Building FIGnition:

The Kit

The kit should look like this and contains:

- A small bag with a USB connector and other components.
- Another small bag without a USB connector in it containing the rest of the components.
- A plastic tube containing 3 sockets: 1x 28 pins + 2 x 8 pins.
- An anti-static bag for your final FIGnition containing the PCB.
- A plastic tube containing 3 chips: An AtMega168, a Microchip 23K640 8Kb SRAM and an AMIC A25L080-F 8Mb Flash Chip. (You may find that the small 8-pin chips are in the anti-static bag).

The first plastic bag contains the following components (it's not antistatic):

	A	B	C	D	E	F
1	**Component**	**Quantity**	**Identification**			
2	1K5 Resistor	6	Brown, Green, Black, Brown			
3	1K Resistor	6	Brown, Black, Black, Brown			
4	220R Resistor	2	Red, Red, Black, Black.			
5	1N4148 Diode	4	Glass+Black stripe. Tiny writing that says: 1N,41,48			
6	LED	1	Red and Translucent (or transparent)			
7	10nF Capacitor	3	Round ceramic disc marked with "10" or "103"			
8	6x6mm Switch	8	Sqaure with protruding buttons!			
9	**Total**	30				

The second bag contains the remaining discrete components:

	A	B	C	D	E	F
1	**Component**	**Quantity**	**Identification**			
2	470R Resistor	1	Yellow, Purple, Black, Black.			
3	68R Resistor	2	Blue, Silver, Black, Gold			
4	22pF Capacitor	2	Round disc marked "22".			
5	3v6 500mW Zener Diode	2	Glass+Black stripe. Tiny writing that says 3v6 somewhere			
6	4.7μF Electrolytic Capacitor	1	Cylindrical with a white stripe.			
7	20.0MHz Crystal	1	Metal oval-shaped can (top view) marked "20.000"			
8	USB Connector	1	A Standard USB B-type connector.			
9	A Phono Connecto	1	Similar size to the USB connector, but with a round end.			
10	**Total**	11				

I would leave the components in their bags until you need each one, don't just tip them out, or at the very least put them in two different trays so they don't get confused.

If you're new to soldering, I'd **STRONGLY** advise you build it with a friend or parent, to help you with checking the circuit and to share the excitement with as you turn it on for the first time and see it work!!! FIGnition is simple to build, as easy as many Lego® kits, but mistakes can be made and are harder to fix.

Soldering The Board

The next stage is to start the building process itself:

1. Make sure you have a sponge for the soldering iron - and make sure it's damp (not dripping).
2. Turn on the soldering iron. For my temperature-controlled one, I turn it to about 3/4 of the way, otherwise just turn it on. Make sure the soldering iron is securely positioned, I wouldn't leave it lying on the workbench; I'd put it on a mount and make sure the mount isn't going to tip up.
3. Get the rest of the equipment you need:
    1. A small 2-3mm wide flat-head screwdriver for levering out ICs.
    2. A fine-tipped pair of pliars.
    3. A wire cutter for snipping the component legs.
    4. A solder sucker (in case you make a mistake, which you probably will, since I do!)
    5. A decent amount of solder. I use lead-free silver solder: Ag 5%, Sn 95.5%, Cu 0.5%. I buy it from Maplin, a consumer electronics store in the UK.
    6. Possibly some extra lighting.
4. For Testing the board, you'll need some additional equipment
    1. A multimeter. I have a cheap one from Maplin. The only feature we'll use is the short-circuit tester, the buzzer.
    2. A Standard USB A-B cable.
    3. A USB power source, for testing purposes I strongly advise using a USB power adapter, that plugs into mains as it is less of a loss than a computer if you have made a serious error.
    4. A Phono lead. (I assume most people have several in the house). An audio phono lead will do as long as it has phono plugs at both ends.

The basic principle is this: solder from the lowest components to the highest ones. That's because I'm assuming you don't have any special PCBs clamps so you want to position the circuit in a stable way while you solder and the best way to do that is to solder components from lowest to highest.

Familiarise yourself with the basic soldering guide. Soldering descrete components is fairly easy.

1. Bend one end of the wire at right-angles using pliars fairly close to the component,
2. Place in its hole,
3. See where the other side should be bent and bend the wire with the pliars at that point. The resistors only just fit the component space so you'll need to bend the wires very close to the components.
4. Then you place the component in its location - the component should be on the front side of the PCB, the side with the "FignitionRevC markings".
5. Splay the legs out the other side - not too much (you don't want them to touch the pins of other components), but enough to keep the component in place when you turn the PCB upside-down to solder it.
6. Solder the component from the rear-side of the PCB as described below.. You don't need very much solder at all on any of the pins.
7. Snip the legs off the component and visually check that the solder joints look good - use a magnifying glass if you need to (see the general soldering guide).

Doing the actual soldering.

1. Solder the resistors first. There's no *best* order, but I think doing all the same resistor values at a time is likely to lead to less mistakes. So, start with:
    1. the 1K5 Resistors (one at a time if you're not familiar with soldering). They should go in: R1, R8, R10, R12, R14, R17. Then:

    2. the 1K Resistors which should go in: R4, R5, R9, R11, R13, R15. Then
    3. the 220R Resistors: R7 and R16.
    4. The 470R Resistor (from the other bag): R6.
    5. The 68R Resistors (from the first bag): R2 and R3.
2. Solder the Diodes next. You have to be careful with the direction of the diodes. The black stripe should go on the same side as the vertical bar on the diode's symbol on the PCB.
    1. The 2 Zener Diodes from the second bag (the bag with the USB connector). They go in D3 and D4.
    2. the 4 Signal Diodes from the first bag. They go in D1, D2 (note: the black stripe is on the left); D6 and D7 (note: the black stripe is on the right) .
3. The IC sockets are next. You need to solder in the sockets, but **DON'T** add the chips - you'll only do that at the very end!
    1. Start with the 8-pin sockets since they're the easiest.
        1. Place them in U2 and U3 so that the notch at the top of the socket points to the top and so that all the pins go through. If they fall out when you turn them up-side down, you may find that you can use something to hold them in place as you turn it but don't use sticky-tape as it'll melt during soldering, use a piece of thin stiff plastic or your screwdriver and then slide it out before soldering.
        2. Solder in the top-left pin and then the bottom-right pin of the socket. This will anchor the whole socket in place so you can solder the rest with ease.
        3. Solder in all the other pins.
    2. Next Solder in the 28-pin socket. Again the notch should point to the top. You'll find it much more difficult to line up the pins so it goes through. Be patient; tease the legs into position, and don't force it or you'll bend some of the legs and make it more difficult. The rest of the steps are the same as above.
4. The disc capacitors come next, they can go in any way round.
    1. Solder the 10nF capacitors C2, C5 and C6 into place, They are there to smooth out the power to the ICs.
    2. Solder the 22nF capacitors next in the locations for C3 and C4.
5. The LED should go next. It has 2 legs. The shorter one should be on the right (the side that connects to R7).
6. The Switches can go in next. The switches look square, but the pins are placed at the sides of the switch. There will be a small section on the switches themselves in the Understanding It section of the web-site.
    1. Place them so they fit nicely in position, they'll hold themselves into place when you turn the PCB up-side down.
    2. Solder them into place. Be careful, some of the switch PCB pads are very close together. You don't want to connect across them or the keyboard won't work. I'll improve this in later PCB revisions.
7. The Electrolytic Capacitor should go in next. The Stripe on the Capacitor says '-' on it, that stripe should be on the *opposite side* to the '+' marking on the PCB. In other respects, that Capacitor is easy to fit and solder.
8. The USB connector should go next. Be careful with soldering the signal pins (the 4 pins arranged in a square) they are closer together than on the other components and don't protrotrude very far through the PCB (they will protrude though). The side pads on the USB are an exception to the rule about not using much solder. Here you want to blob quite a lot onto those connections as they anchor the USB connector when you insert a USB cable - you need those connections to take all the force.
9. The Phono connector is next.
    1. Use the wire cutter to make the plastic lugs on the bottom of the Phono connector a bit shorter. In future PCB revisions there may be extra holes to provide a better fix, but Phono connectors aren't entirely consistant.
    2. Solder in the 3 pins on the Phono connector. There's 4 pads, but the right-

hand one isn't used.

3. Again, you'll need quite a lot of solder here, the Phono connector also needs to be anchored well for when you insert the phono lead.

10. The Crystal is the last component you need to solder into place, it's very easy and doesn't have a special orientation; it's just very tall, so it's last!

Testing The Circuit

Wow - you've actually BUILT the computer now. And now comes the boring tricky bit, you need to meticulously check what you've done.

First you need to check all the joints... No, first you need to go away and have a tea-break. If you don't have any tea, find a shop or store which sells it; buy some and have some tea! You need to take a break at this point!!! Take a break!!!

20 minutes later.

OK, now you need to start checking things.Turn the PCB upside down and carefully check all the joints. Make sure all your connections look good. Good connections tend to look nicely cone shaped. Actually, I'm afraid mine don't always look ideal, but I do know from experience that when you're soldering there's a point where the solder seems to just suck itself onto the pins and pads to make a good contact. Given that, I never accept a connection that has gaping cravasses in the pin/pad connection or doesn't appear to smoothly connect to the pin. I'm also not happy if it looks like there's only a thin layer of solder connecting them both, it works for machine soldering, but hand-soldering doesn't have that level of accuracy.

If you see a problem, remember it's easy to retouch the solder joint and add a tiny amount of solder if there isn't enough.

Also check that there doesn't appear to be any connections where there shouldn't be.

Look for what's called 'solder splashes', random bits of solder splashed across the circuit, they will cause inexplicable problems when checking the PCB... or smoke when you turn it on.

Also, make sure you've snipped all the legs from your components to no more than 1 or 2 mm (mine are generally 2mm) from the bottom of the PCB.

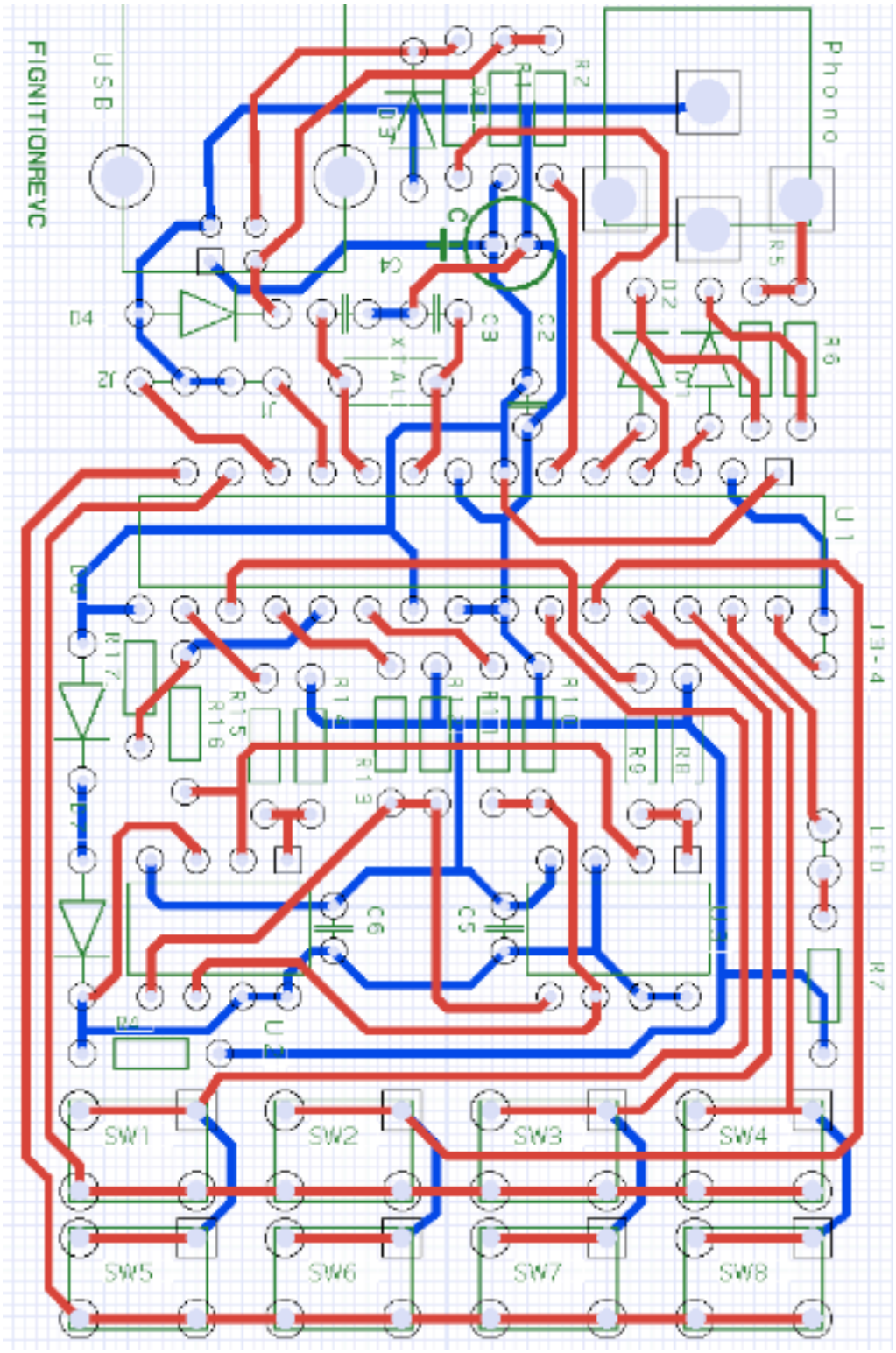
Finally, check to see that all the components are in the right places and right orientations (compare with the photo).

If You've Made a Terrible Mistake!

I've provided a link to how to use a solder sucker.

Testing The Board.

Before powering up the circuit you should check the connections. It's quite exhaustive. The connections correspond to this circuit diagram (Rev C):



Checking Connections

I number the pins on components as follows: ICs and Switches are numbered with pin 1 at the top, left; then Pin 2 below, pin 3 below that until we get to the bottom. Then Pins are numbered going up from the bottom-right of a component. So, SW1:3 is at the bottom right. USB is the exception on my diagram, the pin-numbering is upside-down (Pin1=Bottom right, pin 2= top right, pin 3 = top left, pin 4 = bottom left).

All the simple 2-pin components are numbered with pin 1 on the left (if they're going

horizontally) or pin 1 at the top (if they're vertical). Phono pin 1 is the one at the top.

The connection checks below mean that you start with the component in BOLD and for each of its pins (in Column A) test to see if it connects to all the pins listed in the other columns on that row. Then go to the next row until you've finished checking the component (connections in brackets are reminders about what the connections mean, e.g. (GND)).

	A	B	C	D	E	F
1	**IC:Pin\Connection**					
2	**U1**					
3	1	(VCC)	USB:1			
4	2	J3:1				
5	3	D1:2				
6	4	R3:2				
7	5	D2:2				
8	6	R2:2				
9	7	VCC				
10	8	(GND)	USB:4			
11	9	XTAL:1				
12	10	XTAL:2				
13	11	J1:1				
14	12	J2:2				
15	13	SW1:3				
16	14	SW5:3				
17	15	R15:1				
18	16	R9:1				
19	17	R13:1				
20	18	R16:1				
21	19	R11:1				
22	20	(VCC)	USB:1			
23	21	(GND)	USB:4			
24	22	(GND)	USB:4	U1:21	U1:8	R10:1
25	23	SW1:1				
26	24	SW2:1				
27	25	SW3:1				
28	26	SW4:1	Sw4:2			
29	27	LED:1				
30	28	J3-4:2				
31	**U2**					
32	1	R14:2	R15:2			
33	2	R16:2	U3:2			
34	3	D7:2				
35	4	C6:1				
36	5	R13:2				
37	6	U3:6				
38	7	U2:8	D7:2	R4:2		
39	8	U2:7	C6:2			

	A	B	C	D	E	F
1	IC:Pin\Connection					
2	U3					
3	1	R8:2				
4	2	U2:2	R16:2			
5	3	U3:7	C5:2			
6	4	(GND)	C5:1			
7	5	R12:2				
8	6	U2:6	R10:2			
9	7	U3:8	U3:3			
10	8	(VCC2)	U3:7			
11	SW1					
12	1	SW1:2	SW5:1	U1:23		
13	2	SW1:1				
14	3	SW1:4	U1:13			
15	4	SW1:3	SW2:3			
16	SW2					
17	1	SW2:2	SW6:1	U1:24		
18	2	SW2:1				
19	3	SW1:4	SW2:4			
20	4	SW2:3	SW3:3			
21	SW3					
22	1	SW3:2	SW7:1	U1:25		
23	2	SW3:1				
24	3	SW3:4	SW2:4			
25	4	SW3:3	SW4:3			
26	SW4					
27	1	SW4:2	SW8:1	U1:26		
28	2	SW4:1	U1:26			
29	3	SW3:4	SW4:4			
30	4	SW4:3				
31	SW5					
32	1	SW1:1	SW5:2			
33	2	SW5:1				
34	3	U1:14	SW5:4			
35	4	SW5:3	SW6:3			
36	SW6					
37	1	SW6:2	SW2:1			
38	2	SW6:1				
39	3	SW6:4	SW5:4			
40	4	SW6:3	SW7:3			
41	SW7					
42	1	SW7:2	SW3:1			
43	2	SW7:1				
44	3	SW7:4	SW6:4			
45	4	SW7:3	SW8:3			
46						
47						

	A	B	C	D	E	F
1	**IC:Pin\Connection**					
2	**SW8**					
3	1	SW8:2	SW4:1			
4	2	SW8:1				
5	3	SW8:4	SW7:4			
6	4	SW8:3				
7	**R1**					
8	1	R2:1	USB:2			
9	2	(VCC)	*USB:1*			
10	**R2**					
11	1	R1:1				
12	2	U1:6				
13	**R3**					
14	1	D3:1				
15	2	U1:4				
16	**R4**					
17	1	(GND)	R7:2+R8:1	R10:1+R12:1+R14:1		
18	2	D7:2	U2:7			
19	**R5**					
20	1	R6:1				
21	2	D2:1				
22	**R6**					
23	1	PHONO:1	R5:1			
24	2	D1:1				
25	**R7**					
26	1	LED:2				
27	2	(GND)	R8:1+R4:1	R10:1+R12:1+R14:1		
28	**R8**					
29	1	(GND)	R7:2+R10:1	R12:1+R14:1	C5:1+C6:1	
30	2	U3:1	R9:2			
31	**R9**					
32	1	U1:16				
33	2	R8:2				
34	**R10**					
35	1	(GND)	R7:2+R10:1	R12:1+R14:1	C5:1+C6:1	
36	2	U3:6	R11:2			
37	**R11**					
38	1	U1:19				
39	2	R10:2	U3:6			
40	**R12**					
41	1	(GND)	R7:2+R10:1	R12:1+R14:1	C5:1+C6:1	
42	2	U3:5	R13:2			
43	**R13**					
44	1	U1:17				
45	2	R12:2	U2:5			
46						
47						

	A	B	C	D	E	F
1	IC:Pin\Connection					
2	R14					
3	1	(GND)	R7:2+R10:1	R12:1+R14:1	C5:1+C6:1	
4	2	U2:1	R15:2			
5	R15					
6	1	U1:15				
7	2	U2:1	R14:2			
8	R16					
9	1	U1:18	R17:2			
10	2	U2:2	U3:2			
11	R17					
12	1	(VCC)	D6:1	U1:7+U1:20		
13	2	R16:1				
14	C1					
15	1	(GND)	(PHONO:2)	C2:2		
16	2	(VCC)	R1:2	USB:1	C2:1	
17	C2					
18	1	C1:2 (VCC)	U1:7 (VCC)			
19	2	C1:1 (GND)	U1:8 (GND)			
20	C3					
21	1	XTAL:1				
22	2	C1:1 (GND)	C4:1			
23	C4					
24	1	C3:2				
25	2	XTAL:2				
26	C5					
27	1	U3:4 (GND)	C6:1	R7:2+R8:1+R10:1+R12:1+R14:1		
28	2	(VCC2)	U3:3	U3:7		
29	C6					
30	1	(GND)	U2:4	C5:1		
31	2	(VCC2)	U2:8	C5:2		
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						

	A	B	C	D	E	F
1	IC:Pin\Connection					
2	D1					
3	1	R6:2				
4	2	U1:3 (TX)				
5	D2					
6	1	R5:2				
7	2	U1:5 (OC2B)				
8	D3					
9	1	R3:1	USB:3 (D+)			
10	2	(GND)	USB:4	Phono:2		
11	D4					
12	1	USB:2 (D-)				
13	2	USB:4 (GND)				
14	D5					
15		Doesn't exist.				
16						
17	D6					
18	1	(VCC)	R17:1+C2:1	U1:7+U1:20		
19	2	D7:1				
20	D7					
21	1	D6:2				
22	2	U2:3	R4:2	U2:7		
23	LED					
24	1	U1:27				
25	2	R7:1				
26	XTAL					
27	1	U1:9	C3:1			
28	2	U1:10	C4:2			
29	J1					
30	1	U1:11				
31	2	J2:1 (GND)				
32	J2					
33	1	J1:2 (GND)	D4:2			
34	2	U1:12				
35	J3-4					
36	1	U1:2				
37	2	U1:28				
38	USB					
39	1	(VCC)	C1:2			
40	2	(D-)	D4:1	R1:1		
41	3	(D+)	D3:1			
42	4	(GND)	D4:2	Phono:2	D3:2+C1:1	
43	Phono					
44	1	R6:1				
45	2	USB4 (GND)	C1:1+D3:2			
46						
47						

Checking Shorts

It's just as important to check for shorts - that is, many connections SHOULD NOT connect together. The ones you really need to check are connections next to each other (i.e. U1:1 shouldn't connect to U1:2. U1:2 shouldn't connect to U1:3 etc), since this is where you're likely to have made a mistake.

Check U1's adjacent connections. Only U1:21 and U1:22 should connect to each other.

Check U2's adjacent connections. Only U2:7 and U2:8 should connect.

Check U3's adjacent connections. Only U3:7 and U3:8 should connect.

Check the USB signal connections. None should connect to each other.

Check J3-4, they should not connect to each other.

Check C1, C2, C3, C4 and C5. Pins 1 and 2 should not connect to each other. You may hear a very brief click as the capacitors discharge though.

Pay special attention to the switches, since some of the connections are really close. The Vertical connections on a particular switch should connect, but SW1:1 and SW2:2 shouldn't connect as shouldn't SW2:1 and SW3:2; SW3:1 and SW4:1. Similarly, SW5:2 and SW6:1 shouldn't connect, SW6:2 and SW7:1 shouldn't connect. SW7:2 and SW8:1 shouldn't connect. SW1:3 shouldn't connect to SW5:2, nor should SW1:3 connect to SW5:3. SW2:3 shouldn't connect to SW6:2. SW3:3 shouldn't connect to SW7:2 and SW4:3 shouldn't connect to SW8:2. SW1:2 shouldn't connet to R4:2 and SW1:1 shouldn't connect to R4:1.

LED1 and 2 shouldn't connect and neither should R7:1 and R7:2.

R8:1 and R9:1 shouldn't connect, similarly R10:1 and R11:1 shouldn't connect neither should R12:1 and R13:1 nor R14:1 and R15:1, nor R16:1 and R17:1

The most important thing to check is that VCC and GND aren't shorted.

Testing the Board: The Final Stages

You're now ready to start testing the board with actual power connected! At this stage, the ICs shouldn't be inserted. The first test is tthe non-functioning power on test.

1. First check there's no stray bits of metal under the PCB, nor stuck to the underside of the PCB!
2. Next check the USB-B cable can plug into the USB-B socket. Hold only the edges of the PCB and insert the USB-B cable, then remove it.
3. Connect your USB cable to your USB power adapter.
4. Whilst touching only the edge of the PCB and (whilst getting ready to remove it if there's a problem) insert the USB-B connector.
5. If there's no smoke or pops or anything else, then you've passed the first power-on test!!! Well done!!!

Part Two: Power On With Inserted Chips.

Now **REMOVE** the USB-B lead from the FIGnition computer!!!

Inserting The ICs

For some reason manufacturers supply ICs with their pins splayed out, but the sockets need them to be vertical as shown below:

As Supplied

As they need to be

You'll need to bend them all together so they stay in line, but they're fairly fragile, so you need to be careful. Start with the 8-pin ICs as they're easier.

1. Nold a chip with one end in a pair of pliars and the other end between my fingers.
2. Then I level the pins against a straight wooden surface for one side.
3. Then carefully turn the chip around (being careful not to touch the pins themselves with my fingers)
4. Repeat the process for the other side.
5. Repeat steps 1 to 4 for the other 2 chips.

Now you're ready to insert the chips.

Start with U2 (which says "23K640" on it) then U3 (which says "AMIC" on it) then U1 (which is the big chip!), but don't pick them up yet.

1. Place the PCB on your bench top-side up.
2. Locate the notch on one end of the chip. That's the end that should point to the top of the PCB.
3. Hold the chip by its plastic body, at the top and bottom end, and avoid touching the legs as you might damage it with static electricity.
4. Carefully insert the cihp into its socket WITHOUT bending any of the legs, or twisting them etc. You might need to readjust the legs, but you must make sure they're all located well enough before applying force. You'll need a certain amount of force, but it shouldn't be too hard just using your fingers. Remember to insert the chips with even force since if one side or end goes in first it may twist or bend the legs of the other end, preventing it from fitting.

Again you need to do some checking.

1. Check the pins have all gone in OK (there's no metal pins squiffing out of a socket).
2. Check that the notch on the IC is pointing to the top (otherwise you're likely to burn out the entire chip as you'll connect VCC to it's GND pin and vice-versa).
3. Check that U3, the top one says "AMIC" and that U2 (the bottom one) says "23K640" on it.

Once you've done that you're ready for the next test:

1. Whilst touching only the edge of the PCB and (whilst getting ready to remove it if there's a problem) insert the USB-B connector.
2. If there's no smoke or pops or anything else, then you've passed the SECOND power-on test!!! Well done!!!
3. Wait a little while to see that it continues to be OK. The LED shouldn't light nothing should happen for the moment.

OK, remove the USB-B connector again.

Now let's try it with your TV. CRT TVs work best, and LCD TVs require more precise timing - they can work, but the image may jitter (perhaps a future firmware revision may improve this).

1. Plug one end of your phono lead into your TV.
2. Turn on the TV.
3. Select the correct video input (I guess either SCART or Composite depending on how your phono lead connects to your TV). With the correct connection the image should be a steady black image even before you've powered on the FIGnition computer.
4. Plug the USB-B connector back in without touching any of the keys on the keypad. The FIGnition logo should instantly appear and a couple of seconds later the power-on message should appear!

CONGRATULATIONS - YOU'VE BUILT YOUR OWN COMPUTER FROM SCRATCH AND IT STARTS UP!!!!

Now you need to take another tea break. You've got more testing to do to make sure it works properly!!!

Testing That The Computer Works Well Enough

There's a number of tests you can make to test basic functionality:

- Test the keyboard works by holding the top right key and pressing the others in turn you should get: m, n, o (then on the bottom row), p, q, r, z. Now delete all the characters by hitting the top right button until they've all gone.
- Test the RAM can work. Use the Use-it section and type: **43 const x** <enter> (the computer will display OK). **x .** <enter> and you should see **43 OK**.
- Test the Flash can work.
    - Use the Use-it section to use the editor.
    - Type **0 edit** <enter>. And then move about the screen and enter up to 500 characters of text.
    - Type <command (SW2+SW6)> then Shift (SW5), then 'W' (SW8+SW5) to write your text to block 0 of Flash.
    - The computer should show a bit of gibberish on the top of the screen, and display OK again.
    - Type **cls** <enter> the screen should clear.
    - Type **0 list** <enter> the screen should display the text you edited previously.
- Test the USB uploading works. You'll only need to do this when you want to upload new firmware, but it's good to try doing it as soon as possible. Go to the Use-it link and follow the instructions for upgrading the firmware using avrdude (you'll need avrdude at this point). The procedure is covered there and should work OK.

CONGRATULATIONS AGAIN - YOU'VE BUILT A FIGNITION COMPUTER FROM SCRATCH THE WAY THOUSANDS OF PEOPLE DID IN THE 70S AND IT FULLY WORKS!!!!!! YOU'VE REALLY REALLY DONE IT!!

Now for the fun part of actually making it do things!!!!