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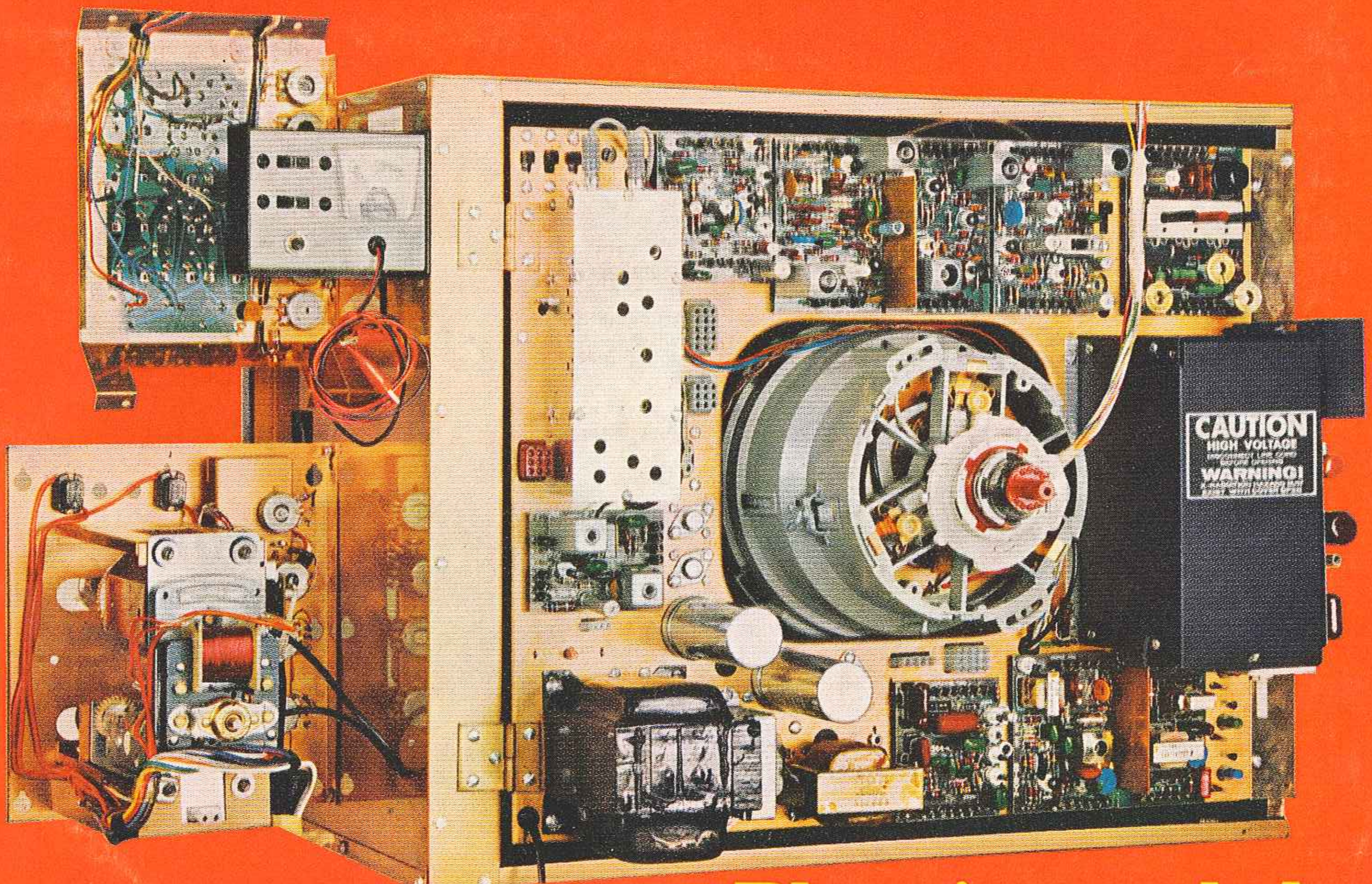

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BRAINS OF AUTOMATION

by JOHN W. DIETRICH

Logic circuits and tape-controlled machines

photo courtesy Westinghouse

TAPE-CONTROLLED WIRING MACHINE cut errors, rapidly finishing complex panels. Fig. 1 (right) shows single-stage NOT elements that invert incoming data. Fig. 2-a—An electrical AND gate. b—A 4-legged AND gate and its symbol.

"INSERT TOOL NUMBER 4 AND MAKE a 0.025-inch cut 4 inches to the right on the horizontal axis."

If a machinist does this it's manual control. If an electronic circuit does the job, it's numerical control, the latest thing in automation. An earlier article on this subject (February, 1969) showed how 8-channel tape is perforated to carry commands.

The photoelectric tape reader scans eight channels, issuing a pulse for each hole. The presence of a hole results in a "true" signal, and the absence of a hole produces a "not-true" signal to logic circuits. (A logic circuit monitors two or more signals to decide if and when a given condition is "true" or "not true.")

The tape reader EL and CH channels (shown in Fig. 4) each have a single purpose only: as detailed earlier, they serve as an end-of-block code and parity check for an odd number of holes, respectively. The other six channels carry all the alphabet and numerals. Fig. 1 shows those six channels with six NOT circuits. A NOT circuit is a single-stage amplifier that provides 180° phase inversion. Each NOT stage inverts the incoming data so that "true" becomes "not true" and vice versa.

Assume that "true" or "high" means +10 volts and "not true" or "low" is zero volts. When input X is true, output X is +10 volts, and output $\overline{X}$ (not X) is zero. When input X is not true, output X is zero, and output $\overline{X}$ is +10 volts. The 12 output lines provide all the logic conditions needed to identify tape-coded numerals and alphabet.

One common logic element is the AND gate shown in Fig. 2. Figure 2-a shows an electrical AND gate. Note that switches 1 *and* 2 *and* 3 *and* 4 must close before the "true" lamp can light.

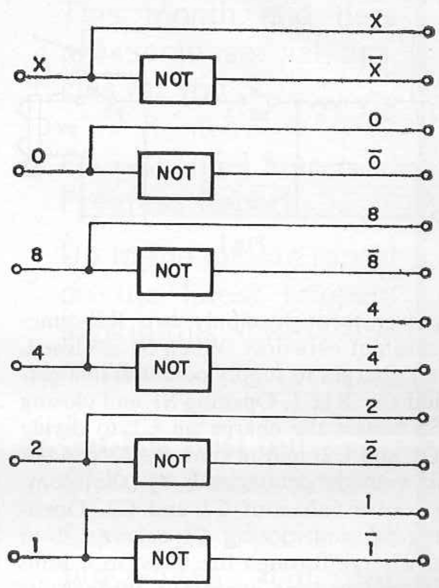
Therefore, an AND gate is a coincidence detector. Figure 2-b shows a 4-legged electronic AND gate, with one example of the symbols for it.

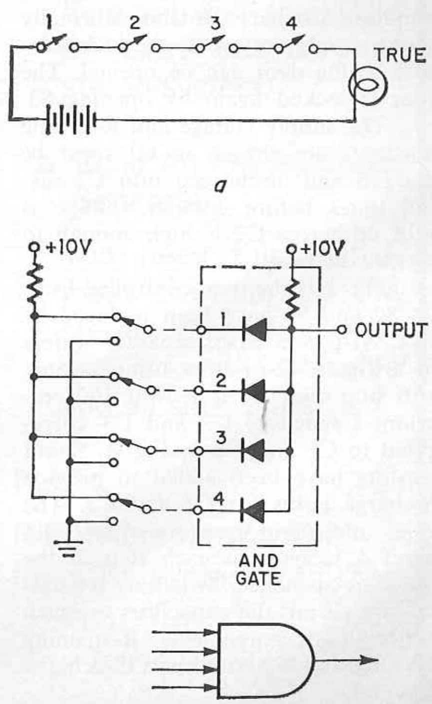
All four inputs to Fig. 2-b must be high (+10 volts) before a high appears at the output. If one or more input legs are low (zero volts), the output is also low. When the cathode is low the small forward resistance of a diode acts as a shunt from output to zero volts. Legs 1 *and* 2 *and* 3 *and* 4 must be true (high) before the output can go high to indicate true. The high back resistance of each diode appears when the cathode is switched to a high.

Two AND gates connected to tape reader data lines to detect letters x and z are shown in Fig. 3. Refer to Fig. 4 for the EIA tape perforation codes. Note that letter x in Fig. 3 has holes in the 1, 2, 4, and 0 channels, and *NO* holes in the 8 and X channels. The CH hole provides parity check only and is not needed to decode the letter. If the CH hole is missing, an even number of holes remains. That stops the tape reader.

The upper gate of Fig. 3 is connected to data lines 1, 2, 4, $\overline{8}$, 0 and $\overline{X}$. When those data lines go high the output of the "x" gate goes high. That condition occurs only when the letter x is in the reader. No other letter has the same combination of tape holes.

Notice the "z" gate in Fig. 3. This is connected to data lines 1, $\overline{2}$, $\overline{4}$, 8, 0, and $\overline{X}$. Check the tape holes for letter z in Fig. 4 and note the tape perforations agree with that data. The





a

b

"z" gate output goes high only when z is in the reader.

The same principle is used to detect any other letter by connecting a six-leg AND gate to the proper lines. Select the proper data lines for any desired letter by noting the perforation code of Fig. 4.

Numerals are detected in 8–4–2–1 code directly from tape and need no gates. Decoding of numbers depends only on one or more numeral channels going high. When the 8 and 1 channels go high, a 9 is read. When 4, 2 and 1 go high, a 7 is read.

Numeral reading is controlled by another logic circuit which recognizes numerals only and is blind to all other data. This permits numerals to be read directly from data lines *when no other character appears on tape.* For example, the numeral recognition gate prevents "a g" from being read as a 7.

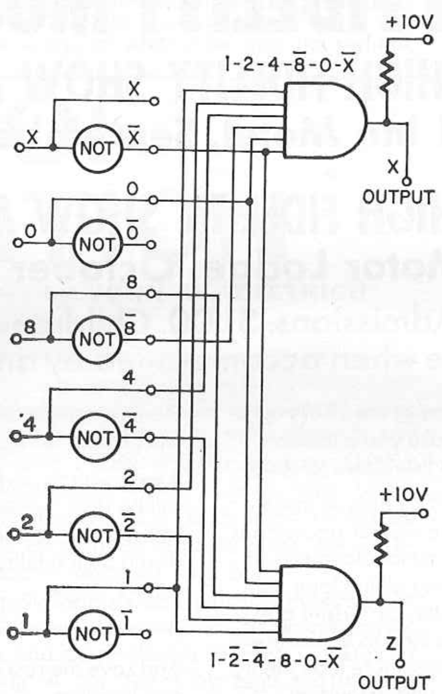


FIG. 3—LETTER DECODING for x and z.

Fig. 5 shows another logic element. Figure 5-a shows an OR gate made up with electrical switches. Note that any one switch (or *all*) causes the "true" lamp to light. The lamp lights when switch 1 *or* 2 *or* 3 *or* 4 is closed.

Figure 5-b shows an electronic OR gate and two forms of symbols for it. Note that when any one diode connects to a high (+10 volts), the output terminal voltage approaches +10 volts. A high through input 1 *or* 2 *or* 3 *or* 4 *causes a high at the output terminal.*

Each diode is forward biased at all times, and diode low forward resistance is in effect, when a true signal appears. Each diode clamps the output level to the input voltage. When all anodes are low, the output is low. If any input goes high (+10 volts), the output also goes high.

The OR gate forms a junction for two or more circuits without interaction between them. For example, the four legs of Fig. 5-b may monitor four dimension tolerance points on a machine. If any one dimension goes out of tolerance, a switch closes and the OR gate output goes high to stop the machine.

Fig. 6 shows three logic circuits for an exercise. Select the one logic circuit which says "Start next cut when tool is in position, with coolant on and table stopped, if both x and y axes are in tolerance." When you have selected an answer, see the correct selection below. **R-E**

The correct answer is Fig. 6-b.

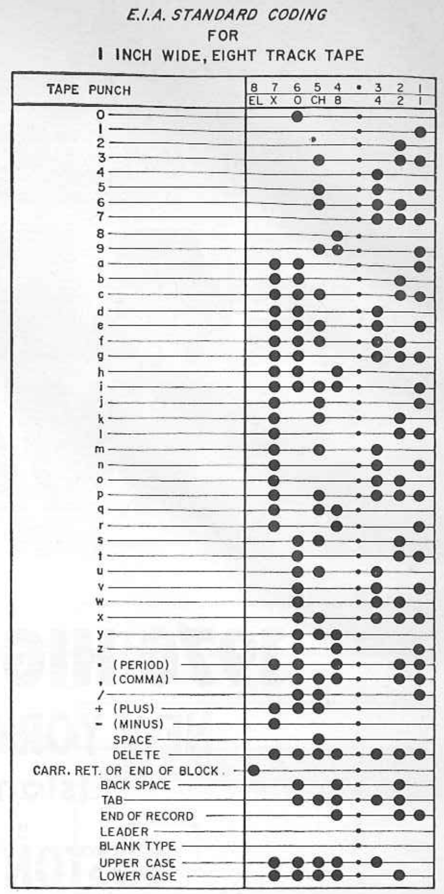
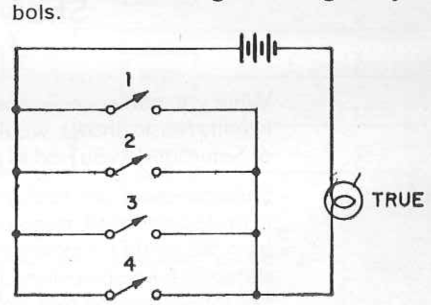
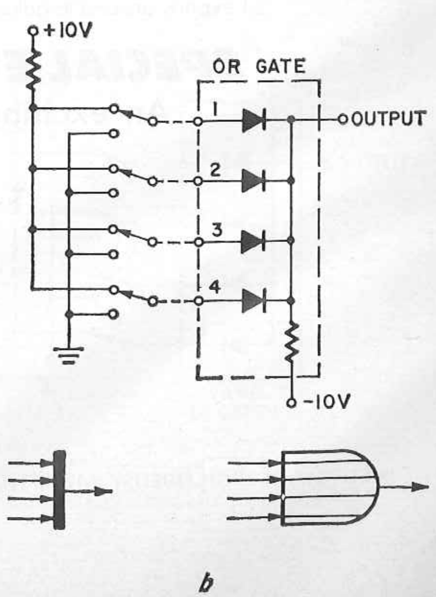


FIG. 4 (ABOVE)—PUNCHED TAPE coding. Fig. 5-a—Electrical switch OR gate. b—Electronic OR gate and gate symbols.



a



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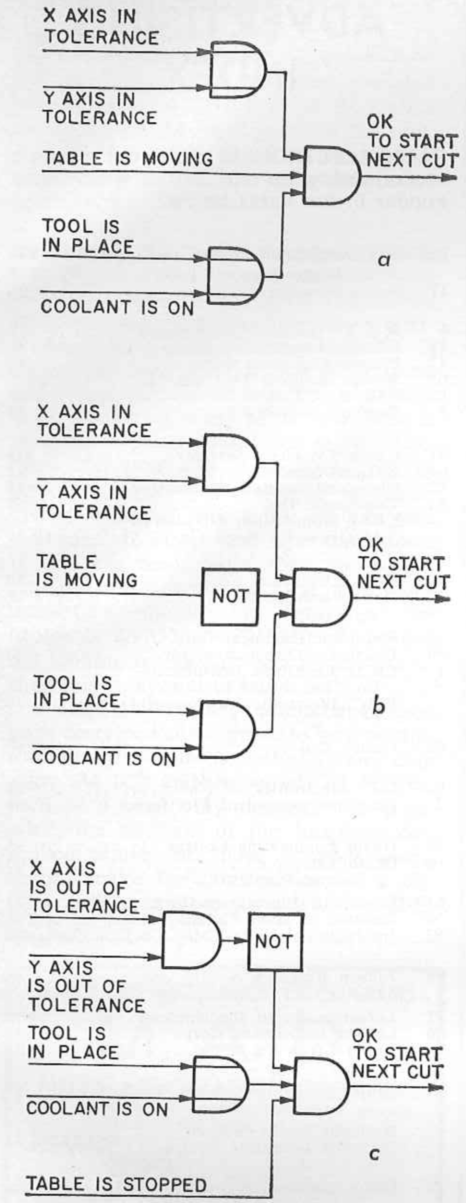

FIG. 6—TEST YOUR KNOWLEDGE. See question in text and select part a, b or c.

MULTIPURPOSE IC DIGITAL CLOCK

by LEO WALKER

Part II

Last month we presented the main section of this article, including all printed-circuit patterns and schematics. We did not have room to include all of the text. The following paragraphs contain added data on the optional circuitry.

Fig. 7 shows the ten-minute timer circuit. When pin 8 of QA in the minutes falls to zero at the end of the "9" count, pin 10 goes high enabling the tone generator to drive the output circuit. Pin 8 output of the decade counter QA in seconds section goes high causing the flip-flop to reset. This means that the tone will be on for 8 seconds since pin 8 of QA goes high on the count of 8 and remains high through the count of 9.

Approximately eight hours of assembly time is required to complete this clock. It's a project that you enjoy everyday because it's always on. It's different from the run of the mill clock. It also shows how far technology has advanced since the cuckoo clock.

Fig. 6 is the schematic for a 100-kHz time base generator for use in applications where power line frequency is subject to change such as when emergency power is used. Of course this leads to another problem and that is memory for the clock while the power is being switched over. A 3.9-volt battery supply floats across the ac supply. The circuit uses a 100-kHz crystal oscillator. The output of the oscillator is devided by 1,000 in three minimum hardware divide-by-10 stages. The ÷6 stage in the clock's main generator is converted to a divide by 10. The 620-ohm resistor tied to pin 6 and 3.9 volts, is removed.

In cases where accuracy is a must and a receiver capable of receiving signals from WWVB on 60-kHz is available, the 1 pps signal can drive the clock.

For operation as a stop watch a spdt switch inserted directly at the input to the ÷60 (seconds) circuit is set to 60 pps.

The START-STOP switch is operated to connect pin 13 of the reset flip-flop to 3.9V through R8, a 620-ohm resistor. This stops the time base from triggering the input of the clock. When the START-STOP switch is set so that pin 9 of the reset flip-flop is connected to 3.9 volts, the clock now runs at a full 60 pps rate.

The minute section of the clock now reads seconds and the hours section now reads minutes. If the 12 hour version of the clock is used, a total time of 13 minutes can be measured; with a 24 hour unit, 24 minutes.

To stop the clock, the START-STOP switch is set so that pin 13 now has 3.9 volts on it. The clock can be set to zero, 00:00:00 by operating the momentary switch. The momentary switch applies 3.9 volts to the reset terminals of all the counters in the clock.

(continued on page 99)