50+ Years of Mechanical Improvements

- How were all the mechanical components so important to previous generations of electronics replaced?
- What impact did the shift from mechanical components have on functionality and quality?

Panel Meter

- S-meter: Now part of an improved central display, but functionally unchanged.
- Bench power supply output voltage: No longer needed, since this is a set point entered through a keypad. Display might monitor set point, output V/I, or both.
- Not everyone likes a digital display for everything: many receivers still have a “real” S-meter.

Panel Meter

Functionality: One “meter” can monitor many functions, determined by software, without the need for a mechanical switch to change function.

Quality: Improved accuracy, repeatability, and ruggedness. Can’t wrap the pointer around the pin, no pivot to break. But needle dynamics are lost.

Potentiometer

- For AF, RF gain controls and a few stubborn hangers-on, panel-mount pots replaced by PC-mount pots.
- For everything else, replaced by digital pots driven (often circuitously) from shaft encoders, e.g., car radio volume controls.
- But, many (most?) small PC-mount pots have a limited lifetime and poor “feel”.

Potentiometer

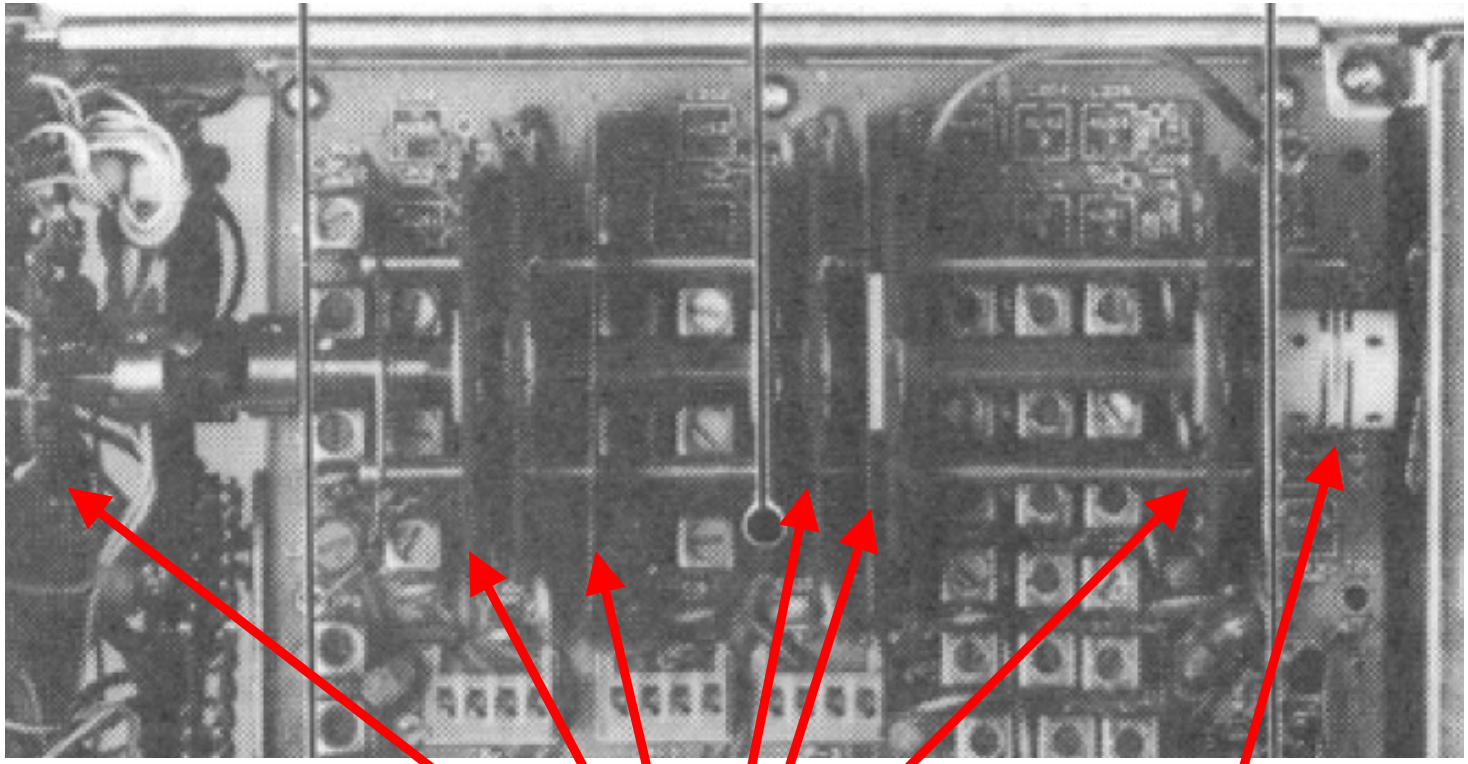
Functionality : Controls' previous positions are stored in software – a great convenience.

Quality: One high-quality encoder can perform many functions, selected by software.

Band Switch

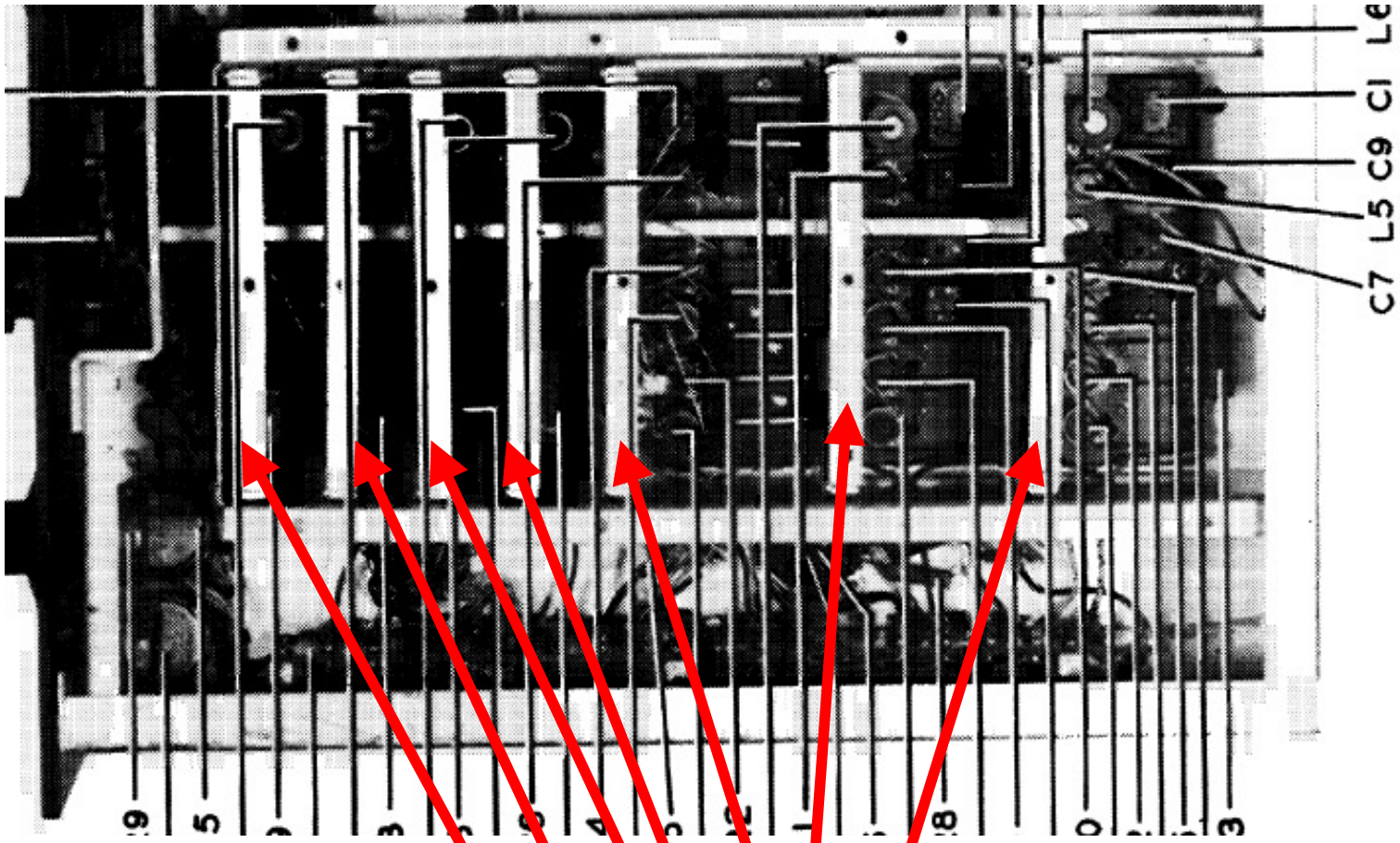
- In communications receivers, signal generators… band switches have entirely disappeared. These instruments now cover a continuous range of frequencies.
- Ham radios retain bands as a convenience. Most switching is done by diodes or FETs, TX tuned-circuit tuning by small relays.

Bandswitches – 1980



TS-180

Bandswitches – 1950



75A-1

Shielding/Torsion Reduction Plates

Band Switch

Functionality: ?

Quality: Software band-switches (or rotary switches in general) seldom break. “Hot Switching” is prevented by software sequencing. Detents and contacts don’t wear out. Wafers don’t get into relative misalignment. Lubrication not required…

Connectors

- Individually-soldered pins replaced by solderless mass terminations with controlled, reproducible characteristics.
- Improvements in plastic extrusion and molding enables tremendous density.
- Component mountings (sockets for transistors, chips, crystals…) disappear entirely, and with them, their parasitic R, L, C, and noisy connections.

Connectors

Functionality: Small size and low cost make the use of connectors vs. point-to-point wiring an easy choice. This greatly improves maintainability.

Quality: Small contact size generally increases contact-to-contact pressure and reliability. Many plastics are more resilient, resistant to UV, and “age” better than older materials like phenolic, rubber, and bakelite.

Cabling

- Insulation characteristics are now very repeatable.
- Standard 0.05” pitch ribbon cables offer standard impedance characteristics for short single-ended runs, and twisted 0.05” ribbon cables are good for longer differential runs. Both are very cheap.
- Flexible PWB cables allow customized impedance characteristics. Show SATA cable

Cabling

- Improvements in insulation materials, extrusion techniques, and flexible substrates for PWB cables make today's cabling much more than the assembly of nicely-laced wires of yesterday.
- Pick up a rat's nest of old rubber, cotton-wrapped, and paper-insulated cables in various states of attack by ozone, heat, humidity, bugs, rats… for something nasty.

Cabling

Functionality: Cables and connectors go hand-in-hand. High-density cabling is not nearly as “scary” as it once was.

Quality: Improved insulation and connector molding and strain relief improve ruggedness and longevity.

Point-to-Point Wiring

- PC boards eliminated wiring between chassis-mounted components.
- Panel-mounted controls and indicators are also PC board mounted, eliminating many different-sized nuts and washers, and “mounts from the front” vs. “mounts from the back” inconsistencies. Front panels are typically no longer structural components.

PC Boards

- PC boards also help tame problems associated with long point-to-point runs just by shortening the runs, and
- Multi-layer PC boards provide built-in shielding and noise mitigation by providing AC ground points anywhere they're needed.
- But noise can also be coupled into the power and ground layers.

PC Boards vs Point-to-Point

Functionality: Current circuit density would be impossible without multi-layer PC boards. Reliable multi-layer boards are a pre-requisite for high-density ICs.

Quality: Consistent mechanical layout, because of the board itself, automated component placement, and automated soldering improves repeatability.

Tuning Assemblies

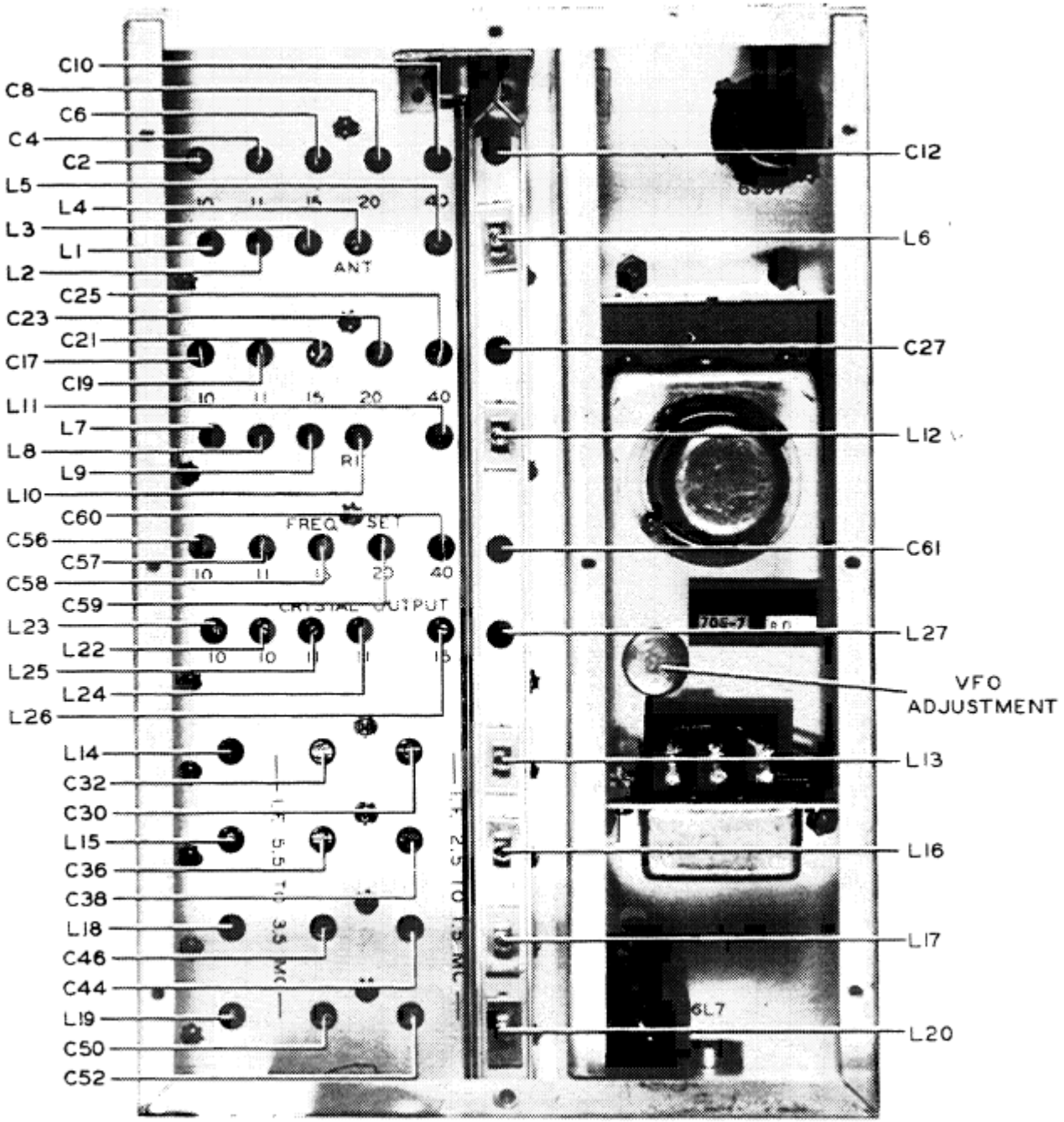
- Elaborate tuning knob/indicator mechanisms were required before digital frequency counters, PLLs, and DDSs, because the knob setting determined the frequency.
- Now we either sample the frequency of the generated signal, or calculate displayed frequency from inputs to the PLL or synthesizer. Tuning speed display resolution are software problems now.

Tuning Assembles (cont'd)

Not only is the single variable capacitor LO tuner and front-end peaking setup gone, but so are

- Permeability-tuned oscillators
- Simple tracking arrangements, like ganged variable capacitors
- Complex tracking arrangements, like the Collins 75A1,2,3,4 tuning deck.

75A1 Tuning Deck



Tuning Assemblies

Functionality: Tuning settings can be remembered. (Well, so could an ART-13 auto-tuner.) Vastly simpler alignment.

Quality: Improved resolution, precision, unit-to-unit and use-to-use repeatability. "Dial linearity" no longer an issue. Long-term stability greatly improved. But phase noise is still an issue.

Component Matching

- Material uniformity on a single chip yields closely-matched components: very important in minimizing op-amp offsets.
- Uniform resistance ratios (vs. absolute values) are very important in A/D and D/A converters.
- In the bad old days, selecting components from a single run or from the same wafer ensured as much uniformity as you could expect.

Component Matching

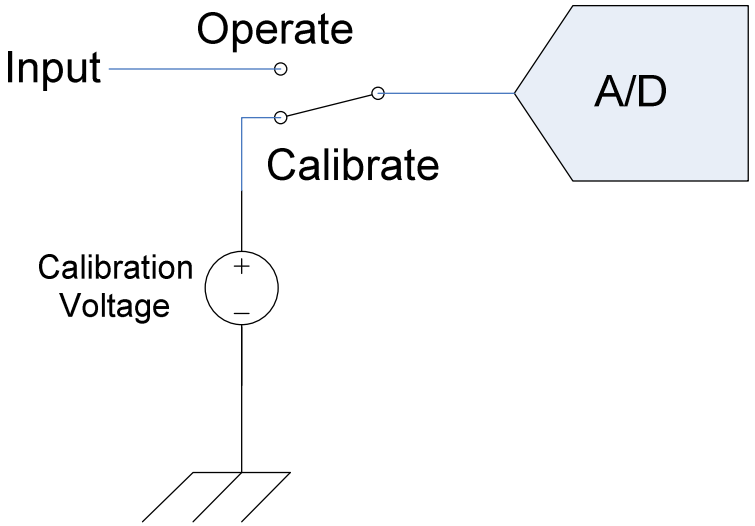
Functionality: Internally-compensated op amps and their dependant circuit elements like instrumentation amps, balanced mixers, current mirrors… would otherwise be impossible.

Quality: Matched-component performance without endless alignment.

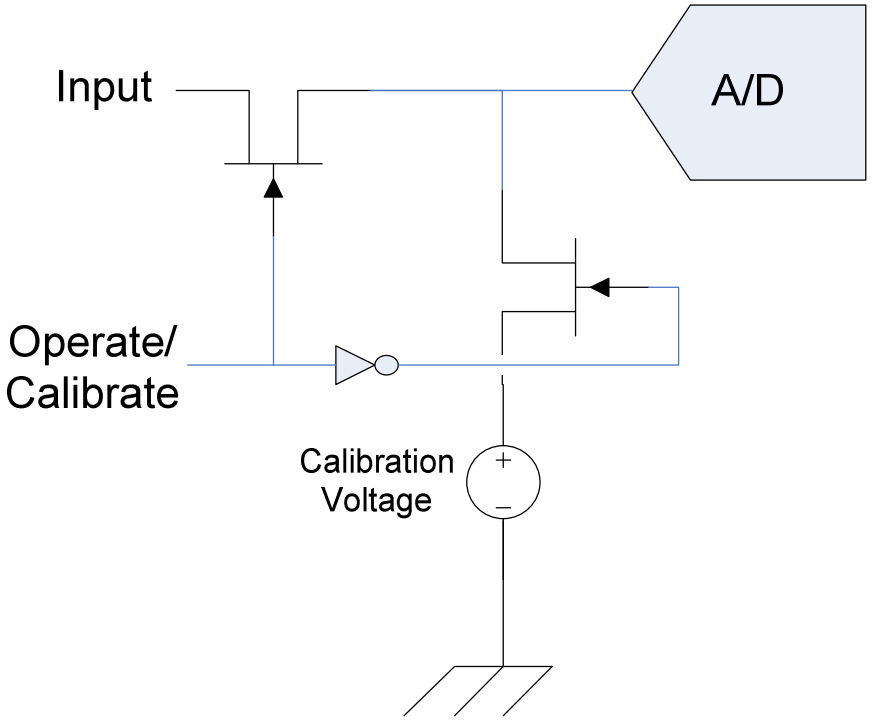
Simple Switches

- Where switches are still required, they are replaced by momentary-contact pushbuttons (often on keypads or single membrane switches) whose ultimate action is handled by software: hence, the disappearance of the good old on/off switch.
- Look at your radio – is there a switch that isn't SPST momentary contact?

Example – Data Acquisition



Old



New

Simple Switches

Functionality: ?

Quality: Low-current, software-debounced pushbuttons seldom wear out.

Crystals

The small size, mechanical stability, and lack of long connecting wires in surface-mount crystals has significantly extended the range of fundamental-mode operation.

- Resistance-weld surface mount quartz – 33 MHz
- Ceramic – 200 MHz

Compare these to FT-243, HC-1, HC-6

Filters

- Monolithic filters have follow the sizes of quartz and ceramic elements up to about 8 poles.
- There's a limit to the performance of monolithic filters compared to discrete-component filters which improved mechanics wouldn't seem to address.
- So don't expect to replace your $100+ filters with monolithics.

Filters

Ceramic, Crystal, Monolithithic Ceramic & Crystal, and DSP filters notwithstanding, the Collins mechanical filter remains an icon of filter performance.

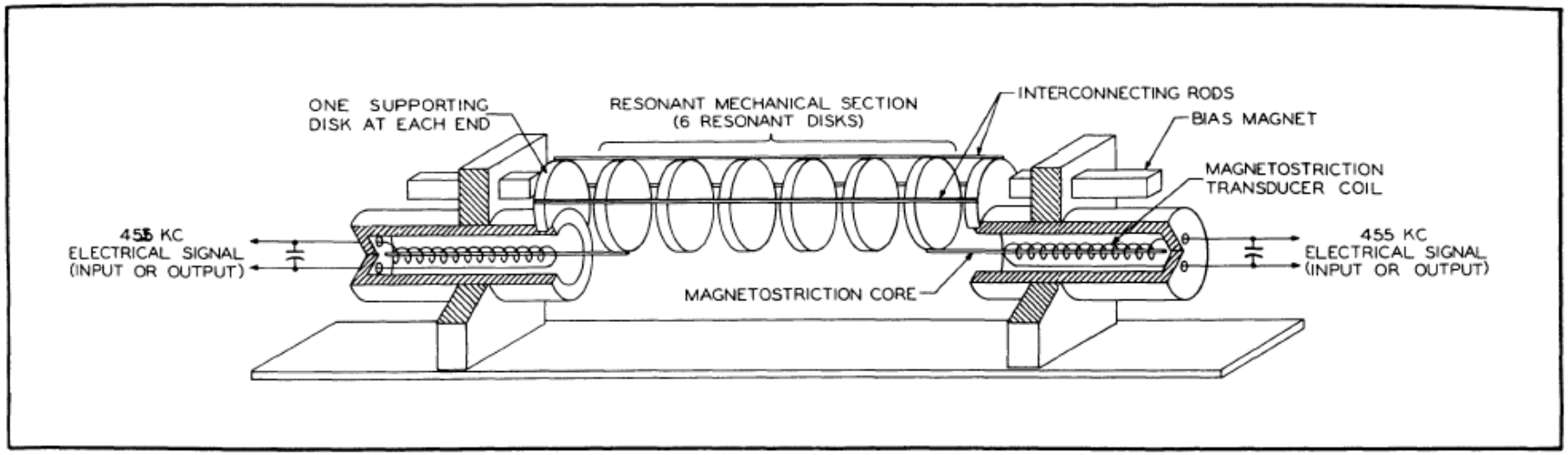


Figure 4-2. A Collins Mechanical Filter, Functional Diagram

Crystals and Monolithic Filters

Functionality: Higher resonant frequencies, lower cost

Quality: Both crystals and filters more rugged than older counterparts. Performance no better, but lower cost makes them more attractive than lower-performance alternatives in low-end radios.

Mechanical Parts Percentage Example

- 1970: Heathkit GR-78 General Coverage Receiver, $130. 142 Electrical parts ($101), 114 Mechanical parts ($107): 44% by count, 51% by cost mechanical.
- 1992: Sangean ATS-818/Radio Shack DX-390 General Coverage Receiver, $175 ($48 in 1970$). 123 Electrical parts, 33 Mechanical parts, 21% mechanical.

One Last Question…

- With the elimination of “old, ingenious, and clunky” mechanical components, have we lost useful expertise, or swept under the rug expendable arcane knowledge?