Micrometers
The Micrometer

Anvil
Spindle
Sleeve (w/ main scale)
Thimble (w/ Vernier scale)
Lock (not shown)
Ratchet knob
Frame
Mechanical Assembly
Threaded Fasteners

Benefits of threaded fasteners

- Ease of assembly
- Allows disassembly and maintenance/repair of assemblies
- Large products may be transported as smaller features/subassemblies and assembled on site
- Often easier to manufacture and join components than produce complex geometries

Set (glued) necks require experienced luthiers for repairs e.g. Les Paul

Through neck are difficult to repair

Bolt on necks are easily replaced e.g. Fender
Screw Terminology

A bolt utilizes a nut whereas a screw engages with a feature.
Thread Terminology

Most common applications utilize a right hand thread (lefty loosy, righty tighty)
Thread Terminology

Multistart or multiple thread screws increase the threading speed and are often used on CNC machines to increase traversal speed.

The lead (engagement per revolution) is $n \times$ pitch where $n$ is the number of starts.
Machine Screws and Capscrews

Machine screws and capscrews have the same general geometry and are designed to be inserted into tapped holes.

Capscrews are generally of higher tolerance and are generally manufactured from higher strength.
Machine Screws and Capscrews

- Pan
- Button
- Large Diameter (Truss)
- Round
- Extra-Wide Low Profile Head
- Binding
- Fillister
- Cheese
- Hex
- Flat
- Oval
- Tamper-Resistant Tri-Groove
- Tamper-Resistant One-Way
- Tamper-Resistant Drilled Spanner
- Phillips
- Torx
- Combination (Phillips/Slotted)
- Slotted
- Tamper-Resistant Pin-in-Torx
- Tamper-Resistant One-Way
- Pozidriv
- Slotted with Vent
Socket Head Capscrews

Socket head cap screws (allen bolts) have a head diameters nominally 1.5 times that of the major diameter and a head height equal to the shank diameter.

Like capscrews, these fasteners are typically fabricated from high strength materials.
Socket Head Capscrews

- **Standard**
- **Button**
- **Flat**
- **Drilled Head**
  - Wire screws together to prevent loosening from vibration.
- **Flange Socket**
- **Flange Button**
- **Low**
- **Vented**
  - Vented hole is drilled through entire length.

- **Hex Socket**
- **Torx**
- **Tamper Resistant Pin-in-Hex Socket**
- **Tamper Resistant Pin-in-Torx**
- **Tamper Resistant High Security**
  - Screws are unique configuration from McMaster-Carr.
**Self-tapping Screws**

**Sheet Metal Screws**
Have a pointed end and widely spaced threads. Self-starting in thin sheet metal. In thicker materials, a drilled hole is recommended.

**Thread-Forming Screws**
Have a blunt point and fine threads. Form threads in metal, plastic, and plywood. A drilled hole is required.

**Thread-Cutting Screws**
Have blunt, tapered, tap-fluted end that cuts machine screw threads and ejects material as it turns. Use in metal, plastic, and plywood. A drilled hole is required.

**Self-Drilling Screws**
Drill their own hole, tap a thread, and fasten material in a single operation. Excellent for use in sheet metal.
Wood Screws

- Flat
- Ribbed Flat Head
- Self-Sinking Flat Head
- Self-Sinking Flat Head with Washer
- Self-Sinking Ribbed Flat Head
- Pan
- Oval
- Round
- Large Diameter Round Head (Timber Screws)
- Round Head Square Neck (Carriage Screws)
- Round Head Ribbed Neck (Carriage Screws)
- Hex Head (Lag Screws)
- Hex Flange Head (Lag Screws)

- Phillips
- Slotted
- Square
- Combination (Phillips/Square)
- Hex
- Torx
- Uni-Drive
Set Screws

Set screws are often used to secure against torsional loads (e.g. gear on shaft, knob on shaft)
Set screws can minimize tooling requirements for attachment
Set Screws

Blind screws (grub screws) have no heads

- **Standard Socket**
  The most common screw style.

- **Slotted**
  Install with a standard slotted screwdriver.

- **Self-Locking Socket**
  Locking element increases holding power. Perfect for tough jobs.

- **Square Head**
  Easy to access by hand or with a wrench when you need more torque.

- **Hollow-Lock Socket**
  Often used to lock other set screws in place, to hold pins, and to adjust spring tension.

- **Swivel Pad Socket**
  Pad swivels to make maximum contact against angled surfaces.
Set Screws

**CUP**
Most popular style. Thin edge digs into contact surface for high holding power.

**CONICAL**

**OVAL**

**DOG**

**FLAT**

**Cup**
Highest holding power of any point style. Sharp tip wedges into surface.

**Knurled Cup**
Knurled improve grip and prevent backing out or loosening.

**Vented Cup**
Vent fluids and gases while holding parts securely in place.

**Cona**

**Flat**
Best for making frequent adjustments. Tip won’t mar contact surface.

**Oval**
Ideal for making frequent adjustments. Tip has small contact area causing little damage.

**Extended Point**
Also known as dog point and pilot point set screws. Often used in place of dowel pin.

**Soft Tip**
Rigid yet soft tip conforms to texture and curves of surface without marring.

**Swivel Ball Bearing**
Also known as ball-ended thrust screws. Ball bearings swivel in all directions.
Common Drives

1. Slotted
2. Phillips
3. Clutch-Drive
4. Torx®
5. Robertson®
6. Allen
Loading

The general rule is that screws / bolts should be axially preloaded in excess of the service load.
Manufacturing a Screw

See: http://youtu.be/3kxcw08p_oY
Interference Fits

Interference (press) fits are used for seating bearings, bushings, or watertight seals.

The quality of the fit/seal depends critically on the difference in sizing between the seated feature and its receiver.
Interference Fits

\[ \sigma_e = \frac{2Ei}{D_p} \]

- Interference stress (effective stress)
- Young’s modulus
- Interference of fit
- Pin diameter

Bronze

\[ D_p = 0.25'' \]

\[ 2'' \]