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What's behind the computer keyboard?

Servicing the RCA CTC 108 unitized chassis

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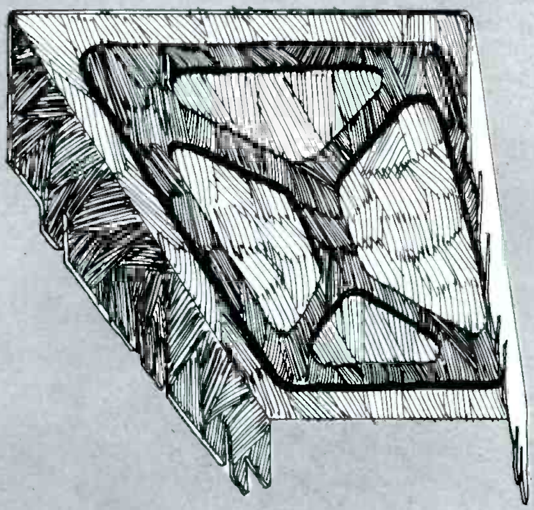
General Electric EP93X168

Module Update



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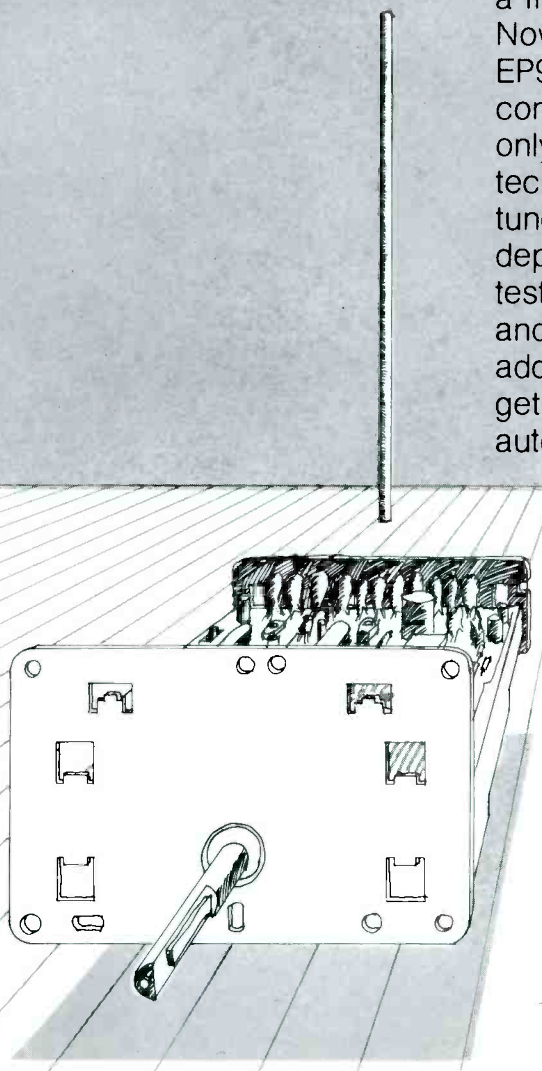

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ELECTRONIC Servicing & Technology

September 1983
Volume 3, No. 9

A few of the instruments that can be used for checking out digital circuitry are a wide-band oscilloscope and a logic system analyzer, which includes a signature analyzer, a logic analyzer and a DVOM. The article on page 16 explains one way digital circuitry is used in electronics. *(Photo courtesy of B&K Precision.)*

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By Stan Vittetoe, CET
Servicing unitized chassis, as opposed to modular chassis, requires a high degree of skill. Fortunately, there are many similarities between manufacturers, so these tips on the RCA CTC108 apply to many different chassis.

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By Joe Carr
The keyboard is the computer operator's means of "talking" to the computer, so understanding the workings of the keyboard is an important step in troubleshooting microcomputers.

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By Sam Wilson, ISCET test director
See how you would do on the Certified Electronic Technician test. This month's questions cover resistors.

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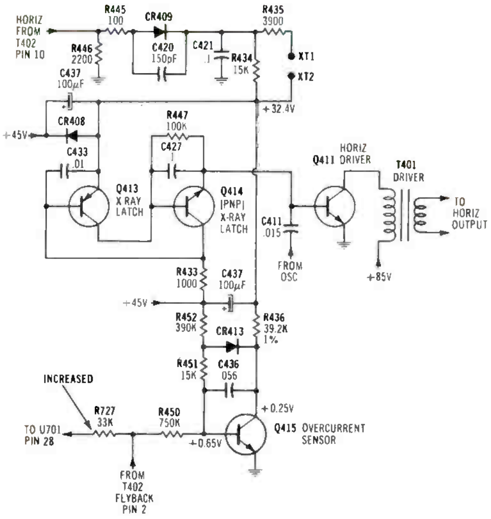

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Next month...

Advances in flat-plan LCD technology have enabled BBC-Metrawatt/Goerz to introduce a new digital scope that measures only 10" x 7" x 3.5" when folded and weighs only 4.3 pounds. The October Technology department describes this instrument, which combines the capabilities of a digital scope, multimeter and transient recorder.

Hey good buddy

In 1975 the FCC made a few changes relaxing the rules governing CB radio operations. Within a year, the FCC was receiving more than 500,000 applications per month for CB licenses.

During this period, everywhere you looked CB antennas sprouted from cars, and drivers were seen speeding down the road with one hand on the wheel and the other holding a microphone to their mouths. The airwaves crackled with CB jargon. Anyone listening ("on the side") to Channel 19 might hear conversations such as, "Hey good buddy, better back off the hammer. There's a smokey with an X-ray machine up ahead." If you knew the jargon, you knew that the speaker was telling another driver to slow down because of a policeman ahead with a radar unit.

Frequently it was possible to travel in unfamiliar territory without a map. CBers who knew the area would help guide a driver to his destination. Someone whose car broke down could call for help via his CB radio, and people had a great time just chatting with each other via the CB.

An entire subculture grew up around the CB. CBers from Boston to Los Angeles began talking in the southern drawl characteristic of CB speech. Terms such as "twenty" (location), "smokey" (policeman), and "convoy" (group of travelers driving together) entered the language. Everyone had a "handle" (code name for a CBer). Even the wife of the president was "First Momma."

Then several country/western style songs came out with CB as their subject. The whole country, it seemed, was communicating via CB and talking about it.

Then it stopped. Abruptly. Presumably, truckers and a handful of other people who spend a lot of time on the road still use their CBs to communicate. But it's a disused item for the most part, these days.

CB radios are now being sold mostly as emergency units. You buy it and put it in the trunk next to the spare tire to use should your car break down.

The CB craze lasted just a few years, then died. What happened? I haven't seen any studies or discussion on the subject, but my guess is that the craze got started when people found that it was an inexpensive, simple way to communicate over distances (something that seems to have fascinated humanity since the days of signal fires, smoke signals and "talking" drums) and died when they found that they really had nothing to say to each other.

With electronic devices of all kinds being cranked out and tried out, it seems likely that the CB experience will be repeated. Will video games last or are they just a fad? How about personal computers? Where will compact digital audiodiscs, videodiscs, videotapes and all the other new electronic equipment be in 10 years?

I don't know the answers, and I don't know anyone who does. But it's a subject that bears careful consideration by anyone who purchases, sells or services electronic equipment.

10-7 Good Buddy. We gone!

Nils Conrad Persson

ELECTRONIC Servicing & Technology

Editorial, advertising and circulation correspondence should be addressed to: P.O. Box 12901, Overland Park, KS 66212-9981 (a suburb of Kansas City, MO); (913) 888-4664.

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Part 1
Servicing the RCA CTC 108 unitized chassis

By Stan Vittetoe, CET

Newer TV receivers can be classified either as unitized or modular (with plug-in panels). Unitized receivers often have all the components (except tuner systems) mounted on one large circuit board, so troubleshooting requires a high degree of skill. Fortunately, many similarities are retained by the manufacturers over several models, and a technician can become familiar with the circuits and the typical failures.

This article is specifically for the RCA CTC108 chassis (Photofact 2030-2), but many explanations and tips apply equally to CTC107, CTC109 and CTC110, although the component identification number on schematics might be different.

All these receivers are the "hot chassis" type, which have dangerous ac voltages between chassis ground and earth ground. To prevent damage to test equipment and shocks to technicians, the receiver *must* be plugged into an isolation transformer. Also, many troubleshooting procedures call for variable line voltages, so a *combination* isolation transformer and variable-voltage transformer is strongly recommended.

Power supplies and start-up

In the past, troubleshooting color TV receivers usually began with the technician making tests in the circuits that were most likely to cause the observed symptoms. Sometimes, these measurements eventually included all the supply voltages for the suspected stages, but the importance of testing supply voltages has a higher priority with late-model receivers. This is because of the many voltage sources that rectification and filtering of horizontal-sweep power from the flyback produce. Remember that no dc voltages can come from these power sources when the horizontal-sweep circuit is dead.

Figure 1 shows a partial schematic of several important CTC108 power supplies, assuming there are no defects or incorrect adjustments. Only the +33.5V zener-regulated voltage source and the SCR-regulated +121V source are derived directly from the +167V main power source. Several other start-up and continuous operation supplies are taken from the +121V regulated source. However, the +121V source cannot operate with more than partial voltage until start-up occurs and two sources of horizontal pulses are supplied to the SCR and its control circuitry.

Various start-and-run (continous operation) and separate start sources and run sources are marked on the schematic. A knowledge of these voltages and how they perform start-up is essential for efficient troubleshooting.

Part defects can stall the start-up sequence at some intermediate stage. In some cases, for example, R437 (which supplies start-up B+ to the driver transistor) has been found open, causing a dead set each time by preventing start-up. Even worse, the resistance sometimes has increased to about 10kΩ, producing erratic start-up.

Also, the shut-down circuitry (which protects by eliminating the driver-transistor gain) is activated by excessive amplitude of some flyback pulses, or by excessive high voltage or high-voltage current. Therefore, correct start-up can be followed instantly by shut-down, perhaps seeming to be start-up failure. Either condition gives the symptoms of loss of all sound, high voltage and raster.

Troubleshooting startup problems

The failure of the CTC108 to achieve proper start-up produces a receiver with no sound, no raster and no high voltage. These outward symptoms can be caused either by an inoperative horizontal-sweep system or by a missing start-up power-supply voltage. Use this checklist to locate the defect:

- Measure the dc voltage at input filter-capacitor C105; it should be +165V or higher. If it is zero, the F101 fuse or RF101 probably is open, perhaps from a shorted bridge rectifier or C105 filter capacitor. A voltage between +100V and +120V might indicate an open C105. When C105 is normal, a low +167V-supply reading hints at excessive load on the bridge-rectifier supply.
- If the C105 dc voltage is normal, measure the +20.5V supply (CR111 cathode), the +182V supply (CR112 cathode) and the collector voltage of Q412 output transistor. If all have typical start-up dc voltages, a defect in one of the three horizontal stages is eliminating the horizontal sweep or the circuit is in shut-down.

- If only one of the three start-up dc voltages is much lower than the typical voltages shown in Figure 1, the defect involves the source of the incorrect voltage. Check all components in and around the source.
- If the three horizontal stages have typical start-up dc voltages and the entire horizontal-sweep system *appears* to be normal, check the overvoltage shut-down safety circuit to determine whether the receiver is in shut down. Refer to the shut-down circuit analysis later in this article.
- If the C105 voltage is approximately +167V, but the +121V regulated voltage is zero, the problem is in the SCR101 regulator circuit. (See Figure 2).

Regulation by SCR

The regulation of the high voltage and picture width in the CTC108 is accomplished by regulating the +121V supply. In turn, the 121V-supply voltage is regulated (in part) by adjustment of the percentage of time a filter capacitor is charged from a source of higher dc voltage. This is integration of dc voltage, a principle used in many other makes of color receivers.

Figure 2 shows a partial schematic of a 121V regulator that has four small transistors and a

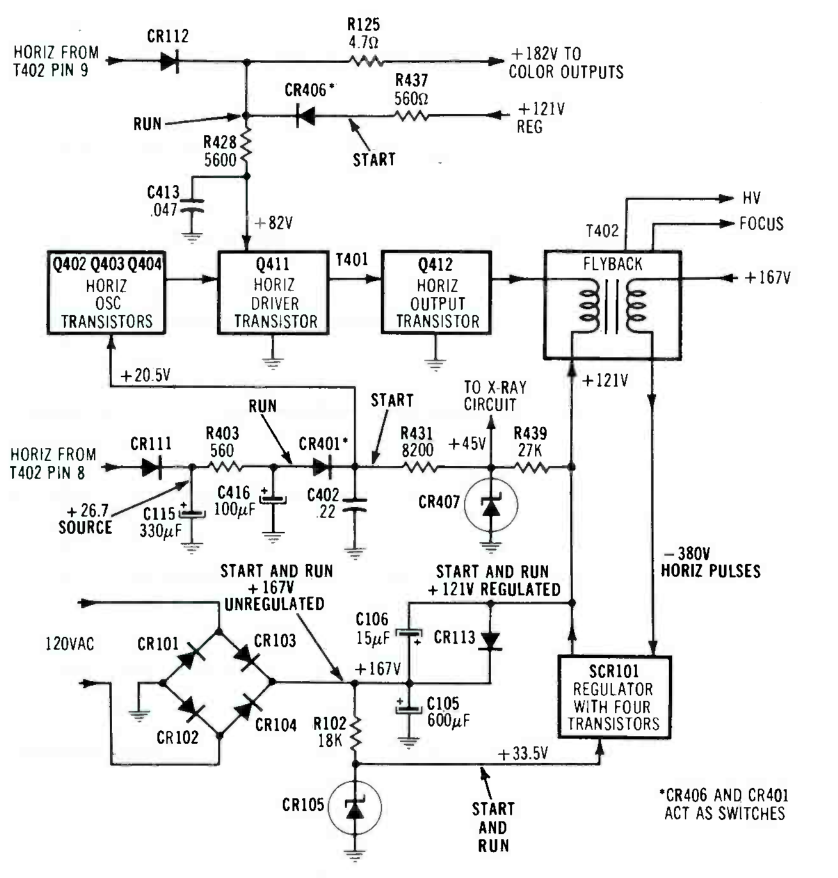

Figure 1. This partial schematic shows several important power supplies.

At turn-on, before the horizontal-sweep system begins to operate, the only CTC108 active power sources are the +167V line-rectified principal source and two others derived from it. All three operate continuously when the power is on. Power from the +167V source passes through R102, where it is regulated by zener diode CR105 to +33.5V, and then applied to the four regulator transistors. The +121V source is regulated by SCR101 and sent to the collector of the horizontal-output transistor Q412.

During start-up, however, Q412 draws no current because it has no base drive, and the +121V supply has only partial voltage. Some voltage from the +121V supply goes through R439 to the overvoltage shut-down circuit, but that is not essential to start-up. About 5V comes from the +121V supply through R439 and R431 to the oscillator circuit (switching diode CR401 is reverse biased by lack of rectified voltage from CR111), providing weak oscillation. Similarly, about +50V for start-up of the Q411 driver transistor is obtained from the +121V source through R437 and switching diode CR406 (which now is forward biased). All three horizontal stages have low dc voltages, so they begin operating correctly but weakly, producing some horizontal deflection and high voltage. Pulse waveforms from the flyback now are rectified, giving partial voltage in several of the supplies.

When the CR111 dc voltage rises above the start-up 5V at the CR401 cathode, CR401 becomes forward biased, passing the higher voltage (which overrides the start-up voltage and gives higher voltage to zener CR407 also) to the oscillator transistors which then provide increased signal to the Q411 driver base.

When the CR112 dc voltage rises above the start-up +50V at the CR406 cathode, CR406 becomes reverse biased, blocking the start-up voltage coming from R437, while the higher CR112 voltage increases the output signal from Q411 that drives Q412. Therefore, the higher dc-supply voltages force the horizontal-sweep system to operate more strongly. In turn, the higher amplitude of horizontal-sweep operation produces higher dc voltages from all the horizontal-rectified voltage supplies. This is a regenerative condition that rapidly reaches maximum and then stabilizes with the dc voltages shown on the schematic, including correct operation of the +121V regulated supply that now has proper pulses for synchronization and SCR turn-off.

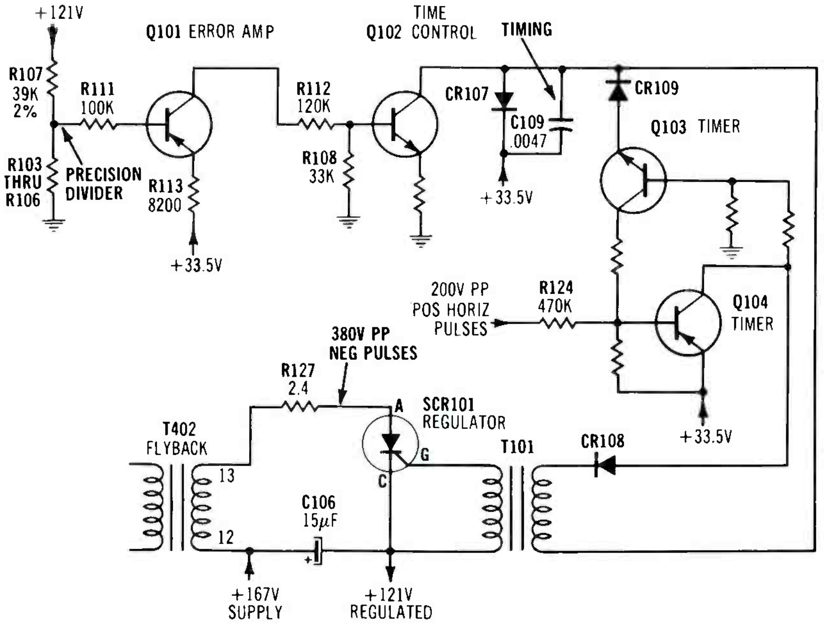

Figure 2a. This CTC108 regulator schematic has been simplified to show the general operation more clearly.

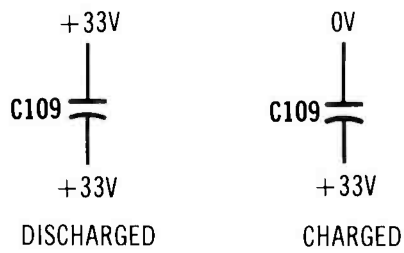

Figure 2b. A discharged capacitor usually is considered to have 0V at both ends. However, in the CTC108, +33V is at both ends of C109 when it is discharged following each Q104 conduction. Zero at one end and +33V at the other represents a full charge.

The four transistors gate-on the SCR101 conduction at the proper time during each horizontal cycle. C106 integrates these dc pulses of SCR current, and the duty cycle of the current pulses is varied as needed to maintain a regulated +121V for the horizontal-output transistor. Pulses from Q103 and Q104 gate-on the SCR101, and the current continues until the next negative-going pulse at the SCR101 anode.

The operation of transistors Q103 and Q104 has been described as a multivibrator action. The circuit is *not* a multivibrator oscillator, but there are some similarities. Notice that the Q104 collector is directly connected by a resistor to the Q103 base, and the Q103 collector is connected through a resistor to the Q104 base. A coupling capacitor at the base of either Q103 or Q104 would have produced a multivibrator, but there is no coupling capacitor. Instead, the circuit is a one-shot regenerative switch that is activated when the Q103 emitter voltage decreases to a point that provides forward bias for the base of NPN-polarity Q103. A rapid regenerative action follows (because the collector/base phases are correct for oscillation). This action ends with the saturation of Q104, forcing voltage from the +33.5V supply through the Q104 emitter/collector, the forward-biased CR108 diode, the primary winding of T101 triggering transformer and on to capacitor C109. Notice that this temporarily connects one end of C109 to the +33.5V at Q104's emitter while the other end is permanently connected to the +33.5V supply. In other words, C109 has just been discharged by having the same voltage at both ends.

Figure 2B shows why this is true. The short-duration pulse of Q104 saturation current passes through the T101 primary, generating a similar pulse in the secondary winding that gates-on SCR101 conduction, raising the +121V-supply voltage. Resistor R127 limits the maximum current flow into C106 and also prevents an ac short across the flyback winding when SCR101 conducts. Next, a circuit action must initiate the Q104 maximum-current pulses (that discharge C109) at proper times.

Actually, C109 must be discharged twice during each horizontal cycle. One discharge is produced during horizontal retrace by a positive flyback pulse through R124 to the Q104 base. This applies a pulse to the SCR101 gate (which is ignored because the SCR is being turned-off by an anode pulse at that time) and also discharges C109, thus preparing C109 to accept a precision-timed charge that triggers the next Q103/Q104 single-shot pulse.

The timing circuit includes Q101 and Q102, which control the slow charging of C109. Emitter voltage for Q101 is stabilized by zener CR105 (see Figure 1), while the Q101 base voltage comes from a precision voltage divider connected between the +21V regulated supply and ground. When the regulated voltage rises, for example, Q101 has a decreased forward bias that reduces the collector positive voltage, which goes through R112 to the Q102 base. This produces decreased Q102 collector current that charges C109 more slowly (the C109 charging current is the Q102 collector current), so a longer time is required for the Q103 emitter (connected to C109) to reach the critical triggering voltage. Therefore, SCR101 current is gated-on later in the cycle, reducing the +121V-supply voltage to normal. Of course, a decrease of +121V-supply voltage because of increased CRT current will reverse the action previously described, increasing the voltage to normal.

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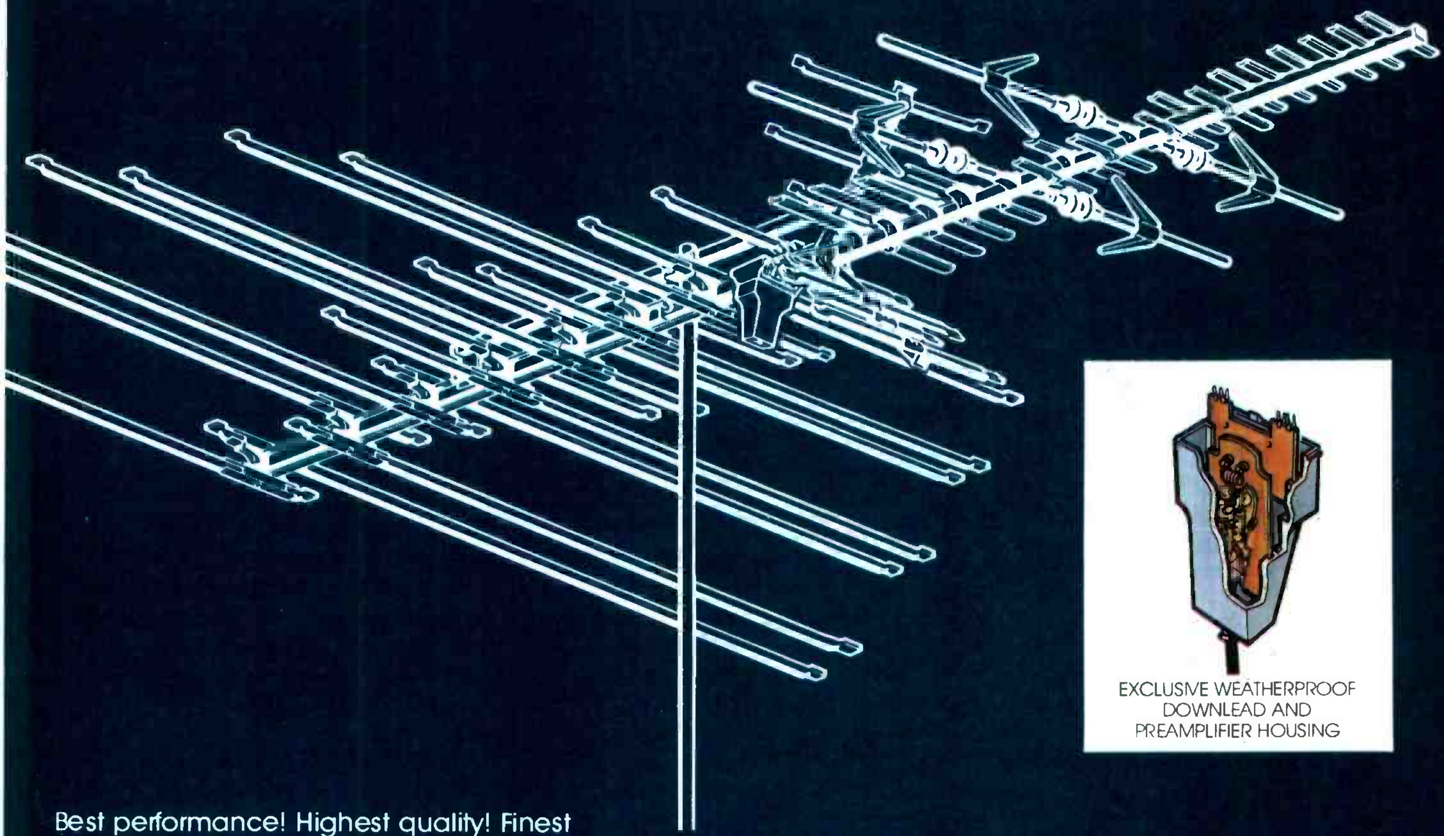

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power SCR. Simply stated, the four transistors gate the SCR into conduction at the proper point during each horizontal-sweep cycle, so the dc voltage from the +167V supply can travel through a flyback winding, a resistor and the SCR anode/cathode conduction and replenish any C106 power needed to maintain +121V at C106 and the SCR101 cathode. Negative-going horizontal-sweep pulses from T402 flyback pin 13 turn off SCR101 conduction of dc current by making the anode more negative than the +121V at the SCR cathode.

When the line voltage is low or the picture tube draws increased high-voltage current, the +121V supply voltage drops. The regulator circuit restores the original voltage by gating-on the SCR101 conduction earlier in each horizontal cycle. A longer time of charging C106 (up to 50% of each cycle) from the +167V supply raises the C106 voltage until the desired +121V is obtained. At the other extreme, higher line voltage or decreased CRT current forces the +121V supply to a higher voltage, which is reduced by gating-on the SCR101 conduction later, giving perhaps only 25% conduction time.

The 4-transistor circuit monitors the +121V-supply voltage, and from the instantaneous dc voltage there, it adjusts the time between the previous horizontal pulse and the beginning of SCR101 conduction. Once gated-on, any SCR current continues until the anode/cathode current is interrupted (becomes zero). Gating off the SCR in this circuit is accomplished by the next negative-going horizontal pulse that reaches the anode. Therefore, regulation correction occurs during each horizontal cycle, with the SCR conduction just prior to each horizontal pulse.

Enhanced regulation

CTC108 regulation operates as described in Figure 2 except for one effect that is seldom explained. Measurements published in the January 1980 issue of **Electronic Servicing** showed only 0.7V

C410 is the principal frequency-determining component, although some resistors and dc voltages also determine and vary the frequency. Notice that Q401, Q402 and Q404 emitters are connected together, sharing a single R418 resistor. For the purpose of analysis, imagine that these three transistors are one transistor with three bases. Q402 and Q403 are connected almost as an unbalanced multivibrator. That is, the Q402 collector is connected directly to the Q403 base, and the Q403 collector is connected through two resistors to the Q402 base. Only a coupling capacitor at the Q402 base is needed to form a multivibrator, but this much of the circuit cannot oscillate.

R423 and C410 form an integrator for the Q403 collector square waves, forming a triangular waveform at the

Q404 base. Because the three emitters are connected together, the Q404 base signal affects the Q402 bias in reverse.

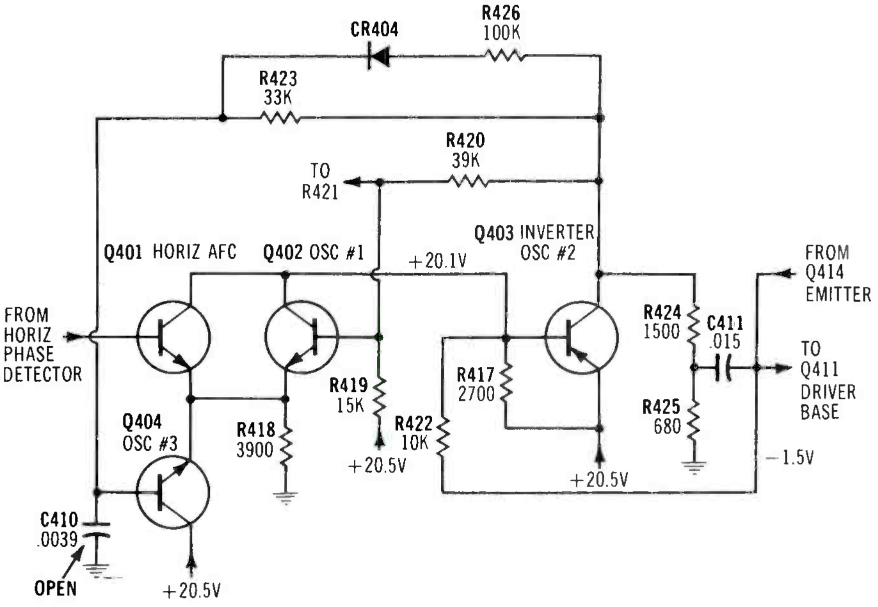

Figure 3. The oscillator circuit of CTC108 can be seen clearly in this schematic.

For example, the triangle positive peak at Q404 base increases the common emitter positive voltage, which is equal to a decrease of the Q402 base voltage. Therefore, Q402 is cut off. When the Q404 base negative peak arrives, Q402 is biased to saturation. In this way, the three transistors become an oscillator (but without a frequency control). Q401 base receives the varying dc voltage produced by the horizontal phase-detector action of CR402/CR403. Also, the Q401 base receives an adjustable dc positive voltage from the R416 horizontal-frequency control. The Q401 emitter is connected to the Q404 and Q402 emitters, so a change of Q401 emitter current affects their bias and varies the oscillator frequency.

variation of the +23V regulated voltage in a CTC99 when the line voltage was varied from 125Vac to 100Vac. That was excellent regulation, but readings made at line voltages lower than 100Vac showed regulated voltages that were *higher* than the source-supply voltage. Of course this is impossible, because no derived voltage can exceed its source.

There is another reverse proof that SCR conduction of dc power cannot be the sole source of the regulated voltage. Waveforms of the CTC99 showed the maximum conduction time of the SCR was only about 50%, even at a 60Vac line voltage. C106 integration of these CTC108 50% duty-cycle dc pulses from the SCR produces only 50% of the supply voltage, and 50% of +167V is +83.5V, which is far below the +121V actually obtained. Obviously, another circuit action is increasing the regulated-voltage level.

Research conducted on the CTC99 previously showed the higher regulated dc voltage was produced by rectification of the SCR-anode pulses that turn off the SCR conduction. Rectification of these pulses appears to be very unlikely, because they are negative-going and ordinarily could produce little rectified dc voltage. However, the +167V introduced at flyback pin 12 shifts the zero-voltage point down on the waveform by the equivalent of 167V peak-to-peak. Therefore, most of the pulse height is positive and can be rectified by the SCR diode action until the pulses become negative and turn off all SCR conduction.

(To be continued next month.)

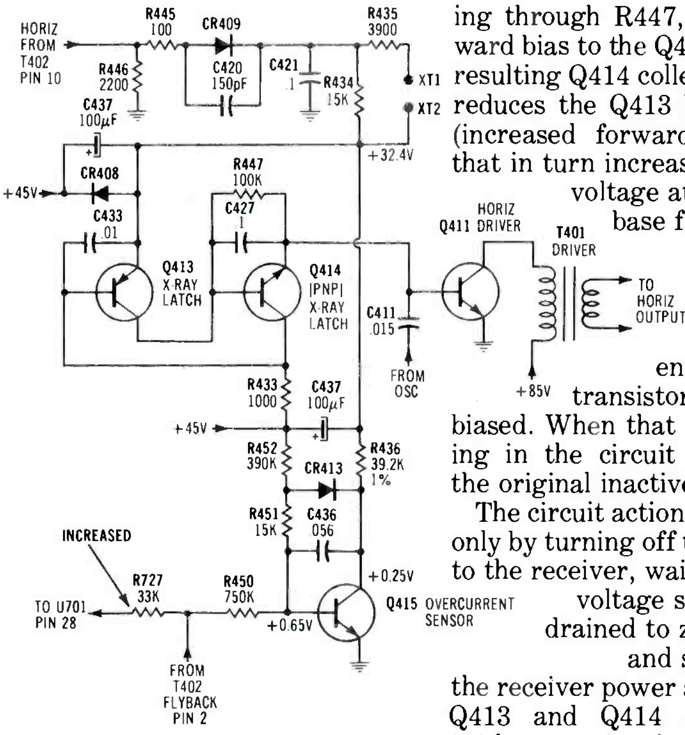

Figure 4. The Q413 and Q414 collectors are shown here.

Q413 and Q414 form a locking switch. The collector of Q413 is connected directly to the Q414 base, and the Q414 collector is connected directly to the Q413 base. At rest, neither transistor has C/E current. Q413 is reverse biased, and Q414 has zero forward bias.

If the Q413 cathode dc voltage becomes +0.6V or more above the Q413 base voltage, this is forward bias that produces Q413 C/E current, which passing through R447, applies forward bias to the Q414 base. The resulting Q414 collector current reduces the Q413 base voltage (increased forward bias), and that in turn increases the Q414 base forward bias. This is a rapid regenerative action that ends with both transistors saturation biased. When that occurs nothing in the circuit can restore the original inactive condition.

The circuit action can be reset only by turning off the ac power to the receiver, waiting until all voltage supplies have drained to zero voltage, and switching on the receiver power again. When Q413 and Q414 are latched (with saturation forward bias) a positive dc voltage from the Q414 emitter is applied to the base of Q411. This excessive forward bias eliminates all Q411 gain, so the horizontal-sweep operation stops.

As noted before, nothing can unlatch the shutdown action except turning off the power. Two different conditions can activate this safety shutdown latch: one is excessive high-voltage current; the other is excessive pulse amplitude from the flyback. Diode CR409 receives horizontal power from pin 10 of the flyback and rectifies it, with C421 acting as the peak-reading filter capacitor.

This voltage (which varies with the flyback pulse amplitudes) is reduced and filtered by R434 and the capacitors before it is applied to the Q413 emitter. Therefore, when the rectified positive voltage exceeds the design point, Q413 draws current, activating the latch as described. Also, the low end of the high-voltage winding on the flyback is monitored by Q415 as an indication of the high-voltage current. Increased current forces pin 2 of the T402 flyback winding to become less positive.

Q415 normally has saturation forward bias (from R452 and R451), so the reduced positive voltage at the flyback decreases (through R450) the Q415 bias when the CRT current is excessive, and the higher Q415 collector voltage applies (through R452, CR413 and R436) a higher positive voltage to the Q413 emitter, activating the shutdown operation that kills the horizontal sweep.

The operation of the shutdown circuit can be tested by shorting together testpoints XT1 and XT2. If the shutdown operation is normal, the sound and picture should disappear. This circuit protects the receiver against two basic overloads.

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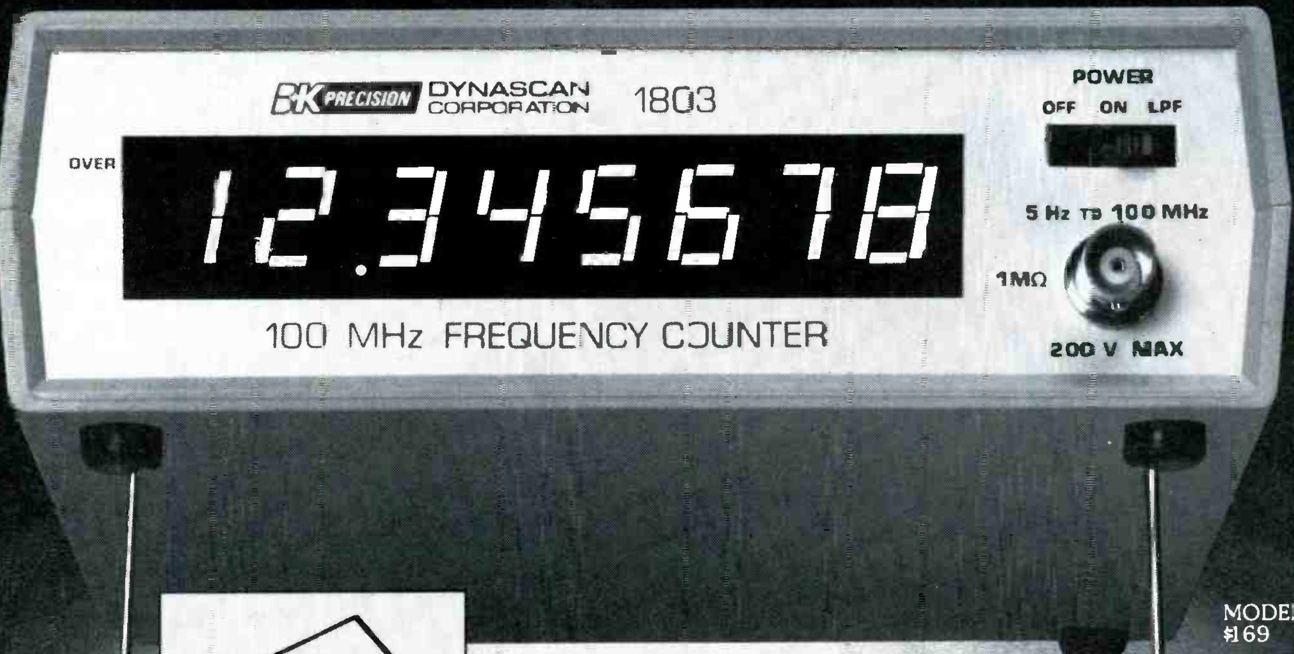

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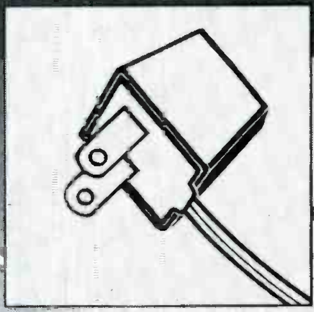

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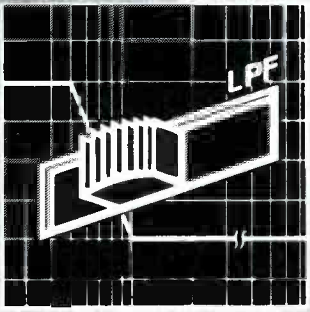

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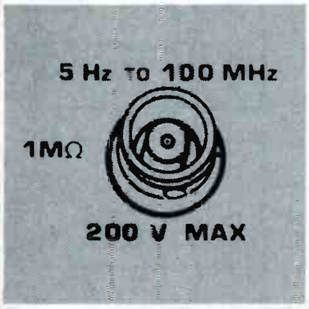

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Circle (10) on Reply Card

tains four independent, non-inverting buffers, each of which has an active-*low* control line. By connecting all four $\overline{CE}$ lines together on the two devices shown in Fig. 4B, the input port is turned on with the $\overline{IN}$ signal generated by the computer. (An $\overline{IN}$ signal is generated when the port address and control signals combine to select a particular port.)

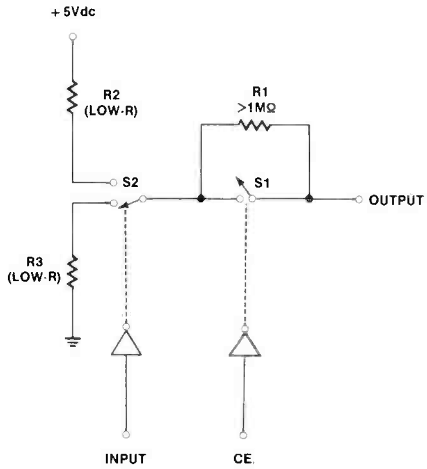

Figure 4a. If no output port is available, one must be provided. In a tri-state output, the third state is a high-impedance in series with the output terminal.

The pair of 74125 devices forms a single 8-bit input port. The input terminals on the chips are treated the same as in Figure 3A. The 74125 is an example of a suitable input chip. The 74126 is similar except that it uses active-*high* chip enable lines. The Intel 8216 and 8226 are 4-bit, bidirectional, non-inverting and inverting, respectively, buffers used for I/O port service. The 8212 Intel device is an 8-bit bidirectional I/O port chip. There are also 8-bit input-only devices such as the 74LS244. Special-purpose I/O chips are made for specific microprocessor chips such as the 6522 for the 6502 and the Z80-PIO for the Z80.

Debouncing keyboards

Mechanical switches don't close cleanly but bounce several times before making solid contact. This phenomenon is rarely a problem in analog circuits, but in digital circuits the noise spikes produced by contact bounce may be interpreted as valid signals. Most keyboards, therefore, require some form of debouncing scheme.

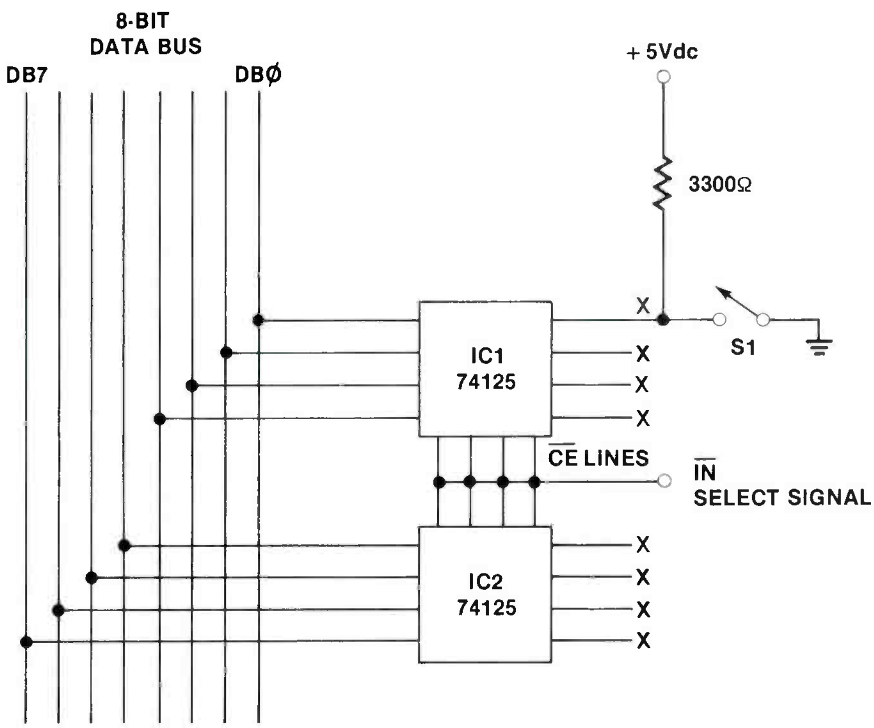

Figure 4b. Here, two 4-bit chips are used to fabricate an 8-bit output port.

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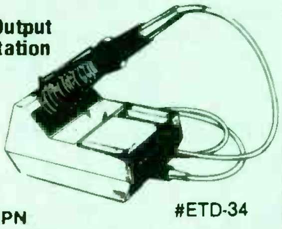

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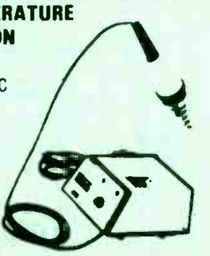

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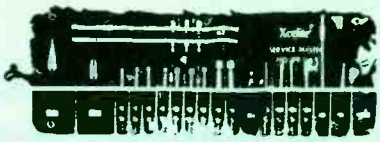

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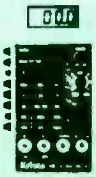

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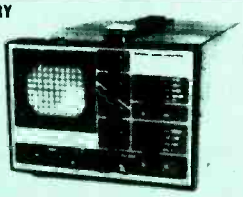

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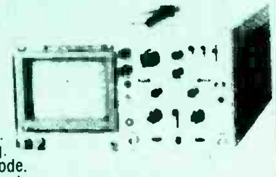

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Circle (12) on Reply Card

There are several strategies for overcoming contact bounce. If a keyboard encoder IC is used, a capacitor will fill the function (see Figure 1). In other cases, such as Figure 3, the switch interfaces directly to a port, so the computer program must do the debouncing. In those machines, the keyboard input or scanning program will contain a time delay loop that reads the port data 5 to 10ms after the port is turned on. The delay gives the contact bounce enough time to die out. Another technique uses circuits such as those in Fig-

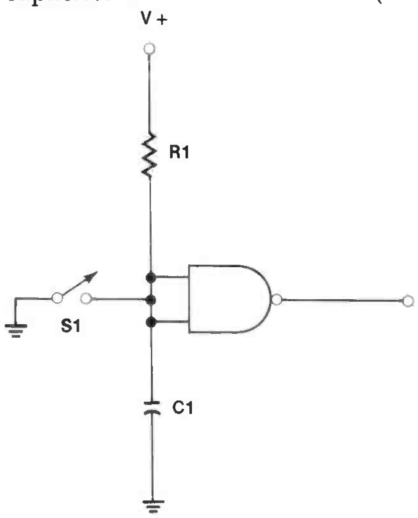

Figure 5a. One method of "debouncing" keyboard inputs is to use a Schmitt trigger or CMOS inverter and an RC network.

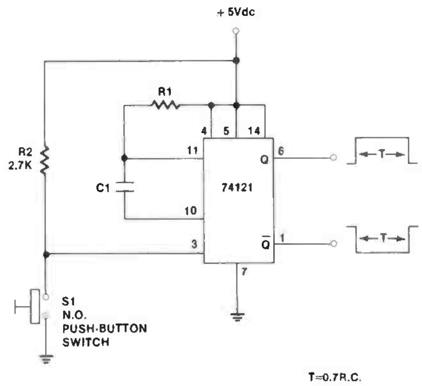

Figure 5b. The 74121 IC monostable multivibrator produces a single pulse of period T = 0.7RC when a negative-going pulse is applied to pin 3.

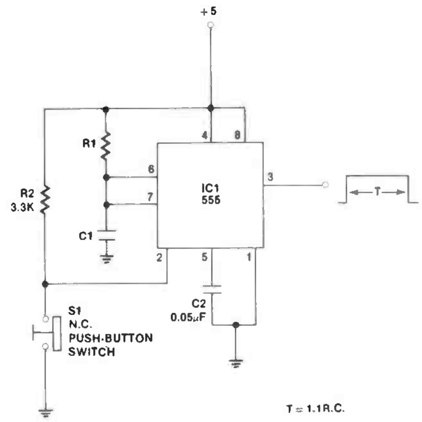

Figure 5c. A 555 Timer IC is another way to provide a stable output pulse even if the input "bounces."

(continued on page 44)

Readers' Exchange

Needed: Schematic, manual or operating instructions for Fairchild frequency meter (counter) model 8220 or same product made by Systron Donner. Will pay expenses or reasonable cost. *Phillip Clay, 5533 Roanoke, Kalamazoo, MI 49002.*

Needed: Sencore LC-53 Z-meter. Please contact with condition and price. *Robert Query, 6346 King Louis Drive, Alexandria, VA 22312; 1-703-354-3721 after 4:30 p.m.*

Needed: Schematic for a TV set from Canada, Fleetwood chassis no. CTS 1965. *Joseph J. Eberhardt, D7 Hans Brinker Street, Box 354, Windmill Village, North Ft. Myers, FL 33903.*

Needed: Pilot TV picture tube #3KP4 (circa 1949 3-inch CRT). *John Miller, 3704 Bold Bidder Drive, Lexington, KY 40502.*

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Needed: Schematic for Sears television, model 562, 40090301. *Barney Lonzo, P.O. Box 112-C15716, Joliet, IL 60434.*

Needed: Original owner's manual and service manual for a Halicrafters model SX-62 radio receiver. *Paul Capito, 637 W. 21st St., Erie, PA 16502.*

Needed: Power transformer for Sansui model 800 stereo receiver. *Fleming's TV, Box 647, Rome, NY 13440; 1-315-337-3340.*

Needed: Schematic and parts list for Philharmonic stereo grand electronic accordion. Willing to pay cost and shipping. Picture tube #25AP22A Hi Lite in good condition. Call or write stating price and condition. *John Iannelli, 1501 Saunders Crescent, Ann Arbor, MI 48103; 1-313-662-9623.*

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(Continued from page 22)

ure 5 to clean up the problem. All three techniques are monostable multivibrators.

The circuit in Figure 5A uses a Schmitt trigger or a CMOS inverter (or inverter-wired gate) and an RC network. In the normal condition (*low* output), switch S1 is open so that capacitor C1 will be charged to V+ (usually +5Vdc). Closing S1 causes C1 to become discharged. In this discharged state, the input sees a *low,* so the output will be *high.* The output remains *high* for a period, T, which is the time required for C1 to charge to what the IC sees as *high.*

Two other monostable multivibrators are shown in Figures 5B and 5C. Both are IC versions. The circuit in Figure 5B is the TTL 74121 device. This device produces a single pulse of period $T = 0.7R_1C_1$ every time a negative-going trigger pulse is received on pin 3. This trigger input normally is held *high* by resistor R2 and is dropped *low* when switch S1 is closed.

The circuit in Figure 5C uses the 555 IC timer chip for the same purpose. A 555 is TTL compatible if the V+ voltage applied to pins 4 and 8 is +5Vdc. If some CMOS device is being addressed by the pulse and uses a V+ greater than +5Vdc, then this cirucit still can be used. The 555 operates to +18Vdc.

Testing a keyboard

From a troubleshooting perspective, it is necessary to know whether a keyboard is producing the correct code and whether the strobe, if used, is present. The key to troubleshooting without using a logic analyzer is to use a device or instrument that will indicate whether a point is *high* or *low.* A bench oscilloscope that is dc-coupled can do this. Vary the position and vertical sensitivity/deflection controls so that the trace is near the bottom of the screen for *low* conditions and near the top for *high* conditions. The strobe signal used on many keyboards may have a fast rise time and short duration. This combination makes the strobe hard to see on some oscilloscopes. Many logic probes, however, have a "pulse catcher" circuit that will latch and turn on a light when the strobe pulse occurs.

A *high/low* indicator can be built using an open-collector TTL inverter, an LED and a resistor (see Figure 6). When the level applied to the input probe is *low,* then the inverter output is *high* so the LED is off. If the input is *high,* the output is *low,* turning the LED on.

One can build an 8-bit state monitor using this circuit. Inverters come in groups of six, so two hex inverter packages will make an 8-bit monitor with four inverter sections left over.

If a keyboard has only switches across an input port, then the criteria in troubleshooting is determining whether each bit is appropriately *high* or *low.* If the keyboard is ASCII-encoded, the *high/low* status of all seven lines must be examined to determine whether the correct ASCII code is present.

Displays

For a terminal or keyboard to interact with a user, there must be some form of display device. The display may be a CRT video terminal, 7-segment numerical display device or an LED indicator lamp that turns on when certain conditions occur.

Figure 7 shows how an LED indicator is interfaced to a computer I/O port. The LED will draw 10 to 20mA, so it cannot be directly driven by the output port bit. Instead, a higher current TTL inverter-with-open-collector-output is used. If the state of output bit

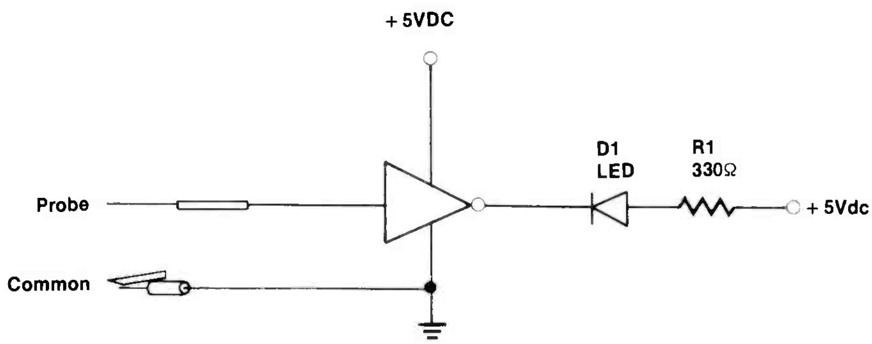

Figure 6. The LED on the *high/low* indicator remains off when a low state is sensed, and turns on when a high state is sensed.

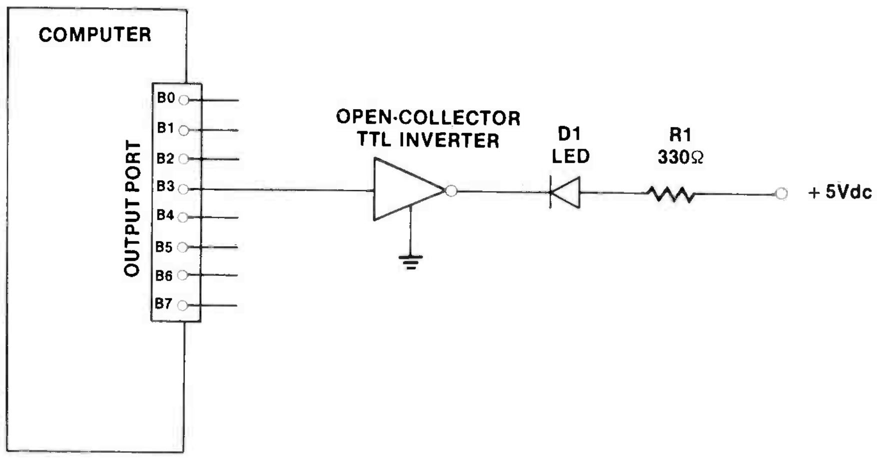

Figure 7. The LED indicator is interfaced to the I/O port through the TTL inverter.

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Circle (17) on Reply Card

B3 is *low*, then the inverter output is *high*. Under this condition, both ends of the LED are at the same potential so no current flows – the LED is off. But when bit B3 is *high*, the LED will turn on. Under this condition, the output of the inverter is *low*, so the LED cathode is grounded and its anode is at +5Vdc. The resistor in series with the LED is used to limit the current to a safe value. Some CMOS inverters and buffers will drive one LED without the need for a resistor. If the LED goes from the inverter to ground, it will light when the output is *high*. If the LED is connected between the inverter and V+, it will light when the output is *low*.

Figure 8 shows interfacing between a latched computer output port and a 7-segment numerical display. Each segment is an LED, so the display can be treated like an ordinary LED. An inverter and resistor are provided for each segment.

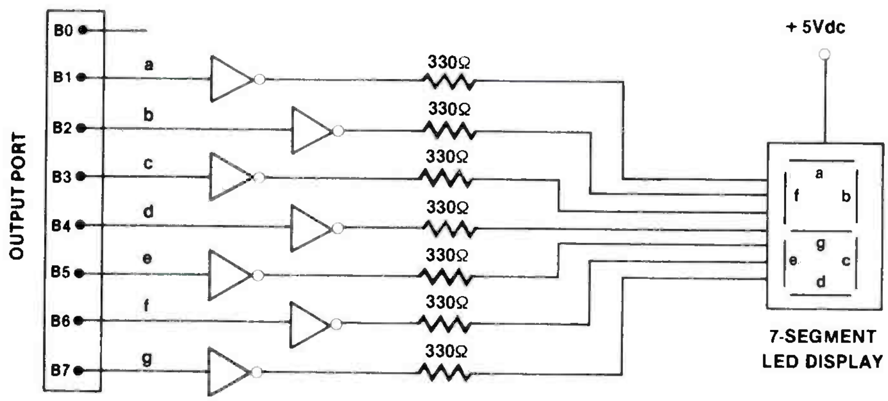

Figure 8. In the case of this latched computer output port, each output line is connected to the appropriate LED segment in the 7-segment display.

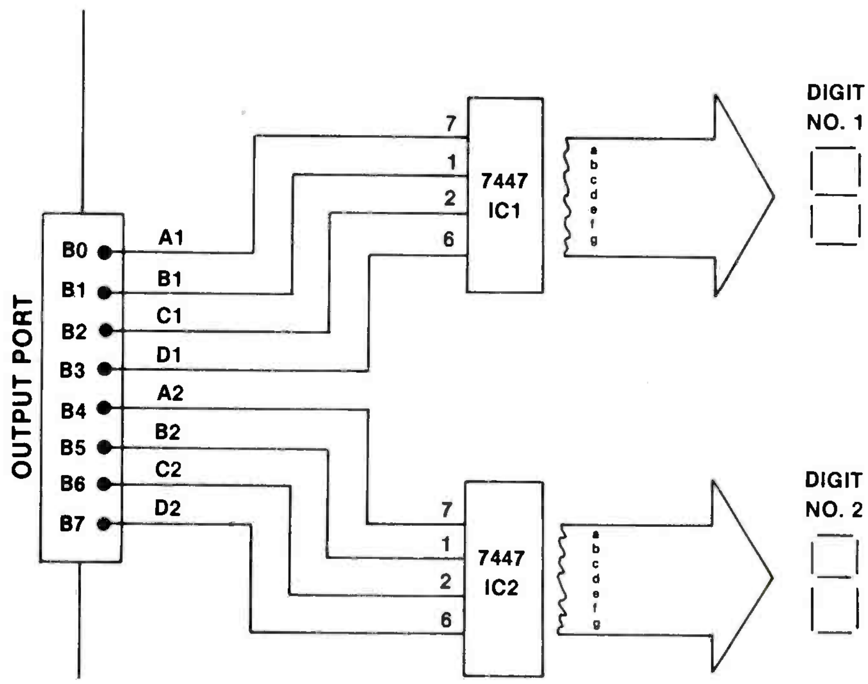

Figure 9. The BCD to 7-segment decoder converts 4-bit binary-coded-decimal number into signals to light the appropriate segments of 7-segment display.

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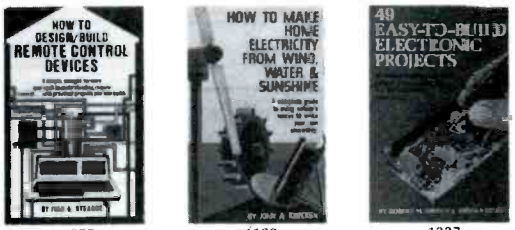

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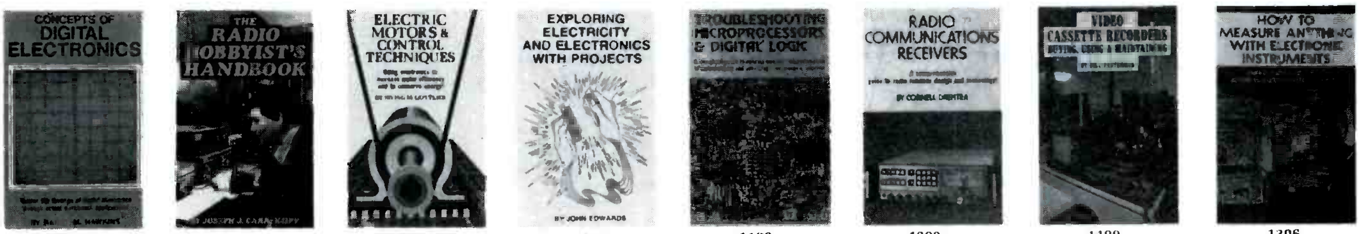

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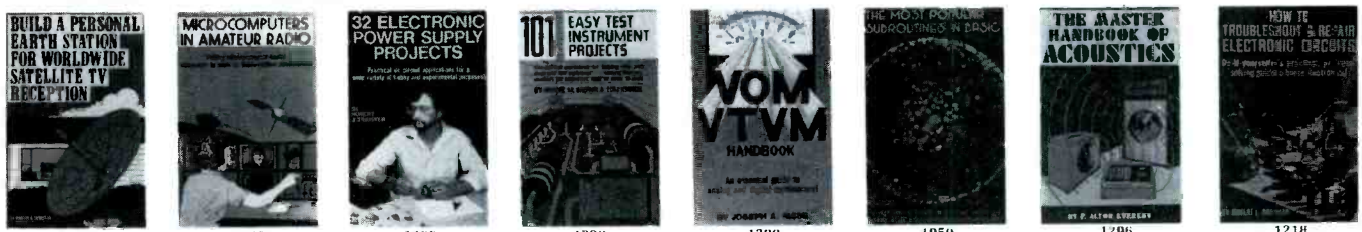

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Circle (20) on Reply Card

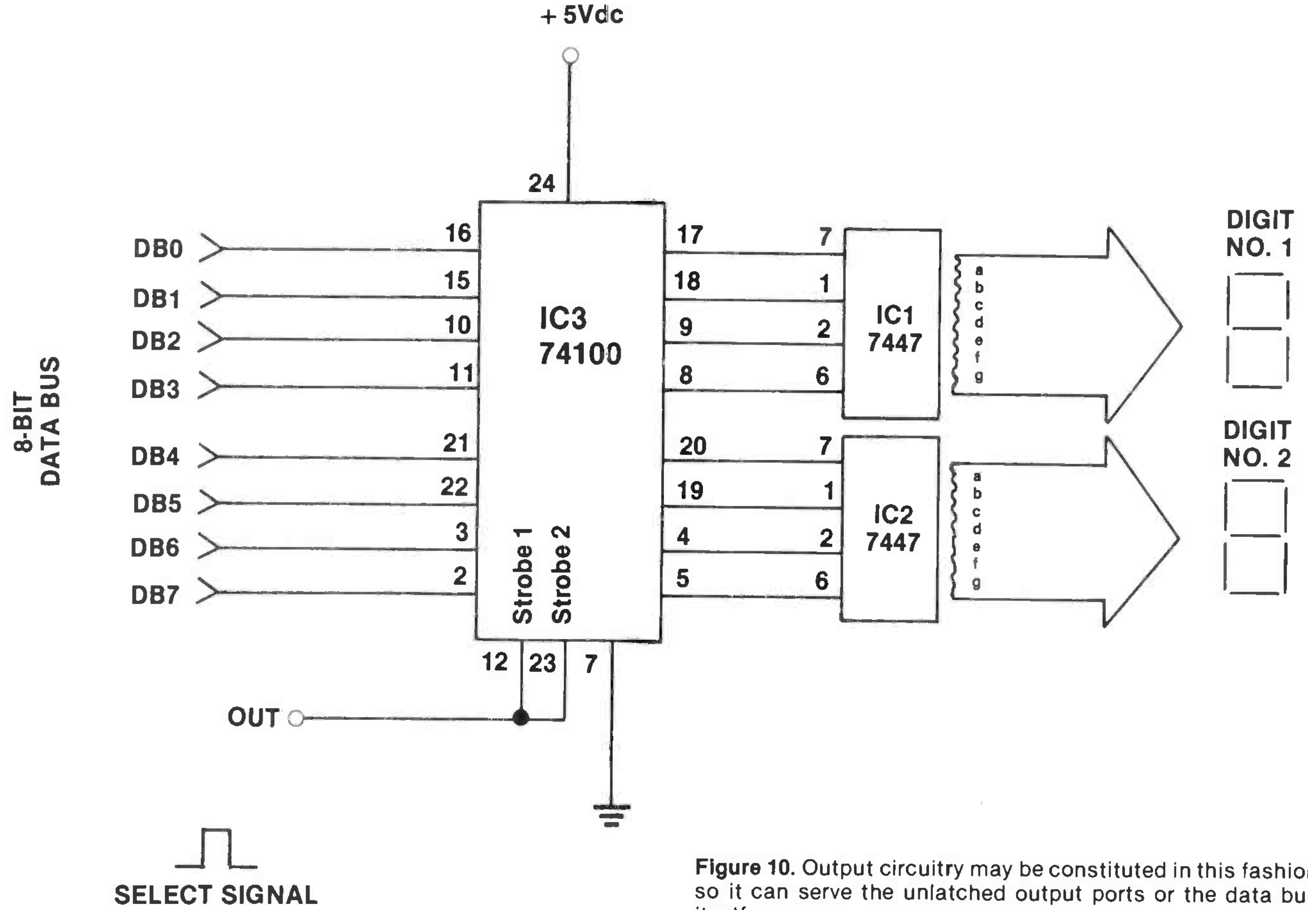


Figure 10. Output circuitry may be constituted in this fashion so it can serve the unlatched output ports or the data bus itself.

Figures 9 and 10 show methods of interfacing LED 7-segment readouts with a data bus or unlatched output port. In Figure 9, a pair of LED readouts is connected to a latched output port via 7447 decoder chips. Each chip is a 4-bit, BCD-to-7-segment decoder that examines the binary coded decimal (BCD) input word and generates the active-*low* 7-segment code that corresponds to the decimal digit. Since BCD codes use four bits to represent the decimal digits 0 through 9, two BCD digits can be packed into one 8-bit word. Most microprocessor chips have instructions that change an 8-bit binary word stored in the accumulator into a pair of equivalent BCD words.

Figure 10 shows the circuit of Figure 9 expanded so that it can serve unlatched output ports or the data bus itself. IC3 is a 74100 dual-quad data latch. Each latch is a 4-bit circuit and consists of four type-D flip-flops. Each 4-bit data latch section of the 74100 has a strobe line that is made by tying all four internal FF clock lines together. If both external strobe lines are connected, then the 74100 acts like a single 8-bit data latch.

The strobe lines are active-*high*, so they will cause data to be transferred from the inputs to the outputs when the strobe is *high*. When the strobe lines go *low* again, the data transferred will remain latched on the output lines. The common strobe line is connected to an *out select* signal in the microcomputer. This signal has several names but almost always is available. It comes active when an output operation to the designated peripheral, such as the LED displays, is designated to receive data. From the outputs of the 74100, the Figure 10 circuit is identical to the Figure 9 circuit.

Custom keyboards are used frequently in special purpose microprocessor-based devices. Basically, troubleshooting boils down to determining the *high/low* status of keyboard lines while a button is actuated and then deciding whether the correct code is present. In addition, if a strobe signal is used, its presence and timing must be correct.

When interfacing a new keyboard to an existing system, be sure that the *high* and *low* voltage levels are compatible and the strobe signal is time-compatible and has the right direction. Also, be sure that the strobe is the right type–continous level or pulse. Some computer software is sensitive if the keyboard output data is latched or unlatched. ES&T

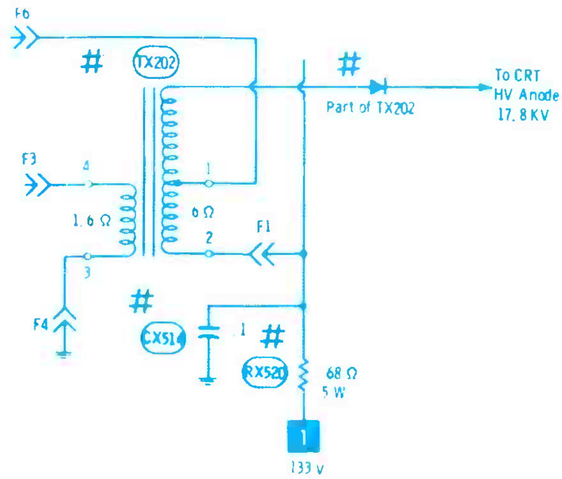
Troubleshooting Tips

No sound or picture
Zenith monochrome model 19GB1
(Photofact 1692-2)

No sound, raster or picture was produced by the 19GB1-chassis Zenith b/w TV receiver. Although the picture-tube anode had almost zero high voltage, the power-supply voltages were normal. The only clue was an overheating resistor RX520 that filtered the +133V supply to the horizontal-output transistor. The 68Ω, 5W resistor (some models have 100Ω, 7W values) had about 50V across it, indicating excessive current drawn by the output transistor.

I removed the QX505 horizontal-output transistor and tested it carefully, but it was not defective. Scope waveforms of the horizontal-oscillator and driver stages appeared to be within tolerance. To test for excessive picture-tube current or a shorted picture tube, I pulled the high-voltage lead out of the CRT-anode and moved it near the chassis, producing a long arc. This proved high voltage (at least unrectified high voltage) was being produced *when the picture tube was not connected to the flyback.* During this time while the lead was disconnected from the CRT, resistor RX520 did not overheat and the voltage drop was minimal. I thought the CRT might have an internal short, so I connected the high-voltage wire and tested the CRT base voltages. All voltages were in tolerance, and gentle tapping of the CRT base and neck did not indicate an intermittent short or leakage.

After the power was turned off, I felt the flyback transformer and found it was abnormally warm. This condition made me suspect that the high-voltage diode inside the flyback was shorted. (A shorted diode applies ac pulses to the CRT capacitance, adding a huge load to the flyback.) As a



test, I temporarily connected a high-voltage rectifier externally between the flyback and the CRT anode. Normal operation was restored when the television was turned on again.

To save the customer the flyback's price when only the high-voltage diode was bad, I cut the high-voltage lead wire and installed the diode permanently, using a surplus of insulation to prevent arcs.

In addition to the lower price charged, there was another benefit. I learned an excellent troubleshooting method for use with other TV receivers in the future.

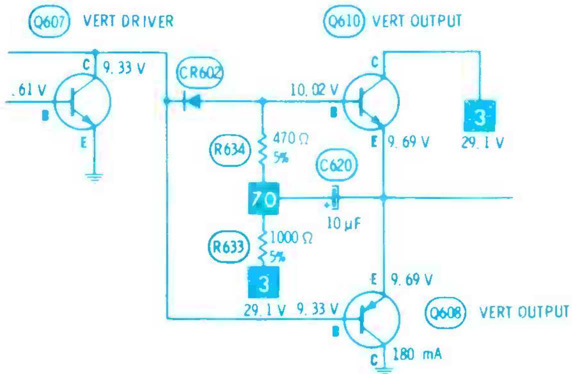
Tommy Small
Gallion, AL

Erratic height
Zenith monochrome 19GB1
(Photofact 1692-2)

According to the customer, the picture collapsed to a bright line at random times. Our preliminary tests confirmed that the problem was an intermittent loss of vertical sweep. Moderate flexing of several parts of the chassis often started or stopped the loss of height, so the b/w receiver was brought to the shop.

Eight transistors (including one vertical-sync injector) are in the vertical-sweep system, and tests located no defects in any of them. The problem seemed to originate with a bad connection, perhaps a solder joint or a hairline crack of the circuit board, but a careful visual examination of the board revealed no such defects.

Next, I decided to check the transistors again by using a high-power ohmmeter that forced the transistor junctions to conduct. Each transistor was tapped while the junction resistance was measured. All transistors were normal except Q608 (the PNP



power-output transistor), which showed erratic base-to-emitter conduction. Evidently, the bond inside the transistor case would open from mechanical movement or strain. The problem was an erratic open circuit, but *it was inside a transistor.*

Of course, replacement of Q608 allowed stable and dependable vertical deflection.

Peter J. Reno
High Bridge, NJ

Books

Editor's note: *Periodically* ***Electronic Servicing & Technology*** *features books dealing with subjects of interest to our readers. Please direct inquiries and orders to the publisher at the address given for each book, rather than to us.*

Servicing Home Video Cassette Recorders, by Marvin Hobbs; Hayden Book Company; 237 pages; $11.95.

This 10-chapter book is a guide to the basic operations and servicing of video tape recorders. It includes a glossary of videocassette terms and two appendices explaining the automatic assembly recording system with special consideration for cable televison.

Some chapters cover video signal circuitry, servo circuit operation and system control operation of the VHS system, and the differences between VHS and Beta. A comparison of the mechanical aspects of these formats also is made.

Other chapters explain the tools and test equipment used for VTR servicing, mechanical adjustments and replacements, and electrical alignment and adjustment. The last chapter covers personal video camera theory and servicing.

Published by Hayden Book Company, 50 Essex St., Rochelle Park, NJ 07662.

Know Your Oscilloscope, by Bob Middleton; Howard W. Sams & Co.; 192 pages; $9.95.

This fourth edition covers oscilloscope basics, cathode-ray tubes, input impedance and sensitivity, the general requirements of power supplies, voltage regulation, power-supply systems, sweep systems, synchronization, vertical amplifiers, the different types of oscilloscope probes and scope tests using different types of generators.

Ways to adjust and service oscilloscopes, methods of taking frequency and phase measurements, methods of amplifier testing and types of digital equipment are discussed in the last four chapters.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206.

Handbook of Advanced Troubleshooting, by John Lenk; Prentice-Hall; 352 pages.

This guide maps a 4-step procedure for troubleshooting communications, television, VCR and microprocessor-based system equipment. It has 174 technical schematics, charts and diagrams.

The handbook gives shortcuts designed to help pinpoint malfunctions in specific circuits and parts, and suggests ways to troubleshoot microprocessor-based systems. The guide also offers alternative procedures to use if microprocessors do not respond to routine approaches.

Published by Prentice-Hall, Englewood Cliffs, NJ 07632.

The VOM-VTVM Handbook, by Joseph A. Risse; Tab Books; 176 pages; $14.95 hardbound, $8.95 paperback.

This book gives information for understanding and using volt-ohm-milliammeters (VOMs), vacuum-tube voltmeters (VTVMs), solid-state electronic voltmeters (SSEVs) and digital VOMs. The principles, uses, advantages, disadvantages, care, maintenance and repair of these test instruments are covered.

The book also examines the internal and external features of typical VOMs, VTVMs, EVMs (electronic voltmeters) and solid-state meters. It shows the functions and characteristics of the important components and provides data on accessories such as high current shunts, test leads, probes and adaptors.

Information on testing, troubleshooting, repair and maintenance procedures is provided. Test sequences are given for capacitance and capacitor-leakage measurement, forward and reverse rectifier tests, fuse testing, open-filament checks, battery testing and sensitive circuit measurements. Plus, readers can learn how to replace instrument batteries, test meter movement, replace rectifiers and calibrate instruments.

The book features review questions after each chapter and answers at the back of the book.

Published by Tab Books, Blue Ridge Summit, PA 17214.

Crash Course in Digital Technology, by Louis E. Frenzel; Howard W. Sams & Co.; 198 pages; $19.95.

This text-style programmed course offers a solid foundation in digital fundamentals to hobbyists, students, industrial training programs and those with even a minimal understanding of electronics. It is written in a programmed learning format using brief informational frames and frequent self-tests. It is a learning tool, rather than a reference, and is illustrated with photography, diagrams and examples.

The author covers what digital means, how it represents real-world phenomena, the devices used in handling digital data, how these devices perform logical operations, how these are combined and more. The instruments used to troubleshoot digital circuits are also discussed.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206.

Build a Personal Earth Station for Worldwide Satellite TV Reception, by Robert J. Traister; Tab Books; 304 pages; $15.95 hardbound, $9.95 paperback.

This comprehensive, do-it-yourself guide tells how to pick the best location for an earth station antenna, and how to assemble the equipment, hook it up, tune it in, and pipe the signals to the television.

The manual reviews standard TV reception fundamentals, then explains how communications satellites work and what happens to TV signals from the time they leave the transmitting earth station until they are received by a "dish." It also provides a refresher course on microwave signals, reception techniques, and antenna and feedline operating characteristics.

Published by Tab Books, Blue Ridge Summit, PA 17214.

Test your electronic knowledge

By Sam Wilson, ISCET test director

The subject this month is resistors. Questions of this type are distributed throughout the CET tests.

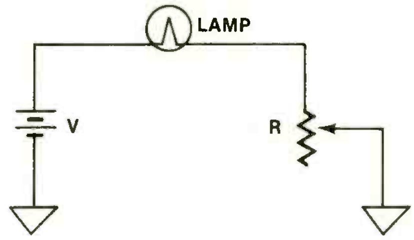


Figure 1

1. In the circuit of Figure 1, variable resistor R is connected as a
   ____A. rheostat.
   ____B. potentiometer.

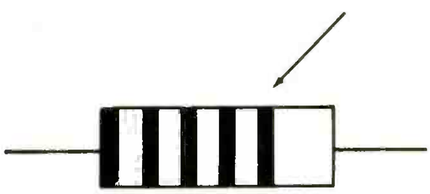


Figure 2

2. For the color-coded carbon resistor of Figure 2, the arrow points to
   ____A. the color for the first digit.
   ____B. the color for the tolerance rating.
   ____C. the color for the power rating.
   ____D. the color for the reliability rating.
   ____E. None of these choices is correct.

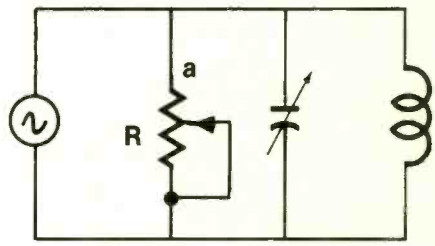


Figure 3

3. The resistor in Figure 3 is called a
   ____A. swamping resistor.
   ____B. surge limiter.
   ____C. parasitic suppressor.
   ____D. foldback limiter.
   ____E. step down resistor.

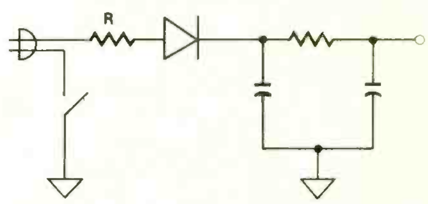


Figure 4

4. For the circuit of Figure 3,

moving the arm of R toward point *a* will

____A. reduce parasitics.
____B. decrease the surge.
____C. broaden the tuned bandwidth.
____D. increase the power absorbed by the circuit.
____E. increase parasitics.

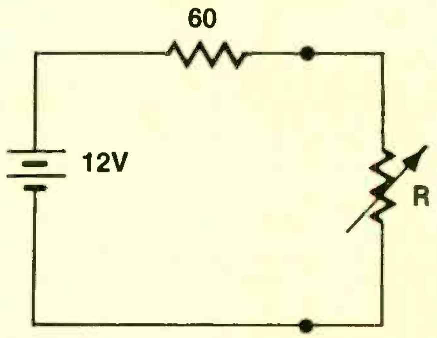


Figure 5

5. In the circuit of Figure 3, adjustment of R
____A. will affect the resonant frequency of the circuit.
____B. will not affect the resonant frequency of the circuit.

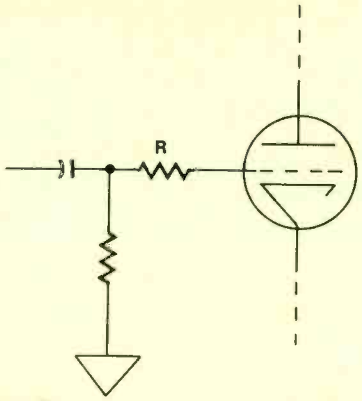


Figure 6

6. The resistance of a voltage-variable resistor (varistor)
____A. increases with an increase in voltage across it.
____B. decreases with an increase in voltage across it.

7. A certain resistor is color coded *yellow purple silver.* The resistance value of the resistor is
____A. 47Ω ± 10%.
____B. 47Ω ± 5%.
____C. 47Ω ± 20%.
____D. 4.7Ω.
____E. 0.47Ω.

8. Resistor R in Figure 4 is
____A. a filter resistor.
____B. a surge limiting resistor.
____C. a parasitic suppressor.
____D. a swamping resistor.
____E. never used as shown.

9. What is the maximum amount of power that can be dissipated by resistor R in Figure 5?
____A. 0.06W
____B. 0.6W
____C. 6W
____D. 0.036W
____E. None of these choices is correct.

10. Figure 6 shows a partial schematic of a high-frequency amplifier. The purpose of R is to
____A. prevent thermal runaway.
____B. prevent parasitic oscillations.
____C. prevent grid emission.
____D. provide a bootstrap input circuit.
____E. provide class A bias.

Answers on page 60.

Literature

Vaco Products' line of professional wire strippers can be found in the *Wire Stripper Catalog.* This 4-page, color catalog contains complete descriptions and illustrations of the easy-to-use wire stripper, multipurpose wire stripper and precision wire stripper. Each of these tools can strip wire, cut wire and bolts, and loop, bend and pull wire.

Also featured are Vaco's other wire strippers, including the self-adjusting wire stripper, automatic wire stripper and wire stripping tool.

Circle (101) on Reply Card

The 1983-84 catalog and buyer's guide of electronic test and measurement instrumentation is available from **Keithley Instruments.** The 100-page catalog includes two new product sections: system components and thermometers. Other product sections are digital multimeters, electrometers/picoammeters, nanovoltmeters and sources. Each product section is preceded by a selector guide. In addition, four product sections are prefaced with technical data, theory of operation, and design considerations.

A new accessory section has photos and descriptions of available accessories. Accessory selector guides are located at the end of appropriate product sections.

Circle (106) on Reply Card

RCA distributor and special products division has published a chart of the *Fastest Moving VHS VCR Parts.* This chart cross-references identification/stock numbers of Magnavox, NAP, Panasonic and Sylvania to RCA stock numbers in order to expedite parts selection for 100 of the industry's fastest-moving mechanical and electrical replacement parts for portable and table-model VHS instruments.

Circle (103) on Reply Card

ETCO Electronics has released a 112-page catalog featuring items from the electronics, communications, telephone, cable TV and video fields. It also has a complete parts selection for the hobbyist or repair shop owner.

A 16-page section of the catalog has been devoted to telephone and related equipment for small systems applications and home use. An addition to this catalog is the classified section.

Circle (104) on Reply Card

A free data sheet describing long strip industrial multiple outlet strips is available from **Perma Power Electronics.** The data sheet describes 10 Sockets Plus outlet strip models, which provide up to 24 outlets.

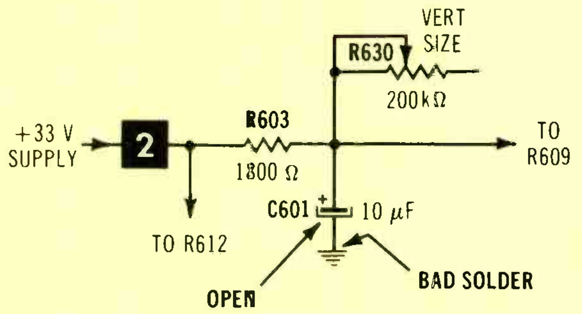
Circle (105) on Reply Card

ES&T

Symcure

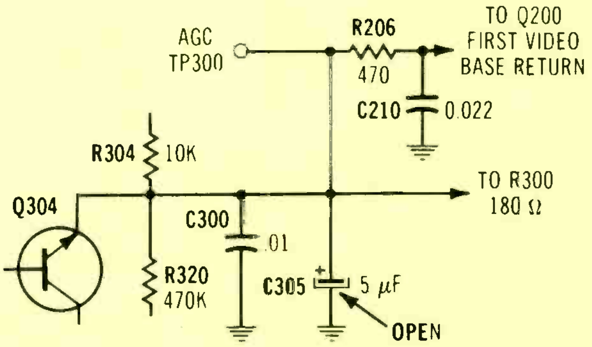
Symptoms and cures compiled from field reports of recurring troubles

Chassis – Admiral 4M10 chassis 1
PHOTOFACT – 1522-1



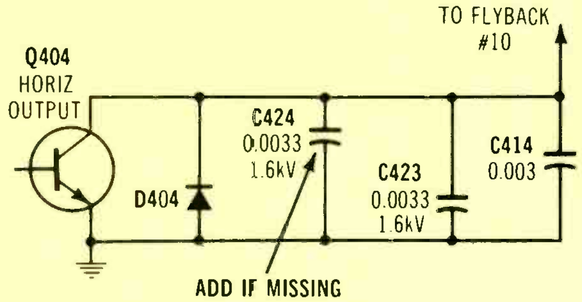
Symptom – Vertical lines near center of picture
Cure – Check capacitor C601, and replace it if open

Chassis – Admiral 4M10 2
PHOTOFACT – 1522-1



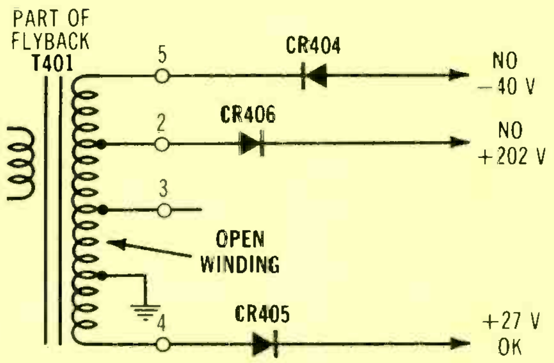
Symptom – Poor AGC, picture pulls and rolls
Cure – Check capacitor C305, and replace it if open

Chassis – Samsung CT501 3
PHOTOFACT – 2055-2



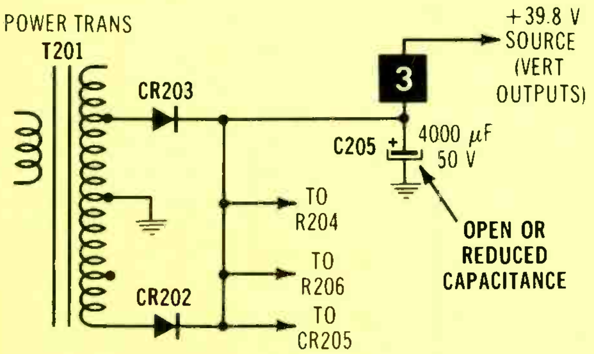
SYMPTOM – Narrow picture and excessive 32kV HV
Cure – Install C424 if it was omitted. Also, change C971 to 180K from 120K

Chassis – RCA CTC90 4
PHOTOFACT – 1710-2



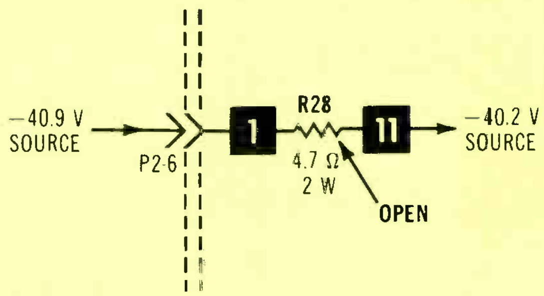
Symptom – No sound and no raster
Cure – Check flyback pin 3 to ground, if open replace the flyback T401

Chassis – RCA CTC81 5
PHOTOFACT – 1572-2



Symptom – Height decreases every 8s regularly
Cure – Check the ripple at C205, and replace it if ripple is excessive (high ripple varies the supply voltage to the vertical-output transistors)

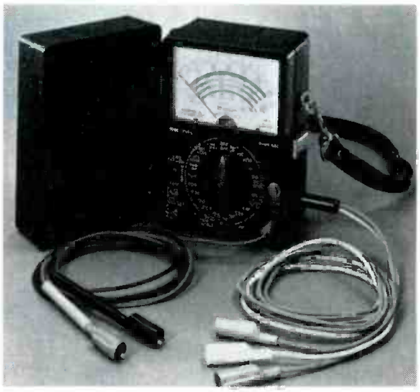
Chassis – RCA CTC90 6
PHOTOFACT – 1710-2



Symptom – No height
Cure – Check R28, and replace it if open

Marketplace

Products



Digital multimeter

Philmetric has expanded its multimeter product group with the 10A-range, 3½-digit LCD readout, side-positioned push-button model MD 210.

The entry has a projected 2000-hour battery life and 0.25% dc accuracy. It provides a selection of 34 ranges and carries a 200μA scale for ac/dc readings.

Equipped with a 9V battery and safety guard test leads to deter shock hazard, the MD 210 features ac and dc current range from 0 to 10A in six steps—0-10A, 0-2000mA, 0-200mA, 0-20mA,

0-2mA and 0-200μA. Resistance range is 0 to 200Ω with a maximum of 200kΩ. Resolution ranges from 100nA to 100μA and to 10mA. Input impedance is 10MΩ for voltage ranges.

Circle (76) on Reply Card

Telephone loop tester

The model 3 loop tester introduced by *Triplett* is a multifunction tester that includes a transmission line test set, 10-tone generator and a volt-ohmmeter. The model 3 is designed for installation or repair service measurement of power influence, circuit noise, circuit loss or line milliamp checks on telephone company or privately installed cable systems.

The 10-tone, sine-wave generator set permits loop-around test capability where no tone is available. Measurements are achieved by simultaneous sending and receiving with the model 3 "talking to itself." Frequency ranges include 304, 404, 504, 750, 1004, 1750, 2804, 3004, 3204 and 4804Hz at -0 to +5% accuracy.

Circle (77) on Reply Card

Soldering aids

The model 699 master soldering aid kit is available from *Desco Industries.* This 42-piece kit contains one of each soldering aid tool from Desco. Tools included are 24 double-ended soldering aids, six stainless steel scriber probes, two double-ended scriber probes and 10 hardwood or nylon probes and soldering aids.

Circle (78) on Reply Card

Video vector display

Leader Instruments has introduced the LBO-51M-V vector display. The LBO-51M-V is driven by R-Y and B-Y video signals from a precision chroma decoder or Tek-

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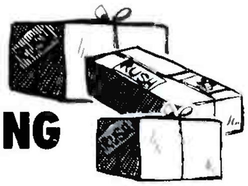

Only ORA Electronics offers free shipping for prepaid orders (in the continental U.S.A.). For COD, charge and open account orders, we charge only actual shipping costs, no handling charges whatsoever!

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All ORA Electronics' semiconductors and many other products are guaranteed for two full years. ORA Electronics has the longest warranty in the industry because we know what we sell: prime grade parts, and they are tested for quality.

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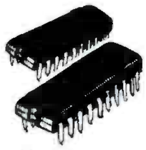

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Circle (39) on Reply Card

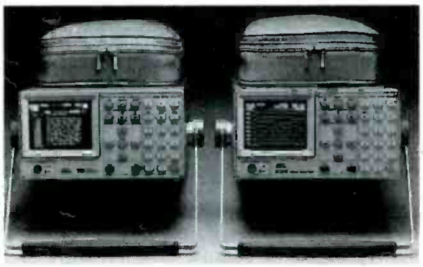
tronix 650HR series picture monitor equipped with R-Y and B-Y outputs.

Its 7.6 x 9.5cm display area has a removable external vectorscope graticule that may be imprinted with user graphics. The 3MHz bandwidth on the X and Y axis and 4MHz on the Z axis permits use of the LBO-51M-V in a variety of vector, waveform, response curve and alphanumeric display presentations.

Circle (80) on Reply Card

Logic analyzer

Tektronix has added the Sony/Tektronix 318 and 338 logic analyzers to its 300 series. The 318 provides 16 parallel channels of data acquisition at up to 50MHz.



The 338 delivers 32 channels at up to 20MHz. Both models provide glitch capture and three levels of triggering. The models weigh 11 pounds each.

Many of the Sony-Tektronix 318/338 functions were implemented in three LSI gate arrays. One chip uses 828 gates to implement counting, multiplexing and latching operations. A second chip employs 797 gates to implement clocking, timing and decoding functions. A third chip implements display controller functions.

Circle (81) on Reply Card

Chip Clip

The Chip Clip from *OK Industries* attaches with a snap-action locking ring that ensures reliable contact with virtually no stress to the tested device. The clamshell design is spring loaded outwardly rather than inwardly. Spacing is regulated to ensure contact and attachment without undue strain on the component. The body is made of high-dielectric nylon, and contacts are hard gold plated. Molded separators eliminate shorts between legs.

Circle (82) on Reply Card

Digital multimeter

Sperry Instruments has introduced its 34-range, 3½-digit, push-button digital multimeter, model DM-3010.

Designed for field and laboratory work, the DM-3010 features a 10Aac/dc range; UL1244-type test leads; 500Vac/dc protection on resistance ranges; overload protection on ranges; ½-inch, 3½-digit LCD display and 200-hour battery life.

Ranges on the DM-3010 are 200mV/2/20/200/1000Vdc; 20mV/2/20/200/750Vac; 200 A/2mA/20mA/200mA/2000mA/10A ac and dc current; and 200/2K/20K/200K/2M/20M high and low power ohms.

Circle (75) on Reply Card

Answers to quiz

From page 55.

1. *A* Rheostats control current; potentiometers control voltage.
2. *D* Older resistors do not have this band.
3. *A* It lowers the Q of the tuned circuit and therefore increases its bandwidth.
4. C If the arm is moved all the way to point *a*, the circuit is shorted. It has the frequency characteristics of a piece of wire (which is a very broad bandwidth).
5. *A*
6. *B*
7. *E* On the CET test you may find the color that represents seven described as purple or violet.
8. *B* The resistor protects the diode against high current during the initial charge of the filter capacitors.
9. *B* Maximum power will occur when R = 60Ω.
10. *B* There are still a few questions on tubes in the CET test.

Circle (40) on Reply Card

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SCRAMBLED TELEVISION, encoding/decoding. New book. Theory/circuits, $9.95 plus $1 shipping. Workshop, Box 393ES, Dept. E, Bethpage, NY 11714. 7-80-tfn

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AUTOMOBILE RADIO and tape replacement parts: Delco, Chrysler, Philco-Ford, Motorola, Panasonic and many others. Large inventory. Laran Electronics, Inc., 3768 Boston Road, Bronx, NY 10469. (212) 881-9600, out of New York State (800) 223-8314. 5-79-tf

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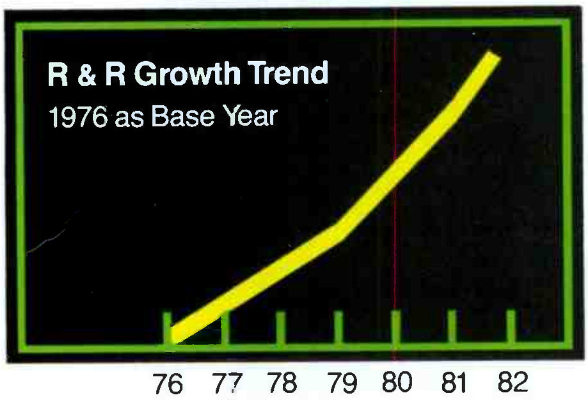

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Year in and year out, Zenith's remanufacturing business gets bigger and bigger. And 1983 appears to be no exception.

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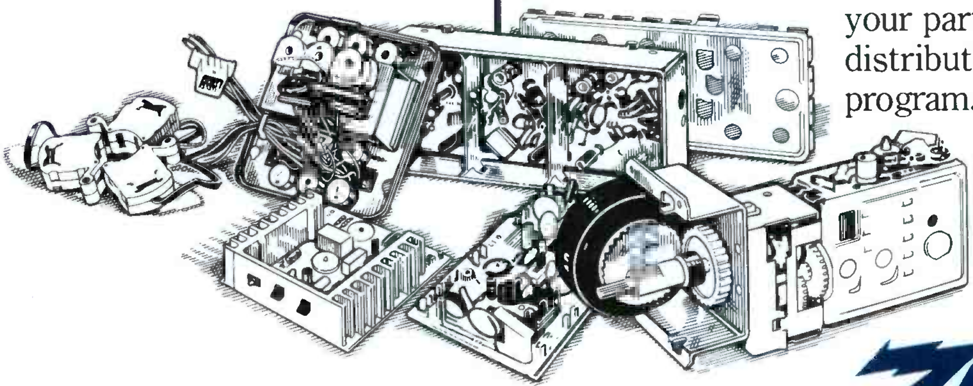
Make sure you are taking advantage of your participating Zenith distributor's exchange program. Call now and tell the Zenith Parts Manager we sent you!



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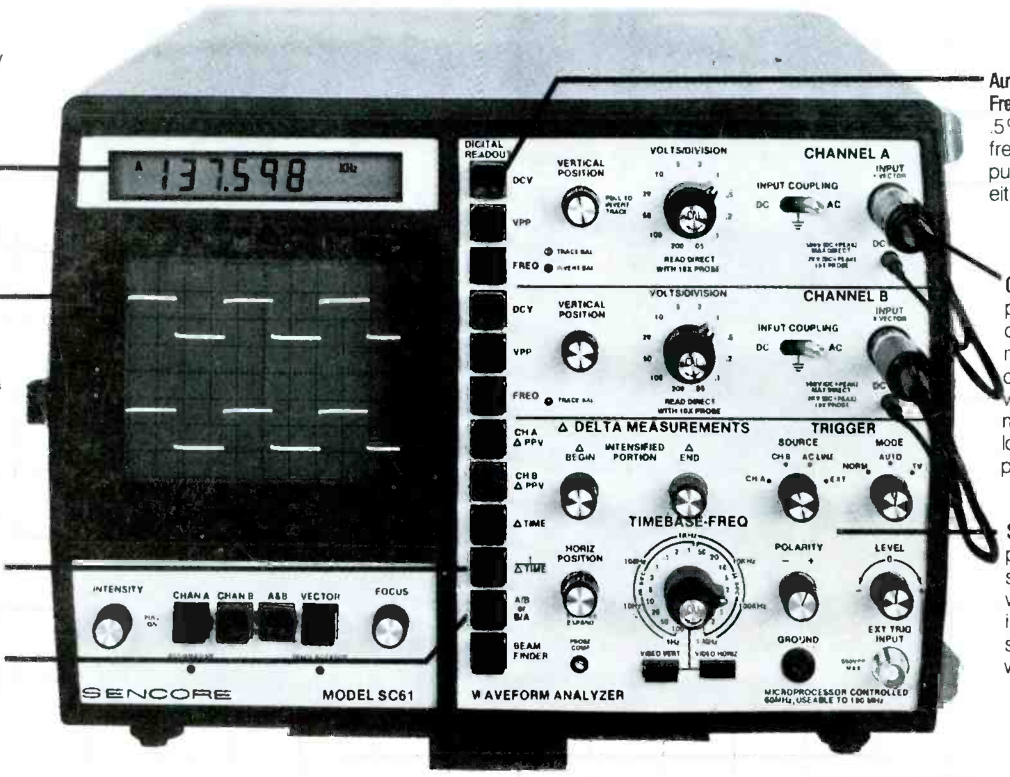

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No more graticule counting. Connect only one probe to view any waveform to 100 MHz. Then, just push a button to read DCV, PPV, frequency and time — automatically!

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