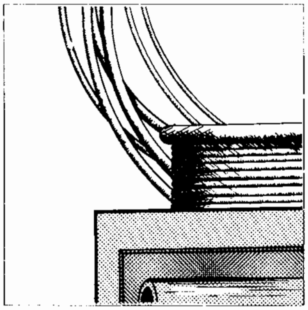
Chapter 1



Materials

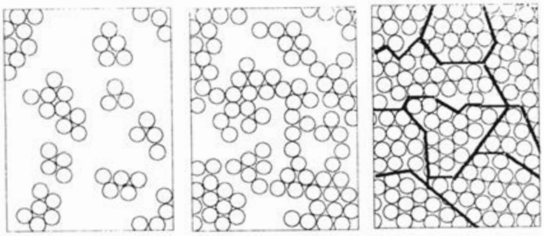
Metallurgy

Though metals have been controlled for centuries, the science of metallurgy is as recent as 1864, when a microscope was first used to study the character of steel. X-rays and wave mechanics extended the understanding of metals with their introduction in 1925.

Recrystalization

When heated to its melting point a metal loses its crystaline organization and becomes fluid. When the heat source is removed and the metal cools, it re-establishes its crystal pattern, starting with the first areas to cool. Many clusters of crystals start to form simultaneously, all having the same order but not necessarily the same orientation.

Crystals move most easily within a semi-ordered structure. The crystals at a grain boundary are caught in a "log jam" with the result that the metal is tough and hard to work.



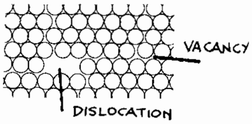
When worked, large crystals are broken into smaller ones, creating more grain boundaries. As a result the metal is work hardened. A similar condition is created when metal is rapidly cooled. Crystals do not have time to grow from a few clusters into an organized structure. Instead, the metal recrystalizes into many small unoriented grains.

In time, even at room temperature, crystals will realign themselves into an organized lattice. By heating the metal we accelerate the movement of atoms and the subsequent recrystalization. This process is called *annealing*.

In its annealed state, the crystal arrangement contains irregularities called vacancies. These facilitate crystal movement and so contribute to malleability. If nonferrous metals are held at annealing temperatures for long periods, the result is a more perfect arrangement and a less malleable material. This is called *heat hardening*.

Vacancies & Dislocations

The amount of activity as a metal cools is quite astounding. At a slow rate of crystal growth, such as 1 mm per day, about 100 layers of atoms per second are being deposited. Crystalization normally occurs much faster than this, so it is not surprizing that few crystals are perfectly formed. Ironically, it is this imperfection that allows the metal to be worked. As various clusters of crystals organize themselves around differently oriented grains, they come to impinge on one another when they meet. The holes this creates are called *vacancies*. These accumulate to form a region in which the symmetry of the crystal lattice is disturbed, which is called a *dislocation*. As the diagrams indicate, it is this distortion that allows metal to be malleable. If the crystals were perfectly arranged they would have no place to move when stressed. Vacancies and dislocations distribute forces throughout metal and allow it to flex.



Gold

Gold was the first precious metal to be worked by man, being available as nuggets that required no smelting. Because of its rarity and luster and the ability to resist corrosion, it has been valued by many cultures.

Materials

DATA: **Au**
Melting Point:
1063 °C
1945 °F
Specific Gravity:
Cast 19.2
Worked 19.3
Atomic Wt: 197.2

- Gold was probably the second metal to be worked by early man, being discovered after copper. Quality gold work can be found from as early as 3000 B.C.
- If all the gold ever found (about 20,000 tons) were cast into a single ingot, it would make only a 20 yard cube.
- Gold has a face-centered cubic crystal.
- Pickles for gold would include Sparex #2 or a mixture of 1 part nitric acid (reagent grade) with 8 parts water.
- Gold dissolves in Aqua Regia and solutions of chlorine and potassium cyanide or sodium cyanide.

Gold-Filled

This term refers to a material on which a layer of gold has been bonded by fusing. The resulting ingot is rolled or drawn to make sheet and wire. A standard practice is to clad the base with 10% (weight) 12K gold. Since 12K is half pure it means the final result, if it were melted down and assayed, would equal 1/20 or 5% pure gold, marked as 1/20 G.F.

Voluntary Product Standard

This U.S. law has set legal tolerances since 1976. It allows variation of 3 parts per 1000 (.072K) on unsoldered goods and .007 (.168K) on soldered objects. This is called *plumb* (i.e. accurate) gold. Manufacturers were given until 1981 to dispose of their old merchandise made at lower standards.

Fineness of Gold

Since fine (pure) gold is too soft for most uses it is alloyed with other metals to achieve a desired hardness. During this process the color, hardness, malleability and melting point can also be altered. Silver and copper are the two most common additives but many other metals can be used.

The relative amount of gold in an alloy is called the *karat*. This word signifies proportion and should not be confused with *carat*, which is a unit of weight.

Decimal Equivalents of Karats

1K	.0417	9K	.3750	17K	.7083
2K	.0833	**10K**	**.4167**	**18K**	**.7500**
3K	.1250	11K	.4583	19K	.7917
4K	.1667	12K	.5000	20K	.8333
5K	.2083	13K	.5417	21K	.8750
6K	.2500	**14K**	**.5833**	22K	.9167
7K	.2917	15K	.6250	23K	.9583
8K	.3333	16K	.6667	24K	1.000

Gold

One ounce of gold can be flattened to a sheet that will cover 100 square feet or drawn to a wire almost a mile long. Gold can be made into a foil that is less than 5 millionths of an inch thick, at which point it is virtually transparent.

Testing

To be scientifically accurate a sample must be assayed in a testing laboratory but these two tests have been used for many years and are often sufficiently accurate for the craftsperson.

Is It Gold?

With a small file, make a scratch in an inconspicuous spot. While wearing rubber gloves, use a wooden, glass or plastic stick to apply a drop of nitric acid to this spot. Observe the reaction. When done, rinse everything well in running water.

• No reaction	it's gold
• Bright green	it's base metal
• Green in scratch	gold layer over base metal.
• Milky in scratch	gold over silver

What Karat Is It?

Determining karat requires a testing kit:

- nitric acid
- aqua regia
- samples of known karat
- touchstone (slate or ceramic)

Safety

The object to be tested is rubbed on the stone (i.e. "touched") to leave a streak. A parallel line is made with one of the test needles. Both marks are flooded with acid and the reactions are observed. When the sample colors at the same rate as the test streak, a match has been made. Nitric acid is used for low karat golds; aqua regia is needed for higher karats.

Formulas

To lower karat

A. Amount to be lowered times its karat.
B. Same amount times the desired karat.
C. Difference between A and B.
D. Divide difference (C) by the quality being made.

To Raise Karat

A. Amount to be raised times its karat.
B. Same amount times the desired karat.
C. Subtract B from A.
D. Difference between pure (24) and desired karat.
E. Divide C by D.

Alloys

- A mixture of roughly equal parts of gold and silver is called *electrum*. This alloy shows maximum hardness at a 50/50 mix.
- The hardest alloy of gold, silver and copper is reached at 50/25/25. This is 12K yellow.
- Any increase of the copper content in a gold alloy will lower its melting point up to18% copper (melts: 880°C 1642°F). To continue lowering, add silver.
- Many kinds and colors of gold solder are commercially available, but in a pinch a gold of a lower karat may be used.

Fluxes

When pouring gold ingots use an even mixture of powdered charcoal and ammonium chloride (sal ammoniac) during melting. This will yield a bright tough ingot that will withstand rolling. **Dangerous fumes are produced.**

If iron or steel are present (for instance as a result of file wear) purify the scraps by melting with a flux of 1 part potassium nitrate (saltpetre) and 2 parts potassium carbonate. After cooling, remelt with the sal ammoniac flux and pour the metal into a warm (not hot) mold.