Circuit Circus

By Charles D. Rakes

CRYSTAL DIODE DETECTORS

I can't think of a more nostalgic time of the year than the present (when mother nature is tuning up for her *coup de grace* and the jolly old geezer in his red undies is about to play chimney sweep) to go back in time and reminisce about the good old days when all soldering was done with an American Beauty iron and batteries only came in A, B, and C sizes. And if the term solid-state was used at all, it was in reference the stature of a prominent citizen.

No, I wouldn't think of going back technically to the good old days, but it could be adventurous to enter a special "time machine" and apply our present day know-how to a popular subject of yesterday. As a youth, when the cold winds of winter howled outside, I could really enjoy settling down to building the latest-published AM-broadcast receiver (BC) circuit and stay up all hours of the night to see how well it would pull in those distant stations.

Of course, now you can purchase a super-sensitive AM/FM radio for less than a "Hamilton" and pick up Cuba and Canada almost any night. But, even in today's fast-paced world, there's still an-itch-that can only be scratched by the performance of a self-made project.

I'm sure you've noticed fewer things are free today, and getting something for nothing legally is a rare occurrence indeed, but with a smidgen of electronic wisdom and a few inexpensive parts it can happen.

RF Power Cell. Our first circuit turns back the hands of time to an era when the crystal-diode detector—better known as a crystal set—was in vogue, and listening to KDKA was the norm. Those very early diode detectors required no battery power and when operated close to a strong station, they could drive a horn speaker to a level that would allow several people to enjoy the program without wearing earphones.

Those crystal sets also did not require an off/on switch, because all operating power came in on the antenna from the station's transmitter, free to the listener. The majority of the stations in the early years were low powered and would not offer much volume to the crystal set user. However, today the air is saturated with a hodgepodge of energy spread throughout the entire RF spectrum.

The simple circuits shown in Figs. 1 and 2 are designed to take advantage of that abundance of free power. The circuit in Fig. 1 is nothing more than a modern-day version of a vintage crystal set with the tedious cat's-whisker detector, of Grandpa's day replaced with a modern 1N34A germanium diode. If you have ever tried to keep a cat's whisker detector in adjustment, you're sure to appreciate the solid-state replacement used in our circuits.

Note: The circuit shown in Figs. 1 and 2 are not designed for radio reception, but instead are designed to serve as *RF power cells.* Granted the output obtained from a single RF cell won't cause the local power company to shudder, but it doesn't send out bills.

Here's how the something-for-nothing circuit works. A long-wire antenna and an earth ground are connected to a parallel tuned circuit

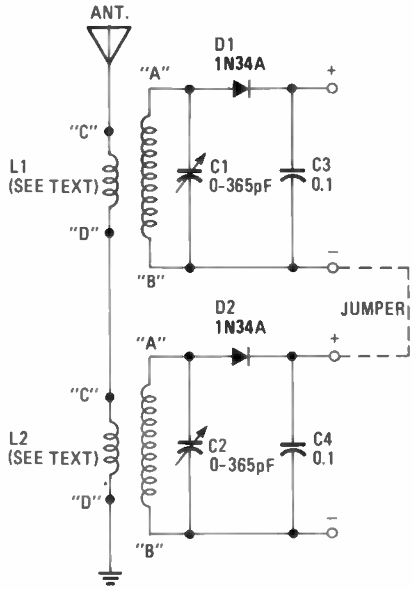

Fig. 2—The single power cell of Fig. 1 can be connected in series, as shown here, to increase the output voltage. A higher current can be obtained by connecting two cells in parallel.

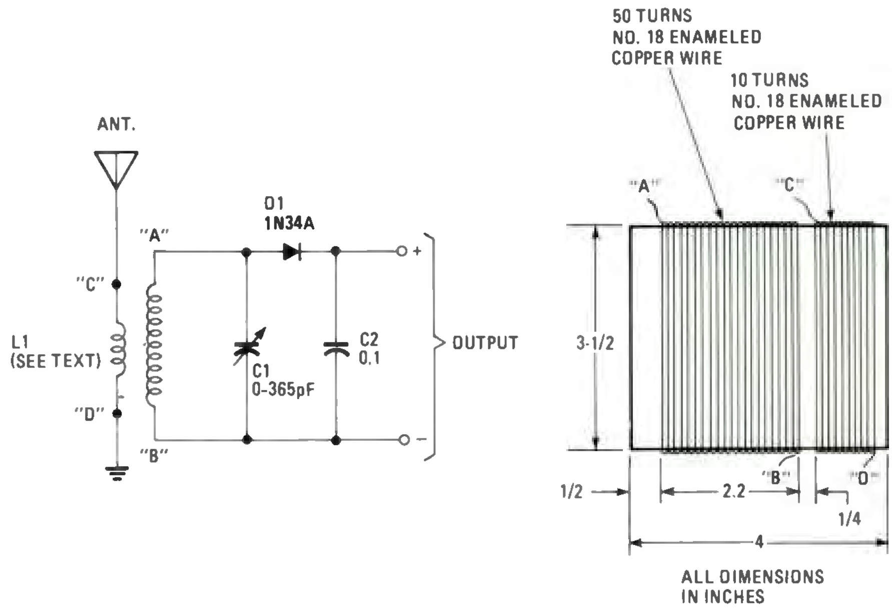

Fig. 1—Shown here is a modern-day version of a vintage crystal set with the cat's-whisker detector replaced by a 1N34A germanium diode. The circuit is designed to serve as an RF power cell.

(consisting of L1 and C1) that's tuned to the strongest local AM broadcast station in the area.

The RF energy is converted (or rectified) to DC by D1. Capacitor C2 removes any RF ripple from the output. If a powerful station is close by, it's possible to obtain a 1- to 3-volt output at a current of several milliamps. The output voltage won't blow your socks off, but it can power a variety of conservative electronic circuits.

The dual cell shown in Fig. 2 is nothing more than two of the tuned circuits connected together with their outputs in series to increase the output voltage. For a higher current output, the two cells can be connected in parallel. If you are a dedicated experimenter, that's an area where an unlimited number of circuit arrangements can be tried to obtain the maximum power output.

First, some real hands-on chores must be completed before testing can begin, such as winding three identical coils; see the winding details in Fig. 1B. As shown, a 4-inch length of 3½-inch diameter PVC tubing is used as a coil form. About 50 turns of #18 enamel-coated copper wire is wound (in solenoid fashion) on the form, leaving at least six inches of wire at each end. Leaving a space of about a quarter inch, wind a second coil of about 10 turns in the same direction. Leave at least six inches of wire at each end.

At the beginning and end of each winding, drill two holes slightly larger than the wire size to loop the ends through to keep the winding in place. Use 100-grit sandpaper to remove the enameled coating from each end of the four wires, and then tin the ends.

It's best to start off with a single RF cell to see how much power is available in your area. The antenna should be as high and as long as possible to pull in the maximum RF signal. A good earth ground should be used to complete the RF path.

Although a 365-pF variable capacitor is specified for C1, almost any salvaged broadcast tuning capacitor will do. The exact capacitor value isn't too critical, so try what you have on hand. If new tuning capacitors are needed, try one of the poly-film RF tuning capacitors available from a few of the mail order houses for about two bucks each. If you want to be old fashioned and stick with the all-metal variables, be ready to spend about 10 dollars each.

PARTS LIST FOR THE RF POWER CELL

- D1—1N34A germanium diode
- C1—365-pF, variable capacitor
- C2—0.1-µF, ceramic disc capacitor
- L1—See text
- Wire, solder, hardware, etc.

PARTS LIST FOR THE DUAL RF POWER CELL

- D1, D2—1N34A germanium diode
- C1, C2—365-pF, variable capacitor
- C3, C4—0.1-µF, ceramic disc capacitor
- L1, L2—See text
- Wire, solder, hardware, etc.

Stick with the 1N34A or a similar germanium diode for D1, because using a silicon diode here requires about twice the threshold voltage for forward conduction and will produce a lower output voltage. Of course, if you live in a real RF hot spot, just about any type of rectifier suitable for RF will produce an output.

With a good antenna and ground connected to the cell, hook either a sensitive ammeter or voltmeter across the output and tune C1 for the greatest output. Here's a chance to travel back in time by connecting a high-impedance set of headphones across the output, and listen to the radio like Gramps did years ago.

The output of two cells can be tied in series, as shown in Fig. 2, or paralleled; whichever configuration best meets the load requirement. If only one strong radio station is available, separate antennas can be used with individual cells to increase the power output even more. That's an area that's wide open for experimentation. VHF and UHF signals are another area where an enormous amount of RF energy is just waiting to be tapped.

Single Transistor BC Radio. The *Single Transistor BC Radio* circuit shown in Fig. 3 is an ideal test circuit for the RF cells. The RF cells and the transistor radio can be built in a nostalgic fashion on a 12-inch square piece of wood, or for a more modern approach use perfboard and pins. In any case, the circuit is non-critical, so build to suit.

The antenna input to the transistor receiver can be connected to the same antenna that drives the RF cells through a small trimmer capacitor (say, about 10 to 50 pF), or operated from a separate antenna. But the best method to use depends on the available signal level found at the antenna(s) terminal.

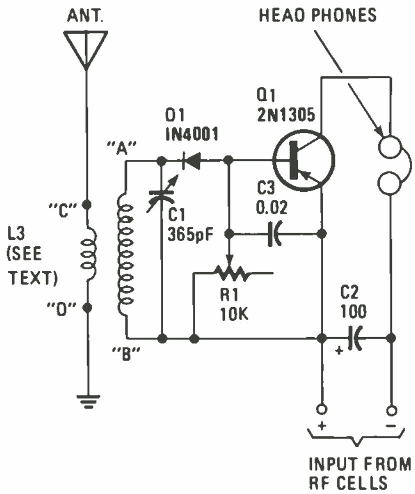

Fig. 3—The Single-Transistor BC Radio circuit can be powered by the RF power cells presented in Fig. 1, and the input to the receiver connected (via a small trimmer capacitor) to the same antenna that drives the power cells.

PARTS LIST FOR THE SINGLE-TRANSISTOR BC RADIO

- Q1—2N1305 general-purpose PNP germanium transistor
- D1—1N34A germanium diode
- C1—365-pF, variable capacitor
- C2—100-µF, 16-WVDC, electrolytic capacitor
- C3—0.02-µF, ceramic-disc capacitor
- R1—10,000-ohm potentiometer
- L3—See text
- Printed circuit or perfboard materials, enclosure, high-impedance headphones (2000-ohms or better), wire, solder, hardware, etc

Resistor R1 should be adjusted to produce the maximum audio volume, while maintaining the best sound quality. That adjustment controls the transistor bias, which is derived from the incoming RF signal. If the receiver offers ample sensitivity, but falls short in the selectivity department, try tapping L3 at its mid point and connecting D1 to the tap. That's just another area that's ideal for trying various schemes to get the best overall circuit operation.

SSBC Reciver. Figure 4 shows the schematic diagram of a *Super-Sensitive BC Receiver*, which is built around a Ferranti ZN414 TRF (tuned radio-frequency) amplifier. With the SSBC receiver, you should be able to pull in stations with a three-foot antenna just about anywhere in the U.S.

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The ZN414 is designed to operate from supply voltages of 1.2 to 1.6 volts, and has a recommended operating voltage of 1.3. The actual voltage is determined by the ZN414's internal AGC action, which depends on the strength of the incoming RF signal.

Resistor R4, along with Q1, simplifies the job of setting the best operating voltage and provides some degree of regulation. Always keep the voltage at the emitter of Q1 below 2 volts, so as not to damage the IC.

Modified SSBC Receiver. If you're located in an area where stations are difficult to pick up, you might try the *Modified SSBC Receiver* circuit shown in Fig. 5. An FET RF-booster stage is connected in front of the SSBC receiver to supercharge the incoming signal. Two RF-tuned circuits (consisting of L1/C1 and L2/C2) are used to add selectivity.

The booster's gain is controlled by R7 and for best results should be kept as low as possible so as not to over drive the input circuitry of the ZN414. The small trimmer capacitor, C5, provides RF coupling between the two tuned input stages to sharpen the selectivity of the booster circuit.

The receiver can be used to drive an external power amplifier or a pair of high-impedance headphones. ■

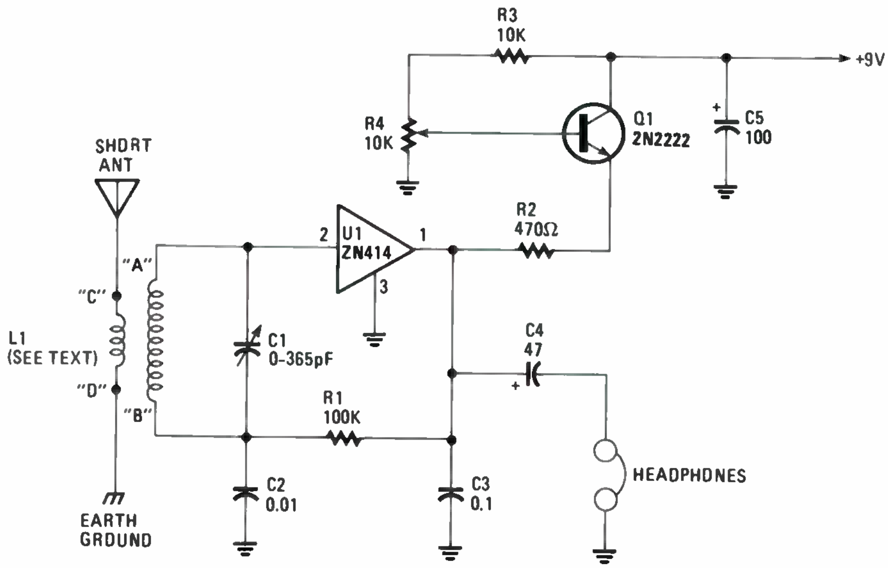

Fig. 4—Shown here is the schematic diagram of the Super-Sensitive BC Receiver, which is built around a Ferranti ZN414 TRF (tuned radio-frequency) amplifier.

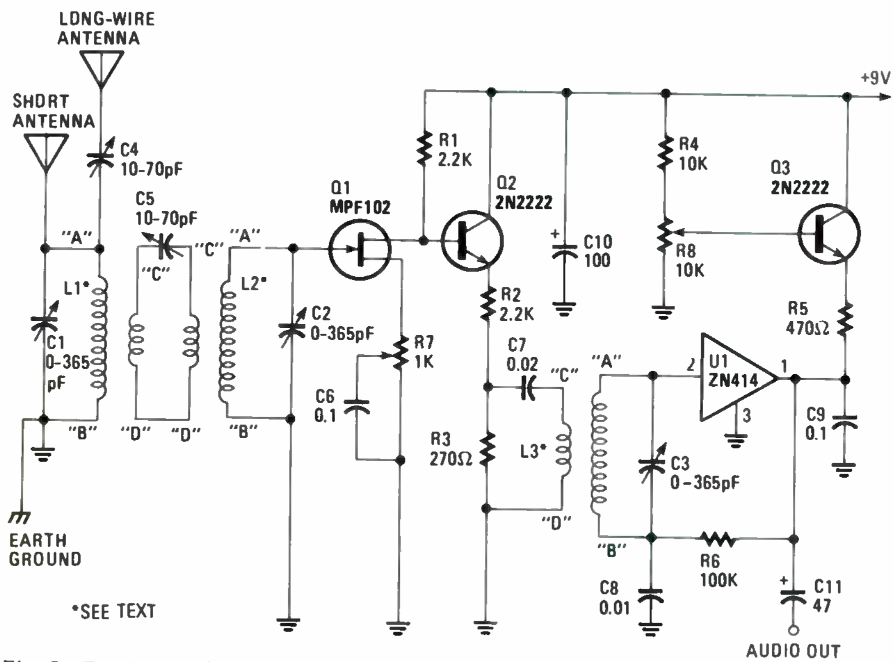

Fig. 5—This is a modified version of the SSBC Receiver. A booster stage is connected in front of the ZN414 receiver to supercharge the incoming signal, and two RF tuned circuits are added to increase selectivity.

PARTS LIST FOR THE SSBC RECEIVER

U1—ZN414 tuned radio-frequency amplifier, integrated circuit
Q1—2N2222 NPN general purpose transistor
R1—100,000-ohm, ¼-watt resistor
R2—470-ohm, ¼-watt resistor
R3—10,000-ohm, ¼-watt resistor
R4—10,000-ohm potentiometer
C1—365-pF, variable capacitor
C2—0.01-µF, ceramic-disc capacitor
C3—0.1-µF, ceramic-disc capacitor
C4—47-µF, 16-WVDC, electrolytic capacitor
C5—100-µF, 16-WVDC, electrolytic capacitor
L1—See text
Printed-circuit or perfboard materials, enclosure, IC sockets, pins, short pull-up antenna, high-impedance headphones (2,000-ohm or better), 9-volt battery and battery holder, wire, solder, hardware, etc.

PARTS LIST FOR THE MODIFIED SSBC RECEIVER

U1—ZN414 tuned radio-frequency amplifier, integrated circuit
Q1—MPF102 or similar field-effect transistor
Q2, Q3—2N2222 (or similar) general-purpose, NPN silicon transistor
R1, R2—2200-ohm, ¼-watt resistor
R3—270-ohm, ¼-watt resistor
R4—10,000-ohm, ¼-watt resistor
R5—470-ohm, ¼-watt resistor
R6—100,000-ohm, ¼-watt resistor
R7—1000-ohm potentiometer
R8—10,000-ohm potentiometer
C1, C2, C3—365-pF, variable capacitor
C4, C5—10-70-pF, trimmer capacitor
C6, C9—0.1-µF, ceramic-disc capacitor
C7—0.02-µF, ceramic-disc capacitor
C8—0.01-µF, ceramic-disc capacitor
C10—100-µF, 16-WVDC, electrolytic capacitor
C11—47-µF, 16-WVDC, electrolytic capacitor
L1, L2, L3—See text
Printed circuit or perfboard materials, 9-volt battery and battery holder, knobs, hookup wire, antenna wire, solder, hardware, etc.

Note: The ZN414 tuned radio-frequency (TRF) amplifier is available from DC Electronics, PO Box 3203, Scottsdale, AZ 85257, and Circuit Specialists, PO Box 3047, Scottsdale, AZ 85257.