Switches, Relays and Contactors

- **The switch is one of the oldest technologies in the electrical electronics industry.**

- **It's task could not be simpler . . . Open and Close an Electric Circuit.**

- **The science of making a switch last and the art of adapting it to millions of different missions drives an huge variety of products from which to choose.**

Two “goesintas” and one “goesouta”

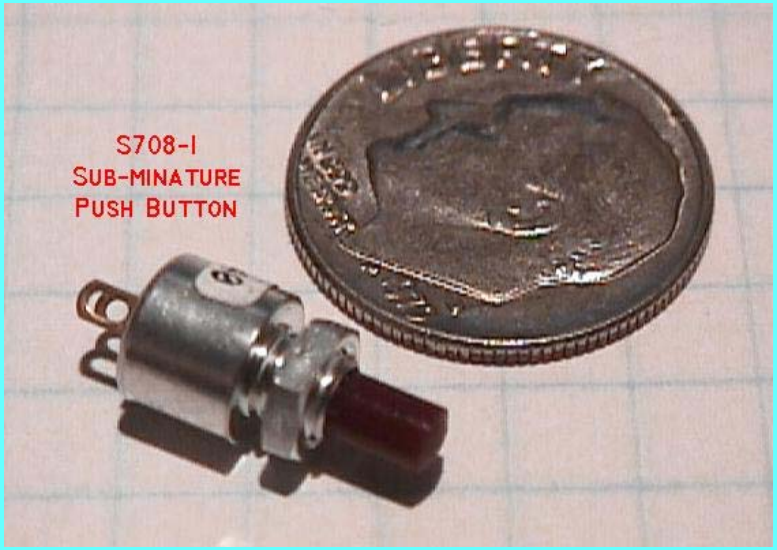
Single Pole, Double Throw SPDT

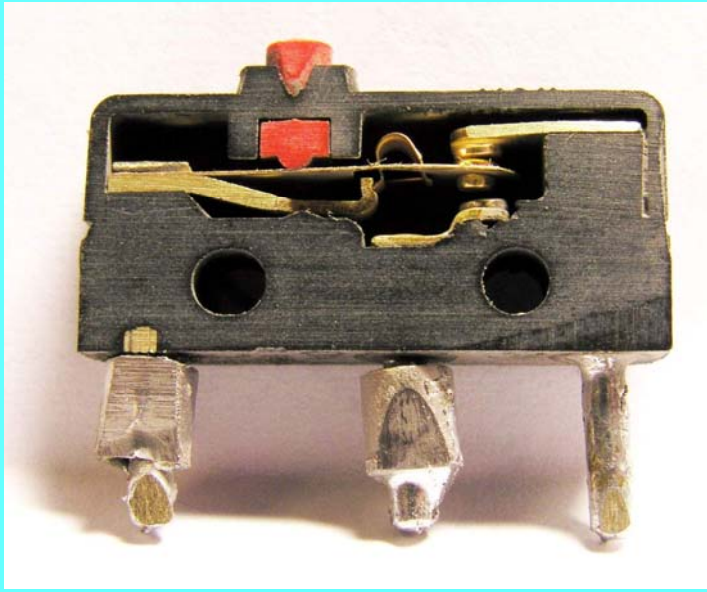
Rudimentary Knife Switch

Single Pole, Single Throw (SPST)

AEC Weekend Seminars

Switches, Relays and Contactors



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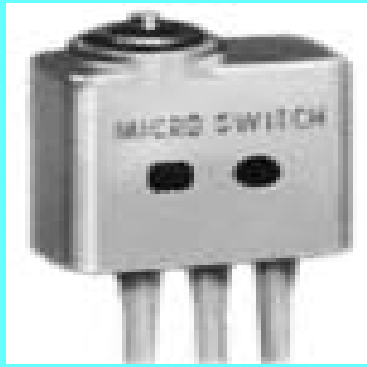
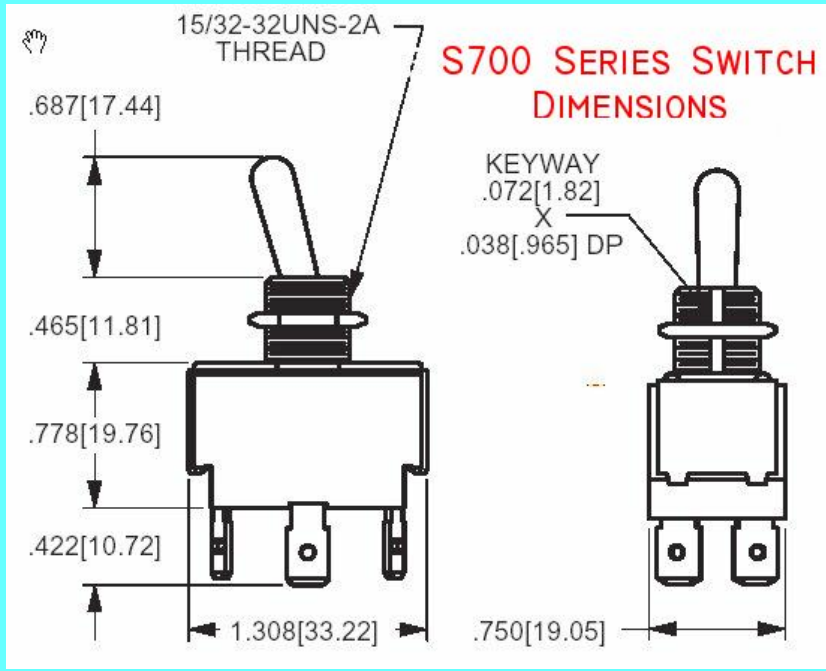
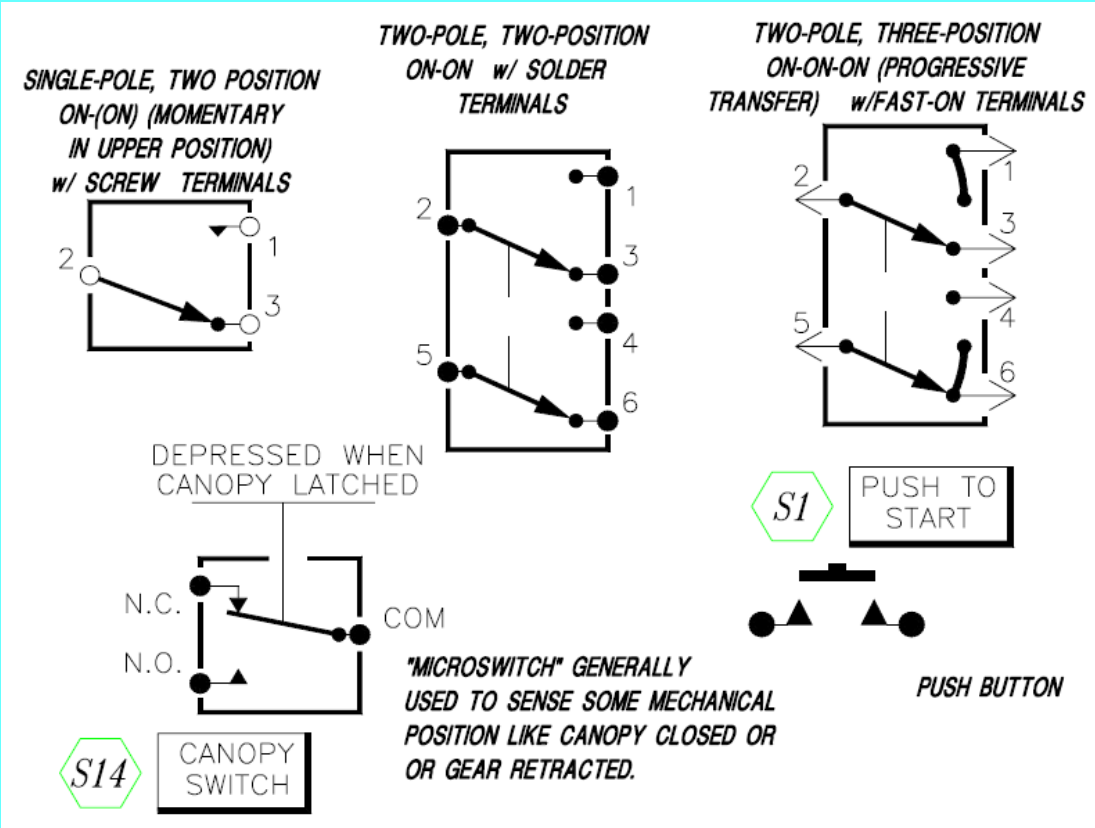

MICRO SWITCH

- **My personal favorite switches are the bat-handle toggle-switch.**
- **They are offered by hundreds of manufacturers in interchangeable styles over the full range of qualities and functionality**
- **The mount with easily fabricated, round holes.**



- **If you choose to use more exotic devices, keep in mind that replacements are brand and part number specific.**
- **You may wish to acquire and preserve spares as a hedge against later procurement problems.**



Schematic symbols can be very informative with respect to characteristics of a device.

- **Progressive transfer**
- **Momentary (spring loaded) connections**
- **Terminal style**
- **Switchspeak is pretty easy to master. For example:**

Switch in upper left is SPDT ON-(ON), parentheses designate a momentary (spring loaded) position. A push-button would be SPST OFF-(ON).

What's all this "ratings" stuff anyhow?

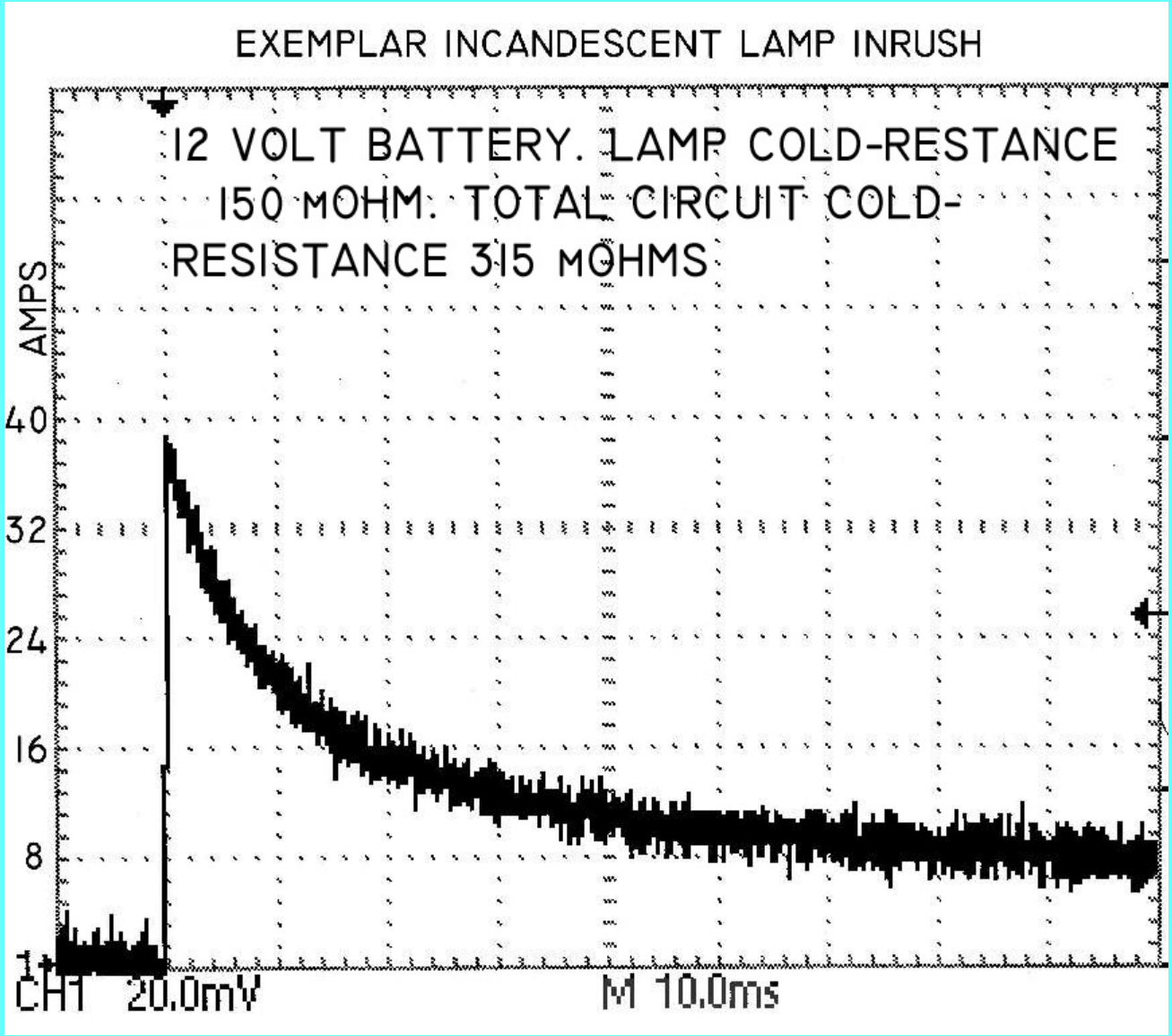
- **Every switch has both electrical and mechanical endurance specifications.**

- **Mechanical endurance says "good for so many cycles under least stressful electrical load". . . Or perhaps no load at all.**

- **Electrical endurance will speak to currents and types of loads at specified voltages.**

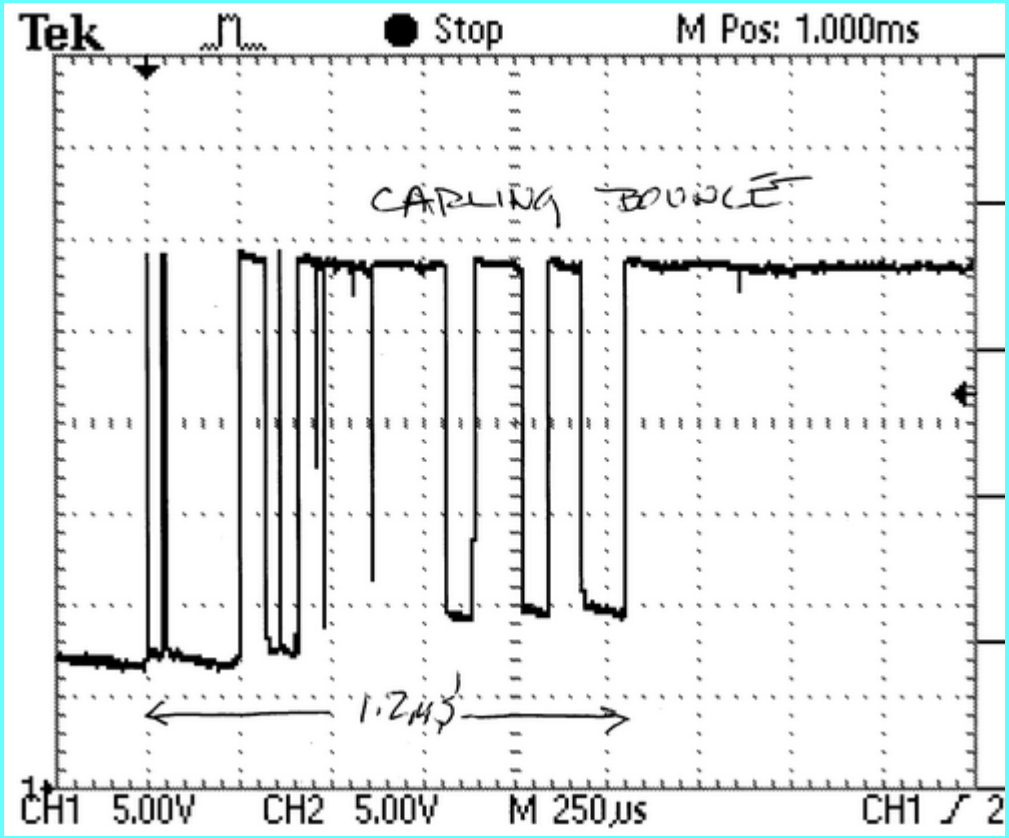
Voltage ratings are maximum recommended.

- **Current ratings are adjusted according to type of load.**
- **Common types of loads are “Resistive”, “Inductive” and “Lamp”.**
- ***You can not know how many cycles any given switch is rated for under any electrical load conditions without consulting engineering data.***



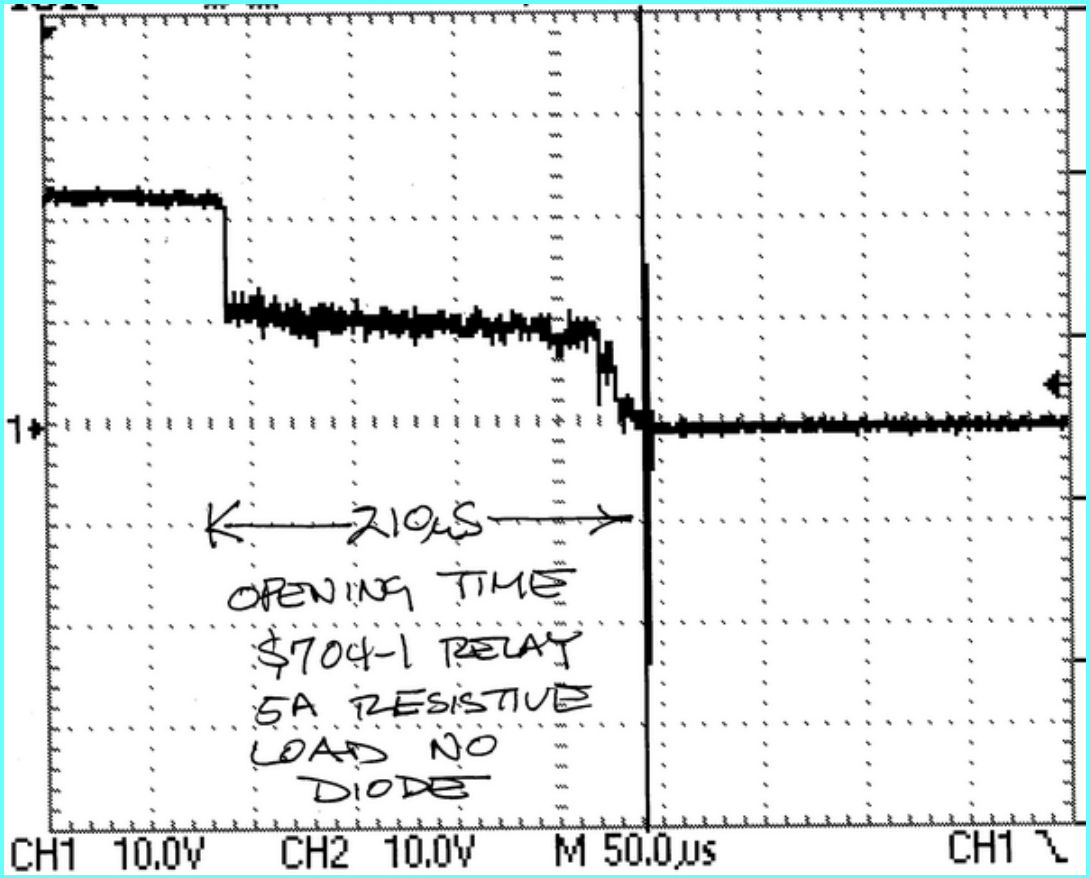
"Lamp Load" references the high inrush characteristic of the incandescent lamp.

Here is a inrush plot for a 55W automotive headlamp bulb.



Typical closure signature for a Carling toggle switch . . .

The contacts CLOSE and then OPEN at least 12 times in ~2 mS.



Contact closure is a CURRENT problem . . .

Contact opening is a VOLTAGE problem . . . An arc forms between the spreading contacts.

- **Some years ago, a writer for Van's AirForce published an article offering advice based on a hosed interpretation of the specification data.**
- **In the following slide, we'll look at engineering catalog data for the full line of Honeywell Microswitch toggle switches.**
- **Note that ALL switches have SOME capability at ALL levels of voltage, varying loads in both AC and DC systems.**

Toggle Switch Ratings Table from Microswitch Catalog									
Elect Code Rating	28 VDC			115 VDC	250 VDC	115 VAC			230 VAC
	IND	RES	LAMP	RES	RES	IND	RES	LAMP	RES
1	15	20	5	.75	.5	10	15	3	6
2	10	15	4	.75	.5	7	15	2	6
3	15	20	7	.75	.5	15	15	4	6
4	10	18	5	.75	.5	8	11	2	6
5	12	20	5	.75	.5	15	15	4	6
6	10	18	4	.75	.5	8	11	2	6

- **Note that ALL switches have SOME capability at ALL levels of voltage, varying loads in both AC and DC systems.**

- **What the chart doesn't tell us is mechanical or electrical cycle specifications for service life of these switches.**

- **Know that nobody rates a manually operated switch for less than several tens of thousands of cycles. Relays are quite often rated in hundreds of thousands of cycles.**

- **The average flight time for a single-engine airplane in the US is ~50 hours/year.**

- **Assuming flight cycle times of 1 hour, a switch in an airplane may get operated under load perhaps 50 times a year . . . usually less.**

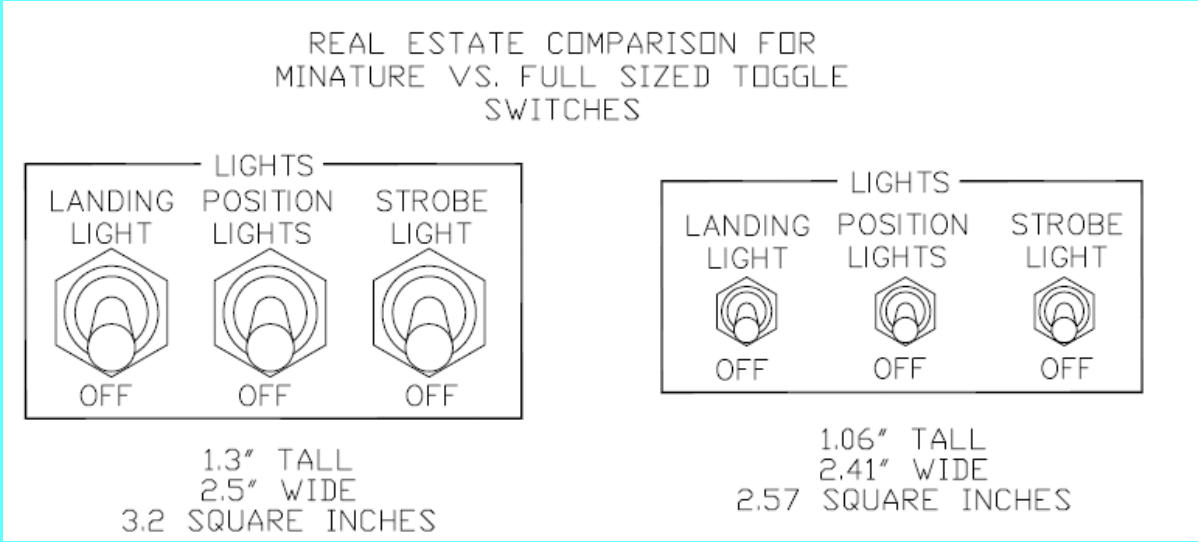
- **How long will it take to ‘wear out’ a 10,000 cycle rated switch?**

- **Experience has demonstrated that a majority of switch failure occurs due to environmental as opposed to service factors.**

- **A switch or relay is more likely to loose functionality due to corrosion or mechanical damage than from worn out contacts or mechanisms.**

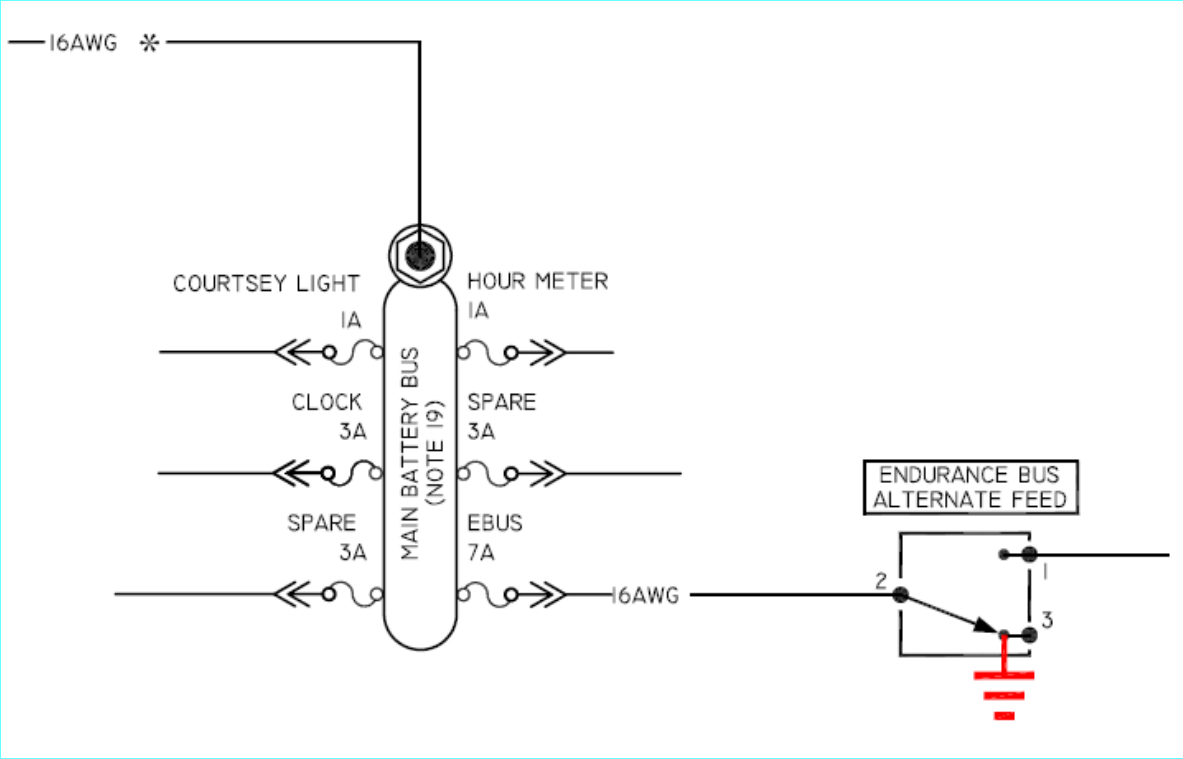
While miniature switches MAY be considered, keep in mind that space on the panel for miniature switches is determined largely by LETTRING sizes for labels.

Half-size switches do not translate to 1/2 sized dimensions for panel placards.

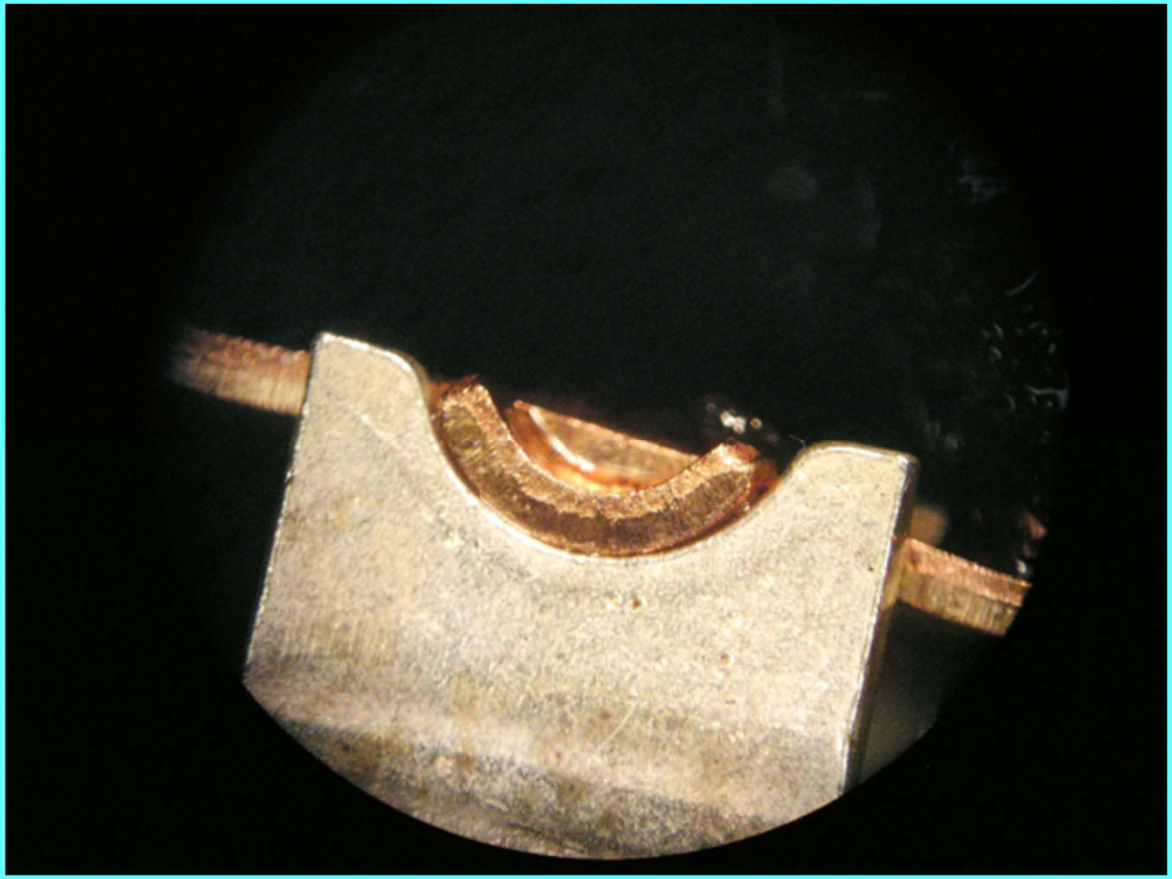


Anatomy of a Switch Failure:

- The switch in this case study pops the supply fuse when the switch was turned OFF . . .



Typical “teeter-totter” switch mechanism. Operating the toggle presses down on either side of the central pivot to rock the contact assembly



- The “teeter-totter” pivots on a cradle that is connected to the switch’s center terminal.

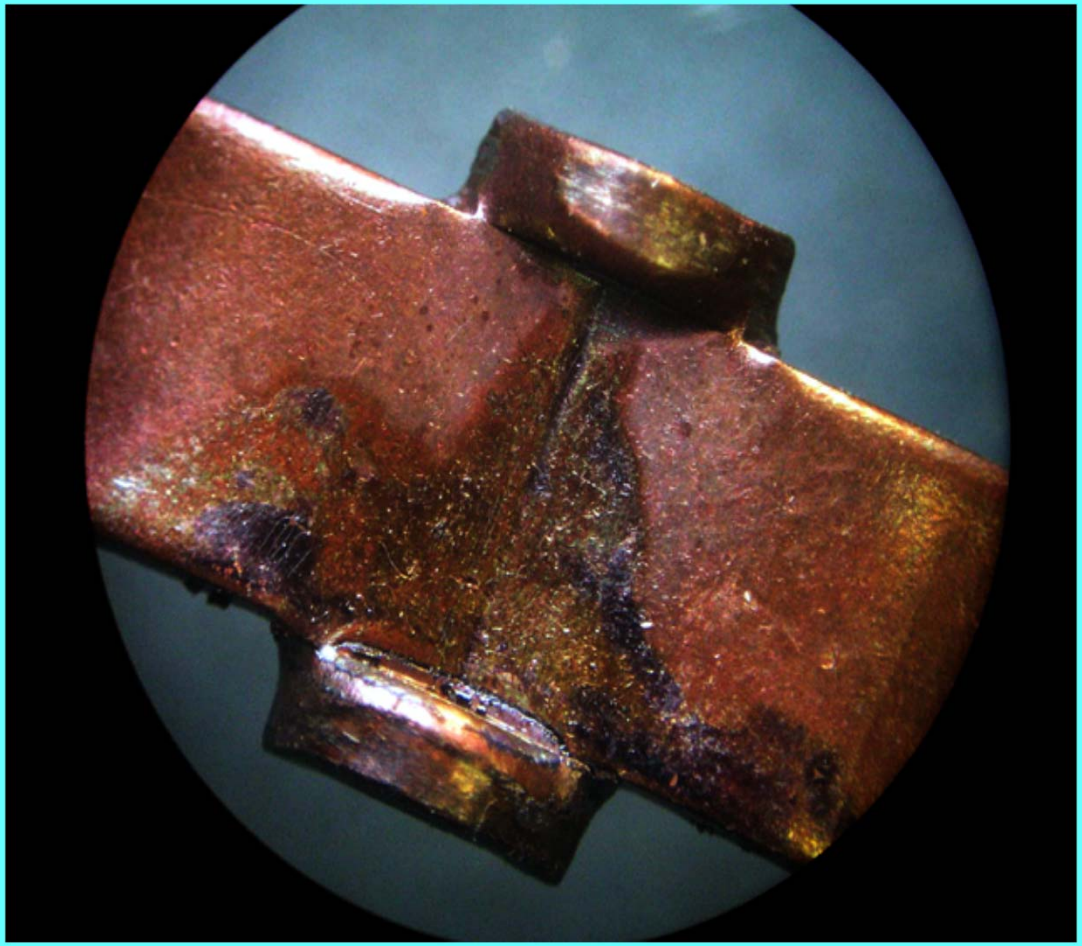
- The need for good electrical connection here is obvious

Signs of overheating and loose terminals . . .

The teeter-totter is sufficiently curved to allow OFF end of switch to rise against the grounded frame . . .

Note bowed teeter-totter and burn mark on inside surface of frame . . .

The failed and a new teeter-totters . . .



The results of heating at the pivot point of the teeter-totter is evident.

The contacts for this switch were in excellent shape.

This switch was NOT overloaded. It was powering a strobe system with an average current draw under 5A.

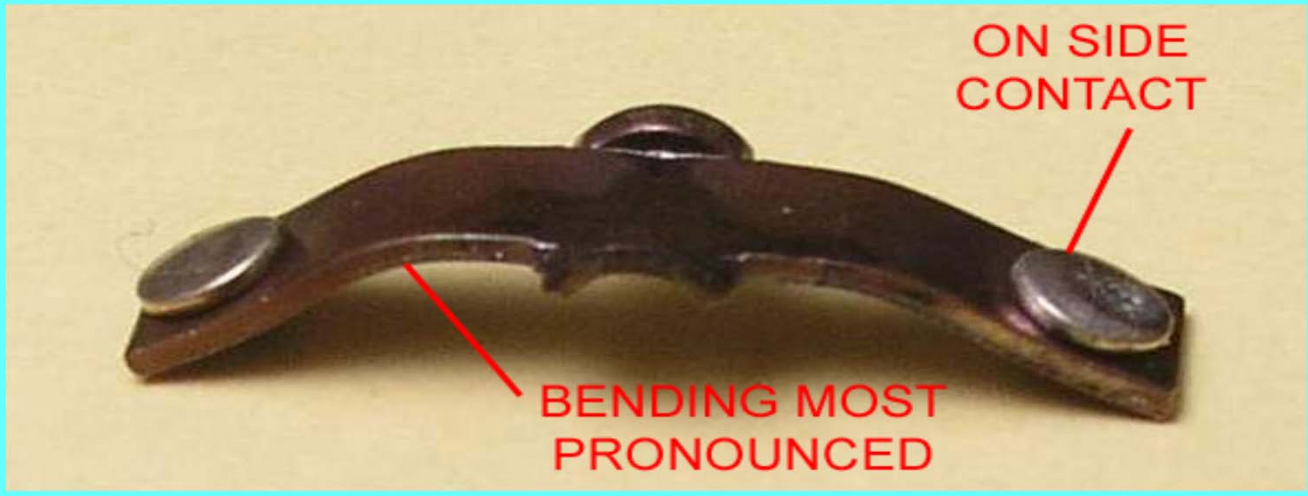
Failure began at the upper pivot point which transferred all the load to the lower pivot and precipitated the heat-induced failure.

The teeter-totter was bent more on the OFF (non-current carrying) side of the part.

This means that the part was being hammered more strongly in the transition from ON to OFF (hot) than during OFF to ON (cool).

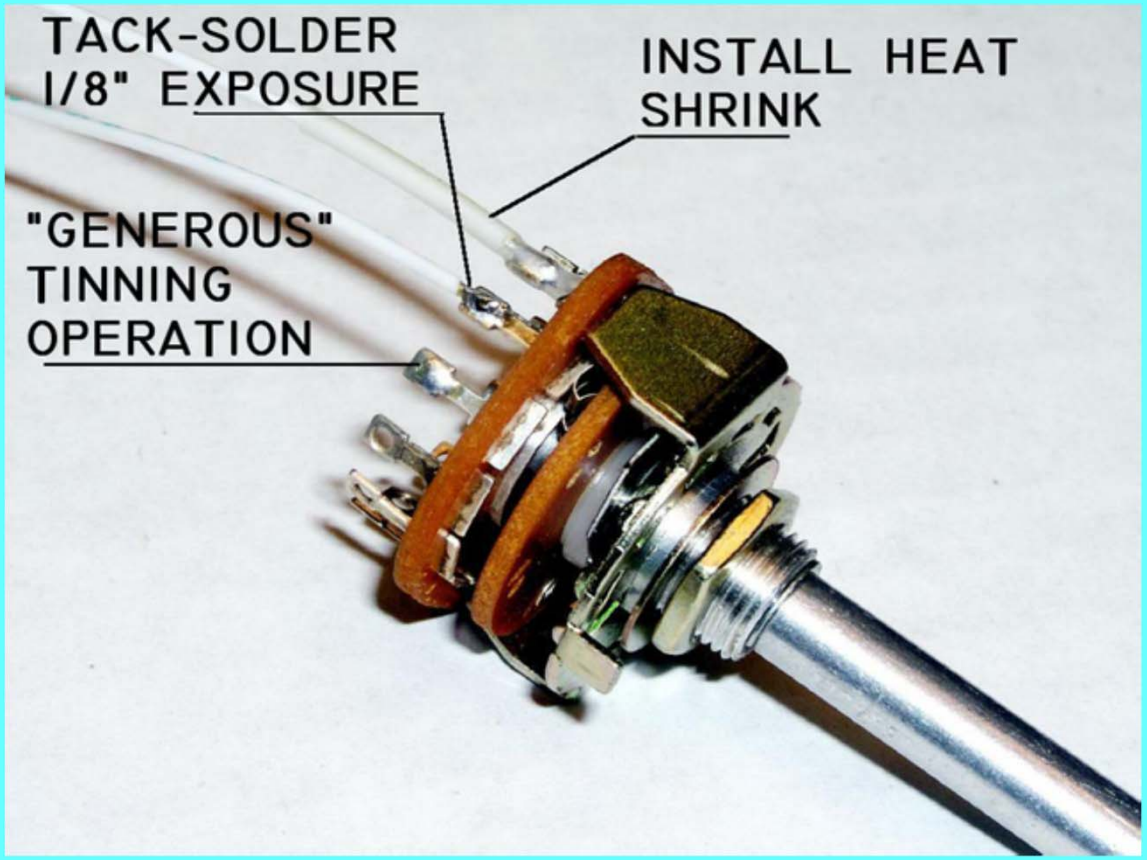
This switch wasn't very old (a few hundred flight hours).

Failure started due to corrosion/poor fit at one pivot point. Heating at the over-loaded pivot caused precipitous increase in resistance that ultimately took t he temper out of the



Depending on the location of your battery and complexity of your system a MANUAL battery master switch may be considered.

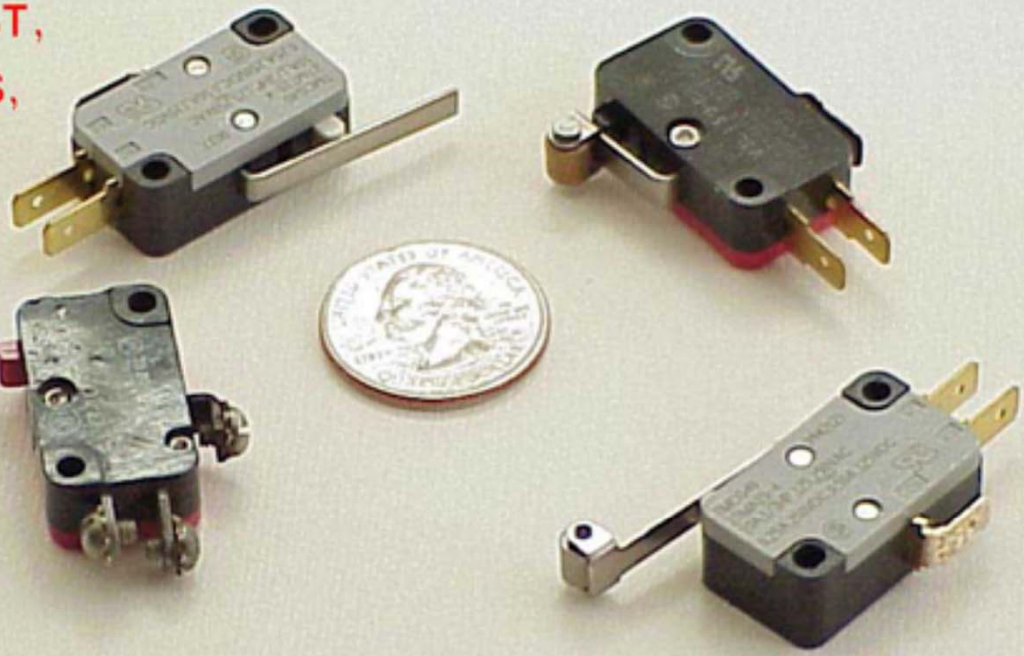
These are relatively light, inexpensive and easy to find. Speed shops and marine parts suppliers are good sources.



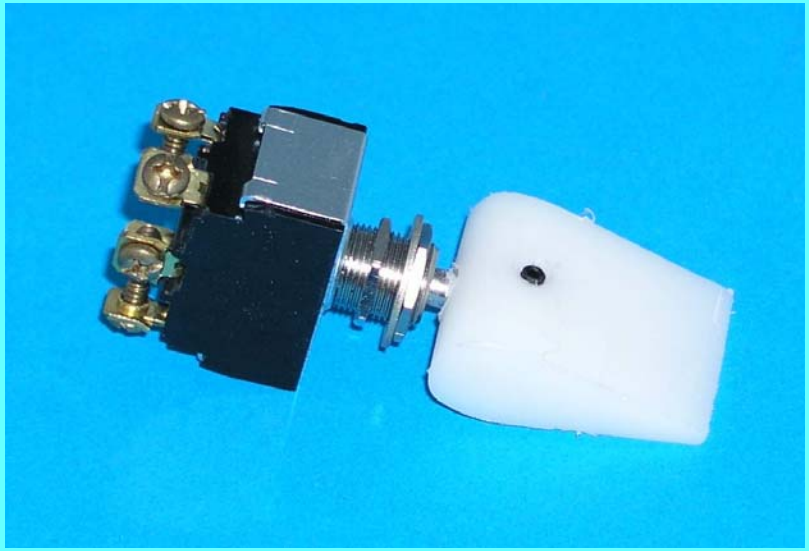
Rotary selector switches offer multi-pole, multi-position functions in a relativelysmall space.

Commonly used for transmitter selector switches or muitiple thermocouple switches were 2 to 3 lines are selected from 2 to 6 sources.

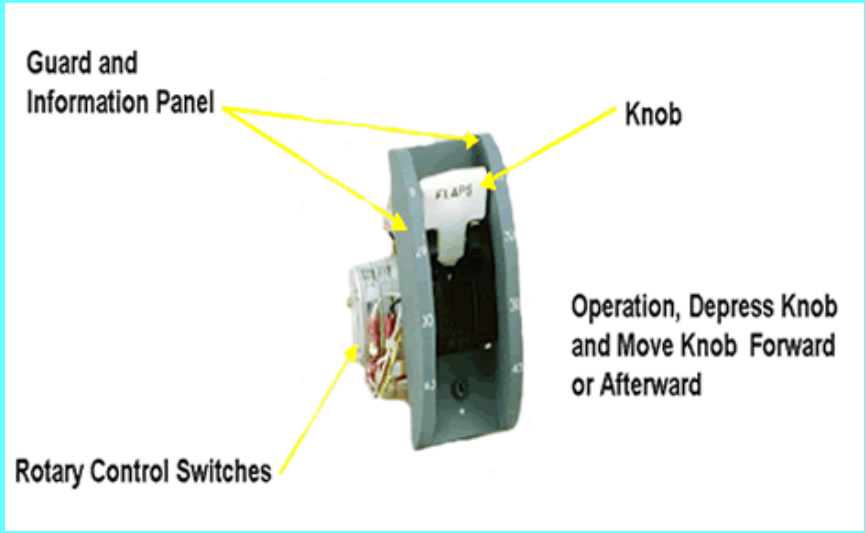
AN ASSORTMENT OF BASIC SWITCHES WITH EXAMPLES OF THE VARIOUS ACTUATOR ACCESSORIES AVAILABLE. YOU CAN GET 'EM LARGER, YOU CAN GET 'EM SMALLLER BUT THIS SIZE AN STYLE OFFER A GOOD COMBINATION OF LOW COST, ROBUSTNESS, AND EASE OF USE.



CHECK OUT THE OMRON BASIC SNAP SWITCHES AT WWW.DIGIKEY.COM DIGIKEY OFFERS A VARIETY OF DEVICES IN THIS STYLE FOR A COUPLE OF DOLLARS EACH.

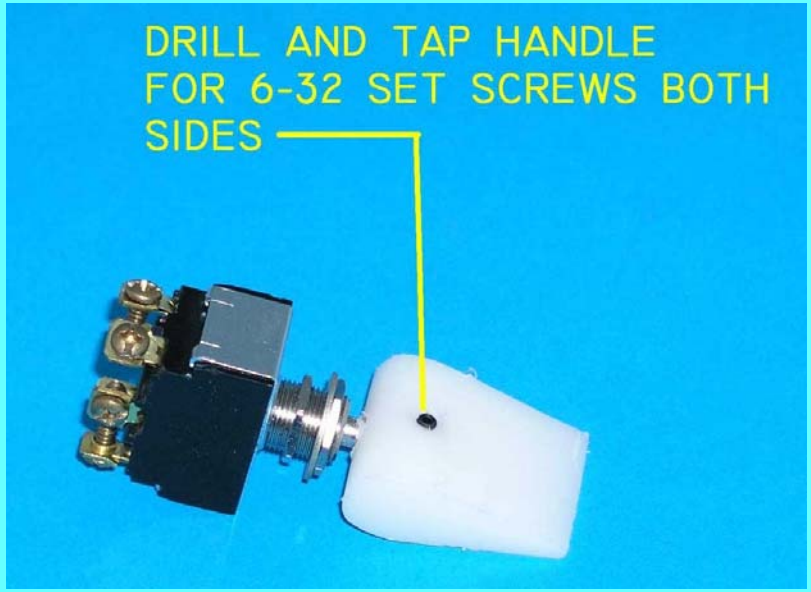


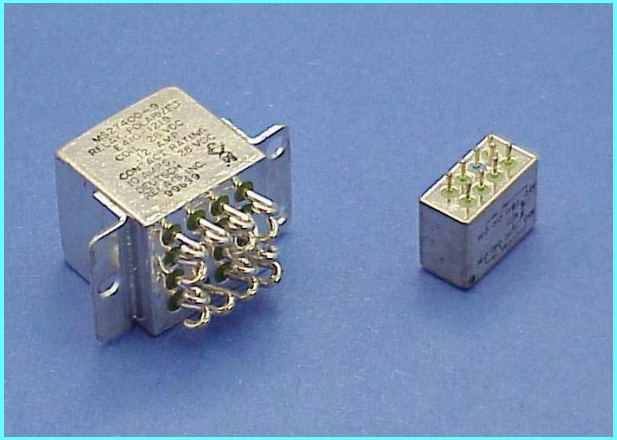
Specialty switches like these crafted for flap controls can be expensive when purchased but relatively easy to build in the shop




SAND FLATS ON UPPER AND LOWER SURFACES OFF TOGGLE HANDLE
DRILL FOR SNUG FIT ON HANDLE

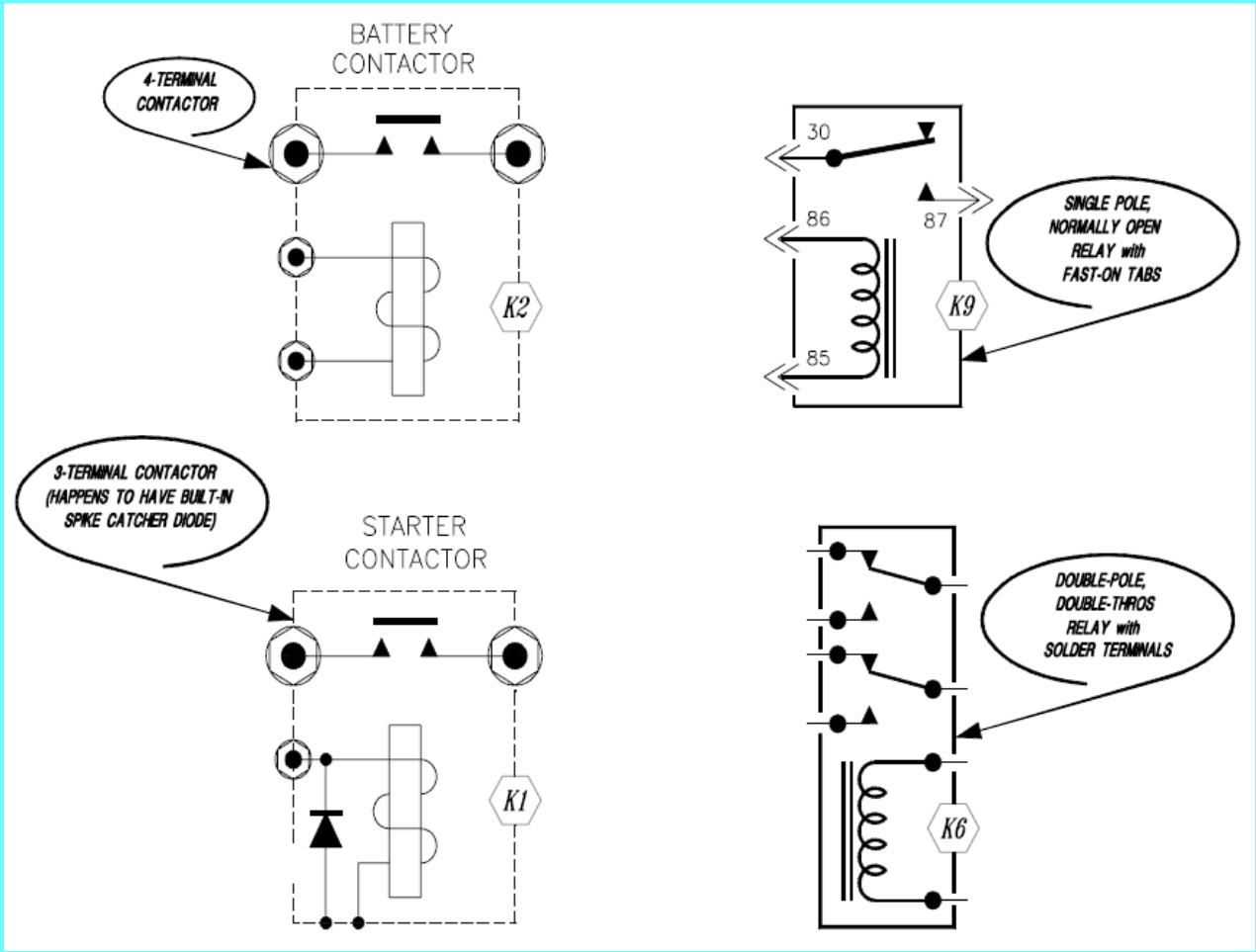

TOGGLE WITH PIN SHAFT AS OPPOSED TO BALL-SOCKET PIVOT (MICROSWITCH IS GOOD BRAND)
FLAP HANDLE SCULPTED FROM ALUMINUM STOCK. APPROX 1.5" LONG x 1.2" WIDE x .625" THICK


DRILL AND TAP HANDLE FOR 6-32 SET SCREWS BOTH SIDES



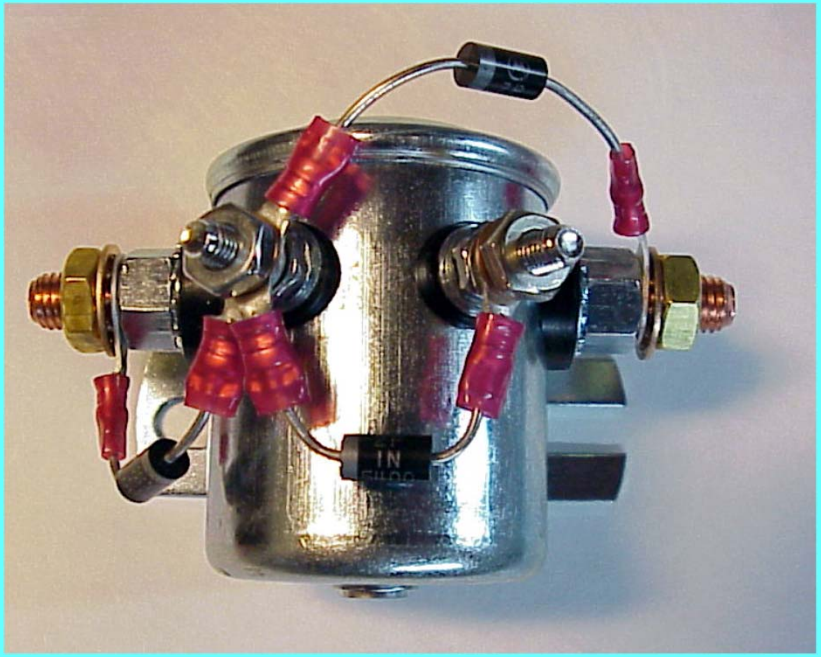
Contactors and relays are simply remote controlled switches. They are used to control:

- Currents too large and/or remote from the cockpit.
- Multiple circuits



Relays and contactors are REMOTLY CONTROLLED switches used for:

- **Controlling large loads**
- **Controlling multi-pole circuits.**



This style contactor has been used on hundreds of thousands of light aircraft.

Power is conducted between the large studs by this copper disk . . .

The disk is raised off the stationary contacts by a spring . . .

The disk is pressed down on the stationary contacts by magnetic attraction to this iron core piece . . .

Magnetic closing force is supplied by this coil of wire around the movable core piece . . .

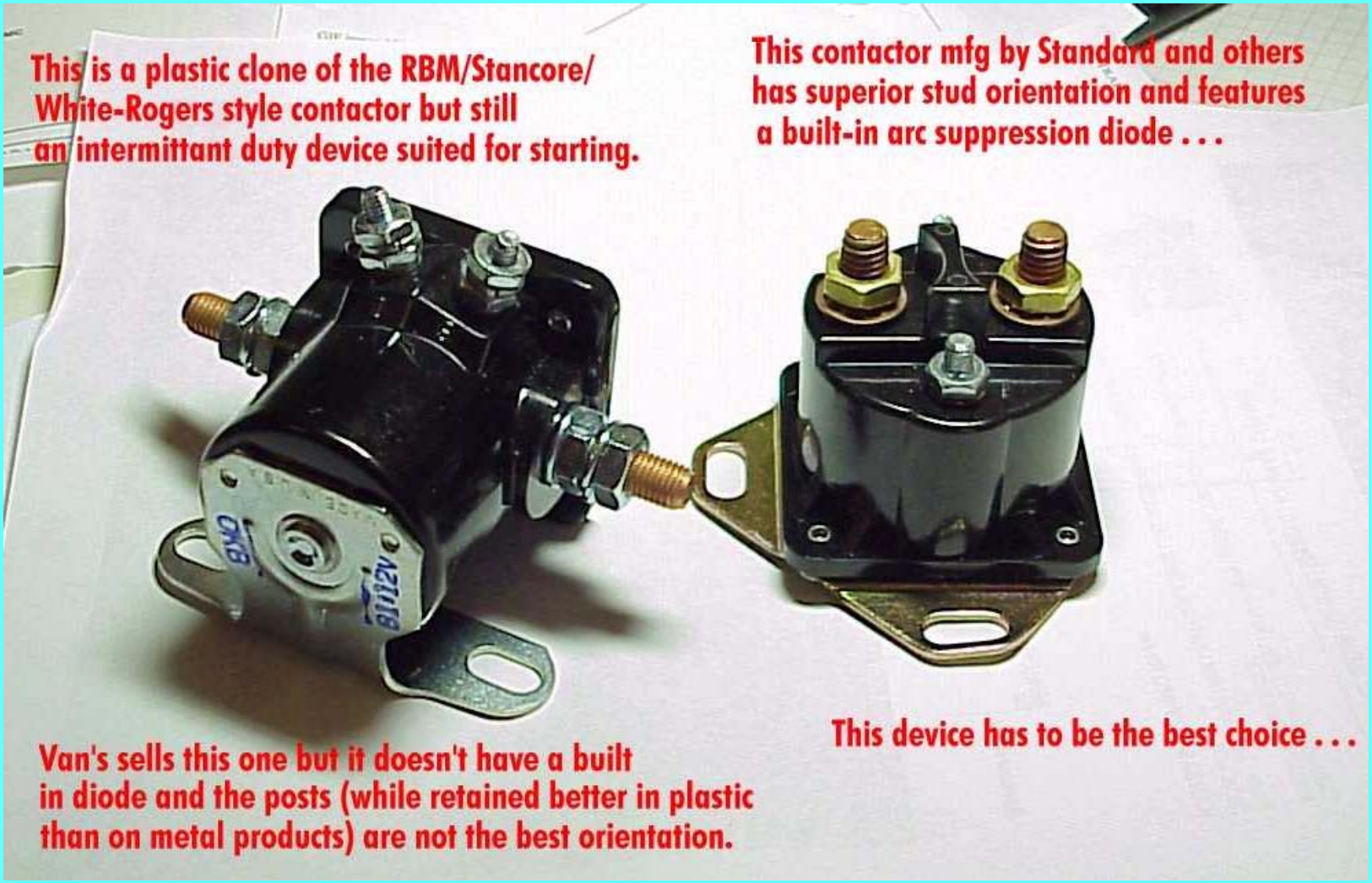
The ‘Connection has fielded a lot of flack over the years for continuing to suggest this style contactor in continuous duty applications on OBAM aircraft. Most detractors cite personal anecdotes of failures . . . Others view this device as ‘only suited for use on garden tractors’.

Failures do happen . . . In this case, failure was not due to abuse, misguided application or environmental conditions.

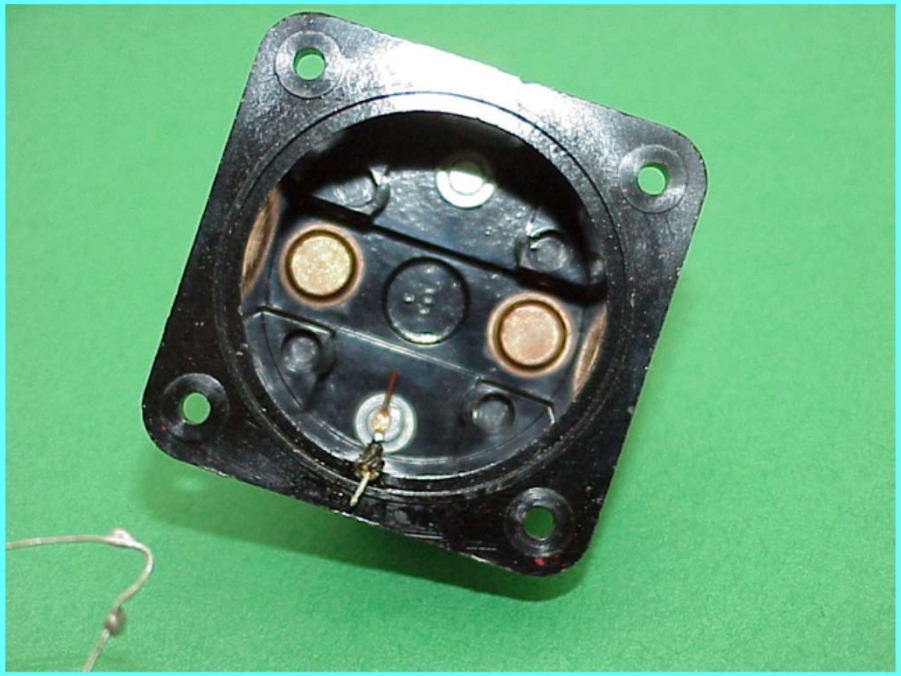
In this instance, the solenoid coil wires were not soldered to their terminals. Continuity was sufficient to pass acceptance tests at factory. The contactor also operated successfully for several hours on the airplane.

It has been suggested that only contactors of this genre' are suited for use on airplanes . . .

This contactor was removed from the air conditioning system of a King Air. The plastic components readily combusted . . .


This is a plastic clone of the RBM/Stancore/
White-Rogers style contactor but still
an intermittant duty device suited for starting.
This contactor mfg by Standard and others
has superior stud orientation and features
a built-in arc suppression diode . . .
Van's sells this one but it doesn't have a built
in diode and the posts (while retained better in plastic
than on metal products) are not the best orientation.
This device has to be the best choice . . .

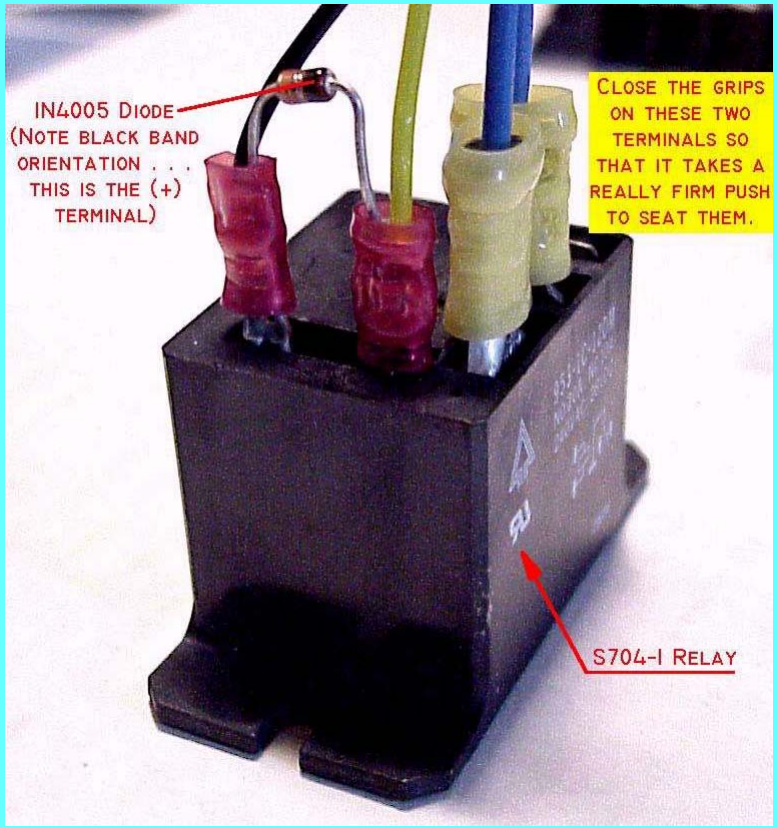
Intermittent duty, high current contactor for use with starters. Note small contact areas.



Moving “contacts” are light, springy, sheets.
Performance depends on small area, high pressure connections.

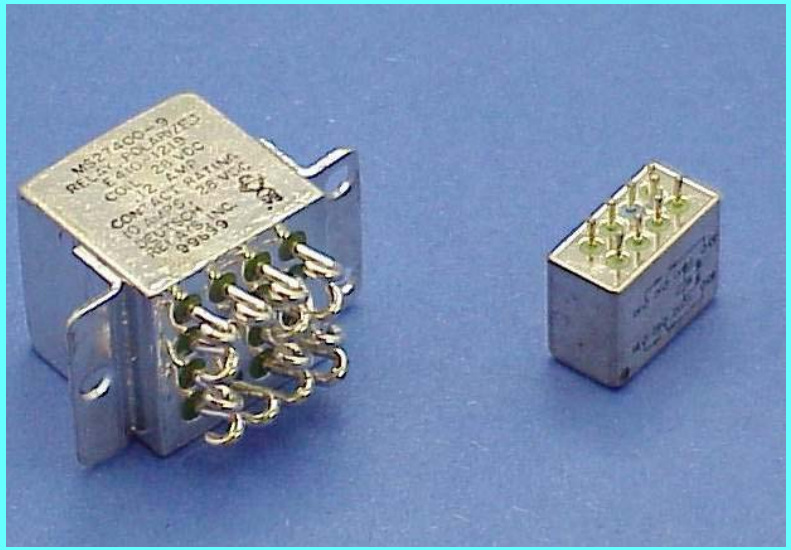
Contactor on the left is a $50 device found on many industrial/automotive applications.

The item below is popular with folks determined to reduce “power losses” in their system but these critters cost about $150.



Examples of medium power relays (10 to 30A ratings)

Automotive plastic relay on left is SPST and costs about $4



Sealed mil-spec relays can cost $30-$150 in small quantities.

Here are some views taken in the ‘hell hole’ of a Beechjet. They show a catastrophic failure of an ‘aircraft quality’ relay . . .

used in the tail surfaces electric de-ice systems.

Yours truly started a development program for an all solid state replacement . . .

. . . an administrative decision moved the program out of house.