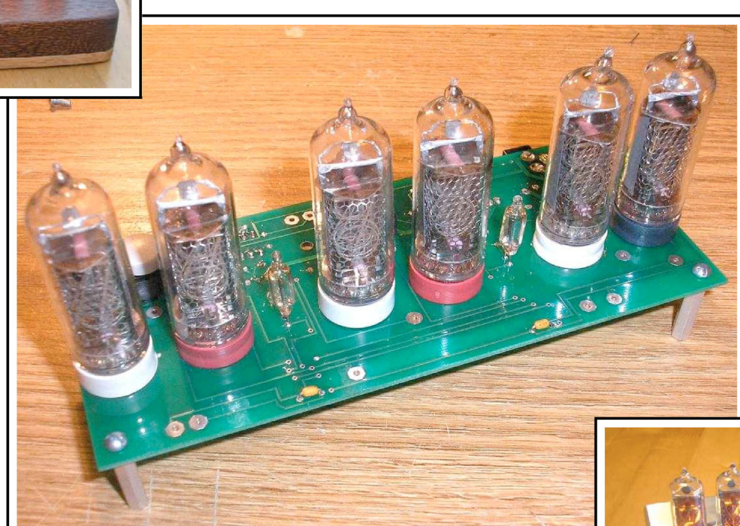
6 Tube IN-14 Nixie Clock Kit
Assembly Instructions

v1.1

Ann Arbor, MI



Scary Warning

DANGER: BUILDING THIS KIT INVOLVES WORKING WITH DANGEROUS, POTENTIALLY LETHAL VOLTAGES. POWER LINE VOLTAGES ARE DANGEROUS. IF YOU ARE NOT EXPERIENCED WORKING WITH DANGEROUS, POTENTIALLY LETHAL VOLTAGES, RETURN THE KIT FOR A REFUND. IF YOU DO NOT ACCEPT FULL RESPONSIBILITY FOR WORKING WITH THESE POTENTIALLY LETHAL VOLTAGES, RETURN THE KIT FOR A REFUND.

BY BUILDING THIS KIT, YOU ACKNOWLEDGE AND AGREE THAT PETER J. JENSEN, LLC, AND ITS MEMBERS, BEAR NO RESPONSIBILITY (OR AS LITTLE AS IS PERMISSIBLE BY LAW) FOR ANY HARM TO PERSON, PROPERTY, OR ANYTHING ELSE ANYBODY CAN THINK OF, DUE TO YOU WORKING WITH THESE DANGEROUS, POTENTIALLY LETHAL VOLTAGES OR BUILDING THIS KIT.

Overview

The trouble with facts is that there are so many of them. - Samuel McChord Crothers, *The Gentle Reader*

The Nixie tube was introduced in 1954, and provided the display for early voltmeters, frequency counters, and multimeters, before being replaced by LCDs and LEDs in the 1970s. They were also found in the first desktop calculators, and even as the display for the Apollo guidance computer. Once utilized primarily in research and military equipment, Nixies are now prized for their retro aesthetics, and featured in this hand-crafted clock. For more history of the Nixie tube technology, see Wikipedia history of the Nixie at http://en.wikipedia.org/wiki/Nixie_tube.

The 6 IN-14 tube Nixie clock kit offered by Peter J. Jensen, LLC displays the Russian IN-14 tubes on a small PCB, suitable for various enclosures. Time is set by two buttons on the back; one advances the hours, the other minutes. The digits fade from one number to the next as the time changes.

Circuit Description – (skip if you like)

The clock is designed to generate 180V DC from a 12V DC source, so the clock can use a "wall wart" power adapter and work anywhere in the world.

The 12V power from the DC socket first passes through a fuse, and then into capacitor C2 to stiffen the supply. The digital logic is powered by a 5V source provided from "dropping resistor" R1, and the 5V Zener D10, along with filter capacitor C1.

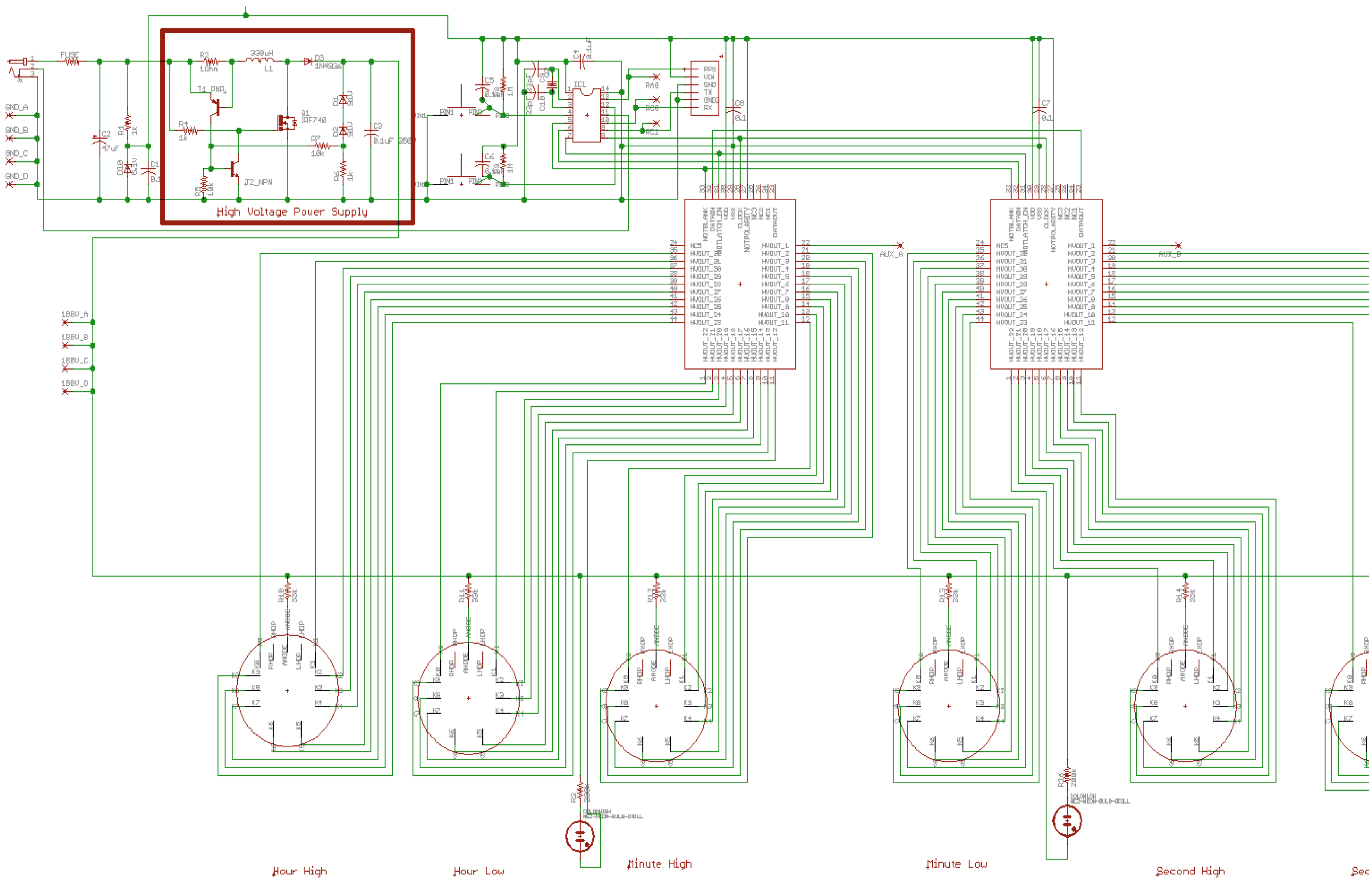
The high voltage is supplied by a switched inductor circuit. By default, R4 biases FET Q1 to conduct, letting current pass through inductor L1. R3 acts as a current sense, which turns on PNP transistor T1 when the current exceeds approximately 0.6A through inductor L1. This in turn turns on NPN transistor T2, and grounds the gate of FET Q1.

FET Q1 turning off, giving the current through L1 no place to go, causes a high voltage ("back EMF") to develop from inductor L1. The current, at high voltage, passes through high speed diode D3 and is filtered by capacitor C3.

If the voltage exceeds 180V, Zeners D1 and D2 will conduct and pass some current back to NPN transistor T2. This acts as feedback, preventing FET Q1 from closing and building up more current in the inductor if the voltage is above 180V.

The entire circuit oscillates between FET Q1 open and closed due to the Gate-Source capacitance in FET Q1, causing a delay between switch-on and switch-off.

The high voltage section provides 180V for the nixies.


High Voltage Power Supply
FUSE
330uH
L1
D3
1N4936
Q1
IRF740
T1_PNP
J2_NPN
GND_A
GND_B
GND_C
GND_D
180V_A
180V_B
180V_C
180V_D
IC1
AUX_A
AUX_B
Hour High
Hour Low
Minute High
Minute Low
Second High

To turn on power to a nixie tube digit, the pin corresponding to the digit is grounded. R11 through R15 limit the current through the nixies to approximately 2.5mA.

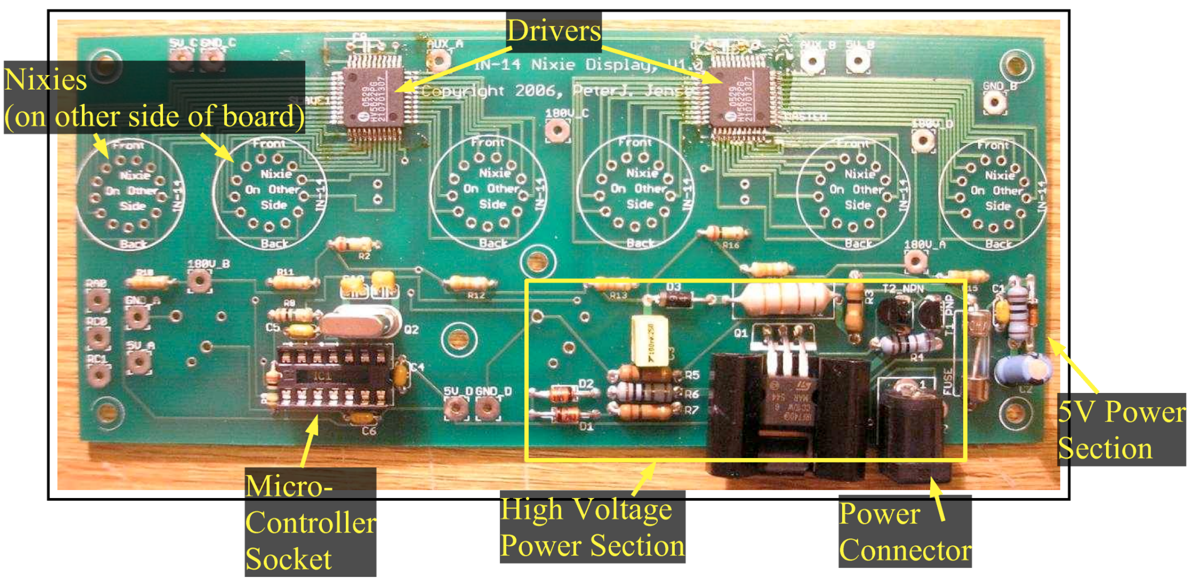
The high voltage driver surface mount device (SMD) is serial programmed by the micro-controller to ground pins based on the time to be displayed. For interested parties, the data sheet for the driver chip can be found at:

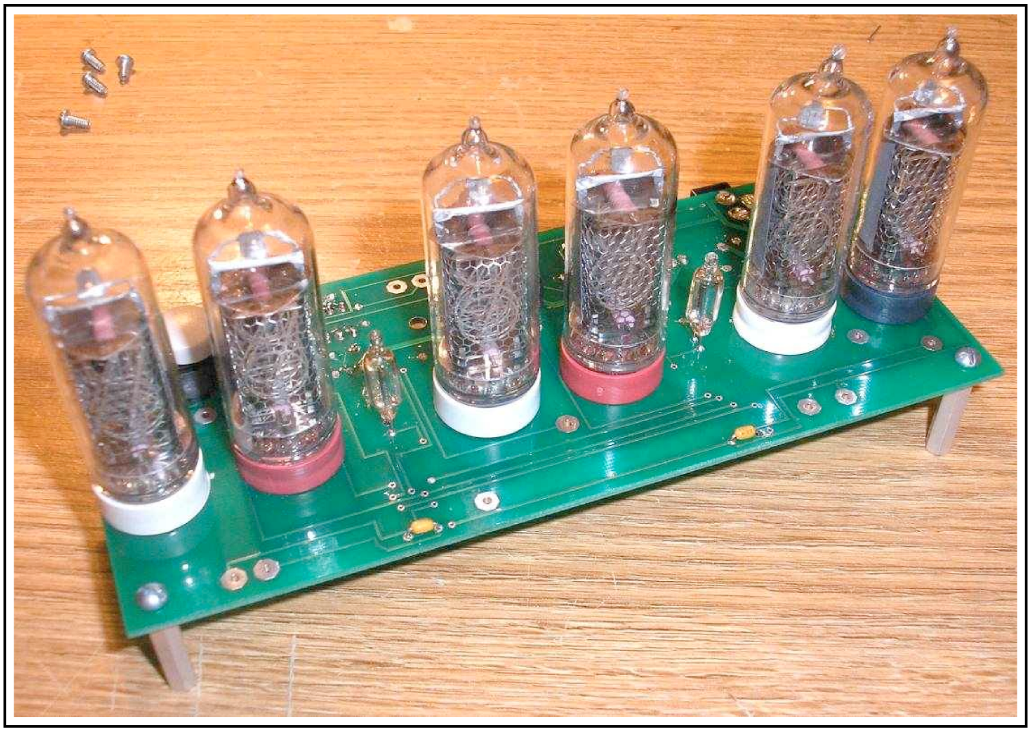
http://www.supertex.com/pdf/datasheets/HV5622.pdf

The micro-controller data sheet can be found at:

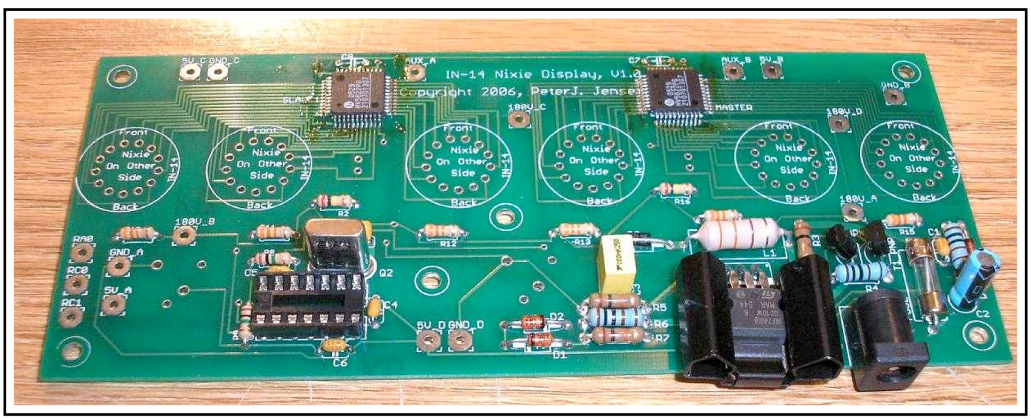
http://ww1.microchip.com/downloads/en/DeviceDoc/40039c.pdf

UPDATE: The second revision of the board includes a place to attach a connector for interfacing with the microcontroller. This is in the lower left of the board, under the button next to the microcontroller. This connector should be left unpopulated, and is provided for future expansion. Also, the new circuit boards with this connector are black instead of green. Otherwise, the new boards are the same as those pictured in this manual.





Finished Clock Picture



View of the bottom of the clock, without the nixies or micro-controller

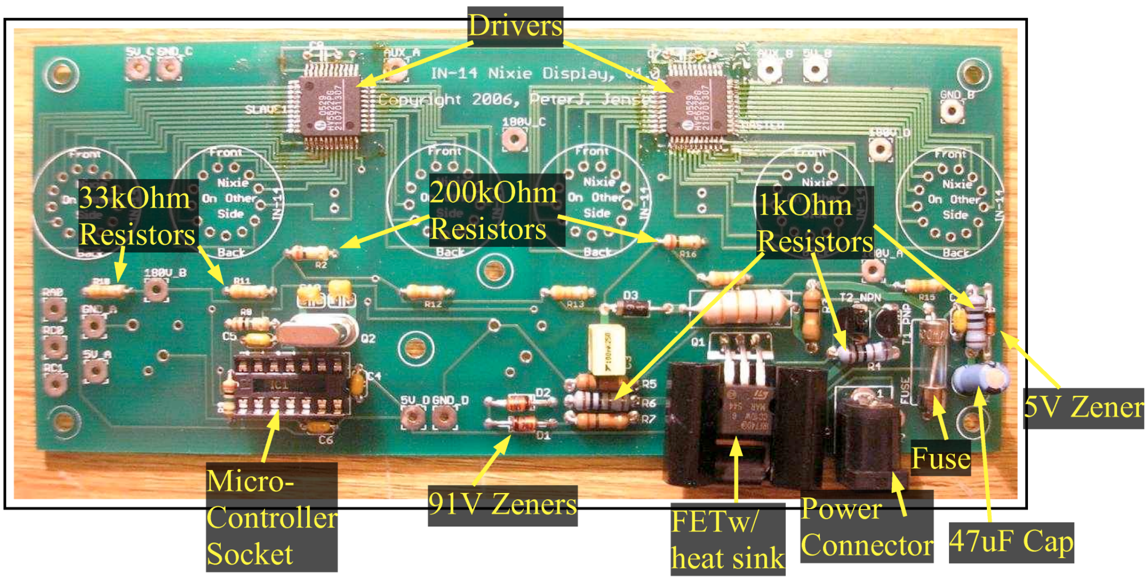
Parts List

To invent, you need a good imagination and a pile of junk.
- Thomas A. Edison (1847 - 1931)

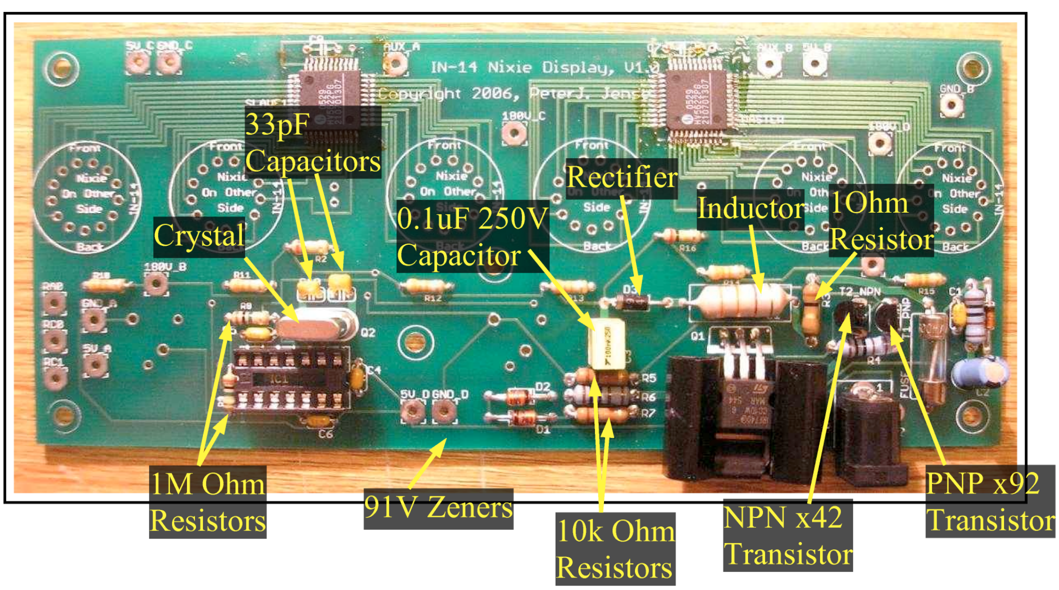
Name	Count
Buttons	2
Capacitor – 0.1uF	6
Capacitor – 0.1uF 250V	1
Capacitor – 33pF	2
Capacitor – 47uF	1
Clock Crystal – 16MHz	1
DC Power Connector	1
DIP Socket – 14 pin	1
Fuse	1
Heat Sink	1
Hex Standoffs	4
High Voltage Driver SMD	2
Inductor 330 uH	1
Microcontroller PIC16F6XX	1
Neon Bulbs	2
Nixies – IN14	6
PCB (Printed Circuit Board)	1
Plastic Spacer for Crystal	1
Rectifier – 1N4936	1
Resistor 1 Ohm	1
Resistor 10k Ohm	2
Resistor 1k Ohm	3
Resistor 1MOhm 1/4 Watt	2
Resistor 200k Ohm	2
Resistor 33kOhm 1/4 Watt	6
Screws for Hex Standoffs	8
Transistor – FET IRF740	1
Transistor – NPN XXX42	1
Transistor – PNP XXX92	1
Zener Diode – 5.1V	1
Zener Diode – 91V	2
Desoldering Braid	

The bipolar transistors can be distinguished because the NPN will end in a 42, and the PNP part number will end in 92. The beginning of the part number can vary depending on the chip manufacturer used.

UPDATE: The second revision of the board includes a place to attach a connector for interfacing with the microcontroller. This is in the lower left of the board, under the button next to the microcontroller. This connector should be left unpopulated, and is provided for future expansion. Also, the new circuit boards with this connector are black instead of green. Otherwise, the new boards are the same as those pictured in this manual.



Part Identification Illustrations



Assembly Instructions

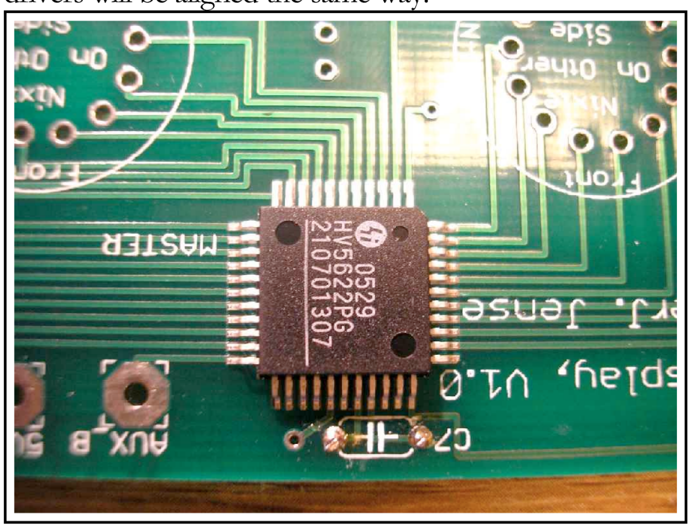
If opportunity doesn't knock, build a door. -
Milton Berle (1908 - 2002)

There are different approaches one can take to assembling this clock. Often the best approach is to build the power supply first, and test it before putting on any of the other parts. However, for this kit I find it easiest to place the High Voltage Driver surface mount chip first. As the first chip placed, the board can lie flat, making placement of the chip and its tiny leads simpler.

1) Locate the PCB, and lie it flat on the work surface, and turn it around so the pads for the driver chips are nearest you.

2) Locate one of the Driver surface mount chips, and place it on the PCB. **Notice the orientation (see picture)**. Each pin should rest on exactly one pad. Both drivers will be aligned the same way.

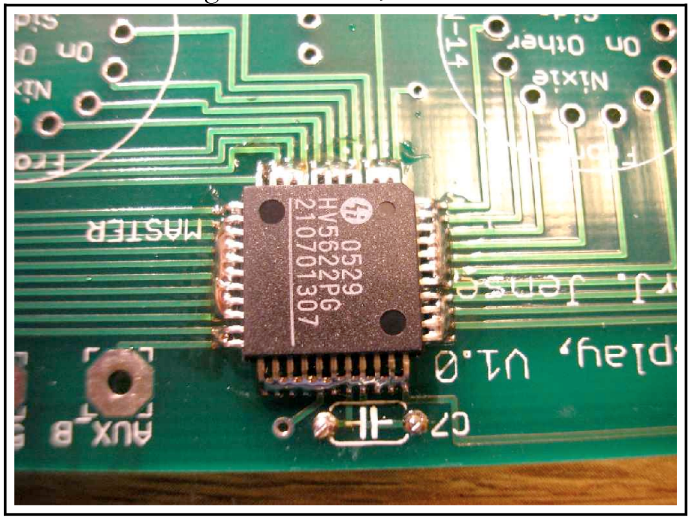
Important: Use the dots in the corners of the driver chip to align the chip. Do not rely on the printed text to be in the correct orientation (it often isn't).



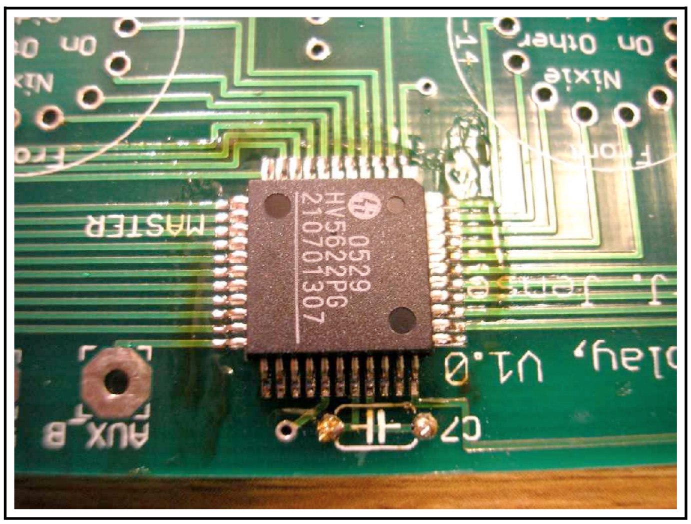
3) The goal of this step is to tack the driver chip down so it doesn't move around when soldering. Use one finger to hold the chip in place with one hand. Press the hot tip of your soldering iron down on one lead at a time with your other hand. Press for about two seconds, pushing the lead down on the solder pad with the hot iron. There is just enough solder on the pads to make a weak mechanical contact.

4) Now melt a bead of solder over all the leads. Keep the soldering iron tip on the green PCB surface, just touching the tips of the leads, as you move it across each row and push in solder. The solder should climb up from the iron tip onto the leads. It will also be flowing around and under the leads. Do not be concerned

about solder bridges at this time, excess solder will be removed in the next step.



5) Finally, remove the excess solder with the copper de-soldering braid. Place the copper braid over the leads, and press the hot iron onto the braid. The solder will melt and cling to the copper braid, and not stay on the leads. You can use a magnifying glass to look for solder bridges, or use pointed probes of a continuity tester or Ohm meter.

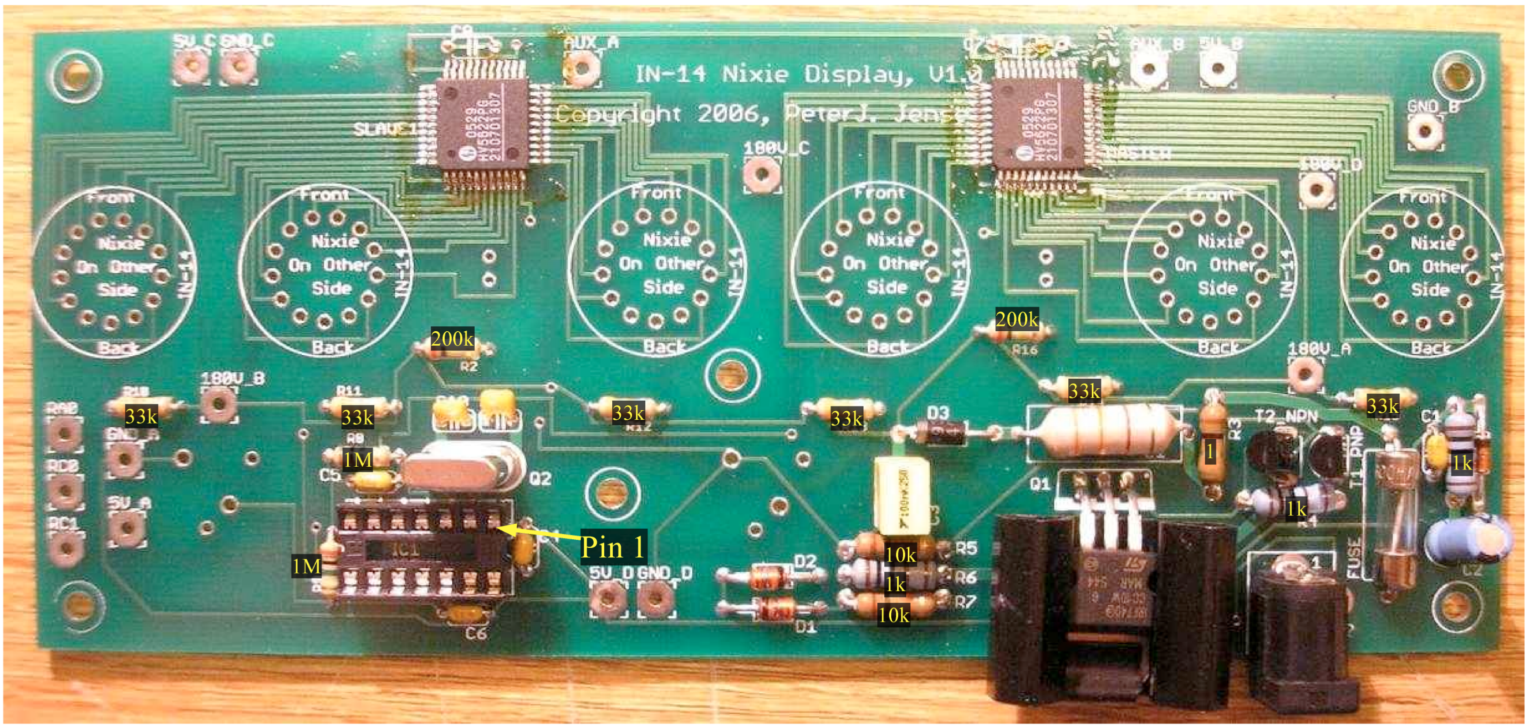


6) Repeat steps 2-5 with the second driver chip. Note that is is oriented the same way.

7) There is a part placement checklist on the next page. Turn the board around and solder in the remaining parts as shown. As you solder in each part, check it off on the checklist.

Capacitor C2 has negative towards the bottom, *all other capacitors do not have an orientation* (orientation does not matter).

Note that the two capacitors near the drivers are placed on the opposite side of the board in the picture. This is to allow better access to the drivers if there is solder rework required. Doing this is optional.

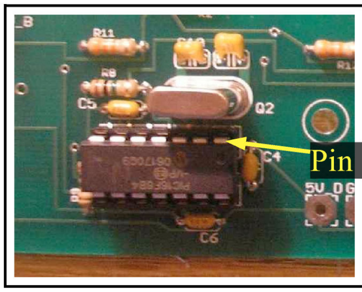


Pin 1, which has the little dimple on the micro controller chip, goes in the space marked in the picture above. Be careful to place the micro controller in with pin one in the upper right as shown. The socket in the picture above is actually installed backwards; the notch should be on the right.

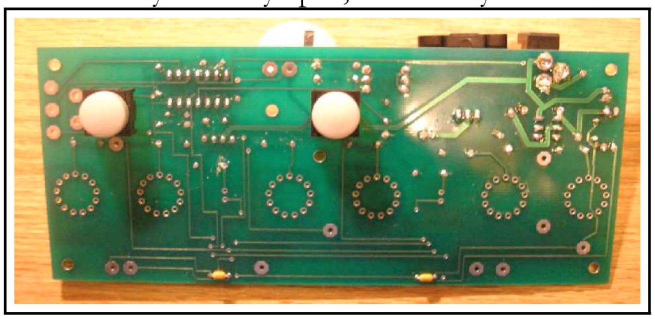
Parts Placement Checklist:

Check	Name	Count	Part #	Note
☐	Capacitor – 0.1uF	6	C1, C4, C5, C6, C7, C8	Small yellow capacitors
☐	Capacitor – 0.1uF 250V	1	C3	Larger, square yellow capcitor
☐	Capacitor – 33pF	2	C9, C10	Two small yellow, leads parallel
☐	Resistor 1 Ohm	1	R3	Brown-Black-Gold-Gold
☐	Resistor 10k Ohm	2	R5, R7	Brown-Black-Orange-Gold
☐	Resistor 1k Ohm	3	R1, R4, R6	Brown-Black-Red-Gold OR Brown-Black-Black-Brown-Brown
☐	Resistor 1MOhm 1/4 Watt	2	R8, R9	Brown-Black-Green-Gold
☐	Resistor 200k Ohm	2	R2, R16	Red-Black-Yellow-Gold
☐	Resistor 33kOhm 1/4 Watt	6	R10, R11, R12, R13, R14, R15	Orange-Orange-Orange-Gold
☐	Rectifier – 1N4936	1	D3	Black rectifier, stripe on the left
☐	Zener Diode – 5.1V	1	D10	This is the smaller of the 3 zener diodes. Stripe on top.
☐	Zener Diode – 91V	2	D1, D2	These are the two larger (½ Watt) Zeners. D1 has stripe on the left, D2 is placed with the stripe on the right.
☐	Transistor – NPN XXX42	1	T2	Part number is written on the transistor, ending in "42"
☐	Transistor – PNP XXX92	1	T1	Part number is written on the transistor, ending in "92"
☐	Clock Crystal – 16MHz	1	Q2	Small metal can. Slide the plastic spacer onto the leads before soldering. The kit now ships with a.shorter sized crystal than the one pictured. The new crystal is more accurate, and also allows the clock to fit into smaller enclosures.
☐	DIP Socket – 14 pin	1	IC1	Black socket, notch goes to the right
☐	Fuse	1	FUSE	Glass tube with metal ends, orientation does not matter
☐	Inductor 330 uH	1	L1	Orange-Orange-Brown-Gold – looks like a large, fat resistor
☐	DC Power Connector	1	J1	
☐	Heat Sink	1		Snaps onto the FET, no solder required
☐	Transistor – FET IRF740	1	Q1	Put Heat sink on first, then place FET on board and bend over away from the inductor, so the back of the heat sink lies flat against the board. Make sure the heat sink does not touch the leads of the FET or the pads on the board.
☐	Capacitor – 47uF	1	C2	Larger blue cap, CHECK ORIENTATION

8) Insert the micro controller into the socket.

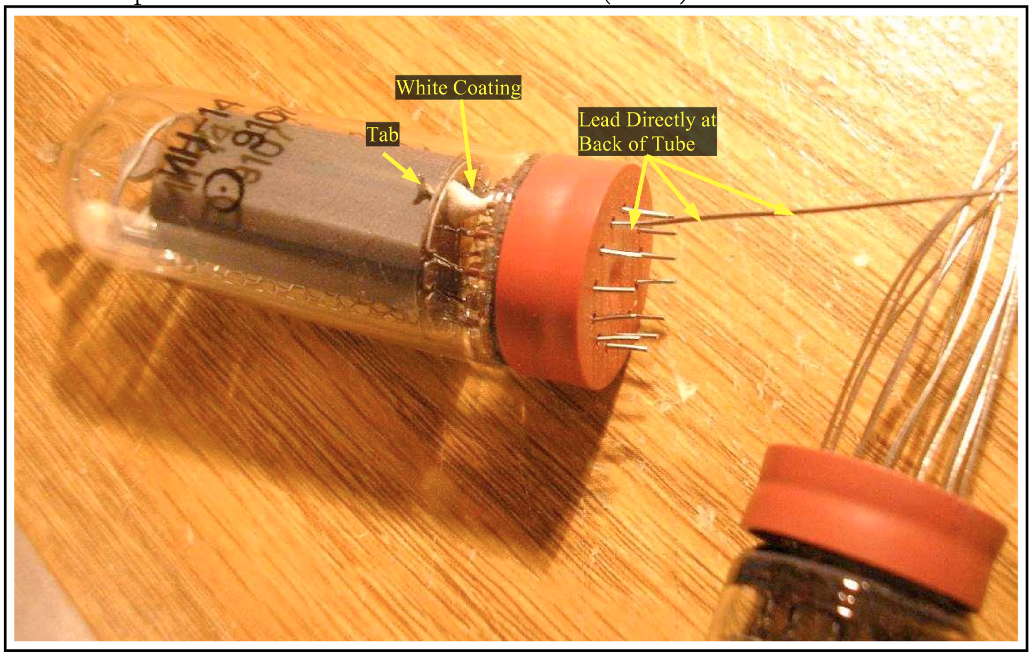


9) Turn the board over and solder in the buttons. The buttons are keyed, and should fit in only one orientation. If your enclosure requires, you may use different buttons. Any normally open, momentary contact button will work.



10) The goal of these steps is to solder in the nixies.

11) Bend over the lead in the nixie that is directly in the back, often connected to the white coating inside the tube, and a small tab visible inside the tube. This is the anode. Snip all the other leads to about 0.2 inches (0.5cm).

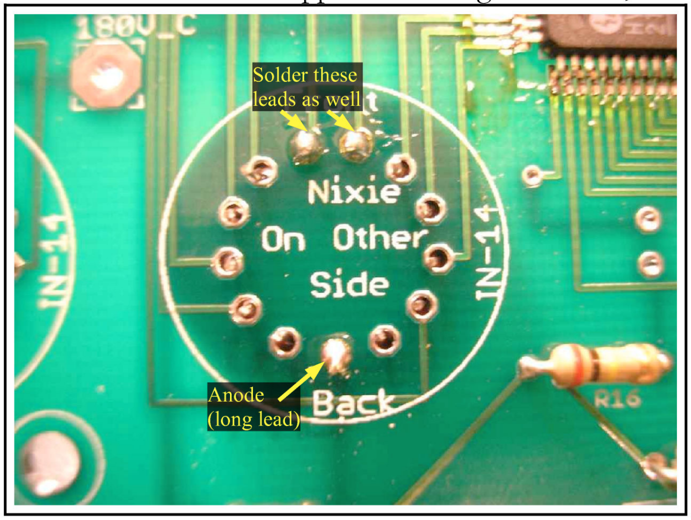


12) Turn the board button side up. Place the one long lead of the nixie through one of the nixie lead holes, closest to the back of the board (the back of the board is the side closer to the buttons and the power input connector). Look at the traces to make sure the lead is in the correct hole. The long lead goes in the hole that is connected to a 33k Ohm dropping resistor, not to the driver chip. On the circuit board, this will be the only hole with a trace leading to it on the nixie side of the board.

13)Turn the board over and look at the holes for the nixie with the long lead sticking through. You can slide the plastic base of the nixie down so it is flush with the board (but so the nixie leads are still inside of the plastic base). In this way, the plastic base is acting a guide. While holding the plastic base flush with the button side of the board board with one hand, look at the holes for this nixie on the parts side of the board. You should be able to see the tips of the leads through the holes when everything is lined up properly. Push the nixie down onto it's plastic base, and all the leads should come through the PCB (this might require a little wiggling while pushing). After doing a couple like this, it should only take a few seconds to get all the leads through the holes.

14) Holding the tube flush against the board, solder in the long anode lead.

15) Solder in the two leads opposite the long anode lead, and snip off the long lead.



16) The nixie can now be adjusted by applying heat to the soldered leads. Make sure the nixie is oriented how you wish it to be when the clock is done. If you have the enclosure available, try fitting the electronics into the enclosure now. Sometimes the electronics will fit better in the enclosure if the nixies are not perfectly flush or right to the circuit board. This is because nixies are not always perfectly straight at the bottom.

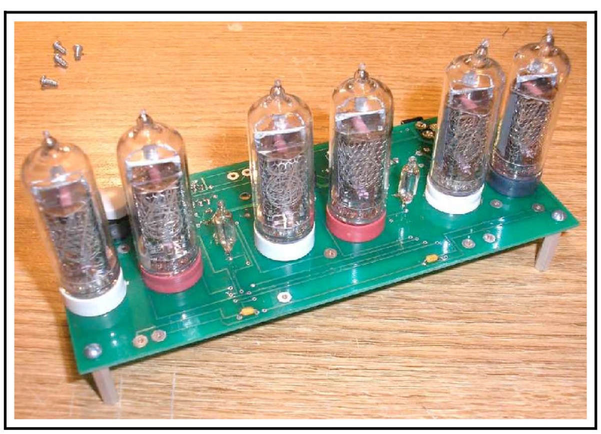
17) Solder in the remaining pins when the nixie is oriented properly.

18) Repeat steps 10 to 16 for the remaining nixies.

19) Solder in the two neon bulbs. The orientation does not matter. You can insert the neon bulbs to the height desired, then bend out the leads on the other side of the board. When you turn the board over to solder, with the everything gently resting on the tops of the nixies, the neon bulb rest at the correct height.

20) Test the clock. See the troubleshooting section if there is a problem.

21) Screw in the standoffs. If you have an enclosure for the electronics, insert the electronics into the enclosure, and enjoy!



Troubleshooting

Bygone troubles are good to tell. – Yiddish Proverb

This section will be increased as I hear from those who have built the kit, and the troubles they have had. Here is a list of mistakes I have made building the clock, and problems kit builders have reported.

Symptom: On a nixie, two numbers light at once.

Cause: There are a few reasons this could happen.

First, check for a solder bridge on the driver chip. This can be done visually with a magnifying glass / eye loupe, or with a Ohm meter. If there is a solder bridge, use the desoldering braid to remove it. Sometimes you may need to add a little solder first, so the solder bridge will flow out when heated.

The other main reason this can happen is the leads are shorted out inside the nixie tube. Sometimes this can be fixed by shaking the tube to separate the wires. If not, the tube will need to be replaced.

Symptom: Display is garbled, many digits display at the same time, or no nixies light at all.

Cause: This is almost always due to a solder bridge or open on the driver chip along the top row. Resolder the top row of leads on each driver and check again. Also check the orientation of the microcontroller chip. See next troubleshooting tip.

Symptom: No nixies light at all.

Cause: Bad power supply connections. Check the 5V to ground (using one of the marked connection points on the board) with a Voltmeter. Also check the 180V connections. If there is no voltage, or low voltage, check the diode directions, capacitor directions, and solder connections. Also make sure the microcontroller is oriented properly.

Symptom: Blue Electrolytic capacitor explodes.

Cause: Capacitor installed backwards. Order a new capacitor.

Symptom: Fuse blows right away when power is applied.

Cause: Electrolytic Capacitor installed backwards, or there is a solder bridge somewhere. The fuse will need to be replaced.

General Checkout:

With the power off:

1) Check all the solder points and re-solder anything that looks suspicious.

2) Check the orientation of the capacitors, diodes, the driver chips, transistors and the micro-controller

3) Check the orientation of the nixies.

DANGER: When working with the clock with power on, there are lethal voltages present. If you are at all uncomfortable with working with high voltages, do not attempt to fix problems with the power on.

Contact me if you are having trouble. Reach me at

support @ tubeclock . com

Peter J. Jensen, LLC

TUBECLOCK.COM

Instructions for the 6-Tube IN14 Clock

Thank you for purchasing this hand-made Nixie clock. The clock has several features which allow you to customize its operation.

To Set the Time:
Press and hold one button at a time. Pressing the left button changes the hours, and pressing the right button adjusts the minutes. Changing the minutes sets the seconds back to 0.

Changing Settings:
There are 7 settings which can be changed, which are in 4 different groups.

Pressing then releasing both buttons at the same time will move to the next setting. When viewing a setting, pressing one button at a time will either increase or decrease the value of the setting.

After a few seconds of not pressing any buttons, the clock will toggle back to the time display automatically.

Setting Group 1: *24 vs. 12 Hour mode*. Press either button (but not both) to highlight the number 12 or 24. If 24 is highlighted, the clock will show 24 hour time. If the 12 is highlighted, it will show 12 hour time.

Setting Group 2: *Brightness*. The clock will display a number on the middle two nixies, between 00 and 10, which is the default brightness level. 10 is the brightest, and 00 is the darkest (nixies off). Press the right button to decrease the brightness setting, and the left button to increase it.

Setting Group 3: *Auto-Dim*. The nixie clock can be set to automatically lower the brightness between two specified hours in the day (such as between 09 and 17 hundred hours, or when you are not at home). There are three, two digit numbers shown at once. The left two nixies show the start hour (0 to 23) of the auto-dim. The middle two nixies show the end time of the auto dim. And the right two nixies show the brightness level (00 to 10). Each time both buttons are pressed and released, the setting being changed will move from start hour, to end hour then to brightness level. You can tell which value is being edited because it will be highlighted. If the start and end hours are the same, the auto-dim is disabled.

Setting Group 4: *Time adjustment*. The internal oscillator may up to 0.005% fast or slow, causing the clock to be slightly fast or slow. To compensate, a small adjustment can be added to the internal time counter. To calculate the correction factor, set the time to a reliable source (i.e., www.time.gov). Wait at least a couple of days, and record how many seconds the clock is fast or slow. The correction factor is as follows:

CF = 3100 – (65536000 * (Number of seconds fast) / (Duration of test))

The (Duration of test) is the time, in seconds, that the clock was allowed to run. If the clock was slow, then (Number of seconds fast) will be a negative number. The number to enter in the middle two nixies is CF/64, rounded down. The number to enter in the right two nixies is the remainder of CF/64.

Enjoy your clock! If you encounter any trouble, please e-mail me, Peter Jensen, at jensen@tubeclock.com.

UPDATES:

The second revision of the board includes a place to attach a connector for interfacing with the microcontroller. This is in the lower left of the board, under the button next to the microcontroller. This connector should be left unpopulated, and is provided for future expansion.

Also, the new circuit boards with this connector are black instead of green. Otherwise, the new boards are the same as those pictured in this manual.

Finally, the 0.1uF 250V capacitor supplied with the kit is now blue instead of yellow, and has a different shape than the one described in this manual. It is smaller and rounded in shape, but the pins will fit in the same spacing as the old square capacitor.