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Forward into the Past!

— a solid-state restoration project for a vintage BC receiver

What do you do when you have an old broadcast receiver mounted in a beautiful console cabinet and you can't buy tubes for it? Why, you convert it to solid state!

A friend approached me with just such a project. He had a Philco broadcast and shortwave receiver, one that his grandfather had used when living on a farm. It was battery-operated, using 1.4-volt series tubes, but powered from a six-volt storage battery and deriving its plate voltage by means of a vibrator. He wanted its appearance unchanged. That meant leaving the tubes (all shot) in their sockets. It also meant using the original coils and tuning capacitors, as he wanted the dial calibration to remain meaningful.

After some hesitation, I undertook the job. The actual man-hours were not recorded, but they would not truly be indicative of the task, because I pursued many false trails before arriving at the circuit ultimately used.

The original circuit is shown in Fig. 1. You'll note that it shows a somewhat conventional superheterodyne configuration, remarkable only in several oddball quirks. One of these, introduced for reasons known only to God and the Philco engineers, is the application of a direct-current bias to two 0.05-uF capacitors. Another, is a third winding on the second intermediate-frequency transformer which carries bias to the screen-grid of the tube in that stage. A semi-educated guess would be that this provided neutralization for the stage.

In common with the usual design of battery-powered receivers of its day, this one derived grid bias voltage from the IR drop across tube filaments. This feature necessitated a complete redesign of biasing circuits, including that of the agc bus.

The job was tackled in three stages. Really, four, if you count the power supply. I took the coward's way out, and bought one from Radio Shack! (It was their catalog no. 22-124.)

The first element is illustrated in Fig. 2, which shows the frequency-conversion stage only. This stage required more work than all others combined. It was a hellcat, pure and simple! The difficulty lay in getting the oscillator to perform properly over the desired frequency spectrum.

As shown, the original converter tube was replaced by two transistors, one as the "first detector" (as we used to call them) and the other as the local oscillator. The original

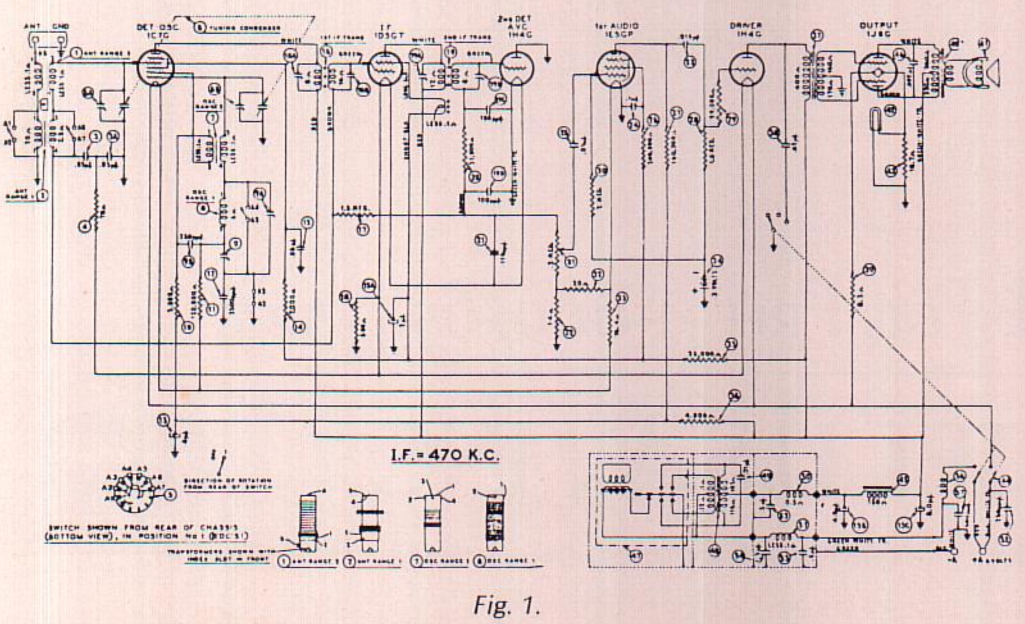

Fig. 1.

coils, padders, trimmers, and variable capacitors were used without modification. And that created a problem!

You might think, as I did, that modern active devices, with their much-superior mutual conductance, would oscillate with the greatest of alacrity. Hah! After trying the hottest bipolars, the hottest junction field-effect, and a variety of insulated-gate field-effect transistors, I ended up with one of the latter. Both gates were paralleled. This one, suitably cajoled, oscillated with vigor at mid-frequencies and with enervation at either extreme. But it did oscillate! That is, it performed satisfactorily on the BC MF band, but poorly on the HF band. It had too much feedback on that frequency range. A 40k-Ohm resistor across the gate coil brought the oscillations under control.

Note that the drain voltage of the oscillator is regulated at nine volts by means of a zener diode. Also note the use of two rf chokes in series, one of 2.5 mH and one of 30 mH. Two are needed for the frequency range, which is from 0.55 MHz to 18 MHz. The associated capacitor (9B in the original circuit) is a part of the frequency-determining circuit, and a very high impedance is required at the "top end" of the cascaded rf chokes.

Two bypass capacitors are used across the source bias resistor to ensure a low reactance to either HF or MF current.

You may question the use of a loading resistor across the secondary of the first i-f transformer. It does tame the wildness of the stage, and introduces only a moderate deterioration of selectivity. There's a certain amount of regeneration in the stage, which tends to provide enhanced selectivity.

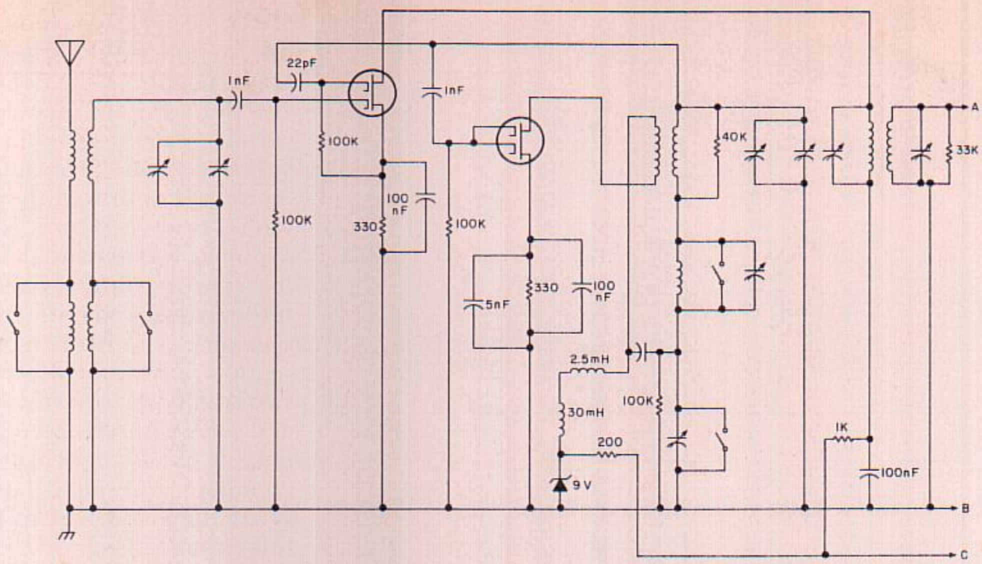

Fig. 2. The dual-band antenna and local oscillator section, plus the first i-f transformer. The FETs may be RCA 40673, ECG 222, or Motorola F2004. The zener diode is a Motorola Z0412. Parts not identified are original components. The 6-pole single-throw switch is the bandswitch.

Fig. 3 shows the i-f stage, the "second detector," and the first af stage. Note the use of 100-Ohm series resistors for the drain and #1 gate of the active device. These, plus the 10k-Ohm resistor in parallel with the primary of the second i-f transformer, are needed to curb a tendency to oscillate. One can understand the use of that third winding on the transformer!

A signal diode is used for the second detector. The two 100-pF capacitors and their associated 51k-Ohm resistor are contained within the can of the original i-f transformer. Both af and agc voltages are taken off the hot side of a 0.5-megohm resistor.

For the first af stage, a dual set of coupling (isolation) capacitors is employed. The smaller one couples from the high impedance of the agc resistor; the larger one couples from the low impedance of the volume control to the input of the bipolar transistor. The value of the 15k-Ohm resistor forming a part of the biasing network was determined by an empirical method. A sine wave audio signal was introduced into the input circuit at a low level. The waveform at the stage's output was observed on an

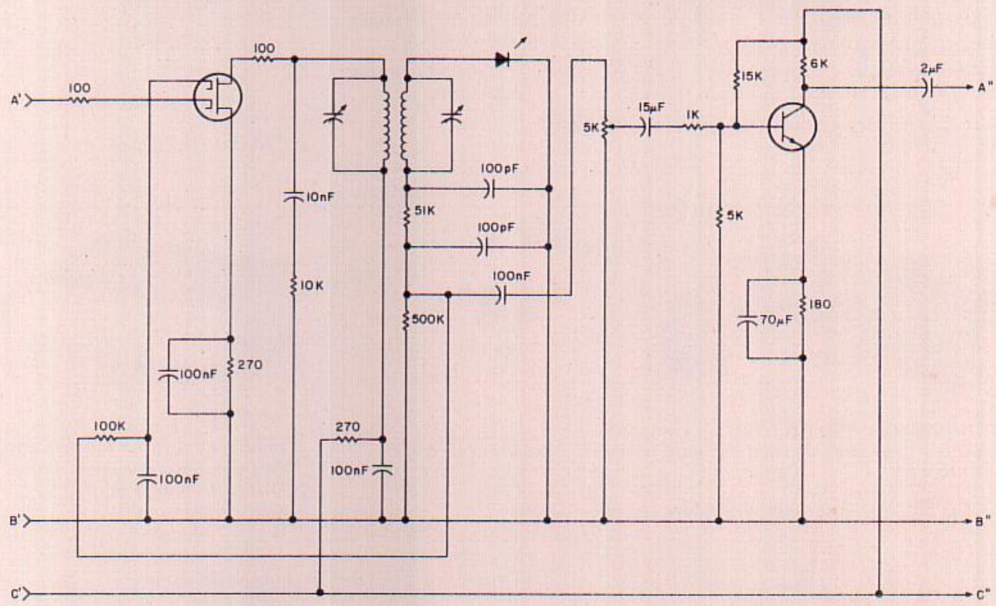

Fig. 3. Intermediate-frequency amplifier, demodulator, and first audio amplifier stages. The FETs may be 40673, ECG 222, or Motorola F2004. Any signal diode will suffice for the demodulator. Try various NPN bipolar transistors to select one for best gain and lowest noise, then adjust bias for best fidelity.

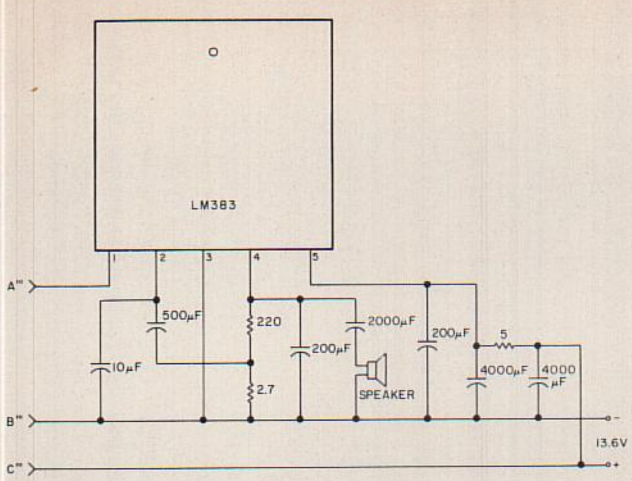

Fig. 4. Audio power amplifier uses Radio Shack LM383.

oscilloscope. Then the level of the input signal was advanced until distortion was observed on an audio voltage crest. The value of the resistor was adjusted until, when overloaded with audio input, the stage went into limiting simultaneously on both positive-going and negative-going peaks.

It was noticed that this stage developed an excessive hum when the gain control was set at zero signal input. The addition of a 1k-Ohm resistor in series with the gate cured the hum.

An audio power amplifier IC seemed the logical way to go for the final stage. The LM383, Radio Shack no. 276-703, looked like a reasonable choice; one was purchased and installed. It required a certain amount of fiddling before operation was satisfactory. It appeared that a very low output impedance was essential for its power supply; also, filtering requirements were rigorous. I added a pi-section low-pass filter of two 4000-uF capacitors, and a 5-Ohm resistor. This helped, but did not entirely eliminate, a residual hum. What remained had to be tolerated.

As mentioned previously, a 13.6-V power supply was procured from Radio Shack. Other than being slightly lacking in filtering, it seems to be quite adequate.

With all its frustrations, the job was interesting and very challenging. Some of the problems were solved by means surely not elegant—more by brute force than nicety.

A number of lessons were learned, some the hard way! For instance, it pays to experiment with a number of bipolar transistors even in an audio stage. The differences in behavior were marked. There seems to be little difference among RCA 40673, Sylvania ECG 222, and Motorola HEP F2004 dual-gate insulated-gate FETs.

Don't be tempted to use any 40-year-old capacitors! Be suspicious of old resistors, too. Be lavish with contact cleaning spray. Don't attempt to use a bipolar transistor with a coil-plus-capacitor combination designed for use with a vacuum tube.

And, above all, don't hesitate tackling a conversion job. It can be done! (The owner agrees!)■