Clay Co.
  14400 E. Lomitas Ave.
  City of Industry, CA (don't have the zip)
  (818) 330-0631

  Sands and fire clays for casting. Though it's liable to increase cost significantly, they do ship and they will split bags. Very helpful in terms of making sure you get the right product for your use.

- Lindsay Publications Inc.
  P. O. Box 538
  Bradley, IL 60915-0538
  (815) 935-5353

  Lindsay publishes books for the home shop, covering casting, forging, machining, and a few plans for building engines and such. It has been reported that their catalog is "a bit bizarre" but the service is fast. Their electrical catalog has cross-over projects that include light (pun intended?) metalworking.

- Little Engines
  13486 Carapace Court
  Manassas, VA 22111
  (703) 791-5322

  Plans, castings, accessories for model rail motive power.

- Logan Actuator Co.
  4956 N. Elston Avenue
  Chicago, IL 60630

(312) 736-7500, (312) 736-6854 (FAX)
e-mail: SLogan@gnn.com
http://www.loganact.com

Spare parts etc. for Logan lathes.

- Mason & Sullivan
  210 Wood County Industrial Park
  Parkersburg, WV 26102-1686
  800-225-1153 (orders), 800-535-4486 (technical advice),
  800-535-4482 (customer service), 304-428-8271 (FAX)

  Supplier of clock kits, plans, parts, and tools. In business since 1947, they recently went out of business, and have re-appeared owned in part by the employees, though they also appear to be affiliated with the Woodcraft company (same address!)

- McMaster-Carr Supply Company
  PO Box 440
  New Brunswick NJ 08903-0440 USA
  (908) 329-3200 (Sales), (908) 329-6666 (Other Departments),
  (908) 329-3772 (FAX)
  http://www.mcmaster.com

  Also has stocking sales centers in Atlanta, Chicago, and Los Angeles.

  Note that they apparently only deal with companies. Jim Harres reports that they refused to send him a catalog.

  Prints an annual 2600+ page catalog. Very complete supplier with tools, screws, shelving, wheels, lamps, heaters, air conditioners, plumbing, electrical supplies, plastics, metals, pumps, containers, motors, gauges, paint brushes, hooks, door hardware, pH testers, microscopes, etc. Metric and english threads and sizes, too. Small bits of information, reference charts and advice are scattered throughout the catalog.

  No minimum order. Satisfaction Guaranteed, whatever that means. No problem with returns, but they ask that you get specific return instructions before shipping anything back. All prices subject to change. Visa and MasterCard accepted. Prices are quoted plus actual shipping.

  Experience with McMaster-Carr is very good. They do update (read: raise) their prices frequently, so don't believe catalog prices. Get a quote before buying. Expect the catalog to be 10% low. Shipments have been prompt, complete, and accurate. Prices seem high, but they make up for it with "one-stop" shopping.

- Merritt's Antiques, Inc.
  P.O. Box 277
  Douglassville, PA 19518-0277
  (610) 689-9541, (610) 689-4538

  Clocks, clock parts, clock repairing tools, etc.

- Metal Buyer's Mart, Ltd. (formerly Metal By Mail)
  N15 W22218 Watertown Rd. #3
  Waukesha, WI 53186
  (800) 657-0721, (414) 547-3606, (414) 547-3860 (FAX)
  http://www.execpc.com/~metal
  e-mail: MBMDAN@aol.com

Also: 1216 Capitol Dr, Unit A
Addison, IL 60101
(708) 628-8620, (708) 628-8747 (FAX)

$3 catalog, which contains decent descriptions of what they sell (hardness, machinability, etc.). Ferrous and nonferrous metals (including Nickel Silver), fasteners, and a few nonmetallic materials such as nylon and teflon. A source for small quantities.

- Metal Lathe Accessories
  Box 88
  Pine Grove Mills, PA 16868

  Mostly castings and raw-parts kits for common and useful lathe accessories, mostly for lathes similar to 9- or 10-inch South Bend and Atlas-style units. A T-slot cross slide, rear mounting tool post, faceplate, milling attachment, boring/facing head, large steady rest, boring and ball-turning tool post, and others. Also a toolpost grinder kit. You can order kits, or just drawings.

- Metal Supply Co.
  4001 G St.
  Philadelphia, PA 19124
  (800) 638-2521

  Supplier of Brass, Copper, sheet, plate, bar, etc.

- Micro Fasteners
  110 Hillcrest Road
  Flemington, NJ 08822
  (800) 892-6917, (908) 806-4050, (908) 788-2607 (FAX)

  They have a growing selection of small nuts, bolts, screws, etc. Their prices seem reasonable, and they'll sell in small lots.
  Call and ask for a catalog.

- MicroKinetics
  1220 Kennestone Circle, suite J
  Marietta GA 30066
  (404) 422-7845, (404) 422-7854 (FAX), (404) 422-2714 (BBS)

  CNC parts such as software, PC controller boards, amplifiers, position sensing, and motors. Kits to do conversions on Sherline lathes and mills, and Bridgeport mills. Also Sherline lathes and mills pre-converted for CNC.

- Micro-Mark
  340 Snyder Avenue
  Berkeleyheights NJ 07922-1595
  (800) 225-1066, (908) 665-9383

  Miniature tools & things, including Sherline lathes and mills. "Weensy" nonferrous tube, rod, sheet. Everything sold in small quantities. Prices not superb, but some of the items can't be found elsewhere.

  Sometimes have sale catalogs with some items marked down as much as 50%.

- Minitech Machinery Corp.

430 Tenth Street, Northwest Suite N-005
Atlanta, GA 30318
(404) 607-7228, (404) 892-6832 FAX, (800) 662-1760
http://www.mindspring.com/~minitech/

CNC software; complete small CNC mills (unknown mfg though it uses a Sherline headstock and motor; also one based strictly on a Sherline), CNC lathe (based on an Emco compact-5 or a Sherline), and retrofit kits for Sherline, Emco, and Prazi.

- J. I. Morris Co.
  394 Elm Street
  Southbridge, MA 01550
  (508) 764-4394, (508) 764-7350 FAX

  "Precision manufactured by us for stock and order. Sizes 0000-160 to 2-56 and popular UNM sizes stocked in many head styles and lengths in both brass and burr-free stainless. Matching taps, chasers and gages available. Write for catalog or send print for prompt quotation." (it has been reported their prices are high)

- MSC Industrial Supply Co.
  151 Sunnyside Blvd
  Plainview, NY 11803
  (800) 645-7270, (800) 255-5067 FAX, (516) 349-0265 FAX
  http://mscdirect.com

  Their 96/97 catalog is 3555 pages, and their selection has been described as "dumbfounding". They claim same-day shipping and seem to meet this goal. I realize non-US callers can't phone US 800 numbers, MSC suggests using the second FAX number above. Also, their NY branch is at (516) 349-0330 if you're non-US and need to talk to somebody. The catalog is free in the 50 USA states, and Puerto Rico and Canada. A CD-ROM version might be available by mid-1997.

  Outside the US, their current (September 1996) policy is:

  * The minimum order size for export orders is US$500
  * Only products in stock at the time of shipment will be included on the order
  * MSC will not process backorders or provide for special orders

- Myford Limited
  Chilwell Road
  Beeston,
  Nottingham,
  NG9 1ER
  ENGLAND Tel +44 (0)115 9254222 Fax +44 (0)115 9431299

  Myford has been making fine small lathes (7 inch, 10 inch, probably a few others) for many years, and at least in the UK they are a common addition to the serious home shop. Quite a few articles have been published over the years describing home-built accessories. In the USA, Blue Ridge is a Myford distributor.

- National Acme/Sheldon
  (419) 334-8971

  Parts for Sheldon lathes, among other things.

Not cheap, no used parts, but the parts are in stock. Example price (July 1995) $311 for cross feed screw for 10" Sheldon lathe.

- NC Tool Co.
  6568 Hunt Rd
  Pleasant Garden, NC 27313
  (800) 446-6498

  A recommended supplier of venturi (non-blower) forges. They do have a catalog, and they are more than helpful when you call. They have several different styles and sizes and are excellent for those just starting out or those already well into this stuff. They are good, simple units and most of all, they work!!! (from "the" Jim Hrisoulas)

- New Life Video Productions
  P.O. Box 175
  Traverse City, Michigan 49685
  (616) 276-7194 FAX

  Video tapes, as discussed elsewhere in the FAQ.

- Nexus Special Interests
  Nexus House
  Boundary Way
  Hemel Hempstead
  HP2 7ST
  United Kingdom
  +44-1442-66551, +44-1442-66998 (FAX), Subscription Hotline:+44-1858-435344

  A sister company of Argus, they now publish Model Engineer magazine. The USA agent is Wise Owl Worldwide Services.

- Nonferrous Metals Co.
  Waterbury, CT
  (203) 274-7255, (203) 274-7202 (FAX)

  Brass and copper mill products (rod, bar, wire, sheet, plate, tube), including Nickel Silver.

- Nordex, Inc.
  50 Newton Road
  P.O. Box 1956
  Danbury, CT. 06813
  (800) 243-0986

  Usual range of precision components. Spur gears down to .25" O.D.

- Norm Larson Books
  5426 E. Hwy 246
  Lompoc, CA 93436
  (800) 743-4766, (805) 735-2095

  "... books on just about every subject about metal working there is."

- Northern Hydraulic
  P.O. Box 1499
  Burnsville, MN 55337-0499
  (800) 533-5545, (612) 894-0083 (FAX)
  http://www.northern-online.com

  Sort of a hardware store by mail. Gasoline engines, pressure washers,

hydraulic pumps and cylinders, air compressors, tools, and so on.

- Omega Engineering
  P.O. Box 2669
  Stamford, CT 06906
  (203) 359-1660
  http://www.industry.net/omega

  Mentioned as a source for pyrometers and/or materials for making thermocouples and other process-measurement stuff.

- Penn Tool Company
  1776 Springfield Ave
  Maplewood, NJ 07040
  (800) 526-4956
  penntool@nji.com
  http://www.trade90.com/

  A very-well-stocked supplier with a very large selection of drills, taps, reamers, and other machining tools. However, in some cases their prices seem outrageous, so check around first. On the other hand, they may be the only source for that odd-sized spiral-flute reamer you need, or that #00 tap. Their catalogs are free; there is a small (196 pages in 1993) one and a large one (410 pages, catalog no. P-912 as of late 1992), so ask for both (they may only send you the short one if you say you're a hobbyist).

- Personal CNC
  4856 W. 129th St.
  Hawthorne, CA 90250
  http://www.lainet.com/pcmotion

  CNC kits for Sherline lathes and mills, and larger machines. Also completely-assembled systems.

- PIC Design
  P.O. Box 1004
  Benson Road
  Middlebury, CT. 06762
  (800) 243-6125

  Usual range of precision components. Gears down to less than 3/8" O.D.

- Pipe & Tube Supply
  PO Box 2852
  1621 North Cypress
  North Little Rock, AR 72114
  (501) 372-6556, (501) 372-7694 FAX

  (Dave Williams writes:)
  I finally found a place that will sell steel or aluminum stock in small quantities. I'm pretty happy with this place - they're fully computerized, know *exactly* what's in inventory, and usually have it cut and waiting before I can get from the cashier's to the warehouse. I've bought very small quantities of metal with no hassle. They've also special ordered some offbeat sizes for me, no problems, no extra charges.

  Since getting small quantities of metal has some up in this group from

time to time, I asked them if they sold mail order. They do, and they'll take orders by phone, mail, or fax.

- Powell's Technical Books
  Portland OR
  (800) 225-6911, (503) 228-0505 (FAX)

  Send a blank email to ping@technical.powells.portland.or.us for an automatic response with further instructions. Significant selection of new & used books on machine shop practice, metallurgy, forge work, among tens of thousands of other used books. You can search the new & used catalog via email or the World Wide Web:
  http://www.technical.powells.portland.or.us

- Power Model Supply
  13260 Summit Drive
  De Soto, MO 63020
  (314) 586-6466

  Similar to Cole's but heavier on the trains. Detailed engineering drawings for about 15 different engines. They also carry various metals.

- Prakken Publications, Inc
  P.O. Box 8623
  Ann Arbor, Michigan 48107
  (313) 769-1211, (800) 530-9673, (313) 769-8383 FAX

  Publishes the Machinist's Ready Reference.

- Prazi International Sales & Martketing Group
  5151 Oceanside, Suite 109
  Huntington Beach, CA 92649
  (800) JR-LATHE (575-2843), (714) 379-1380, (714) 379-1385 (FAX)

  Prazi is a brand of German-made small lathes and milling machines. This company is the US importer/representative. Prazi seems to make good equipment but the prices are reportedly quite high for what you get.

- Premier Fastener Company
  495 E. Parr Blvd
  Reno, NV 89512
  (800) 654-6333

  March 4, 1995: It was mentioned that these folks have titanium files. Not cheap, but they "last like crazy".

- Process Heating Co.
  Seattle, WA
  (206) 682-3414

  These guys do nothing but play with nichrome and other heating elements. They rebuild and refurbish industrial heating elements for furnaces and heaters. They also sell nichrome in 1 lb. lots. They stock every size and shape of nichrome and ferrochrome wire available in the US and all those wierd little ceramic stand-offs for mounting them. They will also design an element to your specifications of amps and volts and heat output.

- Production Tool

(800) 366-3600

Lathe tooling and such, fair prices, and often have the same item at different quality levels (more quality means more money, of course).

- Pyramid Products
  85357 American Canal Rd.
  Niland, CA 92257
  (619) 354-4265
  http://hre.com/pyramid

  Foundry supplies, furnaces, sand, crucibles, tongs, etcetera.

- Reactive Metals Studio
  Box 890
  Clarkdale, AZ 86324
  (800) 876-3434, (520) 634-3434
  reactive@sedona.net

  Titanium, niobium, mokume-gane, shakudo and shibuichi metals. Supplies for anodizing reactive metals (this does NOT include aluminum). Also an extensive line of findings, Sparkie welders and other supplies. Free catalog.

- A.J. Reeves & Co (Birmingham) Ltd.
  Holly Lane
  Marston Green
  Birmingham B37 7AW
  England
  0121-779-5205 (FAX)
  http://www.fotec.co.uk/mehs/reeves/mindex.htm

  Plans and parts for stationary, marine, rail and road steam engines and a number of IC engines as well. Associated parts, materials and books (will ship internationally).

- Reid Tool Supply Company
  2265 Black Creek Road
  Muskegon, MI 49444-2684
  (800) 253-0421, (616) 777-3951, (616) 773-4485 (FAX)

  Prints a 350+ page catalog twice a year.
  Very complete assortment of knobs, screws, clamps, springs, air hoses and couplings, drills, mills, taps, machinist's tooling, and books.
  No minimum order, 30-day return with full refund.
  Offers rework and specialty items with special conditions and terms.
  However, they want a company name before sending a catalog.

- Rhino Robots Inc.
  221 South Water Street
  Champaign, Ill. 61824-4010
  (217) 352-8485, (217) 356-7699 (FAX)

  Mentioned as a seller of CNC tools. The RM-6 is the model of their bench model mill.

- Rio Grande Supply
  4516 Anaheim Ave. NE
  Albuquerque, NM 87113-1668
  (800) 545-6566, (800) 253-9738 (Canada), 95-800-253-9738 (Mexico),

(505) 821-5529 (FAX), (505) 821-7620 (Local/Technical)

Jewelry-making tools. Part of the Bell Group, which also owns River Gems and Findings (below).

- River Gems and Findings
  Dept T1
  6801 Washington NE
  Albuquerque, NM 87109
  (800) 545-6566 orders, (800) 533-3299 service, (505) 344-9671 fax

  Jewelry-making tools, raw metals such as Nickel Silver, more. Apparently a wholesaler, as they want a state tax ID or business license number before sending a catalog. Part of the Bell Group, which also owns Rio Grande Supply, above.

- Robin Materials
  1951-T Colony St.
  Mountain View, CA 94843
  (415) 966-1533, (415) 966-1533 (FAX)
  http://www.rmat.com or e-mail: info@rmat.com

  "Specialty metals since 1981" "Rare alloys & non-standard sizes". For example, titanium, invar, inconel, and so on.

- Rutland Tool & Supply
  16700 E. Gale Avenue
  City of Industry, CA. 91745-0587
  (800) 289-4787, (818) 961-7111, (800) 333-3787 (FAX)

  (courtesy of Jon Bork)

  Rutland is a general machine shop supply house, with a good selection of tools, machines and accessories. They primarily deal with professionals, but I have dealt with them in person and by phone and they have always been helpful and quick. They send out several catalogs yearly including a new safety equipment supply catalog. Their prices are reasonable and they stock both top of the line and "quality import" selections for most items.

  (Will Martin reports they ask for a company name before sending out a catalog)

- S. LaRose, Inc.
  3223 Yanceyville St.
  P.O. Box 21208
  Greensboro, NC 27420
  (910) 621-1936

  Watch and clock movements, repair parts, supplies, tools, equipment. 320-page catalog $2.50.

- Scanlon American Reprints
  P.O. Box 379
  Modesto, CA 95353
  (209) 667-2907

  Scanlon sells many books on clocks.

- Secs, Inc.
  520 Homestead Ave.

Mt. Vernon, N.Y. 10550
(914) 667-5600

General line of precision hardware, gears, pulleys, clutches, etc.

- Sequoia Brass and Copper
  2289 Industrial Pkwy W.
  P.O. Box 4661
  Hayward, CA 94540
  (800) 362-5255

  Aside from the brass/copper implied by the name, also supply
  Nickel Silver (which is mostly copper and contains no silver anyway!).
  Probably a source for various clock brasses.

- Servo Products Company
  433 N. Fair Oaks Ave., Box 90370
  Pasadena, CA 91109
  (818) 796-2460, (818) 796-3845 (FAX)

  Small precision drill presses and milling machines, including a
  whopping expensive CNC mill ($15,000). Power feeds for mills.
  CNC small lathe, CNC add-on for large mills.

- Sherline Products, Inc.
  170 Navajo Street
  San Marcos, CA 92069
  (800) 541-0735, (619) 744-3674, (619) 744-1574 (FAX)
  http://www.sherline.com/sherline

  Sherline makes small mills and small lathes that are generally
  highly regarded for small work such as model-making. Note that
  many other suppliers also stock Sherline, though you can order
  directly from the factory (at the same price) as well. The
  advantage of finding a local supplier is that you may be able
  to try one out, or at least look at it, before spending your money.

- Small Parts, Inc.
  13980 N.W. 58th Court
  P.O. Box 4650
  Miami Lakes, FL. 33014
  (800) 220-4242, (305) 557-8222; (800) 423-9009 (FAX),
  (305) 558-0509 (international FAX)

  Nicest line of supplies and hardware for prototype builders.
  Specifically targeted for small quantities. Catalog includes
  prices. More fun than the Sears catalog used to be.

- Sobel Machinery
  93 Garry Rd.
  Closter, NJ 07624
  (warehouse is at 82 Herbert Ave)
  (201) 768-9645, (201) 768-2842 (FAX)

  "Specializing in parts for American-made machinery."

- South Bend Lathe
  400 West Sample Street
  South Bend, IN 46625
  (219) 289-7771, (800) 24-LATHE (i.e. 245-2843)

Still in South Bend, since 1906. However, current products may be overpriced and no longer appropriate for small home shops. We've also had reports of a real attitude problem on their part.

- Spheric Inc.
  Suite 101A
  428 West Harrison Street
  Claremont CA 91711

  Specialize in tungsten carbide balls used for making highly finished holes in work. The idea is to drill/bore/ream a hole nearly the desired size, then finish it by forcing a hard sphere through it. Spheric sells the balls, and has accumulated know-how in their use. In firearm manufacturing I believe this is called button rifling or button finishing.

- Spring Manufacturers Institute, Inc.
  1865C Hicks Road
  Rolling Meadows, IL 60008

  If you need technical info about making springs, they sell a book entitled Handbook of Spring Design for $10 US (as of 1994).

- The Steam Outlet
  PO Box 1426
  Thonotassassa, FL 33592-1426

  Catalog $5.00. They are supposed to have 1/2 to 40hp steam engines as well as parts and plans.

- MALCOLM G. STEVENS
  78 Summer St.
  P.O. Box 145
  Arlington, MA 02174
  Phone - (617) 648-4112

  A source for foundry supplies (crucibles, molding tools, tongs, shanks, fluxes, and safety equipment)

  Specific crucible sizes stocked appear to be #4 to #70 in clay, graphite, and #10 to #150 in Silicon Carbide. Tell them that you are a hobbyist and would like some literature on foundry equipment. They apparently do not take credit cards but will bill you.

- Stock Drive Products
  2101 Jericho Turnpike
  Box 5416
  New Hyde Park, NY 11042-5416
  (516) 328-3300
  http://www.sdp-si.com/

  The catalogs are actually published jointly by Stock Drive Products (SDP) and Sterling Instruments (SI). Both are divisions of Designatronics (DSG).

  These folks make all sorts of gears, drives, bearings, couplings, and related stuff. Small, not hydroelectric-sized. Ask them for their free publication "Handbook of Gears." They also publish "Handbook of Shafts, Bearings & Couplings," "Handbook of Timing Belts, Chains & Friction Drives," "Handbook of Design Components," "Aluminum Extrusions & Accessories." They also package the whole

set (I asked for just the handbook of gears and got all five).

See also W.M. Berg for a similar product line.

- Stuart Models
  Braye Road,
  Vale,
  Guernsey,
  Channel Islands
  UK GY3 5XA

  Steam engine kits, highly regarded. Coles Power Models is Stuart's U.S. agent.

- Sur-Fin Chemical Corp.
  1530 Spence St.
  Los Angeles, CA 90023
  (213) 262-8108

  Sells pre-mixed patina solutions.

- Surplus Center
  1015 West "O" Street
  P.O. Box 82209
  Lincoln, NE 68501-2209
  (402) 474-4055, (402) 474-5198 (FAX), (800) 488-3407

  Though they originally sold mostly electronic surplus, they now carry a lot of hydraulic surplus and items that may be of metalworking interest such as motors, welders, phase converters, and such. Free catalog.

- Swest, Inc.
  11090 Stemmons Frwy
  Dallas, TX 75220
  (800)527-5057, (214)247-7744, (214)247-5307 fax

  Jewelry-making tools, metals such as Nickel Silver, more. They ask for a company name and business license or tax ID, but may be willing to send a catalog without them.

- Tab Books
  Blue Ridge Summit, PA 17294-0850

  Publish a very large number of books on technical subjects; you should be able to order them through any local bookstore.

- Tee Publishing
  The Fosse
  Fosse Way
  Radford Semele
  Leamington Spa
  Warwickshire CV31 1XN
  England
  01926 614101, 01926 614293 (FAX)
  e-mail: 100544.1675@compuserve.com

  From England, they publish Engineering in Miniature and other magazines. Similar to Argus, they have clockmaking books as well. They state they are the world's only company specializing in back issues of Model Engineer.

- Texas Knifemakers Supply
  Box 79402
  Houston, TX 77279

  Catalog $2

- Tico
  Michigan
  (810) 478-4700

  Mentioned in a post 7/20/95, as a source of Titanium tubing.
  Minimum order is $100.

- Titanium Insustries Inc.
  Corporate Headquarters
  110 Lehigh Drive
  Fairfield, New Jersey, 07004-3044
  (201) 808-0222, Fax: (201) 808-9119
  http://www.titanium.com/

  "The world leader in titanium mill products distribution".
  The web pages include a technical reference guide and an FAQ.

- Traplet Publications Ltd.
  Traplet House
  Severn Drive
  Upton-Upon-Severn
  Worcestershire
  WR8 0JL
  England
  http://www.traplet.co.uk/traplet
  E-Mail: Traplet@Dial.Pipex.Com
  +44 1684 594505

  Traplet Distribution USA
  144 W Sierra Madre Blvd
  Sierra Madre, CA 91024-2435
  U.S.A.
  All U.S. queries should be addressed to Marianne or Kathy.
  Tel. (800) 523-1736, Intl +1 818 836 6931
  Fax. Intl. +1 818 836 6941

  Primary source for "Gas Turbine Engines for Model Aircraft" by Kurt
  Schreckling, and another book by Kamps. Some model stores may also
  carry the book(s), such as Sulphur Springs Steam Models Ltd, Box 6165,
  Chesterfield MO 63006-6165 (per an ad in Feb/Mar '96 "Strictly I.C.").
  See Traplet's web pages, under "Books" for price and ordering info.

- Travers Tool Company, Inc.
  128-15 26th Avenue
  P.O. Box 1550
  Flushing, NY 11354-0108
  (800) 221-0270, (718) 886-7200, (800) 722-0703 (FAX),
  (718) 886-7895 (FAX)

  Prints a 500+ page large catalog once per year, and also sales flyers.
  Very complete line of tooling for machinists, including micrometers,
  mills, drills, reamers, broaches, taps, collets, tool posts, lathe tools,
  grinding wheels and stones, files, gages, vices, indicators,
  precision steel pieces, glops and goos, books, and some power tools.

$25.00 minimum order. Visa, MasterCard, American Express accepted. Replace, refund, or full credit within 60 days of purchase (buyer's choice). Prices are subject to change without notice.

Experience with Travers has been good. They are less expensive than McMaster-Carr and other full-price dealers. They sell premium and no-name lines of many similar tools so that you only buy the "quality" that you need. Their performance on orders was once imperfect, but they stand behind their merchandise, so correcting the error was easy, fast, and painless. I have ordered from them many times, so "one minor error out of many" is a good grade.

- US Cyberlabs

These folks market a cheap CNC kit, but around late January 1995 the newsgroup was unanimous in condemning the company and their product. Very slow delivery, shoddy workmanship, flimsy engineering were all cited. US Cyberlabs is the only entry in the FAQ for which I decided to include a warning, and not their address/phone!

- Vigor, sold by FDJ
  2221 Lee Road, Suite #1
  Winter Park, FL 32789
  (800) 323-6091 (orders)
  (407) 629-6906
  (407) 645-0707 (FAX)

  (FDJ is the company name, and sells the Vigor line)
  Jeweler's tools, video tapes, books, retailing supplies, and many universal tools being targeted at jewelers. Tweezers, ring forms, molds, forges, files, small lathes, loupes, calipers, torches, solders and brazing material, mountings, etc. An informative catalog.

  Very wide selection, but prices seem very high.

- Village Press
  P.O. Box 1810
  2779 Aero Park Drive
  Traverse City, MI 49685
  (800) 447-7367, (616) 946-3712, (616) 946-3289 (FAX)
  http://members.aol.com/vpshop/hsm.htm,
  http://members.aol.com/vpshop/pim.htm,
  http://members.aol.com/steambook/ls.htm
  VPshop@aol.com, Steambook@aol.com

  Publishers of Home Shop Machinist, Projects in Metal, and Live Steam. Some back issues available; older ones are available as parts of several book series. See the individual entries in the "magazines" question. They also publish other books such as "So You Want to Build a Live Steam Locomotive."

- Weldco
  1-800-733-5840

  Mail order welders and supplies.

- Wholesale Tool (Stu Friedberg's favorite)
  PO Box 68
  Warren, MI 48089-0068
  12155 Stephen Drive

Warren, MI 48089-3962
800-521-3420, 800-521-3661 (fax), 313-754-9270, 313-754-8652 (fax)

Broader selection of hand tools, fewer large machines than IP&S.
Fork lifts. No bulk metals, but tool steel, shim stock, threaded rod,
etc. Vast selection of cutting tools and grinding wheels. Scattering of
interesting surplus items. Definitely oriented toward professional
users, not hobbyists. Full line distributors for most instrument makers.

500 page full line catalog twice a year. You have to order by 8 digit
stock number, so copy carefully. :-)

6 locations, main site in Warren, MI. Most items at most locations,
some items in Michigan only, very few at other locations only.
Credit cards, COD's with some payment restrictions
$25 minimum order

The other locations:

PO Box 481
Stoughton, MA 02072-0481
1234 Washington Street (Route 138)
Stoughton, MA 02072-3345, 800-343-1008, 617-344-0338, 617-341-0617 (fax)

PO Box 700
Brandon, FL 33509-0700
9212 Adamo Drive
Tampa, FL 33619-2631
800-237-4689, 813-623-3099, 813-623-5816 (fax)

PO Box 470952
Tulsa, OK 74147-0952
9909 East 55th Place
Tulsa, OK 74146-6404
800-331-4075, 918-627-2240, 918-627-2044 (fax)

PO Box 240965
Charlotte, NC 28224-0965
4200 Barringer Drive
Charlotte, NC 28217-1512
800-438-3580, 704-527-4071, 704-523-7960 (fax)

8100 Pinemont Drive
Houston, TX 77040-6522
800-231-4585, 713-895-7777, 713-895-8113 (fax)

- Wise Owl Worldwide Services
  4314 West 238th Street
  Torrance, CA 90505-4509
  (310) 375-6258, (310) 375-0548 (FAX)

  USA agent for Argus and Nexus publications such as Model Engineer
  magazine, and probably other publications and publishers.

- Wood-Met Services, Inc.
  3314 W. Shoff Circle
  Peoria, IL 61604

  Mail-order sellers of plans, for accessories and projects in both
  wood and metal.

This is the FAQ for rec.crafts.metalworking. It is in several pieces

to keep the overall size of each part below the limits imposed by
some news systems. This is part 2 of 11.

Generally, units below are United States dollars, degrees Fahrenheit,
and all the other silly backwards units we Americans still use. Sorry.

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4. Who makes good lathes/mills/etc?

    Who makes good cars? This is almost purely a personal preference,
    though in general the imported machines (Grizzly, Jet, Enco) seem
    to rate lower than US-built machines (South Bend, Bridgeport). However,
    the imports are usually MUCH less expensive, offsetting some of the
    quality issues for home shops. It has also been reported that South
    Bend has been going "downhill" lately.

    There is some indication that Grizzly equipment is slightly better
    than other "Taiwanese" machines such as Enco, and that Jet is slightly
    better than Grizzly. Prices go up with quality.

    One of the main complaints about Taiwanese machinery is the lack of
    replacement parts and service. Grizzly claims that they keep a supply
    of parts on hand for all their machines. The same factories appear to
    turn out Grizzly, Jet, Delta, and the "no-name" machinery. A few years
    ago Fine Woodworking magazine published an article on this subject.

    Unimats are sometimes considered "toys" rather than real machines,
    though they may do just what you want if you don't push them hard.
    Some Unimat owners are quite pleased, in fact (hi Reg!).
    The Unimat PC may be a nice small CNC lathe; any experiences?

    Unimat, Sherline, and Taig are "micro lathes" in that the swing over the
    bed is less than 5 inches, and the bed is about a foot long. Sherline
    and Taig are made in the US, and Unimat is made in Austria (and hence
    uses metric threads, e.g. in the spindle thread, which may be a pain
    to US buyers). Sherline and Taig both use 3/4 inch x 16 threads in the
    spindle and can thus interchange accessories*. The Taig cannot cut
    threads, while the Sherline and Unimat can (with accessories). Sherline
    and Unimat sell a milling add-on. The Taigs come in unbundled kit form
    where you have to buy everything; they claim an overall accuracy of
    .0004 inch and have excellent parts and service, and also sell a
    watchmaking headstock. Taig is the cheapest at about $250 to get
    started, about $450 for Sherline. It appears the only Unimat now
    being sold is the CNC "Unimat PC", at about $750. Unimat seems to
    charge quite a bit more than normal for accessories. Just keep in
    mind that these are not as rigid or powerful as full-sized lathes.

    * It has been reported that although the Taig and Sherline use a 3/4-16
    spindle thread, the threads on Taig chucks and faceplates are recessed
    far enough that a Sherline lathe will only grab about 1.5 threads, not
    enough to be usable. However, one reader bored out the back of a
    Taig faceplate to 1 inch diameter for about 1/4 inch depth, and reports it
    threads on his Sherline quite well now. So, be careful if purchasing
    a Taig accessory for use on a Sherline lathe!

    Harbor Freight sells a "precision 4x10" mini-lathe for around $700
    with autofeed, change gears for most english threads at extra cost.
    It is actually a 7" lathe which takes standard 2MT tailstock tooling
    and 3/8" cutting tools, and has Electronic Variable Speed (EVS)
    instead of changeable belts. This is larger and sturdier than the

Unimat/Sherline/Taig, and sounds similar to the 8" Grizzly except for the EVS.

What can you do if you have little money? Aside from looking at used equipment, you can actually build a lathe and other machine tools. Dave Gingery wrote an excellent series of books on building your own machine tools with just hand tools. While it's a lot of work, you can learn a lot. First you make an aluminum charcoal foundry, then a lathe, and finish up with a dividing head (five or six books later). Other authors have published detailed plans for making lathes. See the publisher's catalogs from Lindsay, Cole's, Power Model, Tee, Nexus, and Argus.

A very thorough discussion of vertical mills and what to look for was in Home Shop Machinist, July/August and September/October 1993, by Thomas Howard. Here is a very brief summary:

1. Spindle-to-table distance, or "daylight." Remember that by the time you clamp your work in a vise on a rotary table then slap a chuck with a drill into the spindle, you might run out of room. Try to anticipate your needs.
2. Knee mills: A mill where you can raise/lower the table with a crank, as opposed to only raising/lowering the head and/or quill. Knee mills are generally more useful and accurate.
3. Spindle brake: Locks the spindle during tool-changing. Very nice to have.
4. Power downfeed on spindle. A very nice option, relieves tedium when boring, and often yields better surface finish.
5. Spindle taper: determines what type of tooling you can "plug in" to the spindle. R-8 is most popular, and there's lots of inexpensive tooling. Morse and Brown&Sharpe exist and are less popular.
6. Bearings: Apparently it's not as important whether they are ball roller bearings, as the grade. And the better the grade, the longer the machine lasts, more than anything else.
7. Table sizes and travel: Like lathes, you can always use one an inch larger! Don't buy one larger than you have room for. From 6x20 (inch) to 8x30 seems right for most home shops. What will you be doing with it?
8. Power feed on X/Y axes. Very nice to have, just barely falls into the "luxury" status.
9. Table and knee locks: Used to maintain rigid setups when one of the axes won't be changed during an operation. Check for easy access and that they lock solidly.
10. Graduated dials with adjustable zero: an absolute necessity.
11. Adjustable gibs: a necessity.
12. Range and number of speeds. An average is 100-2500 rpm, and 12 to 16 speeds. Howard goes into great depth in his article to explain why you need both a wide range of rpm and many speed, and how those speeds should be spread out in a geometric progression.
13. Motors: be sure you get a motor you can run. Check frequency (60 or 50 Hz), voltage, and 1-phase vs 3-phase. For home-shop use, anywhere from 3/4 to 1-1/2 seems right.
14. One-shot oilers are nice but in many cases they don't work right and are hard to check.
15. Look. If at all possible, examine the machine you want, before you buy.
16. Buying used: you should be experienced enough to know what to test for! Or "borrow" somebody who is.
17. Will it fit? Be sure it can be moved to where you want it. Don't buy then find the stairwell is smaller than you thought. Get professional movers to do the moving; "real" mills are

literally "killers."
18. Tooling: can sometimes double the cost.

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The following comments, regarding the Central Machinery (Harbor Freight Salvage) "Precision 7"x10" Mini Lathe", were originally sent to John Kopf in response to a query of his, asking the opinions of this versus the Grizzley 8x18 lathe.

Date: Tue, 23 Nov 1993 09:40:15 CST
From: <U39466%UICVM@UIC.EDU> (Gordon Pari)

I own a 7 x 10 mini-lathe offered by Harbor Freight. First, the good points. Compact size useful for relatively large turnings...easy to move/store....tight headstock bearings....nice 3-jaw Yamakawa (japanese) chuck....good cross-feed and compound feed...good accuracy overall... Mt2 tailstock compatability...fun to use...3/4" hole in spindle.... quiet without feed engaged....relatively easy to set-up tooling... cuts threads.....has chip tray...uses cheap 3/8 tooling.

Now for the down side....motor on mine with a Dremel speed control substituted for the factory setup has good high-speed power but is lacking in low-speed torque....my set-up produces surges of rpm occasionally... newer version appear to have 2-speed setup that may help... HF parts supply is limited....I could not get jaws for the chuck (I need inside gripping because they were missing..used equipment!)...feed screw is poorly mounted/designed and uses up a lot of available power.....split nut on carriage is prone to disengage...the motor is 120V DC fed by a rectifier and that may be part of my problem.. manual carriage feed wheel/mechanism is not smooth and perhaps needs bushed.

Overall, I love it because I bought it used needing some repairs for $95. Enco in Chicago now offers it for $1000. They are more reputable than HF IMHO. They also cannot provide my jaws or a specifically designed 4-jaw. If I paid $800 I would want the split-nut and RPM/POWER problems completely eliminated. After my initial $95, I have spent about $65 for a live center and tools from Enco. I use it weekly and am learning a lot. A friend who is a lathe operator has used it and is impressed. I hope this helps. If you buy one and find solutions/parts, keep me posted.

Date: Tue, 23 Nov 93 14:48:23 -0800
From: Greg Saville <gregs@sequent.com>

Just one comment, if you end up ordering the Harbor Freight one, DON'T order the $43.00 threading gear set. Though it's not clear in the catalog, it already DOES come with the lathe (unless you order the ~$550 version that says "same as above, but without threading capability.") ...

I've enjoyed the lathe, have been pretty happy with it, but have no other experience to be able to compare it to any other like the Grizzly you're also looking at.

Date: Tue, 30 Nov 93 14:18:01 EST
From: fisher@gaas.enet.dec.com

I purchased one of these mini-lathes this summer.

Since then I have read a few books and learned much about lathes.

If I had to do it over again I would purchase the Grizzly "8"x18" Lathe you mentioned. I kinda like the mini-lathe for 1) the size and 2) the variable speed motor. What I don't like is 1) Support (I had a bent shaft on my cross slide and called them back within 48 hours after receiving the lathe and I still haven't received the replacement part - I think they ordered it from Korea.), 2) It is sufficiently non-standard that Nobody makes a 4 jaw chuck for it or any other bolt on accessories such as a steady rest or a follow rest.

But it seems to work and I have been having fun with it and learning. The size is great - I just finished cutting about 50 brass port holes for a model tub boat.

5. Where do I buy a machine?

Check out the Yellow Pages, the ads in the magazines, and catalogs from the "names and addresses" section elsewhere in this FAQ. For example:

Blue Ridge Machinery and Tools, Inc
Alley Supply Company
Enco
Grizzly
MSC

6. What are good magazines to subscribe to?

- The Home Shop Machinist (HSM), "dedicated to precision metalworking"
  Published 6/year by Village Press (see addresses section), $24.50/year.
  Note that many back issues are not available, though most of the projects are available in the "Projects" book series. Mostly techniques, no steam, some gasoline engine projects, many tooling projects. Probably the best of the US magazines. Some projects will span several issues.

- Projects In Metal (PIM).
  Published 6 times per year by Village Press, $19.
  Mostly projects, few advertisements. Each project is complete in one issue. A "weak sister" to HSM, apparently started in part to handle overflow projects from HSM. Earlier back-issues have been combined into a new book series called "Metalworking".

- Live Steam Magazine.
  Published 6 times per year by Village Press, $31.
  Mostly trains, some techniques, some stationary engines, lots of history and club information. Usually each issue has one stationary engine and two locomotive construction projects in various stages.

- Model Engineer's Workshop
  Published bimonthly by Argus (or is it now Nexus?).
  Described as the British version of HSM, and similar to the tool-oriented writing in Model Engineer. U.S. subscription rate is $38. More "packed" than HSM, and features the uniquely English way of doing machining (e.g., spending hours to make a cutter to make the cutter for gear cutting, when many of us in the US would just order the gear cutter and be done with it).
  See the Model Engineer entry, below, for details on subscriptions.

- Modeltec. "Machinist Projects of Beauty and Usefulness"
  Published by George R. Broad, 12 per year.
  P.O. Box 1226
  St. Cloud, MN 56302
  Phone: (612) 654-0815
  http://www4.infoanalytic.com/modeltec
  $36 per year ($45 in U.S. funds if outside U.S.).
  Similar to Live Steam but not restricted to trains. Lots of projects for railroad cars.

- Strictly IC
  (IC stands for Internal Combustion)
  Published 6 times per year.
  $24.25 (+$2.00 US foreign, WA residents add $2.00 sales tax)
  Robert A. Washburn, editor
  24920 43rd Avenue S.
  Kent, WA 98032

  Concentrates on construction of miniature internal combustion engines, and has a few classified ads, usually for engine castings.

- Gas Engine Magazine
  P.O. Box 328
  Lancaster, PA 17603
  (717) 392-0733, (717) 392-1341 (FAX)

- Model Engineer
  Published twice each month, about $79 US/year (as of 2/2/95)
  Formerly published by Argus, now by Nexus.
  Their USA agent (also for Model Engineer Workshop) is Wise Owl Worldwide Services.

  The king of model machining magazines it has been around for about 100 years. Varied construction articles, lots on trains. Some projects can take years to complete! Extensive back-issues are available from Tee, and we presume from Argus/Nexus since they publish it in the first place!

  An index to back issues is available from:
  G.V. Wilkinson
  129 Springside Road
  Hillcrest 3610
  South Africa
  The index used to cost 30 pounds sterling, and is reportedly much better than Guy Lautard's.

  A computer-readable index is apparently available from Henri Larose, covering about 30 years (growing as he gets time to do more). Cost is 30 UK pounds if in the UK, or $30 US if in the US. Contact the author vie e-mail at 73114.3203@compuserve.com. Or, his mail address is 211 Lanitos Ave, Sunnyvale Ca 94086.

- Engineering in Miniature
  Published monthly, about $30/year.
  Tee Publishing

  Similar to Model Engineer, more steam traction engines.
  Has an extensive collection of back issues of this and other model magazines.

- Clockmaker
  Published 6 times per year, around $30/year
  Tee Publishing
  Discusses how to build mechanical clocks, with many projects spanning several issues. Big names like John Wilding write in this magazine. Classified ads for clockmaking supplies.

- Workshop Masters
  Published by Tee, ceased regular publication in 1991.

- American Machinist
  Penton Publishing
  1100 Superior Ave.
  Cleveland, OH 44114-2543
  (216) 696-7000, (216) 696-0177 (FAX)
  One of those free trade publications with lots of ads.

- Metalworking Digest
  Gordon Publications, Inc.
  301 Gibralter Drive, Box 650
  Morris Plains, NJ 07950-0650
  (201) 292-5100, (201) 898-9281 (FAX)
  Another free trade publication with lots of ads.

- Modern Machine Shop
  6600 Clough Pike
  Cincinnati, OH 45244-4090
  (513) 231-8020, (513) 231-2818 (FAX)
  Another free trade publication with lots of ads.

- Horn & Whistle
  Richard Weisenberher
  2655 North Friendship, Lot #8
  Paducah, Kentucky 42001
  $18 per year. Low budget, in that they publish anything people send in. Some technology, some nostalgia, lots of stuff on meets where they get together and have "steam blasts."

- Traction Engine Magazine

- The Anvil's Ring
  This is the publication of ABANA (see below, associations) published 6 times a year; cost is $24 per year, or you get it as part of the $35 dues for joining ABANA. An index is currently being maintained:
    ftp://wuarchive.wustl.edu/edu/arts/metal/ABANA/RingIndex.txt
  The newsletter of one of their chapters, BAM (Blacksmith's Association of Missouri), is kept at:
    http://wuarchive.wustl.edu/edu/arts/metal/News/BAM/BAM.html
    ftp://wuarchive.wustl.edu/edu/arts/metal/News/BAM/00Latest/
    ftp://wuarchive.wustl.edu/edu/arts/metal/News/BAM/
    For more info on BAM contact: Jim McCarty <JimfromLC@aol.com>

- Anvil
  Published monthly, about $30 per year
  See Centaur Forge, elsewhere.

- American Craft (bi-monthly) (jewelry)
  published by the American Craft Council
  40 West 53rd St.
  New York, NY 10019

(212)956-3535
Current work in metal, clay, glass, wood, textiles, mixed media; featured artists, calendar of events.

- Metalsmith (quarterly) (jewelry)
  published by Society of North American Goldsmiths (SNAG)
  5009 Londonderry Drive
  Tampa, FL 33647
  (813)977-5326, (813)977-8462 fax
  Jewelry, techniques, featured artists, current exhibits.
  An index is at:
  ftp://wuarchive.wustl.edu/edu/arts/metal/SNAG/Metalsmith_Index.txt
  A contact is: Bob Mitchell <rmitchel@cftnet.com>

- Ornament (quarterly)
  P.O. Box 2349
  San Marcos, CA 92079
  Jewelry (metal and beads) and textile/fiber art.

- Machinery Journal
  P.O.Box 7767
  Long Beach, CA
  (310) 595-5731, (310) 424-1563 (FAX)

  Free. A monthly list of machinery dealers.

- Punch Press News
  P.O.Box 127
  Toledo, OH 43607
  (800) 255-0114, (913) 983-4398 (FAX)
  http://www.machinetools.com

  A sort of classified listing of machinery, alphabetical by type of machine; very neatly laid out. Apparently costs $10 for a subscription.

- Weldon F. Stump & Co.
  1313 Campbell
  Toledo, OH 43607
  (419) 243-6221, (419) 243-7277 (FAX)

  No prices, just inventory numbers of used machines, alphabetically listed by type.

- Locator
  Published by the MDNA (Machinery Dealers National Association) in Silver Springs, MD, (301) 585-9494. A monthly listing of used machinery. You can call them for a free list of dealers, and/or a free issue of Locator.

- Used Equipment Directory/Network
  P.O. Box 823
  Hasbrouck Heights, NJ 07604-0823
  (201) 393-9558, (800) 526-6052, (201) 393-9553 (FAX)
  BBS (201) 625-2636 8N1 modem settings
  telnet buyused.hsix.com or http://www.hsix.com

  Used equipment list, available on-line or in printed form. They reportedly will give you one free copy of the printed magazine for evaluation.

- INDUSTRIAL MACHINE TRADER

P.O. Box 1415
Fort Dodge, IA 50501
(800) 247-2000, (515) 955-3753 FAX

A heartland Industrial Group Publication.
"The only weekly nationwide publication that links active buyers and sellers of new and used industrial Machinery"

- The Surplus Record
  20 N. Wacker Dr.
  Chicago, IL 60606
  (312) 372-9077, (312) 372-6537
  tscanlan@surplusrecord.com
  http://www.surplusrecord.com

  An industrial database of used and surplus machinery and equipment. There is also a Listserv: "machine@surplusrecord.com" where users can e-mail their machine tool inquiries, whether the machine(s) are wanted or for sale.

7. Where might one take classes or get instruction?

This depends on several factors, mostly where you live. Good places to check out include community colleges (universities sometimes will have classes in metalworking, but perhaps only for already-enrolled students or faculty/staff). Sometimes a high school will offer night or weekend classes to the public, funding permitting. Also look for vocational/technical schools, and possibly even art schools since some metal sculpturing requires a firm background in welding. In a few cases there may be specialized schools in your area, so check your yellow pages or ask around.

Some examples: John C. Campbell Folk School in Brasstown NC (800) 562-2440, Craft Center in Ripley WV.

Some schools also offer room and board and/or campground hookups.

8. Where can I get raw material for my projects?

The Yellow Pages are often a good place to start. Also, the advertisements in magazines like Home Shop Machinist.

Another way is to go find your nearest junk yard and/or metal recycling business and scrounge around. Make friends with a machinist at the nearest mining operation and ask for their throwaway "scraps". Order from a supply company (see ads in the magazines, and/or the "names and addresses" section elsewhere in this FAQ).

Sometimes you can discover a creative re-use. For example, buy a few old aluminum automotive pistons, perhaps from your junk yard or a garage that rebuilds engines. Cut off the top and clean it up on your lathe. Now you have a nice round blank to start some project with. Similar discoveries should be posted to the newsgroup!

Some of the magazines have ads for small "garage" shops that produce specialized castings.

9. Where can I get tools, drill bits, etc.?

Many of the places that sell equipment also sell tools but there are also outlets that only sell accessories such as

lathe bits, drills, taps, and so on. Scan the "names and addresses" section elsewhere in this FAQ.

10. What are some of the related professional/hobby associations?

ABANA - Artist Blacksmiths Association of North America
PO Box 206
Washington, MO 63090
(314) 390-2133
Dues are $35 per year, which also includes their publication "The Anvil's Ring" (see earlier, magazines)

The British counterpart is apparently the BABA (British Artist Blacksmiths Association) but I don't have an address for them.

The American Society of Mechanical Engineers (ASME)
345 East 47th Street
New York, NY 10017
(800) 843-2763, toll-free Mexico phone: 95-800-843-2763
toll phone: (201) 882-1167; fax: (201) 882-1717 & (201) 882-5155
email: infocentral@asme.org

The ASME publishes codes and standards for drafting, pressure vessels, machine tool accuracy, etc. There was recently a thread in which a gentleman asked about alternate sources for an ANSI standard (published by the ASME). Unfortunately, the third-party publishers charge more for these documents than the ASME does (the originator). In this particular case the third-party wanted $100 for a standard that the ASME charges $23 for.

The Society of Model & Experimental Engineers (SMEE)
Marshall House
28 Wanless Road
London
SE24 0WH

Society of North American Gold Smiths, SNAG
5009 Londonderry Drive
Tampa, FL 33647
(813)977-5326, (813)977-8462 fax
They publish the quarterly magazine Metalsmith (q.v.), and a bi-monthly newsletter, and you get both for the $55 membership. The membership also gives you a discount on the annual conference. You can also contact them via e-mail at rmitchel@cftnet.com.

MDNA (Machinery Dealers National Association)
Silver Spring, MD
(301) 585-9494

You can call them, or drop e-mail to morton@interserv.com for a list of machinery dealers. They publish a magazine called the Locator which lists over 25,000 separate metalworking machines each month; you can also ask them for a single free copy if you don't want to subscribe.

American Welding Society (AWS)
(800) 443-9353, (305) 443-9353
http://www.amweld.org/

"Founded in 1919, the American Welding Society is dedicated to providing high quality services to our members and the industry which will advance the science, technology and applications of materials joining throughout

the world."

ASTM -- American Society for Testing and Materials
(610) 832-9585

Publishes various manuals and publications relating to metalworking, among other things.

11. How do I harden/temper metal?

Heat treating is a *huge* subject, and depends on the metal, and intended use. Most of the time, this question is asked regarding steel, so we'll give a brief description of that, based on an article in Home Shop Machinist (Sept/Oct 1991, "Heat Treating Basics" by Steve Acker).

[Also thanks to Steve Gaudio (?) for his post of 18-Sep-1992, and clarification by Tim Eisele]

Iron will, at common temperatures, organize itself into an atomic structure that is called "body centered cubic." This consists of overlapping cubes with an atom at each corner, and one more in the center of the cube. But above roughly 1400 degrees F there is a change in structure to "face centered cubic" and the central atoms migrate to the faces of the cubes. This latter form is not magnetic.

Steel is basically iron with some carbon mixed in, though modern alloys have various other metals and substances as well. When steel is heated to the critical temperature (about 1400 degrees F), the iron will change to face centered, and the carbon atoms will migrate into the central position formerly occupied by an iron atom. This form of red-hot steel is called austentite. Since it is not magnetic, a magnet may be used to determine when the critical temperature has been reached (though the magnetism may be lost before the transition, so this is only approximate). Complete migration of the carbon atoms may take a minute or two.

If you let this cool slowly, the iron atoms migrate back into the cube and force the carbon back out, resulting in soft steel called pearlite. If the sample was formerly hard, this softening process is called annealing.

If you cool (quench) the sample suddenly by immersing it in oil or water, the carbon atoms are trapped, and the result is a very hard, brittle steel. Too brittle for most uses. The structure is now a body centered tetragonal form called martensite.

So, the next step is to heat it back up, to between 200 and 800 degrees F or so, depending on the desired end hardness. This allows some of the hardness to relieved and is called tempering. The amount of tempering that is desirable depends on the final use. Cutting tools are very hard, knife blades less so because they must flex under use rather than break. Tempering is a trade-off between hardness and flexibility.

Accurately measuring the tempering temperature is important. A nice, expensive thermostatically-controlled oven is great. Or, some special compounds can be applied that melt or change color at the right temp, such as Tempilstik and Tempilaq. If the steel is clean to start with, then you may notice that it goes through certain color changes as it heats up, with understandably vague descriptions such as "light straw" indicating about 440 degrees F,

and purple=520. These colors are not incandescence colors, but are viewed in normal room light. The colors are due to types of surface oxidation that are temperature dependent.

When quenching, it is often very important to avoid stirring a part because this will cool one side much more quickly than the other, and might cause warping. For knife blades, as an example, move it strictly up and down during the quench.

Case hardening is a bit trickier, and involves heating the object in some sort of agent that promotes hardening at the surface. Liquid cyanide works well but should be out of the question for the home machinist. Luckily there are substitutes available from suppliers, one being called Kasenit, for example. Note that hardness is often measured using a "Rockwell C" scale, with 63 being very hard and 35 being fairly soft.

A type of steel called "drill rod" is especially useful for home/hobby use. As its name implies, it is the type of steel used for drills, and is available is round or square form (square drills?). Drill rod is also very useful around the shop because it is usually made to very accurate dimensions. Some types of drill rod are formulated for hardening via heating then quenching in oil, while others are quenched in water. The difference is that water will cool more quickly because it's a good conductor (though it may also form a steam "jacket" that moderates this effect), while oil will cool more slowly. Since rapid cooling may warp a part, this could make a difference in the final product.

There is also an "air hardening" steel, though it seems to be quite a bit more expensive than other steels.

It has been reported, by way of example, that you can make springs out of hacksaw blades by annealing, bending, hardening, then tempering by heating to a "metallic blue" and quenching in oil. I suspect lots of experimenting may be in order before you get things just right. Remember the steel must be clean (no paint etc.) to see the colors.

Quenching in oil may be a fire hazard. Take proper precautions, such as removing flammable materials from the area, wear proper clothing, and have an extinguisher handy. Even quenching in water presents the risk of scalding from steam or splattered water.

As one newsgroup reader pointed out, not only are there a gerbillion alloys, but zillions of treatments to choose from, and this is just for steels. Other metals, like brass, can be hardened by "working" the metal, by bending, hammering, peening, etc. Brass is usually annealed with a quench, which is the opposite of steel.

It's best to carefully research your particular project first, especially if it's something that is valuable.

A recent book, "Simplified Tool Steel Heat Treatment and Selection Guide" by Bill Bryson, may be of some help.
$31.95 from Bill Bryson, Dept. HSM, RR 1, Box 4243, Union, NH 03887.
I purchased this, and was surprised to spend $32 on 100 pages of loose-leaf pages. The information is geared more towards the small commercial shop than the home shop, and thus deals with issues such as atmospheric control (using stainless-steel foil) and using accurate temperatures. In the home shop, we usually read about methods like "hit it with a torch then drop it in a bucket of oil." Bryson goes

beyond this, discussing accurate methods that might be out of reach for some of us, but just barely. He also has a chapter on cryogenic treatment, that can also be used in the home shop via dry ice. http://www.worldpath.net/~hisaim for more info and ordering info.

Power Model Supply recently (December 1992) listed two small heat treating ovens in an HSM ad. 2000 degrees F, 4x4x4 inch $330, 6x6x6 $435. Write them for more info or see the ad.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 3 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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12. How do I wire up this strange motor?

(with thanks to Bill Brown)

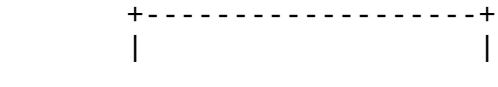
The following describes how to deal with an AC/DC "universal" motor that has 4 unmarked wires coming out. Be sure you don't have some other motor, such as a 3-phase unit.

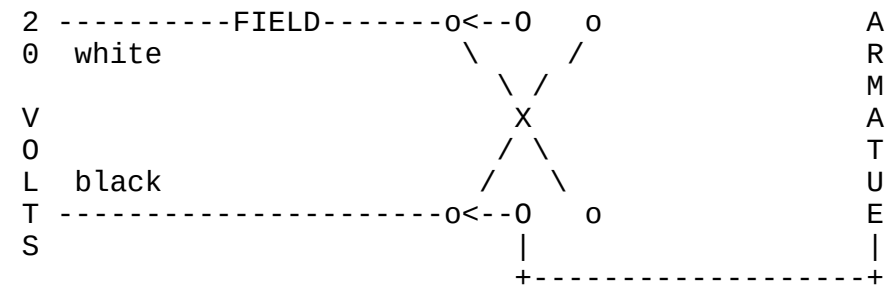
Other motors are covered in an FAQ for the newsgroup rec.woodworking. The FAQ postings (six of them) for rec.woodworking are normally posted around the first of each month, and possibly also posted to the newsgroup news.answers. I can't say how long *your* news system will choose to keep these around! Look for "Frequently Asked Questions about Electric Motors." Also, the "Electrical Wiring FAQ" may be of interest.

The universal motor is called that because it can run on AC or DC. Older units might have been designed this way because very early power distribution had not settled on AC or DC, or with 50 or 60 cycles. Thus, such a motor could be used universally, in all locations provided the voltage was within reason. This still may be a concern with some on-site jobs feeding power tools from DC sources such as portable welding rigs. Another nice thing about these motors is that they are easily reversible. They are also easily speed-controlled, such as in hand drills, whereas induction motors prefer to run at or near synchronous speed.

The first task is to determine which two wires go to the armature, and which go to the field winding. If you can't tell by examining where the wires go (or the nameplate), get an ohmmeter and connect it to the wires until you find two that show some continuity. Rotate the shaft slowly by hand and note if the resistance changes as you turn it. If it does, you probably have the armature, and the fluctuations are due to the brushes making and breaking contact with the commutator. The other winding (field coil) should show a steady resistance.

Presuming you want the ability to reverse the motor, find a switch that can handle the rated current, in the double-pole-double-throw configuration with a center-off position. The suggested hook-up is (as usual, a bad ASCII graphic):





NOTE: no connection at "X";
Include a green-wire frame ground if at all possible

Avoid reversing the motor while it is moving in the "other" direction as this could severely stress the switch and motor (particularly the brushes). Move the switch to the center (off) position, and continue on to the other direction after the motor has stopped.

Please, always be careful when dealing with electricity. If you don't feel comfortable and safe doing such a hook-up, find someone who can do it for you, or at least who can check what you're doing.

13. How do I deal with mail-order suppliers?
The following suggestions were offered by Stu Friedberg --

Get the catalogs and know what you want. There are often many sizes, models, and sources of an "X", so you need to know which particular X when you write and especially when you call to place an order. Even the smallest industrial supply houses deal in tens of thousands of items, which means even very knowledgeable order-takers can't always give you the information you need over the phone. Reserve queries about details for stuff that you couldn't figure out for yourself.

Many of the order takers are very helpful and knowledgeable. At *SOME* sources the order takers can actually go look in the stock bins, take a micrometer to measure a shaft diameter, etc. I have had people at three different companies do something like this for me. However, some companies have computerized centralized order taking at a location completely separate from their stocking locations, so don't *assume* people can tell you anything that's not written in the catalog. I've had one company tell me to just order a set of change gears and return them if I couldn't use them. This wasn't crazy, the order taker simply had no relevant information available.

Get the catalogs and shop around. Very often there are *big* differences in price between identical items, and even more often one source will have a unique or slightly different item at an excellent price compared to the "standard" item. There are lots of reasons for this. I have seen 2 to 1 price ratios on things like shim stock (from the same manufacturer) and "can't twist" clamps (from different manufactures but of equal quality). Occasionally, you will find 10 to 1 price ratios on things like boxes of hose clamps. Great deals if you look around. If you can, examine a tool at a local store (where the prices may be higher) to see what the quality is like, before placing the order by mail or telephone.

You can also learn a great deal by perusing the catalogs, both

about tools in general, and about specific details of specific tools. There's seldom enough room in a catalog to print all the manufacturer's data, but different sources will select different stuff to print. I have many times used one company's catalog to select the precise thing I wanted, then bought it from another company because the price was better.

Most suppliers ship quickly if they have a credit card authorization. If they don't ship within two working days on a routine basis, shop somewhere else in the future. One full working day is quite common.

I have had only one bad incident in the 4 or 5 years I've been buying industrial stuff by telephone, and came through with no losses. A supply company (which entered bankruptcy proceedings just a little while ago, by the way) charged my credit card for the full amount of my order, didn't ship for a month, and was completely clueless as to when they would ship my order. That is intolerable, and protection against abuse like that is one good reason to use a credit card rather than sending a check. You don't need to sue to get your money back if the merchant doesn't come through. (If it's not obvious, I got my money back and started to throw out that company's catalogs as they arrived.)

Some industrial suppliers don't do back orders because it slows things down. The stock pickers send what's in stock and mark out of stock items on the invoice. This may be a little different from retail mail order sources you've dealt with in the past. Contact them about what's in stock and when it's expected to be available.

Be prepared to return an item. Having to return an item because it was misshipped, defective, or of unsatisfactory quality is *NOT* an indictment of the supplier. If you do enough shopping for industrial supplies, you will find that you have to do a partial return maybe 1 time in 5. Don't get mad; don't get upset. It's routine. Industrial supply and consumer retail have different expectations about quality control.

When you return an item, follow instructions. Many, but not all, suppliers require you to contact them for a "return authorization" number, which you must write on the outside of the package. You should include a copy of the invoice in the package. This is *NOT* an opportunity for the supplier to screw you over. This is a routine matter, and most of them just ask you to note on the invoice what was wrong and if you want credit, a refund, an exchange for something else, or whatever.

14. How to sharpen knives, chisels, and other tools?
This is actually a tricky subject, and beyond the scope of this FAQ. However, an excellent book on sharpening knives and similar tools is:

   The Razor Edge Book of Sharpening, by John Juranitch.
   1985 by Warner Books, ISBN 0-446-38002-4, $12.50

This book can sometimes be found in the larger knife stores, such as frequently found in USA malls (e.g. Cutlery World). It is a bit biased in that John also sells sharpening equipment, but the techniques are fundamental and can be used with competitor's equipment such as Lansky's. Another source for the book is Knife World Books, (800) 828-7751 Ext 71.

Sharpening drill bits has never seemed easy. If you have lots of

money, Darex makes drill and mill sharpeners, and Glendo's Accu-Finish line addresses simpler cutting bits (and they even re-sell some Darex tools in conjunction with their grinders). Black and Decker reportedly make a decent drill sharpener (1/8" to 1/2") for around $250.

On 3/18/96, Curt Anderson (anderson@darex.com) posted a nice summary of some sharpening methods for drills:

I'll list a few options and the pros and cons.

1. Sharpening off-hand. PRO: No expensive equipment other than a grinder is needed. There is certain satisfaction in knowing how to hand sharpen. CON: Its unlikely that the drill is ground concentricly or that the angles of the point are equal in length and degree. Thus the drill is really just cutting on one side. Therefore, the holes may not be the size or shape you expected.
2. There are various drill sharpeners sold in hardware stores. E.g.: the Accu-sharp, the Multi-sharp and the Martek. PRO: They are relatively cheap $69 and under. Some even sharpen other tools like chisels and knives. CON: In my opinion, they really do a lousy job on drills. For one thing, the operator is expected grind equal amounts off both cutting edges (this by eyeballing). Other than the more consistent angle, the drill might as well be sharpened by hand.
3. Another option is a machine-shop-quality sharpener like the Darex. (I should say that I work for Darex, so I'm somewhat biased). For those interested there is an extensive list of Darex pros, see http://www.darex.com). PRO: Accuracy and simplicity. The Darex (and some of our competitors) produce accurate drills and on-size holes. Drill points can be changed to meet the needs of varying materials. CON: The price. Our least expensive sharpener is the M3 at $298. Although, we sell a lot of M3s and even our more expensive models through "HomeShop Machinist", etc., we realize that the price may not be worth the convenience of having sharp, accurate drills for the casual hobbyists.
4. Another option is to send your drills to a sharpening service. (Jim Harvey of this newsgroup will sharpen your drills with a Darex. He is on the web. We have a link to Jim's sharpening service at http://www.darex.com/links.htm) PRO: You get drills that are as good as new at the angle and relief you want for a cost much less than new. CON: You may have to wait a day or two to get your drills back.
5. Run down to the hardware store each time you need a drill. Or keep a supply on hand.
   PRO: No big expenditures. CON: It's a hassle.

---------- (end of note by curt)

Some of the magazines will print articles from time to time on sharpening, and/or building sharpening equipment. For example, there is an article in the March/April 1996 issue of Home Shop Machinist by Frank McLean on setting up and using the less-expensive drill grinding attachments.

15. The following text on safety was donated by Gary Preckshot:

The forces involved in metalworking machinery are far higher than most people expect. You can either be struck by shrapnel or pulled into a machine by being caught by a moving part. There are several rules that reduce these hazards:

a) Don't wear loose clothes, ties, unsecured braids, or jewelry.
b) Turn off machines and *WAIT* for rundown before approaching the working area. You'll spend a lot more time in an ER than you'll ever save by jumping in right away.

c) Don't snap chips using a shop towel. Use a brush or air.
d) Don't mess with long chips curling off a turning. If you get build up, stop the machine and remove the chips wearing leather gloves and using pliers.
e) Keep power transmission belts of any kind isolated and guarded. Flat leather belts are especially hazardous because they tend to be unguarded on crowned cone pulleys.

If in doubt, add more clamps. If in doubt, chuck more deeply or use a collet. A turning that comes adrift can damage both the lathe and you. A workpiece that shifts can damage both the mill and you.

Stuff gets hot when cut. Let it cool before picking it up.

Metal cutting generally leaves a sharp burr. Break the edges with a file or a de-burring tool before you release the work for general handling.

Don't let kids, wives, husbands, girlfriends, or boyfriends close to metalworking operations without training or close supervision.

Chips are extremely sharp. Long, curled chips from lathe turnings are especially dangerous because kids, wives, husbands, girlfriends, or boyfriends see only how pretty they are. You can get a very deep cut by handling such chips with your hands. Have a system for removing and storing chips. Use it regularly.

Use eye protection - ALWAYS.

Beware of fascination. Metal cutting tools flash and glint as they spin. An unwary person may reach toward the pretty, shiny tool. This is no joke. It happens. Then you take a trip to the local ER.

Don't watch welding without adequate dark glass filters.

You can get a tan in 2 minutes and a burn in five on any exposed skin close to arc welding. It doesn't hurt for about 3 hours, but then it hurts for days. Cover up.

Don't play with air. Not only can it inject chips (by blowing them) into your body, but it can inject oily air as well. Sometimes right through the skin. Air is no joke.

In general, no horseplay in the shop. Banish anybody who can't understand this simple rule. This is one place where absolute dictatorship is better than democracy.

Take your time. You'll save on rework time, machine repair, and medical costs.

16. How do I drill round holes?

In May 1993 the following question was posted. This brought a lot of useful suggestions for a problem often seen ...

Subject: I can't drill round holes

> I am trying to drill 1/4" holes in 3/32" mild steel with a H/S twist bit in a 12" Delta bench press. The holes are not round. They tend towards the triangular. The piece I am drilling has a 1 1/4" square cross section. The distortion is worst in the exit hole through the

bottom of the member. What is going on? Is there anything I can do to correct the problem?

Morgan Hall gave the following shot as to how a simple twist drill manages to create a non-circular hole:

Hint -- look at the rotor and housing of a Mazda rotary engine

You can model the working end of a drill bit as a single straight line of finite length. If you fix one end and try to rotate it, the opposite end of the line sweeps out an arc. (the drill flexes) After about 1/3 revolution, the stuck end breaks free and sweeps out another arc while the formerly free end sticks. With alternate ends sticking, then breaking free, the arcs will form a kind of polygon with arcs of radius equal to the drill's diameter. After the first cuts, the "corners" of the polygon tend to stop the sweeping cut for each drill flute. The most common I've seen is the triangular hole, but other polygons are definitely possible. I suspect that this occurrence is related to some sort of resonance in the drilling setup.

The suggestions that followed may be useful to anyone trying to drill holes. Some of them may qualify as 'obvious' but they're still worth bearing in mind...

* Ensure the drill is sharp.
* Make sure the work is firmly clamped
* Don't try and run the bit too fast for the drill size and work material.
* Don't force the feed rate; as with *any* cutting process, let the cutter do the cutting.
* Keep as much of the drill in the chuck as possible. The more flexibility there is in the drill, the more likely you are to have problems.
* When drilling thin material, it is often useful to provide some form of backing clamped to the work. This has the added advantage of keeping the burrs to a minimum.
* The drill tip may need to be ground to a different angle, depending on the material being worked.
* An undersize pilot hole is often a good idea. If you are drilling using a mark made with a centre punch and the tip of the drill is larger than the mark, you are unlikely to get accurate placement.
* Don't forget to use a cutting lubricant
* The quality of the hole is only going to be as good as the machine you are using will allow. If the drill spindle is sloppy, there may be nothing you can do about it.

As a final comment, if you really want a round, accurately sized hole, you are unlikely to get it with a twist drill. Drill undersize and use a reamer if it's important.

Another alternative to very finely finished holes is to force a hard polished sphere through a slightly undersized hole. See the vendor list, under "Spheric".

17. What's TIG and MIG?

TIG - Tungsten Inert Gas; also called GTAW -- Gas Tungsten Arc Weld, but nobody calls it that except the American Welding Society (AWS)

A small torch with a tungsten electrode is used to make the arc inside an envelope of an inert gas, usually argon or some argon mixture. A filler rod is manually introduced to complete the weld. The resulting weld is very pretty and usually requires no further finish. It is

used mostly for welding sheets of mild steel, stainless steel or aluminum. The better machines have a foot control and a high frequency arc starter. Any sizable stick welder can be retro-fitted to do TIG welding, but without the foot control.

MIG - Metal Inert Gas

MIG and wire feed are the same thing. In this process, a consumable wire electrode is fed from a spool to the torch where the weld occurs inside an envelop of pure carbon dioxide, pure argon or a mixture of both. The weld continues as long as the operator has the trigger depressed and there is something to weld. This process is very fast, easy to learn and results in fairly good looking (better with argon) and strong welds. Most production welding of mild steel is now done with MIG welding. There is no slag to chip, but there is a slight thin coating of a glassy material that probably should be wire brushed off before painting. MIG welding can be used for thin or thick materials and is commonly used on mild steel, stainless and aluminum. Some common features of MIG machines are spot welding and stitch welding of sheet metal.

There is a special wire called flux core that can be used in a MIG welder without the shielding gas. This process leaves a slag coating that must be chipped off. For most people on this group there isn't much use for flux core, as it was developed to reduce cost for large-scale welding where the cost of Argon starts piling up.

There are fairly cheap 120 volt MIG welders that will only weld thin sheet metal. A more practical 240 volt machine that will weld up to about .25 inch is about $1500-$2000 new, $800-$1200 used. The machine I have will do MIG welding and stick welding, but most are MIG only. A machine that will weld .25 inch in a single pass will still weld thicker materials with multiple passes.

18. MIG welding technique.

(The following was submitted by James Swonger on May 4, 1993)

The quality of a MIG weld is controlled by gas flow, the qualities of that gas, the "heat" and feed rate settings. While getting a quality weld is less dependent on "touch" than gas or arc welding, it does depend on the right combination of the settable machine parameters.

There are three modes of material transfer in a wire feed machine. One is "blob mode", where the wire sticks, then melts locally, then breaks. This occurs at the lower end of the heat/wire feed range. I say heat/feed rate as a ratio, because this pretty much determines which deposition mode you will see. Blob mode welds are the lowest penetration and lowest transferre heat, because there's almost no real arc action, just mostly resistive heating of the wire and contact point.

The second mode as you move up the range is a soft arc with the metal being pushed through it. You'll recognize this mode when it happens; there's no more "wire push", the sound changes from a random snapping to a more uniform sizzle and everything just gets smooth. This is what I consider the ideal mode. The arc is stable but most of its energy is transferred into melting the fed wire and a localized area of the workpiece. In this mode I see about 1/4" of heat affected zone around the weld (automotive sheet metal thickness), and by proper setting I can get perfect penetration which I define to be some backside protrusion but no sag or burn-through. The handpiece ("gun") in this mode may have a

buzzing feel to it but none of the bucking you get in blob mode.

The third mode is when heat is much higher than the wire feed rate needs. This mode is akin to traditional arc welding, except with a fed wire. The arc energy now is biased more into the workpiece, with attendant heating and penetration. The wire still adds filler but there is more tendency to undercut, eat back and blow through especially on thin pieces. In this high heat/feed mode the buzzing/sizzling sound is replaced by a more purely electrical arc sound (whispering/crackling). This mode is desirable when welding pieces much thicker than the wire, especially when you haven't taken the bother of grinding proper chamfers and need to get penetration.

Gas flow provides an important cooling effect. This is one reason why flux cored wire is harder to use on sheet metal; there's no place for the weld heat to go except the workpiece. Argon, A75 and CO2 have different welding characteristics. Argon will make the weld "sit up" higher, CO2 gives the most penetration and A75 is in the middle somewhere. Only Argon is suitable for aluminum; A75 is sort of marginal for stainless (leaves some carbon) but pretty ideal for general mild steel use.

An adjustable regulator provides more latitude in balancing arc heat/feed and cooling. A high flow of gas can reduce warpage while allowing faster material transfer. I have a cheap preset flow regulator which is a compromise setting, compromise price type deal.

To minimize panel warpage you must apply some technique as well. The MIG machine does not eliminate the need for skill; it just lets you apply your attention to more important things and lets you slide on some of the basics. Warping results from too much differential heating and expansion in the workpiece. By understanding the material and equipment you can keep this from being a problem.

Duty cycle is one simple way of further reducing overall heat input. By welding in short, spaced beads you can join panels without overheating any large areas. First the piece should be "tacked" every few inches, with bead lengths of 1/2" or so. Make several passes after that, filling in the gaps bit by bit and not working any one region for long. The workpiece's thermal spreading will cool the small HAZ (*) pretty quickly if the total heat deposited remains small. A spot cools much more rapidly than a line.

The edge of a thin metal piece presents a special case, a "boundary condition" which behaves differently than the bulk. With half the heat dissipation ability of the bulk, the edge will tend to burn back, distort and so on. This can be addressed by reducing heat (although this may force you into running blob mode), by different choice of metal overlap configuration and by carefully running the arc.

A true butt joint in thin material is difficult to make. A -perfect- butting is hard to do on formed sheet metal, and any gaps will tend to enlarge in the welding process. For this reason a lapped weld is often preferred. A panel can be flanged to let the two pieces overlap but keep the final surface flush. The flange provides a backup as well in case of erosion of the edge on the top piece.

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A second sort of joint is a butted-V which protects the edges as the weld hits the sidewalls without necessarily reaching the bottom of the groove.

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Places like Eastwood sell specialty tools for making both types of flanges on sheet metal. Of course, you need to be careful not to cause deformation from the flanging process itself. I have made my own flanging tool for the first form out of an extra pair of Channel-Loks with extra jaw material brazed in and ground to shape. The Eastwood tool is Vise-Grip based and looks like it's a bit better as far as force required to make the flange due to the compound action. I think a pair of beat up sheet metal shears might be a better basis for making a new one.

(*) HAZ = Heat Affected Zone; the area where you see thermally-induced material changes in the workpiece. This is basically the extent of any visible surface discoloration when using the MIG, although if you run the gas after stopping the arc you may not even be able to see anything because oxygen is excluded. If you remove the gas and arc together you will get the normal thin oxidation layer like you see when grinding or heating to temper. The outside of the blue oxide region is the periphery of the HAZ, although the material effects there are probably negligible.

The following was submitted by mrehmus@ix.netcom.com

Use of MIG for body work. A bad idea fostered on us amateurs by our ignorance. If you look at the available wire for MIG, you don't find anything much softer than S60 or higher wire. In general, the higher the yield strength of metal, the harder it is to work. (Try forming tool-steel as a test). The weld bead left by a MIG is very hard relative to the body sheet metal and is almost impossible to work. It also cracks very easily even if one trys to anneal the metal in the weld. In restoring a 1967 Mercury Cougar I finally had to teach myself hammer welding using a welding torch. The results were much better!!

1. The seam is the same thickness as the parent sheet metal.
2. The seam is as soft or softer than the parent sheet metal.
3. The seam and the surrounding sheet metal are easily worked to remove any defects caused by the welding process.

Should anyone want to equal the hammer welding process but with an electric source of heat, TIG is the only way to go. The filler metal selection is much, much wider and the TIG can be run way down to 10 amps or so which would probably let you weld aluminum foil if you wished. Oh yea, in the professional welder's world, the common opinion is that a TIG weld is superior to MIG.

So why do the professional body shops like the MIG? It is necessary for the welding of high-strength steel that is commonly used in the structural parts of the modern automobile. Not, I repeat, NOT for the external sheet metal. The external sheet metal (the part we can see) is still mild steel because of the expense and difficulty of making sheet metal forming dies that would last and give good results with high-strength steel. Remember that body shops replace whole panels, they rarely "patch" a panel. The high-quality restoration shops use TIG or (usually) a torch and hammer welding.

GOOD video tapes to know about:

"Learning MIG Welding" by SIP

(one source is J.C. Whitney, their # 12VL7580P, $26.99; their phone number is (312) 431-6102)
"Hammerwelding Techniques" by Car Guy Videotapes
"Patch Panel Installation" by Car Guy Videotapes

I have watched these tapes many times, always learning more at every session.

The tape on MIG welding uses a good visual filter technique to show every type of weld puddle. After viewing the tape, my MIG welding has been much better.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 4 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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19. Which MIG welder should I buy?

We frequently see "What should I buy" questions; one example is "What MIG welder should I buy?" There is no definite answer, and the prospective buyer should read the other entries in this FAQ regarding welding. What follows is an example of such a question and the answers received (June, 1993). We claim no responsibility for correctness or liability for your money!

Keith King asked:

I'm looking at the purchase of a MIG welder for auto body repair and other light welding jobs around the homestead and I don't have much background on this type of equipment.

The models I'm looking at are the Lincoln SP-100 and the Miller 130. Both models are 110v portables. The Miller has a higher rating but I'm not sure if that's critical for my applications. The Lincoln has the advantage of having infinitely variable power output vs. stepped output for the Miller and the salesman said the gun on the Lincoln was a "Tweako?" whatever that means. Both units are similarly priced/warranted etc.

Century has a bunch of lower priced, shorter warranty, cheaper looking, MIG welders.

Does anyone have any experience/opinions on these welders or other MIGs to help me make a more informed purchase.

Jim Narem answered/asked:

I'm also interested in MIG welders for sheet metal and roll bar work. I've used the Italian made SIP 110V MIG unit. It works; it was worth $100 (purchased at some close-out sale) but not the $350 that places want retail. It's tough to get parts; even the tips have to be ordered. The wire feed mechanism sucks.

I've seen some new Lincoln's on the market; both are wire feed welders with optional MIG kits as opposed to the SP-100 and SP-130 which are purpose build MIG units.

Lincoln Weld-Pak 100, 88 amp, 18V @ 20% duty, 110V, $354 w/MIG kit.
Lincoln Weld-Pak 125, 130 amp, 20v @ 30% duty, 220V, $556 w/MIG kit.
(Prices are Connecticut Home Depot, tax bandit not included)

The MIG kits are about $80 each, they have a gas flow regulator, solenoid and (I think) a different gun.

Does anyone have any experience with these welders? They seem cost effective compared to the SP-100 and SP-130 but I'm nervous since Lincoln seems to be releasing some home/consumer grade equipment (like their new AC arc welder with the cheezy variable amperage control).

There are also several Century MIG units commonly available at large home improvement shops (yup, WELD on that new addition). I've used their AC/DC arc welder and was impressed with its cost/performance. Has anyone used any of the Century MIGs?

Ken Clarke answered:

I took an evening welding class at a technical high school (10 weeks) and got to try various types of welding (stick, MIG, TIG, and oxy/acetylene. Also got some good tips on safety, and on how to by a MIG welder.

The instructor spoke of the "big three" in the welding business (Miller, Lincoln, and Hobart). He was a confirmed "Miller" man, but we used Lincoln (and Airco) welders in the tech. school. I now think that it makes sense to buy whatever you decide to buy at your favorite welding supply store. The guys there have lots of good advice and if you go with one of the big three, you will not have any problem getting parts and consumables for your welder.

I looked around for a while and compared the 110v portable welders by Lincoln and Miller and Hobart. My favorite welding supply house was having a "package deal" that included the Hobart Handler 120. Included in the package was the welder, a 2 lb. spool of .024 wire, a Jackson welders mask with the 4x5 face plate (get a number 10 shade), a *good* pair of welders gloves, a 55 cu. ft. tank of shielding gas (C25 which is 25 percent CO2 and 75 percent Argon), a dual-gauge regulator and connecting hose. This was about 1.5 years ago and I believe I paid $625 for the package.

The Hobart has been great. It works fine on auto body panels and I have also done work on exhaust systems, mailbox posts, minibike mufflers, lawnmower parts, and am finishing up a trailer axle for a friend this weekend.

So, I guess I'm advocating the Hobart, but if you can get a good deal on the Miller or the Lincoln, those would probably be fine, too.

A few of the features on the Hobart that I liked were:

1. A "purge" feature, that allows you to set the flow rate on the shielding gas without spooling out wire.

2. The wire feed mechanism that lets you set the tension on the drive wheel but also lets you change wire spools without moving the setting.

3. The ergonomics of the unit, the way the wire spool goes in, the way the lid hinges down (not up like the others).

4. Five year warranty on power diodes and SCRs, three years on major components and one year on parts and labor.

I would stay away from the Century welder. I don't think it has the quality of the "big three". I think you would have trouble getting parts, probably would have to order them. All parts for the big three can be had at local welding supply houses, in-stock. Also, the "Tweeko" comment is referring to the gun end of the welder. I hear that it's supposed to be a very common industry-standard type of part. Parts for the Tweeko handle/gun should be available at any welding supply house.

Jim Swonger answered:

"Tweako" is actually Tweco, a manufacturer of MIG and TIG handpieces and such. What this means is that parts are pretty readily available; they're everywhere.

For sheet metal welding you'll run nowhere near the maximum heat setting on any machine. On my 160 I'm down on "2" for heat. The higher current machines of some of the cheaper brands need to be looked at carefully; some of them have -very- low duty cycles, leading me to believe that the critical parts are not much, if any, better than the cheaper models.

The "purge" feature is good to have; however if you do not find a machine with it you can add it pretty simply. An auxiliary control switch for the solenoid valve is all it takes, in parallel with the relay that runs off the gun trigger.

For serious sheet metal work spot and stitch modes are very nice amenities, allowing you to tack up a large piece with spaced short beads, minimizing distortion and allowing a fast, even hand motion. You can get by without it, but if it comes free or cheap...

Quite a while later (26-Sep-1993), mrehmus@ix.netcom.com wrote --

I've owned a Century 90 amp MIG welder for 4 or 5 years now. Never a problem with the unit and I've put three large reels of 0.024" wire through it. The one time I thought I had a problem the people at Century were very helpful. Century may not be one of the "big three" but they have been around for a very long time (mainly they make many of the professional battery chargers sold in this country, so I'm told).

Other comments that have come up from various sources, especially Ken Clarke:

Arc welders are often rated for a particular duty cycle, such as 30%. This means you can weld for about 3 minutes at full power, then you have to let the welder cool off for 7 minutes. The cheap units are typically low duty cycle, where the professional units have a high duty cycle. Also, units are often rated at a certain lower amperage where they can safely be operated at a higher percentage; for example, a 200 amp unit might be rated at 50 amps @ 100%, 100 amps at @ 60%, and 200 amps at 30%. Look for some sort of automatic cutoff to protect your investment in case you get carried away.

DC systems are nicer than AC systems, especially if you can reverse polarity. AC systems splatter a bit more. DC doesn't as much, and makes a nicer weld as a result. Reversing polarity apparently can

direct heat away from, or to, the workpiece; directing it away from a sheet metal weld can reduce warpage.

Inverter models run off DC, or rectified line current. Their portability is the main selling point, for field welding where 220V isn't available. For the home or small shop, they are probably overkill.

Large spools of wire, or other welding supplies, may corrode before they get used up in a hobby environment. Dry storage is important to preserve them.

In late 1995 (10/1), Ernie Leimkuhler (ernieleim@aol.com) wrote:

The best of all the baby migs are the Lincoln SP-125, Miller 130, and Hobart Handler 120. All 3 are gas MIGs that can also run flux-core (but why would you want to if you don't have to ?). I own a Handler 120 and have loved it for the last 3 years. I've welded stainless, aluminum and steel with it without a hitch, although the aluminum capability of all the baby migs is pretty limited. For regular steel I use a 75% argon / 25% CO2 mix, but if I need to do a bunch of stainless I swap my 75/25 bottle in for a bottle of Helium-tri-mix. This gives hotter, cleaner welds on stainless and as long as you own your tank it doesn't cost much to swap out for a specific job and then swap back. Eventually I suppose I'll buy another tank, but for now it doesn't seem worth it.

Flux-core is only recomended where a sheilding gas is likely to get blown away, such as in-the-field repairs. It is considerably nastier and means a lot of cleanup.

BTW instead of buying 10 lb. ($50 - $60) spools of stainless, I buy the little 1.1 lb ($6 - $7)spools made for spooler guns. This saves a bit of money for small jobs, but if you are doing a lot of stainless, it is cheaper per pound to buy the 10 lb spools.

Remeber to match you filler metal on stainless, other wise you can get some funky welds. 308L SS filler wire is used for 304 SS. 316L SS filler wire is used for 316 SS.
(The "L" stands for elevated temperature stable).

The Hobart, Lincoln , and Miller machines all run close to $500 for a package.

I would stay away from the cheesier brands on principle allthough some members of this newsgroup have bought them and been quite satisfied. The problem is that the low end companies tend to have probems with warranty repairs and replacment parts, whereas the larger companies have certified repair stations all over the country.

All these machines have similar max output amps and tend to max out on 1/4 inch plate steel. For thick sections just preheat to above 400 deg F.

-- to which Jim Campbell (campbellj@fdtc.flo.TEC.SC.US) replied:

The Chicago Electric systems also have a clever marketing scheme that uses non-standard wire diameters that may commit you to using their systems and materials only. That's probably why their machines are priced rock-bottom, especially through Harbour Freight.

For those asking Mig theory questions, are you getting enough info in your operator's manual (When all else fails)? A good little book

on Mig is ESAB's "Mig Welding Handbook" revised in 1994. Only $7.50 and evaluation copies FREE for students/educators/advisors to schools, or whatever. ESAB was once Union Carbide/Linde. They may sell a small Mig unit too, but I am not familiar with theirs. ESAB's snail mail is: PO Box 100545 Florence, SC 29501-0545 and voice is (803) 669-4411. (I do not work for them, but use their mechanized stuff).

20. Books on welding. Courtesy of kenm@daffy.cac.washington.edu
Here's a source of good and inexpensive welding books.
A catalog is available from:

Lincoln Arc Welding Foundation
PO Box 17035
Cleveland, OH 44117

They list a couple of dozen titles. Here are nutshell reviews of the ones I've seen:

Metals and How to Weld Them, 400 pg, $5.00

A great book on the metallurgy of welding. It's not a how-to-weld book, but instead answered the Why? type questions I've had for years.

Principles of Industrial Welding, 384 pg, $6.50

Your run-of-the-mill textbook.

Design of Weldments, 464 pg, $7.00

A text on the design of welded machinery etc. There is a different book on welded structures. Well worth it it you are designing your own projects.

New Lessons in Arc Welding, 528 pg, $5.00

Hard to describe - kind of a lab manual for a welding tips. Certainly worth the $5.

Arc Welded Projects Vol 2, 272 pg, $5.00
Arc Welded Projects Vol 3, 170 pg, $4.50

Full of short (couple of page) descriptions of all kinds of rather ambitious projects - a tractor snowblower, log splitter, chariot, sailboat, woodstove, ...

These are good books at any price, and great books at these prices.

According to Jim Campbell (campbellj@fdtc.flo.TEC.SC.US):

For those asking Mig theory questions, are you getting enough info in your operator's manual (When all else fails)? A good little book on Mig is ESAB's "Mig Welding Handbook" revised in 1994. Only $7.50 and evaluation copies FREE for students/educators/advisors to schools, or whatever. ESAB was once Union Carbide/Linde. They may sell a small Mig unit too, but I am not familiar with theirs. ESAB's snail mail is: PO Box 100545 Florence, SC 29501-0545 and voice is (803) 669-4411. (I do not work for them, but use their mechanized stuff).

21. Soldering/brazing topics.

There sometimes seems a fine line between soldering (several types, at that), brazing, and welding. Here we try to shed some light on soldering and brazing.

The following was contributed by Tim Kirby around 3/3/93 when the newsgroup was discussing the "true meaning" of silver soldering and the distinction between hard and soft solder.

: Can anyone remember the "official" difference between
: Hard & Soft solders ?

While browsing for something else entirely, I found my copy of

'Model Locomotive and Marine Boilers'
[Argus Press, 1988, ISBN 0-85242-923-1]

by Martin Evans (well known in the Model Engineering field, at least in the UK) from which I have gratuitously (and without prejudice) stolen the following extract for your contemplation. As an aside, this is a useful book for those interested in designing and building boilers.

Chapter 3, page 55: Silver Soldering and Brazing

Soldering and brazing are processes which involve the joining of metals by the addition of molten filler metal of substantially different composition, at temperatures well below their melting point. An important difference between silver-soldering and brazing or welding is that the brazing alloy or filler material must be drawn by capillary forces right through the mating joint surfaces, and not merely deposited at the edges.

Soft Solders are generally accepted as including the alloys of low melting point up to about 400 deg. C. They are usually based on Tin or Lead with small additions of antimony and sometimes silver.

Hard solders, or silver-solders, are those alloys suitable for soldering which have melting points from 400 deg. C. up to about 800 deg. C. (see BSI 1845/1964)

[for those who don't understand that reference, BSI is the British Standards Institute, similar in function to (for example) ANSI. BSI 1845 probably details this stuff in excruciating detail ;-) ... Tim.]

Brazing alloys are alloys suitable for brazing (sic) which have melting points from about 800 deg. C. up to about 1000 deg. C.

It should however be understood that there is no definite line of demarcation between silver-solders and brazing alloys. The former always contain a proportion of silver, while the brazing alloys generally contain copper, zinc and sometimes tin. Brazing alloys containing copper and phosphorus are also available but these are not recommended for boiler work.

22. What are bolt grades?

We frequently see questions regarding bolt grades, so here's a partial list. Please note that just because a bolt is grade 2 does not mean it will break easily. Grading only refers to the minimum strength, not the maximum. Thus, if a machine uses a soft bolt as a safety shear pin, and you happen to replace it with a grade 2 bolt that was actually manufactured to grade 8 specs (but was marked down because

too many of the bolts in the lot failed, so the whole lot was marked down) you could create some serious problems. Replace safety-related items with proper stuff! Also beware of improperly-marked forgeries. If your application is critical, test some samples or get certified hardware (not that readers of rec.crafts.metalworking are likely to be building interstate bridges or spacecraft, but it's worth saying).

A note on "strength" which is actually a complex subject. First, note that there is a maximum "dry" tightening torque, and that part of this torque goes to overcoming friction. Thus, a lubricated bolt should be tightened to a lesser torque, as much as 1/2 the dry torque. Note too that bolts are rated as to their minimum tensile strength (presumably before breaking) and also their "proof" load, which is I believe the maximum load they can be subjected to as proof of their being grade "n", but this load is higher than the maximum suggested operating load. Thus, like automobile mileage figures, use these numbers for comparison only. I suggest reading the below-listed references before building any life-critical contraption. And remember that tensile strength is not the same as shearing strength. And note that there have been many scandals over the years involving manufacturers or distributors who certify hardware as high grade, incorrectly.

John M. Peterson kindly typed this in on July 20, 1993, and I have added a few strength figures (jk):

Taken from Machinery's Handbook 23 , page 1286.
Torque: see Pocket Ref, by Thomas Glover, page 250.
Strength: Standard Handbook for Mechanical Engineers, 7th ed., page 8-35. This also has a table of safe loads, as well as tensile and shearing strengths.

ASTM and SAE Grade Markings for Steel Bolts and Screws

Grade Marking	Spec.	Material
No Mark	SAE - Grade 1 ASTM - A 307 SAE - Grade 2	Low or Medium Carbon Steel Low Carbon Steel Low or Medium Carbon Steel
-- --	SAE - Grade 3	Medium Carbon Steel
| / \ |	SAE - Grade 5 ASTM - A 409 Min Tensile Strength: 105,000 to 120,000 psi Proof load: 74,000 to 85,000 psi	Medium Carbon Steel Quenched and Tempered
| \ / |	SAE - Grade 5.2	Low Carbon Martensite Steel Quenched and Tempered

-- --	SAE - Grade 6	Medium Carbon Steel Tempered
	ASTM - A 325 Type 1	Medium Carbon Steel Quenched and Tempered Radial dashes optional
A 325		
	ASTM - A 325 Type 2	Low Carbon Martensite Steel Quenched and Tempered
A 325		
	ASTM - A 325 Type 3	Atmospheric Corrosion (Weathering) Steel, Quenched and Tempered
A 325		
	ASTM - A 354 Grade BC	Alloy Steel, Quenched and Tempered
BC		
	SAE - Grade 7	Medium Carbon Alloy Steel Quenched and Tempered, Roll Threaded After Heat Treatment
-- --	Min Tensile Strength: 133,000 psi Proof load: 105,000 psi	
	SAE - Grade 8	Medium Carbon Alloy Steel Quenched and Tempered
	ASTM - A 354 Grade BD	Alloy Steel, Quenched and Tempered
	Min Tensile Strength: 150,000 psi Proof load: 120,000 psi	
\/	SAE - Grade 8.2	Low Carbon Martensite Steel Quenched and Tempered
	ASTM - A 490 Type 1	Alloy Steel, Quenched and Tempered
A 490		
	ASTM - A 490 Type 3	Atmospheric Corrosion (Weathering) Steel, Quenched and Tempered
A 490		

23. What is XYZ made of?

Metals

1. What is Brass made of?
   Brass is a combination of copper and zinc, in approximately the ratio of 2/3 to 1/3, respectively. Sometimes lead (about 3%) is added to improve machinability.

2. What is Bronze made of?
   Bronze is usually made of copper and tin. However bronze describes any bronze colored alloy even if it doesn't have any tin. Various bronze alloys include silicon, manganese or phosphorus. Mostly bronze is used for bearings.

3. Steels
   Steel is a refined iron where the impurities carbon, silicon, sulphur and phosphorus are removed and then the iron is combined with carbon and/or chromium and/or nickel. Various other metals may be added to create a nearly infinite variety of steel and steel alloys. A few common steels are discussed below.

   a. What is CRS? Cold Rolled Steel.

   b. What is HRS? Hot Rolled Steel.

   c. What is HSS? High Speed Steel.

   d. What is stainless steel?
      Stainless steel is low in carbon but has about 20% chromium. Stainless has a beautiful finish but it is very hard to machine.

   Both CRS and HRS are mild steels. Mild steels have a low carbon (<.3%) content and therefore can't be hardened. CRS is formed (into bars, rods or angles ...) "cold" and therefore has internal stresses inside. Because of these stresses, an intricate part, like a one piece crankshaft, or a heat treated part may distort. CRS has a smooth surface, which requires no additional finishing. The steel stock found in the hardware store or home improvement center is usually CRS. HRS is formed hot so it does not have any internal stresses but it has a rough black scale surface. HRS is a little cheaper, but CRS is easier to find. HRS is used for welding, so a welding shop with steel stock would be a good source for HRS. HSS is a carbon steel (0.3%<carbon<1.7%) that also contains tungsten. HSS is used to make tool cutters (drills, taps, dies...). HSS cannot be easily hardened or annealed in the home shop. Drill rod and tool steel are also carbon steels that can be hardened and annealed in the home shop to machine custom tools. But they cannot take the heat of, nor do they wear as well as HSS.

4. Nickel Silver, or "German Silver" doesn't even have any silver in it. An alloy of copper, nickel, and zinc. Also called "white brass".

24. How do I build a furnace or forge?

Geoffrey Keyes posted this on August 26 1993, and it looked good enough to include in the FAQ. JK

Ok boys and girls, I'm going to attempt to put together what I know about propane forges/furnaces. This may be somewhat rough since I am doing this extempore. I'll be happy to answer any specific questions people may have.

A disclaimer up front. I am not an expert on these beasts and I am not responsible for any injuries, deaths, fires, unexplained explosions, or irate neighbors. The following is what I have tried or seen tried.

A little history. I first saw one of these in operation at a North West Blacksmith Association (NWBA) novice class about six years ago. Since then I have built three versions, Mk III is operating just fine today. I hope to be operating, part time at least, officially as Ravens Forge by the first of the year.

Gas furnaces are commonly called forges. In fact, a forge is open topped and a furnace is closed. In my opinion an open topped version would lose too much heat to be valuable. The two basic types I've seen have been
1) The brick pile,
2) The pipe or box.

Basically, the furnace is a closed space, open at one or both ends, lined with insulation, with an inlet for air and gas to enter.

THE BRICK PILE
Just what the name suggests, is a pile bricks with a pipe stuffed in one side. The bricks are stacked to provide an open space and the air inlet is inserted into the space. A fan is attached to the end of the pipe and the gas line enters between the fan and the box. The opening is covered by a stack of bricks which can be moved around to provide an opening big enough for whatever stock is being used. Since I haven't mentioned it until now, these bricks are fire or refractory brick. Normal red brick will explode under the thermal stress and even fire brick will break down over time.

The first brick pile I saw is still in use. The problems with them are they leak flame and unburned gas though all of the joints and they generally lose too much heat for welding.

THE PIPE
This is what I am using today. Same basic form, a closed box, insulated, with a pipe for the air and gas to enter.

My furnace is a piece of 1/4 steel pipe, 16 in long, with a 1/4 plate welded on the back. About half way down one side a piece of 1 1/2 in pipe is welded to the body. There are two pieces of angle iron welded to the bottom of the case to keep it from rolling over and a shelf welded to the opposite side of the case from the inlet pipe. I use the shelf to preheat steel and to keep my tea cup hot.

Attached to the end of the pipe is a fan, in this case an old hair dryer. About midway between the fan and the case there is a hole drilled for the gas inlet. I use two inches of insulation (on which more later) in the case and a pile of fire brick to close up the open end, with just enough space for my stock to enter. The gas source is a 5lb propane bottle. The whole thing sits on the end of 55 gal drum.

The air/gas inlet can be as simple as a piece of pipe or a complicated as you like, basically you're going to have to experiment with the size of the outlet end. I put a twisted piece of steel in the end of mine

to impart some swirl to the gas as it enters the furnace. This works, but not as well as I would like. Don't push the end of the tube to far into the furnace, since it will just burn off. This is a sort of self correcting problem since if it is too far into the fire it will just disappear over time.

I've got a valve on mine, between the fan and the gas inlet. However, my fan is too wimpy for me to use the valve much. The fan is blowing its heart out just keeping up. My next modification will be a burlier fan.

INSULATION
The insulation used by most of the smiths I know is called KAOWOOL, which is a Johns-Manville product. There is also INSWOOL made by A.P. Green. Both of these are spun ceramic blankets. WARNING The ceramic fibers are fairly friable when the blanket is new and unheated. I suspect that breathing them is a bad idea, so use a filter mask when building your furnace and during the first firing. After that the surface gets hard and crusty and the problem seems to go away.

Some smiths I read about have used castable refractory cements to build furnace bodies, but I don't have any direct experience with them. Fire brick, KAOWOOL, and the like can be found under "Refractories" in the yellow pages or try ceramic supply houses. I bought my first KAOWOOL from a ceramic supply.

LIGHTING UP
This is an exciting process. First insert a burning piece of paper into the fire box, turn on the fan, then turn on the gas. There should be a whump and then a burst of flame. Now adjust the gas so that fire is not streaming out of every crack. Give it enough time for the box to heat up (2-5 min) and off you go.

SAFETY
Propane is a flammable, heavier than air gas. It will accumulate on the floor until it gets a spark. Then it burns very fast. If enclosed at all it will explode. Check all of your valves and connections frequently.

A regulator AND a blowback valve are a good idea.

I got most of this info word of mouth and by trying it out myself. However, there are some publications that may be helpful.

The summer 1991 Vol 5 Num 3 of Knives Illustrated has a pair of good articles on gas forges.

ABANA
P.O.Box 206
Washington, MO 63090
(314) 390-2133

This is the largest blacksmiths association in the US and is a source for all kinds of good stuff. In particular they sell plans for a furnace.

"A recuperative gas fired forge furnace"
Sandia National Labs.

I don't know what they charge for these plans anymore.

W.L. Goddard
473 Durham Ave.

Eugene OR 97404

Wayne writes a column for BLADE magazine and is an ABS Master Smith. He also used to sell a pamphlet of basic bladesmthing info including a section on gas furnaces. I don't know if these are still available.

As I said above, I am not an expert and am not responsible for any problems, injuries, or unexplained fires that might result from any of the above info. On the other hand, I have used a furnace described above to forge and heat treat approximately a dozen knives with good results and no injuries or other accidents. If there are questions or if things are not clear (almost a certainty) please feel free to contact me at

keyes@monitor.wa.com

Good forging

Geoff Keyes
Ravens Forge

Another recommended book is "The Complete Bladesmith" subtitled "Forging Your Way to Perfection", by Jim Hrisoulas. ISBN 0-87364-430-1, published by Paladin Press.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 5 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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25. What is Damascus steel?

We often see the question "what is Damascus steel" and the next question, "how do I make it" or "where do I get it". In an attempt to answer this question, I've put together several responses that have shown up in the past.

From: dgerty@cclink.draper.com (Dave Gerty)
Wadsworth, Kum and Sherby wrote a good article in Metal Progress, June '86, presenting the welded Damascus and Japanese steels as well as the original wootz material. Sherby and Wadsworth wrote a very readable 6 page article in Scientific American (Feb 1985). Most modern and medeival European Damascus steel is pattern welded, but the original material was thermomechanically processed from wootz to produce the pattern. To paraphrase/plagarize a little:

Damascus steel is named for the place where Europeans first encountered it during the crusades. The steel itself was made in India, where it was known as wootz. It was traded in the form of castings or cakes about the size of a hockey puck. The Indians either added carbon to wrought iron (very low carbon) or removed it from pig iron (>4% C).

From: johnri@saturn.wwc.edu (RICHARD ALLAN JOHNSON)
"Damascus" steel is usually created nowadays when 2 materials with differing carbon content or differing properties such as high and low

carbon or high carbon and nickel are forge welded together to form one solid billet. My experience is that in general, Damascus does not stay shaving-sharp as long as straight carbon steel but when it dulls it leaves a microscopic saw edge that will cut flesh like nothing else.

From: sfm1@ns1.cc.lehigh.edu (SCOTT F. MASTROIANNI)

Simply speaking, Damascus steel is an antiquated term popularly used to describe various pattern welded steels. The term was originally used to describe steel from Damascus which had intricate and subtle patterns in it due to the way the steel was made and wrought -- the pattern was a by-product rather than a set goal. These steels contain alternate layers of differing alloy steels that have been forge welded together into a single laminated billet. Frequently these billets are then twisted or physically manipulated in some other manner and/or rewelded to other similar billets. After this laminate steel has been formed into the final shape for which it had been destined, i.e. a knife, object d'art, etc. it is usually etched with some strong acid solution. The etching process will affect the different alloys in different ways; some will etch deeper, producing a noticeable topography, and some will turn darker. The effect is to produce a pattern in the steel of great contrast and beauty.

A Damascus or pattern welded steel blade does not have to be any weaker than single alloy, and frequently it is as good if not better in all properties: edge holding, toughness, cutting ability, sharpenability. It is usual practice to use a high carbon and a low carbon alloy as the constituents of a Damascus blade. This unites the best of both worlds: The high carbon steel grants the blade its cutting ability while the low carbon alloy adds to the toughness and shock resistance. It is not necessary to use low carbon alloys at all. Two high carbon steels with greatly differing trace element profiles can be welded to show patterns. I have even read of 440C stainless being forge welded to tool steel -- this can't be an easy process though. In addition, if the pattern in the blade is complex, and many of the laminations cross perpendicular to the edge of the blade, micro-serrations are formed which add to the cutting ability of a well-made Damascus blade.

Wayne Goddard, a Master Bladesmith of the ABA and a colleague of Jim Hrisoulas (whose book I recommend for a much better treatise on this subject than I have given here), has a continuing program of testing the properties and performance of forged blades. He has tested hundreds of blades, and found that well made pattern welded blades cut and hold their edges just as well as single alloy blades. The Damascus blades are usually much tougher than all but the strongest (52100 or 5160) single alloy blades.

In addition to _The Complete Bladesmith_, I heartily recommend "The Blade" magazine to anyone interested in the latest developments in Pattern welded steel and knifemaking in general.

Robert Allen, rja@sun.com, wrote:

I've had the opportunity to discuss Damascus manufacturing with Jerry Fisk and John Smith, two makers who do excellent Damascus. Let's see if I can remember the basics:

"Damascus" as used by most makers today means a layered material made from a mixture of high and low carbon steels. Makers differ the mix

according to their pet mixes. A billet of alternating layers is forge welded, then folded and re-folded to the desired number of layers. I've been told that more than 200-300 layers is counter-productive, as at that point you start to get too much carbon migration between the layers and you end up with a homogeneous medium carbon steel. The point of Damascus, I've been told, is that the high carbon component gives up a bit of carbon to the low carbon component. When the blade is hardened, the high carbon component gets fairly tough, which gives you good edge holding, and the low carbon component gets a little harder. The point of all this is that damascus is supposed to have a "micro-serrated" edge, which lasts a long time. The theory as I understand it is that the low carbon component wears faster than the high carbon component, giving you an "aggressive" edge that can't be beat. The two Damascus blades I have seem to bear this out, beyond what merely varying the the grit on a sharpening stone would do.

After forging a Damascus blade, it is etched in one of several acid mixtures, which causes the pattern caused by the layering to emerge. Typically damascus is then blued to bring out the contrast between the layers. Damascus is often modified by forming to create specific patterns in the steel. Some makers have produced small American flags in the pattern. Note that such patterns are produced strictly for the sake of art, not for performance. Popular performance oriented patterns are ladder pattern (has ladder "rungs" the length of the blade), San Mai (various makers wrap a carbon steel layer between two damascus layers), random pattern, etc. Some makers claim the different patterns offer different structural or cutting advantages. The patterns are made by machining the billet or blade with the pattern, then re-heating and the material and hammering it flat, etc. There is also cable Damascus which is forge welded cable. Most makers I've spoken with told me their cable Damascus looked good, but wasn't as strong as the other Damascus. Cable Damascus has a unique reptile-scale type pattern.

A good Damascus should OUT-perform straight carbon steel in most areas, but particularly in edge holding. Some makers say their Damascus is not as springlike, and so the blades will not spring back as close to true as a carbon steel blade will, under a vise-bending test. I've found that most famous makers are honest about their Damascus. Tim (?) Winkler told me he makes Damascus strictly because it looks nice. Wayne Valakovich (sp?) told me that his normal Damascus isn't as good as his carbon steel, but that his high-density Damascus is better. Fisk and Smith both say their Damascus is better than their carbon steel in most regards, although it still is not as springlike as their high carbon blades.

I've cut down small trees with a Fisk Damascus blade, with no apparent wear on the edge. I have a Smith bowie which cuts through blue jeans with zero apparent effort.

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jschmidt@netcom.com suggests that knife blanks may be available from K & G Finishing Supplies, (602) 537-8877. Also everything else you might need to finish a knife.

Books that discuss Damascus steel, either historically or how-to:

Custom Knifemaking
10 Projects from a Master Craftsman
Tim McCreight
Stackpole Books 1985 ISBN 0-8117-2175-2
7 1/4" x 9 1/4" 222 pg. paperbound ($14.95, $20.50 in Ca. when I got it)

A History of Metallography:
The development of ideas on the structure of metals before 1890
by Cyril Stanley Smith
1960 -- The University of Chicago
Library of Congress Catalog Number: 60-7243

"DAMASCUS-USA" distributes a catalog. It says on the cover "World leader in hand made forged-to-shape Damascus Cutlery Steel. More of our knives are in use world-wide than anyone else's." It looks like they mostly sell ready-made Damascus knives but there is a page where you can order Damascus Billets (Bar stock) in any size or pattern. This apparently is a one-man operation, by Dr. Robert Charlton (919) 482 4992.

Another source is "True Grit", 760 Francis street, Suite N, Ontario, California 91761.

The book "The Complete Bladesmith" by Jim Hrisoulas has also been recommended.

26. How do I repair/replace this old leather belt?

A big problem with some lathes is that the drive belt, or one/some of the belts, are assembled with the lathe and are not meant to be replaced without disassembling the headstock. This is a task that is difficult at best. Older South Bend and others use a flat leather belt, glued or stitched. Newer lathes sometimes use a V-belt in the headstock to transfer power from one set of pulleys to a set of pulleys on the spindle.

For V-belts, there is at least one linked replacement. Gates Rubber Company makes "Nu-T-Link" belting that can be cut to length, threaded into position, and joined with special T-pins. The pins might get in the way, depending on the application, so be careful to check out clearances before you buy. (ref: HSM Jan/Feb 1992 pg 6-7). You might look in the yellow pages in your area for bearing/belting or other mechanical suppliers.

Flat leather belts sometimes just start slipping well before they break. One suggested fix was to apply "friction tape" to the pulleys, especially if they are polished. It needs occasional replacement, but is cheap and easy. Another fix is to apply some sort of belt dressing; one person suggested contacting New England Belting in Springfield MA. They may also be able to supply a replacement. Also try Hudson Belting in Worcester Massachussets at (508) 756-0090. A non-leather replacement is called Texalon, made by J.E. Roads & Sons, 2100 West 11th street, Wilmington DE 19899 (phone (302) 655-6513). It is sold through Hermance Machine Company, 178 Campbell Street, Williamsport PA 17701, phone (717) 326-9157, and possibly others. (ref: HSM March/April 1993, pg 8-9). Texalon is cut to length, the ends prepared, and then glued.

In March/April 1992 HSM (page 41) another replacement was mentioned, "Powertwist" made by Fenner Mannheim, 311 West Stiegel, Mannheim PA 17545-1010. This is made from interlocking segments, and may be available from bearing suppliers such as Industrial Bearing Company.

At least for Logan lathes, there is the manufacturer:
Logan Actuator Co.
4956 N. Elston Ave
Chicago, IL 60630
(312) 736-7500, (312) 736-6854 (FAX)
They may even have belts correctly sized for other brands such as South Bend.

I have also heard of stitching a brass cabinet hinge onto a leather belt, then assembling in place (as long as the hinge pin can be secured from dropping out!).

Also, per a post 5/17/94, try Page Belting in Concord, New Hampshire.

27. Can I use a drill press as a cheap vertical mill?

Sometimes people want to use a drill press with an X/Y table attached as a cheap vertical mill. Will this work?

Generally, yes, but you should not do this. The bearings in a drill press are not designed for side loads. This may cause premature failure of the bearings, and may also cause significant sideways deflection and wandering (if you must do this, don't expect finish-quality cuts). If you extend the spindle down very far towards the work, the deflection could be quite severe. Mill spindles are more stout than drill spindles.

In some presses, the chuck is held in only by a taper. Side pressure could cause the chuck to fall out. Some milling tools are not designed to be held by a drill chuck, or if your spindle does have a taper, the taper will be wrong (mills usually use either a Morse or "R" taper while drills often use a Jacobs taper; check this out before buying any tools).

An X/Y table often does not come with finely-marked dials, and may in fact be quite inaccurate. For coarse cuts this may be OK. Note too that a real mill will have controlled Z-axis feed, while on a drill press this too will be quite rough to control.

As for how big a cut you can make, or how accurate your setup will be, there is no consensus. You'll have to set it up and try it. Considering the bearing/deflection problems, moderately light cuts would be recommended.

Speculation: use end mills, not fly cutters (or at least avoid fly cutters, or be careful). Depending on the setup, a cutter may enter the work, then due to the deflection the cutter might be driven into the work farther, jam, and break itself or the work. An end mill cuts more or less continuously and might not have the same problem.

Paul Amaranth <amaranth@vela.acs.oakland.edu> volunteered his experience:

I have only machined soft materials (copper, plexiglass and other plastics). I would not recommend using anything but very light cuts (if at all) in anything harder.

As you would expect, I had a number of problems. Fine vertical depth adjustments are difficult. I set the quill stop at the desired depth and held it in place by hand. You could move the table up, but most drill presses seem to use a fairly coarse rack and pinion for the table.

I used an endmill, which worked fairly well.

Any backlash in your x/y table will get you into a load of trouble. This may not be too serious if you're facing off a surface, but will cause lots of problems if you want to make slots or cutouts with any precision. Backlash may also cause chatter.

In summary: this works if it's absolutely the only way you can do it, you don't need a lot of precision and you're working with soft materials. I got around these limitations by buying a real mill.

Alternatives: If you have a lathe, consider buying/making a milling attachment, if your work size and lathe will allow. Consider buying an inexpensive mill/drill machine if you can't quite afford a mill.

In general, some of the same comments apply to buying a mill/drill or other combined unit as opposed to a dedicated machine for each purpose. Mill/drill machines are not as rigid for milling as a pure milling machine, but may be the only alternative before the money runs out. Combinations seem to work adequately for many woodworking applications but metalworking generally requires a lot more force.

28. What is involved in building a steam engine?

NOTE: see also the FAQ entry in rec.models.railroad on live steam railroad modeling.
See also http://mindlink.net/Ron_Stewart/livsteam.html, http://www.bendigo.net.au/~jstein/livestm.html, and http://edge.edge.net/~vrbass/steamfaq.htm.

(with thanks to Tim Kirby and Ian Kirby (no relation))

The creation of working steam engines, be they stationary engines, road engines, marine or rail locomotives, is quite a common hobby throughout the world. Many people who would like to get involved in such modelling are, however, frequently at a loss as to how to start. What follows is a set of simple pointers to get you on board.

- Magazines and Journals

There are four (English language) magazines that specifically deal with this subject.

"Model Engineer" and "Engineering in Miniature" from the UK
"Modeltec" and "Live Steam" from the USA
(they may be available from a local worthwhile model store; alternatively, check the FAQ book list for the publishers)

Reading any of these magazines will quickly give a feel for the hobby.

- Clubs and Associations

They are all over the world. Look through the magazines listed above for club addresses; most if not all of them have the names and addresses of clubs all over the world. If you can't find a club remotely near you, here are a couple of suggestions:

Try posting a request on the net! It can be a remarkable resource.
Try writing to the editor of one of the magazines.

- Scales and sizes

Stationary engines are most often tabletop sizes; they can be very decorative and interesting exercises in machining but are not often "used" once built.

Marine engines are often built as decorative or "stationary" models, however you may also find some installed in model boats. Some of the suppliers in the magazines listed above may provide more information about marine engines.

Road locomotives are usually referred to purely by scale, most often somewhere in the range of 3/4" scale (3/4 inch to the foot) to 4" scale (4":1'). A farm traction engine in 3/4" scale will probably be around 12" or 14" long - quite handleable by most people. A 4" scale model is 1/3 full size - big, heavy and arguably no longer "Model Engineering", at least with respect to the resources available to the average mortal.

Rail locomotive scales can be a little more confusing because of a tendency to refer to them by the rail gauge that they run on. Unfortunately the gauges are not completely standardized for some scales (although one might expect that they would be). The following table lists the most common "larger scales" and the gauge lines they run on (based on a nominal 4' 8.5" so-called standard (USA) gauge track):

3/4" scale (0.75":1') = 3.5" gauge
1" scale (1.00":1') = 4.75" or 5" gauge
1.5" scale (1.50":1') = 7.25" or 7.5" gauge

There are 10.25" and 15" lines as well as smaller (2.5" gauge, Gauge 1) that are modelled in live steam. Availability of land, track and facilities will often affect a builders choice of scale. Note that the modelling of narrow or broad gauge models introduces another confusion factor - a 1.5":1' scale model of a prototype that ran on 3'6" gauge track in real life would result in a track gauge of 5.25". This would commonly be adjusted to fit on a 5" or 4.75" gauge line.

- It must cost a fortune and take forever

Not necessarily. There are many suppliers in this hobby who can provide as much or as little as you need, from a set of original blueprints for a prototype, through those who can provide scaled drawings of proven models, books giving detailed operation-by-operation procedures on how to create a model, sets of castings that need machining or even ready machined kits that can be assembled on a kitchen table... or they will sell you a complete, ready-to-run model.

The amount of money spent will vary typically as a function of how big the model will be, how much work the builder does (as opposed to buying ready-built parts) and what resources the builder has in his/her workshop.

Needless to say, the amount of time spent building such a model will be a function of the same things. As a rule of thumb, the more you do yourself, the cheaper it is and the longer it will take you.

Reading the classified advertisements in the magazines listed you may be able to pick up a part-complete or secondhand model for less than the cost of the parts new (though you are at the mercy of the workmanship of the builder. Let the buyer beware).

- What about boilers?

The subject of boilers is complex; each country has its own rules and regulations - which could never be justly covered here. Some pointers, though:

+ If you build a 'published plan', there is probably a published boiler plan to go with it. This usually means it is a proven design, which is *good*.

+ Steam clubs will have some sort of regular boiler inspection and test requirement. Talk to the appointed boiler inspector at your club.

+ If you are in the slightest bit wary or unhappy about building a boiler, *get some help from someone who knows what they are doing*. Some companies will sell you "standard" boilers for published designs ready made; there are others who specialize in building custom boilers.

  You may be able to lower the cost by doing all the preparation work and getting someone else to (braze/weld/whatever) the bits together.

+ Remember... this is a pressure vessel full of very hot water and steam. You *really* do not want it to fail. You will probably be closest to the boiler if it does...

- What's a good book on the subject?

There are many, many books available on this and associated subjects; some are general texts, some specialize in particular aspects. A good place to start is (unsurprisingly) read through a couple of issues of the magazines mentioned; most of the publishers (Village Press, TEE, Argus/Nexus) publish and/or sell a number of texts; writing to the publishers should elicit a list of currently available books. Also try some of the suppliers catalogs found in the magazines; A.J. Reeves Ltd., Power Model Supply and Coles Power models all carry books on general topics and specialist areas such as boilers, valve gear etc.

- Do you have any other advice?

Reading the magazines is all well and good, but try to find someone to talk to who has had some experience - this can not only save lots of frustration but can also lead to lots of very useful shortcuts and even material help. It may mean finding and joining a club, which, if one is considering building a rail vehicle, at least means that there will be somewhere to run it when completed, without then having to build a track too!

The first-time builder is strongly recommended to consider choosing a published *model* design (from one of the magazines or plan suppliers) where all the scaling is done, and the finished article will work if built according to the plans. Converting full size prototype drawings to a working scale model is not recommended for the "normal" first-timer! As you might expect, the published plans cover some models suitable for the beginner and others best attempted by an experienced builder. Again, we cannot recommend strongly enough getting advice from a club of some sort if you can find one.

Ask the supplier if the design was ever serialized in any of the magazines and if the text is available, either as copies, back issues or as a published book - blow-by-blow instructions can be very reassuring, even if you know what you are doing in a machine shop.

Choose wisely, so that interest is maintained. In particular with rail

models, you need some rail to run it on. Unless you are fortunate enough to have plenty of land and money, you will probably want to run on a club track - find out what your local club has before you build or you may spend several years creating a beautiful working model with nowhere to run it. If there are several gauges available at your track of choice, consider carefully which track you want to be able to run on.

29. How do I anodize aluminum?

(pieced together from various sources, including the newsgroup. JK) (note, there is also an explanation of anodizing, and aluminum in general, at http://www.bikepro.com/products/metals/alum.html)

First, this is only meant to apply to aluminum. Other metals, such as titanium, niobium, and possibly magnesium and others, can also be anodized.

Aluminum oxidizes very quickly, and rapidly forms an aluminum oxide coating that inhibits further oxidization. This coating is useless as is, in terms of protecting the metal, because it is so thin. A thicker coating can be produced by immersing the part in an electrolytic solution and passing an electrical current through it, similar to electroplating. The resulting film is nearly colorless, and can be easily dyed because it is very porous at the molecular level. Then, by placing the part in boiling water, the film's pores can be sealed; the oxide changes from one form to another as a result.

To be more specific, parts should be very clean and grease-free. Commercial plants will first clean and etch the surface in a caustic solution, such as lye (sodium hydroxide), followed by a thorough wash. The parts are placed in an acid solution, such as 15-25% sulphuric acid, and connected to the positive source of a power supply (use only aluminum hardware to make the connection; no copper in the solution!). The part(s) comprise the anode, and the cathode is lead (lead sheet, or the whole tank might be lead). Appropriate current is applied, e.g. 1.5 amps per decimeter (3.4 square inches). This lasts 15-25 minutes if no dying is planned, or 45-60 minutes for dying.

Dying is the next step, if desired. Since the pores are extremely small, many common dyes will not work. Some wool dyes are known to work, or you can purchase commercial anodizing dyes from an industrial supplier. Typically this involves immersion in the dye solution, which may have to be heated to be effective. (Steve Rayner reports that telescope builders like a black anodizing dye called Nigrosin Biological Stain, which is water soluble and mixed 1 teaspoon full to a quart of water; his bottle is labeled Aldrich 19,828-5 and cost around $35.00 Canadian, for 25 grams).

Sealing is then done by putting the part in boiling water, which changes the film from gamma aluminum oxide a hydrated form called boehmite. Boil for about 20 minutes.

Another anodizing process involves using chromic acid. This is not suitable for alloys with more than 5% copper. The film is thinner, but very durable. The very thin film is also a benefit when very close tolerances must be maintained. However, because chromic acid is a very nasty chemical, its use on an amateur basis is discouraged, and its commercial use may be closely regulated.

Anodizing is sensitive to the type of alloy. For example, alloys for die casting have a lot of silicon, which makes it pour and mold well, but it makes anodizing almost impossible.

By all means, find a few references and read them carefully before attempting anodization. If at all possible, try it out on scrap pieces before attempting it on your masterpiece. Be sure to flush the part completely to remove remaining acid.

An alternative is to use a commercial firm to do the anodizing. Some net folks report they can be a bit rough to deal with, as they may be more used to dealing with large jobs and may not appreciate a home machinist with a single 5-inch part. Look in the phone book under anodizing, plating, or electroplating.

Some have reported using a lye solution to treat the surface, which yields a fairly uniform fuzzy surface, that may be acceptable as a final surface without further treatment. Don't use a strong solution or the aluminum will disappear too fast; do this in a well ventilated area, as hydrogen gas is emitted, stay away from flames/sparks, and remember that lye will eat people as well as aluminum! The resulting surface can be dyed, or painted with a chromate primer. (One tablespoon of lye per pint of water has been suggested).

Another alternative is a product called Aluminum Black from Birchwood Casey, which is often advertised in model railroading magazines, and may also be available via gun stores (it is in the Brownells catalog). Brownells also lists a nickel plating solution for aluminum, though it appears non-trivial to use.

See also the ArtMetal WWW pages at
http://wuarchive.wustl.edu/edu/arts/metal/ArtMetal.html
for information on anodizing for artists (more specifically,
http://wuarchive.wustl.edu/edu/arts/metal/TOC/finishes/anodize.html)

References:

Aluminum (Volume 3): Fabrication and Finishing
Kent Van Horn, Editor
American Society for Metals, 1967
Library of Congress #66-16222
813 pages

Electroplating for the Amateur, by L. Warburton.
Model & Allied Publications.
Available via Argus.

The Surface Treatment and Finishing of Aluminum and its Alloys, Edited by S. Wernick, R. Pinner, and P.G. Sheasby. Published 1987 by ASM International, Metals Park, Ohio. 2 volumes.

ARTISTS ANODIZING ALUMINUM- the sulphuric acid process, by David LaPlantz. ISBN: 0-942002-03-2, apparently published by Press de LaPlantz Inc.
Box 220 Bayside, CA USA 95524; It's about $20 US.
The book is extremely thorough and contains several methods of anodizing with lots of pictures and references.
It is intended for small individual pieces, at home in the garage or basement.

Metal Finishing - Guidebook and Directory.
Metals and Plastics Publications, Inc.
One University Plaza,
Hackensack, NJ 07601

Anodizing Aluminum, by Harold Hoffman.
Available from H & H Publihing, 7174 Hoffman Road, San Angelo, Texas, USA 76905, or Centaur Forge.
This book seems fairly complete, with supplier sources.

Anodizing Aluminum in the Amateur Workshop, Ham Radio Magazine, January 1979, pages 62-69, by David W. Hembling.
Sadly, this magazine is out of business, but should be in larger libraries, or available via inter-library loan.
This article lists several other references, including addresses for dye makers.

Passivating Aluminum Alloys, in 73 Magazine, September 1965, pages 74-80, by Robert A. Kidder.

Some jewelry-making suppliers deal with anodizing.

The magazines Strictly IC and Model Engineer allegedly have discussed this, but I don't have exact references.

Argus Workshop Practice Series, number 11, by J Poyner.

Sandoz Chemicals Corp (now apparently Clarion Corp) supplies dyes for aluminum anodizing. Their phone number is (704) 331-7000.

Kepro in Fenton, MO sells black aluminum anodizing dye for their aluminum anodized nameplate kit. They sell it in small quantities. The phone number is (800) 325-3878 or (314) 343-1630.

How to Anodize Aluminum, Popular Science February 1963, pages 144-146.

ADDENDUM: On May 16, 1996, Patrick M. Riggs (pmr0811@tamu.edu) posted this nice description of how *he* anodizes aluminum, and copper as well. JK

A long time ago, I came to this newsgroup asking for answers on how to anodize aluminum, and nobody really had advice. Since then, of course, I've seen lots of suggestions. In any case, at that point I promised to post if I had any results, and never posted except to mention my success. Well, while there are probably better methods out there, this is what worked for me, and has continued to work for me. I hope this is helpful. BTW, it has been a while, and Sandoz chemical is now called Clarion corp. Their proprietary anodal ms-1 is basically a weak nickel acetate solution. As to where to get sulphuric acid, I wouldn't know, since I work at a university where such things are readily available.

I hope this helps, and thanks to those who gave me advice along the way.

Oh yeah, and be careful . . . sulphuric acid is dangerous (I have "bad lab practice" reminders in more than one pair of shorts -- not that I recommend wearing shorts in the lab . . .) and eats an awful lot of otherwise sturdy materials. Also, beware of the high currents. I, of

course, take no responsibility for anything (and that seems to be my problem in general).

Hard anodizing:

Sulfuric acid at 13% by volume, at a temperature of 3 degrees C. Note that the temperature is not overly important, so long as it is close. The current density should be ~15 amps/square foot. The aluminum piece should stay in the bath for at least 2 hours, with four hours being optimum.

As an alternative to hard anodization, leave all conditions the same except for the temperature, which should be 70-75 degrees C. The difference in the two procedures is the thickness and quality of the anodic layer. Hard anodization leave the material more absorptive.

The cathode, or negative lead, should be lead, with the anode to cathode proportion being about 1:1.

For dyeing the object, there are two options:

Rit dye:

Rit is a standard wool dye, which can be purchased at any grocery store. This method is both inexpensive and offers a wide variety of colors. The drawbacks are that Rit, an organic dye, is not light fast, and will fade in direct sunlight.

With Rit, simply prepare a bath of about 50ml/litre at about 70 degrees celsius. One hour minimum is required, with the preferable duration matching the anodization time.

Black MLW:

Black MLW can be purchased from Sandoz Chemical (my contact was Ron Rupple (214) 423-1674, the sales rep for texas. The company is based at (704) 331-7000.) The price is between $15/lb and $60/lb (don't have an exact quote, but this is the range of prices for all of their black dyes). Small test quantities can be obtained.

Black MLW is favorable because it is a) light fast in the visible (being inorganic), and b) a rather flat black. It's drawbacks are expense (a minimum order is 5 lbs, which is an awful lot of dye), and requires special working procedures (the dust is hazardous to the lungs).

Black MLW is, however, simpler, and more convenient, to use. The temperature should be between 51 and 60 degrees C. The duration being 5-10 minutes depending on quality of blackness desired. The concentration (keep this in mind before ordering 5+ pounds) is 10 grams/litre.

Sealing:

The sealing process hydrates the porous anodic layer, closing it, protecting it, and sealing in the dye. For most applications, sealing is desirable.

Supposedly, this process can be done with boiling water, but I've only managed the following.

1) Simply leave the piece in the dye bath, and boil the dye bath for one hour. This will require removal of the excess dye afterwards and is not generally recommended.

2) 2% anodal MS-1 (again from sandoz chemical (though, nickel acetate should work as a substitute). The temperature of the bath should be between 70 and 87 degrees C, with a duration of 5-20 minutes (depending on porosity and thickness of coating . . . longer never hurts).

Note that after each step, the object should be rinsed with deionized water to avoid contamination. I did this all with distilled water, though deionized water should still work.

Important information about the piece. The purity of the aluminum is important. The higher the silicon content, the less likely the process is too work. Also, the product should be newly machined (for a shinier, more professional finish) or sandblasted (for a flatter, though less even, finish). All oil, dirt, glass beads, etc, must be removed prior to the anodization process. This can be done by thorough cleaning with acetone and methonal (soap is dangerous, since phosphates in the solution tend to negate the anodization process). For better cleaning, immerse the part in 1 tsp/200 litres NaOH (be careful). For small parts this is undesirable, since the NaOH actually removes aluminum. After this bath, a smutty brown finish is obtained. To remove, rinse the part, and soak in a 10% nitric acid solution until a satin finish is obtained.

Copper anodization:

While aluminum anodization is typically clear (depending on the alloy and the process used (there are various other processes using different acids, the most common being chromic and oxalic), copper, at least via this process, anodizes black.

The desired voltage is 6 volts across the circuit. The bath should be 120 grams/ litre of NaOH. The temperature MUST be between 82 and 99 degrees C or the process will not even begin. The duration of the anodization process is 30 seconds to 3 minutes, depending again on the quality of black desired . . . more time, flatter black. The cathode is Steel in a 1:1 ratio. Again the piece must be dirt/ grease free.

This process will also work for brass, though it is shinier. Also, different colors may appear under the black, depending on the brass.

For both of these metals, remember that they oxidize quickly in air (which is not the same as the anodized layer . . . though in aluminum, this layer is also protective). Therefore, they should be anodized as soon as possible after machining and preparing.

ADDENDUM: On August 12, 1995, Jerry Kimberlin (kimberln@crl.com) posted the following on blackening aluminum. In this case it is not an anodizing finish, but this seemed to best place to stick the information! JK

There have been several postings about blackening aluminum recently. I wrote an article for *Live Steam* magazine back about 1977 on the subject and have modified it a little since then. I do use it myself and thought that it would be of interest to the newsgroup. So:

BLACKENING ALUMINUM

by

JEROME KIMBERLIN

There are several ways to color aluminum black and among them are black anodizing and paint. You could rub dirt into the aluminum surface, I suppose, but of all the methods, I think chemical coloring is the superior method. It is certainly cheaper, faster, and home use allows the model engineer greater flexibility in the timing of his decoration of models in progress.

Surface preparation of parts to be colored black is all important as any irregularities are not covered by this finish. Paint does build up and fill in scratches and other voids. Castings, however, should look like castings if the prototype used castings, so surface finish is always adjustable to the builders idea. The point here is to emphasize that this blackening technique will not cover up mistakes.

You will need three chemicals. These are: Nitric Acid, Copper Nitrate, and Potassium Permanganate. You will also need some good quality water - either distilled or deionized. I will give the dimensions of the mixture in both metric and English units so that both types of measures are accommodated:

Take:	water	3 quarts	750ml
Add	Acid	1/2 oz	5ml
Add	Copper	3 oz	25gm
Add	Permanganate	1 oz	10gm
Add	Water to make	1 gal	1 liter

Obviously you will have to make up more or less solution to fill the container you will use to color aluminum parts and the parts to be colored should be completely covered by the solution. You should use a glass or plastic container. A metal container will poison the solution prematurely.

At 75 degrees F (24 C) temperature, the blackening process will take about 15 minutes using a fresh solution. If it takes longer it means the solution is deficient in one of the components. Usually, copper nitrate and nitric acid need be added.

Aluminum is a strange metal to most of us. While we cannot see it, the surface of a newly machined or cleaned piece of aluminum combines with oxygen in the air to form a self protecting coating of aluminum oxide. This happens within minutes. If this surface continues to grow (get thicker) the blackening solution described here will not work satisfactorily. Thus, the piece to be colored should be cleaned just before immersing into the coloring solution. In my experience, glass bead blasting is a superior way to clean the aluminum surface and the choice of bead size determines surface finish. Once the bead blasting has been accomplished, the beads can be washed off with hot water and the aluminum piece immersed in the blackening solution. I recommend that the time between blasting (cleaning) and immersion in the blackening solution be less than two hours. I once waited five hours and was disappointed in the results. Once the blackening process has been completed, wash off the workpiece with tap water, drain and spray with WD-40 or other water displacing oil.

There are a number of ways to clean aluminum satisfactorily. It is possible to simply sand the surface clean, or scrub it clean with an abrasive. One can also chem clean aluminum by degreasing the workpiece then dipping it into lye (Draino, for instance) for a few minutes or seconds as required, then rinsing. The shape of

the workpiece and the model engineer's facilities often dictate what method of surface preparation will be used.

Model engineers wishing to use this solution to blacken aluminum castings or other parts should be aware that the chemical components may be hazardous. While the solution itself is not particularly dangerous it can make your hands purple, so use rubber or plastic gloves. Potassium Permanganate is classified as an oxidizer even though dilute solutions of it are used throughout the world to sterilize vegetables used in salads, etc. Concentrated nitric acid is just plain bad. The technique for using it is to pour out a little in a glass container and then use an eye dropper to transfer the liquid to a measuring container when the volume wanted is small, such as that described here. Nitric acid also turns your hands yellow, hurts, and removes fingerprints. A good way to avoid eye damage is to wear a face shield such as the one you should be wearing when working in front of your grinder.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 6 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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30. Rust! How do I deal with rust?

Some machinists live in areas where rust prevention is important, such as those in humid areas. There are various steps to reduce the problem, and sometimes several steps need to be taken simultaneously. Here are some ideas from previous posts on the topic:

Doug White <gwhite@ll.mit.edu> wrote, on 2 Jun 94:

I have a lot of expensive tools/toys that I have a LOT of trouble keeping from rusting. Over the years, I have tried many different tricks and products, and I've summarized my results below.

The paper is called VPI Paper (Vapor Phase Inhibitor), and it's available from Brownell's (address in FAQ), as are raw crystals. You want to make sure that the 'dusty' side of the paper faces the tool, and don't be surprised if some plastics (vinyl tool pouches) end up with a funny white surface. It doesn't seem to hurt the plastic, but it's disconcerting until you get used to it. The tools will stay rust free much longer if they are sealed in a tight box, or a zip lock bag. In theory, you should replace the paper annually if it's exposed to the air on a semi-regular basis.

There is also another similar product called Zrust. This comes in a number of forms, typically plastic 'cartridges' and flat plastic squares. They are also available from Brownells, but if you think you are going to be using a lot of this stuff, you're better off locating a dealer and buying direct. The cartridges can handle an entire tool box or cabinet, and the little squares are good for smaller containers. Once again, the tools should be stored in some sort of container. The more airtight it is, the less frequently you will need to replace the rust-inhibitor.

A company called Hydrosorbent sells silica gel desiccant in several convenient sizes. The nice thing about these is that they have an indicator to tell when they're saturated, and you can 'recharge' them in the oven. I use the small aluminum packs for some of my tools, and

all of my target pistols. There is a new company that makes the same sort of thing in a plastic case that you can recharge in the microwave. If anyone knows where to get these, I'd love to find out.

I also use a dehumidifier in my basement. I live near Boston, and in the summer when my basement is still cool, the relative humidity goes through the roof. I have a 25' x 30' basement, and a 25 pint capacity dehumidifier can keep the RH down to around 50% without running continuously. It's best if you have a drain, so you don't have to remember to empty the bucket all the time. Mine costs me about $20/month in electricity for 3-4 months each year. If you go looking for a dehumidifier, get one that has a freeze-up cutout, and a hose connection on the machine, not the tank. This saves a lot of space, and gets the water source up higher for easy draining. As it is, I have mine up on top of a small set of shelves so that it will drain into the laundry sink. Check Consumer Reports for the most efficient model you can get, it will pay for itself in electricity in short order.

Brownells also used to sell 'Gunsmith's Soap', which was supposed to neutralize the pH of your skin before handling things. They discontinued this before I could get a chance to try it, but I have found that washing your hands to remove salts from perspiration can help. If anyone knows a source for 'Gunsmiths Soap', I'd love to try some.

The one last trick I use when I'm handling something I don't want to rust (like when I'm disassembling a target pistol) is to wear cotton "inspection gloves" that have been lightly sprayed with a thin rust preventative oil. This simultaneously prevents me from etching things with my corrosive perspiration, and lightly coats everything I touch with oil. If you are concerned about what the oil does to your skin, you can wear latex gloves underneath the cotton. It doesn't work well for really delicate work, and you have to be careful not to let anything slip through your fingers.

There are several spray treatments that work well for storage. My current favorite was developed by Boeing, and is called BoeShield T-9. It's available from many marine supply houses. After the carrier evaporates, it leaves a thin surface film that does an excellent job of protecting steel from corrosion.
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Doug White <gwhite@ll.mit.edu> followed up on the above, on Fri, 3 Jun 1994, with these addresses:

Hydosorbent Co.
Box 437
Ashley Falls, MA 01222
(413) 229-2967

Sells Silica Gel descant packages in the following sizes:
750 gram aluminum canister, 6"H x 4"D, protects 57 cubic ft., $24
360 gram carton, 2" x 4" x 5", protects 27 cubic ft., $10.75
40 gram aluminum box, 4" x 2" x 1/2", protects 3 cubic ft., $5.95
26 gram packets, 2 12" x 4", protects 2 cubic ft., $12.00/10

All but the packets are re-chargeable in an oven. Post-paid, but $2.00 shipping charge. They take MC/VISA

Northern Instruments Corp.
Lake Industrial Park
6680 N. Hwy. 49
Lino Lakes, MN 55014

(612) 784-1250

These folks sell a variety of VPI products. The two most useful ones are their Zerust Vapor Capsules and Plastabs. The capsules are plastic and have and adhesive strip to stick them into tool chests, machine tool cabinets etc. The Plastabs are small squares cut from a 1/16" yellow sheet.

The capsules come in several sizes, and are rated by radius of protection, and lifetime:

VC-1-1, 1' protection radius for 1 year
VC-2-1, 2' protection radius for 1 year
VC-2-2, 2' protection radius for 2 years
VC-6-2, 6' protection radius for 2 years

The only ones I have a price on is the VC-2-1, which were $5 each. The protection life varies with the degree to which the container is sealed. The capsules have a label to mark when they were installed so you know when to replace them. Considering the cost, you may be better off with the silica gel canisters. They will need recharging more often, but have an indicator.

I couldn't find any detailed literature on the Plastabs, but I bought a sack with over 500 1/2" squares for $60. They are much easier to use than VPI paper for small tools and parts. I just toss one or two into a zip lock bag of small tool case. These are sold in the 3/4" size by Brownells as 'Rust-Blox' (see below), where they claim they are good for 300 cubic inches. Brownells wants $27.20 for 100, which is a good bit more expensive than buying them in bulk from the Zerust people. You'll need to call them to find a local distributor. The shelf life is probably limited, even well sealed in a plastic bag, so if you don't need a lot, Brownells may still be cheaper.

Brownells Inc.
200 S. Street
Montezuma, IA 50171-9989
(516) 623-5401

This is a gunsmith supply house, and sells a lot of good tools and other gadgets that even non-gunsmiths can use. They have an extensive range of rust preventing supplies. They sell the Hydrosorbent canisters for slightly less than Hydrosorbent does, and they carry the VPI tablets in small (but more expensive) quantities than N. Instruments. They also sell VPI paper and Cosmoline (THE original GI rust preventative grease). The paper comes in 12" sq sheets, and can protect 1 cubic ft. for 2 years MINIMUM. Typically, it lasts much longer. They carry half a dozen varieties of aerosol rust preventatives, greases etc.

Stock #		
415-100-040	40 gram silica gel cartridge	$5.50
415-100-360	360 gram silica gel carton	$9.95
415-100-750	750 gram silica gel canister	$22.50
084-058-050	50 Rust-Blox Vapor Tabs	$15.70
084-058-100	100 Rust-Blox Vapor Tabs	$27.20
084-031-010	VPI Paper, 10 sheets, 12" x 12"	$4.20
084-031-010	VPI Paper, 50 sheets, 12" x 12"	$14.88

I think that exhausts everything I know about rust prevention. I've been fighting the battle ever since I moved from New Mexico 24 years

ago, and I hope this can save someone some trouble.

Doug White
MIT Lincoln Laboratory

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If the parts are small enough for that treatment then you can use "Blue Bags". They are made by Bianchi ostensibly to store handguns in, but I find that any rustable metal parts are protected by them. They have zip lock style tops and come in several sizes. I believe they also sell some in rifle sizes but without the zip lock closure.

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For rust removal, the most common suggestion was Naval Jelly by Duro, available at many hardware stores. It contains dilute phosphoric acid as its main ingredient. Be prepared to apply a proper preventive after removal, as the metal will be left in a vulnerable condition.

31. Are there any machinery museums?

There are several museums that deal in some way with metalworking. Basically, if it has something to do with big machinery or manufacturing, it's a candidate for this list. This includes transportation museums because they often have interesting machinery like locomotives.

This list is organized by geographic areas.

U.S.A.

Maine

Owls Head Transportation Museum, just South of Rockland, Maine (about midway up the Maine coast). Many airplanes, but also bicycles, static and cutaway aircraft engines, automobiles, and early steam and gasoline engines. In summertime they do car shows and regular weekend flying shows, and run some of the other equipment such as a Buffalo Springfield steam roller and a one-cylinder Mogul tractor. Occasionally have auctions of engines, model and full-size, and other mechanical stuff; these are consignment auctions that benefit the museum, not "overstock" of the museum itself. Phone (207) 594-4418.
http://www.midcoast.com/~ohtm/

Pennsylvania

Coolspring Power Museum,
Box 19,
Coolspring PA 15730.
Phone (814) 849-6883.
This is a museum mostly of turn-of-the-century engines, many operable. The museum is in western Pennsylvania on route 36 about midway between Punxsutawney and Brooksville. For the past 10 years they sponsor a show with many collectors showing their engines. In 1995 this is scheduled for June 16-18.

Vermont

American Precision Museum,
P.O. Box 679,

Windsor, VT 05089,
(802) 674-5781.
http://ourworld.compuserve.com/homepages/Precision_Museum/
On display are mostly metalworking tools which date from the early 1800s up through some of the first numerically controlled machines. In addition there is some woodworking equipment. The museum is located just off U.S. route 5 or South Main St. in Windsor, Vermont and from May 20 to November 1 it is open 9 to 5 on weekdays and 10 to 4 on Saturdays, Sundays and Holidays.

DC (Discrict of Columbia)

The Smithsonian Museums, Washington DC.

Massachusetts

Boston Computer Museum. Lots of computers of course, if you are interested. They also have a mechanical "computer" that plays tic-tac-toe made from tinkertoys and string. Also a robotics display which should be enjoyed by metalworkers.

Cambridge: the Science Museum has several mechanical displays and a full machine shop in the basement.
Future: In Greenfield, Massachussets, they are trying to put together a cutting tool museum. As of this writing (6/15/94) they are still trying to find a place to house it, so it may be mid-1995 or so before it opens. May have early steam/gasoline engines when open. (8/26/94: plans are to put it in the old Greenfield Tap and Die plant).

Around central Massachussets, there is also the Springfield Armoury, LS Starrett, Old Sturbridge Village (a colonial "theme" village), Charles River Museum of Industry (154 Moody Street, Waltham, MA 02154 tele (617) 893-5410), a textile museum in Lowell with machinery and lots of displays of cloth, and the American Precision Museum (mentioned earlier); all within an hour and a half of Greenfield.

The L.S. Starrett Co. Crescent Street, Athol, Massachusetts 01331 USA. (Contact person is Joel Shaughnessy in the Personnel Office in Building 7, open 8-12 AM and 1-5 PM tele: (508) 249-3551 x 295, and it is suggested to phone ahead for a guided tour reservation). The museum is opened by tour only and the guide will spend time with interested visitors. Factory tours of two hours duration are also possible.

Nantucket Island (off Massachusetts) has a 1740 windmill grinding corn (maze) when there is enough wind and it's wooden works are a fine example of the tech of the time... they also have machinery for manufacture of candles from whale oil in the Whaling museum there.

At Saugus (North of Boston), the iron works is a fine example of a 1650 iron works right down to a replica of one of only 8 rolling and slitting mills that existed in the world at that time.

Another trolley museum is forming now in Shelburne Falls, about 10 miles west of Greenfield, which will restore the original trolley car which served that town and may have a small workshop/carbarn by 1995/1996(?). (That is c/o Shelburne Chamber of Commerce.)

Rhode Island

Old Slater Cotton Mill in Pawtucket. Machine shop
with vintage machinery, much in running condition.

Tennessee

National Ornamental Metal Museum, Memphis TN. (901) 744-6380

Dixie Gun Works, in Union City. They demo how gun barrels
were forged around the time of the American Civil War. Lots of
machinery, automobiles, nostalgic junk, photos, and of course guns.

New Mexico

Los Alamos National Lab (New Mexico) has a museum, including things
like the Beryllium-Copper tools used in early atomic bomb work.

Michigan

Henry Ford Museum, and/or Greenfield Village (adjacent to the
museum), near Dearborn/Detroit Michigan. Very large, described as a
paradise for mechanical engineering nuts. The museum is 12 acres,
and the village is 93 acres. One day is inadequate for a full visit!
Old cars, steam engines, restored 1880s factories, Thomas Edison's
workshop (Henry Ford had Edison's "old" workshop/lab in Menlo Park,
New Jersey, disassembled and moved to Michigan; Edison's newer lab
is in West Orange, New Jersey) and Henry Ford's workshop.

New Jersey

Thomas Edison's lab is in West Orange, New Jersey (not Menlo Park).
It is officially the Edison National Historical Site and run by
the National Park Service. What is there is the remnant of a factory
complex that employed some 10,000 people at its peak, before WWI.
The factory is gone, but there is a sizable two-story brick building,
the lab, and several smaller buildings. The whole facility has
been preserved since Edison's death in the 1930s. The lab contains
a large machine shop, still set up as it would have been back then.
It's called the "heavy machine shop", and it has the larger planers,
lathes, and other machines. All driven from line shafts, which were
actuated by large electric motors (of course!). There is, or had
been, a second shop (the "precision shop") on the second floor.
Access is only by tour. The takes 35 minutes, stops for 3
minutes to look at the roped-off heavy machine shop (there's also a
chem lab, a library, and some other stuff). The precision shop
is off limits. The level of detail is geared to the interest of the
general public, and don't confuse the schoolchildren.
It's at Main Street and Lakeside Avenue, in West Orange.

Connecticut

Lock Museum of America, Inc.
P. O. Box 104
Terryville, CT 06786-0104
phone (203) 589-6359, (203) 589-6359 (FAX)
I don't have any information on this other than the above;
not even a street address! May only be open on weekends.

Connecticut Electric Railway Museum at Warehouse Point (2 miles from
I-91, about 20 miles north of Hartford) has a repair shop with the
usual machine shop tools for its fine collection of trolley cars.

Ohio

The museum of the early industrial revolution is located in Coalbrookdale (AKA Iron Bridge Gorge), has a lot of early steam engines -- walking beam, etc. The last working producer of wrought iron in England donated the complete factory when they went out of business.

Future: the National Inventors' Hall of Fame due to open in 1995 in Akron... the PR says that it will allow "Visitors to tinker with wind tunnels, lathes, molds and other engines of creation".

Colorado

Colorado Springs: just north is an excellent museum dealing with hard rock mining, including working examples of machinery. The Museum of Western Mining is just off I-25 at exit 156 (North gate of the Air Force academy). Colorado Springs is about 60 miles south of Denver. They even have blacksmithing classes.

Denver has one of the US Mints, where they stamp out coins (not printed money). Tours; kind of boring, but it doesn't take too long.

Denver also has the Forney Transportation Museum, which I think is a real dump *except* they have a Big Boy locomotive on display you can walk right up to and look over (world's largest steam locomotive).

East of Denver is the Georgetown Loop, a small historical railroad that also has a hardrock mine tour.

Just east of Denver, near Golden, is the Colorado Railroad Museum.

If you are in Durango, the Durango & Silverton railroad (a nice narrow-gauge mountain scenic tour) has tours of their steam engine shop, including the only known remaining engine-wheel "quartering" machine (sets loco wheels at 90 degrees on the shaft).

Fort Collins (North of Denver): Fort Collins Municipal Railway operates a vintage Birney electric street car on an original route on West Mountain Avenue on weekends and holidays noon to 5pm from May through September each year. Web page is at http://www.fortnet.org/CITY/Trolley/

Timnath Northwestern Railway at the Swetsville Zoo near Timnath Colorado just east of Fort Collins is the second longest 18 inch gauge railroad in the US and includes a 1/2 size (!) steam locomotive. Also operable antique engines and machinery.

Montana

Miracle of America Museum, 58176 Highway 93, Polson, Montana 59860.

Nevada

Nevada Northern Railway, in Ely. A nice 18-mile excursion train, but for $2.50 you can get a walking tour of their facilities which includes the engine machine shop. Impressively large lathes and such, needed to service the steam and diesel engines.

California

Santa Monica Flying Museum. Santa Monica, CA. Don't know much about it except they have on display a "rotary" engine where the crank and pistons are stationary, and the case revolves.

The Antique Gas & Steam Engine Museum, run in part by the California Early Day Gas Engine & Tractor Association. 2400 North Santa Fe Avenue, Vista CA 92083. Call (619) 941-1791 or (800) 5-TRACTOR. Steam, gas, tractors, blacksmith shop, farm implements. Twice a year for two consecutive weekends they start engines, run tractors, and such (apparently the last 2 weekends in June and October).

Canada

Museum of Steam and Technology, in Hamilton, Ontario. Built around the original City of Hamilton waterworks plant and contains the two original Gartshore compound rotative beam pumping engines from the 1850s. These engines stand about four stories high. The museum also contains quite a bit of steam model oriented exhibits.

England

The museum at Iron Bridge (or Ironbridge Gorge) deals with the history of the metals industry.

Black Country Museum in Dudley (West of Birmingham, in the Midlands). This was in the heart of small-scale Victorian engineering, and it's now a restored canal basin & canal tunnel (boat rides available) together with a number of small terraced houses and manufactories. Most of the houses have an outbuilding in their back yards with the workshops of nailmakers, chainmakers etc.

The Hunday tractor museum (just off the A69 Newcastle-Carlisle road). A farm museum with tractors, implements, stationary engines, etc. They reportedly also have a grass landing strip for airplanes, but you'd better call before landing!

There's a museum in Bath (walk up-hill from the Assembly Rooms) which has an interesting collection of old workshop machinery (and an old fizzy-water bottling plant).

If you're in Bristol then visit the Industrial Museum which has a good collection of aero engines.

The Amberley (?spel) Chalk Pits Museum, Sussex. Perhaps not too relevant to this group, as there's more besides old metalwork-style engineering. But their narrow gauge factory railway is still running, along with a couple of stationary engines. Also, a good collection of old radio sets and related equipment, and for some, the prize exhibit, a UAX13 telephone exchange, still operating, which runs the museum phone system. Add to that a small collection of old domestic electrical appliances, demonstrations of old crafts, printing presses, etc.

The Cambridge (or is it Cambridgeshire) Museum of Technology, Cambridge. The old water pumping station on the River Cam, and they still run the horizontal oscillating steam engines. These were replaced by single-cylinder gas engines which they also run. There are a couple of

other engines to see, the original boilers, a small collection of electrical stuff, a collection of printing presses, and a few other things. This museum only opens occasionally, so check opening times before visiting.

The Hove Engineerium, near Brighton. There are about 3 or 4 stationary steam engines that are run at some weekends, together with a very nice collection of model engines, etc.

Science Museum of London has a recently-built "difference engine", as designed by Charles Babbage (see February 1993 Scientific American). An amazing machine.

Kew Bridge Pumping Museum just West of London, across the bridge from Kew Gardens. Lots of steam engines working each weekend, including a 90-inch beam engine. Also internal combustion engines. Dave Edmondson has info and pictures at http://www.cre.canon.co.uk/~davide/kbsm

The Mechanical Music Museum is a short walk up the road from the Kew museum (above).

NRM (National Railway Museum) in York, England. A great place to go look at Railway stuff in general, lots of nice big steam engines. The NRM is expanding their workshop/restoration area and opening it up to the public (from behind a barrier, obviously) so you can go and watch them rebuilding and maintaining their "stock".

National Railway Museum (NRM)
Leeman Road Voice: +44-904-621261
York YO2 4XJ FAX: +44-904-611112

Manchester Museum of Science and Industry.
Manchester was one of the primary centers of the industrial revolution - the railroad trials in the 1820's were run between Manchester and Liverpool (Stevenson's Rocket won, of course), and the area was the heart of the cotton and silk industry. The first canal in Britain originated near Manchester to carry coal to factories, and Alan Turing did much of his computer work here. There was also a thriving automobile and aircraft industry.

To support all these activities, there was lots of machinery manufactured and used in the area. The museum has many stationary engines (they claim the world's largest collection of working engines), in steam most days; also steam railroad engines, one of which does short trips on weekends. Also a great collection of microscopes, and interesting exhibits on computers, electricity and gas generation, sewers (as in sewage), cotton spinning and weaving (they demonstrate machinery at all stages from raw cotton to finished cloth). The machine shop where the museum staff work on many projects has a viewing gallery, and this also houses an exhibit of old machine tools, including a Holzapfel lathe.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 7 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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32. How do I cut metal?

Jim Driscoll (driscoll@curacao.dartmouth.edu) posted a list of cutting methods, ranging from simple to exotic. There were several subsequent suggestions and additions.

- Snips

Sometimes also called shears, though true shears are large machines (see entry below).

These things are scissors that will cut light gauge metal [up to 23-18 gauge, depending on type] and are comparatively inexpensive [$15-$42, W. W. Grainger (WWG)]. The lighter the material the easier they are to use, and the more likely it is that you can cut a curved shape successfully.

Especially in aviation use, snips come in "left", "right", and "straight" styles. This refers to the direction in which you must move the tool as you cut.

There are electric versions of these, called electric shears, that will cut up to 12ga mild, cut down to 1in radius, and cost from $204-$612. I have no experience with these.

- Knock-out Punches

Sometimes what you want to cut is a circle, or a slot for a computer connector. In these cases there are standard punches that will cut these shapes accurately. You first drill a pilot hole and put the cutter on one side, the die on the other, and then draw them together by turning a threaded bolt. The larger sizes require a hydraulic driver.

The manufacturer claims that these are good up to 10 gauge mild, but I have managed to cut holes in 12ga stainless (a tad thinner, but stronger). These things cost $17-$66 (WWG) for up to 2in, considerably more for the larger sizes ($309 for 4in).

- Hack Saw

You probably already know about this, but don't forget it. Its portable and cheap, but can be tiring. Use both hands, and buy the best blade you can afford. Any blade can break, so be careful. Cutting fluid reportedly helps, just as it does in lathe/mill cutting. The right number of teeth per inch (tpi) can also be important; as a rule of thumb, you want 3 teeth in the work, so for example you'd want 6 to 12 tpi for 1/2-inch stock.

- SawzAll

Sawzall is a trademark of Milwaukee for a reciprocating saw, more or less a jigsaw on steroids (And don't forget the jigsaw!). These cost $136-$187 and with enough patience and blades can cut fairly heavy material in complex shapes (well, at least curves of 3in radius). One metal fabricator I met cuts the patterns for his stainless cones with a Sawzall. He has just broken down an purchased a plasma torch (q.v.).

- Band Saw upright/cutoff

These come in every size from the tiny to the unimaginably big. They come in two basic styles, an upright version that is better for trying

to cut shapes, and a cut-off version that has the throat arranged so that an arbitrarily large length can be cut off of an arbitrarily long piece of stock. These things, for a reasonable size for a home shop cost from $150-$5000. I have a version of the cheesey cut-off saw sold by Enco and others for about $200. It has its limitations, but I am happy with it.

- Grinder with Cutoff Wheel

With an angle grinder or a die grinder equipped with a cut-off wheel, you can cut pipe, tube, rounds, flats, sheet, and maybe even plate, but only in straight line, or maybe a very large radius curve. If you already have a grinder, this is a very inexpensive solution ($4 for an abrasive wheel).

There are also cutoff wheels designed for use in circular saws.

- Chop Saw

This is basically a mitre saw with an abrasive cutoff wheel. It's the kind of thing a contractor users to cut metal studs or rebar, but I use one to cut pipe, tube, rounds, and flat stock quickly. They cost $233-$502.

- Nibbler

These look a bit like a jigsaw, but instead of a blade, they have a punch and die assembly. They work by punching out material 1-2000 times per minute along the cutting path. Some are designed with a round punch so that the tool can be turned in any direction and the cut continued for cutting intricate shapes. These cost from $318 (16ga mild) to $1060 (8ga mild). You can rent these at my local tool rental store.

There are also small hand-powered nibblers from Radio Shack and the like, useful for odd holes in small chassis and the like.

- Lathe/Milling Machine

Don't forget that you can use a lathe to cut off material to a precise length or to finish a crudely cut piece to a more precise dimension.

A milling machine can be used to mill slots for connectors as well as other crazily shaped holes in heavier material.

- Shear

(sometimes "shear" is also used to describe snips, discussed earlier)

A shear is basically a giant pair of scissors that is designed to cut sheet or plate along a straight line into two pieces rather cleanly and somewhat precisely (+-1/32). A small 30in combination shear, brake, and roll, that is manually powered and can shear 20ga mild costs $1095. Shears, however, are made unimaginably large, and if you go to a shipyard, you can probably get your 2in plate sheared there. It is probably outside the budget of most to actually buy a shear for anything but very light material. Your best bet is to find a welding shop in a cheap part of town, that has operated for generations, that seems to have nothing to do, and that has a shear.

- Flame Cutting

The idea behind flame cutting is to heat up ferrous metal until it starts to burn, and then direct oxygen at it in the direction you want to cut to continue the burn in that direction. When I was on a tight budget I successfully got my job done with a $20 hardware store oxygen/propane outfit, but for about $200-$300 plus the rental/deposit on the tanks you can have a nice welding/cutting rig that will cut 6in plate.

You can cut fairly intricate shapes with this, and depending on your skill and dexterity and the thickness of the material they will have a fairly clean edge.

One drawback of this method is that it is material specific. It will not cut stainless, for instance. (Well, actually I have seen the results of someone ``severing'' stainless with a burning rig [``cut'' would be a bit generous considering the results], and I am suspicious that what really happened was that the stainless was melted away.)

- Plasma Cutting

A plasma torch transfers an electric arc from the torch to the work piece which heats up a stream of gas (usually just compressed air) to a plasma. The thin stream of plasma is so hot that it will cut any known metal (That is, according to my manual. I am suspicious that it will cut all the unknown ones too.) A hand held torch that can cut 1/8in mild costs about $1000 and you need a compressor or an air cylinder too. The quality of the cut is very good if you have enough power for the thickness of the material and if you can move the torch smoothly.

I have a 30amp plasma torch from HyperTherm that I am very pleased with. I use it to cut stainless and use nitrogen for the cutting gas.

If you are considering buying one of these, you should know that 30 amps from one manufacturer may not cut as much or as well as 20 amps from another. Also, when one manufacturer claims that their machine will cut 1/2" plate it may not be the same quality of cut as another machine that claims to cut 1/2": the closer you push the machine to its limit, the worse the cut.

- Laser Cutting

A friend of a friend in the Netherlands has one of these that looks like a scroll saw and cuts thick material cleanly, rapidly, and intricately. I have no knowledge of small units like this in this country despite modest attempts to find them. There is no particular reason why these should be terribly expensive.

Warning: Many of the cutting methods above utilize tools with which it is quite easy to injure yourself. It is important to lean and follow the proper precautions in using tools and equipment. I know this because, for example, I burned myself with liquid propane out of ignorance of the proper safety precautions for handling fork lift propane cylinders.

On 7/1/96, Edward Haas <steamer@west.net> contributed a few more:

- Cold Saws

A circular saw that runs at low speed, using a blade with "flat" teeth, i.e. no bevelling to one side or the other like on a wood-cutting blade. Runs with a soluble oil being pumped over the blade, soaking the work that way. Very useful and fast. Good for cutting most anything and doing so *much* faster than a bandsaw/chopsaw arrangement. Unlike an abrasive saw, it will not clog or balk at nonferrous alloys such as aluminum. I use one for cutting alloy #4130 in a production set-up to make hex keys and it is quite accurate and time-efficient.

- Wet Abrasive Cutoff Saw

These use a small-ish "blade" (actually what is referred to as a "rubber wheel"), maybe 6in. in diameter with a *very* narrow kerf: mine uses a blade only .050in. or so thick. Rotational speed is around 5,000rpm and with coolant shot onto either side of the wheel, an instant fog is produced, so an enclosure is recommended. The advantages: it will cut *anything*, hard or soft makes no difference; the finish is superb: you can see your reflection in a piece of hardened shaft; the burrs left are minimal, making it ideal for cutting small or delicate parts (I'm told it's the method most used for cutting hypodermic tubing, etc.). Not cheap: figure $5,000 for a good one (and there are some bad ones out there: I've got one!)

33. What kind of oil should I use on my lathe/mill?

This is certainly a frequently asked question! The first answer is to use whatever the manufacturer's manual suggests, presuming you have a manual for your machine.

Feed-screw threads, half nuts, back gears and similar are usually lubricated with a heavy oil such as Vactra 2, or grease if protected from chips and swarf. Some suggest a mixture of oil and STP oil treatment.

Beds and "ways" are often treated with special oils, called "way oils". ISO 68 (light to medium weight). Examples: Exxon Febis K 68, Shell Tona T-68, Sun way lub 1180, Mobil Vactra No 2, Texaco Way lube 68, Gulf Gulfway 68, Cheveron Vistac 68X.

Spindle bearings call for "spindle oil" such as Exxon Nutto H32, Shell Tellus V32, BP HLP32, Castrol Hyspin AWS32, and Mobil DTE 32 (in this case the 32 is the ISO VG32 spec, about the same as SAE 10-weight, and is what Myford recommends for their lathes). ISO grade 22 is also used.

All three types are available from the better supply outfits, such as MSC. Remember that the money you spend on proper oils will be a lot less than the cost of replacing the machine!

South Bend, for example, recommends four different lubricants for their 9" and 10" lathes: CE1671 bed way lube, CE1603 medium machine oil, CE-1600 light machine oil, and CE1625 teflon grease. These are available from South Bend.

A suggestion I've read is to oil lathe ways before using, to clean off dust/grunge that may have accumulated since you last used it. After work is finished, wipe off but leave a film for rust prevention.

Multigrade motor lubricants are not recommended. They are full of all sorts of stuff to make the oil work inside an internal combustion

engine. Use a straight 30 or 20 grade oil with no detergent if you can't find anything else. A transmission oil might be OK in an oil-filled gearcase.

Elsewhere we mentioned the book "A Brief treatise on Oiling Machine Tools" (Guy Lautard) but nobody's posted a review yet.

34. What are the various tapers (Morse, JT, R8, etc.)?

Unfortunately, there are many different tapers, and not enough space to tabulate them here. For details, consult a good reference such as Machinery's Handbook, or Machinists' Ready Reference.

First, why use tapers? Two basic reasons. At shallow angles, a tapered rod will tend to stick in a matching socket. This is frequently used to hold tools such as drills or centers in a lathe tailstock, allowing rapid change. At steep or shallow angles, a taper allows mating parts to line up very accurately. Note that the shallow tapers such as Morse may tend to get stuck if too much force is used, and this can turn into an interesting problem when you try to separate them!

Tapers are poor holders for large side-loads, in which case you need a drawbolt or drawbar. Here, a threaded bar is used to pull (draw) the tool into the socket and hold it in place. This is commonly used in milling machines and for collets.

Shallow tapers such as Morse are "grabby" and need some force to break free. Beyond a certain angle, a taper is self-releasing if the coefficient of friction is less than the tangent of the taper angle.

Tapers can be sensitive to chips and dirt, so keep them clean. A gouged taper socket can usually be cleaned up nicely with a taper reamer, if you can borrow one.

Morse: Very common in lathe spindles and tailstocks. Different standard sizes exist, such as MT1, MT2, and so on. The actual taper varies from one size to the next.

```
   MT0   small=.2520 inch, large=.3561 inch, taper=.62460 in/ft
   MT1   small=.3690 inch, large=.4750 inch, taper=.59858 in/ft
   MT2   small=.5720 inch, large=.7000 inch, taper=.59941 in/ft
   MT3   small=.7780 inch, large=.9380 inch, taper=.60235 in/ft
   MT4   small=1.020 inch, large=1.231 inch, taper=.62326 in/ft
   4 1/2 small=1.266 inch, large=1.500 inch, taper=.62400 in/ft
   MT5   small=1.475 inch, large=1.748 inch, taper=.63151 in/ft
   MT6   small=2.116 inch, large=2.494 inch, taper=.62565 in/ft
   MT7   small=2.750 inch, large=3.270 inch, taper=.62400 in/ft
```

These values are for the "business" part of the taper, and exclude whatever the taper is attached to, such as a drill or a center, and also excludes the tang, if any. Note that there is no overlap, making it practically impossible to mate mis-matched tapers (this may also explain the different taper rates). Some MT accessories such as drills will have a flat tang on the end, intended to mate with a matching slot in the socket, to give a setup better strength against rotation; in this case the taper is primarily being used for alignment, and to hold the drill from falling out when not being used. Most small home-sized lathes use between MT0 (e.g. the Sherline) and MT4. Larger taper sockets may include a sideways slot, intended for a flat tapered knock-out bar to facilitate tool removal. Machinery's Handbook claims that Morse

tapers are the only type of taper used on drills that have a taper shank.

Morse Stub: a variation of Morse, but less than half as long. Same numbers as Morse, and correspond to the large end; that is, you can make a Morse Stub #3 by slicing off the end of a standard Morse #3 (excluding the problem of making the tang, if any).

Brown & Sharpe tapers are similar to Morse tapers, but are found on some end mills and reamers, and on milling machines and grinding machines, also dividing heads. Sometimes they have a tang, sometimes they are drilled and tapped for a draw-bolt. Some examples:

```
   BS1   small=.20000 inch, large=.23922 inch, taper=.50200 in/ft
   BS2   small=.25000 inch, large=.29968 inch, taper=.50200 in/ft
   BS3   small=.31250 inch, large=.37525 inch, taper=.50200 in/ft
   BS4   small=.3500  inch, large=.4023  inch, taper=.50240 in/ft
   BS5-BS18 see references.  Taper varies with number.
```

Jarno: Used on various machines, such as profiling machines and die-sinking machines, and on some lathes. An attempt to create a very simple taper: all of them are .6 inch of taper per foot, the diameter at the large end is as many eighths, the diameter at the small end is as many tenths, and the length as many half-inches as the number of the taper (i.e. machinists making tapers didn't have to use big formulae or tables). Some examples:

```
   2   small=.2, large=.25
   3   small=.3, large=.375
   4-20 see references, or compute from formulae above.
```

Jacobs Taper: commonly used to mount a drill chuck to a machine, whether a drill press or a lathe tailstock. Since most chucks use a female Jacobs, such as JT6, and most tailstocks are female Morse, an adapter bar is usually used here, with the appropriate tapers on each end. The taper varies quite a bit with taper number.

```
   0   small=.22844, large=.2500, taper=.59145 inch per foot
   1   small=.33341, large=.3840, taper=.92508 inch per foot
   2   small=.48764, large=.5590, taper=.97861 inch per foot
   2S  small=.48764, large=.5488, taper=.97861 inch per foot
   3   small=.74610, large=.8110, taper=.63898 inch per foot
   4   small=1.0372, large=1.1240, taper=.62886 inch per foot
   5   small=1.3161, large=1.4130, taper=.62010 inch per foot
   6   small=.6241,  large=.6760, taper=.62292 inch per foot
  33   small=.5605,  large=.6240, taper=.76194 inch per foot
```

Nubers 0-5 appear to have been original, in that number 6 and number 33 are smaller than 5, and have a length of exactly 1 inch, and thus seem like later additions to the series. Note some Jacobs chucks also have a threaded tang; see Machinery's Handbook for details.

R8: Frequently used on milling machine spindles. Lots of tooling is available for R8. Requires the use of a drawbar as the angle is relatively "blunt" and usage is often vertical with large side loads. The taper is apparently 16 degrees 51 minutes, and the relevant diameters are .949 and 1.25 inches. The drawbar thread is 7/16-20

Others:

American National Standard Tapers: really several families. The "self-holding" series appears largely identical to Morse except for details of the tang dimensions: ANS continues the

taper all the way down the sides of the tang, while Morse ends the taper at the start of the tang, with a straight-sided tang that starts out a bit smaller than where the taper left off. Some very small tapers are based on Brown & Sharp (they have fractional numbers), and some large ones use a taper of .75 inch per foot (numbers 200-1200). They also have a separate family of steep tapers, numbered 5-30 in steps of 5, apparently meant for milling machine spindles and such.

British Standard Tapers: mentioned in Machinery's Handbook but not really explained. Sorry.

35. What is Electric Discharge Machining (EDM)?

EDM is a method for producing holes and slots, or other shapes, by using an electric discharge (spark) to remove unwanted material. It is also called spark erosion. Sometimes it is used to produce a part, such as producing a slot in a very hard metal, and sometimes it is used to "rescue" a part such as removing a broken tap.

The basic idea is to move an electrode very close to the work piece, and repeatedly produce a spark between the two. This is best done while immersed in a dielectric liquid rather than in air, and it helps if the proper distance can be automatically maintained. Note that the electrode gets eaten as well as the workpiece, and some compensation must be made for this. Very good finish can be achieved, though at reduced speed. EDM is not a fast method; some jobs can take days to produce holes, so its use is limited to jobs that cannot easily be done in other ways (e.g. oblong slots or complex shapes, sometimes in very hard material). Note too the work must be conductive so it does not work on materials such as glass or ceramic, or most plastics.

A good overview is in the Metals Handbook published by the American Society for Metals (ASM), volume 3, "Machining" (page 227 of the 8th edition, 1967).

A wire EDM machine uses a wire (usually brass) as the electrode, which passes between guides like a bandsaw blade. The wire may be used only once. As it runs from a spool through the job, it is eroded and reduced in diameter by as much as 1/3. The old immersion system has now been largely replaced by flushing nozzles which surround the upper and lower wire guides. These blast the dielectric through the cut. This system works well, and has the tremendous advantage of being quick to shut off to remove parts, rethread broken wire, etc.

As to the functionality of the wire EDM system, just imagine what you can do with a wire that leaves a .010" kerf through 6" thick stainless steel without heating it up. With the CNC control a taper can be imparted to the workpiece, because even the low-end machines have independently controlled upper and lower guide movement. High-end machines are mostly a way of getting more power (and therefore faster operation); more capacity; and convenience features, like automatic wire threading and a sinker-EDM head to create internal starting holes in hard material.

EDM is well-suited for automated control. In fact, it seems almost the only way to go, which usually puts sophisticated

EDM out of the reach of most home shop machinists. Luckily, the fundamentals are simple enough you can get by without computer control at the expense of constantly adjusting the gap manually, as is the case in the Popular Science article.

An easily-built system is described in Popular Science, March 1968, pages 149-153. However, it is electrically dangerous from a shock standpoint, and suggests using kerosene as the dielectric which is a strong fire hazard. This machine was reworked a bit in the January 1991 issue of Home Shop Machinist (HSM), with a few notes in March 1991 (page 11), July 1991 (pages 4-6), May 1992 (pages 10-11), May 1994 (page 44), and May 1995 (page 19). EDM was described in February 1993 in Electronics Now (pages 79-81) along with a list of EDM resources, with a followup in the May 1993 issue (pages 78-80) that references the Popular Science and HSM articles. This machine requires "manual" feed of the electrode. Please note that non-flammable dielectrics should be used, and are available from supply companies such as MSC (I have also heard of using de-ionized water as the dielectric).

A more complex system was described in the July 16 and August 6 1976 issues of Model Engineer magazine (with a letter in the November 5 1976 issue, and a followup in the October 2 1981 issue). In this case a small stepping motor is used to automatically feed the electrode. This is a great improvement, but complicates building the system unless one of your other hobbies is electronics.

From August 1993 to April 1994, Strictly IC magazine published a serial on building another stepper-driven machine. Being newer, it may be easier to build because the parts listed are probably still available. But, again, electronics should be another hobby (or perhaps you have a friend who needs some machining done?). The series also suffers a bit from the author re-designing the system as the series was published, but who ever builds something as published, anyway? (There was also a letter on the project, in February 1995)

In May 1995, HSM started a six-part (one year) series on another complex EDM system, inspired by the Model Engineer series but updated to use contemporary parts.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 8 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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36. Solvent safety

Doug White (gwhite@ll.mit.edu) posted this on 11/16/94 regarding safety of some common solvents:

HEALTH HAZARDS OF COMMON CHEMICAL CLEANING SOLVENTS

People in several different newsgroups I subscribe to use chemical solvents for various projects. A while back in rec.bicycles, there was a discussion of the health hazards of using these solvents. A friend of mine is in the laboratory safety business, and ran off copies of the 'Material Safety Data Sheets' (MSDS) for many of the common solvents. It's a bit tricky to cover everything, because some are known by several

different names, and MSDS's from different sources don't list things in a consistent manner. I've attempted to consolidate this information into something that covers the critical differences between the solvents, and that is easy to understand for people like me who aren't safety experts or chemists.

I've listed these (roughly) in decreasing order of 'nastiness'. It's difficult to do a precise ranking, because some solvents are greater risks depending on whether you touch it, breath it, drink it, or set it on fire. If there is anything you like to use that you don't see here, just call the manufacturer and ask for the MSDS on the product. They are required by law to send you one. There are several key things I would watch out for:

1) How flammable is it? Solvents are rated either highly flammable, flammable, combustible, or non-flammable, depending on the flashpoint. I believe anything with a flashpoint below 100F is considered at least flammable.

2) Check the Time Weighted Average exposure limit. This is usually listed in parts per million, or milligrams per cubic meter (mg/M*3). This will give a rough feel for how toxic the stuff is.

3) Look for specific problems. Can it be toxic if absorb through the skin? Is it just an eye irritant, or will contact cause damage?

Because all of these solvents dissolve grease and oil, at a minimum, they will leach the oils out of your skin. With prolonged exposure, this can cause irritation and dermatitis. Your senses are a good warning system. If a mere whiff of something makes your eyes water and your head spin, it's probably not too good for you. Whatever you like to use, do so with adequate ventilation, gloves, eye protection, and away from any source of combustion.

Nitrobenzine: (AKA Essence of Mirbane, Mirbane oil) I've included this because it used to be used in some gun cleaning solvents. It was removed because of health risks. Nasty stuff.

Very toxic by inhalation, skin contact, or ingestion
Irritating to eyes, respiratory system and skin
Danger of cumulative effects, causes nervous system disorders
Combustible, Flashpoint = 190F, 87C
Readily absorbed through skin, do not breath vapor.
Time Weighted Average exposure limit 1 part per million (5 mg/M*3)

Kerosene: (AKA Coal Oil, Range Oil) Easy to obtain. This was my father's favorite all-round solvent. Works well on bicycles chains.

Toxic by inhalation or ingestion
Irritating to eyes, respiratory system and skin
Attacks central nervous system
Combustible, Flashpoint = 100F, 38C
Time Weighted Average exposure limit 14 parts per million (100 mg/M*3)

Lacquer Thinner: This is a mixture of a variety of chemicals, and will vary with manufacturer. Some of the components are pretty nasty, but information on the mixture is not very complete. The brand I have a data sheet on contains: Isopropanol, n Butyl Acetate, Methanol, Acetone, VM&P Naptha, Toluene, and Hexane. This is a particularly effective solvent, and works very well removing hardened grease and grime from old

machine tools.

 Toxic by inhalation, minimal toxicity by ingestion
 Irritating to eyes, respiratory system and skin
 Attacks central nervous system
 Flammable, Flashpoint = -10F, -23C
 The Worst component (Hexane) has a Time Weighted Average exposure limit
 of 50 parts per million, but it's percentage in the mixture is unknown

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Naptha: (AKA Lighter Fluid, Petroleum Ether) This is one of my favorite cleaning solvents, because it doesn't attack most plastics or paint. It's great for removing adhesive from tape and labels. Although it is listed as a skin irritant, it isn't toxic if you spill some on your hands.

 Toxic by inhalation or ingestion
 Irritating to eyes, respiratory system and skin
 Attacks central nervous system
 Highly Flammable, Flashpoint = -57F, -49C
 Time Weighted Average exposure limit 100 parts per million (400 mg/M*3)

Paint Thinner: (AKA Mineral Spirits, Petroleum Naptha) A common solvent, readily available at most hardware stores. It is considered non-irritating to eyes.

 Toxic by inhalation or ingestion
 Irritating to respiratory system, slightly irritating to skin
 Attacks central nervous system
 Combustible, Flashpoint = 111F, 44C
 Time Weighted Average exposure limit 100 parts per million (400 mg/M*3)

Turpentine: (AKA Spirit or Oil of Turpentine) I never use this anymore, but it was THE standard paint brush cleaner before latex paints came out.

 Toxic by inhalation or ingestion
 Irritating to eyes, respiratory system and skin
 Can penetrate skin to produce systemic effects. Can cause eye damage
 Prolonged exposure can cause allergenic sensitization.
 Combustible to Flammable, Flashpoint = 90-115F, 32-46C
 Time Weighted Average exposure limit 100 parts per million (560 mg/M*3)

Acetone: (AKA Methyl Ketone, Propanone, Pyroacetic Ether) The one unique application I know of for acetone is that it dissolves cyanoacrylate glues (SuperGlue). It will attack many plastics.

 Toxic by inhalation or ingestion
 Irritating to respiratory system and skin
 Risk of serious damage to eyes
 Attacks liver and kidneys
 Flammable, Flashpoint = 1F, -17C
 Time Weighted Average exposure limit 200-1000 parts per million
 (470-2400 mg/M*3) (Varies substantially from country to country)

Denatured Alcohol: (Denatured Ethanol) This is ethyl alcohol with just enough 'denaturant' to make you violently ill if you try to make a cocktail out of it. Denaturants vary, but the most common one is a few percent methyl alcohol (methanol). I couldn't find a MSDS on the 'denatured' version, so the info below is from the ethanol MSDS. The only major difference should be in toxicity by ingestion, which is the whole point of the denaturant. Ethanol is a fairly mild solvent, and

may require more patience and elbow grease than others. On the other hand, it's pretty safe. Water dissolves in it, so you can use it to dry off delicate items that have gotten wet, or have been washed in water first. Ethanol will cleanly remove even the most fossilized protective paper from acrylic plastic (Plexiglass), if you let it soak overnight in a plastic bag.

Somewhat toxic by ingestion (mostly because of denaturant)
Excessive exposure to vapors can cause eye and respiratory irritation
Flammable, Flashpoint = 50-55F, 10-13C
Time Weighted Average exposure limit 1000 parts per million (1900 mg/M*3)

Orange Oil: (AKA OptiClear & lots of other tradenames) This is listed as a 'food oil distillate'. It's a volatile liquid extracted from orange peels, and smells like oranges. The manufacture of 'OptiClear' recommends it as a replacement for 'toluene, xylene, or chlorinated hydrocarbons such as TCE' (Trichloroethylene). It is biodegradable. This is the only type of solvent that is listed as GRAS (Generally Regarded as Safe).

Not considered toxic
Can cause skin irritation
Combustible, Flashpoint = 140F, 60C
No exposure limit

Before everyone floods me with email asking where you can get this stuff, 'OptiClear' is an optical grade solvent used at the lab where I work. It's probably a bit more refined (and expensive) than what most people need. The price info I have is very old, but lists a case of four 1 gallon jugs for $86. It's manufactured by:

National Diagnostics, Inc.
1013-1017 Kennedy Blvd.
Manville, NJ 08835
(201) 722-8600

I have seen ads for other brands of orange based solvents, but haven't ever bought any. My local hardware stores don't seem to carry it. If someone has a good source, I'd love to hear about it.

37. What does "gage" (or "gauge") mean?

Webster's seems to prefer "gauge", but Machinery's Ready Reference uses "gage" for sheet, and "gauge" for wire. Strictly speaking, "gauge" is a measuring device, and "gage" a measurement system, but common usage has corrupted the distinction.

An arbitrary assignment of numbers to size, used on sheet, wire, and many other things (tubing, shotgun bore, needles, and so on). Unfortunately there are so many different standards that using gage to specify a material is almost useless, and perhaps even dangerous. If in doubt, use decimals.

For example, in U.S. gage, the standard for sheet metal is based on the weight of the metal, not on the thickness. 16-gage is listed as approximately .0625 inch thick and 40 ounces per square foot (the original standard was based on wrought iron at .2778 pounds per cubic inch; steel has almost entirely superseded wrought iron for sheet use, at .2833 pounds per cubic inch). Smaller numbers refer to greater thickness. There is no formula for converting gage to thickness or weight.

Wire might be specified in American or Browne & Sharpe, Birmingham or Stubs, Washburn & Moen, Trenton Iron Co., Stubs' Steel, Imperial Wire gage, music wire gauge, or others. In the US, I've commonly seen electrical wire in AWG (American Wire Gauge); even-numbered values are much more common than odd ones. As an example, 12-gauge wire is .081" (AWG), .109" (Birmingham or Stubs), .105" (Washburn & Moen), .028" (music wire gauge). In most cases a larger gauge means smaller wire, except music wire goes the other way around!

If you need specific values for specific gages, many are listed in various references such as Machinery's Handbook.

On September 20, 1994, Rowland Carson posted a nice list of most of the gauge systems in use worldwide:

Alhoff & Muller Music Wire Gauge		music wire
American Screw & Wire Co Music Wire Gauge		music wire, spring wire
American Zinc Gauge		zinc sheet
ASA B32.1		uncoated thin flat metals USA
Birmingham Gauge	BG	iron hoop & strip, steel sheet
Birmingham Wire Gauge	BWG	iron & steel telephone wire
Birmingham Wire Gauge for Silver & Gold		silver & gold
Brown & Sharpe Wire Gauge	B & S	non-ferrous sheet & strip
Brunton Music Wire Gauge		music wire
Card Wire Gauge	CWG	fibre yarns
Continental Zinc Gauge		sheet & strip
English Music Wire Gauge		music wire
English Zinc Wire Gauge		zinc sheet
Felten & Guilleame Music Wire Gauge		music wire
German Sheet Gauge		sheet metal
Instrument Wire Gauge		instrument wire
ISO Metric Preferred Series (R388)		all applications
Junge de Paris		copper wires
Lancashire Pinion Wire Gauge	LPG	cast steel drill rods
Mathieson & Hegeler Gauge	M & H	zinc sheet
Millimetre Wire Gauge		steel wire
National Wire Gauge	NWG	steel wire
Poehlimann Music Wire Gauge		music wire
Printers Wire Gauge		printers wire
Roebling Wire Gauge		steel wire
Sewing & Darning Needle Series		sewing & darning needles
Standard Wire Gauge	SWG	wire & strip, tube thickness
Stitching Wire Gauge		
Stubs Iron WIre Gauge		iron wire
Stubs Steel Wire Gauge		steel drill rod
Tinplate		finished tinplate
Twist Drill & Steel Wire Gauge		drill rod
US Galvanised Sheet Gauge	GSG	galvanised sheet
US Manufacturers' Standard Gauge	MSG	iron & steel sheets & plates
US Standard Gauge	USG	stainless steel
US Steel Wire Gauge	USSWG	steel wire
Washburn & Moen Gauge	WG	steel wire
Warrington Wire Gauge		steel wire
Yorkshire Wire Gauge		steel wire

38. Leveling a lathe

Most people agree that a lathe should be properly leveled to get the best accuracy. This seems to be true of large lathes more than small ones even if they are extremely heavy. One method is to use a precision

level, though Charlie Greenman (greenmana@delphi.com) pointed out the following method (late January 1995) which was also written up in August 1995's Projects In Metal by Steve Wellcome:

I'll talk about this one more time, as it's worth it and you can go truly crazy doing lathe alignment with a level unless it's a new or totally unworn lathe bed AND the top of the inverted V's (which do not contact anything) are perfect. The saddle (on a V-bed lathe) does not touch the top of the V's (or it had better not). And it is the top of those V's that you are using to to align the bed. It is also the top of the V's on which things large and small fall. So if you have a new lathe bed then fine, spend $100 or so, spend a month making one, or borrow an alignment level and have at it. Or you can depend on simple geometry -- the fact that anything held in a chuck in the headstock HAS to revolve about the axis of the headstock spindle, and use that technique to align the lathe bed...

A good setup level indicates .0005"/foot and they are expensive.

You can set up your lathe this way. This works I've done it. You have to put some means of adjusting the feet of the lathe bed that you can adjust. The last chapter of Tubal Cain's Workholding in the Lathe has a beautiful description of this. Get the lathe fairly level and somewhat tightened down. Get a good round rod that is very round and the same diameter end to end. A nontrashed car strut will work. Put the rod in the 3-jaw chuck. Get something like the Starrett last word and put it on it's magbase and the magbase on the compound. Rotate the rod in the 3-jaw and adjust the compound using the cross-slide such that the swing on the dial exactly straddles the 0. Say there is 6thou total runout at the chuck. You'd want 3thou on each side of the 0.

Run the carriage down toward the tailstock and again rotate the bar. The actual runout you get is not important. What is important is that the reading on both sides of the 0 is the same. If there's 20 thou total runout, you'd want 10 thou on each side of the 0. If it is say -8 and plus 12 that means that the right front leg (tailstock end, nearest you) is high. Lower it a bit. Go back to the headstock and again set the dti so that it straddles the 0, move to the tailstock end of the bar and check it again. When you get it such that the magnitude straddles the 0 at the chuck end of the rod (the carriage as close to the headstock as you can get it) and it straddles the 0 at the tailstock end, you've aligned the lathe bed. Now, here's the pisser. You can see, quite literally, how much (if any) wear there is in the bed by checking the rod along the way. You will probably find that there is some wear up near the headstock. And you can see how much wear there is by seeing the difference in the straddle on the dti. If you have a .0001 dti, all the better.

What is important on the rod is that it is round and smooth and the same diameter. It does not matter if it is straight as you know damned well that it's going to be swinging around the headstock axis no matter how bent! The only problem with a really bent rod is the runout might go beyond the range of your dti. You might want to read this a couple of times and think about it before doing it. :-) This is not originial with me (I'm not smart enough). It is, I believe, original with Arthur Gaucher, a retired tool and die maker who has forgotten more about this stuff than I shall ever know.

...

I had a pretty whacked Logan lathe bed and this technique told me how whacked it was and where. You can jack up the right front leg (the near side of the tailstock end) to compensate for one hell of a lot of bed wear but unhappily the tailstock will no longer be anywhere near aligned

with the headstock! So it won't really fix anything, but it will tell you the truth about your lathe bed. And itt will allow you to 'average' the error such that you minimize the problem of a *little* bed wear without throwing the tailstock out by much.

39. Wind Chimes

From time to time people ask how to make wind chimes, especially how to calculate the lengths of the tubes/rods. There is no precise answer to this question! Let's discuss it.

There was an article in Projects In Metal, December 1991, "Eight-tube Wind Chimes" by Thomas F. Howard. This is probably also reprinted in one of the "Metalworking" books by Village Press that condense issues of the magazine. I'll refer to this article in a few places simply as "Howard".

First, there are lots of aspects of making one, other than how long to cut the chimes. How many chimes? What kind of chord do you want (major, minor, pentatonic, etc.). How should you arrange them? How big should the clapper be?

First we'll discuss the chimes themselves, and address material and length.

Different materials react in different ways. The tone will depend on the material (steel, aluminum, brass, the exact alloy, heat treatment and so on), whether you are using a solid cylinder or a tube, and if a tube, the wall thickness. It may also depend on the hanging method, and the tone quality will depend on how you strike a tube (with a hard object or a soft one, for example). Howard suggests hardwoods.

Note that with a whistle, such as an organ pipe, the pitch is determined primarily by the length of the air column. It is the air that vibrates. The pipe material helps determine the "timbre" or "voice" of the pipe, but the air column determines the pitch. In a wind chime, the pipe itself is being struck and the air column has little to do with things (especially if the pipe is a solid cylinder!).

Generally you will need to cut by trial and error, using a piano or some other reference if you want to get close. You can also do it by ear if you're either good or tolerant. But we can help you get close.

If a chime is cut in half, the new tone will be *four* times the frequency, or two octaves up in pitch. To progress from one standard musical note to the next, each note is different in frequency by the twelfth root of 2, or about 1.059463. For chimes, we need the square root of this number, which is about 1.0293. In other words, if our "reference" chime is 1 foot long, the next lower note in the equal-tempered scale would be 1.0293 feet or 1 foot and .3516 inches or close to 1 foot, 23/64 inches. Many people can detect notes out of tune (relative to another) by a few percent of one note. So, cutting the chimes to proper length is important.

One formula was presented in a book, "Music, Physics and Engineering" by Olsen, for a tube, free at both ends:

$$f=1.133 \pi K v / (l^2)$$

$$K=\sqrt{a^2 + ai^2} / 2$$

{radius of gyration of a hollow circular cylinder}

Here pi=3.14159..., f is frequency (in Hz), l is length (in cm) and v is the velocity of sound in the material of the tube wall (eg Aluminium is 5.1E5 cm/s). Note that K is different for different cross-sections (I think it is K=a/2 for a solid circular bar). a and ai are the outer and inner radius of the tube (in cm).

See also "Basic Acoustics" by Donald E. Hall, Harper & Row, NY, 1987. This book points out that for two bars being identical except in their lengths, their frequencies are related as:

f1 / f2 = (L1 / L2)^2

There are several different musical scales to choose from. In the Western world, scales revolve around 12 equally spaced tones (equal tempered) but most music uses only 8 of the twelve. Which 8? This determines whether the scale is "major" or "minor" (or one of several less common scales). Another scale for wind chimes is the pentatonic scale (5 tones) used by eastern music. The advantage here is that no combination of pentatonic notes is considered dissonant (displeasing).

Construction details: The chimes and clapper should be spaced so the clapper will hit either one chime, or two chimes, and no more. The order of the chimes is important for two reasons: It helps keep the weights distributed so the whole thing does not tilt, and it ensures that any pair of chimes will sound nice when struck together.

OK, so much for the theory. Let's take a look at suggested lengths, courtesy of Howard:

> 16 7/8, 17 3/8, 18 7/16, 19 1/2, 20 3/4, 21 3/8, 22 3/4, 224 1/8.
> Eight chimes. Viewed from the top, he shows a hanging order starting at the 12:00 position of chime 1, 5, 2, 6, 3, 7, 4, and 8. For 1/2" OD tubing with a 2-inch clapper, the chimes are placed on a 4.5-inch diameter. These lengths are close to theory for a major chord, but rounded to the nearest 16th.
>
> 16 5/8, 17 5/8, 19 1/4, 20 7/16, 21 5/8, 23 3/4.
> This is a six-chimer, hung with the same spacing as the one above but leaving two gaps: (blank), 1, 4, 2, (blank), 5, 3, and 6.

Another consideration is how/where to hang each chime. It has been reported that hanging them .2242xlength from the end works well because this is a node point of the fundamental frequency (in other words, it wiggles less there!). If you hang them using nylon fishing line be certain to deburr the hole and smooth it, and don't place anything valuable under it (like a glass table)!. Also note the actual distance varies for each chime.

On the topic of materials, soft metals such as copper will generate "soft" tones, like hitting a bottle with a rubber mallet. Hard metals like steels or certain aluminum alloys giver a sharper tone, like hitting a bottle with a ball peen hammer (not including breakage). Sharper tones seem to be common on very small chimes (a few inches to maybe 6 inches) which also seem to use solid rods. Softer tones are common on large ones (a foot or more). Also, larger OD is supposed to yield softer tones and longer-lasting tones.

Cutting the chimes requires some thought, especially if you make a few hundred. Some suggest a chop saw with an abrasive blade, to get a better finish than you'd achieve with a toothed blade. Remember that aluminum

dust is flammable and burns very hot, so don't let it accumulate. Use a blade that is compatible with what you're cutting.

Some people like to use electrical conduit for the chimes. Other suggest seamless "chro-mo" 4130 bicycle frame tubing, while copper water pipe also seems useful. Possibly plugging one end or both will alter the sound but I'm not sure how at this point.

This is the FAQ for rec.crafts.metalworking. It is in several pieces to keep the overall size of each part below the limits imposed by some news systems. This is part 9 of 11.

Generally, units below are United States dollars, degrees Fahrenheit, and all the other silly backwards units we Americans still use. Sorry.

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40. Patinas

"Patina" -- "A surface appearance of something grown beautiful esp. with age or use."

Usually used in reference to copper, but also applicable to bronze, steel, and other materials.

This is a very broad topic that depends greatly on the material being treated, purity of the treatment, environment, and eye of the beholder. There must be hundreds or thousands of ways to do this, and some of them may be old wives' tales. I have no way to verify these! For the most part these are quotes from postings. For the most part it seems to rely on ammonia or other nitrogen compounds. Note that ammonia can cause brass to stress fracture (e.g. don't clean firearm cartridges with it!).

Cleaning the work is often stressed, and you can't usually get the patina quickly. It takes time to simulate age!

"It is common practice to treat copper roofs with ammonium sulphate to form the green color quickly; it is not exactly an oxide, and simple weathering sometimes does not do the trick." (From: John Whitmore, whit@carson.u.washington.edu).

"Unless you want to waste a lot of time experimenting and then still possibly not get a coating that will stay green, use a commercial patina made for that purpose. We use it in stained glass work. I'm sure it is available from anywhere that sells sculpture or architectural supplies." (From: John De Armond, jgd@dixie.com).

"Currently I patinate the brass with "Verde-It" (a chloride acid) and a blacking acid (selenium-based). Can anyone recommend other surface treatments? I also shine with anti-oxidants "Nevr-Dull" and "Peek". How long will these last? Can I do better? (I got tired of lacquering wires...)" (From: Matt Brand, brand@b.ils.nwu.edu)

[Electroplating a patina] "...the method consists of treating the copper anodically in a solution of:

magnesium sulphate	10 percent
magnesium hydroxide	2 percent
potassium bromate	2 percent

Solution is held at about 95 degrees C, current density of about 0.04 A/(dm squared) for fifteen minutes. Initially deposit is CuS04.Cu(OH)2, but increases in basicity on exposure until the composition of the patina is reached.

This is from H. Silman, et. al., Protective and Decorative Coatings for Metals, Finishing Publications..." (From: Rob Pauley, rob.pauley@gtri.gatech.edu).

"Here are a couple of green patinas to try:
1 Tbsp ammonium chloride (Sal ammoniac)
1 Tbsp salt
1 oz ammonia
1 qt. bottled or distilled water
Mix all in a plastic container that will be only for the patina mix and not used for other things. Warm or hot water will help the solids dissolve better. Spray the patina on the clean oil free copper and let set for 2 or 3 hours to dry then repeat 3 or so more times until you get what you want. You can also soak sawdust with the patina and pack it around the copper piece and seal it in a plastic bag for a day or 3. I have never used this patina but I have seen it and it can be very nice and smooth.
I have used the following patina a lot. In a glass container mix up some nitric acid with water (1 part acid (reagent 75% pure) to 2 parts water). Always add the acid to the water slowly. Add to that mix some scraps of copper to dissolve in the acid until the acid no longer dissolves the copper. Do this outside where no body will get into it because it makes a deadly nitrous gas (not nitrous oxide). The solution will be a very dark blue. You have just made cupric nitrate. You can use a brush to apply the patina. Using a torch to accelerate the drying can work well but be careful not to over heat because it will turn black and crusty. The fumes are not good to breathe. This patina can also be used like the first patina.
All patinas can, after they have set a few days, be waxed with paste wax (car wax). I have a copper bowl with the second patina on it that was waxed 3 years ago and it still looks good." (From: marck3@aol.com)

"You can get cupric nitrate at chemical supply houses. It works vary fast. I got a nice effect by dissolving about 2 tablespoons of the cupric nitrate crystals in a plastic spray bottle (with about 1 quart water). This was one of those sprayers that "Fantastic" cleaner comes in. Pre-heating the copper alters the mottling and texture too. Experiment on copper scraps with different strengths of solution and amount of patina solution applied." (From: Daniel Wold, danw@panix.com)

"To colour Copper or Brass Green:

Cupric nitrate	$Cu(NO_3)_2$	40 grams
Ammonium chloride	NH_4Cl	40 grams
Calcium chloride	$CaCl_2, 2H_2O$	40 grams

Add distilled water to make 1 litre. Brush onto a clean surface. This is from an old text book, I haven't tried this one, but others in the book have worked well for me." (From: Steve Rayner, ud233@freenet.Victoria.BC.CA)

"The most common is to wash with a mild solution of salammoniac dissolved in water. Just brush (or preferably spray) it on & allow to air dry. Repeat as necessary to achieve the desired results.
If you want an old roofers trick, and one that is much more effective I might add, piss on it! It is still common practice for the roofing crew to all pee in a communal bucket and pour it over the roof at the end of each day to force a patina." (From: Gary Hubert, gary.hubert@canrem.com)

"Well, one thing that works well for me is dormant spray, the lime/sulfur kind. You can get it at your gardening supply store. Produces some really colorful patinas depending on strength of solution and how long you dip the metal." (From: coppers@teleport.com)

"Personally I use a solution of lime/sulfur dormant spray (very weak) and let it sit for up to three months in solution. Or if your area has hard water (lots of minerals) just drop it in the toilet tank and let it sit until it looks good (this is a technique used by antiquities forgers). A good solid patina takes time." (From: Carl Mork, carl.mork@nwcs.org)

"NOTE: no patina is truly "tough". None of them can resist scratching. All you can expect is that light surface contact won't 'knock' bits off. You should plan to treat any patina with lacquer or plain wood wax. Three methods come to mind:

Get a plastic or glass sealable container. Put your copper in it and cover it with a layer of salt. Put an open container of ammonia in there. Seal the whole thing up, come back several hours later. This gives a blue-green surface.

Make up a solution of 2 cups water, 1 tablespoon salt, 1 tablespoon ammonium chloride. Put it in a spray bottle. Heat copper to over the boiling point of water. Lightly spray the surface. The water should immediately "sizzle" off. The color will take 5-15 minutes to develop. May be repeated. This gives a more green than blue color.

Get a container, fill with sawdust. Saturate the sawdust with ammonia. Add lots of salt, mix well. Bury your copper in it. Come back in an hour. This gives a very nice speckly blue&green surface. You can control the speckle by how well it's all mixed together and how fine the sawdust is."
(From: Mike Schechter Mike_Schechter@isr.syr.edu)

"From - 'Creative Gold and Silversmithing' by Sharr Choate
Colouring Copper Green
"A patina is produced on the metal by brushing the surface with a solution consisting of 1 gram each of copper nitrate, ammonia chloride, calcium chloride, and 1 ounce of water. When the colour is reached the article is set aside to dry.
A patina can also be produced by pouring a hot solution consisting of 1 1/2 grams of copper nitrate and 6 ounces of water onto the metal and allowing it to dry." (Quoted by darrell.markewitz@ambassador.com)

"The best 'cookbook' I have with patina formula is:
METHODS FOR MODERN SCULPTORS [see reference section, below]
For pre-mixed patina and coloring solutions in small amounts, the JAX brand handled by Merritt's Antiques at 610-689-9541 are OK. They have several at $7.50/pint. For my own work, I brew my own. Depending on what color or effect I want, I use cupric nitrate, ammonium chloride and burned oils, alone or in combination. For those who want to experiment with small pieces, get some "gun bluing" at the local sporting goods store and try different times and dilutions."
(from: brnzcaster@aol.com)

"This [METHODS FOR MODERN SCULPTORS] is an OK book. Starting from absolute scratch, I have been able to get the simplest recipes to work. However, *there is no substitute for watching somebody do it*. My advice to amateurs is, read the book first, then spy on your local foundry, and see what the motion is like for heating an area evenly with a torch, how to use a stipple brush, the way a cupric nitrate solution should sizzle, how to keep drips away, what to do when you've flamed the end of your brush and there are bits of charred bristle everywhere. A thousand things that will never be in the book." (From: sheba@panix.com)

"Regarding the hot oil patina: I preheat the metal, same as with the aqueous solutions. Use the *minimum* amount of oil. Sometimes I cut it with mineral spirits. Mostly, I stick with either Linseed or Tung oils." (From: brnzcaster@aol.com)

"Copper (II) sulfide solution will react with the copper, but will produce a greener tint. It does interesting things to other metals, too. Copper sulfide comes as a solution, or translucent-blue pebbles (like rock salt) or a fine blue powder. The latter two can be dissolved in hot water to produce the solution." (From: Derek Streeter, dms27@cornell.edu)

"I believe you mean copper sulphate. Copper sulphide is a black, insoluble material responsible for the color of some patinas along with the oxide. I have used copper sulphate, and it fits the description of the compound that you are describing. Have fun."
(From: jgerken@sdcc10.ucsd.edu)

"As for coloring metal - this is not my field, but I know a tiny bit about it. In my opinion, it is best to color metal by changing the color of the metal itself (rather than by painting it). There are several books on the subject; "The Art of Patinas" and "The Coloring, Bronzing and Patinization of Metals" [see reference section, below] are two that come to mind. These processes involve oxidizing or chemically reacting the surface of the metal to make it change color - usually, this also protects the metal from further reaction to the elements. If you wish to obtain some references on this subject, I can recommend [Craft Books]. They have, at least, the book on Coloring, Bronzing and Patination."
(From: douglas.wiggins@nwcs.org)

"Clean and degrease the metal and dunk it in liquid flours of sulfur. Brass doesn't put on a patina like bronze (brass being around 1/3 zinc). At least that's my experience." (From: coppers@teleport.com)

"A salt water or vinegar solution sprayed on the metal and sealed with an open container of ammonia will produce a blue patina. I have enclosed it in tupperware and garbage bags according to the size of the piece. The fumes will react with the solution." (From: romeug@aol.com)

"A permanent Patina for Copper (quoting from Henley's book):
Green -

Sodium chloride	37 parts
Ammonia water	75 parts
Ammonium chloride	37 parts
Strong wine vinegar	5,000 parts

Mix and dissolve. Apply to object to be treated, with a camel's-hair pencil. Repeat the operation until the desired shade of green is reached.
<end quote>
First off you may be wondering where to get these chemicals:

- Sodium chloride - This is table salt (NaCl)
- Ammonia water - This is what you buy when you buy liquid ammonia cleaner (get the stuff without any other cleaning agents added).
- Ammonium chloride - This is a little tougher. This is sometimes used in things like solder flux. However, it is also found in many of those kids chemistry sets. Try a good hobby shop - they often carry replacement chemicals for those sets (these are usually a little pricey for what you get, but you don't need much).
- Strong wine vinegar - Well, you can by wine vinegar from the grocery store (this is maybe 7% acetic acid). However, since acetic acid is the chemical we're looking for, and it's also used in photo fixing, you can find acetic acid in 28% and glacial(100%) at a good photo shop. 28% is by far good enough.

Henley's says to use a camels hair brush, I've used one of those small, triangular makeup sponges with success. Keep in mind that the patina (verdigris) will appear as the solution dries on the copper surface. Several applications will probably necessary to get the depth of color you want. Heating the copper helps also, but isn't necessary. Note! Don't soak the copper in the solution, it won't turn green and the acetic acid will eventually start to eat away the copper!

Also, the copper should be CLEAN when you do this. Steel wool and and then wipe it with Hydrochloric acid (Muratic acid at your hardware store - and be careful - rubber gloves, protect the eyes and get some ventilation). I usually wipe off whatever remains of the HCL when I'm done with a little distilled water." (From: Eric Kasten, Tigger@ibm.cl.msu.edu)

[Brown/black on bronze] "Liver of sulfur is, as obtained by me from Bryant Labs, Potash Sulfurated (Lumps). I think that means "lumps of sulfurated potash". It turns copper alloys brown, more or less attractively varying with the exact alloy. By using a very concentrated solution and/or several applications a dark brown can be produced, but nothing I'd call "black". Adding some ammonium sulfide (a _truly foul-smelling liquid also obtainable from Bryant) helps for that, it gives a bluer-toned brown by itself. Either works ok cold and very well hot." (From: sheba@panix.com)

[It has been reported that "liver of sulfur" is potassium sulfide, or a mixture of potassium sulfides. JK]

"Oppi Untracht has a few books out, one is called "Jewelry Concepts and Technology", published by Doubleday. Another is "Metal Techniques for Craftsmen (Persons)", also try Rio Grande Supply 800 443-6766, they have great tech support and supplies." (From: Denise M. Maier, denisem@nyc.pipeline.com)

[Rust finish on Ironwork} "Many metalworker/artists use muriatic acid to get the finish you are after. Use with plenty of ventilation! Do some background checking on how to mix acid with water (never pour water into acid; do only vice-versa), what dilution to use, how to neutralize surface after etching, how to handle, store, and dispose of the acid. You can get some at a masonry-supplies store (it is used to etch unwanted concrete grout off stone and brick). Be careful!" (From: Laurence R Swain, lswain@world.std.com)

Steve Rayner (ud233@freenet.Victoria.BC.CA) posted the following on March 6 1996 as a way of bluing/blackening brass:

> I just found this in an old Popular Mechanics book. The formula may be of use to some of you.
>
> Sodium thiosulphate (Hypo) 1/2 pound
> Lead acetate.....2 Oz.
> Water.....1 gallon (U.S.)
>
> Heat to near boiling (200 F.), and immerse work piece in solution suspended by a brass wire. Add more lead acetate to deepen the colour, and speed up the reaction.
>
> I would suggest using a pyrex container, as the hypo will react with iron directly blackening the container.

- - - - - - - -

An article by Rand Esser, esser@artmetal.pdial.interpath.net, was posted as part of a "newsletter" from ArtMetal. Rand has kindly allowed me to include the information here, with the following notice:

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The introduction included:

Rand Esser, a Raleigh, North Carolina metalworker who specializes in lamps and furniture, demonstrated the application of various patinas on steel and brass. Rand uses chemicals to achieve different oxidized surfaces on metal, often layering patinas on top of each other to achieve unique and distinctive effects. The patinas are then sealed with hot wax.

The article follows:

PATINAS ON STEEL

By Rand Esser

The patinas demonstrated at the March 12 meeting were copper sulfate solution, Black Topaz, and Rusty Red.

I mix my own copper sulfate solution by mixing copper sulfate crystals with water, a little at a time, until the water will no longer dissolve the copper sulfate. Copper sulfate is available at Southern States stores.

Black Topaz and Rusty Red are sold by Sur-Fin Chemical Corporation. Sur-Fin will send you a finish kit including seven six ounce bottles of their finishes for $50 (they also sell patinas for other metals). Larger sizes from one to fifty-gallons are available.

These finishes result in a variety of effects depending on strength of the solution, reaction time, relative humidity, temperature, surface texture, and type of top coating.

The Rusty Red and copper sulfate solution create similar effects. The Rusty red seems to be a bit more red and the copper sulfate is a bit more orange. I prefer the copper sulfate solution. It is more beautiful and less expensive than the Rusty Red.

TIPS FOR PATINAS ON STEEL

The surface to be finished must be completely clean. Remove all scale by sandblasting or wire brushing. Different surface textures will create different results. Sand blasted surfaces tend to be more dull and require a shorter reaction time. Wire brushed surfaces will be shinier, but require a longer reaction time. I sandblast first to remove the scale and then wire brush to create a shiny surface.

Remove all grease, oil, and, dirt with mineral spirits. Surface must be white glove clean for best results. Different concentrations of the finish solutions give different results. Sur-Fin recommends diluting the Black Topaz 1:10 with water. I have used the Black Topaz at 1:5 with a very brown /black result. Different reaction times give different results. I

usually leave the solutions on for just a few minutes. The Black Topaz ranges from a jet black with a short reaction time to bluish, greenish, black with longer reaction times to brown/black with very long reaction times. The Rusty Red and copper sulfate solutions range from a light copper plating effect to light rust to a dark crusty rust depending upon reaction time.

Some interesting effects can be created by using two or more finishes on the same piece. The Rusty Red and copper sulfate solution will work on top of the Black Topaz finish. The Black Topaz does not seem to work on top of the others. I often begin with the Black Topaz and drizzle, drip, or brush a pattern on specific areas of the surface, leaving other areas bare. I then allow the Black Topaz solution to react until it is dry. Then I come back and coat the entire piece with the Black Topaz solution and quickly rinse the piece in water to stop the reaction. The areas treated first will have a different tone than the areas treated later. I then come back over the piece with the Rusty Red and/or copper sulfate solution and brush, drip, drop or drizzle it in specific areas to create coppery or rusty highlights. The entire piece is then thoroughly rinsed with water to stop the reaction.

TOP COATING

Once you have stopped the reaction by rinsing with water, allow the piece to air dry or speed up the process by heating it with a torch. At this point the piece is not very pretty. You will not know what the piece will ultimately look like until you apply a top coat.

I usually heat the piece with a torch until it is barely hot and then apply wax with a lint free cloth. I have heard that linseed oil also works well. At this point the patina will reveal itself in its final state. By applying more wax and rubbing I can usually remove some of the more rusty spots revealing coppery areas. Additional coatings of wax will create a shinier finish with more depth.

SAFETY

These chemicals are poisonous. They will irritate your skin and eyes.

Wear rubber gloves, goggles, protective clothing, and a respirator.

Read the labels on these products and dispose of properly.

Keep them away from your kids.

PERSISTENCE

It takes time and experimentation to get good results with these chemicals. Your finishes are likely to look different from mine due to the many variables involved. I am continually experimenting with different finishes on metals, steel in particular. I would like to compile a data base of information on this subject to share with other metalworkers.

If you have information that you would like to share please let me know.

Rand Esser
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Raleigh, North Carolina 27604

or send e-mail to:
esser@artmetal.pdial.interpath.net

Vendor Addresses for Pre-Mixed Patinas:

Sur-Fin Chemical Corp.
1530 Spence St.
Los Angeles, CA 90023
(213) 262-8108

Chemicals for mixing your own patinas.
Bryant Laboratory
1101 Fifth St.
Berkeley, CA 94710
800 367-3141

Supplier of Brass, Copper, sheet, plate, bar, etc.
Metal Supply Co.
4001 G St.
Philadelphia, PA 19124
800-638-2521

[end of Rand's article]

On March 29, 1996, Charles Lewton-Brain (brainnet@cadvision.com) posted some advice on cleaning, and patinas on steel.

It is really impportant to have a clean surface for goodresults: This may be Fantastick scrubbings, or more:

Cleaning Metal Surfaces, copyright Lewton-Brain 1985-91
For all metal coloring and electroplating a clean metal surface is essential. The cleaning process must remove mineral oils, organic oils and greases as well as traces of chemicals on the surface. It must remove oxidation which might interfere with the metal coloration or plating adhesion and it should possible activate or roughen the metal surface to better receive the treatment.

Cleaning may be accomplished using mechanical (abrasive), chemical (heating, solvents, pickling with acids) and electrolytic (electrocleaning, electrostripping) means. Examples of easily achieved clean surfaces include sandblasted ones and ones scrubbed well twice with rinsings using Fantastic. A pumice rub followed by scrubbing with dishwashing liquid and ammonia on a toothbrush does pretty well. Repeated scrubs with Fantastic work. Best of all is electrocleaning.

A simple procedure is:

1.0 Anneal and pickle in suitable acid.
1.1 Rinse 3-5 times in running water.
1.2 Dip into simmering ammonia and detergent solution and scrub well.
1.3 Rinse well 5 - 10 times.

NB: electrocleaning can be used after step 1.3. While steps 1.0-1.3 produce a quite clean surface by themselves if one is electrocleaning it

is not a bad idea to pre-clean using steps 1.0-1.3 so as to make the electrocleaning solution last longer and lower it's work load in cleaning the metal surface.

A much better and surer procedure is:

2.0 Remove oxides with pumice
2.1 Rinse well.
2.2 Electroclean for 1.5 - 2.5 minutes, object as cathode, then reverse the polarity for a few seconds.
2.3 Rinse 3- 5 times in running water.
2.4 Dip in 1:10 sulfuric acid to neutralize the electrocleaning solution and activate surface. (15 seconds or so).
2.5 Rinse 3 - 5 times in running water.

After cleaning, the metal should be placed in running or circulating water (preferably distilled) to avoid oxidation until it is plated or coloured. One can of course plate or colour immediately after cleaning. In all cleaning methods the piece must either be wired to suspend it in the solution or held with tweezers. It must afterwards be very well rinsed to remove all traces of cleaning chemicals. Do not touch the surface once it is free of grease.

Sand blasting may be substituted for steps 1.0 and 2.0 above, a sand blasted surface is clean but can be damaged easily as well as being matte in appearance.

Sample Electrocleaning solution:

Sodium carbonate 50 grams Current density: 1-3A/dm2
Trisodium phosphate 25 grams Polarity: 1 - 3 minutes
Cathodic (of work)
Sodium Hydroxide 25 grams 5 - 10 seconds Anodic
Water 2000 ml
Operating Temperature 60-70C

PATINA ON STEEL:

A method of patinating steel, copyright Lewton-Brain 1990

Warning: This procedure should be undertaken with appropriate precautions; goggles, gloves, protective clothing, adequate ventilation.

As part of a large scale patination project in which I patinated a steel roof surface 24 by 48 feet on both sides I performed some 40 experiments to find out how to patinate the steel which was a requirement for structural reasons. In doing so I also experimented with paint, buying over $350.00 worth of spray paint, eventually finding one single color which for all intents and purposes is green patina. When placed in recesses and the high areas are rubbed off it is indistinguishable from a cupric nitrate patina. It is a car paint: GM 42, 1980 Chevrolet Medium Green. While this is ideal for smaller surfaces my paint experiments did not produce the surface effects I required on the large scale work. I reasoned that if I could plate the steel with copper and then convert the copper to patina in a fume not only would the job be easier but it would also be safer than dealing with solvents or corrosive patination techniques (such as a cupric nitrate patination) over large surface areas. I was dealing with 4 x 8 foot sheet steel to be equally patinated on both sides simultaneously. Other types of objects might be easier to deal with. 'Tents' of polyethylene plastic sheeting stapled to a framework of 'economy' studs were built. The construction of such a tent

requires that it be sealed (draped onto the floor from the frame and then weighted down). The object inside is positioned on supports of some kind so that it is suspended off the floor in the air inside the tent. Then pans of household ammonia are placed underneath the object. The fumes attack copper or copper based alloy surfaces. Under normal conditions one can activate a copper containing surface with a dilute salt solution to speed up the procedure and obtain a blue patination but this proved too corrosive for dealing with steel. The final procedure chosen was as follows:

1) The steel was cleaned well. Sandblasting would be ideal but was impractical for the project. Solvents were also out for safety reasons on such large surfaces without good ventilation. We ended up using Fantastic cleaner. Two scrubbings with Fantastic on large sponges and good rinsings in between and after were adequate most of the time. The surfaces were then left damp with the rinse water. Only the edges were handled to avoid contamination of the cleaned surfaces.
2) A contact plating solution for copper plating was prepared (see below) and this was applied to the steel using paint rollers (goggles/gloves!). Brushes work also but the paint roller is a bit more gentle. Plating occurs instantly. Several passes may be made over the same area, without pressing hard, which can remove the delicate plating. The surface was then rinsed very well. If areas of the plating lifted grease residues were the cause and a further local Fantastic sponging and good rinsing sufficed to allow plating to take place. After final rinsing the steel (held by the edges) was taken to the tent. One moves fast to retain the surface moisture.
3) The steel was then placed in the tent and pans of ammonia enclosed under it. The tent was sealed. The centers of the thin sheet sagged causing pooling, therefore we built a wooden support with a single nail pointing upwards to support the sheet. More stable objects would not need support, though pooling may be factor to consider depending upon the surface relief. The time required to convert the copper plating was optimal at about 1-1 and a half hours.
4) The steel was removed and gently rinsed as scrubbing or hard spraying can remove the delicate patina surface. It will be a mixture of blues, greens and hints of brownish red where pooling has occurred and the surface dried. In my case I chose to re-introduce pink spatter marks to the surface by spattering droplets of the contact plating solution onto the patina surface where they instantly went pinkish-brown. The steel was then dried with fans and immediately sealed using clear automobile enamel paint. I then went back with stencils and gold spray paint to further modify the surface.
The steps in the procedure are then: Clean, rinse,plate, rinse, fume, rinse, dry and seal.

The conversion process
The copper on the surface is attacked by ammonia liquid, not as much by the fume which has a different chemical composition than the liquid. The water dampened surface slowly takes in ammonia fumes where they are converted to ammonia liquid in solution so that they can attack the copper. The purpose of the pans of ammonia below the object is to provide a constant vapor pressure which replenishes the ammonia on the surface at a constant rate as it is used up in converting the copper to patina. This system therefore ensures better overall constant dilution control than beginning with ammonia on the surface.

Control Factors:
Resists: Resists may be used to prevent plating or to prevent the plating from being converted to patina by the fumes. Resists to plating may be a greasy material (litho-crayon, oil) or thinned rubber cement. Other

resists require too much cleaning time and may need solvents for removal. Resists to patination may be a protective spray through stencils (Pam) or thinned rubber cement. Pattern control through resists is easy.
Time: Time is a factor in all fumings. Experiment with various times on sample pieces to have a palette of process marks (colors, tones, effects) to choose from.
Pooling: Where pooling occurs variations in color will result. Pooling can be encouraged and controlled by local application of greases before or during patination and by the position and shape of the object. Various liquid thicknesses cause surface variations.
Sealers: Sealers will each have a characteristic effect on the surface. I recommend making a palette of various sealing options over a patinated surface. Examples of sealers include waxes, oils, lacquers, transparent acrylics, enamels, varnishes and so on. They often have a tendency to darken the colors on the surface. I prefer clear auto enamel or Spray-Lac number 1473 professional Finish Clear Dead Flat lacquer. It is available from Star Chemical based in Hinsdale Illinois, Deerfield Beach, Florida and Dallas Texas. It is an industrial quality spray and requires good ventilation. It is very unobtrusive on a surface. With any spray the surface chosen can be glossy, like paint (in which case why not use paint?) or shortly after spraying can be matted down with a cloth pad for better surface control.
Other Chemicals: I mentioned dilute salt solutions earlier. Many chemicals will modify surfaces. (Remember never to mix bleach and ammonia). Experimentation and sample making will offer the user control choices. Suggestions for initial investigations include salt, vinegar, baking soda and local heating. There are a number of patination books available including one I sell on patinas for small studios.

Contact Plating Solution Recipe
All safety warnings apply. Always add Acid to Water!! Goggles/Gloves!

250 grams copper sulfate ($CuSO_4$) Technical grade chemicals for this solution is fine.
42 cc sulfuric acid
Distilled water to the 1000 ml level.

Put about 800cc water into plastic or glass container after marking the 1000cc level on it. Add the copper sulfate and stir to dissolve. Slowly pour a thin stream of acid into the swirling water. Heat is evolved-be aware of this. Rinse the acid container with distilled water and top up the mixture with it to the 1000 ml level. This solution can also be used as an electroforming solution for growing copper. Remember, acids are dangerous. A dust mask is suggested around chemicals. Work cleanly. Copper salts are toxic and irritant and should be handled with care. Dispose of properly.

BOOKS:

Ron Young's books are very good for larger scale work. His Contemporary Patination makes up for the poor safety attitude in the Methods for Modern Sculptors book. The former is a working, useful studio guide to patination unlike the monumental Colouring, Bronzing and Patination of Metals put out in 1983 by Hughes and Rowe.

Author	Title
Ronald Young, Robert Fennell	Methods for Modern Sculptors
Ronald Young	Contemporary Patination

Source: Ronald Young
Sculpt-Nouveau
21 Redwood Drive
San Rafael, California,
94901, USA

If ordering books through the mail New World Books is to be recommended. They will obtain for one any book in print in North America for 10-30% off the list price, including Jewelry Concepts and Technology by Untracht for about $70.00. Their address is:

Source: New World Books
2 Cains Road, PO Box 89
Suffern, New York, 10901, USA

Cheap Thrills in the Tool Shop, goldsmithing tricks book by Charles Lewton-Brain. Also 'Patinas for Small Studios" 15.50 plus 3.00 shipping.

Source: Brain Press, Box 1624, Ste M, Calgary, Alberta, T2P 1N3, Canada (403) 263-3955, fax: (403) 283-9053, Email to brainnet@cadvision.com (offers 10% discount to internet users)

[end of text by Charles Lewton-Brain]

References:

_Henley's_Formulas_For_Home_and_Workshop_
Edited by Gardner D. Hiscox, M.E.
Avenel Books, New York (C) 1979
Originally published as _Henley's_Twentieth_
Century_Formulas_Recipes_and_Processes_,
1907; Revised Edition 1927.

METHODS FOR MODERN SCULPTORS, Ronald Young and Robert Fennell
ISBN 0-9603744-0-X [available from Lindsay, catalog number 1257,
for $16.95 US]

Contemporary Patination, by Ronald Young. Newer than METHODS FOR MODERN SCULPTORS, with a better attitude towards safety.

The Coloring, Bronzing and Patinization of Metals
by Richard Hughes and Michael Rowe, published by Crafts Council,
1982, U.K.(ISBN 0 903798 60 3)

The Art of Patinas by Michael Edge, Artesia Press,
PO Box 21, Springfield, Oregon 97477
(503) 746-0094
$24.95 including shipping

Finishing Handbook and Directory
(this may be the same book as below)

-Metal Finishing - Guidebook and Directory_
Metals and Plastics Publications, Inc
One University Plaza
Hackensack, NJ 07601

Protective and Decorative Coatings for Metals
H. Silman, et. al.
Finishing Publications, LTD., 1978 (ISBN 0 904477-03-7)

Cheap Thrills in the Tool Shop, goldsmithing tricks book
by Charles Lewton-Brain.

Patinas for Small Studios, by Charles Lewton-Brain.

Suppliers: (see last part of FAQ for addresses and phone numbers)
Bryant Laboratory (chemicals, recipes)
Craft Books
Merritt's Antiques
Jax Chemical
Johnson Atelier Sculpture/Casting Supplies
Lindsay Publications (METHODS FOR MODERN SCULPTORS)
River Gems and Findings (formerly Rio Grande)
Sur-Fin Chemical Corp.
Brain Press
New World Books
stained-glass, and/or woodworking suppliers

41. Removing Broken Taps

No matter how careful you are, some day you'll break a tap and wonder how to rescue your workpiece. There are several solutions that have come up in the past.

a. One way is Electric Discharge Machining, discussed elsewhere. If you have an EDM system, you're in luck. Alternatively try to find a machine shop in your area that has one and will do this sort of work. The basic idea is to spark erode away most of the tap (if small) or at least one part of it, so the rest can be removed by just picking out the remaining pieces.

b. There are commercial tap removers that have fingers which slip between the flutes, so you can grip the tap and remove it. This may not work well on small taps, and you have to buy the remover. It may be possible to build one but it might not work as well.

c. If the workpiece is non-ferrous (and has no other ferrous pieces attached or embedded), you can mix up a saturated solution of aluminum Sulfate at 120 degrees F, and soak the workpiece in it. This should dissolve the tap in a few hours (or a few days at room temperature). A plastic tray such as Tupperware is best.

d. Another person suggested nitric acid, if the workpiece is aluminum. Test it on chips to be sure it won't eat the workpiece. If the hole is blind, you may need to force some circulation by pouring out the "spent" acid and re-immersing from time to time. Note this is dangerous, nitric acid is nasty stuff; this might be best done outdoors to avoid damage to tools from fumes.

d. If size permits, grind out part of the tap with a Dremel tool or equivalent, with a suitable grinding bit.

e. In some cases, you can try to simply drill out the tap. This will depend on how hard the tap is (mainly the core), and how good a drill you have. It may be difficult to get a good start if the break is irregular or slanted. You may end up breaking the drill.

f. Throw away the work piece and start over.

g. Of course the easiest solution is to not break the tap in the

first place. Use proper technique, lubrication, etcetera.
Keeping them sharp has been suggested; Darex makes a tap sharpener, though it may be expensive for the home shop machinist.

42. Machining plastic

OK, this is a metalworking newsgroup, but the question does come up from time to time, and Jim Harvey did a good job of summarizing past messages and experience. Please contact Jim, jim@hre.com, if you have questions/comments.

These instructions are appropriate for the following materials;
- Nylon 101 and other type 6/6 Nylons
- Monocast (r) and other type 6 nylons
- Nylatron (r) GS,GSM,NSB,and NSM Nylons
- Acetal
- Delrin
- Delrin AF (Tm dupont)
- Q200.5 (Crosslinked Polystyrene)

Drilling:

More heat is generated in drilling than in any other machining operation, causing difficulties not usually associated with fabricating metals. Extra care must be taken to prevent problems such as gumming, melted surfaces, crazing, and cracks around the drill hole.
A low helix angle (14 - 17 degrees) with polished flutes is the recommended tool for drilling industrial thermoplastics. This type of drill with a large flute area permits a free flow of chips and minimizes the chance of overheating and gumming. High speed twist drills with standard spiral flutes (30 deg helix) may also be used successfully.
Chip ejection is an important consideration in drilling. If the chips are not removed from the flutes as quickly as possible, friction will develop and result in poor finish, dimensional changes and discoloration.

Drill Design:
Drills should be designed with the proper point angle and lip clearance (90 - 118 deg / 9 15 deg respectively) for heavy wall or thick sections. Angles of 115 - 130 should be used for thin sections or thin wall pieces.
An asymmetrical cutting edge is desirable in both thin and heavy section work.

Drill speed:

The following chart lists the recommended speeds for drilling in plastics

Drill size	RPM
#60 - 33	5000
#32 - 17	3000
#16 - 1	2500
1/16	5000
1/8	3000
3/16	2500
1/4	1700
5/16	1700

3/8	1300
7/16	1000
1/2	1000
A thru D	2500
E thru M	1700
N thru Z	1300

Feeds should be .004" - .015" per rev. for Nylon 101,NSB,GS,GSM,MC901, and Acetal although rake angles and helix angles will differ slightly Lip relief should be 9 - 16deg for the nylons (the higher numbers for larger diameter drills)and 10 - 25 degrees for Acetal

Q200.5 Acrylic should feed .004"-.010" with a 15deg lip relief angle.

Drilling Large Diameter holes in the lathe

A slow spiral (low helix angle) drill or a general purpose drill ground to a point angle of 118 deg, with a lip clearance angle of 9 - 15 deg. is recommended. In either case, the lip rake should be ground off (dubbed) and the web thinned.

Spade drills have been used successfully in drilling large diameter holes in these materials. They seem to work best in increments of 1" to enlarge the hole from pilot to finished size.

In order to prevent excess stress in the thermoplastic material, a trueing cut is recommended on the OD of the material on the chucking end. Using standard chuck jaws that have been radiused to the contour of the OD, or a step collet for maximum contact on the holding surface. Chuck the rod as lightly as possible on the trued end, applying only enough pressure to the piece to prevent slippage. It is imperative that a sufficient supply of cutting fluid is directed to the drill tip as it is advanced into the part.

Start with a pilot hole (maximum diameter 1/2") at a speed of 600 - 1000 rpm using a positive feed of approximately .005" per rev. If at all possible, do NOT feed by hand due to the tendency of the drill to grab causing stress cracks. If you must feed by hand, grind (dub) the cutting edge (rake angle) of the drill slightly to reduce this tendency.

If the pilot hole must be drilled by hand, reduce the chisel edge of the drill by thinning the web. A secondary drilling at a speed of 400 -500 rpm is required to expand the hole to 1" diameter.

Finally, bore the ID to the desired diameter using a single point boring tool. Using the following information:

Light cuts of 1/16" to 1/8"
Light feeds of .003" - .007" per revolution
Depending on the rigidity of the machine, cuts as heavy as 3/8" and feeds of .015" per revolution can be achieved.
0 - 5deg NEGATIVE rake is preferred to balance cutting pressures.

Important!
Sharp Tools with large clearances are IMPERATIVE!
HSS tools can be used for very short runs ONLY if the edges are kept extremely sharp.
For long runs, or production work, Diamond tipped or Tungsten carbide tools honed with a fine 400 - 600 grit diamond wheel are preferred.
Carbide tools should ALWAYS be used in turning the following

materials:

Nylatron GS, GSM, NSB, NSM, and MC 901 at speeds greater than 600 fpm.

Vertical Milling

Vertical milling , using face mills, end mills, shell mills, and fly cutters is the most common method of milling thermoplastics.

Extremely high spindle speeds and table speeds are possible with the use of adequate holding fixtures, but because of the flexibility inherent to the material itself, extreme care is needed with regard to the methods of holding and/or clamping, in order to reduce the possibility of deformation.

When milling parts with a thin cross section, the entire part should be encased in the fixture, leaving only the actual surface to be machined exposed. (Just enough opening for the cutter to enter). This prevents the part from deflecting away from the cutter. A staggered tooth roughing end mill works best for this method on a vertical mill.

Cutters should be kept extremely sharp at all times to eliminate the tendency of the material to produce burrs on the milled edge. Cutters should be used ONLY for thermoplastic and never have been used on steel or other ferrous or non ferrous material.

When using a shell mill, it is wise to tilt the head slightly to have just the periphery of the cutter contact the work. This will avoid cutter drag marks on the workpiece. The use of a square cornered cutter is to be preferred as well (over those with a chamfered corner) as fewer burrs will be developed over the course of the cut.

If horizontal milling is required, staggered tooth side milling cutters will produce a more accurate clean slot or groove, with minimum difficulty. Slab milling cutters amy also be used, however, they require greater care to produce similar quality finishes.

Chatter marks may develop and chips may accumulate in front of the cutter and get pulled into the cutting surface. Degradation of the surface can result in this case. Therefore when using slab milling cutters a slower spindle speed is advised.

Burrs at the end of a run-out can be eliminated when a piece of slightly harder material (brass or aluminum for example) is placed at the end of the work where the run-out will occur. The cutter then can travel past the work piece and into the harder material. If burrs do occur they can be removed with a razor knife as a second operation.

Coolant is not normally necessary in milling, although we use a synthetic flood coolant when dimensional tolerance is required. Mist systems may also be used successfully, as well as mist/air systems. The use of air also helps to blow chips away from the cut area minimizing the possibility of chips binding between the cutter and the work.

I hope this will be of some help to those who are working with these and other plastics. We do a lot of work with these materials and have found the above to work quite well for our purposes.