Electronic Scorekeeper for Recreation Rooms

Dial your scores into a two-player, double-digit scoreboard

BY JOSEPH FORTUNA

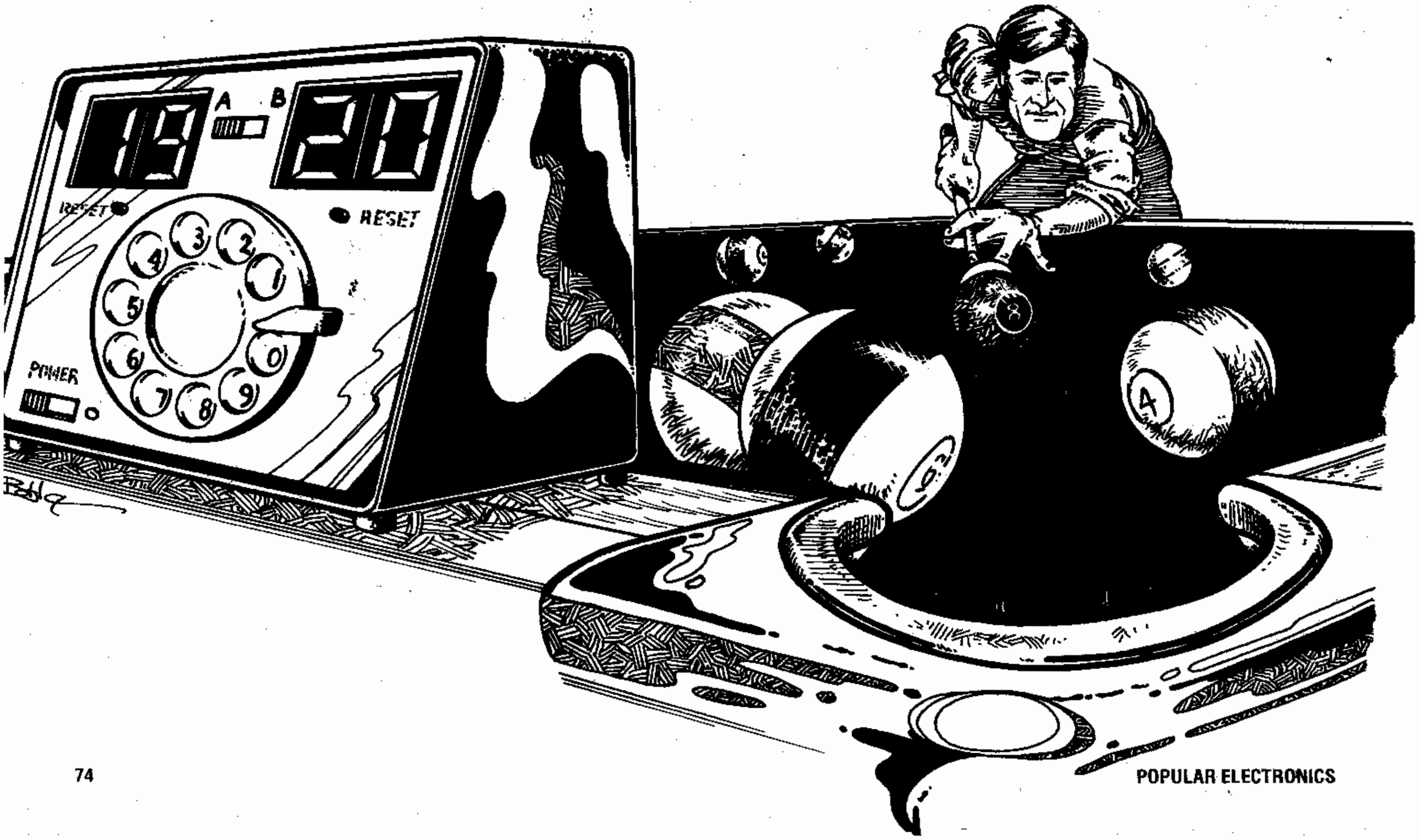
GAMES in which the scores for individual players must be kept are a popular pastime. Not so popular is the usual search for paper and pencil needed for keeping the score. The Electronic Scorekeeper described here eliminates the search so you can get right to the game. As designed, the Scorekeeper can keep score for two players up to a maximum count of 99. However, with a couple of simple modifications, the number of players and the count range can be increased as desired. The circuit uses readily available and inexpensive TTL devices and seven-segment numeric LED displays.

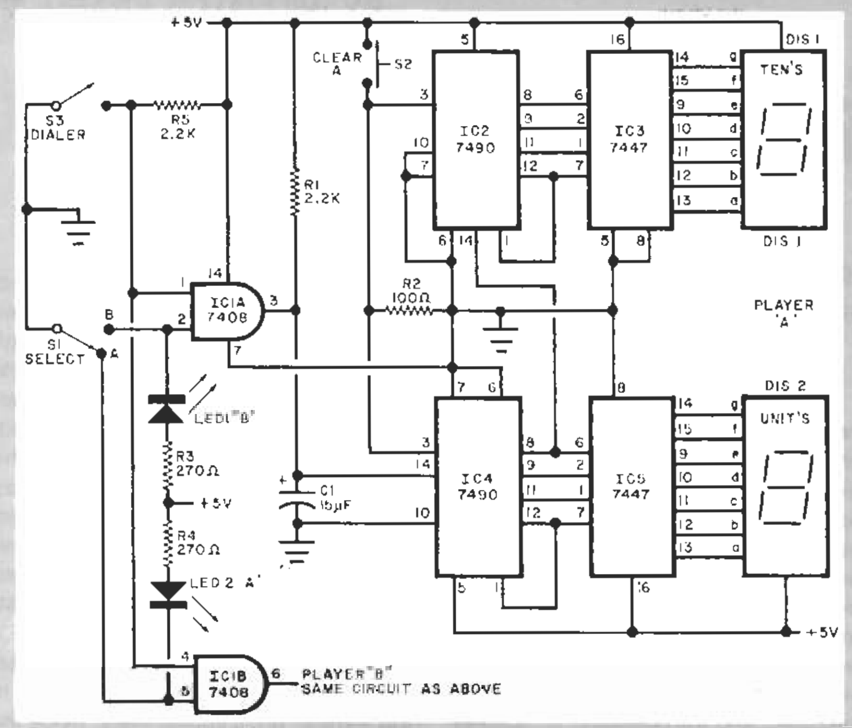
About the Circuit. Since the circuit for each player is identical, only the circuit for player A is shown in Fig. 1. Player B's circuit connects to the pin-6 output of gate *IC1B*. Integrated circuits *IC4* and *IC5* and display *DIS2* make up a conventional 0-to-9 units decade counter whose carry output at pin 8 of *IC4* is fed to a similar tens counter made up of *IC2, IC3,* and *DIS1*. Seven-segment displays *DIS1* and *DIS2* are common-anode LED types.

The count for the circuit shown in Fig. 1 can easily be increased as desired simply by adding extra decade counters. When the additional decade counters are used, the input of each successive counter is connected to the carry output of the preceding counter and the RESET lines are connected in common.

Both decade counters shown in Fig. 1 are set to zero by operating CLEAR pushbutton switch *S2* to momentarily raise the reset-to-zero (RST) input at pin 3 of *IC2* and *IC4* to high and then back to ground as the switch is released and pulldown is accomplished by *R2*. When *S2* is pressed and released, both *DIS1* and *DIS2* should display zeros.

SELECTOR switch *S1* permits the person keeping score to choose between player A and player B for score display





PARTS LIST

C1—15-μF, 15-volt electrolytic
DIS1, DIS2—Common-anode 7-segment LED display
IC1—7408 quad AND gate
IC2, IC4—7490 decade counter
IC3, IC5—7447 BCD-to-7-segment decoder
LED1, LED2—Any discrete red LED
R1, R5—2200-ohm, ½-watt resistor
R2—100-ohm, ½-watt resistor
R3, R4—270-ohm, ½-watt resistor
S1—Dpst switch
S2—Normally open pushbutton switch
S3—Telephone dialer-switch mechanism (see text)
Misc.—Duplicate circuit for player B; regulated 5-volt, 1-ampere dc power supply; perforated or printed-circuit board and hardware; suitable enclosure; sockets for ICs (optional); machine hardware; hookup wire; solder; dry-transfer lettering kit; etc.

Fig. 1. Schematic shows scorekeeping circuit for only one player.

and incrementing. When the player-A position is selected, pin 5 of *IC1B* is grounded and held low, causing *LED2* for player A to come on. At this time, the output of *IC1B* is low and the gate is disabled. Hence, the player-B decade counters will not operate.

Pin 1 of *IC1A* and pin 4 of *IC1B* are made high by pullup resistor *R5*, and mechanical DIALER switch *S3* is connected from ground to this common point. (A surplus mechanical telephone-dial switch assembly can be used for *S3* to allow you to conveniently "dial in" the score updates. Alternatively, you can substitute an ordinary normally open pushbutton switch for this operation, but it will have to be operated for each and every unit increment in the scoring.)

Operating *S3* shorts the common *IC1A* pin-1 *IC1B* pin-4 point to ground the same number of times selected on the DIALER. As the DIALER is operated, IC1A turns on and off with each closure of *S3*. This generates one or more input pulses, depending on the DIALER number selected, for player A's decade counter. (This assumes *S1* is set to A; operation is identical for player B, except that *S1* must be set to B.) Every time the *IC4* units decade overflows at the tenth pulse from *IC1A*, the carry output from *IC4* toggles the *IC2* decade counter.

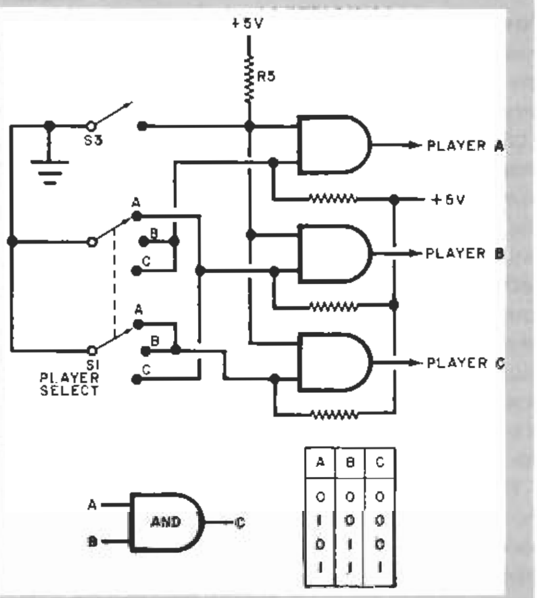
The circuit in Fig. 1 can be expanded to keep score for more than two players, as shown in Fig. 2. Note here that separate player LEDs are not used. Using the AND gate and truth table shown, you can design further switching to increase the number of players beyond the three shown in Fig. 2.

Construction. Since component layout is not critical, you can use just about any wiring technique that suits you. Perhaps most convenient is a printed-circuit board of your own design, but perforated board and Wire Wrapping is equally suitable. In either case, it is recommended that you use sockets for the ICs.

Once you have assembled and checked the circuit, mount it in an enclosure so that the two pairs of displays can easily be viewed. Mount the LEDs and switches, including the DIALER mechanism, on the top of the enclosure. Finally, use a dry-transfer lettering kit to label the switches and LEDs according to function.

Power for the Scorekeeper can be obtained from any regulated 5-volt dc supply capable of delivering 1 ampere or more of current. ◇

Fig. 2. A scorekeeper for more than two people can be made by using AND gates and switching as shown here as long as truth table is satisfied.



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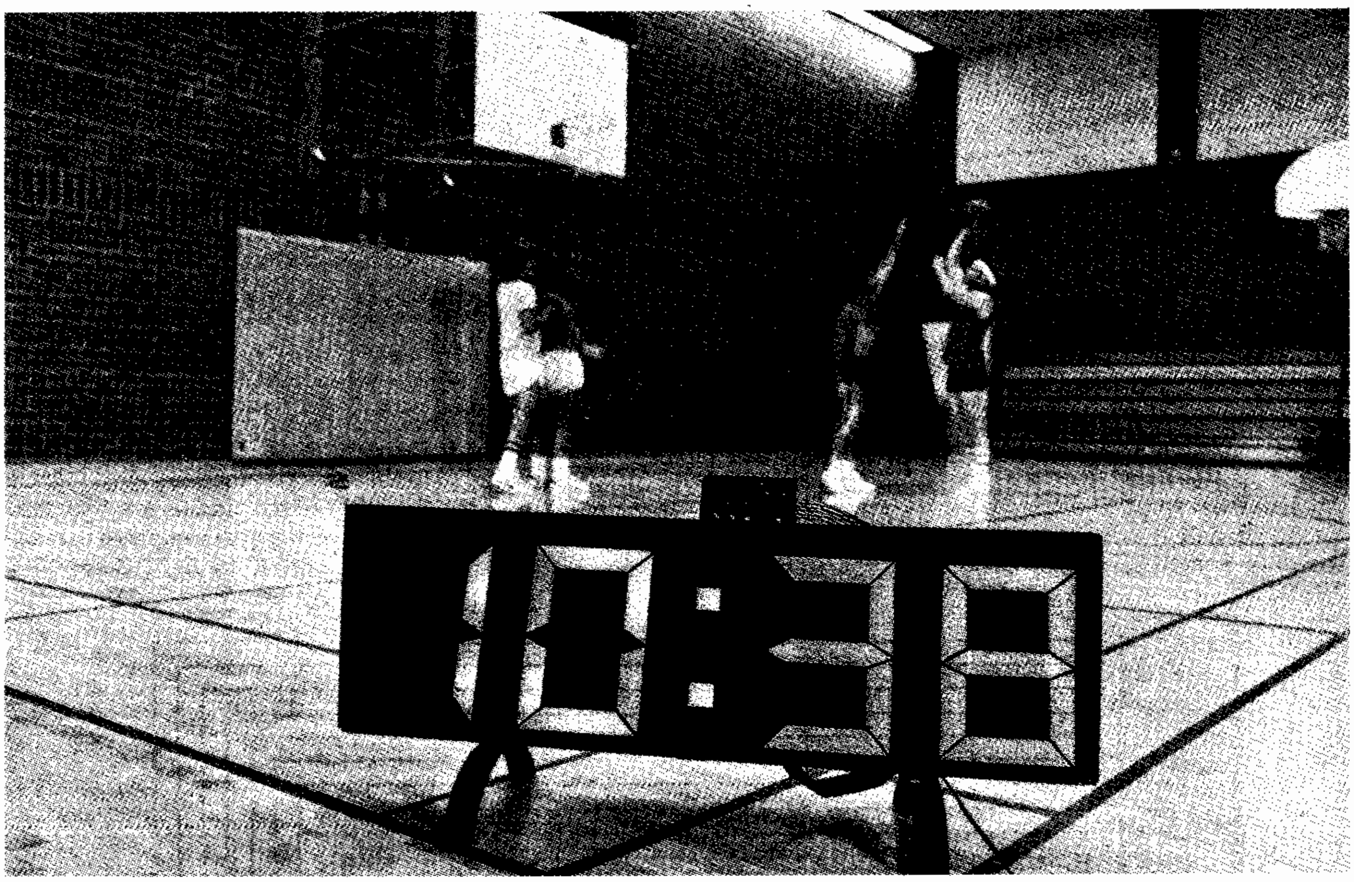


A DIGITAL TIMER-SCOREBOARD FOR ATHLETIC EVENTS

Gymnasium-sized digital readouts simultaneously time up or down and keep score. Ideal for schools and amateur sports groups.

BY PHILIP HARMS

ELECTRONIC timers and scoreboards for athletic events are often too expensive for amateur organizations and small school groups. This is particularly true of a display that can be read across a gymnasium or stadium. The combination timer/scoreboard described here can be built with readily available components (TTL logic), many of which can be obtained from surplus dealers. Though variations on the display are possible, the prototype has four seven-segment digits, each one foot high. It can be built for about $100.

The project has two independent modes of operation — timing and score displaying — both remotely controlled. Usually, the time is displayed, but while the score is being displayed, the internal electronic clock keeps operating so that the time display is always available. In addition, the timing can be made to run backward and the operator can start the timer at any selected time and run the time up or down from that point. If it is desired to stop the timing (for time-outs in basketball or football), this can also be done. The readouts will hold the time and will start to operate (either up or down) when timing is resumed.

The four-digit readout can be set to indicate a preset score. When the time is displayed, a colon is lit between the two sets of digits. For a score, there is no colon. Provision is also made for an instant test of all the display lamps.

The electronic portion of the scoreboard control is easily assembled on printed circuit boards. Though some carpentry is involved in the construction of the display, it is not beyond the capability of a high-school

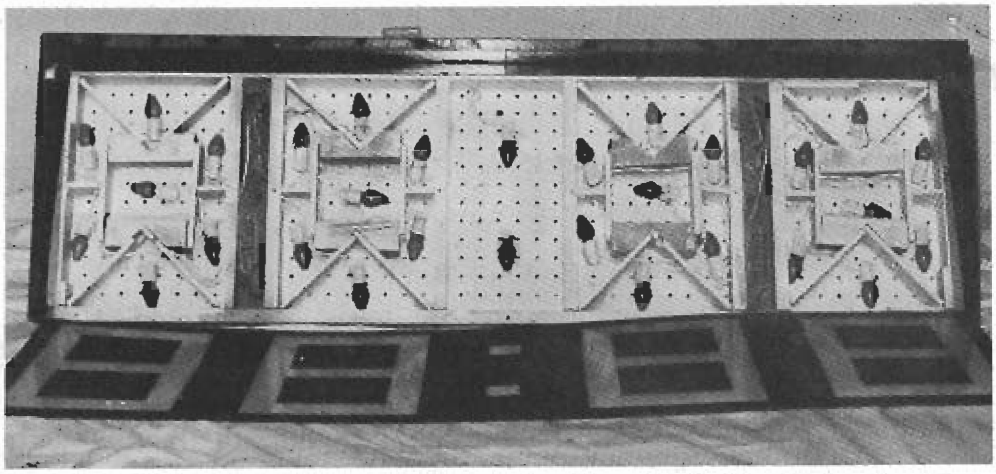


Photo of interior of prototype display board shows how lamps are placed in each segment and for colon. Note plastic front panel with all but figures painted flat black.

student. Ordinary 7½-watt lamps (Christmas-tree type) are used to illuminate the display. The remote control board and the display are connected by a multi-conductor cable.

Circuit Operation. An overall logic diagram is shown in Fig. 1. Portions of the circuit are shown in individual schematics and will be discussed separately.

Control Box. The control switches for the various functions are shown in Fig. 2. All of the circuits to which they are connected are terminated in resistors connected to the +5-volt line.

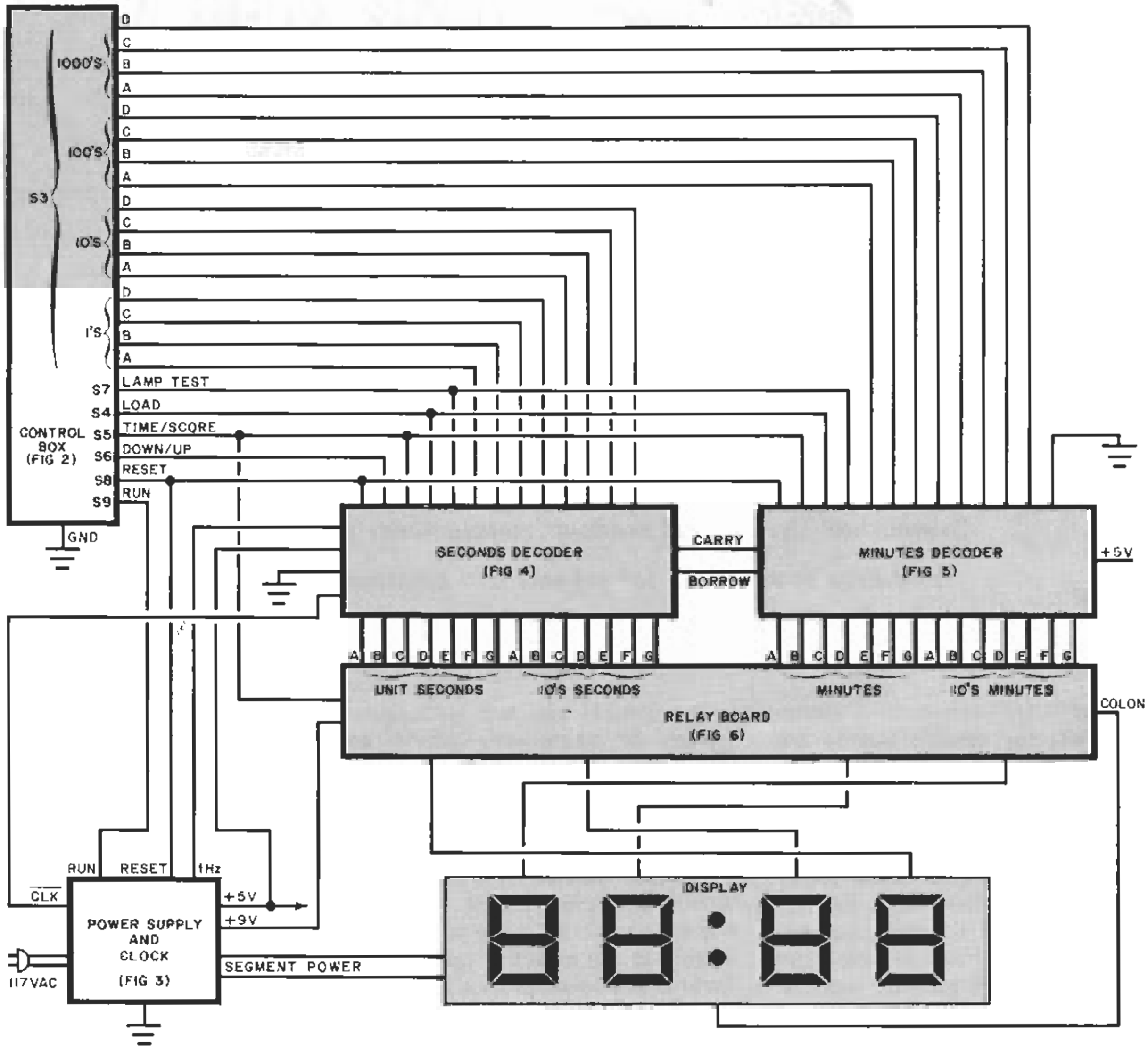
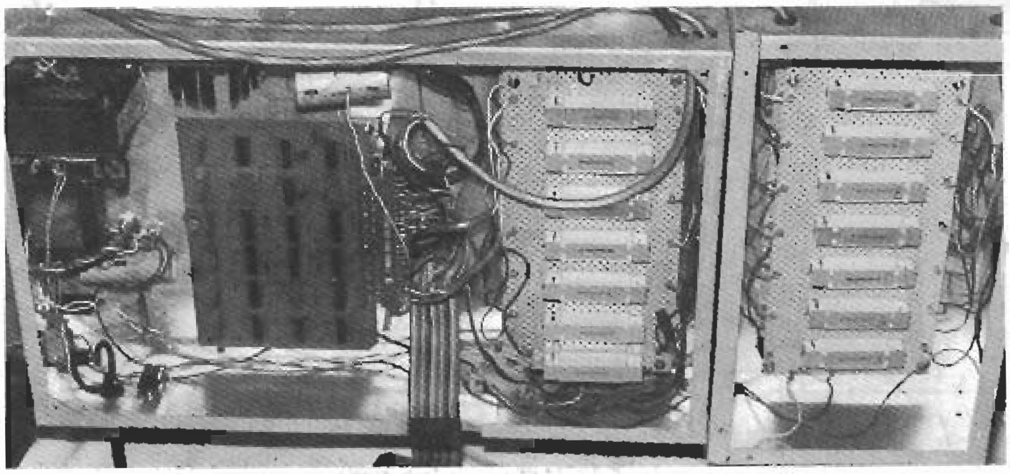


***Fig. 1.* Overall block diagram of the system. Schematics of individual sections are identified by figure number.**



Interior of the two electronic chassis. The power supply, main electronic board, and relay board for two digits are in one chassis. Relay boards for other two digits are in second chassis.

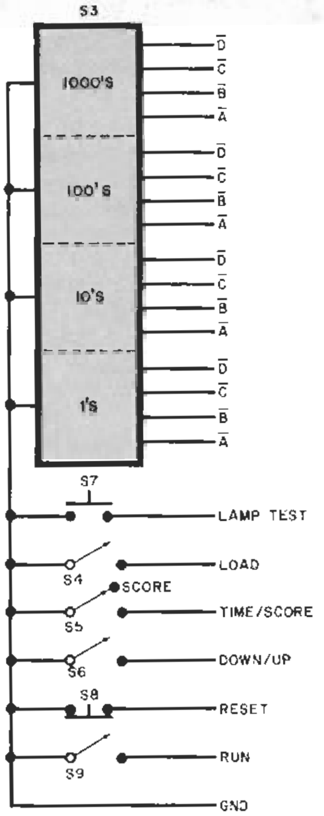


Fig. 2. Control box determines operation of the system. Connection to rest of system is through multiconductor cable.

Thus, when the switches are open, the lines indicate a logic 1 state.

The four sections of thumbwheel switch *S3* have a complementary BCD output. Each section has a common wiper contact and four output lines. System ground is tied to each common line and the selected code is presented at the output terminals. The complementary BCD code is as follows: (C = closed contact; O = open contact)

	D	C	B	A
Digit	8	4	2	1
0	C	C	C	C
1	C	C	C	O
2	C	C	O	C
3	C	C	O	O
4	C	O	C	C
5	C	O	C	O
6	C	O	O	C
7	C	O	O	O
8	O	C	C	C
9	O	C	C	O

Power Supply and Clock. The system requires two power supplies (Fig. 3). One, using a two-transistor regulator, provides +5 volts for the logic. The other is a simple rectifier (*D4*) and filter (*C2*) circuit to provide 9 volts for the segment relays.

The 117-volt ac supply is applied to the display lamps to light each segment. When *S2* is closed, the full ac supply is applied to provide a bright display. With *S2* open, diode *D1* permits only the positive half cycles to be applied to the lamps, producing a dimmer display.

Integrated circuit *IC8* is a one-shot multivibrator which provides a clean 60-Hz pulse from the ac supply so that any noise on the power line can't cause false timing. This pulse is then coupled to *IC9* (a divide-by-six counter). To prevent contact bounce from the *RUN* switch from producing false signals, the switch signal is conditioned by *IC7*. The latter operates *IC10C* (an AND gate) to allow the 60-Hz signal to pass to the countdown circuits.

Seconds Decoder. In this circuit (Fig. 4), *IC12* is an up/down counter whose direction is controlled by *S6* in the control box. Note that the 1-Hz signal is applied to *IC12* through two sections of *IC10*. These gates control the up and down count lines. When the unit is set to time up, the 1-Hz clock is routed to pin 5. For count down, the input is to pin 4.

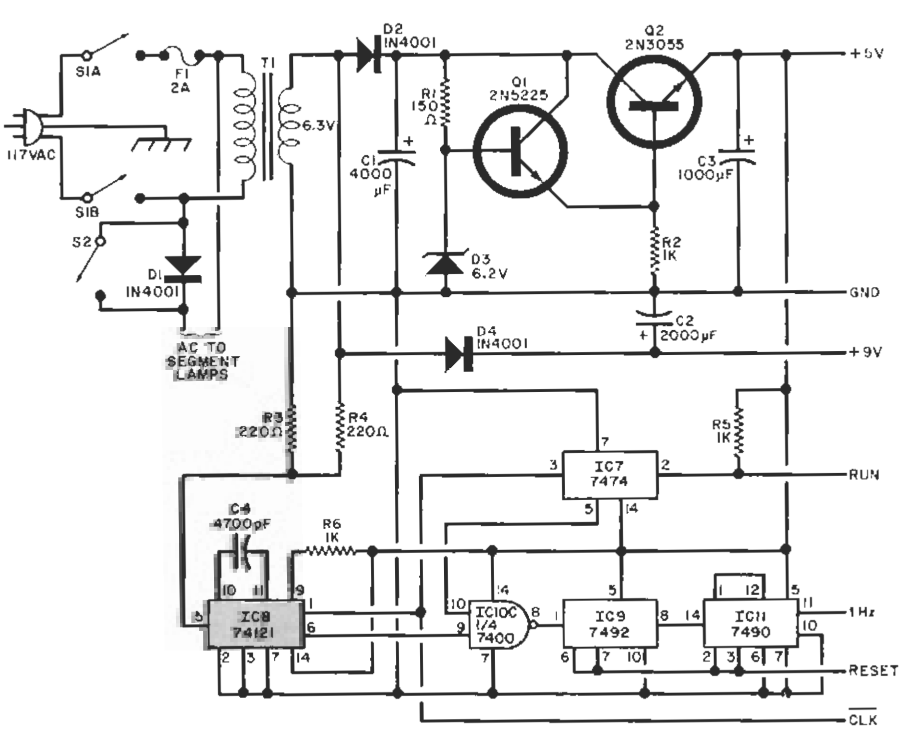


Fig. 3. Regulated 5-volt supply is used for TTL. The 60-Hz is counted down to produce 1-Hz clock pulse for timing.

PARTS LIST

C1—4000-µF, 15-V tantalum capacitor
C2—2000-µF, 15-V tantalum capacitor
C3—1000-µF, 15-V tantalum capacitor
C4—4700-pF, 100-V ceramic capacitor
C5 to C10—0.1-µF, 100-V ceramic capacitor
D1,D2,D4—Diode (1N4001 or similar)
D3—6.2-V zener diode
D5 to D33—1N914 diode
F1—2A fuse and holder
I1 to I30—117-V, 7½-W incandescent lamp
IC1,IC2,IC12,IC17—74192 decade up/down counter
IC3,IC4,IC13,IC18—8233 quad 2-to-1 multiplexer
IC5,IC6,IC14,IC19—7447 BCD-to-7-segment decoder
IC7—7474 dual-D flip-flop
IC8—74121 monostable multivibrator
IC9—7492 divide-by-6/12 counter
IC10—7400 quad 2-input NAND gate
IC11—7490 decade counter
IC15,IC16—74153 dual 4-to-1 multiplexer
IC20—7404 hex inverter
IC21,IC22—74H21 dual 4-input AND gate
IC23—7473 dual JK flip-flop
IC24—7410 triple 3-input NAND gate
K1 to K29—12-V reed relay
Q1,Q3—2N5225 transistor
Q2—2N3055 transistor
R1—150-ohm, ½-W resistor
R2,R5,R6,R11—1000-ohm, ½-W resistor
R3,R4—220-ohm, ½-W resistor
R7 to R10, R12 to R26—2200-ohm, ½-W resistor
R27—4700-ohm, ½-W resistor
S1—Dpst switch
S2,S4,S6,S9—Spst switch
S3—Four-decade thumbwheel switch (EECO 1776 or similar)
S5—Spst switch
S7—Normally open spst pushbutton switch
S8—Normally closed spst pushbutton switch
T1—6.3-V, 2-A filament transformer
Misc.—Heat sink kit for Q2; lamp sockets (30); hookup wire; 1" × 2" wood strips for display frame; pegboard for display back; translucent white plastic for display front, glossy white or silver paint; flat black paint; thin wood or metal strips for segment dividers; suitable metal chassis; multiconductor cable; press-on type; mounting hardware; line cord; perforated board; IC sockets (24); component mounting clips; etc.

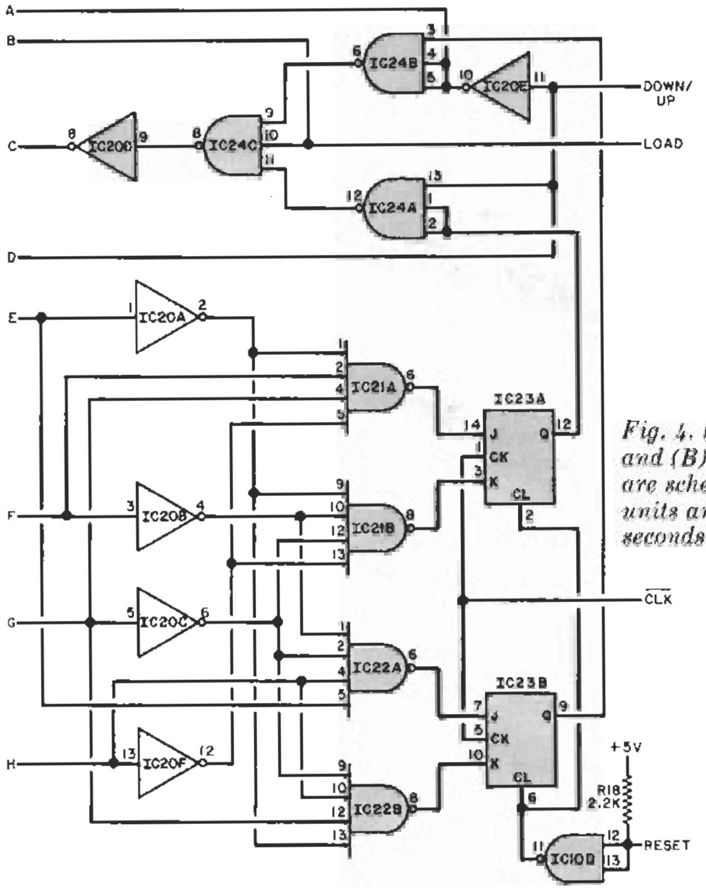
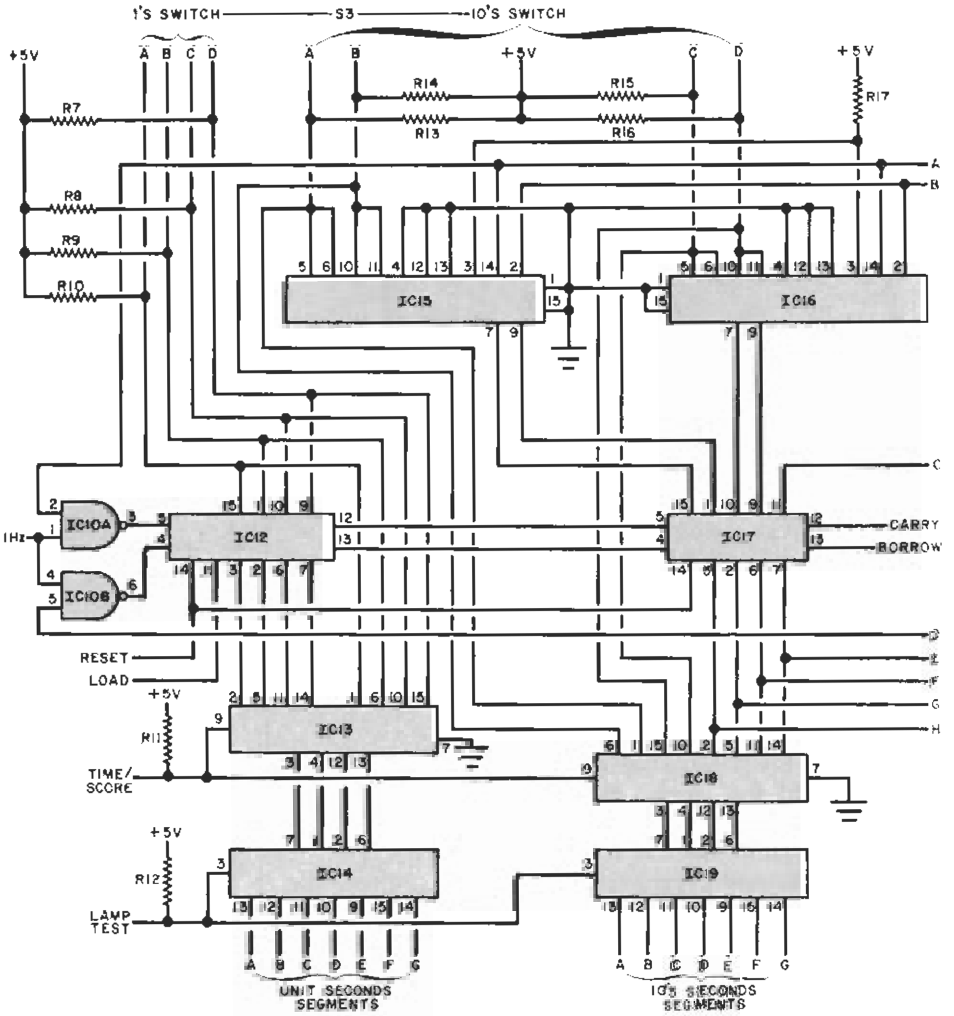


Fig. 4. (A), left, and (B), below, are schematics of units and tens of seconds stages.



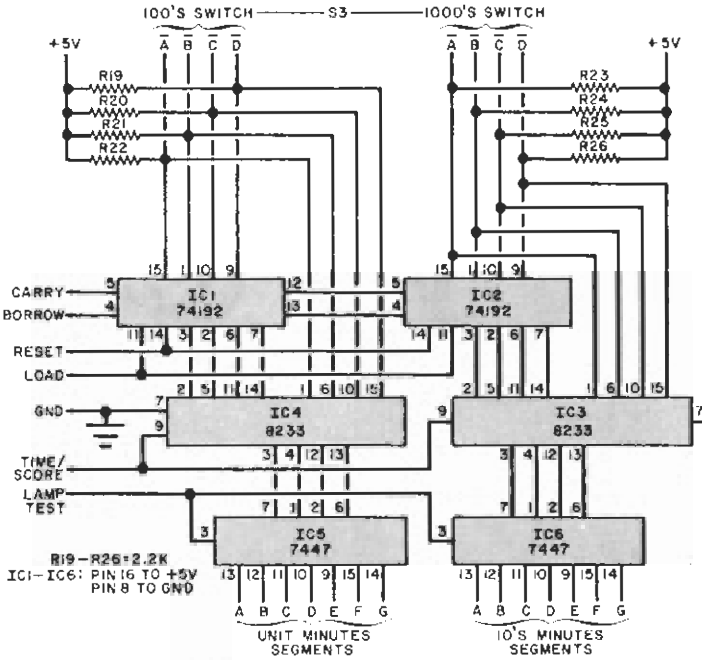


Fig. 5. Schematic of the units and tens of minutes stages. Part of circuit is also used to preset the score.

When pin 11 of *IC12* is low, the BCD present on pins 15, 1, 10, and 9 is loaded into the counter; and when timing begins, it starts from this preset code. The preset code is generated in the applicable thumbwheel switch in the control box.

When the counter is being clocked (up or down), carry and borrow lines cascade *IC12* to *IC17*, another decade up/down counter that forms the 10's of seconds counter. Each time *IC12* reaches a zero on its up count, an output pulse increments *IC17*. Likewise, on a down count, a borrow pulse is generated for every zero transition. Integrated circuit *IC13* acts as a four-pole, two-position switch. When pin 9 is low (indicating a score display), the BCD code from the thumbwheel switch is routed to *IC14*. When pin 9 is high, the BCD from counter *IC12* is routed to *IC13*. Note that changing the display from TIME to SCORE does not affect the timing operation. The selected output from *IC13* is decoded in *IC14* and converted to seven-segment format with the standard segment (A through G) designations.

Decade counters can be cascaded for as many digits as required. However, since a minute consists of 60 seconds (not 100), external circuitry must be added to *IC17* to make it a divide-by-six counter. This is not too much of a problem, except that both up and down counting are involved. For counting, up, the sequence must be 1-2-3-4-5-0-1-2 etc.; while for counting down, the sequence is 5-4-3-2-1-0-5-4 etc.

The feedback to produce this logic is implemented as follows (for the up count; the down count logic is identical). When the counter cycles from 5 to 6, we want it to replace the 6 with a 0. The 6 count from *IC17* is sensed by *IC21A* and the resulting high state presented to the J (pin 14) input of *IC23A* is stored. The high output of *IC23A* causes *IC17* to enter a load condition; and, at the same time, *IC14* and *IC16* (arranged as a four-pole, four-position switch) force a count of 0 into the counter. When this 0 is detected by *IC23A*, the load command is removed and the counter continues to time from the 0 state. While the invalid 6 digit would be displayed, it is only for 1/60 of a second and will not be observed. *IC15* is wired for a code of 0 (used during time up) and a code of 5 (used during time down), with the BCD

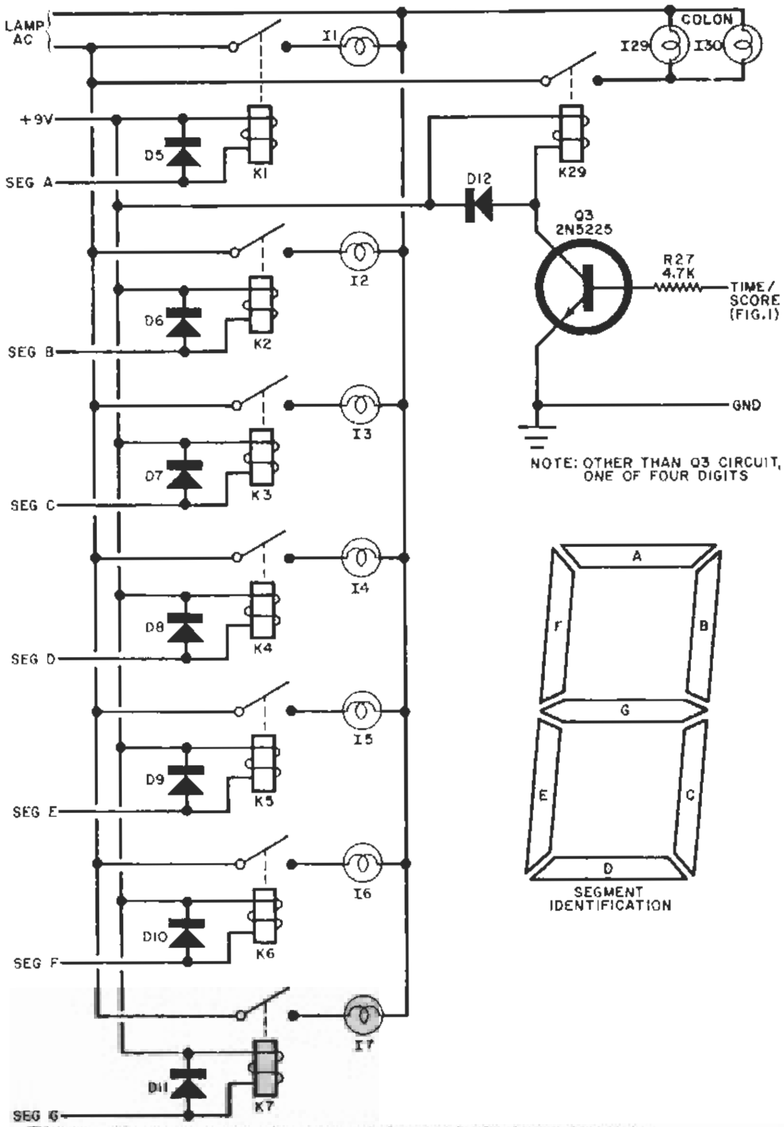


Fig. 6. There is one relay board for each digit in display. Relay circuit for colon display is on only one board.

code from the thumbwheel switch routed into the counter during the normal loading time.

The minutes and tens of minutes decoders are shown in Fig. 5. These are conventional circuits receiving their instructions from the control box.

Relay Board. The outputs of the BCD-to-seven-segment decoders (*IC14, IC19, IC5,* and *IC6*) are connected to their respective reed relay coils shown in Fig. 6. Other than the colon circuit, the reed-relay circuits are duplicated for each digit on the display. One side of each relay coil is connected to the nine-volt supply and the other to the decoder output. The diode across each coil eliminates the inductive spike that is generated when the segment drive voltage is removed. The switching is arranged so that each 117-volt segment lamp is placed in the circuit as its reed relay operates.

Transistor *Q3* saturates when the TIME switch on the control box is operated. This energizes *K29* and *I29* and *I30* to form the colon.

Horn Option. An additional circuit (not included in the prototype) can be used to sound a horn or buzzer at zero time (Fig. 7). The BCD code from each counter is routed to its own four-input NOR gate (7425). When all lines are at a zero level (zero time), the output of four-input NAND gate (7420) goes low causing the SR flip-flop composed of the two 7400 NAND gates to produce a high state. This state is retained until the RESET switch on the control box is operated. The output transistor is used to operate a relay whose switch contacts should have the capability of handling the current demand of the selected horn or buzzer. Any relay that can operate at 9 volts can be used and the transistor should have sufficient collector current (when saturated) to operate the relay coil.

Construction. The electronic circuits can be wired on perforated boards, using sockets for the IC's. No particular arrangement is required. The circuits can be grouped on boards as shown in the schematics, but separate boards will be required for each relay system (Fig. 6). (Only one colon circuit is needed.) In the prototype, most of the circuits, including two sets of segment lamp drivers, were assembled in one aluminum box (12" × 17" × 3") with the other two segment driver circuits in a smaller box (8" × 12" × 3"). Other, possibly smaller arrangements could be used; but if overall size is not important, the extra room facilitates wiring and maintenance.

Since the logic circuits operate at low frequencies, special layouts are not necessary. However, since there are current spikes flowing in the 5-volt and ground leads, it is a good idea to insert bypass capacitors (0.1 μF) between each 5-volt line and ground. Decoupling all counter IC's is also a good idea.

The control box can be connected to the electronic circuits through a length of multiconductor cable, or the control box can be mounted on the larger package.

The display board can be constructed to fit your needs. The prototype was 48" long and 14" high. A wooden frame was constructed. The front face was made of translucent white plastic (available from most building supply stores) the same size as the frame. The face was prepared by masking out the four digits (seven segments each) and the colon on the back of the face. The back was then sprayed with flat black paint so that only digits and colon remained translucent.

Pegboard was used to mount the lights and provide ventilation. After cutting the board to size, it was painted glossy white (or silver) to add brightness to the lamps. A 7½-watt lamp socket was mounted at the center of each segment and wired as shown in Fig. 6. Pressboard or sheet aluminum was then used to separate the lamps for each segment so that the light did not spill over. Black masking tape can also be used to avoid light spill.

The front face can be secured to the frame in any way that will provide a good overall appearance. Keep in mind that the front may have to be removed to replace lamps. A light shade can be added over the top of the front to make the digits more visible in bright ambient light. It has been found that yellow lamps in the display provide better definition. However, avoid lamps rated at more than 7½ watts, or the reed relays may be damaged. If brighter lamps are needed, an extra driving stage (with SCR's or triacs) will be necessary.

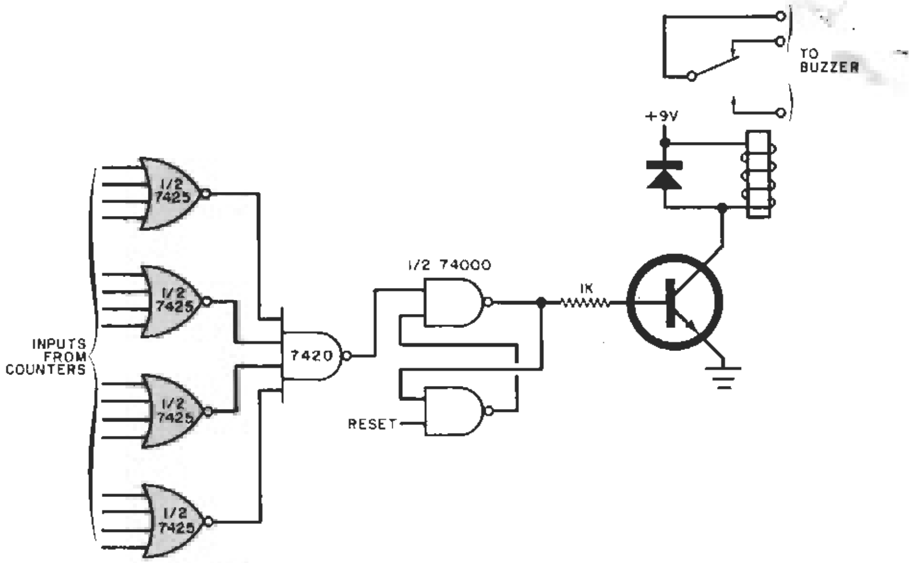


Fig. 7. This optional circuit can take the outputs from the counters and connect power to sound a horn accessory when the time is 00:00.

Operation. The controls are as follows:

THUMBWHEEL SWITCH: Used to set in the time and score.

LAMP TEST: Lights all segments of all digits for testing.

LOAD: Timer is forced to time set by thumbwheel switches.

TIME/SCORE: In the TIME position, the display indicates the preset time and the colon is lit. In SCORE, the colon is dark and the display indicates the score preset on the thumbwheel switches.

DOWN: Makes the timer count down from preset time. If switch is not closed, time counts up from preset time.

RESET: Returns timer to all zeroes.

RUN: Starts timer. When opened, the timer stops. (This switch is useful for time-out periods.) ◈

price, such as the $15 for the MN3001. For OEM needs, contact Matsushita (Panasonic), One Panasonic Way, Secaucus, NJ 07094.

TIME AND SCORE

I would like to pass on to my fellow hobbyists the following corrections for "Build a Giant-Size Digital Timer-Scoreboard For Athletic Events" (August 1975): connect pin 6 (not pin 5) of *IC7* to pin 10 of *IC10*; connect pin 4 (not pin 2) of *IC8* to ground; reverse the pins 4 and 5 connections of *IC12*; connect pin 7 to ground and pin 14 to V_{cc} to get power to *IC12* through *IC22* and *IC24* if you're using 14-pin DIP's (for 16-pin DIP's, pins 8 and 16 go to ground and V_{cc}, respectively); connect pin 4 to V_{cc} and pin 11 to ground to get power to *IC23*.—*Phillip Partin, Homestead, FL*

Large Digital Scoreboard

Do your achievements go unnoticed? Build this big, bright display board and make sure that everyone knows the score.

By Ken Wood

THIS SCOREBOARD has been designed for use in a gymnasium or other large area and uses regular light bulbs to provide a large, bright display easily visible from a distance. The scores or other numerical information are normally entered from thumbwheel switches but the system could also be adapted to accept data from a microcomputer. The basic model has a four digit display which could be used to show a two-digit score for each of two teams, but the number of digits can easily be increased to suit other applications.

The Circuit

The heart of this project is a digit driver module. This uses a 7447A, BCD to seven segment decoder, to drive a digit composed of regular 15W decorator light bulbs via seven triacs. The BCD information in fed serially through a shift register, and used to drive the display.

One module is used per digit in the display, and they are chained together so that they form a long shift register of four bits per digit. The control logic is isolated from the 120V line by an opto-isolator module at the start of the chain, and only one o these is needed for the display.

Third module is a power supply. This provides two separate 5V supplies, one for the circuitry in the display drivers and theother for circuitry isolated from the 120V supply by the opto-isolator module. The supplies shown only offer up to 100mA, so for displays with lots of digits a different regulator may be needed.

Finally there is a controller module. This takes data from up to four thumbwheel switches and turns it into a serial stream to send to the display drivers. It also takes 120V zero crossing pulses from the power supply and uses them to time the serial transmission. This allows the display to be updated while the displays are off at the zero crossing point of the AC cycle.

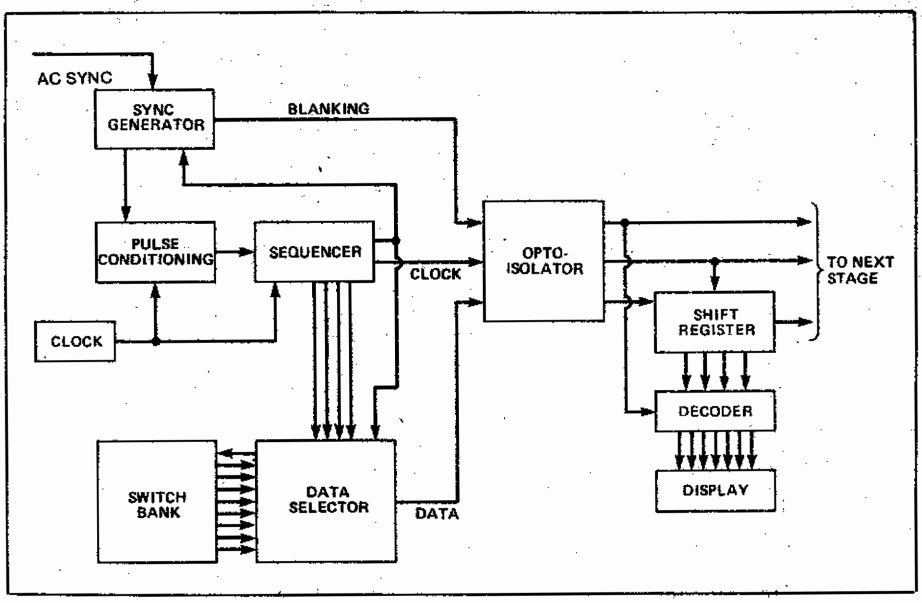


Fig. 1 Block diagram of the complete system.

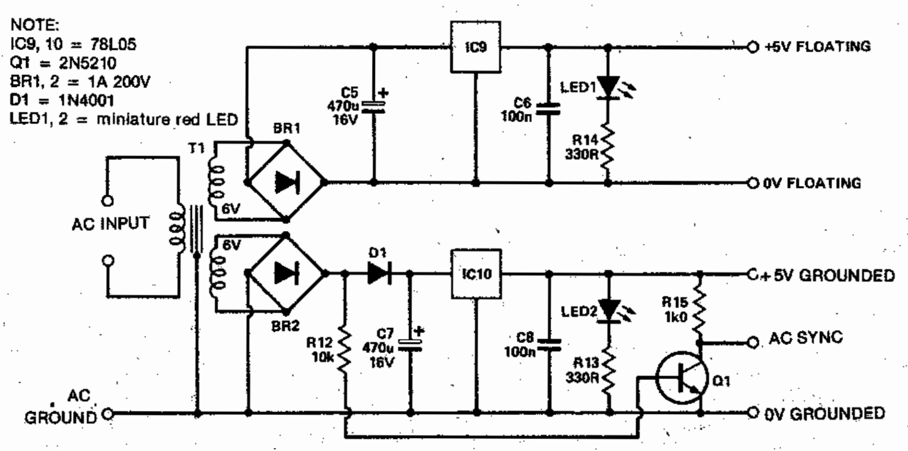


Fig. 2 Circuit diagram of the power supply. Note the use of separate grounded and floating +5v supplies. The controller operates from the grounded supply.

The power supply is in two sections, each of which has a bridge rectifier and a smoothing capacitor followed by a voltage regulator (ICs 9 and 10). C6 and C8 cut out any high frequency spikes and protect the regulators from oscillation. Each section is also fitted with an LED and current limiting resistor as a visual check of operation.

The section that supplies power to the control electronics has its 0V connected to ground as a safety precaution, and also provides AC sync pulses to the controller module. The bridge rectifier BR2 is isolated from the smoothing capacitor with a diode D1, so full wave rectified AC waveform appears at the junction between D1 and R12. This is fed to TR1, which is driven hard on for all but the brief interval when the waveform is at less than 0.7V, 100 times a second.

The AC sync pulses are not necessarily at the zero crossing point of the AC because of the phase shifts that can occur through the transformer. To overcome this, they are fed into a monostable IC1a which is trimmed so that its output is truly at the AC zero crossing point. This is fed into a second monostable whose output is gated with the controller blanking output to hold the triacs off for a period into the AC half cycle. This achieves the dimming function.

IC2a, 2b, and 3a produce a square wave clock at about 50KHz. It is also used to control the operation of the remainder of the module.

IC4a, 4b, and 6a produce a pulse lasting for exactly one clock period at each AC crossing. This is used to reset IC7, a four bit counter. The counter controls IC8, an eight input multiplexer, to sequence through the bit inputs from the thumbwheel switches. Output D from the counter selects one switch bank or the other via IC2d.

When the counter reaches 15 the carry output goes high and the counter is inhibited via IC2e. This means that after each AC zero crossing, the data bits from the thumbwheel switches appear in turn at the serial data output and via IC2f and 5c at the shift data output to the digit drivers.

The beginning and end of this sequence is detected by IC3b which produces an envelope signal while data is coming out of the controller. The signal is made available to an external controller via IC6, and also gates the shift data and shift clock outputs to the digit drivers. It is also fed into the blanking signal so that, even with a very short period set for the monostable IC1b, the triacs cannot come on while data is being transmitted.

The three control signals connected to the digit drivers are fed through an opto-isolator circuit to prevent any AC potentials from reaching the control circuits, thereby making the unit completely safe for connection to a home computer for example.

Each of the three channels is identical, so reference will be made to one channel only. An emitter-follower transistor Q2 drives the LED in the opto-isolator IC11. The opto-isolator transistor, biased by R19 to improve its high frequency response, is buffered by a Schmitt trigger (IC14a and R25), and a final output buffer IC14b drives the output.

IC15 is a four bit shift register, which converts the serial data to parallel at its outputs. The fourth output passes serial data on to the next driver module in the chain, thus with four digit drivers each gets its new data after sixteen clocks. The parallel BCD data is decoded by IC16 to form the segment drive to each of seven triacs.

The blanking signal drives Q5 which switches off the outputs of IC16, preventing the possibility of a digit being displayed while the shifting process goes on and allowing the display to be dimmed.

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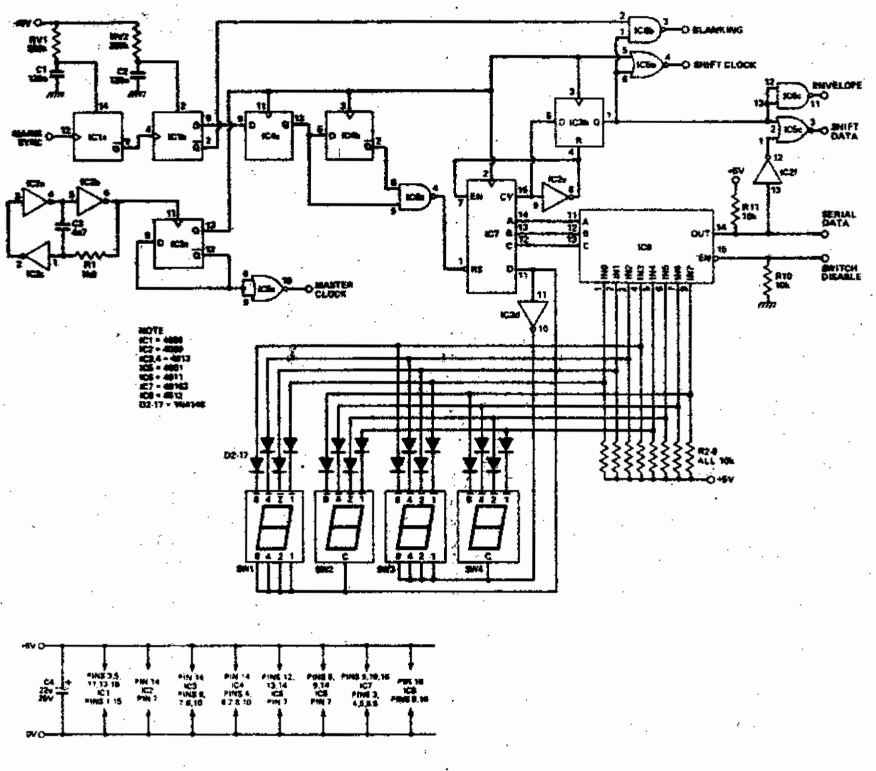


Fig. 3 Circuit details for the controller.

How it Works

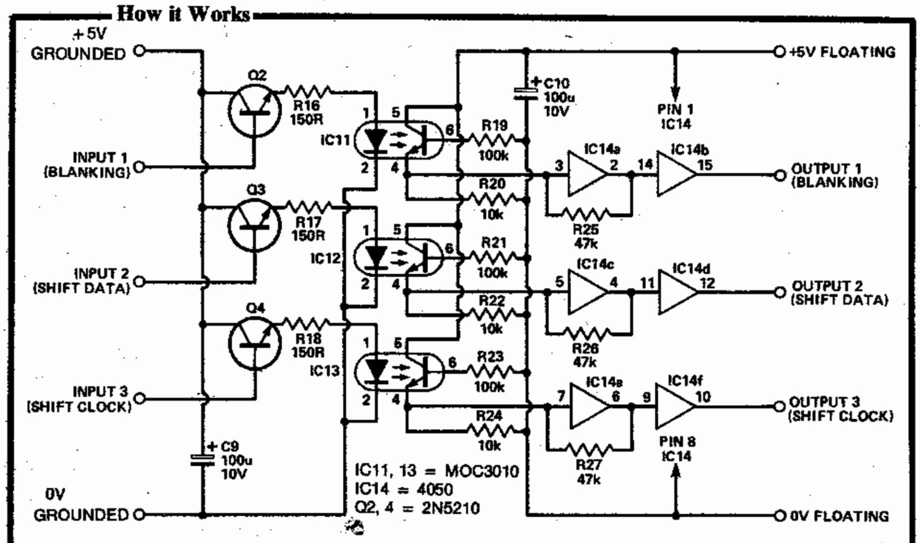
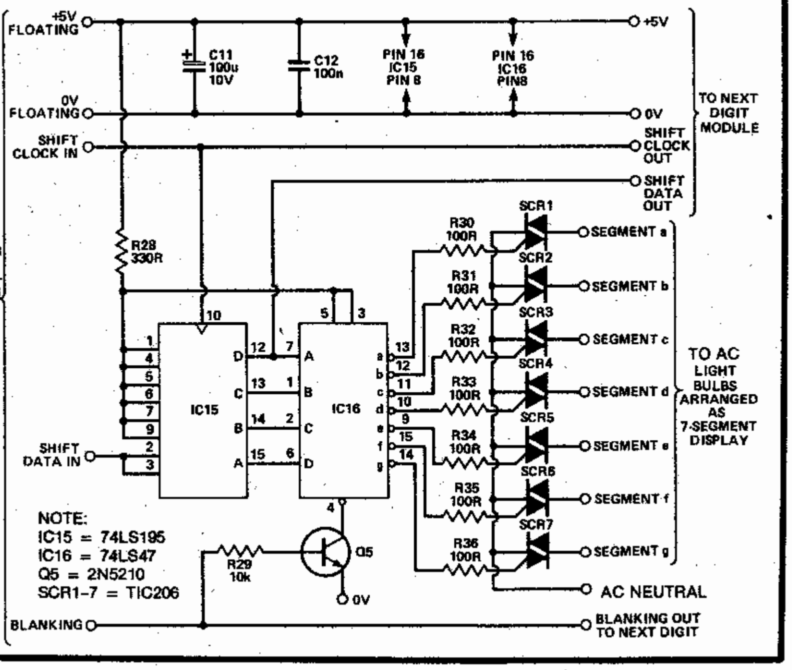


Fig. 4 Circuit of the optoisolator module.



The controller also provides connections so that the display can be driven by a special purpose external controller, or by a simple I/O port on a home computer. In the case of a display with more than four digits, this is probably the easiest way to enter data and the circuitry for the thumbwheel switches can be omitted.

Construction

The box should be built first, and this is probably the trickiest part. It's not possible to give exact details and dimensions because these will vary according to the size of the digits and the number required. Fig. 6 shows the arrangement used in the prototype and this should be a used only as a guide.

The circuit boards are all single sided except for the controller which is double sided. The leads of the components on the controller board are used to bridge between tracks on each side of the board; components should be soldered on the top side as well as the bottom. Unfortunately this rules out sockets for the ICs.

Printed circuit board pins are used for the flying lead connections to the power supply (except the 120V into the transformer), the isolator module, and the display drivers. In the case of the display drivers, no flying leads are used for the triac-to-lamp connections. The pins should be installed first, followed by the wire links, the resistors, capacitors, and the semiconductors. Be careful with the ICs, some are CMOS types. Leave the power supply, transformer, and triacs for the time being.

The triacs on the digit driver modules are mounted with a small heatsink sandwiched between them and the board. This is a length of aluminum strip, details are given in Fig. 9. The heatsink also provides the extra two mounting points for the board. Each triac is bolted to the board through the heatsink with a mica washer and bushing to insulate the tab. Silicone grease should be used between the tab and the aluminum to improve heat transfer.

Two of the pins on each triac are bent down to pass through the board, while the centre pin is bent up for a flying lead connection to the lamps. Only after the triac–heatsink assembly has been completed should the triacs be soldered to the board.

CASE AND CONTROL PANEL

D2-17	1N4148
FS1	panel-mounting fuse holder and 3A fuselink
LP1	panel-mounting mains neon
SK1	7-pin DIN socket or other multipole connector to choice
SW1-4	BCD ten position thumbwheel swtich with true and inverse outputs
SW5	DPST toggle or other mains on-off switch

15W light bulbs, lampholders as required; wood, brackets, etc, for enclosure; coloured filter for front of display; small aluminum panel for the controls and nuts and bolts to mount; cable ties or spiral wrap or similar, stand-off pillars, nuts and bolts for mounting PCB's; ribbon cable, writing etc. The thumbwheel switches are available from Electro Sonic, 1100 Gordon Baker Rd., Downsview, Ontario (416) 494-1555.

POWER SUPPLY

Resistors
(all ¼W 5%)

R12	10k
R13,14	330R
R15	1k

Capacitors

C5,7	470u 16V radial electrolytic
C6, 8	100n 5% polycarbonate

Semiconductors

IC9, 10	78L05
Q1	2N5210
D1	1N4001
BR1,2	1A, 200V (General Inst.)
LED1,2	miniature red LED

Miscellaneous

T1	6-0-6V, 500mA mains transformer, chassis mounting

PCB; 1mm terminal pins; ground tag; nuts and bolts for mounting transformer. The bridge rectifiers are available from Active Components.

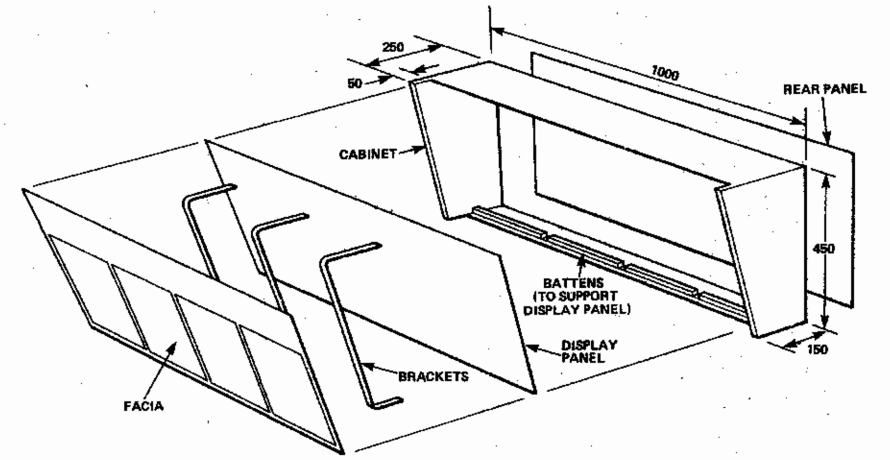


Fig. 6 Details of the cabinet used for the prototype.

The bulb sockets can be mounted on a wooden panel which is also used as the chassis for the PCBs. Mount the PCBs with standoff pillars and keep the inter-wiring neat by using spiral wrap around the cables. Make sure suitable cable is used for the AC supply to the lamps, between the lamps and triacs, and the returns from the digit driver boards.

The supply, return, and ground wires have been taken to a central supply point rather than chaining them from point to point. This includes the power supply module as well as each display. Remember that quite a bit of AC voltage and current is present throughout much of the wiring; wire it for safety.

The diodes associated with the thumbwheel switches are integral with the switches themselves, and the arrangement shown uses the inverse data outputs. If the switches used do not have inverse outputs, turn all the diodes around, swap the common connections for the two pairs of digits and alter the pull-up resistors on the controller module so that they pull down to 0V. If a display of less than four digits is required, simply omit switches and diodes starting with SW1, then SW2, etc.

Any convenient connector can be used for the outlet to the external controller. A seven pin DIN socket has been used in the prototype. The external controller can interrogate the thumbwheel switches by intercepting the serial data and control signals. It can inject data in place of the switch data by driving the switch disable input to a logic 1 (3.7V+), at which point the output of IC8 goes high impedance and can be driven externally.

If the switch inputs are never going to be used, the controller module may be dedicated to external control by omitting IC4,7, and 8, as well as R2 to R9. The copper track on the component side of the board leading to IC3 pin 1 should be cut (close to the IC only) and a wire link soldered between the pad of IC8 pin 15 and IC5 pin 2. This allows the external controller to generate the envelope signal. IC6 pins 5 and 6, and IC3 pins 4 and 5 must be wired to 0V to protect their CMOS inputs.

Setting Up and Use

Boot up the power supply with its outputs disconnected, if all is well, the LEDs should light to show that something is getting through. Check that both outputs are producing 5V.

Very little intermediate checking can be done on the rest of the circuitry so be careful while poking around the digit

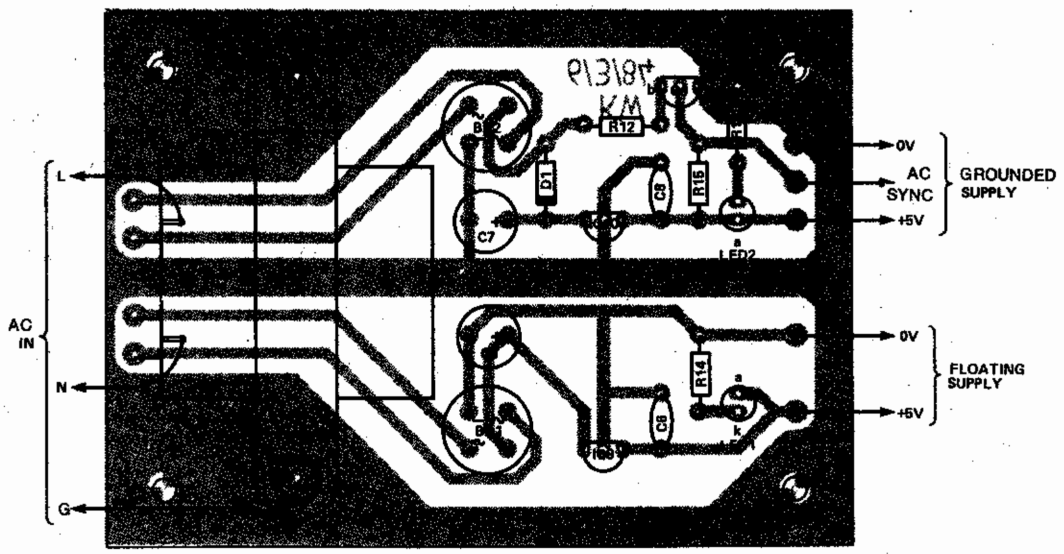


Fig. 7 Component overlay of the power supply board. Note the ground connection to the frame of the transformer and the AC connections taken directly to the transformer, not to the PCB.

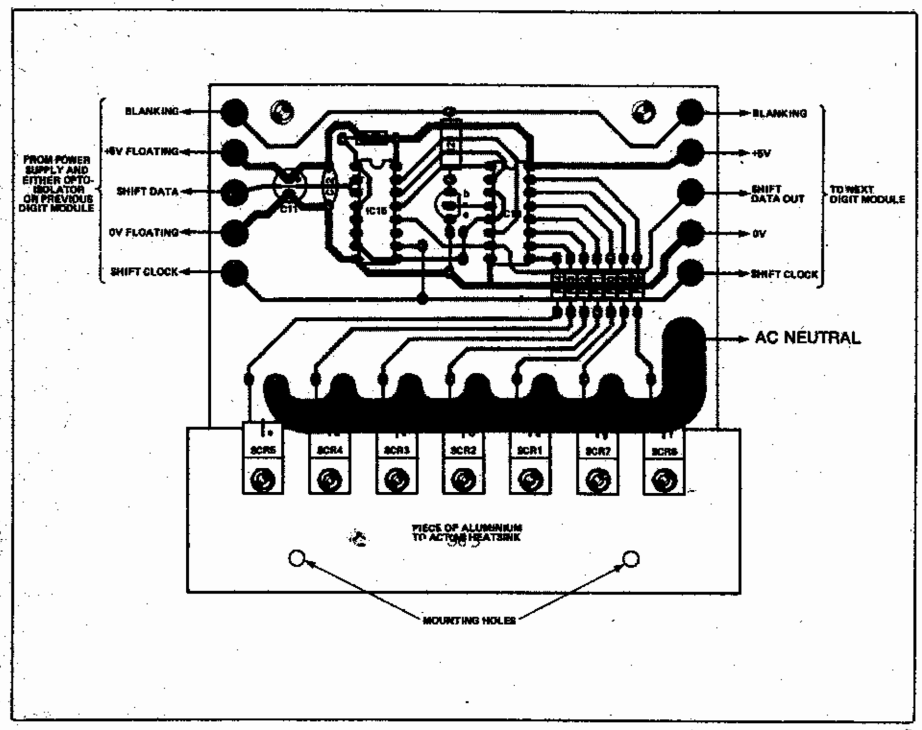


Fig. 8 Component overlay of a digit driver board. The lamp connections are made directly to the centre pins of the triacs.

DIGIT DRIVER MODULE

Resistors
(all ¼W 5%)

R28	330R
R29	10k
R30-36	100R

Capacitors

C11	100u 10V radial electrolytic
C12	100n polycarbonate

Semiconductors

Q5	2N5210
IC15	74LS195
IC16	74LS47
SCR1-7	TIC206

Miscellaneous
PCB; 1mm terminal pins; nuts and bolts, mica washers and insulating bushes for triacs; heatsink (see text); IC sockets if desired — 2 off 16 pin DIL.

driver areas as these are ripe with AC voltages.

Make the set-up adjustments with a single bulb plugged in somewhere, and arrange for the display to show all 8s. Set RV1 on the controller module fully anticlockwise and RV2 fully clockwise. Switch the unit on and the lamp should be at full brightness. Using an insulated screwdriver so that AC hum does not affect adjustments, slowly turn RV1 clockwise until the lamp suddenly goes dim, and stop there. Now turn RV2 anticlockwise and the lamp should increase in brightness. The lamp may now be set to the desired operating brightness.

If the display is to be run at full brightness, either because you need that much light or because you want to keep RF interference to a minimum, continue to turn RV2 anticlockwise until the lamp suddenly goes out then turn it back to the point where the lamp comes on again.

The display is now ready for use, so switch off and install all the lamps. Keep a few spare triacs on hand as well because when bulbs blow they tend to take the triac with them. Running the display at a reduced brightness should help a little.

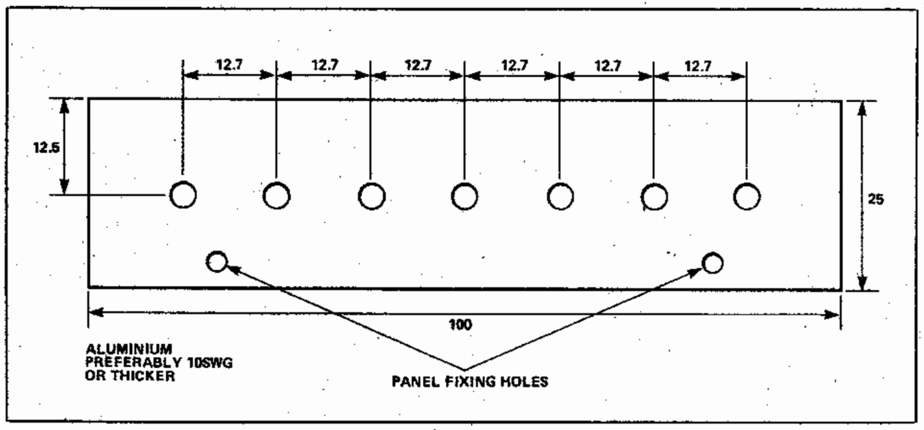


Fig. 9 Drilling details of the heatsink for the digit driver board.

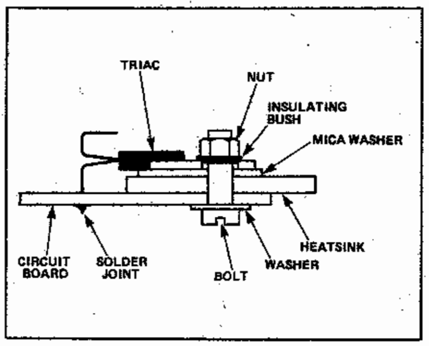


Fig. 10 Mounting arrangements for the triacs.

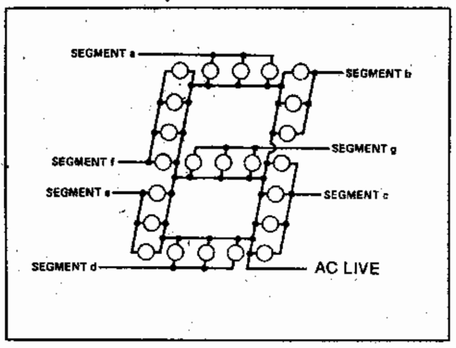


Fig. 11 How the lamps are connected to form a seven segment display.

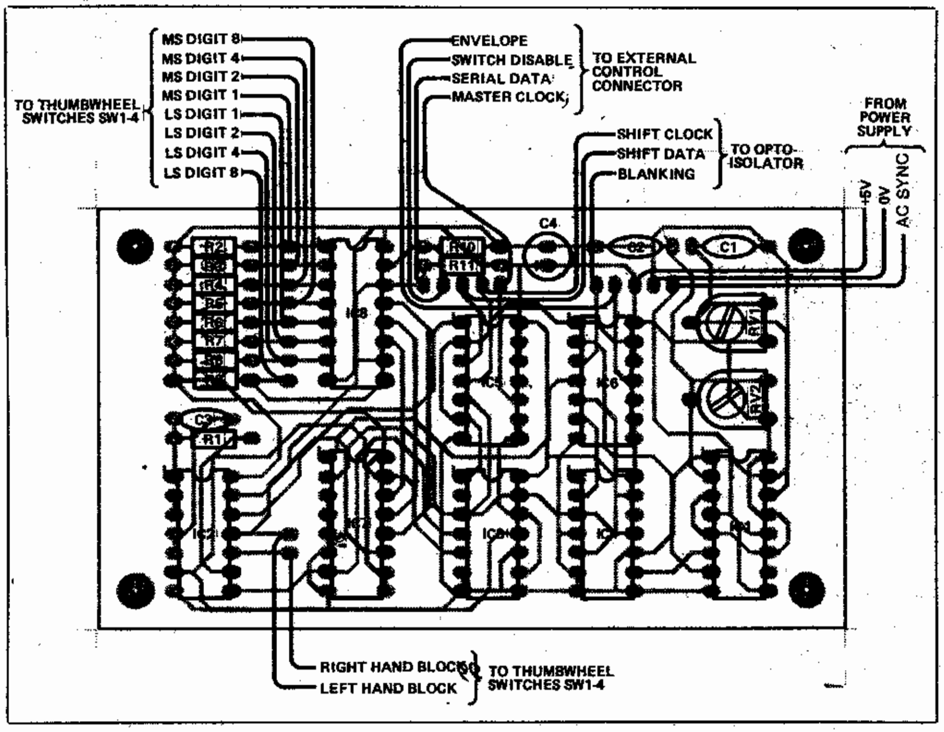


Fig. 12 Component overlay of the controller board.

CONTROLLER MODULE

Resistors
(all ¼W 5%)

R1	1k8
R2-11	10k
RV1,2	220k miniature horizontal preset

Capacitors

C1, 2	120n 5% polycarbonate
C3	4n7 5% polycarbonate
C4	22u 25V radial electrolytic

Semiconductors

IC1	4098
IC2	4069
IC3,4	4013
IC5	4001
IC6	4011
IC7	40163
IC8	4512

Miscellaneous
PCB

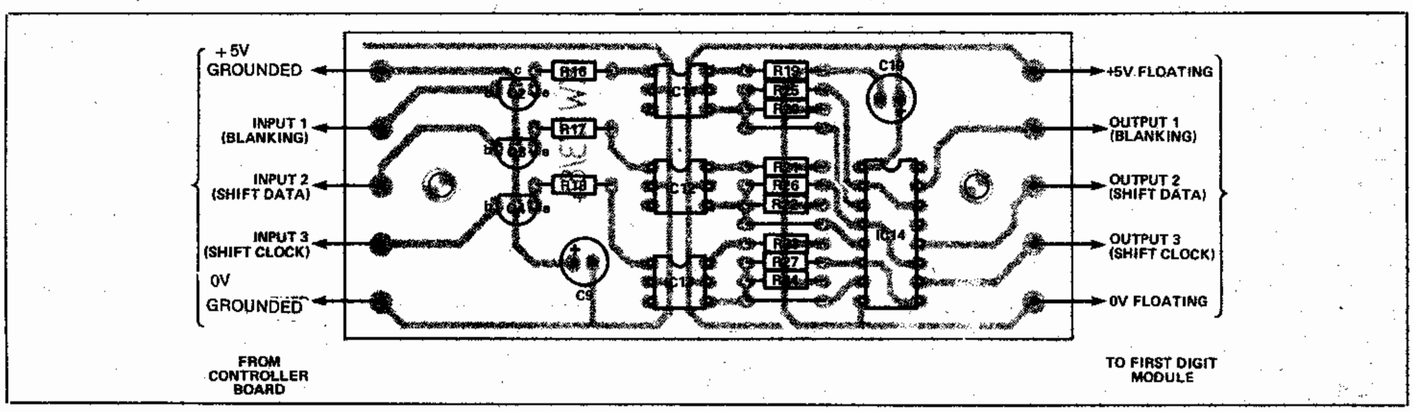


Fig. 13 Component overlay of the optoisolator board.

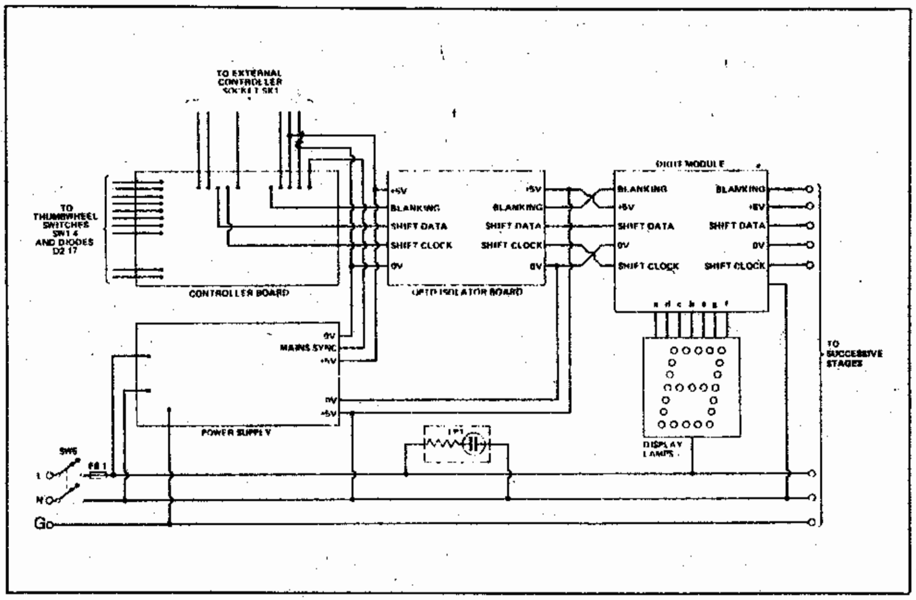


Fig. 14 Interconnection of the boards.

ISOLATOR MODULE

Resistors
(all ¼ W 5%)

R16-18	150R
R19,21,23	100k
R20,22,24	10k
R25-27	47k

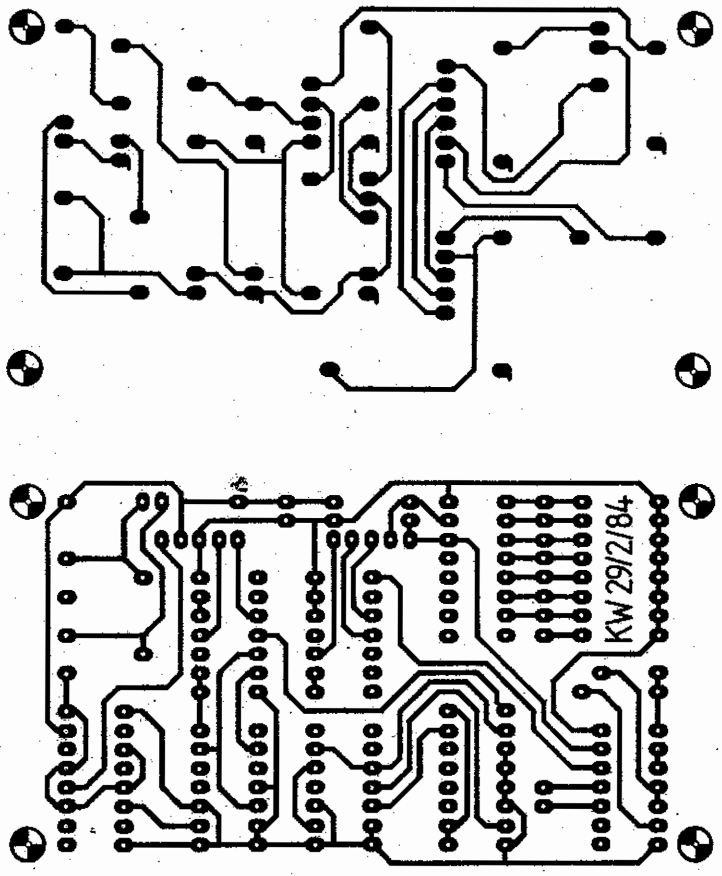
Capacitors

C9,10	100u 10V radial electrolytic

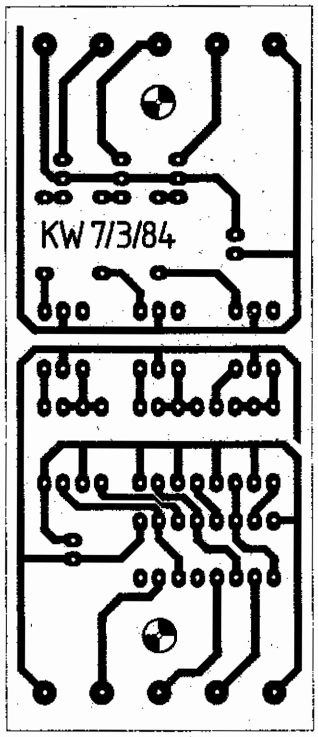
Semidconductors

Q2-4	2N5210
IC11-13	MOC3010 opto-isolator.
IC14	4050

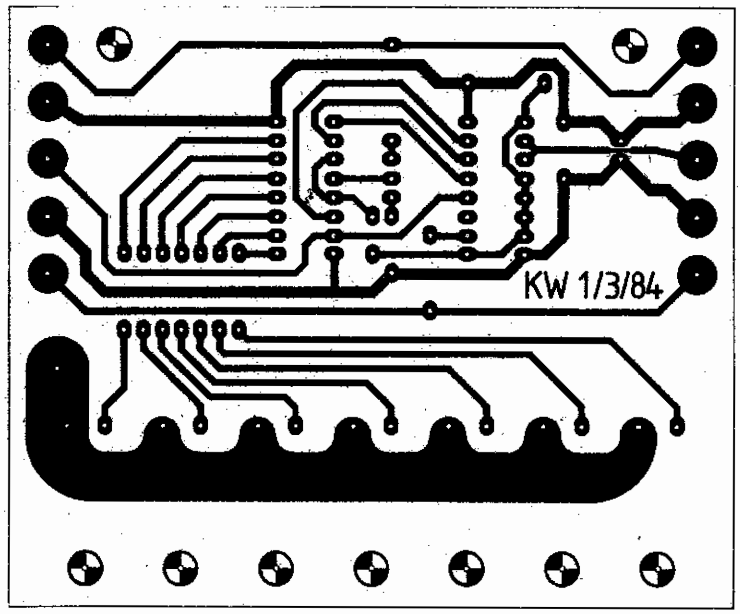
Miscellaneous
PCB; 1mm terminal pins; IC socket if desired — 1 off 16 pin DIL



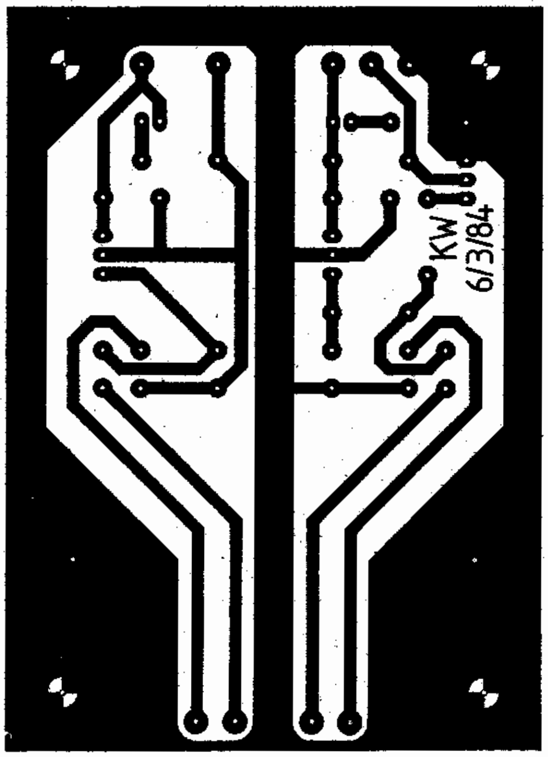
The top and bottom patterns for the scoreboard controller module.



The pattern for the scoreboard opto-isolator module.



The digit driver board pattern for the scoreboard



The power supply board pattern for the scoreboard. ■