Fig. 1—The 1977 Delco digital AM/FM radio and FM stereo unit shown in the elapsed-time-mode.

Delco Goes Digital In 1977

A penetrating look at a new AM/FM radio and FM-stereo auto unit that features digital readout of frequency, time, day and elapsed time

By Joseph J. Carr, C.E.T.

■ One of the new auto electronic products you'll see, and possibly work on, in 1977 is Delco's new digital AM/FM radio and FM-stereo model. Shown in Fig. 1, the new unit uses a "3½-digit", yellow LED, seven-segment digital read-out that displays AM and FM frequency, the time-of-day, day-of-the-month and elapsed time.

The time-of-day is continuously displayed on the digital read-out except when the radio is first turned on, the station-frequency is changed, or the user pushes a special frequency recall button. The AM or FM frequency is displayed for about five seconds, and then the readout automatically reverts to the time-of-day. The time-of-day and calendar are set by a screwdriver adjustment behind the removable front bezel, or cover.

The radio portion of the 1977 Delco digital radio is basically the same IC design as reported in 1976. However, there is a difference in the audio section. In this new model, a DM-84 "bridge audio" power IC module is used. This means that only *ungrounded* loudspeakers can be used with this model. And any extra speakers that might be installed later should also be of the ungrounded type. The somewhat standard practice in car radio installation of grounding one speaker terminal so that only one wire need be run could possibly destroy the bridge audio IC.

CMOS IC's Call For Careful Handling

In addition to the need for ungrounded speakers, the CMOS integrated circuits used in the new model require very special handling. These complimentary metal oxide semiconductor chips

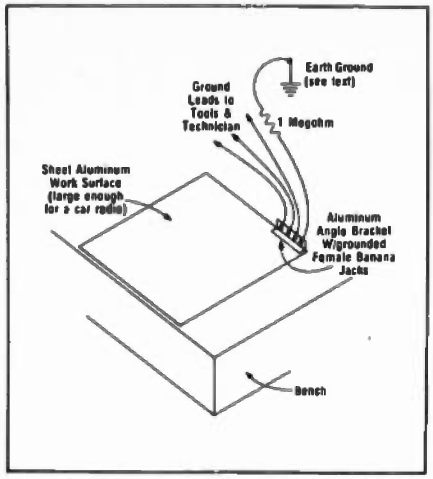

Fig. 2—Diagram of a grounded work surface required for safe handling of CMOS IC devices used in Delco's new digital radio.

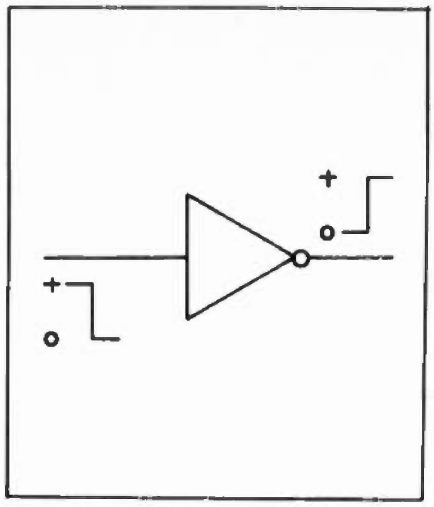

Fig. 4—Diagram of a typical inverter element with an output that is opposite of the input.

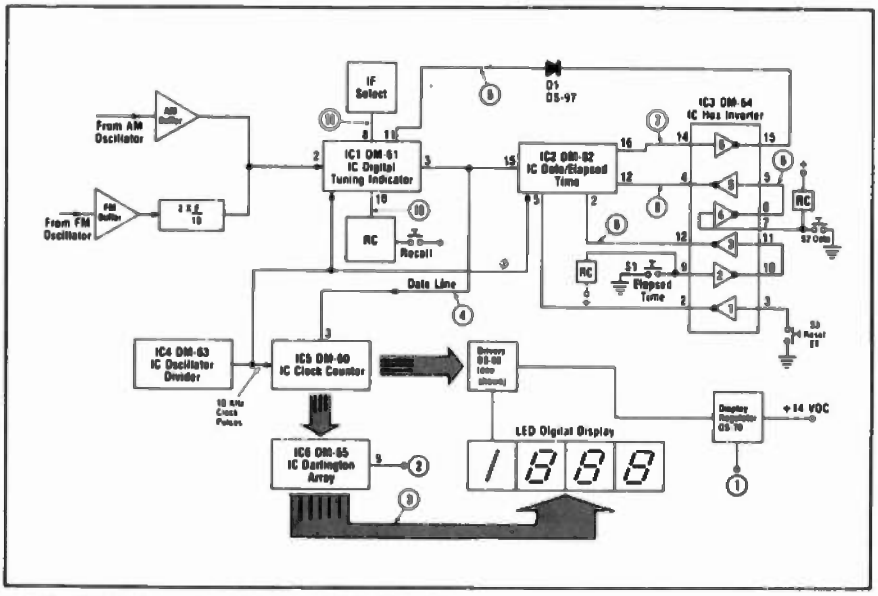

Fig. 3—Block diagram of the digital subassembly.

(CMOS) require the same precautions used when working with unprotected metal oxide semiconductor field effect transistors (MOSFET's). *Everything* that could possibly come in contact with the device must be grounded.

For proper grounding, Delco recommends a cookie sheet as a temporary work surface. For those who want a more permanent fixture, we suggest a sheet of aluminum mounted on the service bench. (See Fig. 2). A ground bracket, made of right-angle aluminum stock, is fitted with several ground banana jacks (either uninsulated, or insulated with the center connector grounded).

The banana jacks are then used to connect ground wires to all of your tools. This includes the soldering iron tip, a pair of tweezers for chip-handling, and even a wrist band for the technician.

To prepare the wrist-band, simply solder one end of test probe wire (because it's flexible) to the flat surface of a regular metal watchband. Of course, be sure to file away the chrome plating before soldering.

The aluminum ground plate then must be connected to earth ground through a 1 megohm resistor. For earth ground, you can use either a real ground rod, clamp it to a *cold* water pipe, or to the screw on any properly wired AC outlet cover plate. One grounding method I've found convenient is with the use of model G3 "Groundlets". These devices, made by Instrutek, Inc., 15 Lincoln Park Center, Annapolis, Md., 21401, provide three binding posts bonded directly to the duplex outlet box cover plate.

Replacement CMOS chips are packed with the pins embedded in a black foam, rubber-like material that is electrically conductive. Do *NOT* take the IC out of the black foam until you are ready to use it—and then only if you are properly grounded. As you know, these chips are expensive, and careless handling to satisfy curiosity will cost you money, and lots of it.

A block diagram of the digital portion of the radio is shown in Fig. 3. As you can see, the heart of the digital subassembly is a set of special CMOS IC modules. These include: the DM-61 *digital tuning indicator* (ICDTI), DM-62 *date-elapsed time* (ICDET), DM-63 *oscillator-divider* (ICOD), DM-60 *clock counter* (ICC), and the DM-65 *Darlington array* (ICDA). In addition, several special transistors are used, including the DS-513, used as a voltage regulator, and the DS-60 Darlington transistors used as display switches.

Frequency Display

As mentioned, the AM or FM frequency is displayed for five seconds after turn-on, when the frequency changes, and when the recall button is depressed.

The recall condition in the frequency mode is manually selected, but the other two methods for obtaining frequency display are automatic. The circuits contain an internal memory and a comparator. If the frequency changes more than 10 KHz on AM or 100 KHz on FM the comparator issues an output command that turns on the frequency display for the five second period.

The five-second display period at set turn-on is due to the memory of the circuit being 'empty', which is interpreted by the comparator as a large frequency difference. After the five second period, the memory circuit has new data from the time circuit to operate on and it will not display frequency again until the station is changed or the recall switch is depressed.

The digital readout is determined by data from either the digital tuning indicator (ICDTI) or the date-elapsed-time (ICDET), which is passed along a common bus to the clock counter (ICC), where it is processed and decoded for multiplexed display.

The complex nature of these cir-

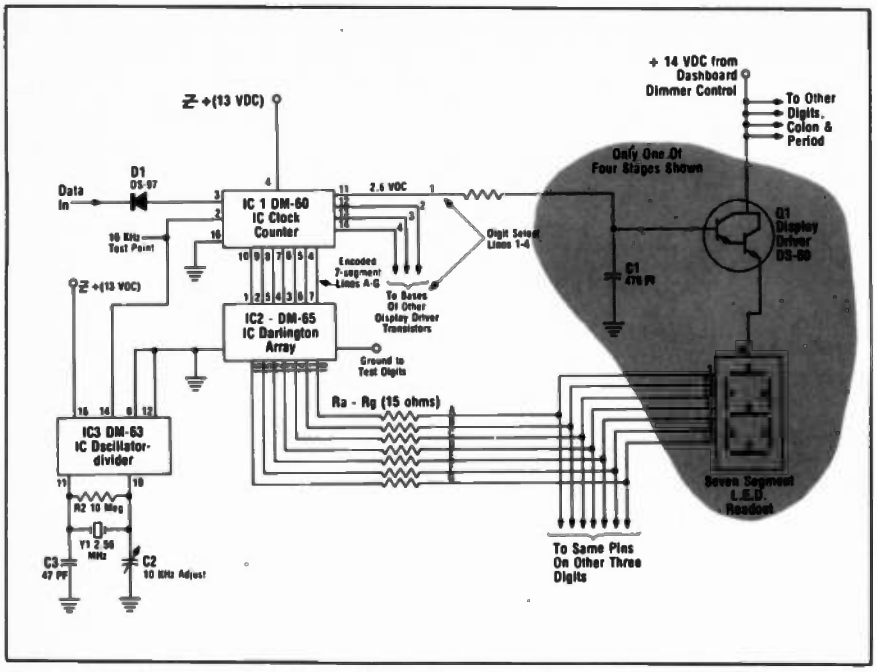

Fig. 5—Block diagram of the multiplexed display circuit with only one of the four DS-60 display driver transistors shown.

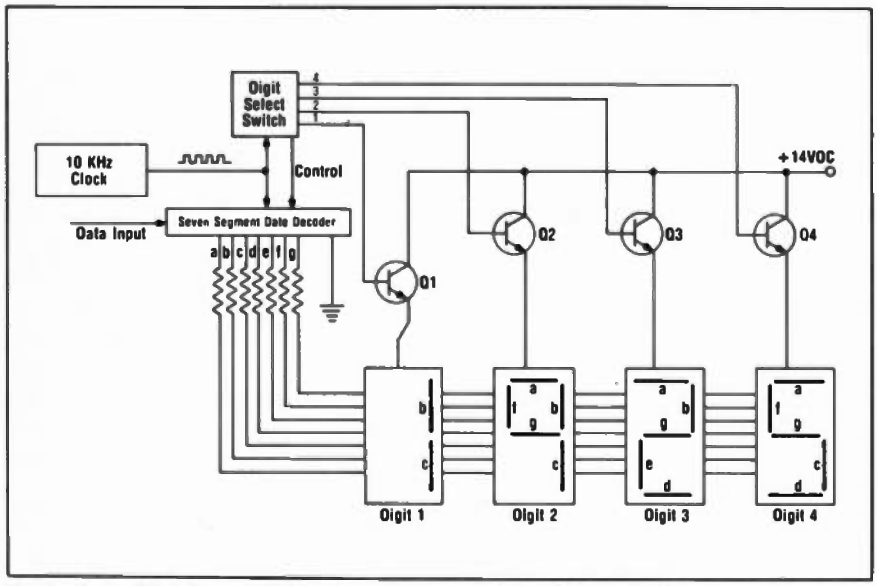

Fig. 6—A simplified diagram of a display multiplex circuit showing how the ICC turns on just one digit at a time.

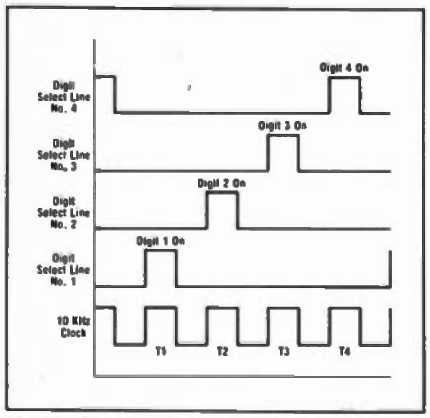

Fig. 7—Diagram showing the timing of the multiplex circuit, with all electronic switching controlled by 10 KHz clock pulses.

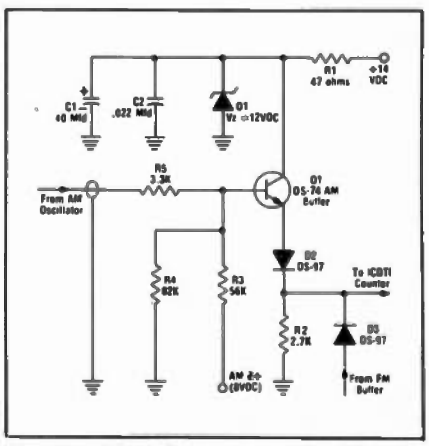

Fig. 8A—Schematic drawing of the AM buffer section.

cuits requires a 10 KHz synchronization signal, also used as the time-base for the counter. The 10 KHz signal can be set with a small variable capacitor, but care must be used when doing so. Be sure to use an accurate frequency meter such as a digital counter. Any counter suitable for CB service will do for this job. Do not depend on your oscilloscope's time base, or some ancient 10 KHz audio oscillator.

Date and Elapsed Time Control

The date-of-the-month and elapsed-time display is controlled by IC 3, (DM-64) which is a "hex inverter." For those unfamiliar with the world of digital electronics, an inverter is a digital circuit element that gives an output signal that is the opposite of its input signal. In diagrams, it is represented by a triangle, most often with a circle at its apex (Fig. 4).

In digital electronics we have only two possible signal states, or levels: *high* and *low*. In the high condition, called logic level "1", the voltage will have some positive value. In the older IC devices, level "1" was +5 VDC, but in the CMOS, "1" might be represented by any voltage level between +4 VDC and +18 VDC. The logical "0" is the low stage and that usually means the point is grounded, or very near ground (i.e., less than 1 volt).

The rules for inverter operation are simple:

1. A high input (1) gives a low (0) output.
2. A low input (0) gives a high output (1).

DM-64 in Fig. 3, is a hex inverter with six (hex) independent inverter circuits that control the Date and Elapsed Time IC, DM-62, by making certain pins either high or low. For example, switch S3, when depressed, grounds the input of hex inverter (HI) No. 1. This causes the output of HI No. 1 to go high for an instant and resets the elapsed time counter (DM-62).

Similarly, when switch S2 is closed, it grounds the input of hex inverter No. 4, making its output (pin 6) high. Because the output of hex inverter No. 4 is connected to

the input of hex inverter No. 5, the output of hex inverter No. 5 goes low, grounding pin No. 12 on the date and elapsed time IC (DM-62). This causes the date to display. An RC network keeps the date turned on for a short time, after which the display reverts to time-of-day.

How The Display Circuit Works

In order to reduce current requirements and circuit complexity, the new Delco digital radio uses a method of "display multiplexing." Although only one of the LED readouts is turned on at any one time, the rate at which the circuit switches through the four separate readouts is so high (10 KHz) that one gets the illusion of a steady, continuous display.

In the Delco readout system, there are seven individual LED bars arranged in a figure 8 pattern, for each of the four readouts. Circuitry for one of the four readout stages is shown in Fig. 5. The arabic numeral, or digit, that is displayed is determined by which of these segments is turned on and producing light. For example, if segments a, b, and c are turned on, a "7" will be displayed. On the other hand, if f, g, b, and c segments are turned on, we will see a "4".

A total of eleven Darlington transistors are used as switches to control the four LED readouts. Seven of these Darlington transistors, operating as segment drivers, are located inside the Darlington Array (DM-65). The other four are type DS-60 display drivers, used to sequentially supply +14 VDC to the LED readouts. These four are mounted outside DM-65. (See Fig. 3).

The proper seven-segment code for each of the four readouts is determined by the DM-60 IC Clock Counter (ICC) as it examines the input data. It operates in this case, then, as a decoder. The ICC also sequentially activates the four *digit select* lines, pins 11 through 14. When a new line is selected, power is applied through a DS-60 display driver transistor to the appropriate digit. At this same time, the DM-60 also passes the seven-segment code through the Darlington Array IC (ICDA) to the segment lines, a through g. Each of these lines will take on a "1" or "0" value as needed for the par-

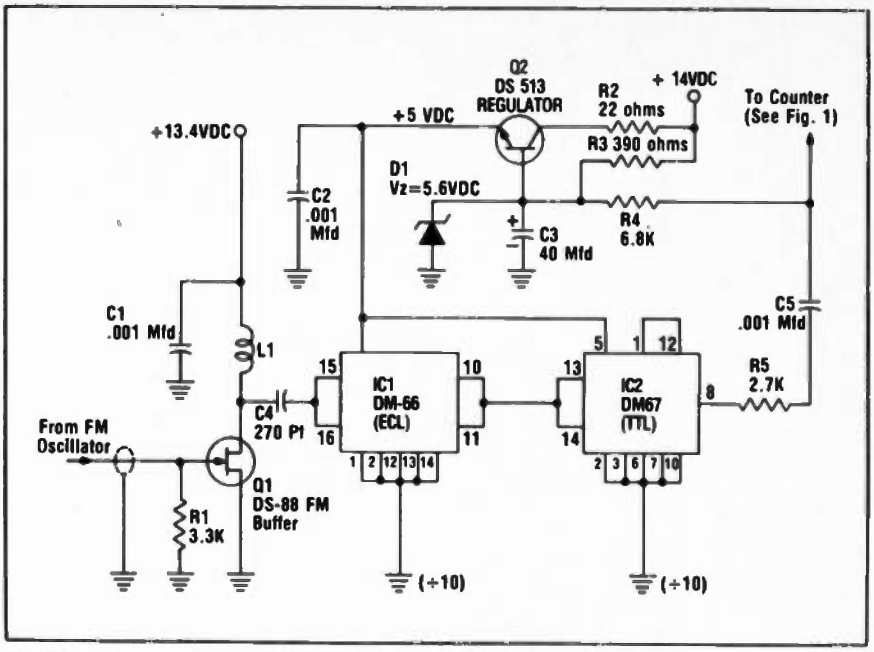

Fig. 8B—Schematic drawing of the FM buffer section and the divide-by-100 stages.

Digital Radio Troubleshooting Procedure

Table I

STEP & TEST POINT	NAME/DESIGNATION	TEST	COMMENTS/RESULTS
1	display regulator	measure voltage	Should be +5 to +9. Do not proceed until this voltage is present
2	lamp test	ground "2"	All L.E.D. segments should light up and read "18:8.8"
3	segment control	ground pins 10 -16 on DM-65 one at a time	See table II for results to expect
4	data line input	ground DM-60 pin 3	clock overrides all other functions
5	ICDTI status	ground DM-61 pin 11	Frequency display locked out
6	status control	voltage on DM-64 pin 15	Depress "date", "elapsed time" or "reset". Voltage should go *low*
7	status control	voltage on DM-64 pin 14	Depress "date", "elapsed time", or "reset". Voltage goes *high*
8	"ET select"	voltage on DM-62 pin 2	Depress "reset" or "elapsed time," voltage goes low. Depress "recall" or "date", voltage goes high
9	date select	voltage on DM-62 pin 12	depress "date", voltage goes low. depress "recall", "ET", or "reset." voltage goes high
10	Frequency display gate	Voltage on DM-61 pin 10	depress "freq". Voltage goes high. Depress ET or reset. voltage goes low
11	I.F. select	Voltage on DM-61 pin 8	Place bandswitch in FM. Voltage should be high. Place bandswitch in AM. Voltage should be low

ticular number to be displayed. An "0" on a line will provide a path to ground for the segment to which it is connected, and this allows the LED bar to light up.

Display Multiplexing

In the case of display multiplexing, not to be confused with stereo multiplexing, we are using the process described earlier where only one of the four digits is turned on at any one time. This is the way that electronic calculator displays also operate. In Fig. 6, we show a simplified diagram to illustrate how display multiplexing works in the new Delco unit.

As shown, all similar pins on each of the four readouts are tied together. In other words, all segment "a" pins are connected together, as are all of the other six pins, "b" through "g". Thus, the seven-segment code appearing on lines a through g is applied simultaneously to all four digits.

However, the particular digit that is activated at any instant in time is the only one that will turn on. This occurs because the four digit select lines from the clock counter IC are sequentially activated so that when a high appears on a digit select line, the DS-60 associated with it will become forward biased and will pass power to the next digit to be lighted.

For example, suppose we want to display the number "1925" on multiplexed display as shown in Fig. 6. Also, let us assume that the display is scanned left to right so that the left-most digit turns on first and the right-most digit turns on last.

As we proceed, refer to Fig. 6, and Fig. 7, which shows the timing diagram for the multiplexer. As you'll notice in both diagrams, the 10 KHz clock synchronizes the whole sequence of events.

For purposes of explanation, we assume in Fig. 7 that pulse time one (t1) occurs at a time when digit No. 1 is to be lighted. At t1, the line select switch causes select line No. 1 to go high, and at the same time, it tells the decoder to place the proper code on lines a through g. In our example, we want a "1" on the display, so the decoder grounds segment lines b and c and leaves the other high.

The high condition of line No. 1 forward-biases transistor Q1, and

allows power to be applied to the common anode connection of digit 1. Current then flows from ground, through the decoder, and segment lines b and c, through LED cathodes b and c (this turns on bars b and c), then to Q1 and back to the +14 VDC supply.

At time t2, line No. 2 goes high, activating digit No. 2. At the same time, the decoder is told to supply the code to turn on segments a, b, c, f, and g. This lights up a "9".

Similarly, at time t3, digit No. 3 turns on and a "2" is displayed and at time t4, digit No. 4 turns on and a "5" is displayed. Only one digit is activated at any one time, but the 10 KHz switching rate is so fast that you perceive a steady display.

Other Circuits Of Note

Most of the remaining circuitry in the Delco 1977 digital radio is of the same sort used in previous models. There is one noteworthy difference, however, in the buffering circuits between AM and FM local oscillators and the frequency counter input. The buffer amplifiers between the frequency counter and AM and FM local oscillators are shown in Figs. 8A and 8B.

The AM buffer is simply an emitter-follower feeding a diode rectifier. The buffer is needed to prevent loading of the AM local oscillator by the counter. The diode is used to convert sinewaves from the local oscillator to pulses required by the counter.

The FM buffer is a little different because the digital tuning indicator IC (DM-61 or ICDTI) cannot handle signals in the 100 MHz range directly. The FM buffer uses a DS-88 JFET to amplify signals from the FM local oscillator and to pass them on to a two-stage divide-by-100 (f/100) section.

This f/100 stage is actually two f/10 stages in cascade (10 x 10 = 100). The first f/10 stage (IC1) is a decade divider of the emitter coupled logic (ECL) family. This family of digital logic IC's can operate to at least 120 MHz, so they'll easily handle the FM local oscillator signal.

The next stage (IC2) is a more common TTL decade divider that is good only to 20 to 30 MHz. It is satisfactory in this case, though, because the ECL stage reduces the FM local oscillator signal to a range less than 12 MHz.

The two dividers, IC1 and IC2, require a supply voltage that is within 5% of +5VDC in order to operate properly. Overvoltage will damage them.

Transistor Q2 in Fig. 8B, a type DS-513, combines with Zener diode D1 to form a voltage regulator that drops the +14 VDC to +5 VDC.

If you ever find excessive voltage on the +5VDC line, be sure to check not only for a leaky DS-513 or an open D1, but also the DM-67 and DM-66. If you ever find either a DM-67 or DM-66 defective, do not install a replacement until the regulated power supply is checked and determined to be in good condition.

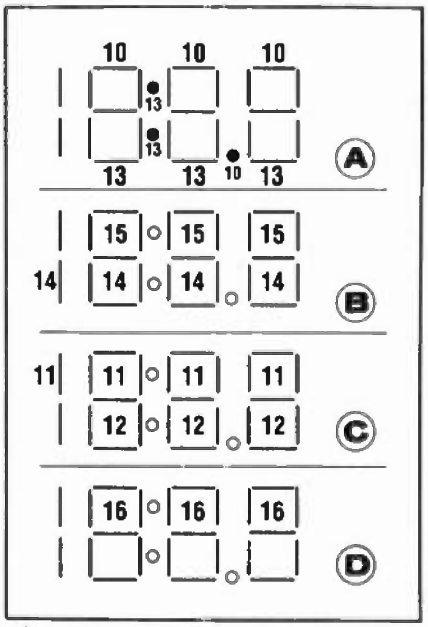

Table II—Pin grounding procedure for segment control. Ground pins 10 to 16 on DM-65, one by one. Figures in table indicate which segments will light up for each DM-65 pin. *Caution*: If you use an alligator clip or screw driver for grounding, make the ground-end connection first, then the connection to the DM-65 pin.

Troubleshooting the Digital Section

To aid in troubleshooting the Delco digital radio, we've prepared a chart of logical steps as shown in Table I. The troubleshooting steps on the chart correspond to circled numbers in Fig. 3. For efficient, safe diagnosis, we recommend a review of the procedures for handling CMOS devices and the construction of the grounded work area described. In addition, you'll find it worthwhile to acquire the 1977 Delco service manual (publication No. 6D-1977-1, dated Sept., 1976) from a Delco wholesale parts distributor. ■