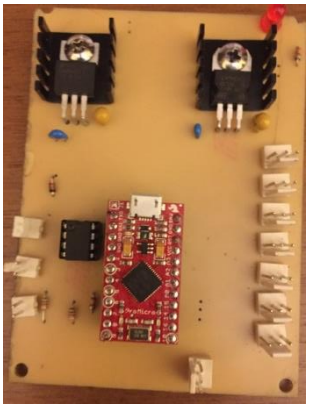
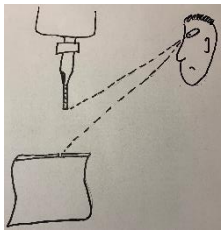
An Index System for Hand Drilling Circuit Boards, Version 1.3

By R. G. Sparber



No, I was not drunk when I drilled the holes for this circuit board. I did the best I could while sober. Looks really bad near the bottom left corner, doesn't it?

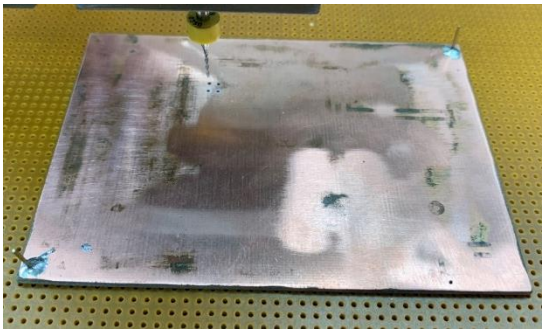
Most of the connectors had to be twisted into position.



Parallax makes it nearly impossible to align the end of the tiny spinning drill with an equally tiny spot on the board. Consider that the drill is around 0.04 inches in diameter and is around ¼ inches above the surface. I must carefully lower the drill to reduce parallax yet not touch-down until I'm at the right spot. Time to look for a better way to do this.

Ah, this is much better! See how all the holes are in a nice straight line and on grid. The alignment is good enough that sockets smoothly drop into place. The parallax problem has been eliminated and the entire process is about ten times faster.

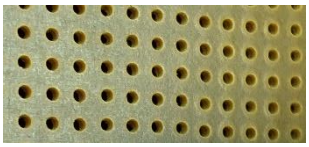
This is where we are headed. →



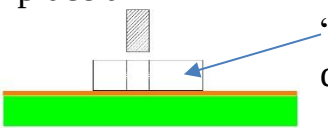
A video of me drilled a straight line of holes can be seen at

https://www.youtube.com/watch?v=bnjrcg_Vjo4

Evolution of An Idea



If you look online, you will see YouTube videos that show how to place a



"perf board" on top of the circuit board to be drilled. It is used as a drill guide.

This works fairly well but has a few problems:

- You need to mark which perf board holes to drill because you can't see the artwork etched into the copper underneath it.
- You must visually align the drill in the center of each hole. Parallax is still a problem but not as bad since the drill can enter the perf board before it starts cutting the hole. It still takes a lot of time to get this alignment right.

My solution to this problem cooked in the back of my head for over a year. Then the glimmer of a solution popped into my head:

I don't want to mark which holes to drill – this is necessary because the drill guide is on top of the circuit board. Fine, put it under the circuit board so it is out of the way!

I don't want to visually align the drill in the center of each hole – why not use alignment pins mounted in the circuit board that engages the drill guide?

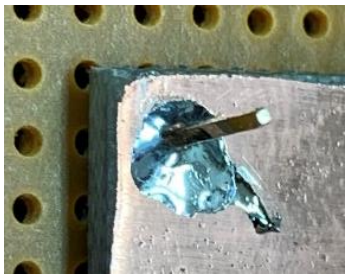
In order to explain where these insights led me, I will first show you the set up of the tool, take a short visit to theory, and then show you the results. This will be followed by error analysis.

The Process

I'm using a scrap piece of circuit board here but assume that all holes to be drilled are on a 0.1 inch grid, just like the perf board. That is how I design my boards.

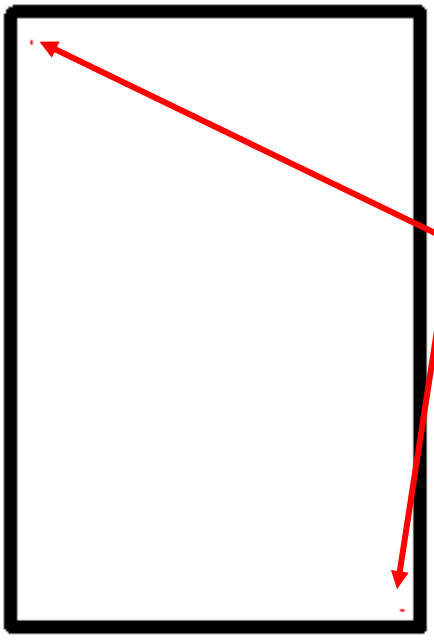
I start by selecting a hole location near a corner of the circuit board. It is carefully drilled free hand with my Dremel drill press.

The tiny drill cuts a hole that it is a snug fit on a connector pin. These are the same pins that I use for all board mounted connectors and for component sockets.



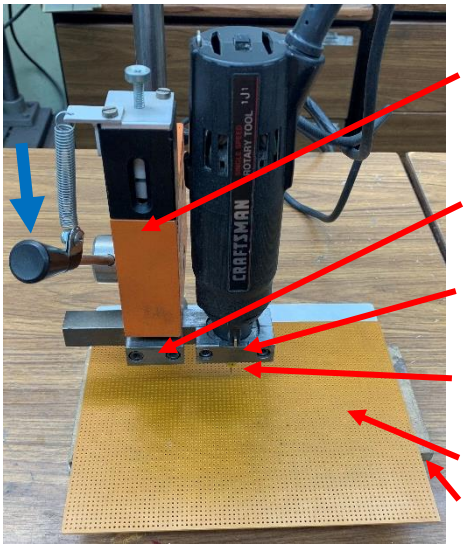
The pin is fed through the circuit board and into a piece of perf board below it. The perf board is flat on the table. This sets the stick-out of the pin at the same thickness as the perf-board. I then solder it in place while keeping the pin as vertical as possible.

The plastic collar that is part of the connector makes a nice handle on the top of each pin.



The process is repeated at a hole located near the opposite corner of the circuit board.

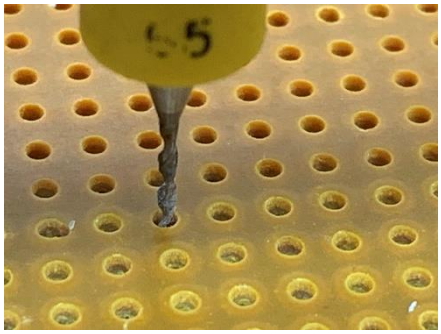
Remember, these two pins are located on a 0.1 inch grid along with all holes to be drilled on this circuit board.



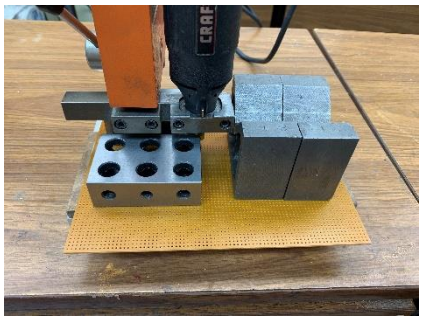
Now let's look at my Dremel drill press. The downfeed mechanism was repurposed from a medical device. It moves very smoothly plus has no perceivable side play.
One clamp holds onto a stud on the bottom of the downfeed mechanism while the other holds onto the bottom of the Dremel. Pushing down on the spring-loaded lever (blue arrow) feeds a tiny drill bit down.

There is a sheet of perf board on the drill press table. The table is a piece of MDF bolted to the aluminum base.

The perf-board was glued to the MDF using white Elmer's Glue. This has a few advantages. First of all, I can get the perf-board off of the table when it is worn out by pouring water on it. The glue is water soluble. Second, since no fasteners were used, I have access to every hole on the perf-board. And third, I have some work time before the glue sets.



During the glue's work time, I slid around the perf board until I could lower the drill down through one of the holes. Alignment is critical here so I took my time. Note that the drill diameter matches the perf board which helps a lot.



Then weights were placed on the perf board until the glue dried.

You may be wondering, about now, what this all is supposed to do. Fair enough, let's consider how this all works by first looking at just motion along the one axis.

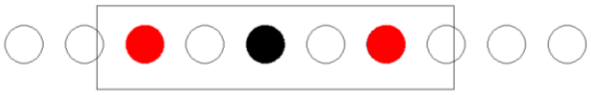
A Little Theory

For clarity, I will limit this discussion to a single line but will later expand to two dimensions. The following are all X-ray views looking down through the drill press.

Say I have a series of perf board holes spaced 0.1 inch apart. My drill is located precisely over the black hole.

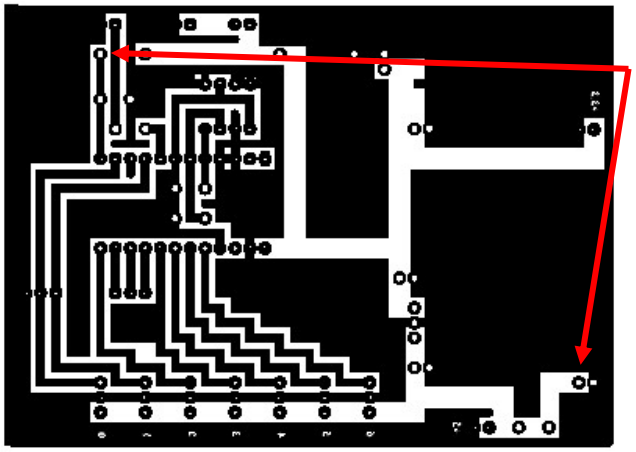
I have my one-dimensional circuit board with its locator pins shown as red dots. I want to drill the hole outlined in the middle. The pins and the needed hole are all spaced 0.1 inches apart.

In the ideal case, my line is defined by any two points. In practice, there is play between the pins and perf board holes. This error is minimized by placing these pins as far apart as possible.



When I drop the circuit board's locator pins into the correct perf board holes, the hole I want to drill in the circuit board is aligned with the drill. Any hole I drill on this circuit board will be on 0.1 inch centers as long as the pins engage with holes in the perf board.

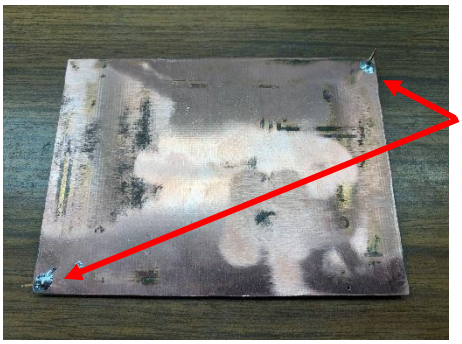
Now, if this works for one dimension, it will work for two. Instead of a line of perf board holes, I have an array. I want my pins as far apart as possible which means they go on opposite corners of the circuit board.



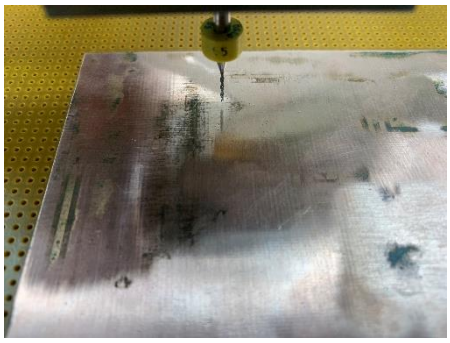
If I was drilling this artwork, I would place my locator pins in existing hole locations. They are all on the same 0.1 inches grid.

Let's try this out.

Sorry to say, but I only have a crappy piece of circuit board to drill. It would be far more credible if artwork was available.

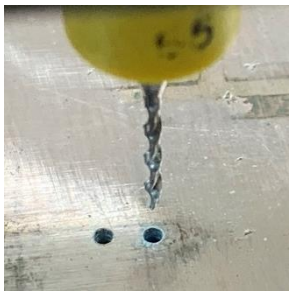


I took a piece of scrap copper clad board and installed pins on opposite corners. These pins are on the 0.1 inch grid of the circuit board but no artwork was etched.



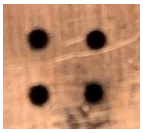
I drop the circuit board down on my perf board and move it around until my locator pins drop into holes near the position of my first hole. A little care must be taken to be sure the board is square to the perf board grid of holes.

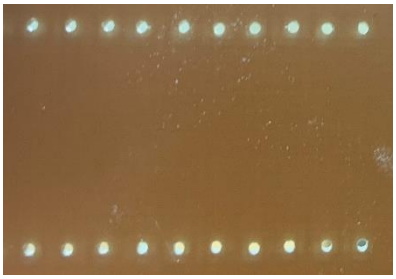
The hole I am about to drill will be on the 0.1 inch grid found on my circuit board because my two locator pins are on this grid and the drill is also on the grid.



Next, I lift up my circuit board until the locator pins disengage from the perf board. I drop it down in the set of holes adjacent to the last set. This placed my drill 0.1 inch to the right of my first hole. Without needing to align the drill better than to the nearest 0.1 inch, I drill down and am confident that I am on grid.

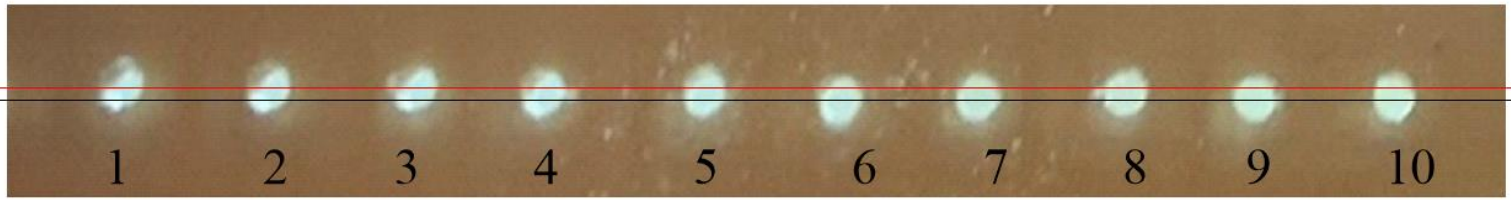
The process quickly repeats until I have drilled four holes in a square.





Here you see a series of holes ready to accept a large connector.

When I look closer, errors are evident.



Holes 1 through 5 are centered along the red line. Holes 6 through 10 are centered along the black line. These holes are 0.04 inches in diameter and on 0.1 inch centers.

Using my 2D graphics program, I was able to estimate the vertical distance between red and black lines to be 0.008 inches. I don't know what caused this shift but more testing should expose the error source.

Subsequent testing showed that the board was warped. In this run, I held the board down flat as I drilled. Although not perfect, I think it is better. It is good enough to permit a connector to slip right in.

The next day, I did more testing and now see that my feedrate is another major source of error. By feeding the drill into the board slower, the holes line up. I suggest taking taking a full second to feed down on each hole.

Bottom line: be sure the board is pressed down on the perf board before starting to drill and then take a full second to drill each hole.

Over time, the holes in the perf board will enlarge cause play in the locator pins. I will then dump water on the perf board to release the glue, wash off the old glue, put down fresh Elmer's glue, and align a new perf board. The worn out perf board is still usable for building circuits.

Acknowledgment

Thanks to Donald Locker for finding a typo.

I welcome your comments and questions.

If you wish to be contacted each time I publish an article, email me with just "Subscribe" in the subject line. If you are on this list and have had enough, email me "Unsubscribe" in the subject line.

Rick Sparber
Rgsparber.ha@gmail.com
Rick.Sparber.org