DR. I. Q., I HAVE A LADY IN THE BALCONY…
Why do tips wear out so fast?

Tip life is affected by several things. Predominant amongst them are tip temperature, abrasion, and chemical reaction between the tip, the solder, the flux and the board. We all know that the higher the temperature, the shorter the tip life will be; we all know that rubbing the tip across a rough surface will wear away the metal; we all know that a very active and highly acidic flux will devour the tips much faster than will a nice, calm one.

Let us then consider the effects of chemistry as they obtain to intermetallic reactions.

Relative (chemical) activity levels and Brinell hardness values for candidate plating metals.

METAL	ACTIVITY	HARDNESS
Chromium (Cr)	Relatively highest	1120
Iron (Fe)	↓	490
Cadmium (Cd)		203
Cobalt (Co)		700
Nickel (Ni)		700
Tin (Sn)		51
Lead (Pb)		38
Antimony (Sb)		294
Bismuth (Bi)		94
Copper (Cu)	Relatively lowest	87

If you place two of these dissimilar metals together and either wait a while or heat them, or both if you are so inclined, you will discover, upon analysis, that the less active metal has been invaded by the more active one. Kind of like international politics, that way.

Tin is higher on the activity scale than copper; therefore tin will begin to replace copper at soldering temperatures, eating away at the tip; hence it is common practice to plate the tips with a more active metal. Iron and nickel are higher on the activity scale than tin, so are useful for plating soldering tips[1]. They will not be eaten away by the *tin*; this is an imperfect world, though, so other things happen to them.

(Note that many HMP solders are rich in tin. If the plating cracks the copper core will go bye-bye, cat-quick.)

Going down that list of activity:

Chromium is readily available, relatively inexpensive, and easy to handle, besides being rather pretty in a yellowish sort of way - would be good, too, if it would 'wet'. However, it is higher on the activity scale than iron, though not as susceptible to oxidation. To-day chromium is looked upon with disdain by the environmentalist True Believers because of a bad movie… it gets the watermelons[2] all hot and bothered, as it is not good for a person when consumed in large quantities.[3]

Iron is common and cheap; iron wets well; iron is almost ideal, except - it reacts readily with oxygen even at 'room' temperatures, and more so at soldering temperatures; acids, as one might expect, affect iron more readily than is desirable (solder fluxes are, in the main, acidic); iron is relatively soft and abrades over time.

[1] The EPA suggests silver. They would.
[2] A watermelon, like an environmental activist, is green on the outside and red on the inside.
[3] Some manufacturers offer, or have offered chromium-plated tips. They have met with indifferent success.

Cadmium is too soft for plating; pure cadmium can be cut with a knife. Cadmium and its compounds are highly toxic. Silver solder, which contains cadmium, should be handled with respect.

Cobalt is prettier, and often used as a bluish metal coating, but cobalt is not only expensive, it don't wet worth a damn, is very brittle hence difficult to form (though quite amenable to electroplating). Besides, we need all the cobalt we can get to make cobalt bombs with. It costs more than nickel, too.

Nickel we have dealt with - it is similar to iron in its physical properties, but as it is less active chemically it is, as I have mentioned three several times, markedly resistant to oxidation and corrosion.

Tin and *lead* are listed here only to show their relation to other metals as regards chemical activity.

Antimony and *bismuth* are constituents of many 'lead-free' solders; less active than tin or lead, they are still more active than copper; ionic replacement may still take place at the higher temperatures used with these solders.

Copper is there. Of course. Copper is soft, and wants protection from abrasion and, to some extent, chemical reaction when used as a heat-transfer medium in soldering.

The *Brinell hardness scale* is an approximation based upon a widely accepted standard test. Hardness of the plating material is important because the harder the plating, the less likely it is to abrade rapidly. In general, it is also true that the harder the plating material the less wettable it will be, hence the more flux (or more active flux) required.

Suggestions for further study:

Make up a batch of thirty identical tips. Plate ten with iron, just as they are to-day; plate ten with nickel, of the same thickness as the iron; plate ten with chromium, again of the same thickness as the iron. Try to solder with them, and try to wear them out, using HMP solder (pick one) and the regular RMA flux. Repeat with more highly activated flux, if the fancy-shmancy tips don't work. (But we know nickel works.)

That nasty black goo that forms on the tips when trying to solder at 10,000° K.?

That nasty black goo is partially burned RMA flux. Pine-resin contains all kinds of lovely organic compounds, and organic compounds love to combust when heated. I am not going to enter into a lengthy discussion of terpenes, aldehydes, or the acids found in pine resin. These acids are what make the flux work; like most naturally occurring organic acids they are relatively mild in and of themselves. At soldering temperatures pyrolysis[4] changes the chemical make-up of the terpenes, aldehydes and acids, transforming them into the nasty black goo. The goo can be wiped off the tip; its presence should alert the operator to the fact that he, she or it is using too much flux.

[4] A three-dollar word meaning 'a chemical change brought about by heat'. The stuff hasn't quite caught fire, but is about to. Pyrolysis is what makes a tough roast tender, if you simmer it long enough in red wine at 225° F.