SUPERCLOCK III

Premium quality digital clock time-zone conversions, and indivitualized

By DON LANCASTER

A WIDE RANGE OF ELECTRONIC DIGITAL clocks is available today. These run from $5 drugstore flip-flip-ltip novelties through $50 to $100 surplus TTL jobs up through manufacturer's prototype dligital timepieces costing many thousands of dollas. The vast majority of them are hard to build, difficult to set, lose their time on a momentary power dropout, and cannot be adapted to automatic pushbutton time zone conversion, 12-24-hour operation, or to making themselves self-resettling and always accurate by using National Bureau of Standards time code services.

Not so with the **Radio-Electronics** Superclock III. Here is an attractive, up-to-date digital clock that gives you any even-hour time zone in the world *instantly* at the press of a bulton. This plug-in modular unit uses only *eight* integrated circuits, for high noise immunity and easy assembly. It presents its time on low-voltage, highly attractive 28-dot Light Emitting Diode (LED) dis- plays. It accepts *either* time pulses *or* a time code, or both simultaneously. Thus, you can use virtually *any* source of timing information. By adding one of a number of suitable adapter plug-ins, you can sel up a *direct digital display* of *National Bureau of Standards* time, either as broadcast, or converted to your local 12-hour time or any other time zone in the world.

For instance, you can use two IC's to form a conventional "me-too" power-line divider just like anybody else. Or, you can go 10 a I-MHz crystal and *single* ic divider thai gives you one second per day quartz stability along with your choice of setting speeds, one pulse per second, or one pulse per minute out. If you want, this lets you run on battery power, or - by floating a banery across your power supply - you can eliminate any time dropouts and keep constant, accurate time during a power outage.

Beller still, you can build a time decoder for any of the widely available National Bureau of Standards timing signals, load these inlo the clock in parallel, and alway's have *exactly* the right time, hands off and unattended.

One possibility is to use an ordinary communications receiver and a simple decoder that extracts the lOO-Hz subcarrier time code broadcast by WWV. (We'll show you how in a future issue). Or, if you live in the western United States, you can build a WWVB 6O-kHz receiver and display the NBS 24-hour.a-day time code. Very shortly. you should be able to clip the Superclock III and a suitable decoder directly onto your TV set, and receive time signals broadcast by the networks. As soon as these signals are available on a permanent basis (tests have been going on for over a year), we'll show you how to use them for fully automatic, *always accurate* operation. Other somewhat more specialized time signals you can use include the Omega system, the NBS satellite system, and foreign equivalents to NBS broadcasts.

One good combination is a time base *and* a time decoder. This way, the Superclock runs as an ordinary clock till you send it a valid time code signal. If it has to, it then changes its time to match the code, and takes off from there. Thus, viewing ooe network television program or tuning in WWV once a day keeps you aocurate forever.

About the circuit

Fig. 1 shows the schematic and parts list of the Superclock III main clock module. This single PC board measures 4-1/4 x 6-1/4 inches. It holds 8 ic's, including the time zone computer-on-a-chip and a six-station time zone selector, along with the hours-minutes-seconds counters and displays. Forty pins wortb of plug.in connector allows you to input serial time, a parallel time code, or gel out signals for AM/PM, days counting. and expansion to more tban six time zones. Internal program jumpers on a clearly marked and well arranged "program bay" let you pick either 12 or 2400-hour operation of the basic clock. Power requirements are 5 volts at 700 rnA and -12 volts at 25 ma-the later needed only for time zone conversion.

We'll look into this module first. Then we'll look at details on a dual time-base/AM-PM module and finally some case, power supply, and setting details. In future issues, if enough readers are interested, we'll talk about the WWV receiver, the television time receiver, aod maybe some of the more specialized add-ons.

The seconds counter consists of conventional cascaded divide-by-ten and divide-by-six counters. The counter ic's selected have both parallel and serial entry. This means you can either count input pulses arriving at a 1 pps rate, or you can parallel load a time code word at the proper time for an exact update. *Reset* and *Load* lines are individually brought out. External connections to these must be short and low capacitance. Bringing the *Reset* line briefly to grouod sets the seconds to 00. Briefly grounding the *Load* input preloads a selected number into the counter. For instance, the WWVB code is "ready' 20 seconds after each minute with a typical decoder; you thus parallel-load the correct hours and minutes words into the hours and minutes counter and a "20" into the seconds counter, doing so twenty seconds after every minute, thus compensating for the necessary decoder processing time. WWV reception usually is ready "30" seconds after each minute, while the TV time code can be made ready either on the minute, every ten seconds. or every second, depending upon the decoder complexity. The outputs of the seconds and ten seconds counter go directly to the seconds readouts, which carry their own internal latch and decoder. The "40" seconds" digital output is brought off the board. Normally it is cascaded to the "minutes" input, except during set• ting times.

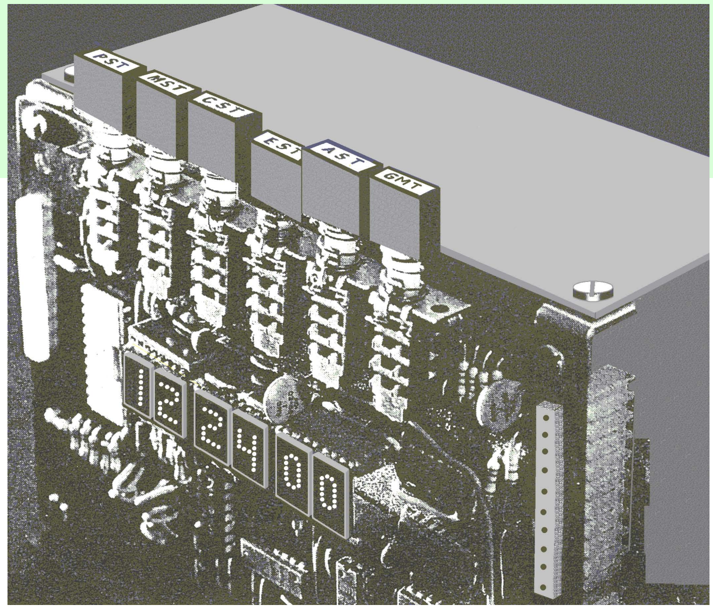
The readouts are *Hewlett Packard* 5082-7300's. Tbey are O.3 inch high and present an attractive 28-dot bright red character. Since they have their own in•ternal latching and decoding, Ihey greatly simplify the rest of the clock. Tbey are socket mounted.

The minutes counters are identical to the seconds counter. The minutes counter is normally driven from tbe seconds carry except during setting, so it has its own input pin brought off the board. This also lets you run without seconds for low cost. If you don't want seconds, you leave the seconds counters but not the readouts in place if you're using a line-operated time base. With the crystal time base, you can get the 1 ppm directly out of the time base and delete the seconds portion of the circuit entirely. Either way saves cost.

The minute counters drive their own readouts directly. *Reset* and *Load* inputs are brought out separately for

DIGITAL TIMEKEEPER

offers instant pubhbutton 12-24 hour capability, easy packaging.



decoders that provide a minute update at a time different than the hour update. If you are not using any time base, all the counters, hours, minutes, and seconds, serve simply as storage latches. While this is also obviously cheaper, it presents the right time only when a valid code is received by a decoder. In this mode, you have to be *continuously* receiving time signals for a valid display. With the time base, all you need is an occasional (once per day) valid update, with automatic fill-in being provided between update times.

The hours counter operates in two distinct modes, one for 12-hour operation and one for 2400-hour operation. Program jumpers decide which mode your clock will be in. For local time only, you can pick between 12 or 2400-hour, but if you want a GMT display or if you are using a WWV or WWVB receiver, the clock MUST be in the 2400-hour mode. The time zone chip will then convert to give you your local 12-hour time. The TV time system requires a 12-hour counting mode.

The hours counter consists of a divide-by-ten and a "0-1" or "0-1-2" counter. A three-input gate (IC7) decodes the required time to shorten the count sequence as needed in each mode. The time through the gate is long enough to insure that a self-annihilating coincidence or a partial reset cannot occur.

In the l2-hour mode, the "1" output and its parallel input are *inverted*. Now, the counter resets to state "1" instead of state "0", but otherwise still counts in the usual way as an ordinary decade counter does. The three-input gate detects state "10 and 2 and I", automatically shifting the counter from a 12:59 count to 1:00. In the 240O-hour mode, state "20 and 4" is decoded, but the inverters are nOf used, automatically going from 23:59 to 00:00 on the next minute.

Load (L) and *Reset (RST)* lines are brought out, and the "40 minute" output directly drives the "hours count" input. A "2" and a "10" output is also brought off the board-useful for AM-PM and day counting. This lets the day and the AM-PM change one minute past 11: 59, unlike the counter reset that takes place one minute past 12: 59. An external jumper between the gate and the hours reset must be provided.

In an ordinary 12-hour, serial input digital clock, the two counters "left over" in the ten second and ten minute slots may be used for the "10 hour" and "AM-PM" counters. This cannot be done if you need the parallel update capability and if you need a 20-hour counter. Thus, the apparently "extra" IC6 is definitely needed in the Superclock III to allow its performance extras.

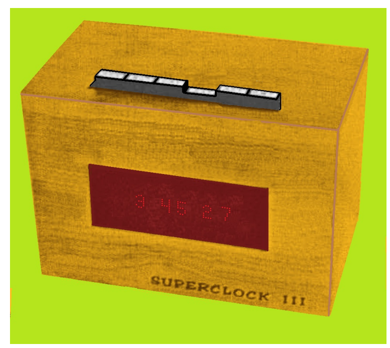
It is easy to convert from 12 to 2400 hours by cbanging the five program jumpers in the programming block.

Time zone conversion

The single IC computer-on-a-chip time-zone converter in the Superclock III converts any 12 or 2400-hour time zone in the world into itself or any *other* 12 hour time zone, except for those few countries whose time is out of line with the rest of the world by 15 or 30 minutes. An improved version of the basic time zone IC also keeps track of AM-PM anywhere in the world.

Six pushbuuons on top of your clock can give you any U.S. time or GMT. Instantly and without disturbing the input time code. Or, you can expand to 12 or 24 buttons and get world-wide operation.

The time zone chip does such nice things as converting WWV's 2400-hour Greenwich Mean Time into your local 12-hour time, or shifts the West Coast time broadcast by the television time code to your own local time. It also gives you instant daylight saving time corrections. Hams and SWL's will find the combination of 2400-hour GMT and l2-hour local time on the same clock display particularly usefuL



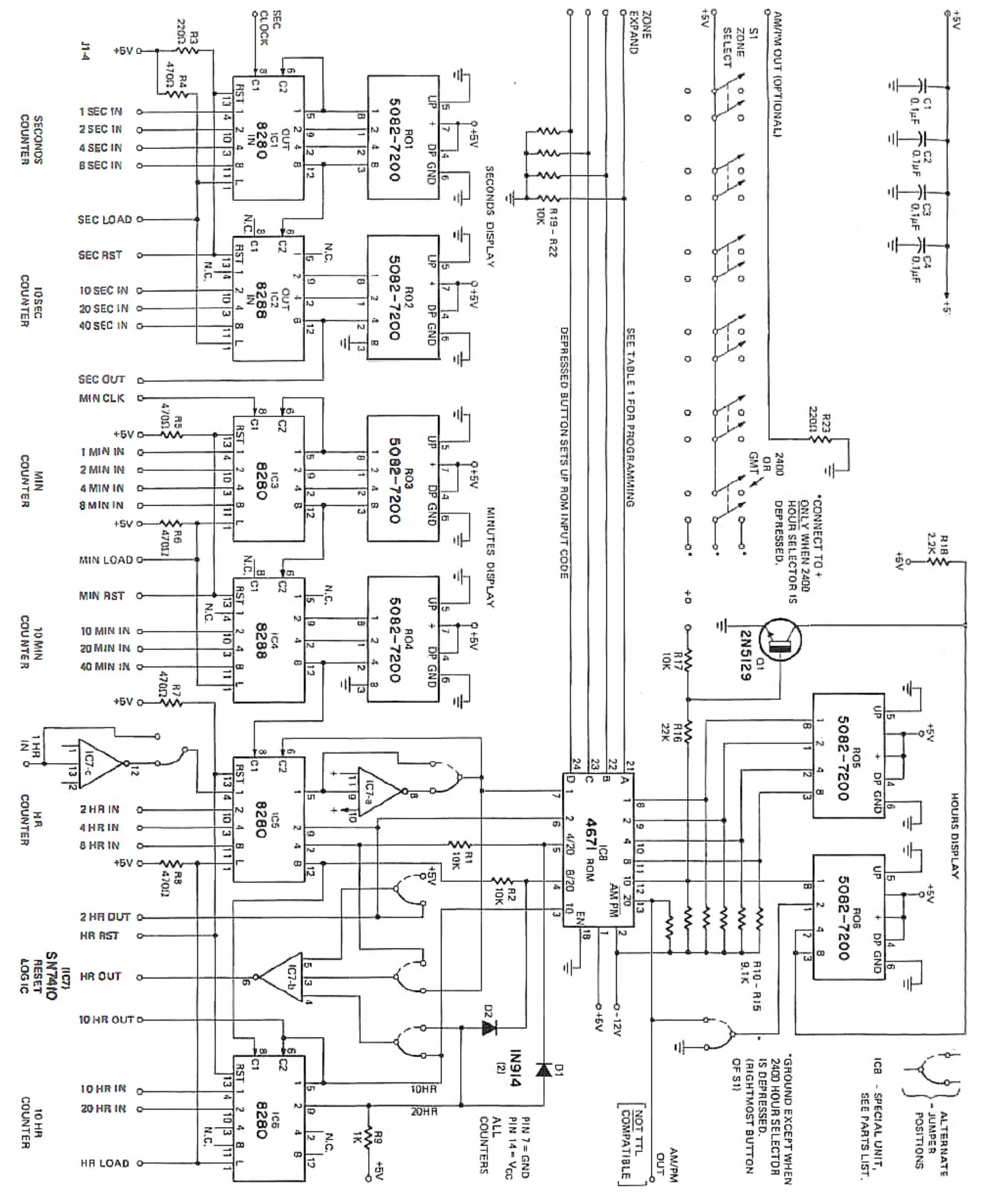
SUPERCLOCK UNDRESSED (top) to show interior. Circuit boards are joined through connectors. CABINET (above) is prototype. You'll want to design your own.

The cost of the Superclock varies with the options, but it generally runs less than double what you'd pay for a plain old *Nixie* surplus TTL job. This, of course, is only a tiny fraction of the cost of any other available system that gives you an always accurate, self resetting NBS time display. As far as we know, this is the *only* system now avail- able with instant single-ic time zone pushbuuon conversion. Circuit boards, complete kits, time zone kits, cases, and all individual parts are available from at least one source as shown in the parts list.

The time zone conversion is handled with a MOS (Read-Only-Memory) computer-on-a-chip that automatically adds or subtracts the correct number of hours as needed. The chip has five time inputs, called "1", "2", "4 or 20",k "8" or "20" and "10". These are connected to their respective tennivals on the hours counter. An OR circuit formed of a resistor and a diode is used on both the "4 or

20" and "8 or 20" inputs. This still handles all the valid time codes, but nicely cuts the cost of the computer-on-a-chip in half by saving an input. Since this is a MOS computer chip, there is no loading on the OR circuit.

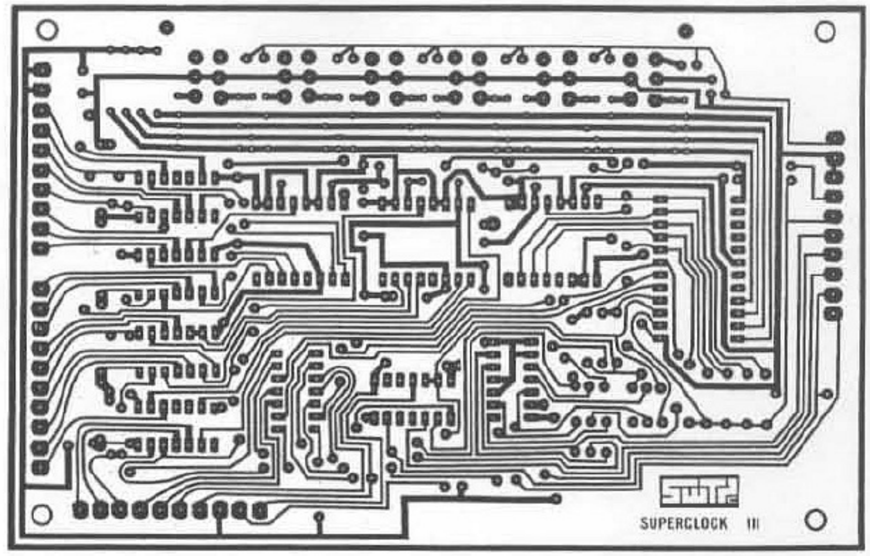
There are also four "code select" inputs that pick the output code or time zone shift you want. You route these to a pushbuttoon assembly that either connects the four lines to +5V or to ground through a 10,000 Ohm resistor. Ground is called a "0"; + 5 is called a "1". The code combinations will be explained in detail next month. Here, briefly are a few examples. A 0000 input *passes on* the input time to the output, and you get the *same* 12 or 24-hour output that you sent in. 000l *subtracts* one hour and gives you a *twelve*-hour output that is an hour *behind* the 12 or 2400-hour input you sent it. Thus a "9 o'clock" input or a "2100" input both show up as an output "9 o'clock" output. Note that



you can also think of this as *adding* 11 bours. Thus the same code position handles a -1 or +11 bour shift. 0010 subtracts two hours or adds ten; 0011 subtracts three hours or adds nine; and so on, up to 1011 which subtracts 11 bours or adds 1 The codes "12" through "15" (1100, 1101, 1110, and 1111) are not valid inputs to the computer and should not be used.

The lC8 chip has six outputs. "1", "2", "4", "8", "0". and "20" or "AM-PM". Each output then goes to its respective terminal on the hours or ten hours readout. Each output should drive the readout or one TIL standard load or one one transistor. It cannot simultaneously drive both the readout and another TIL input. To use the chip, you simply punch the code you want on the select lines: it then should automatically convert the input time to the output time, and automatically take care of addition, subtraction, carrying, borrowing, going from 12 to 1, subtracting 12 from high 2400 inputs etc. The chip might also be used on any digital clock that has a Binary Codcd Decimal (BCD) hours time code and any TTL or MOS compatible outputs. Thus, if you already have an ordinary digital clock, you can easily add only the time zone feature of the Superclock III if you want to.

The "20 or AM-PM" output serves two purposes. It is available only on



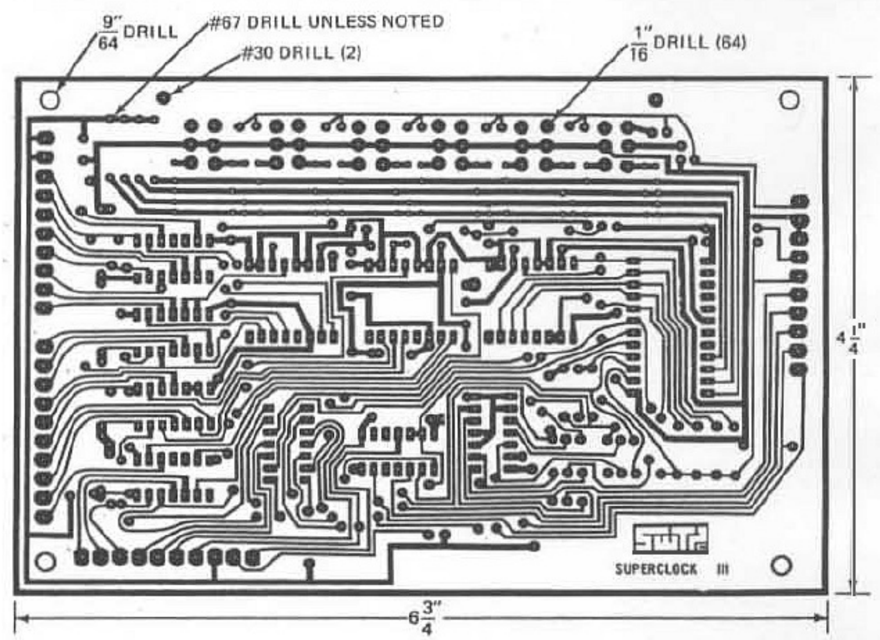


FIG. 1 (left)-THE MAIN CLOCK MODULE, schematic of the PC board. All program jumpers are shown in the 12 hour position.

FIG. 2 (above)-THE PRINTED CIRCUIT BOARD is made from 1/16-inch G-10 PC Glass epoxy.

FIG. 3-DRILLING GUIDE indicates four sizes of holes needed on the PC board. Use dimensions when photographing foil pattern.

(MAIN CLOCK BOARD)

R1. R2, R17, R19. R20, R21, R22—10,000 ohms
R3. R23—220 ohms
R4 to R8—470 ohms
R9—1000 ohms
R10 to R15—9,100 ohms
R16—22,000 ohms
R18—2,200 ohms
All resistors ¼-watt carbon.
C1 to C4—0.
D1.D2—1N914 or similar silicon diode
IC1, IC3, IC5, IC6—8260 TTL parallel load decimal counter (Signetics)
IC2.IC4—8288 TTL parallel load base 12 counter (Signetics)
IC7 5N7410 TTL Triple 3-input gate
IC8—Time zone read-only memory (ROM) Southwest No. 4671
J1 to J4—10-pin connector, modified Molex 09-57-1105
Q1—2N5129 transistor
RO1-6—LED readout with internal latch and decoder driver, Hawlett Packard 5082-7300
S1—Six-station pushbutton selector assembly
MISC:—No. 24 solid wire for jumpers; programming diodes. 1N914 (4); 6¾ x 4¼ x 1/16-inch printed circuit board; sockets or socket strips for readouts (6 sets of eight contacts each); mounting hardware for 53; solder. Sleeving for No. 24 jumpers

NOTE: The following parts are available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas 78216:

Front board No. CLM-b, $8.75.

Complete front board with all parts including read-only-memory (ROM) and readouts. No. CLM-2, $110.00.

Rear board for crystal time base etc. No. CLR-b, $4.75.

Rear board with crystal, IC's, etc. No. CLR-2, $22.75.

Power supply kit complete, No. CI.S-2, $12.50.

We have not provided a case for the clock because we have found that with projects of this type, the builder prefers to express his ingenuity by designing his own case or by building the device into existing equipment.

PARTS LISTS
SUPPORT MODULE

(A) Crystal Timebase:
R1—5.1-megohm, ¼-watt carbon
C1—20 pF mica
C2—4-40 pF trimmer
C3, C4—0.1 μF, 10-volt disc ceramic
IC1—MK5009 Timebase Divider (MOSTEK), a special design by and build for Don Lancaster for this project.
Xtal1—1.0 MHz xtal, parallel resonant into 32-PF load

(B) Line Timebase
R1—4,700-ohm, ¼-watt carbon
R2—1,000-ohm, ¼-watt carbon
R3, R4—2,200-ohm, ¼-watt carbon
C1—220 μF, 6-volt electrolytic
C2—0.1 μF,
C3—10 μF, 10-volt electrolytic
C4—1,000-pF disc ceramic
D1—1N914 silicon diode
IC1—8288 Base 12 counter (Signetics)
IC2—8280 Base 10 counter (Signetics)
Q1—2N5129

(C) AM/PM Circuitry
R1—10,000-ohm, ¼-watt carbon
R2—2,200-ohm, ¼-watt carbon
R3, R4—330-ohm, ¼-watt carbon
C1—0.1 μF, 10-volt disc ceramic
IC1—SN7474 Dual D flip-flop, TTL
IC2—SN7486 Quad EXCLUSIVE-OR TTL
L1, L2—Red LED panel lamp, Monsanto MV 5023 or equal
Q1—2N5129 transistor

(D) Setting Circuitry and Connectors
501,4—10-pin female connectors. Molex 09-52-3103
C1—1 μF, 10-volt electrolytic
S1—spst slide switch
S2, S3—spdt pushbutton
——Misc. mounting hardware
——Red Plexiglas front filter

later time zone chips; this was a feature added to the basic chip. For code 0000, the output drives the "20" on the readout. For any other code, the output is a "1" if the AM-PM in the selected zone is *different* from the input zone, and the output is a "0" if the AM-PM in the selected zone is the same. This "same-different" output can be used with an external EXCLUSIVE OR gate to change your AM-PM lights or leave them the same as the input code, giving you automatic AM-PM conversion anywhere in the world.

The "20" input to the display may be grounded instead of connected to the time zone chip If you never use the 2400 hour output. Otherwise, you have to rig up switching that automatically connects the "20" input on the display readout to the time zone on code 0000 and to ground on all other codes. As is easily done with the time zone selector switch. The AM-PM output is always right, even on 0000 for a 12-bour clock, but it should be switched out with a 2400.hour input on tbe 0000 code selection.

The readouts used do not have internal zero blanking. Transistor Q1 is used to erase the leading zero in the display for the 12-hour modes. It does so by jumping the input code into a disallowed state ("12" or "14") if a "1" is not present on the input, thus blanking the display. Q1 must be disabled on the 0000 program if you are using the 2400 hour mode of the clock, or if you simply like the zero in front.

A six-station pushbutton selector sets up the time zone code, as well as an "add-subtract" signa] used in the external AM-PM circuity. If the zone select code needs only 0, 1, or 2 ones in its code, you can wire these directly to the needed separate switch terminals. If you need more than two connections per switch you have to add diodes, pointing from +5 to the select lines, to eliminate any "sneak paths" that short out the code. Your Zone Expand outputs may be used with twelve or 24 buttons to get any time zone in the world instead of just six.

Construction

A prinled circuit board is essential for this project. You can get one commercially, or you can etch and drill your own, using the full-size guide of Fig. 2 and the component location guide of Fig. 3. Debug the circuit as you build it, rather than assembling everything at once. Thus, you'll probably want to build up the power supply and a source of TIL 1 pps pulses before you begin. Or you can build the time base module described later in this article. Either way, be sure you have a good power supply and a valid source of input signals before you begin assembly.

Start with the resistors and bypass capacitors. Use all the excess leads for the numerous jumpers which mount exactly as shown on the component or bare side of the board. Decide whether you want 12 or 2400 hour operation and then add the five program jumpers as shown on the marked PC board. Jumpers go to the left for 12-hour and to the right for 2400-hour operation. The ten pin connectors may nexi be trimmed and soldered in place. Note that they project from the foil side. This is followed up by the readout sockets. Note that some types of socket are offset sligbLly. Unless they all "point" the same way, you will end up with either a crooked readout or a non-uniform and too-c1ose-together spacing of one readout group.

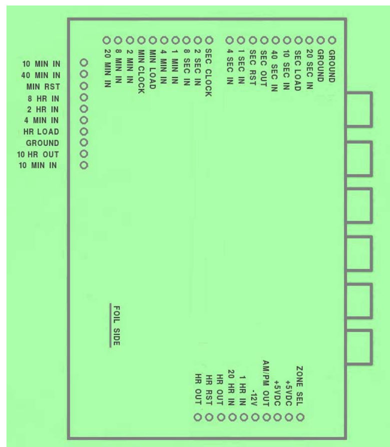


FIG. 4-CONNECTIONS on clock board mate with corresponding terminals on the board with the support circuitry.

Apply power and monitor the current. It should be zero or very low. Now remove the power and insert ICl. Reapply power and measure the voltage progressively on pins 5,9,2, and 12, while applying a 1 pps signal to the "SEC CLOCK" input. You should get a progressive division 2,4,8, and 10, indicating that the counter is working, with the outputs changing in BCD fashion every one, two, four, eight or ten seconds. If all is well, remove the power, insert the readot (numeral "up" chip "down") in your seconds slot, and slowly bring up your supply voltage, noting the current. It should be around 100 ma. The readout should count seconds. At this point it is a good idea to check the other five readouts carefully for identical operation. Be very careful to keep the readouts right side up.

After this, you can add the ten seconds counter and readout, followed by the minutes and ten minutes counters and readouts, one at a time, and picking up only 100 ma extra per stage. Note that the MINUTE CLOCK input must get *externally* connected to either your SECONDS OUT terminal or to your pulse source.

If all is well, you can add IC5,6, and 7, and jumper the "HR OUT" and "HR RESET" teminals externally. View the outputs with a high-speed clock to see that they are counting properly. Some *temporary* jumpers may be added from the time zone inputs to the time zone outputs to get the readouts to operate. You also have to temporarily short OR circuit resistors R1 and R2 and ground the collector (or short collector to emitter) on Q1. The hours counter should now work and current should be around 700 rnA. You might like to check the operation of both the 12- and 2400-hour use modes by changing the jumpers back and forth.

The blanking short may now be removed and Q1 added. This should erase the leading zero on the display. After this, remove all the temprary jumpers and add diodes DI and D2, along with the selector switch. Arrange the switch and diodes to get the desired time code. (full details next month). Be sure to use diodes every time you have to use one switch contact for two purposes. Now check the -12 volt supply to see that it is the right vo1tage and properly applied to the PC board.

The time zone ROM chip is a reasonably rugged device. but exceptionally careless handling can damage it. It should be left in its protective carrier until ready for insertion. Then solder it in place rapidly with a small soldering *iron*. Be exceptionally careful to observe the code dot and notch. **Reverse polarity will damage this chip permanently!**

Once you are certain all is well, punch the 0000 code button (or leave all the buttons up) and apply power. Your circuit should behave as if the chip wasn't there, with the input time being direcLly displayed. Now check out the various buttons to verify that the chip is operating correctly.

This should complete the assembly and debugging of the main clock board. An AM-PM light emltting diode may be added to the holes shown in the upper left comer of the board.

Next month, we conclude with more construction details, describe options and show how to set up the push buttons for the time zones. **R-E**

SUPERCLOCK III NEW DIGITAL TIMEPIECE

(PART II)

LAST MONTH WE PRESENTED THE MAJOR portions of Superclock. This issue we conclude tbe siory. You'll find a com- plete schematic for the power supply, time set controls, two kinds of time base circuits, an AM-PM circuit. Circuit- board patterns for Ihe time zone change board and several additional photo- graphic views of portions of the clock. You should now be able to complete the assembly of your unit.

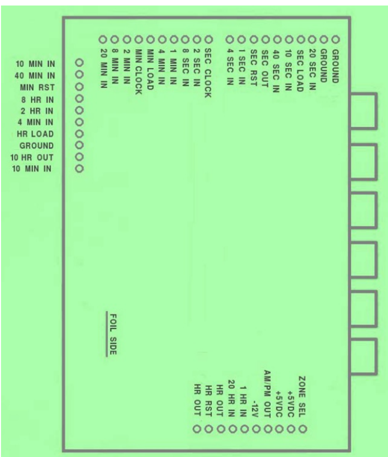
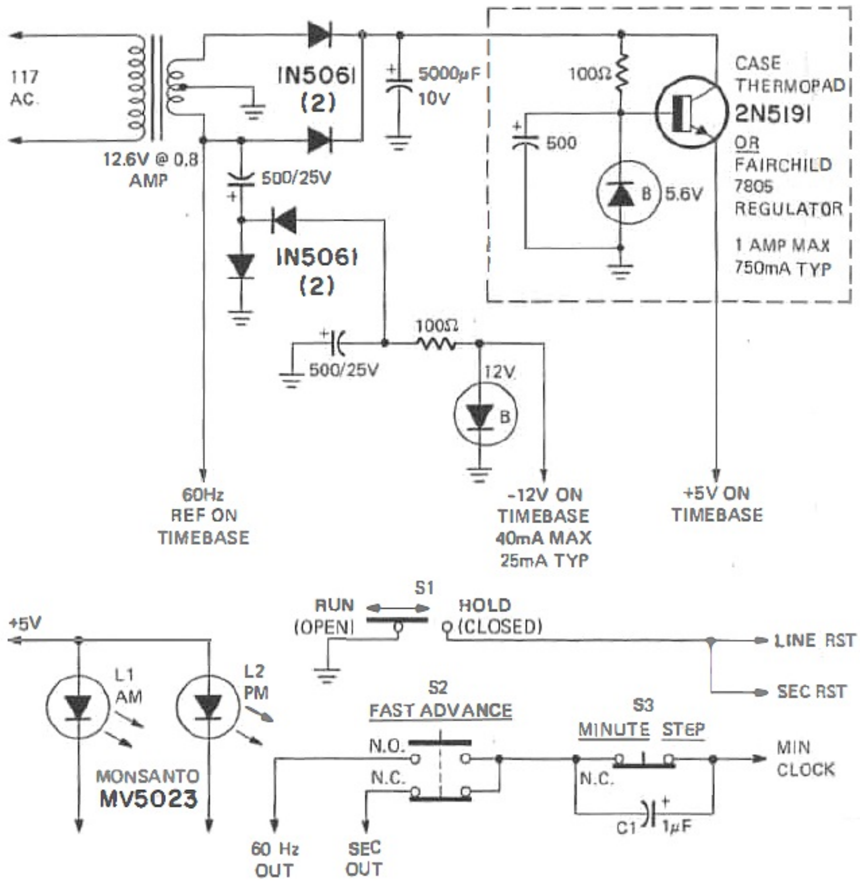


FIG. 4-(above) CONNECTIONS on clock board made wlth corresponding terminals on the board with the support circuitry.

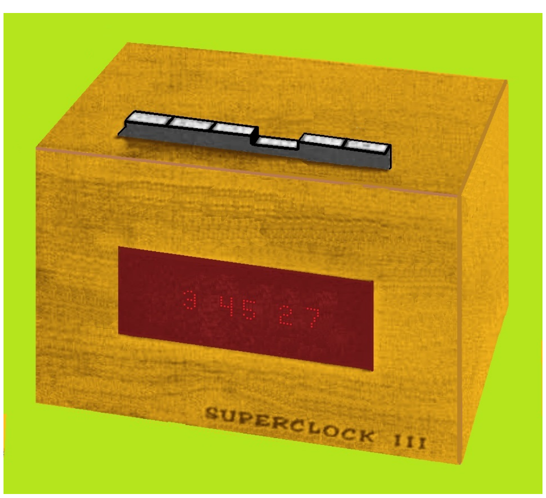
FIG. 5-(rlght) POWER SUPPLY schemal1c and details of time set circuitry. Close-up photos of the power supply are shown at the bottom of pages 60 and 61.

Fig. 4 shows the external con- nections to the main cloclr: board, viewed from the *foil side* or the rear. If you design your own time base or de- coder board, note that the connectors are offset slightly between their pins and their holes, and be sure to allow for this on the PC layout.

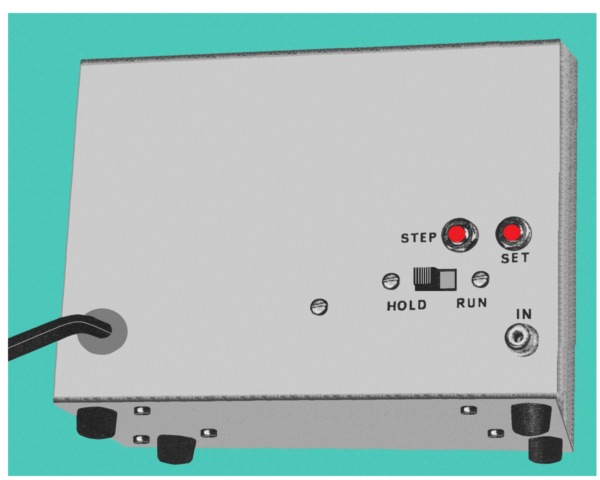
A conventional time base (line op- erated), a crystal time base using a



FINISHED SUPERCLOCK in one case configuration. It will be interesting to learn what case styles readers use



REAR VIEW OF SUPERCLOCK CHASSIS. Note position of Stop, Set, Hold-Run switches and BCD input.



Final details of the Superclock construction. Power supply, timebase generators, and optional AM-PM circuit are described. Photos of the power supply are included.

BY DON LANCASTER

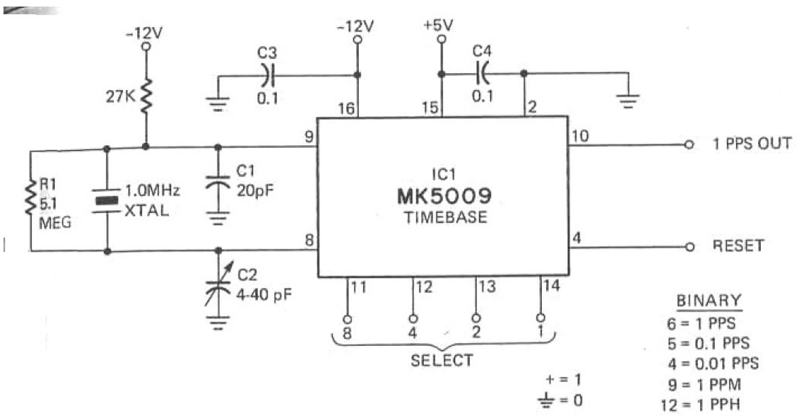
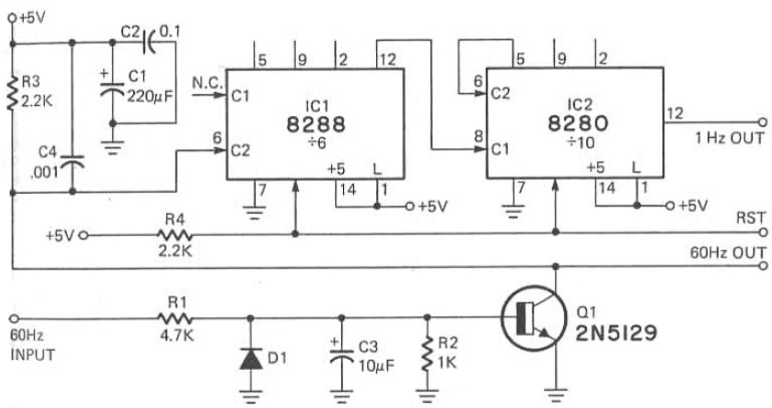


FIG. 6-(above) CRYSTAL CONTROLLED timebase circuit is actually easier to build than the line frequency timebase circuit shown in FIG7 (below). However, the timebase IC used in the crystal circuit is relatively expensive.



single IC and automatic AM-PM display circuitry, is shown in Fig. 6 and Fig. 7. The parts list is on page 62. If you are doing your own PC board. free drawings are available as decribed on page 62.

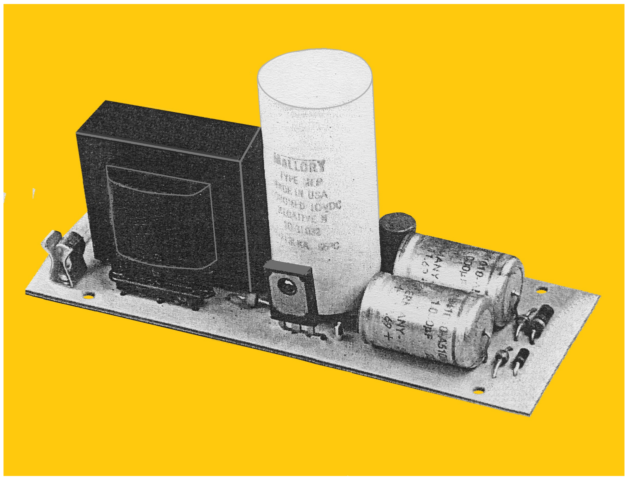
Fig. 5 shows the power supply and the setting circuitry. Keep the leads short on the setting switches and pushbuttons.

The setting circuit consists of a slide switch and two pushbuttons. You arrange things so the slide switch resets the divider chain on the time source and the seconds counter. and so that one pushbutton routes 60 Hz into the *minutes* counter and the remaining one steps the minutes counter. Thus, to set the clock, you switch the seconds to "hold" and a 00 display. Now, run the fast setting button till you have the AM-PM right and are a dozen minutes shy of the right time. Finally hit the minutes step pushbutton often enough to get the right time. Then release the count-hold switch. This scheme is much faster, easier. and more foolproof than the majority of circuits used on most conventional digital clocks .

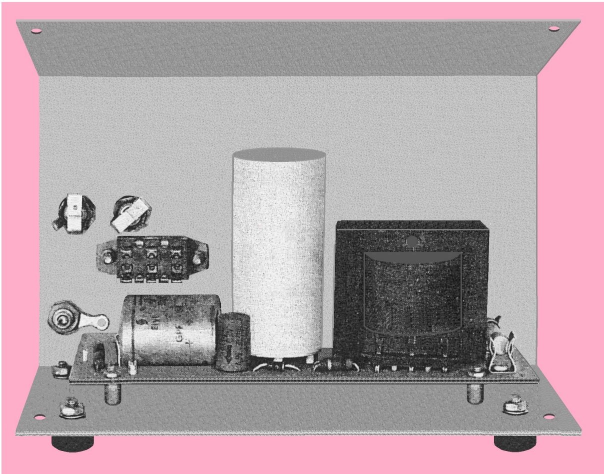
A suitable wooden case may be added, along with a front window of red Plexiglas. A red front filter is essential for best contrast; red #2423 Plexiglas in1/8-inch thickness is ideal. **R-E**

More infonnation on the support module can be found on the nut page, along with a complete parts list.

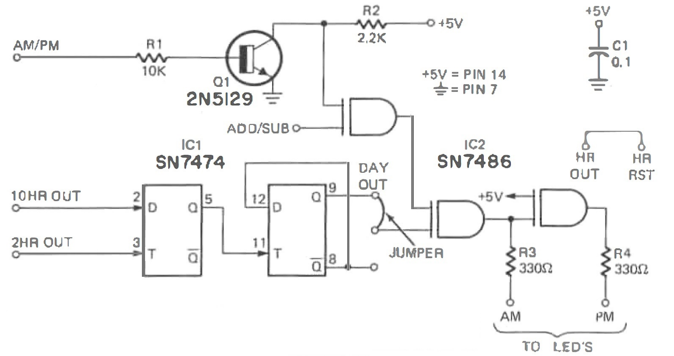
REGULATED POWER SUPPLY is bolted to clock chassis. Use insulated hardware when mounting the supply.

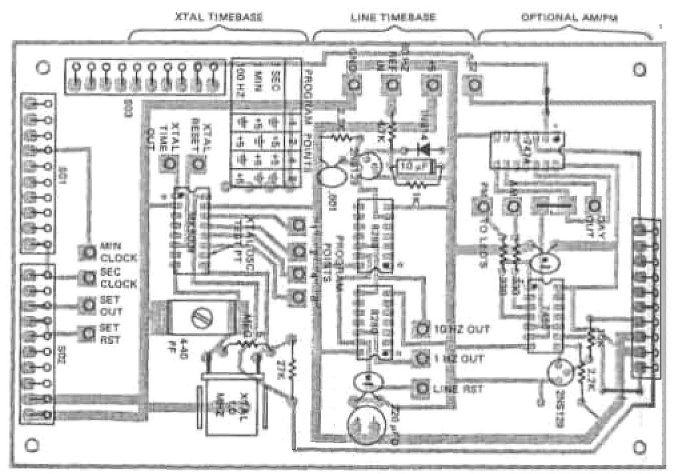


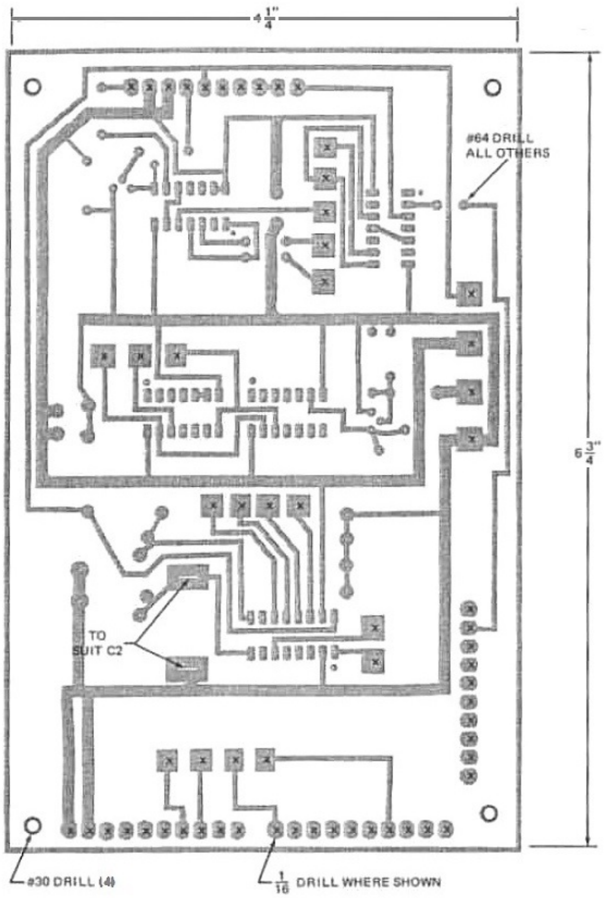
LOOKING INTO THE REAR OF THE CASAE you can see how the regulated power supply is mounted and positioned.



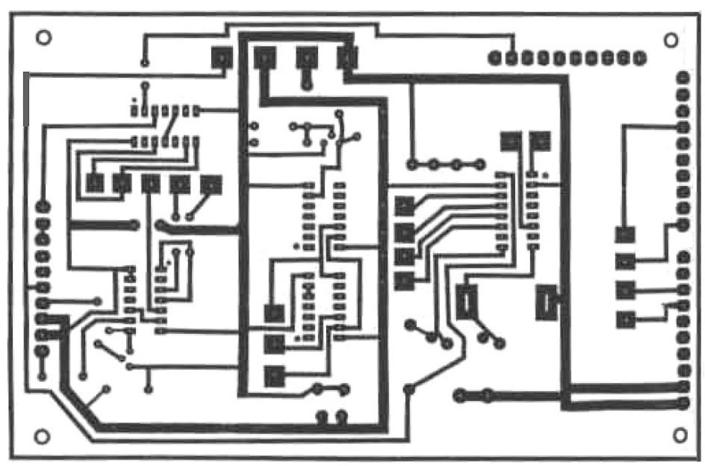
AM-PM CIRCUIT develops a pulse every 12 hours to trigger an optional AM-PM indicator. The indicator consists of two individual LED's.







THREE CIRCUIT-BOARD DIAGRAMS needed to assemble your own support board. View at left shows jumpers and drill sizes. Drawing above indicates position of components on the support module board. Diagram below is reduced size illustration of the foil pattern on the support board.



PARTS LISTS
SUPPORT MODULE

(A) Crystal Timebase:
R1—5.1-megohm, ¼-watt carbon
C1—20 pF mica
C2—4-40 pF trimmer
C3, C4—0.1 μF, 10-volt disc ceramic
IC1—MK5009 Timebase Divider (MOSTEK), a special design by and build for Don Lancaster for this project.
XTAL1—1.0 MHz xtal, parallel resonant into 32-pF load

(B) Line Timebase
R1—4,700-ohm, ¼-watt carbon
R2—1,000-ohm, ¼-watt carbon
R3, R4—2,200-ohm, ¼-watt carbon
C1—220 μF, 8-volt electrolytic
C2—0.1 μF, 10-volt disc ceramic
C3—10 μF, 10-volt electrolytic
C4—1,000-pF disc ceramic
D1—1N914 silicon diode
IC1—8288 Base 12 counter (Signetics)
IC2—8280 Base 10 counter (Signetics)
Q1—2N5129

(C) AM/PM Circuitry
R1—10,000-ohm, ¼-watt carbon
R2—2,200-ohm, ¼-watt carbon
R3, R4—330-ohm, ¼-watt carbon
C1—0.1 μF, 10-volt disc ceramic
IC1—SN7474 Dual D flip-flop, TTL
IC2—SN7486 Quad EXCLUSIVE-OR TTL
L1, L2—Red LED panel lamp, Monsanto MV5023 or equal
Q1—2N5129 transistor

(D) Setting Circuitry and Connectors
S01,4—10-pin female connectors, Molex 09-52-3103
C1—1 μF, 10-volt electrolytic
S1—spst slide switch
S2,S3—spdt pushbutton
– –Misc. mounting hardware
– –Red Plexiglas front filter