EML 2322L -- MAE Design and Manufacturing Laboratory

Soldering and Brazing

- Soldering and brazing are *liquid-solid phase bonding processes*. *Liquid* means that the filler metal is melted; *solid* means that the base material(s) are not melted. The *phase* is the state at which bonding takes place between the solid base material and the liquid filler material. The bond between the base material and filler metal is a *metallurgical bond* because **no melting or alloying of the base metal occurs**. If done correctly, this bond results in a joint having 2 or 3 times the tensile strength of the filler metal itself.

- Soldering and brazing differ only in that soldering takes place at a temperature below 840°F and brazing occurs at a temperature above 840°F.

- In brazing, the parts being joined must be fitted so that the joint (gap) spacing is very small (**less than 0.025"**). This small spacing allows a *capillary action* to draw the filler metal into the joint when the parts reach the proper temperature. (*Capillary action* is the result of adhesion and surface tension. Adhesion of water to the walls of a vessel will cause an upward force on the liquid at the edges and result in a meniscus which turns upward. The surface tension acts to hold the surface intact, so instead of just the edges moving upward, the whole liquid surface is dragged upward.)

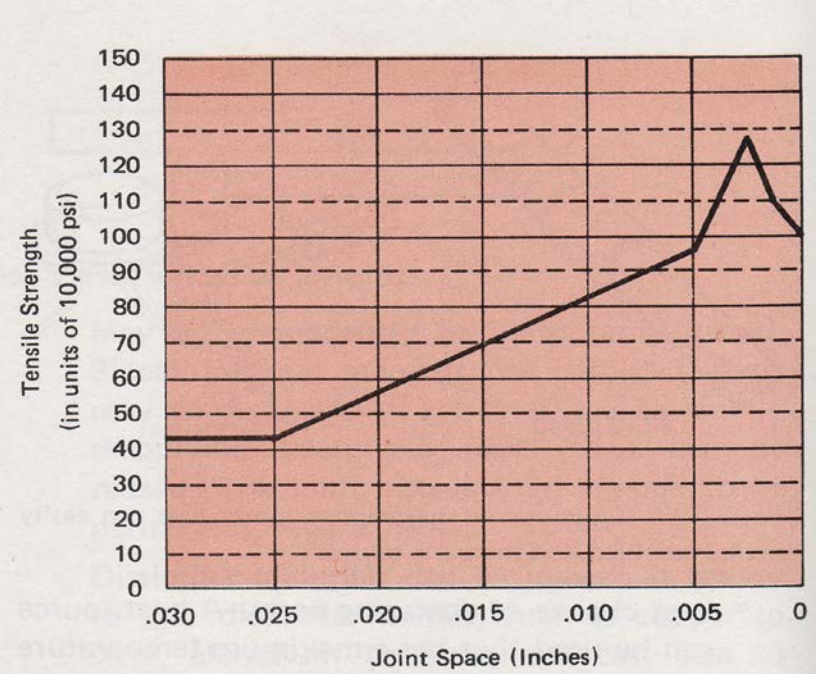

Table 19-1 Tensile Strength of Brazed Joint Increases as Joint Space Decreases

Advantages of Soldering and Brazing

Low temperature. Since the base metal does not have to melt, a low-temp heat source can be used. This minimized distortion and creates a smaller heat-affected zone (HAZ).

May be permanently or temporarily joined. Since the base metal is not damaged, parts may be disassembled at a later time by simply reapplying heat. The parts then can be reused. The joint also is solid enough to be permanent.

Dissimilar metals can be joined. It is easy to join dissimilar metals, such as copper to steel, aluminum to brass, and cast iron to stainless steel. It is also possible to join nonmetals, i.e. ceramics are easily brazed to each other or to metals.

Speed of joining. Parts can be preassembled and furnace soldered or brazed in large quantities. A lower temperature means less time in heating.

Less chance of damaging parts. A heat source can be used that has a max temp below that which may cause damage to the parts (base material).

Parts of varying thickness can be joined. Very thin parts or a thin part and a thick part can be joined without burning through or overheating them.

Easy realignment. Parts can be easily realigned by reheating the joint, repositioning the parts and allowing the filler metal to solidify.

Common Soldering and Brazing Methods

Torch soldering and brazing. Oxy-fuel or air-fuel torches can be used manually or automatically. Advantages of this method include the following:

- **Versatility.** Small and large parts can be joined with the same torch.
- **Portability.** A torch is very portable. Anywhere a set of fuel cylinders can be taken and the hoses can reach can be soldered or brazed with a torch.
- **Speed.** The flame of the torch is one of the quickest ways of heating the material to be joined.

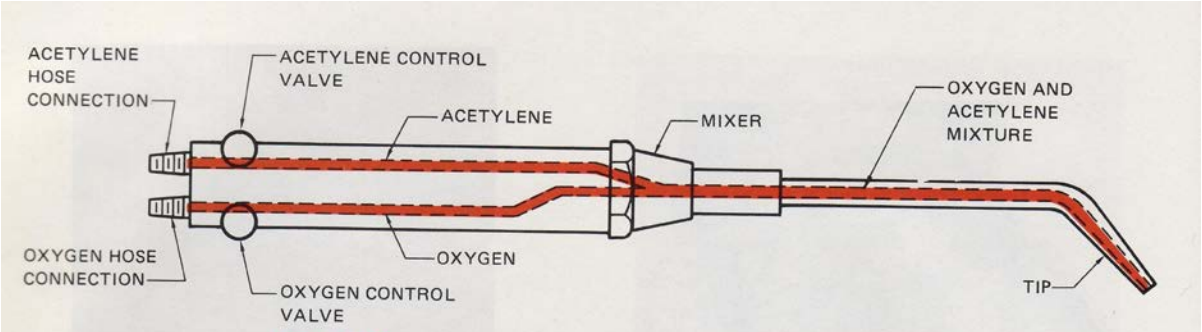

Figure 4-19 Schematic drawing of an oxyacetylene welding torch

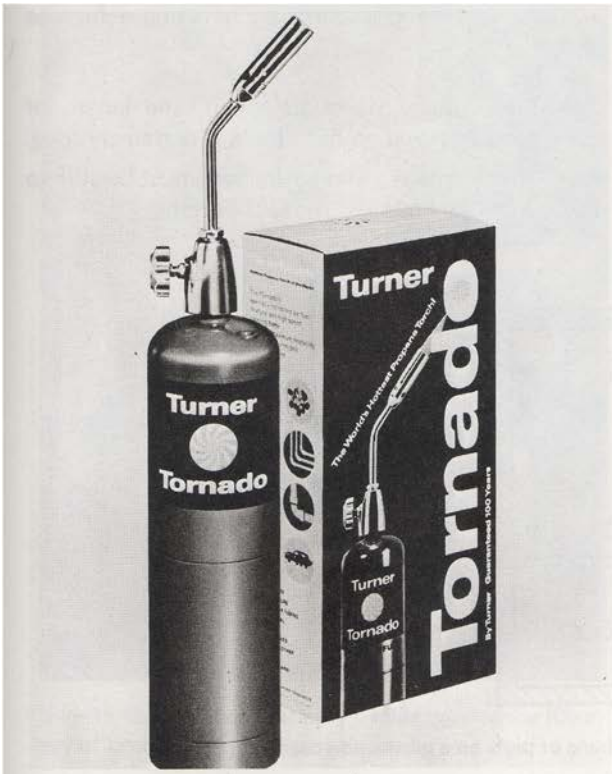

Figure 19-12 An air propane torch can be used in soldering joints. (Courtesy of Turner Corporation)

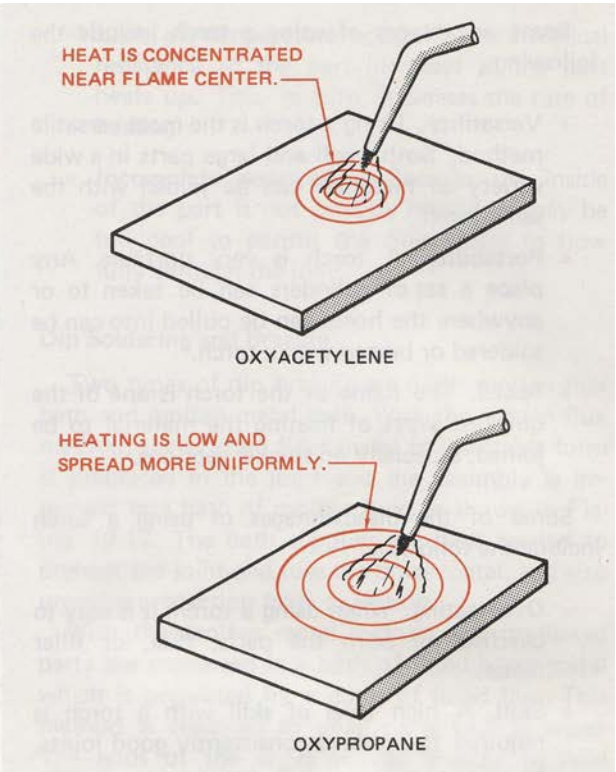

Figure 19-13 The high temperature of an oxyacetylene flame may cause localized overheating.

Furnace soldering and brazing. In this method the parts are heated to their soldering or brazing temp by passing them through or putting them into a furnace. The parts may be placed in the oven manually or fed through on a conveyor belt. Some the advantages are:

- **Temperature control.** The furnace can be accurately controlled to ensure the parts will not overheat.
- **Controlled atmosphere.** The furnace can be filled with an inert gas to prevent oxides from forming on the parts.
- **Uniform heating.** The uniform heating of the parts reduces stresses and distortion.
- **Mass production.**, inert gas environment, uniform heating and furnaces lend themselves well to mass production, since it's easy to produce quality parts consistently.

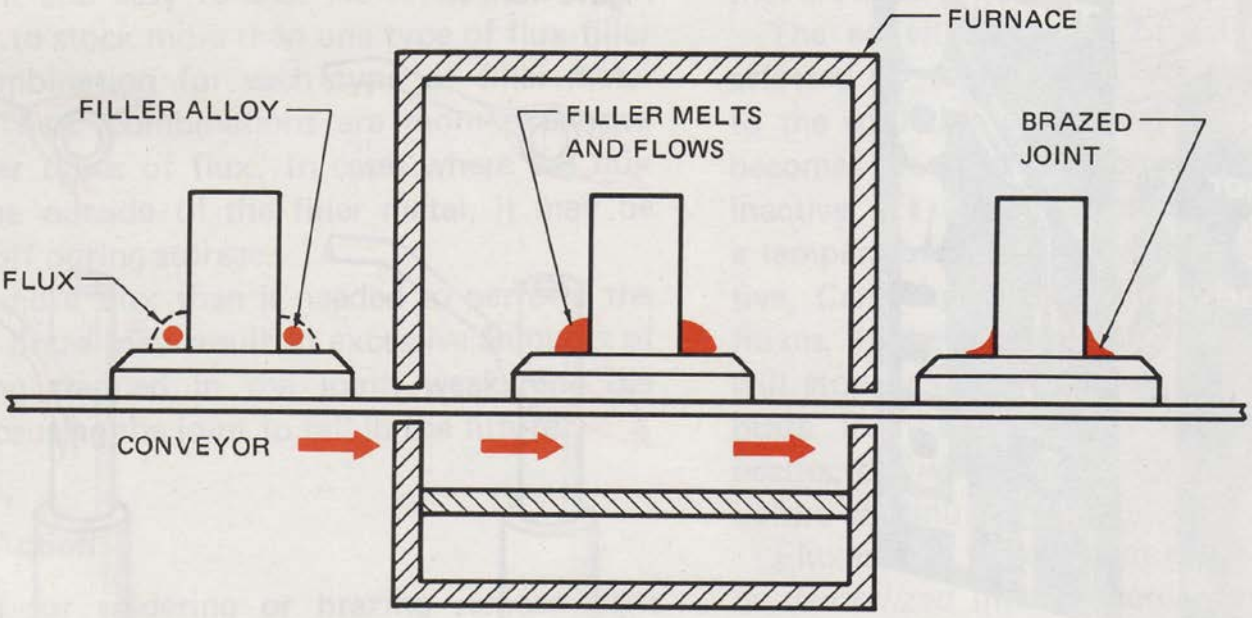

Figure 19-15 Furnace brazing permits the rapid joining of parts on a production basis.

Filler Metals

The type of filler metal used for any specific joint is selected by considering the following:

- Material(s) being joined
- Strength required
- Joint design
- Availability & cost
- Appearance
- Service (corrosion)
- Heating process

The following table shows common brazing filler metals used to join base metals.

Base Metal	Brazing Filler Metal
Aluminum	BAlSi, aluminum silicon
Carbon Steel	BCuZn, brass (copper-zinc) BCu, copper alloy BAg, silver alloy
Alloy Steel	BAg, silver alloy BNi, nickel alloy
Stainless Steel	BAg, silver alloy BAu, gold base alloy BNi, nickel alloy
Cast Iron	BCuZn, brass (copper-zinc)
Galvanized Iron	BCuZn, brass (copper-zinc)
Nickel	BAu, gold base alloy BAg, silver alloy BNi, nickel alloy
Nickel-copper Alloy	BNi, nickel alloy BAg, silver alloy BCuZn, brass (copper-zinc)
Copper	BCuZn, brass (copper-zinc) BAg, silver alloy BCuP, copper-phosphorus
Silicon Bronze	BCuZn, brass (copper-zinc) BAg, silver alloy BCuP, copper-phosphorus
Tungsten	BCuP, copper-phosphorus

Table 19-5 Base Metals and Common Brazing Filler Metals Used to Join the Base Metals

Examples of Brazed joints

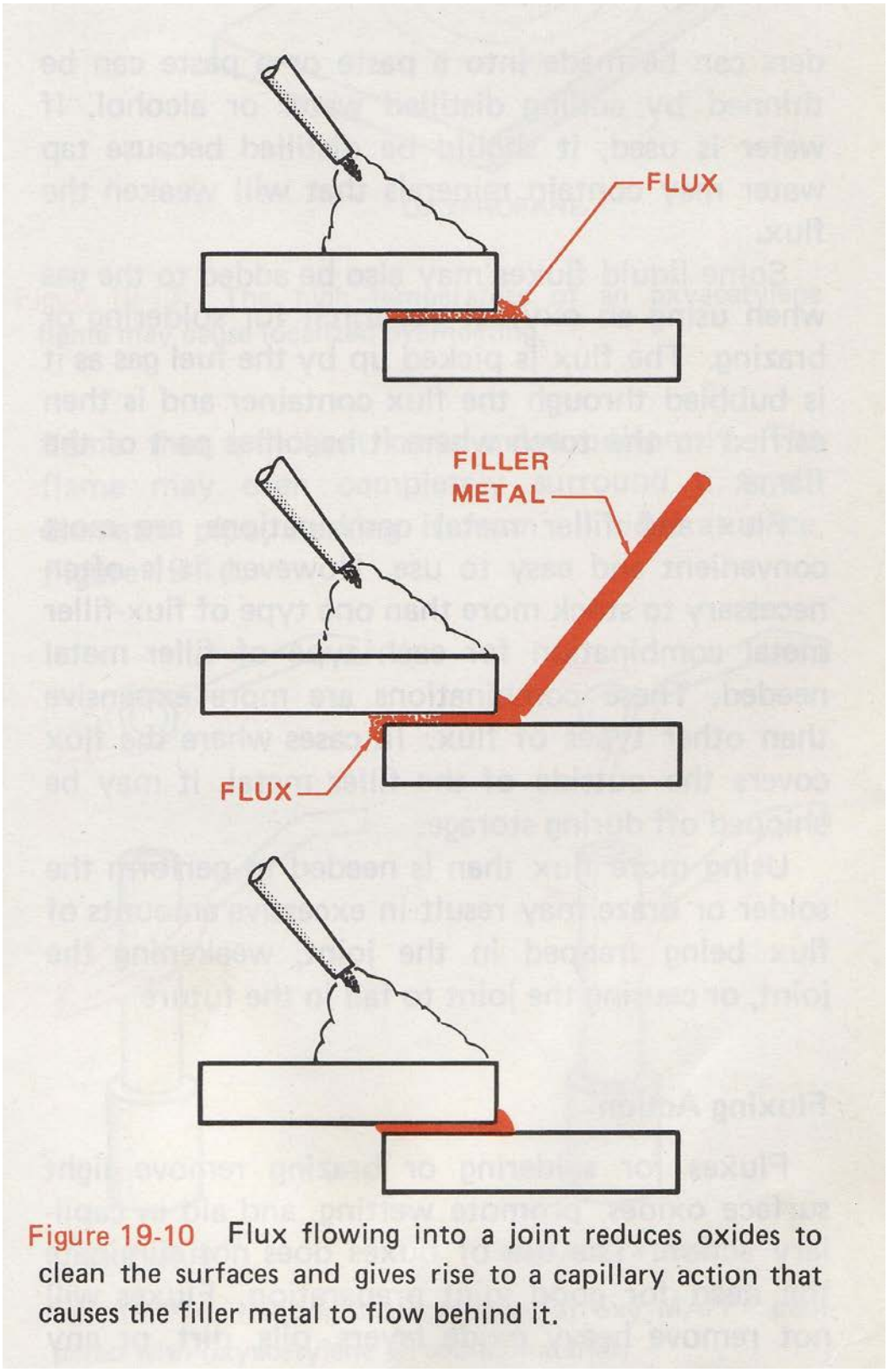

Figure 19-10 Flux flowing into a joint reduces oxides to clean the surfaces and gives rise to a capillary action that causes the filler metal to flow behind it.

Examples of Brazed joints (con't)

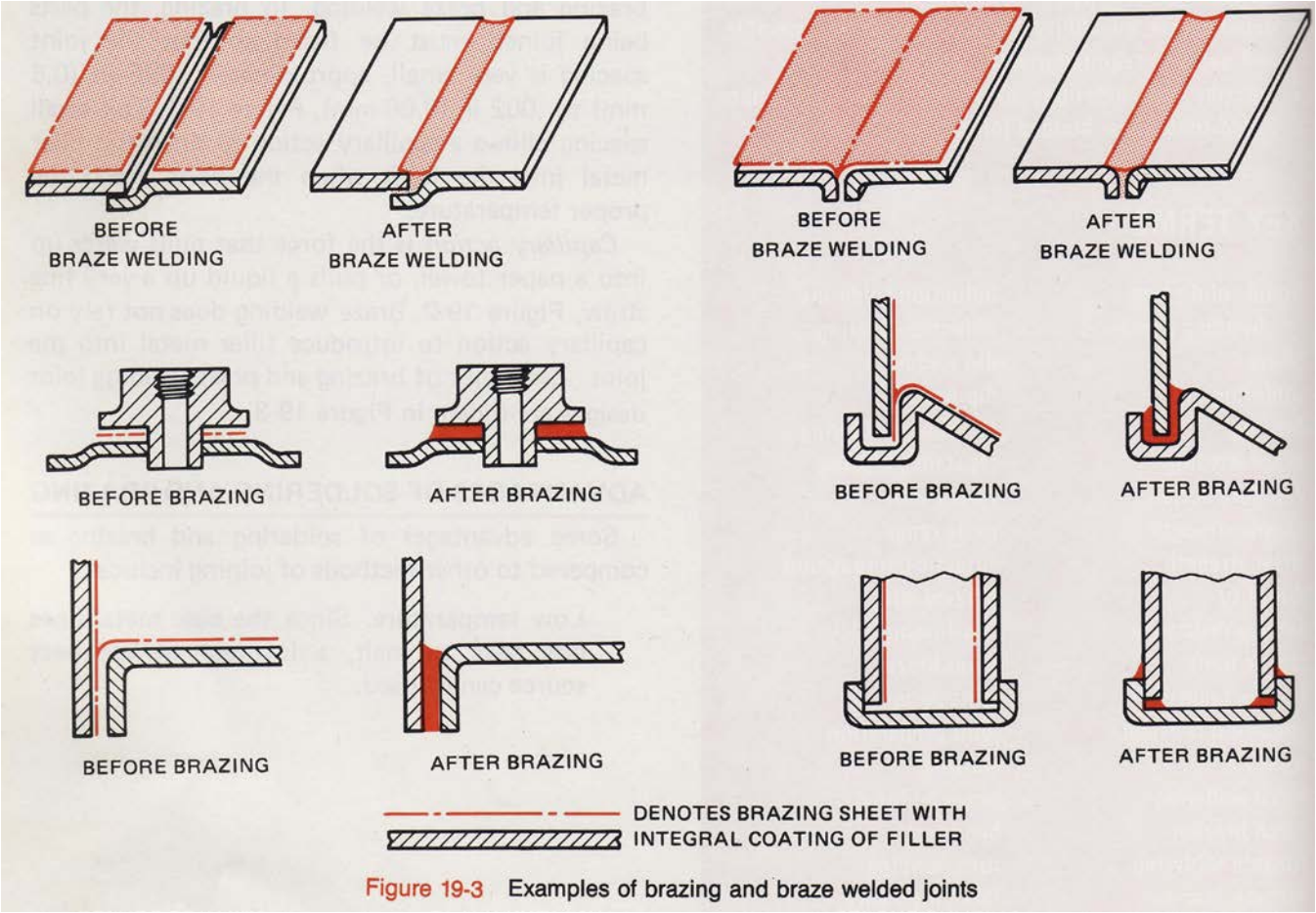

Figure 19-3 Examples of brazing and braze welded joints

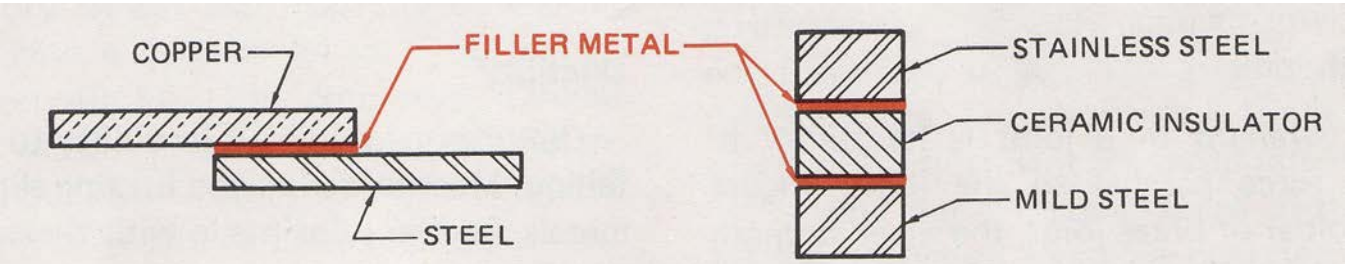

Figure 19-5 Dissimilar materials joined

Brazing Photos

PLATE 10

The base metal is heated and the brazing rod is touched to it to determine if the brazing temperature has been reached.

PLATE 11

The brazing rod is dipped into the leading edge of the braze pool.

Copyright notice:

Much of the previous information and photo slides were taken from Larry Jeffus' and Harold Johnson's ***Welding Principles and Applications***. This book contains a wealth of knowledge regarding the soldering and brazing techniques summarized in these abbreviated lecture notes.