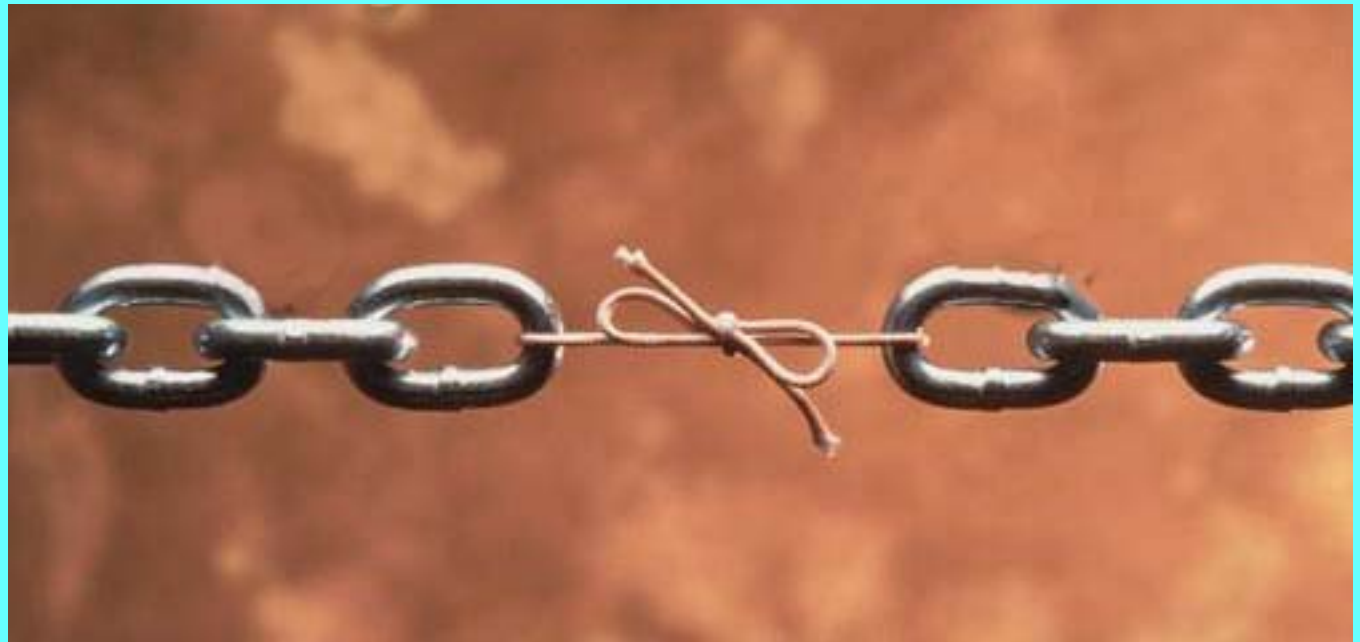


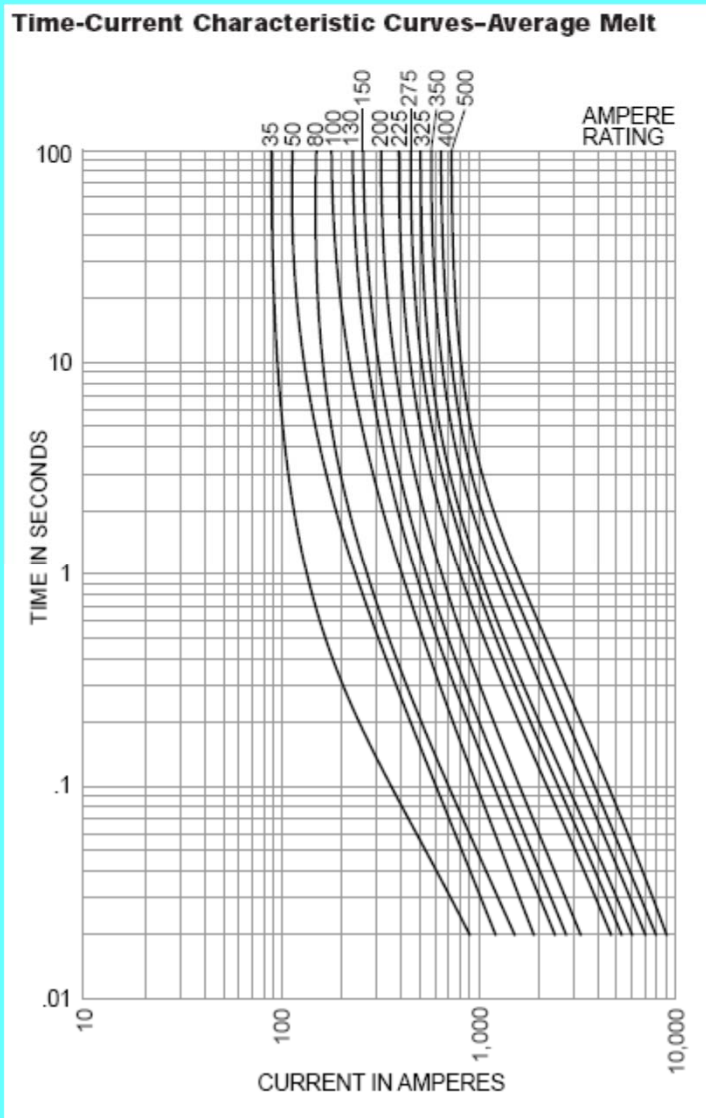
# Circuit Protection

Weak Link in the Chain . .

**A Weak Link in the Chain . . .**

**The very first time an experimenter connected a wire to a low impedance energy source, there was value for including a “weak link” in conductors to prevent fault events from becoming catastrophic.**





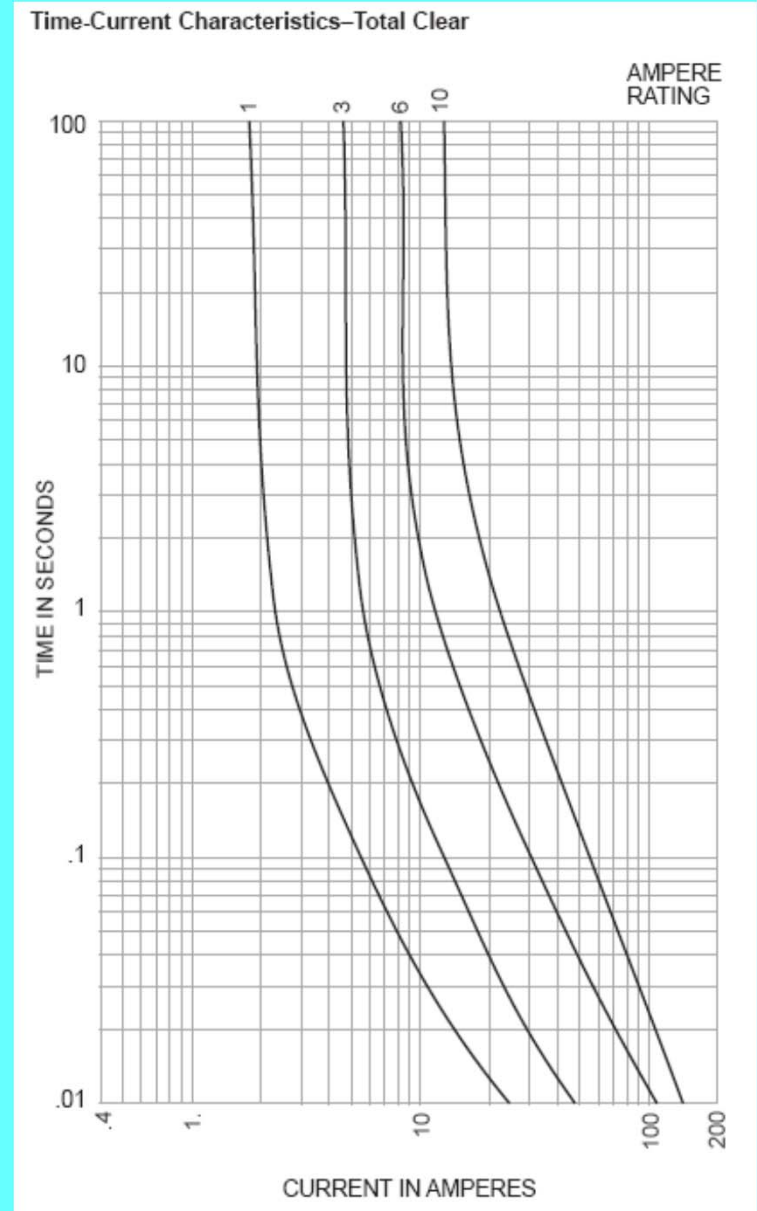
- These devices have an exceedingly robust  $I^2T$  characteristic.
- Note that a 35A rated ANL limiter will carry about 90A indefinitely . . .
- And opens in about 100 mSec at 360A

## AEC Weekend Seminars

### A Weak Link in the Chain . . .

## Circuit Protection

- **Early commercial protection capitalized on an existing connector (light bulb base) as a handy package for “plug fuses”**



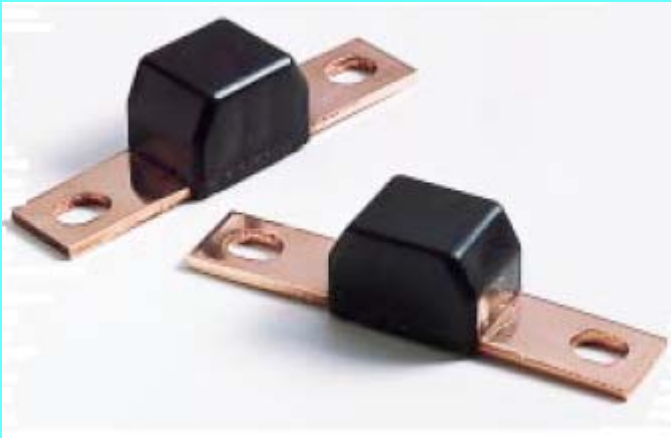


**ANL/ANN “Current Limiters” are widely used in high current feeders on aircraft.**

**These devices are designed to be inserted into really “FAT” feeders with fault potentials in the thousands of amps . . .**



- The styles and functional choices for fusing is a huge industry and offers a wide variety of specialized styles and ratings.



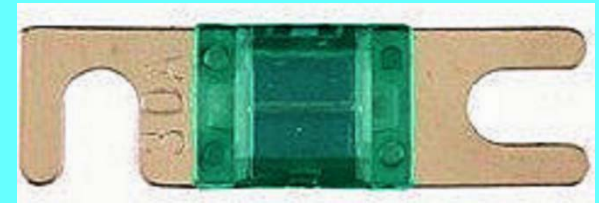
## AEC Weekend Seminars

### A Weak Link in the Chain . . .

- There is a miniature version of the ANL ‘fat fuses’. GREAT alternative in both size and cost of the legacy products popular in aviation.
- Holders for the “MINI-ANL” devices are available in two styles:
- **AVOID** any terminal system that mashes wire strands under a setscrew . . .



## Circuit Protection



The technology of choice brings the ANL tabs into electrical contact with **TERMINALS** on **SHARED** studs . . .

## AEC Weekend Seminars

### A Weak Link in the Chain . . .

## Circuit Protection

- **Very familiar fuses used in automobiles and other low voltage systems. Easy to make, easy to replace but terrible resistance to environmental conditions.**
- **Not environmentally robust due to Large area/low pressure contacts.**





- **Modern automotive fuses have plastic molded bodies and one-piece tab-fuse construction.**
- **Low area/high pressure contacts.**
- **Available in ratings from 1 to 80 amps.**

**Color Ratings For STANDARD and MINI Fuses**

Fuse Amp Rating	Identification Color
3	Violet
5	Tan
7.5	Brown
10	Red
15	Blue
20	Yellow
25	Colorless
30	Green



**MAXI**

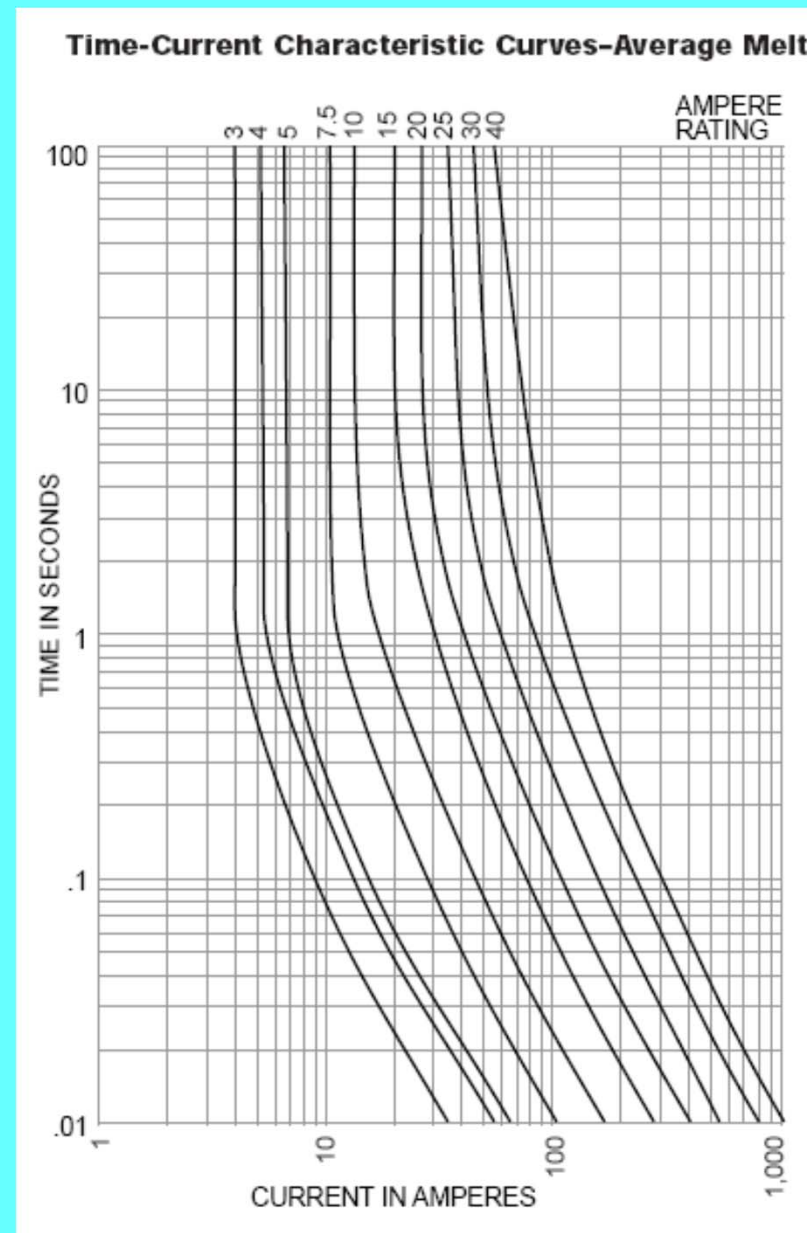
**STANDARD**

**MINI**

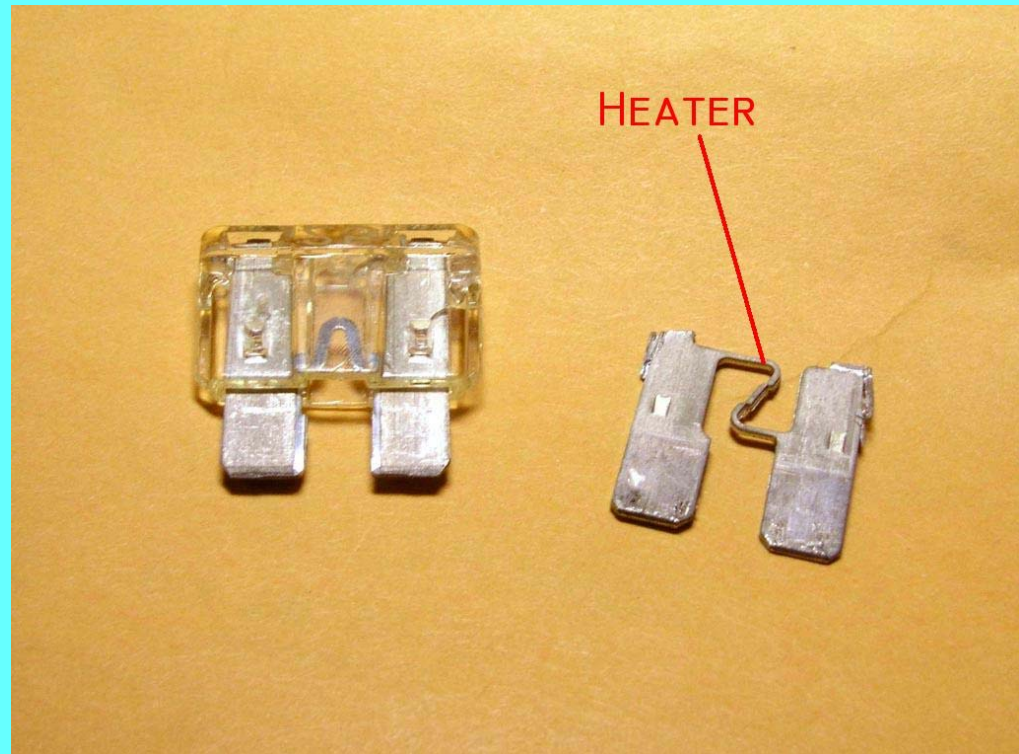
**Color Ratings For MAXI Fuses**

Fuse Amp Rating	Identification Color
20	Yellow
30	Green
40	Amber
50	Red
60	Blue
70	Brown
80	Colorless

- **ATC Plastic low voltage fuses are relatively fast. Note that the 3A curve goes asymptotic to the 4A ordinate at about 1 second and above.**



- Note the one-piece design for fusible section and connection tabs.
- The tabs provide low-area, high-pressure, gas-tight connection with the mating receptacle.

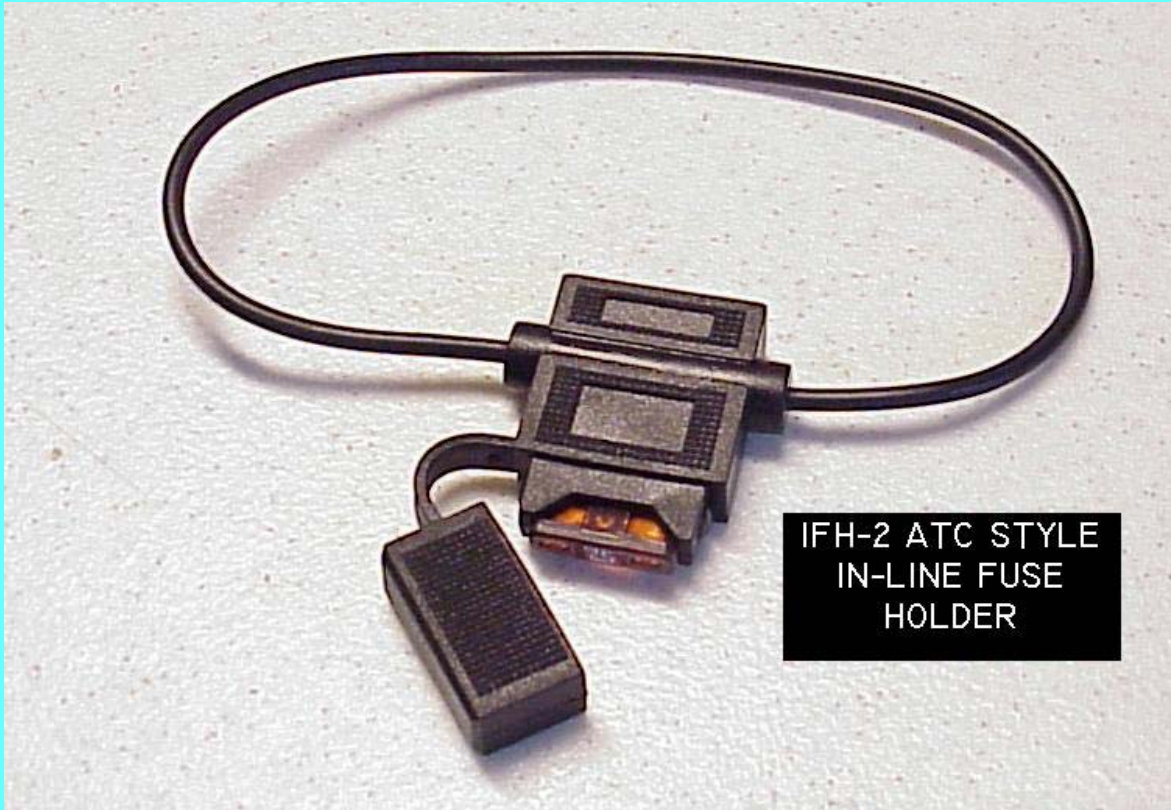


- **A number of manufacturers offer multi-slot, fuse blocks that accept both the standard and miniature automotive, plug-in fuses.**

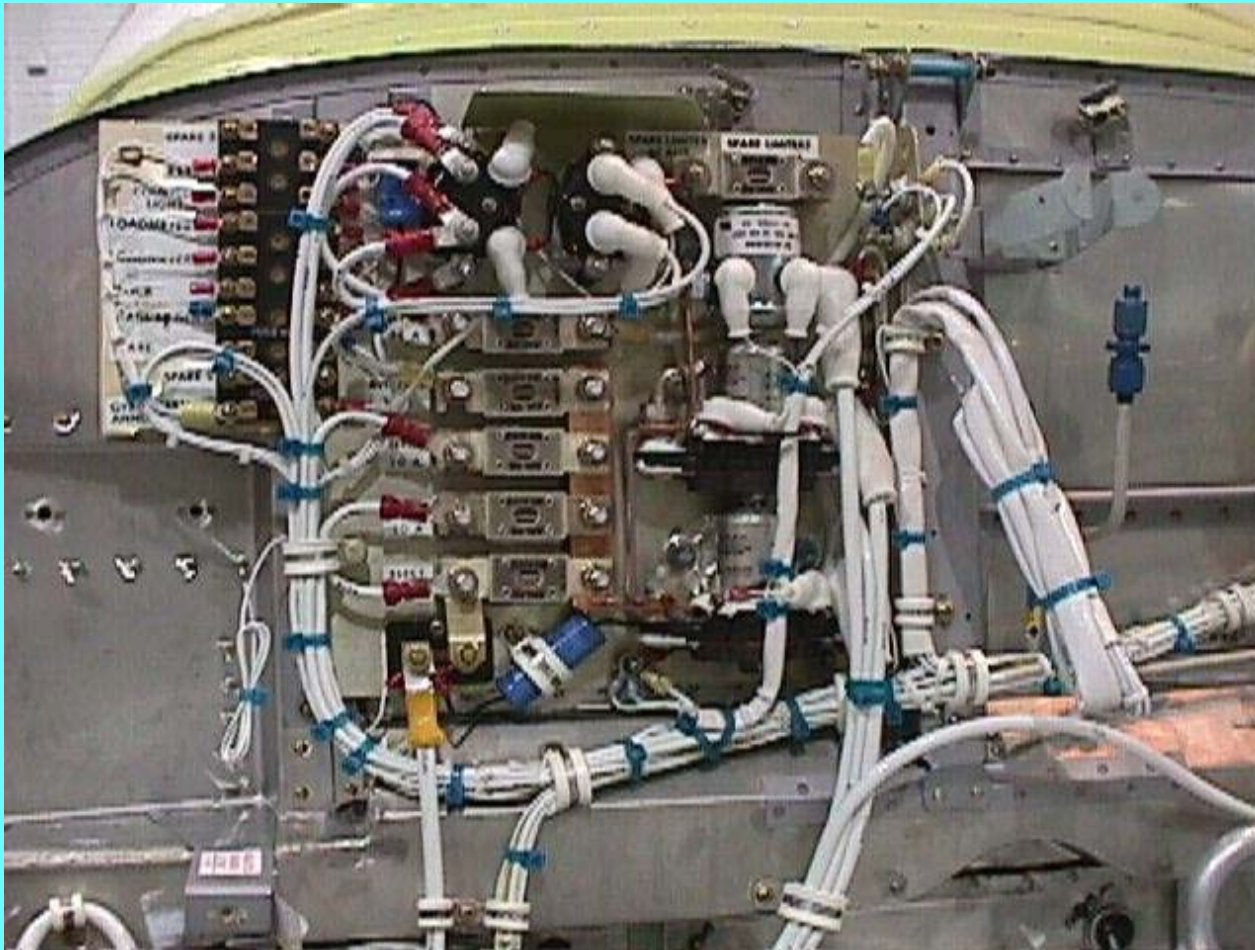


- **This technology offers an exceedingly attractive cost of ownership.**
- **Installs fast (4 screws and Fast-On tabs)**
- **Replaces easy**
- **Low initial cost**
- **Very reliable protection against circuit faults**





**Environmentally robust, single-fuse, inline holders are available from most auto parts stores**



**Many folks are belabored of the notion that fuses are “antiquated” and somehow inferior to the “aircraft quality circuit breaker” . . .**

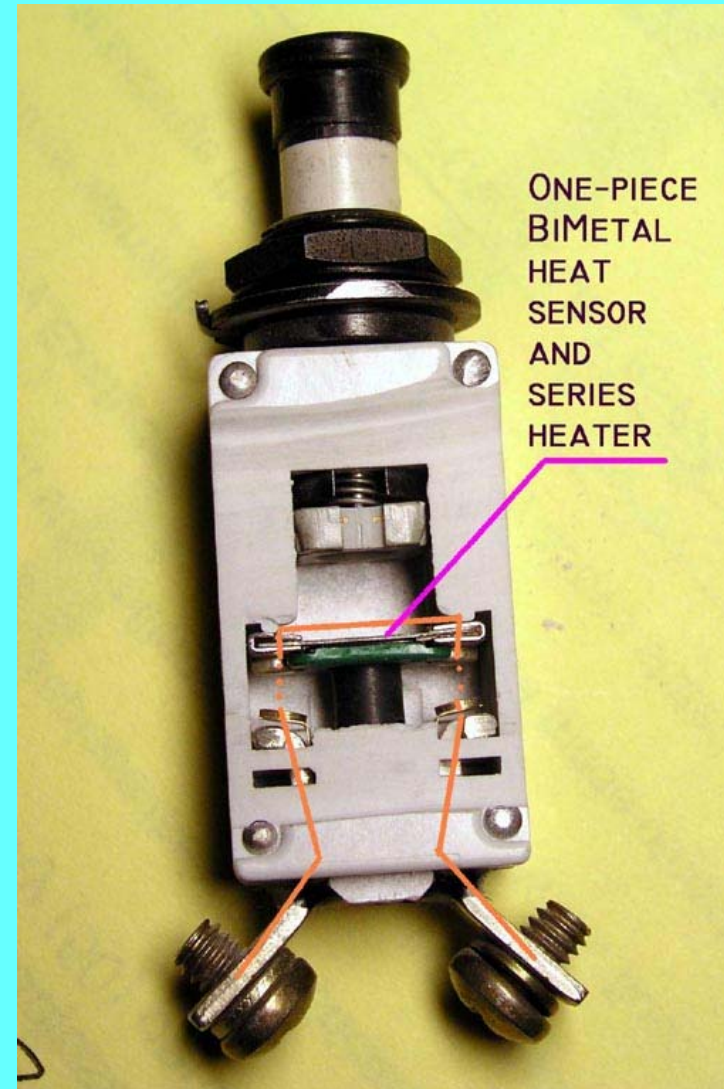
**Consider this view of the firewall on a new A36 Bonanza . . .**

- Modern miniature low voltage breaker
- General purpose breaker-of-choice throughout commercial and military aviation.



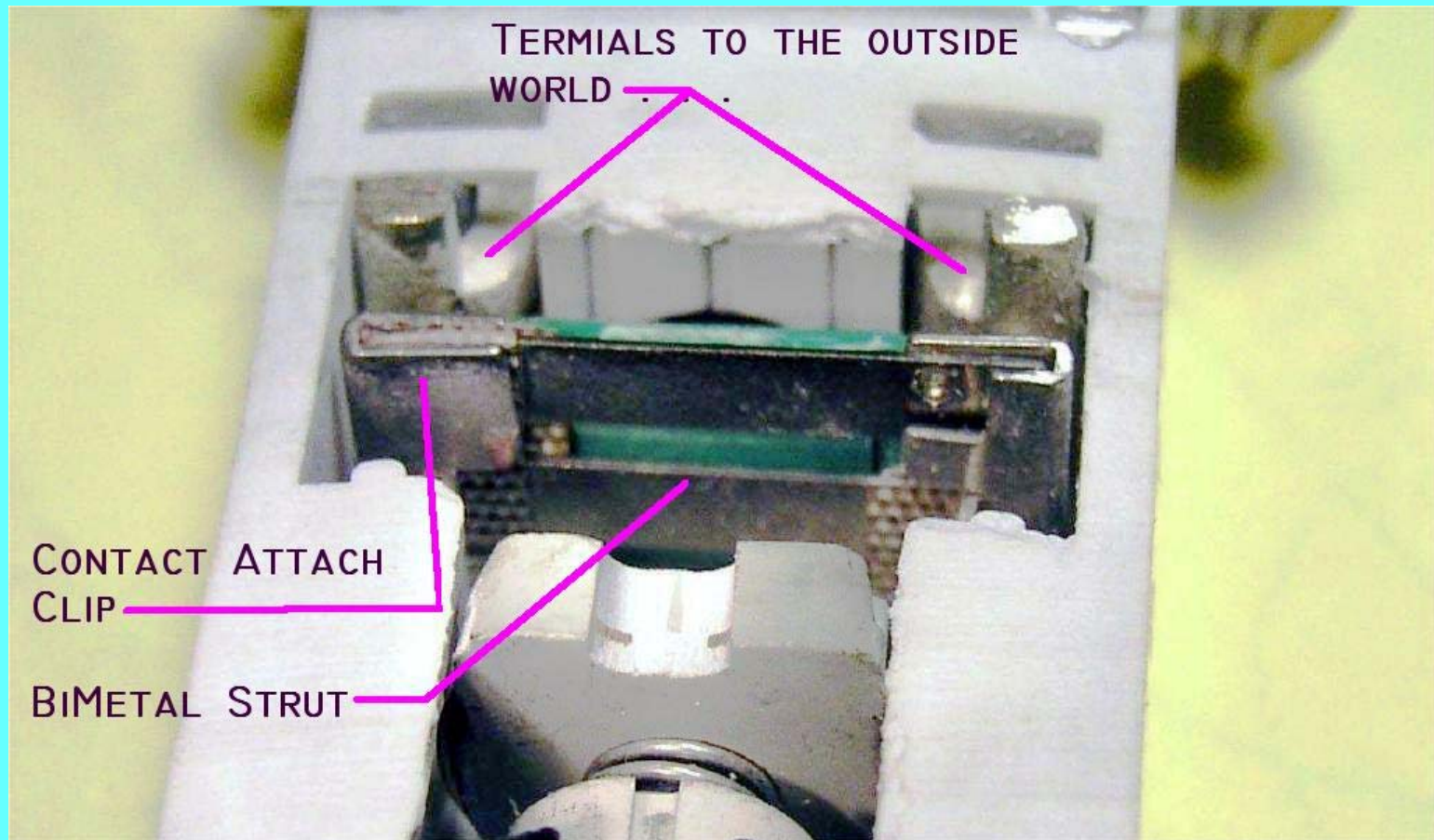


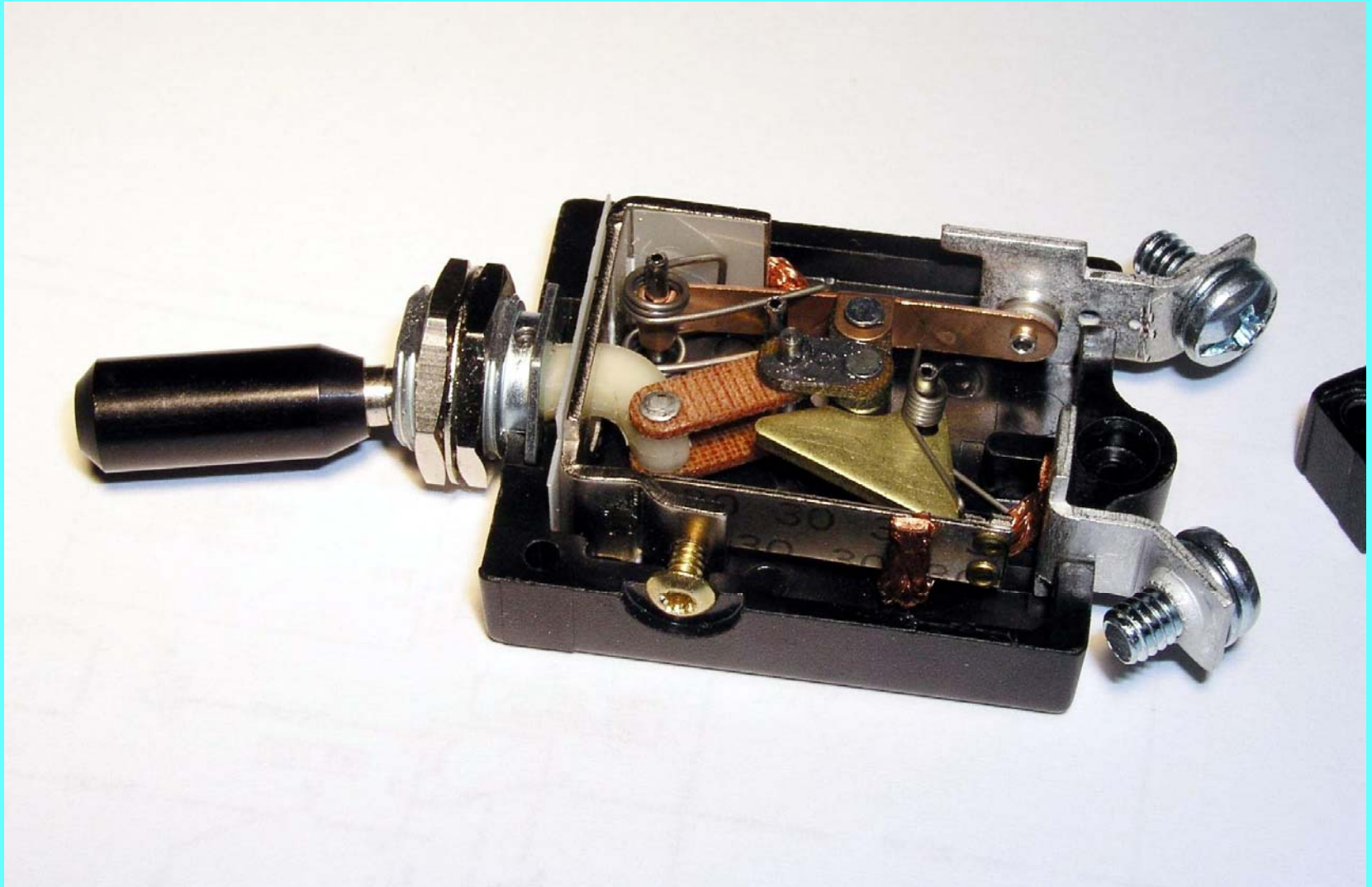
- Modern miniature low voltage breaker
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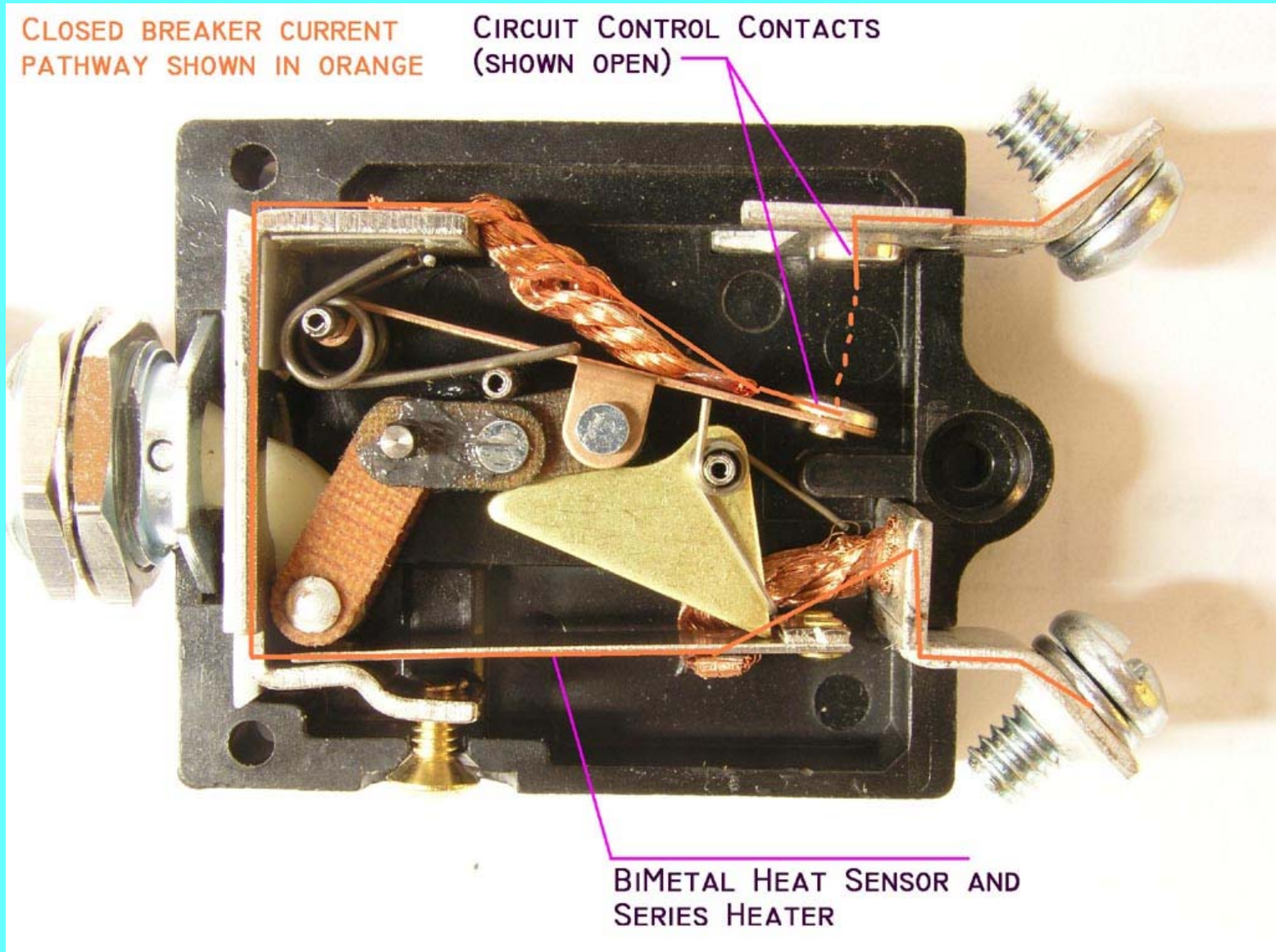


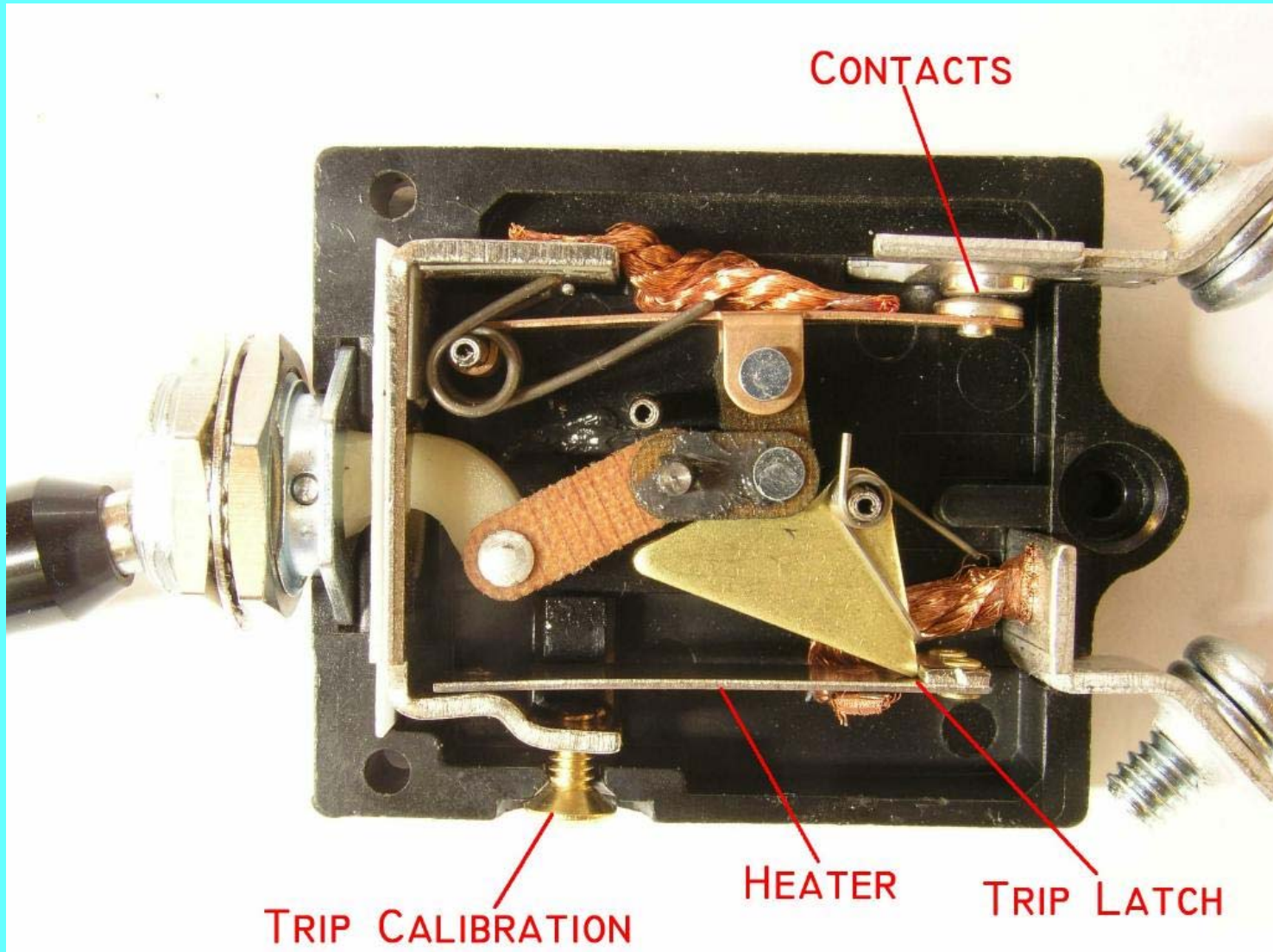
- This design remarkable for lack of braided jumpers, lack levers and shafts, double break contacts, integral heater/contact carrier assembly.



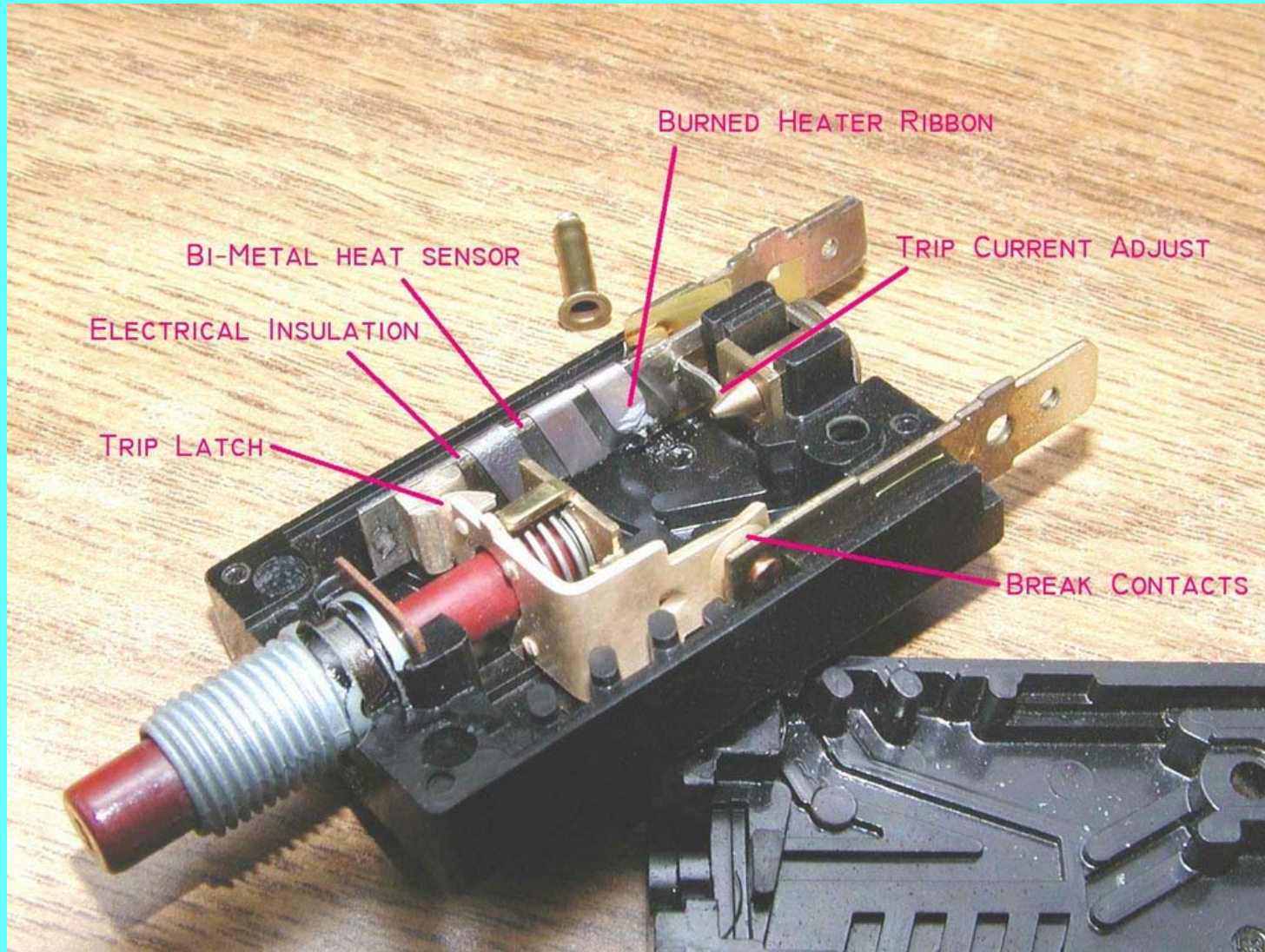








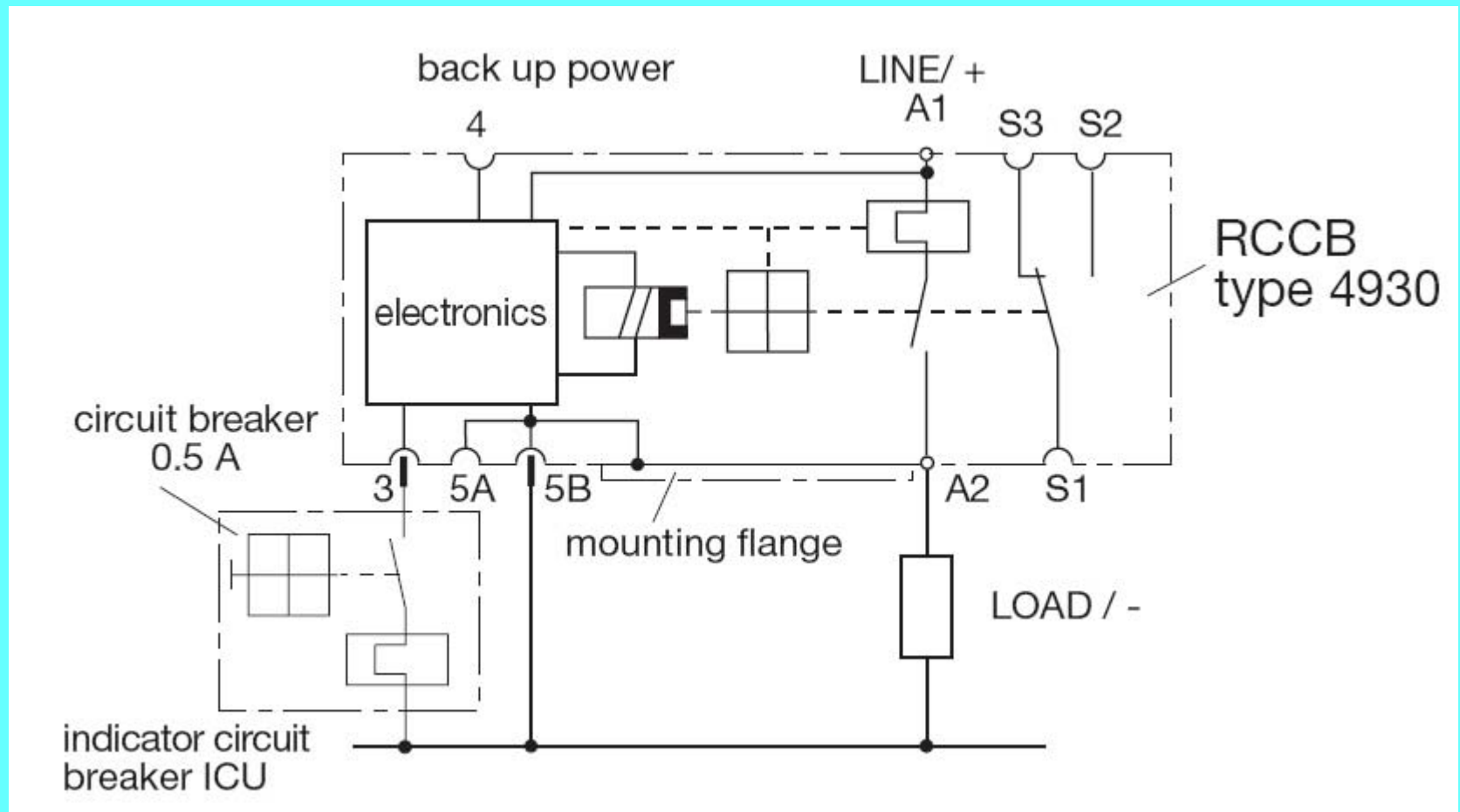




- Remote controlled circuit breakers are a class of contactor fitted with current sensing circuitry. Some products are fitted with “arc detection” circuitry to sense soft faults.



- An exemplar RCCB block diagram shows driving electronics and how it's "slaved" to a small (usually 2A) breaker in the cockpit . . .



- Overview of feeder fault protection technologies . . .
  - Fuses may be fabricated in a huge array of package sizes, fault clearance ratings, system operating voltages and time delay characteristics. Fuses are generally faster than breakers operating in milliseconds when present with hard faults.



- Overview of feeder fault protection technologies . . .
  - Circuit breakers are fuses that don't need replacement but they're more expensive, installation labor intensive, and take up more room in the airplane. They're generally slower than fuses.
  - Switch-Breakers are mechanically complex and not nearly as long lived as separate switch-breaker or switch-fuse combinations. However, they do offer some savings in manufacturing labor.

- Overview of feeder fault protection technologies . . .
  - Remote Controlled Circuit Breakers (RCCB) are electronically controlled contactors that are very versatile. They're easy to tailor for trip time vs. current characteristics. They also offer auxiliary indication and control contacts.
  - RCCBs may also be configured to sense the unique signature of a soft fault (arcing at current levels below the current rating of the breaker).