build a digital countdown timer

A versatile countdown timer with keyboard programming that can control various external devices. The time interval can be programmed in increments of one second from one second to approx. 11,000 years

GEORGE R. BAUMGRAS

TIMERS OF ONE TYPE OR ANOTHER, ranging from the simple mechanically actuated switches to highly sophisticated electronic controls, are an essential part of modern technology. Industrial processes, laboratory experiments, photography, functional testing and similar operations represent only a few of the more serious applications, but we also find them useful in the household as appointment reminders, alarm clocks, kitchen aids and so on. Somewhere within this broad spectrum there are many requirements for a reasonably-priced programmable countdown timer that affords superior accuracy and versatility and is not too difficult to build.

Most of the recent circuits, although they may use the latest in integrated circuits, usually suffer from at least one of several drawbacks—precise intervals cannot be programmed, the time period available is somewhat limited, or calibration is frequently required and uncertain at best. The countdown timer described here eliminates all of these deficiencies, and for that reason is called SPOT (Superior Programmable Optimized Timer). The prime objectives established for its development were: acceptable cost—about $125 for parts, the use of readily available and generally well understood components, long-term accuracy without need for calibration and, of course, a wide range of uses. SPOT can be programmed, in increments of one second, for any period from one second to eight digits worth of hours (about 11,000 years), which is of course, far beyond any possible need but does eliminate one of the drawbacks mentioned. Assuming there will be diligent frequency monitoring by the local electric utility and there are no power failures, the total timing error for any period selected will be .17 seconds plus the pull-in time of the relay, both of which are known factors. On a percentage basis, this represents an error of about .3% for one minute, and correspondingly less for longer periods.

Operation

Using the timer is extremely simple—the desired interval is entered manually via the keyboard in the same manner that a number is entered into a calculator. The ALARM and RELAY switches on the front panel are set for the desired operation and the START pushbutton is depressed—and that's it. In the prototype, the START pushbutton is labeled "+" for convenience. This pushbutton also enters a negative number into the calculator memory. At the end of the programmed time period, the alarm will sound if the ALARM pushbutton was depressed, and the relay will open or close depending on the position of the RELAY pushbutton.

The LED display continuously shows the remaining time in seconds, minutes and the last significant hour as it is being programmed in, and throughout the timing period. Most entries will be for less than 10 hours which is why only 5 digits are displayed. However, if there are 6 or more digits stored in the memory, a small LED lamp will light to indicate that there may have been a keyboard error or that there are hours in the memory.

The digits may be entered into the program in any convenient form, in some cases eliminating the need to convert seconds into minutes or minutes into hours. For example, 90 seconds is equal to 1 minute and 30 seconds. This time period can be entered in either form. An entry of 9 hours, 99 minutes and 99 seconds is therefore exactly the same amount of time as if we had entered 10 hours, 40 minutes and 39 seconds. The display will eventually revert to normal readings. In the latter example, at the end of 40 minutes and 40 seconds it would read 9:59:59 and continue to read in "clock" time from thereon.

The timer described here contains one modification that the original does not. This modification permits the timer to emit an audible "beep" at one-second intervals. This feature can be inhibited by a rear-panel MUTE switch. The countdown timer (see Fig. 1) consists

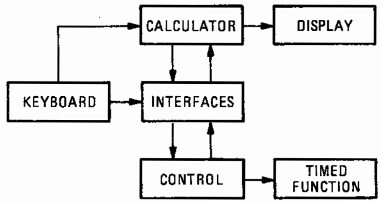


FIG. 1—FUNCTIONAL BLOCKS of the countdown timer are shown.

of a calculator circuit, control circuit, interface IC, keyboard display and timed function. The calculator circuit (see Fig. 2) closely resembles the circuit specified for the CT-5001 calculator IC. The difference being that it is tailored to perform only add and subtract arithmetic, and the ÷, ×, minus sign, overflow decimal point, and 6 of the digit outputs have no function. This particular IC was selected because, in addition to being available at low cost (under $4), it can handle a diode-encoded keyboard system and readily accepts external commands at a suitable rate.

The control circuit (see Fig. 3) has many functions, performing as a timebase, decimal-to-clock converter, electronic keyboard simulator and zero balance detector in addition to manipulating the alarm and relay functions. The 7400 series TTL logic IC's were selected as a practical alternative, again because they are available at low prices and are not particularly difficult to design a circuit around. The interface

PARTS LIST
CALCULATOR AND KEYBOARD

All resistors are ¼-watt, 10%, unless noted.
R1-R14—100,000 ohms
R15—150,000 ohms
R16-R27—4700 ohms
R28-R31—27,000 ohms
R32—5100 ohms
R33—2200 ohms
R34-R46—12,000 ohms
R47—1000 ohms
R48—10,000 ohms
R49—680 ohms
R50, R51—470 ohms
R52-R58—47 ohms
R59—330 ohms
C1—10-μF, 25 volt, electrolytic
C2, C3—470-pF disc
C3, C4—220-pF, 5%, disc
D1-D8—1N4001
D9-D29—1N914 or 1N4148
LED 1—discrete LED, 0.16-inch maximum diameter
Q1-Q26—MPS6563 or equal, TO-92 case
Q27-Q41—2N2222, 2N3904, or equal, TO-92 case
IC1—CT5001 calculator IC
MISC.—Keyboard switches with "0" through "9", "CL" and "+ =" legends (Oak Industries, Inc., Switch Division, Crystal Lake, IL 60014. Switch No. 415), 40-pin socket for DIP.

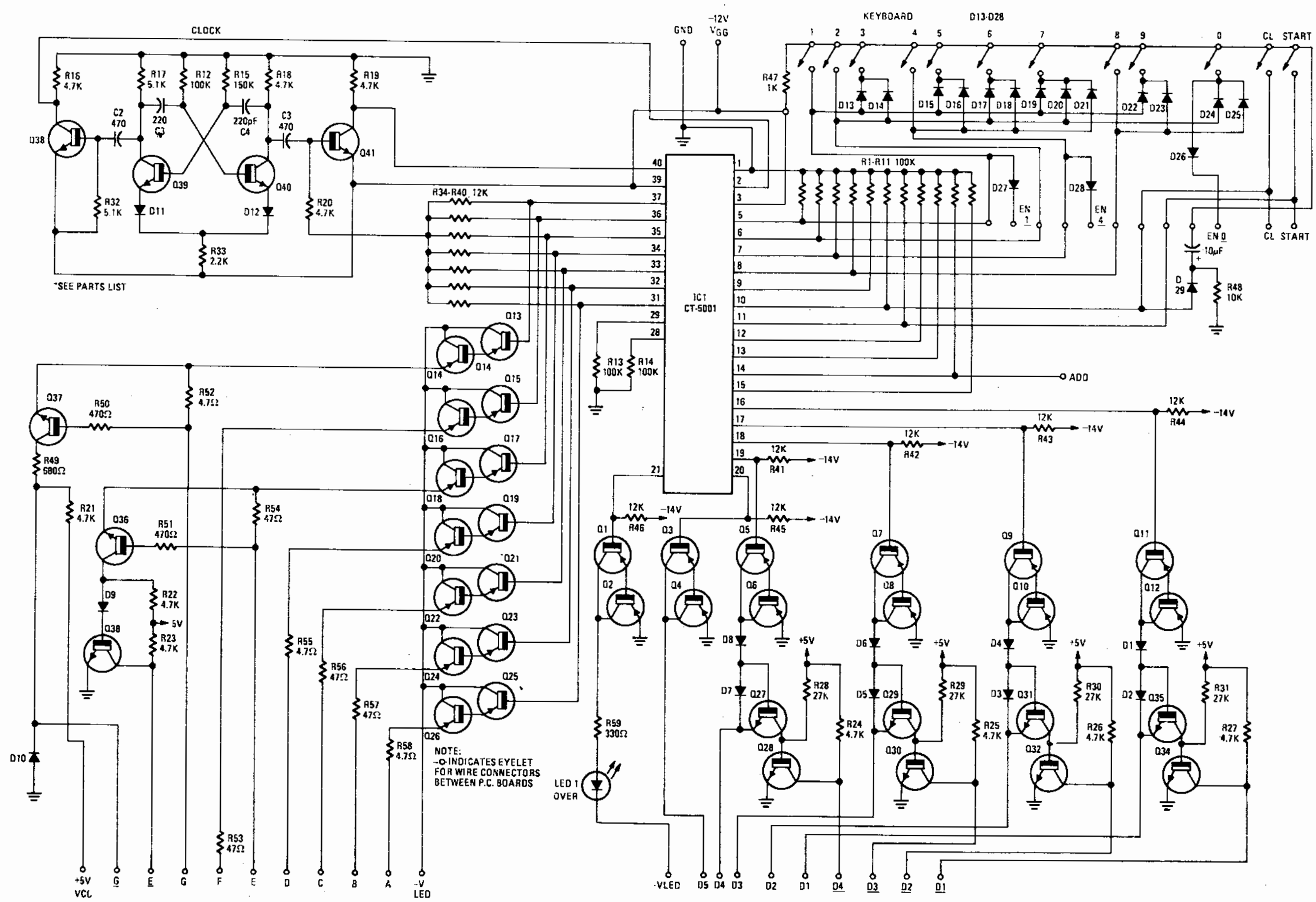


FIG. 2—CALCULATOR AND KEYBOARD circuitry is built around CT-5001 integrated circuit.

PARTS LIST
ALARM CIRCUIT

All resistors are ¼-watt, 5%, unless noted.

R1—10,000 ohm
R2—1 megohm
R3, R5—13,000 ohm
R4—50,000-ohm trimmer
R6—100 ohm
R7—6800 ohm
R8—3300 ohm
R9—4700 ohm
C1—0.47-μF disc
C2—.005-μF disc
C3—20-μF, 25V, electrolytic
D1-D3—1N4000
Q1, Q2—2N2222
S4—SPST switch
IC1, IC2—555 timer
SPKR—3-inch, 4-8 ohm, speaker

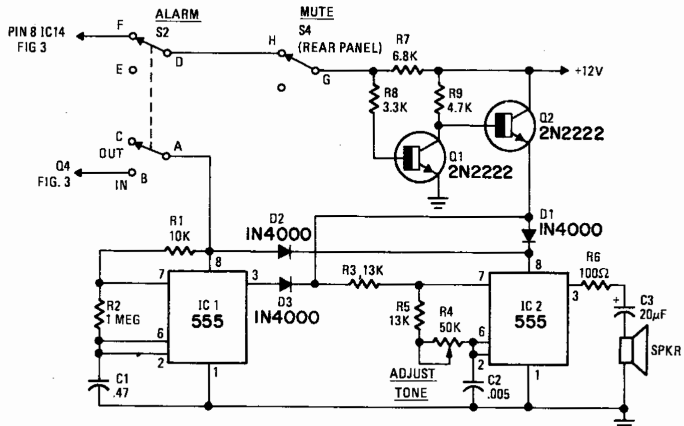


FIG. 5—ALARM CIRCUIT emits an audible alarm at the end of the programmed interval. Mute switch inhibits alarm from emitting an audible "beep" once-every-second during the programmed interval.

PARTS LIST
CONTROL CIRCUIT

All resistors are ¼-watt, 10%, unless noted.

R1-R3—300 ohm
R4—10,000 ohm
R5—33,000 ohm
R6, R7—1000 ohm
R8, R9—12,000 ohm
R10-R19—18,000 ohm
R20-R24—4700 ohm
R25—470 ohm
R26—470 ohm, ½ watt
R27-R29—3300 ohm
R30—2700 ohm
C1—4.7-μF, 20V, electrolytic
C2, C3—10-μF, 20V, electrolytic
C4—2.2-μF, 20V, electrolytic
C5—0.1-μF, 50V, disc
C6—0.47-μF, 50V disc
Q1-Q3, Q5—2N2222, 2N3904, or equal
Q4—2N5296 or equal
Q6-Q13—MPS6563 or equal
D1-D8—1N914 or 1N4148
D9—1N4001
IC1, IC2—7420
IC3, IC4, IC7, IC13, IC15—7400
IC5, IC8, IC9, IC14, IC16—7490
IC6—7442
IC10, IC11—7404
IC12—7410
IC17—7492
S1, S2—DPDT switch, push-push type (Radio Shack)
RY1—DPDT, 12VDC coil, 10A contacts

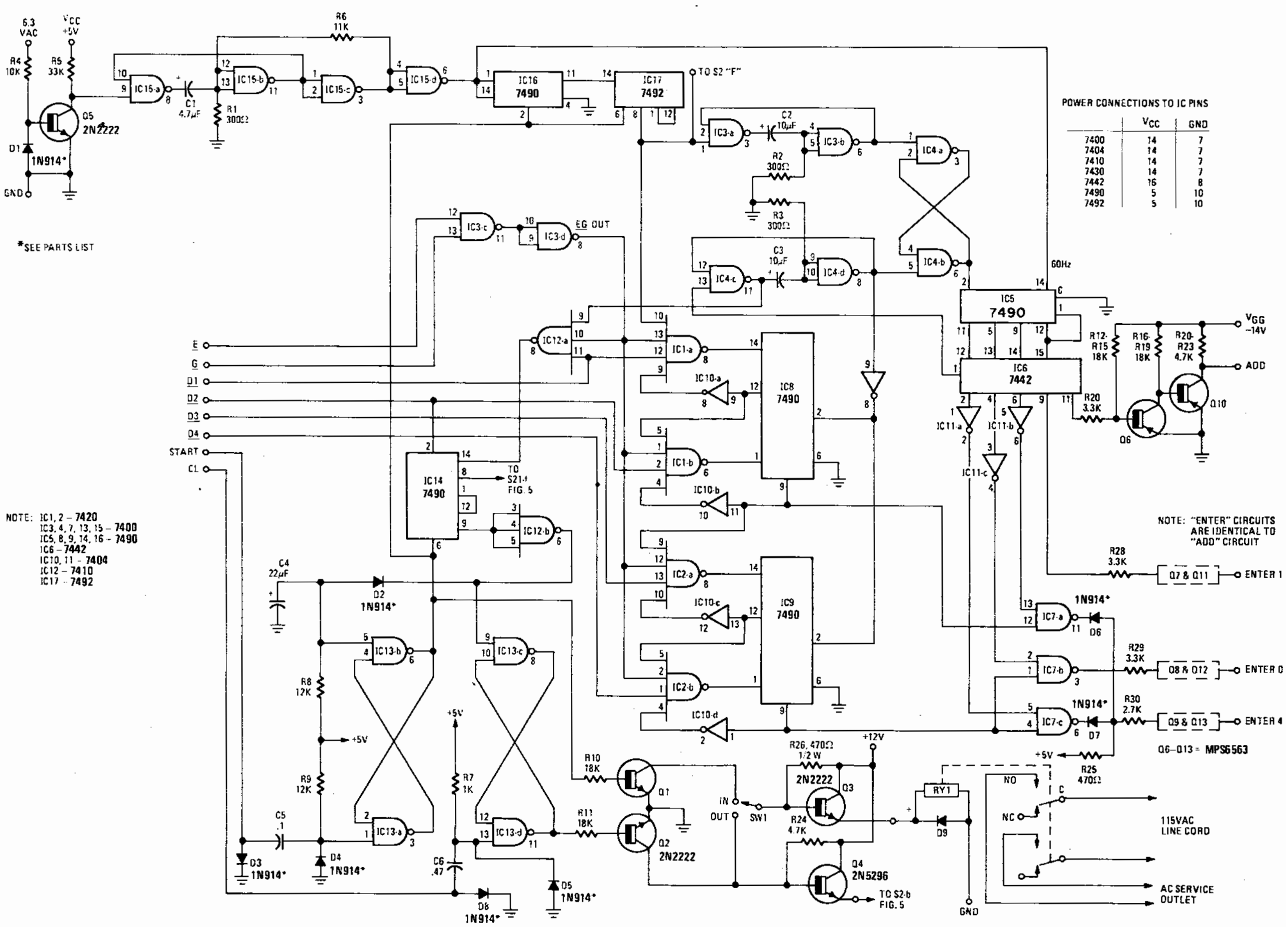


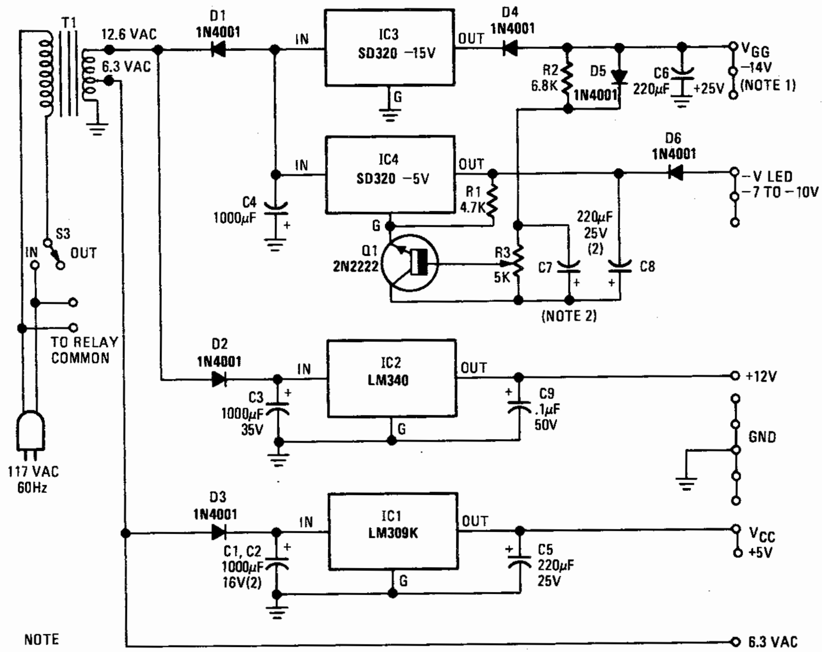
FIG. 3—CONTROL CIRCUITRY contains the timebase, decimal-to-clock converter, electronic keyboard simulator and zero-balance detector.

components are required because of the difference in logic levels and polarity between the two systems. The display circuit is the conventional multiplexed common anode type, plus the addition of the colon. The LED displays must be as specified or very similar because the segment current (20 mA average) is used to trigger the interface circuits.

The power supply circuit shown in Fig. 4 was designed around four IC voltage regulators, all of which operate well under their specified ratings. The LED voltage from IC4 can be varied over a −7 to −10 volt range by means of the voltage divider R1, Q1 and the trimmer R3. Trimmer R3 is used to vary the display brightness over a narrow range and should initially be set at minimum. At some setting of R3, the display will be at or near the specified brightness and the current through the segments will be within the limits required to operate the interfaces.

The alarm circuit shown in Fig. 5 emits a hee-haw sound. An assortment of sounds is possible, ranging from whistles to bird calls, or a commercial unit such as a Sonalert could be used.

Next month, the article continues with the construction details and the circuit board and component layouts.



NOTE

1. THE CT500, IC MAY NOT OPERATE PROPERLY AT LESS THAN -15V, HOWEVER, VGG SHOULD NOT BE MORE THAN -14V. ADD A DIODE IN SERIES WITH D4 IF VGG IS HIGHER THAN -14V AT 40 MA.

2. SET R3 INITIALLY FOR MINIMUM LED VOLTAGE. AFTER ASSEMBLY, INCREASE TO ADEQUATE LED BRIGHTNESS, APPROXIMATELY -.9V. IF -V LED IS TOO HIGH OR TOO LOW, INTERFACE CIRCUITS FOR SEGMENTS E AND G WILL BE ADVERSELY AFFECTED.

FIG. 4—POWER-SUPPLY CIRCUIT uses IC regulators to derive the various voltages.

PARTS LIST
DISPLAY BOARD

IN1-IN3—MAN6A, 7-segment, 0.6-inch high
IN4-IN5—MAN 64A, 7-segment, 0.4-inch high
LED1, LED2—discrete LED's, 0.16-inch maximum diameter
R1—120 to 330 ohms, ¼-watt (value required to suit LED's selected)

PARTS LIST
POWER SUPPLY

R1—4700 ohm, ¼ W, 10%
R2—6800 ohm, ¼ W, 10%
R3—5000-ohm trimmer
C1, C2—1000-µF, 16V, electrolytic
C3, C4—1000-µF, 35V, electrolytic
C5-C8—220-µF, 25V, electrolytic
C9—0.1-µF, 50V, disc
D1-D6—1N4001 or equal
Q1—2N2222 or equal
IC1—LM309K, +5V regulator
IC2—LM340T, +12V regulator
IC3—SD320, —15V regulator
IC4—SD320, —5V regulator
S3—SPDT switch, push-push type (use DPDT, Radio Shack or equal.)
T1—117V primary, 12.6V @ 1.2A secondary

PURPLE POEM

I think that I shall never see
Anything drive me up my tree
Quite as fast as a balky TV.
This accursed, balky, blind, TV
Is a black-and-white Sears model 528.70623.
The sound is O.K. clear and nice,
The screen has a raster but blank as ice.
From Sams Photofacts 1134,
I dove into the circuit to give it whatfor.
An audio signal at the video detect
Produced bars on the screen as sure as heck.
The volts in the IF I checked just for fun
For the sound from the speaker said they weren't the ones.
I've checked by every known means
All components from IF to picture screen.
I'd appreciate help if you don't mind my rhyme
Before I completely go out of my mind.—D.G., West Chester, PA.

If I were you, the AGC
I'd check as closely as can be.
For this if dead can well suffice
To make the screen as blank as ice.
It kills the picture, as you see,
Tho' sound can often sneak home free!

FLYBACK REPLACEMENT

I can't locate a replacement flyback for this Setchell-Carlson black-and-white TV, and the company is out of business. Do you know where I could find one?—G.P., Governor's Island, NY.

I don't, but my Triad catalogue does! It's listed in there. A Triad D-638 flyback will replace the original TWF-110X.

THIN WHITE LINE

Read your Clinic for years. I laughed a little but I also learned a lot. Now I need help. Magnavox T915 set with everything fine except for a thin white line in the center of the picture (and raster). Tried everything I can think of with no results.—W.P., Columbus, OH.

If my memory serves me (which it usually doesn't), this is due to an open .0082 µF capacitor connected from the hot terminal of the yoke socket to ground on the horizontal yoke connection. Be sure to use one with at least a 1 kV rating, there's a pretty good pulse voltage at this point.

(Field Feedback: Your memory is good! That was it.)

HUM PROBLEM

If you have audio hum in a Truetone GEC4617A-67 color TV, relocate the ground lead from the volume control. It's now connected to the negative terminal of filter capacitor C904. Move this to the grounded terminal of the terminal strip located above and to the left of C904. This is directly to the metal chassis. (Thanks to a Truetone factory service note.)

build a digital countdown timer

PART II

A versatile countdown timer with keyboard programming that can control various external devices. The time interval can be programmed in increments of one second from one second to approx. 11,000 years

GEORGE R. BAUMGRAS

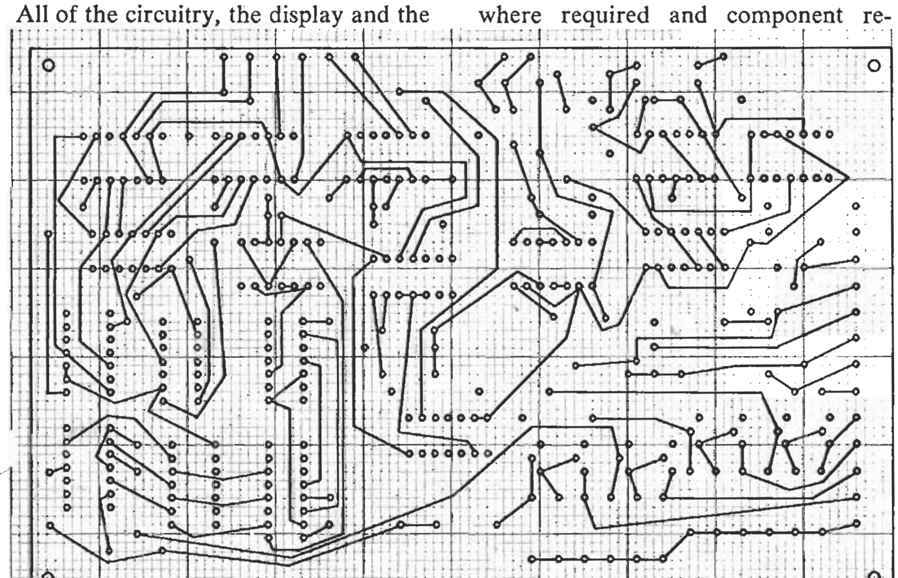
THE FIRST PART OF THIS ARTICLE (AUgust, 1976) presented the schematic diagram and a description of the digital countdown timer.

This second and concluding part of the article presents the board layouts and the construction details.

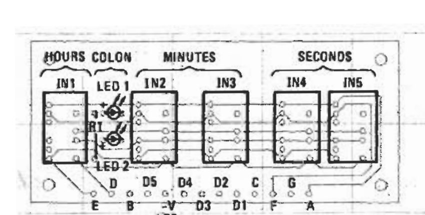
Construction

All of the circuitry, the display and the keyboard were mounted on 6 printed-circuit boards and assembled in a custom-made cabinet measuring 5" high × 8½" wide × 6" deep, affording plenty of room for wiring, switches, the relay and the transformer. Wire-wrap sockets were used for the displays and the TTL IC's so that connections could be soldered on both sides of the board where required and component replacement would be easy. All connections between boards were made with No. 22 stranded and color-coded wire, and No. 12 was used between the relay and the AC outlet. The line cord connects directly to the relay common-terminals and should be rated at 10 amps minimum.

The only components that require selective purchase are the discrete transistors, other than Q3. Both the silicon NPN and PNP types are rated at 40V (B_{VCE}), 600 mA (I_C), should have a current gain (β) of at least 80 and a

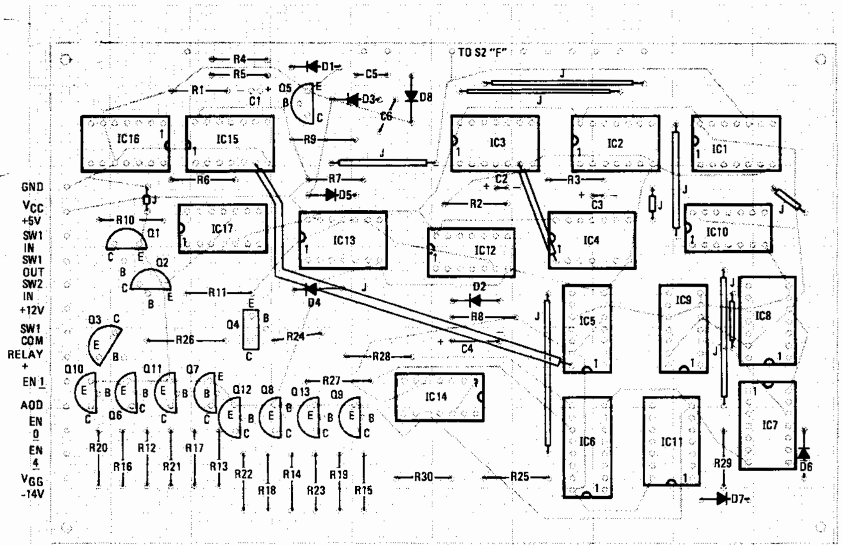


CONTROL BOARD, view of bottom side of double-sided board. Grid is 10 lines per inch.



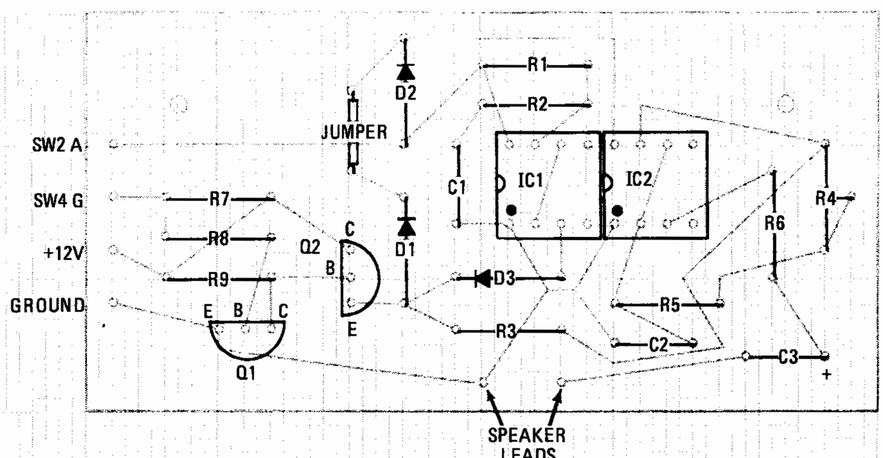
NOTES:
1. ALL PARTS LOCATED ON COMPONENT SIDE
2. WIRE WRAP SOCKETS EXTENDING .2" ABOVE BOARD REQUIRED TO PERMIT SOLDERING
3. CUT OFF SOCKET PINS 4, 9, 12 AND 14.

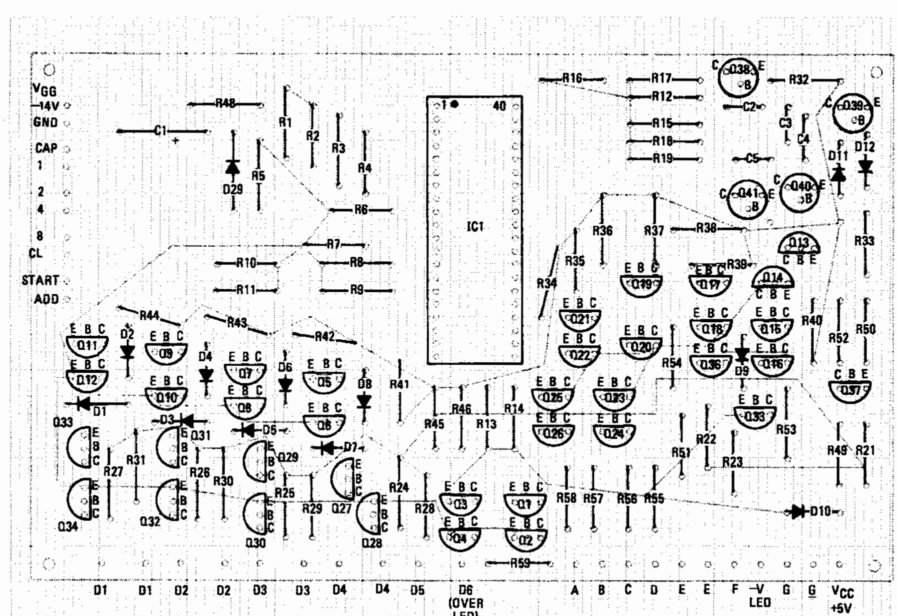
DISPLAY BOARD, view of component side of board with components shown. Layout may be used to generate PC board or perforated board. Grid is 10 lines to the inch. Actual board size is 4" × 17." (10.2 cm × 4.3 cm).



NOTE:
1. ALL PARTS THIS SIDE
2. WIRE-WRAP SOCKETS EXTENDING .2" ABOVE BOARD REQUIRED TO PERMIT SOLDERING BOTH SIDES.
3. INSTALL JUMPERS AS SHOWN-INSULATE AS REQUIRED. PIN-TO-PIN JUMPERS SHOULD BE ON OTHER SIDE.

This mode of construction lets you lay out and make your own circuit boards. *Note:* Our artist goofed on some boards and drew some IC pins too far apart. Just make sure that the IC terminal pins fall exactly on consecutive one-tenth inch line intersections and all else will work out OK.

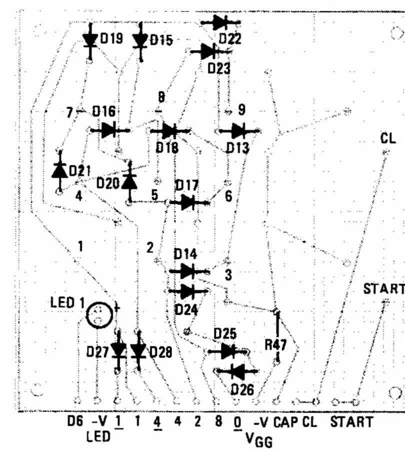




CONTROL BOARD (top left), view of component side of double-sided board with component placement. Layout may be used to make printed-circuit board of perforated board. Actual board size is 4" × 6.4" (10.2 cm × 16.3 cm). Grid is 10 lines-per-inch.

ALARM BOARD (middle left), view of component side of board with components shown. Layout may be used to generate PC board or perforated board. Grid is 10 lines to the inch. Actual board size is 3" × 1.5" (7.6 cm × 3.8 cm).

CALCULATOR BOARD (bottom left), view of component side of double-sided board with component placement. Grid is 10 lines per inch. Layout may be used to generate printed-circuit board or perforated board. Actual board size is 4" × 6.4" (10.2 cm × 16.3 cm).

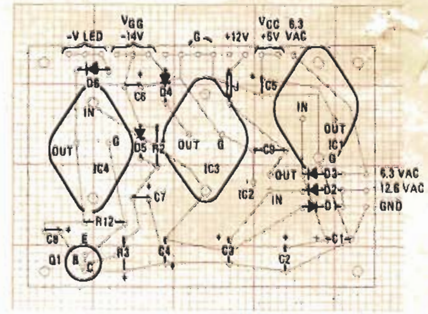


NOTE:
1. HOLES MARKED ● CONNECT TO AND LOCATE BODY OF OAK #415 SWITCHES.
2. UNDERLINED NUMBERS CONNECT TO CONTROL CIRCUIT BOARD. "OVER" LED CONNECTIONS ARE TO BE LOCATED PER SWITCH BODY PATTERN, REPLACING DECIMAL POINT KEY NORMALLY USED.
3. RESISTOR AND DIODES LOCATED ON BOTTOM SIDE–SWITCH BODIES ARE MOUNTED ON COMPONENT SIDE OF BOARD.

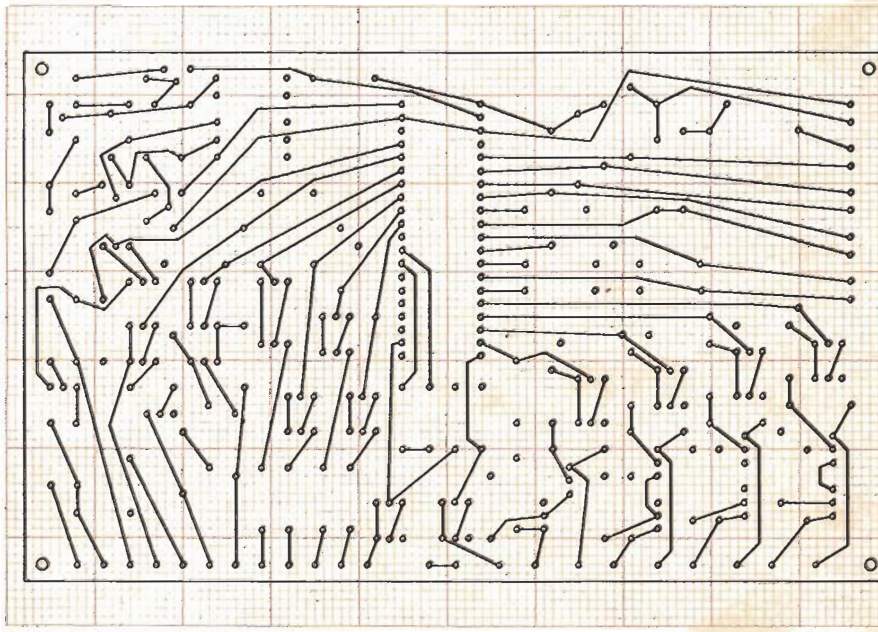
KEYBOARD, view of component side of board with components shown. Layout may be used to generate PC board or perforated board. Grid is 10 lines to the inch. Actual board size is 4" × 4" (10.2 cm × 10.2 cm).

TO-92 case. Those used in the prototype appear to be house numbered, the NPN type being marked M311 and similar to a 2N3904 or 2N2222. The PNP's were marked M236 and similar to MPS6563 or HEP716. Suitable equivalents should be available from surplus outlets for around 20¢ each. These two transistor-types are used throughout the design and each was tested before use. Two of the NPN units that appeared to be matched were selected during testing and used as Q39 and Q40 in the calculator clock circuit shown in Fig. 2. All of the IC's, diodes and resistors were also checked and although not a single bad part was found, the effort was considered worthwhile since a malfunction would be difficult to track down once the total package is put together.

Where a more complex timing function is demanded, several additional modes are possible. For example, the terminals of switch S2, instead of operating an alarm, can be rewired to provide +12 volts at 30 mA to two receptacles on the rear panel; thus initiating either of two external functions. A third receptacle interfaced with the START input will permit remote, sequential, or automatically controlled triggering of the countdown process. A similar input to the CLEAR function can be used for remote or emergency turn-off, and the normally-closed contacts of the relay could also be brought out to the rear panel. In a darkroom application, the normally-closed relay contacts can be used to control the safelight while the enlarger is controlled by the normally-open relay contacts. Thus the safelights will be switched off when the enlarger is on, and vice versa. Probably many other adaptations of the basic scheme will become obvious. **R-E**



POWER SUPPLY BOARD, view of top of single-sided board. Actual board size is 4.25" × 3" (10.8 cm × 7.6 cm.) Grid is 10 lines to the inch. Layout can be used to generate PC board.



CALCULATOR BOARD, view of bottom side of double-sided board. Grid is 10 lines per inch.

BRIGHTNESS CONTROL HAS NO EFFECT

Turning the brightness control on this Philco 22QT79 has no effect. I'd welcome any help.—S.E., Norfolk, VA.

Look in the cathode circuit of the 12GN7 video-output tube. (A little crowded in there, isn't it? There are *three* different controls all in the circuit!) First is the PICTURE-PEAKING, next the CONTRAST, and finally the BRIGHTNESS. The BRIGHTNESS control finally returns to the +20 volt source. See diagram.

The brightness control has one end tied to the slider. Moving this varies the voltage on the 12GN7 cathode, and so changes the bias that in turn changes the brightness. I'd say that it was quite possible that the slider contact on the control was either open or shorted to one end of the control.

Alternate possibility is that the +20-volt supply is not correct. Be sure that it's present on the low end of this control and then check to make sure that the control does vary the voltage.