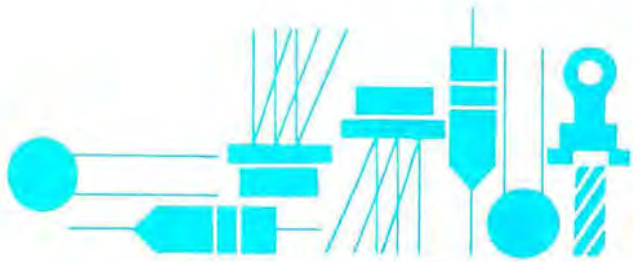

Solid State

By Lou Garner

THE VOLTAGE COMPARATOR

SUITABLE for use in a variety of applications in logic, control and instrumentation equipment, voltage comparators are available from most large semiconductor manufacturers as well as a number of the smaller specialty firms. In its basic form, the voltage comparator is essentially a modified differential amplifier with two stable output states, responding when an applied input voltage crosses a pre-established threshold level.

Typical of currently available voltage comparators, the "111 family" consists of three standard types offered in a variety of packages by at least two major suppliers, RCA's Solid State Division (Somerville, NJ 08876) and the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051). The RCA types are identified as the CA111, CA211 and CA311, while the corresponding

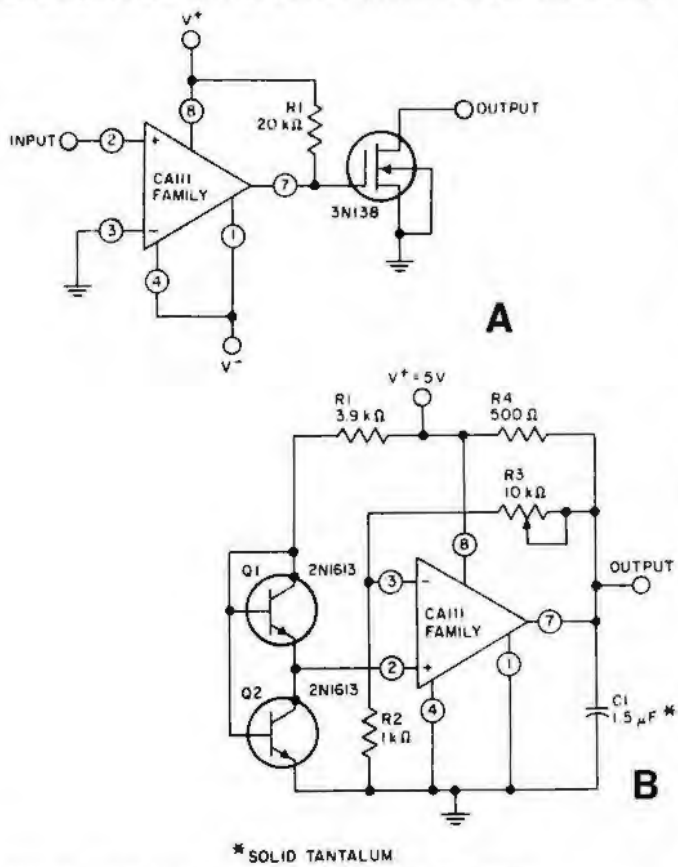

Fig. 1. Type III comparator in a zero-crossing detector (A), and an adjustable reference supply (B).

National Semiconductor devices are designated the LM111H, LM211H and LM311H, respectively. All three types are fabricated using monolithic silicon chips. The basic "111" circuit comprises 24 transistors, two zener diodes, and 19 resistors.

The 111 family devices can be operated on dual power supplies of up to ±15 volts or on single dc supplies down to 5 volts. They can drive lamps or relays, and can switch voltages up to 50 volts (40 volts for the 311) at currents of up to 50 mA. The three devices in the family are similar as far as maximum ratings, general specifications, and applications are concerned, differing primarily in their ambient operating temperature ratings and, in the case of the 311, in maximum input offset and bias current specifications. In all three devices, both the inputs and outputs can be isolated from system ground, permitting the output to drive loads referenced to ground, the negative supply, or the positive supply. Their common response time is specified at 200 ns.

Both the RCA and equivalent National Semiconductor devices are supplied in 8-lead TO-5 style case with identical terminal connections. In addition, National Semiconductor offers both the 111 and 211 devices in 10-lead flat packages and 14-lead DIPs, with the 311 offered in a special 8-pin DIP as well. National Semiconductor identifies its TO-5 packaged devices with an "H" suffix, its flat packages with an "F" suffix, its 14-pin DIP with a "D" suffix, and its special 8-pin DIP with an "N" suffix.

Extremely versatile, voltage comparators may be used in a broad range of circuit applications, both individually and in conjunction with other IC's and discrete devices. Because of their versatility, these devices are ideal for many hobbyist and experimenter projects.

A simple zero-crossing detector suitable for use in switching, control, and instrument applications is given in Fig. 1(A). Here, the voltage comparator is used to drive a MOSFET which, in turn, serves as the output switching element.

The low-voltage adjustable reference supply circuit shown in Fig. 1(B) utilizes two npn transistors, *Q1* and *Q2*, in conjunction with the basic voltage comparator. Potentiometer *R3* serves as the output level control. As indicated, output filter capacitor *C1* should be a solid tantalum-type electrolytic.

Two 100-kHz signal sources are illustrated in Fig. 2—a free-running multivibrator featuring a square-wave output signal at (A) and a crystal-controlled oscillator at (B). Each requires but a single IC and is designed to operate on a single-ended 5-volt dc source. The multivibrator may be used as a clock source in counters and timers or even as part of a secondary frequency standard.

Finally, a type 111 voltage comparator is teamed with a 101A op amp and discrete devices in the 10-Hz to 10-kHz voltage-controlled oscillator (VCO) circuit given in Fig. 3. Supplying both triangular and square-wave output signals simultaneously, this circuit could be used as part of a function generator or an electronic musical instrument. A

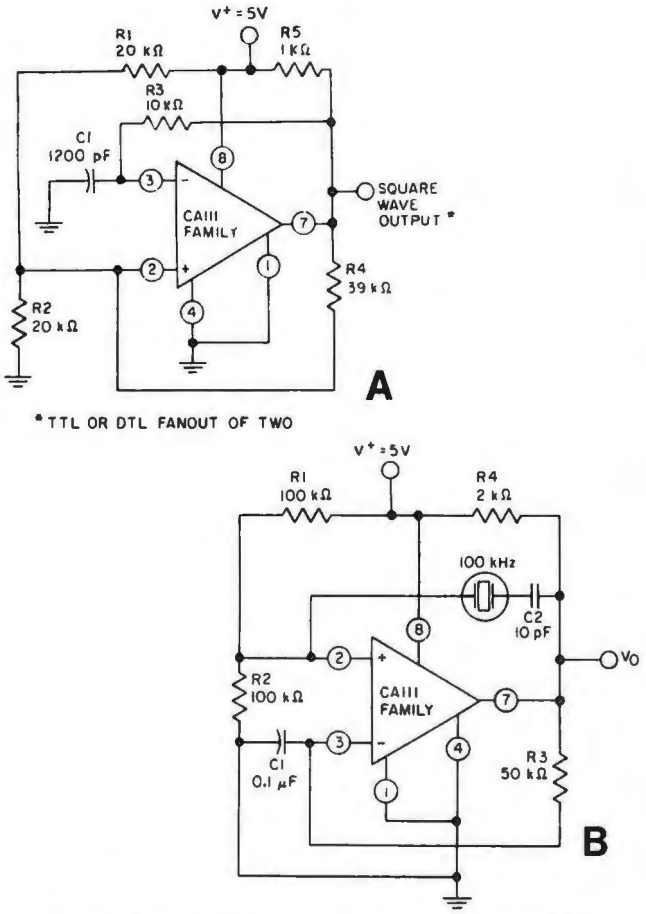

Fig. 2. A 100-kHz free-running multivibrator (A), and 100-kHz crystal-controlled oscillator (B).

dual 15-volt dc power supply is required for circuit operation. In practice, the circuit's instantaneous operating frequency is determined by its input control voltage (from 5 mV to 5 V), while its maximum frequency is established by feedback capacitor *C1*. Potentiometer *R8* serves as a semi-fixed symmetry control and is adjusted for a symmetrical square-wave output when the minimum (5 mV) control voltage is applied to the input terminal.

The three circuits we've examined are but a small sampling of those described in manufacturers' published literature. Among the other circuits found in both RCA and National Semiconductor publications are a *digital transmission isolator, solenoid driver, precision squarer, strobed relay driver, precision photodiode comparator, magnetic transducer detector*, both *positive and negative peak detectors*, and *switching power amplifiers*, all of which further illustrate the voltage comparator's amazing versatility.

Readers' Circuits. John M. King (1194 Idylberry Road, San Rafael, CA 94903), who submitted the low-light indicator circuit featured in last September's column, has come up with another winner. As his previous circuit, John developed the project to solve a problem encounterd by his son, who received a slot car racing set for Christmas. After a while, John and his son found that the 45-ohm rheostat speed controllers supplied with the set were far from satisfactory. If the cars were operated at slow speeds, they would tend to stall with even minor load increases, such as a slope or increased friction on some track sections. If additional power were supplied to pull up an incline, the cars would tend to speed up and crash off the track on the downhill side. John's solution, illustrated in Fig. 4, was a voltage-regulated dc power supply with both a continuous "speed" control and a "top speed" fixed adjustment.

Referring to the schematic diagram, line voltage is stepped down by *T1*, rectified by a full-wave bridge rectifier (*RECT.*), and filtered by capacitor *C1*. A commercial 3-terminal voltage regulator, *IC1*, establishes a constant output voltage. The regulator, in turn, is supplied with a variable control voltage pedestal by a voltage-divider consisting of speed control *R2*, top-speed adjustment *R3*, fixed resistor *R4*, and reference dc voltage obtained from zener diode *D1*. Capacitor *C2* provides filtering

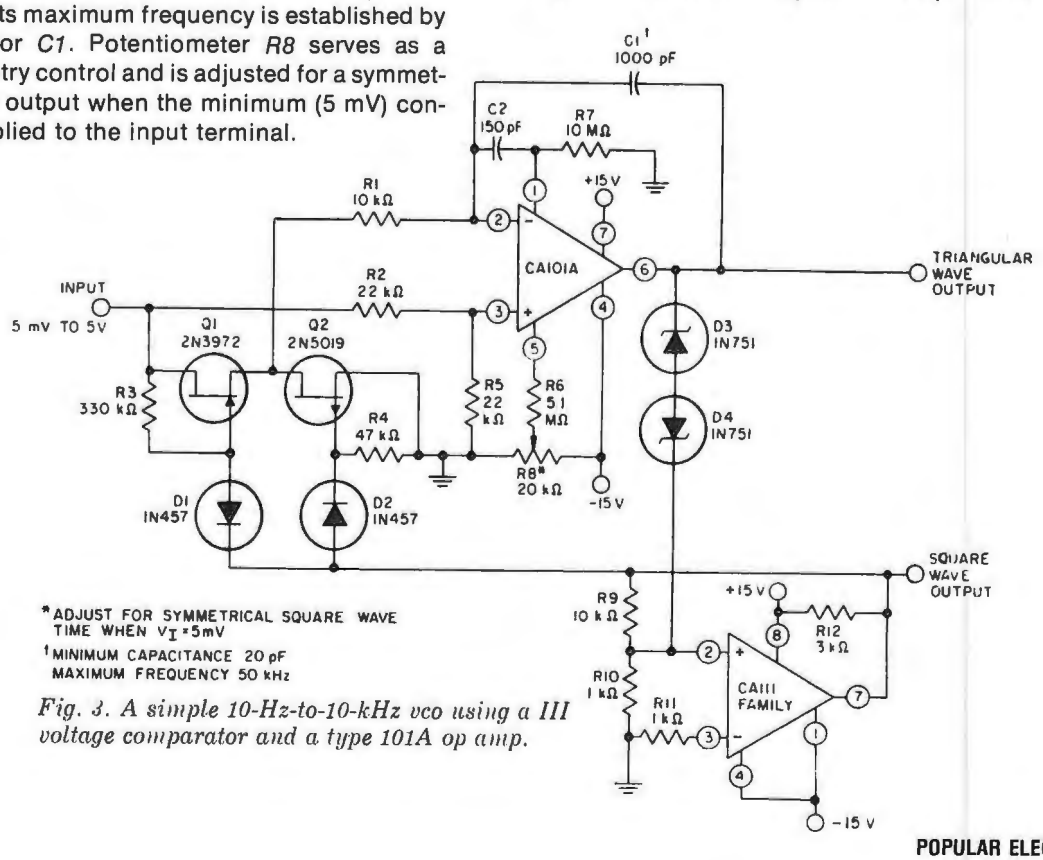

Fig. 3. A simple 10-Hz-to-10-kHz vco using a III voltage comparator and a type 101A op amp.

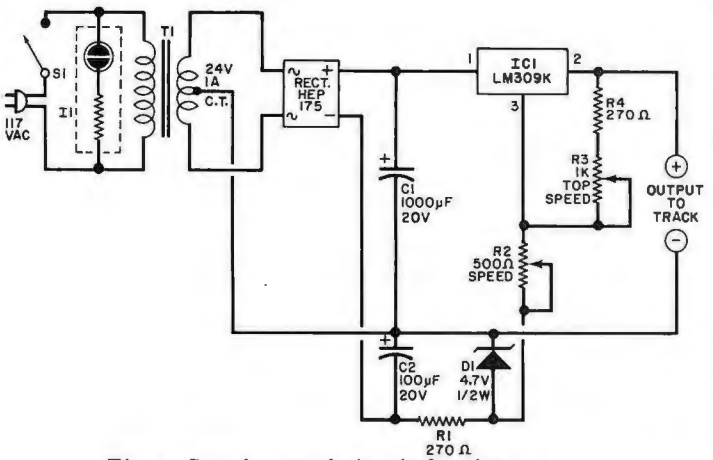

Fig. 4. Speed control circuit for slot cars and HO model trains as submitted by a reader.

for the reference voltage while series resistor *R1* limits the zener's current.

John used standard, readily available components in assembling his model. Power switch *S1* is a spst rotary type mounted on the 500-ohm speed-control potentiometer, *R2*. A 115-volt neon-type lamp assembly (with integral dropping resistor) serves as pilot lamp *I1*.

Since layout and lead dress are not critical, conventional construction techniques may be used for assembling the project. John built his original model in a 4"×5"×3" aluminum box, using the box itself as a heat sink for the voltage-regulator IC. With relatively few components needed, he used point-to-point wiring, providing a terminal strip to support the smaller parts.

With a maximum output of from 4.5 to 12 volts dc (depending on *R3's* setting) at approximately 1 A, the controller can be used with HO gauge model trains as well as slot cars. Separate controllers are needed, naturally, for each car in multi-car set-ups or for each train layout.

Anticipating that some builders might wish to use the power supply for other than model train or slot car control applications, John checked the circuit's overall performance. He measured a ripple of 25 mV at 10 volts output with a drain of 1 A, and found that the ripple could be reduced to less than 1 mV by adding a 50-μF capacitor between the negative output terminal and pin 3 on the regulator IC. The ripple at full output is somewhat higher, but the output voltage change is less than 2% from zero to full load.

Suggested by reader John Hornibrook (Box 1165, Silver City, NM 88061), the circuit shown in Fig. 5 might be called a *seeing aid* for the blind. Basically a light-controlled oscillator, the circuit provides an audible signal which changes in pitch with different light levels, thus permitting a user to "scan" the area in his immediate vicinity for changes in light contrast. John indicates that little practice is required for the user to detect objects in his immediate path, such as trees, telephone poles, other persons, walls, and so on, and thus to avoid collisions.

Except for photocell *PC1*, the circuit is a conventional collector-coupled multivibrator. The circuit's frequency will vary as *PC1's* instantaneous resistance varies and this, in turn, depends upon the amount of light falling on the photocell's sensitive area. Base resistor *R2* is made adjustable to permit the user to pre-adjust the circuit's frequency to a comfortable tone under average light conditions. The circuit's output signal, generated across emitter resistors

R4 and *R5*, is coupled to an external earphone through jack *J1*.

The circuit can be wired on perf board sized to fit and mounted on spacers inside a metal box or similar case small enough to be held conveniently in one's hand. The inside of the box should be blackened and all cracks covered with tape to make it light-tight. A lens should be provided to focus incoming light on the photocell. This is cemented behind a small ($^3/_{16}$") hole drilled in one end of the case, with the photocell mounted in the lens's focal plane. The photocell is modified by covering with opaque black tape, except for a $^1/_{16}$" vertical slit on its face. John used a 1" diameter lens with a 3" focal length, but other small lenses may be used if the photocell is positioned at the proper focal point.

To use the completed instrument, plug a moderate impedance earphone into jack *J1*. Switch on and adjust *R2* for a pleasing tone with the lens pointed towards an open area. Next, move the unit back and forth to "scan" the area. As the instrument is moved past objects of varying contrast, there should be a change in the pitch of the audio signal. The instrument's effective sensitivity will depend on one's hearing acuity, on the degree of light contrast between detected objects and background lighting, and, to some extent, on *R2's* adjustment, as well as upon the degree of skill acquired through practice.

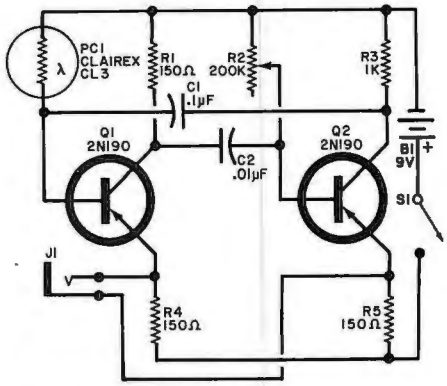

Fig. 5. Audible signal varies with different light levels.

Device/Product News. A new LED digit driver specifically designed for use in digital clocks and desk-top calculators has been introduced by *National Semiconductor Corp.* Identified as the DS8863, the new IC contains eight independent channels, each capable of sinking up to 500 mA. Intended for use in display systems employing LED's in the common-cathode multiplexed configuration, the device can be used with displays up to 0.6 inch high and even with digits made up of individual lamps. Featuring high-gain Darlington circuits and requiring a maximum input drive of only 2 mA, the DS8863 interfaces directly with MOS clock and calculator circuits.

If you're using round case TO-5 type IC's, but have a breadboard or circuit layout designed for DIP's, you'll want to check into a series of inexpensive mounting pads now available from *Bivar, Inc.* (1617 Edinger Ave., Santa Ana, CA 92705). Molded of high-strength plastic, these handy components have funnel-shaped, self-aligning entry holes which will accept devices with circular patterned leads, forming the leads into a DIP pattern at exit. Posts on the top and feet on the bottom of the pads provide extra lead exposure for heat dissipation and permit easy probe insertion for circuit tests. Three color-coded versions of the mounting pads are currently available: an 8-lead blue pad, Part No. 808-187, a 10-lead red pad, Part No. 810-187, and a 12-lead white pad, Part No. 812-187. All three versions are priced at $9.05 per hundred in quantities of 100 to 499, dropping to $36.25 per thousand in quantities above 10,000.

Thinking about assembling a digital watch? There's good news from the West Coast—a new low-voltage CMOS IC chip which contains all of the LSI circuitry required to make a digital watch is now available from *Siliconix, Inc.* (2201 Laurelwood Road, Santa Clara, CA 95054). In addition to the chip, type DF111, all that is required for watch assembly are a 32.768-kHz crystal, a battery, a LED display with drivers, and three switches, plus, of course, a case and hardware. Options are provided for sensors to indicate low-battery conditions and ambient light level. Functional down to 2.2 volts typical, the chip's nominal voltage range is 2.7 to 3.4 volts, supplied by two silver-oxide cells. The DF111 provides for a multiplexed four-digit, seven-segment LED display which will indicate days (date), hours, minutes, and seconds. Days, hours, and minutes may be set independently, and seconds may be synchronized from another time source. Optional displays are 12 or 24 hours, and an AM indicator is available with the 12-hour option. ◈