On Countersinking

Release 1

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1 Preface

I first wrote about countersinking a few months ago and, by pure chance, the article just sat around unpublished. Meanwhile, countersinking from time to time, it became clear to me that the process, while reasonably effective, was not the intuitive cure-all that I had originally hoped. Fortunately, there was still the opportunity to add some thoughts. So this is actually two articles in one, the original followed by an entirely different approach that I think is just as accurate and much more user-friendly. See what you think.

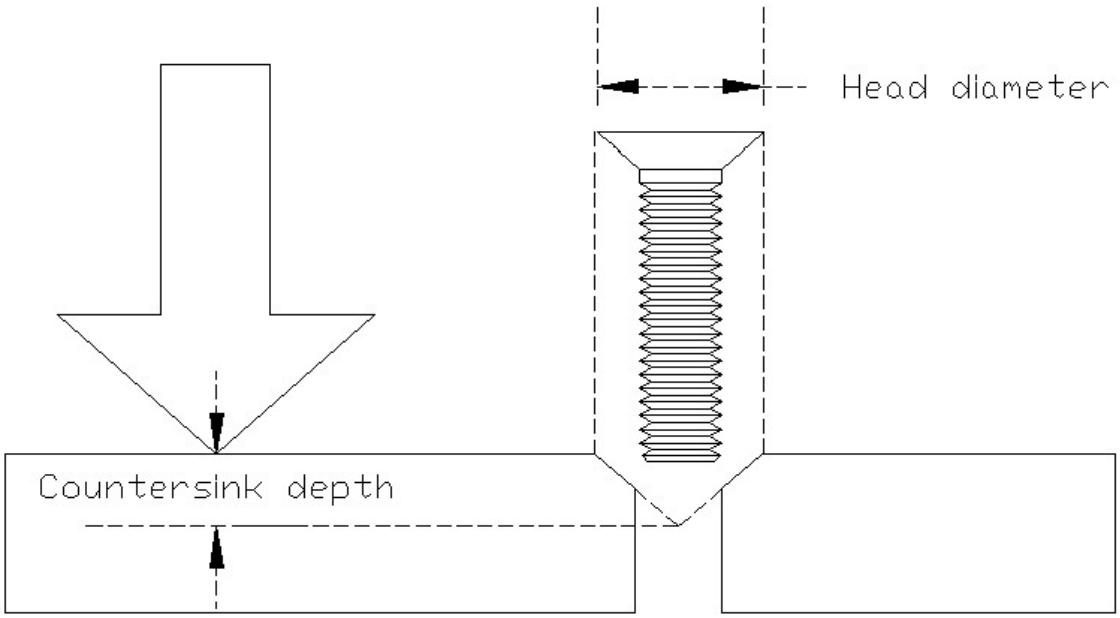
2 The Original Article

2.1 Introduction

For years I did half-vast countersinking the old-fashioned way, - trial and error. Then recently I decided there just had to be a better way and went looking for it. It's got to be out there somewhere, but I couldn't find it anywhere. So maybe there's room for a description of the best technique I've been able to come up with on my own. Here it is.

2.2 Countersink Depth

The following diagram shows how the countersink depth is determined.

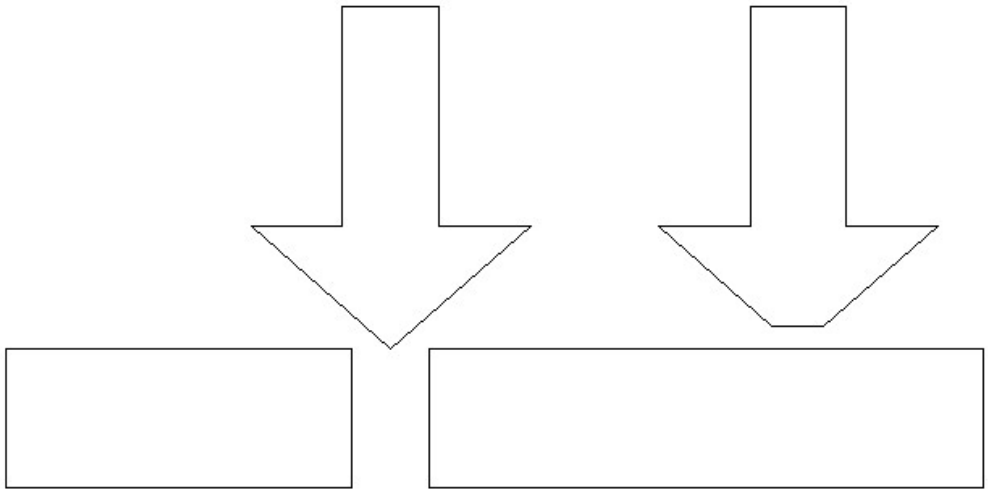


For any given countersink angle, the depth of a perfect countersink recess is a constant fraction of the screw head diameter. The following table shows the fractions for each of the countersink angles listed by Severance Tools . I've never needed any but the 82 and 90 but you never know so I calculated them all. The derivation math is at the end of this article.

Countersink Angle		Depth Factor
Included	Center-line	
60	30	0.866
82	41	0.575
90	45	0.500
100	50	0.420
110	55	0.350
120	60	0.289

So, if you have, say, an 82° 10-32 FHMS whose head diameter measures .366", then its countersink depth will be $.366 \times .575 = .210in$. In my experience, the heads of mass-market fasteners don't seem to be made to any particular standard, are pretty variable in diameter and really need to be measured. It must give the CNC folks real headaches.

2.3 Practical Application

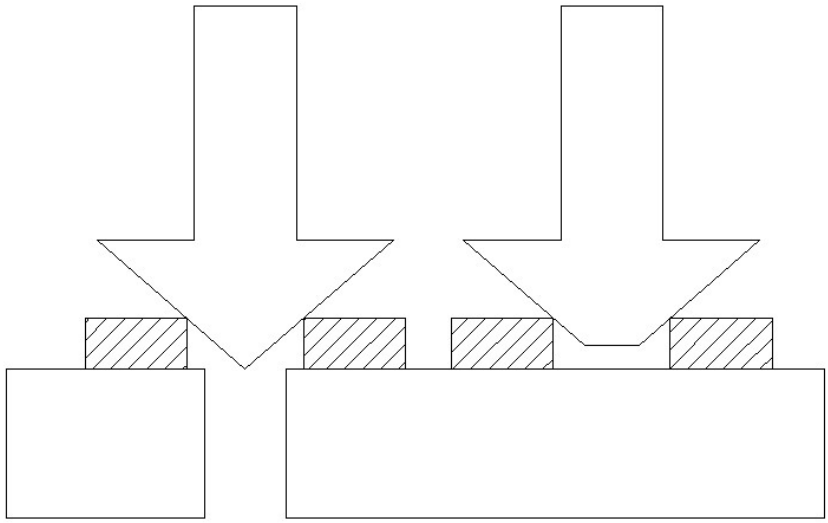


Actually trying to apply the depth measurement in practice leads to a bit of a problem. The starting point must be that at which the pointed tip of the countersink just touches the stock surface. But maybe the countersink doesn't have a point. Maybe the tip is truncated to a flat. Even with a point, if it's over the pilot hole you just drilled, there's no surface left there to contact.

What we need is a gauge.

2.4 A Setup Gauge

Here is a schematic of a simple gauge.



In use, the sequence is:

- Slip the gauge between the countersink and work and lower the spindle to contact the gauge.
- Lock the quill and set the depth stop to the countersink depth increment.
- Unlock the quill, raise it, remove the gauge and complete the countersink.

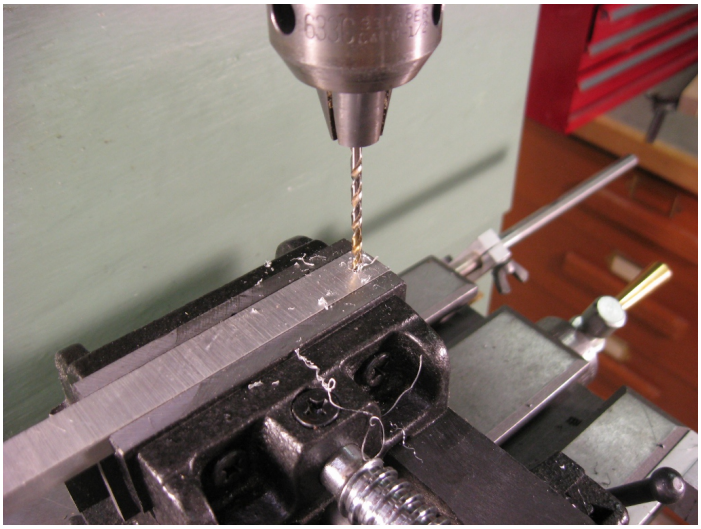
Again, in practice, this may not be so easy. Today many drill presses don't have a quill lock and/or the depth stop is not linear but circular, a lockable rotating collar on the feed handle arbor. You can hang a weight on the feed handle to simulate a lock but it's almost impossible to get an accurate setting with a circular depth stop. Precise countersink depths depend on precise spindle control. Without it you're pretty much back to trial and error.

On a brighter note, the gauge is easy to make. Just drill a hole in a piece of CRS. I find 1/8" a good thickness because it lets me use commonly available drills for the holes. If you use uncommonly large or tiny countersinks, a different combination of thickness and hole diameter may be needed. If so, the formula at the end of the article defines the relationship.

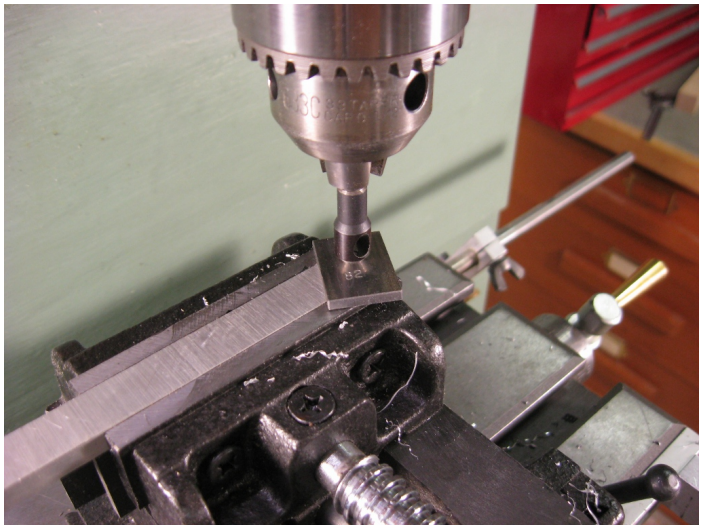
Here is a table showing the hole sizes needed for the various countersink angles in 1/8" gauge stock.

Hole Sizes for 1/8" Countersink Gauge Stock			
Countersink Angle (Degrees)	Ideal Hole Size (Inches)	Drill	
		ID	Size
60	0.144	#27	0.144
82	0.217	7/32"	0.219
90	0.250	1/4"	0.250
100	0.298	19/64"	0.297
110	0.357	T	0.358
120	0.433	11mm	0.433

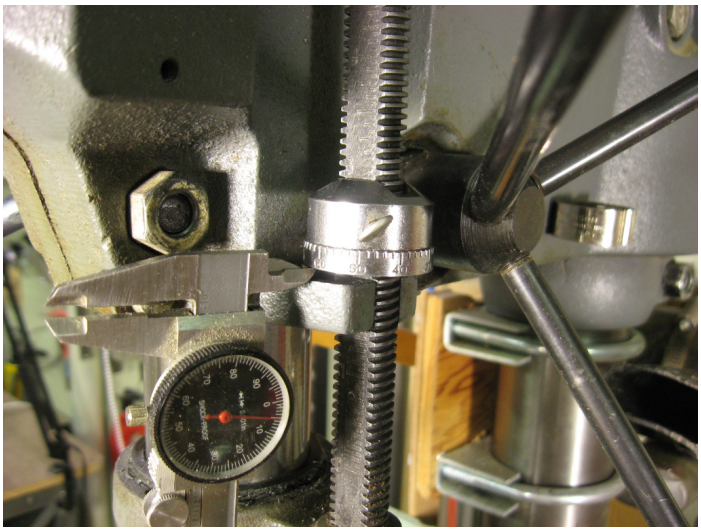
2.5 Doing it



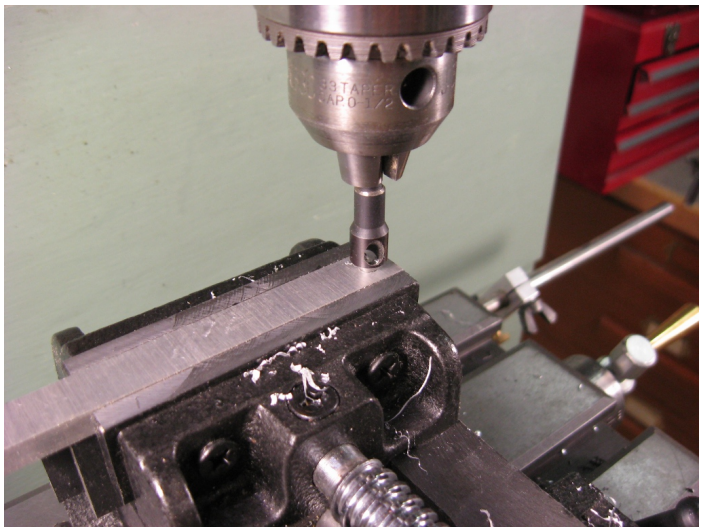
Drill a pilot hole



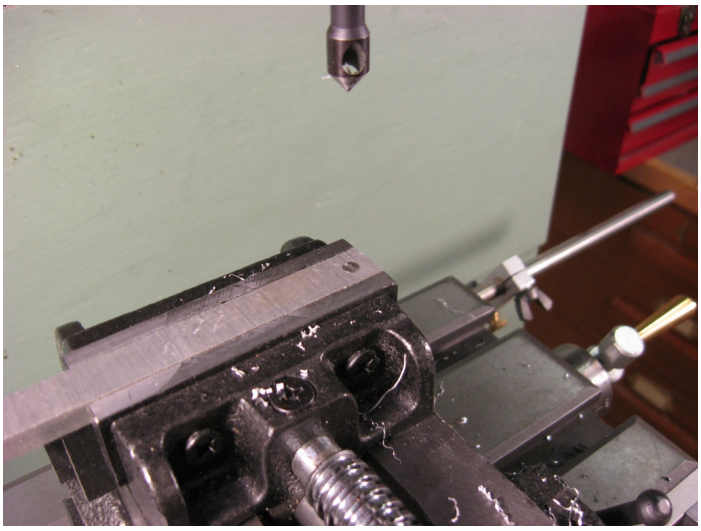
Lock on the countersink gauge



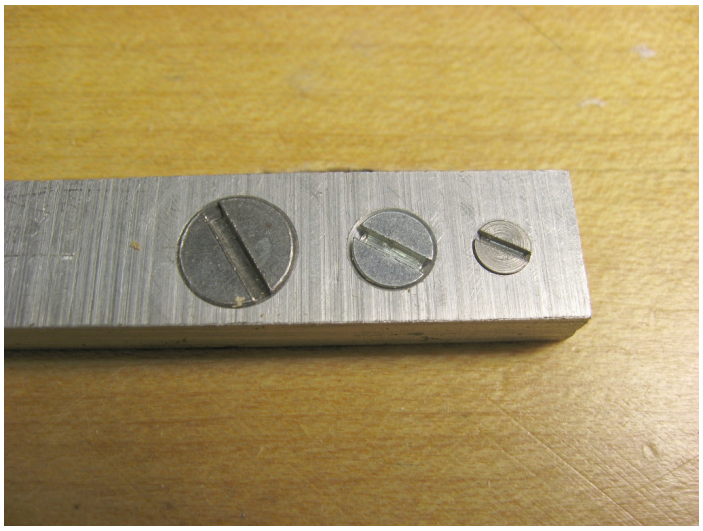
Set the countersink depth



Remove gauge and do the countersinking



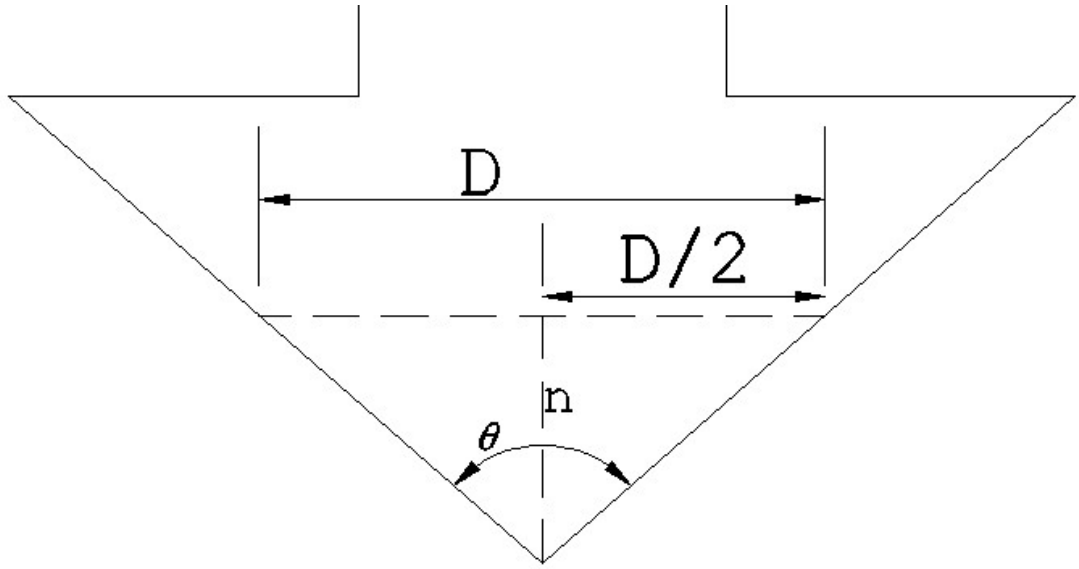
Observe the fit



Do some more for practice

2.6 The Math

Depth Factors



Where:

- D = Screw head diameter
- θ = Countersink included angle
- n = Depth of countersink recess

Find the value of x where $n = Dx$

Solving:

$$x = \frac{n}{D}$$

$$x = \frac{\frac{n}{(\frac{D}{2})}\frac{D}{2}}{D}$$

$$x = \frac{(cot\frac{\theta}{2})(\frac{D}{2})}{D}$$

$$x = \frac{\frac{cot\frac{\theta}{2}}{2}D}{D}$$

$$x = \frac{cot\frac{\theta}{2}}{2}$$

Application:

The depth factor for a countersink with an 82° included angle,

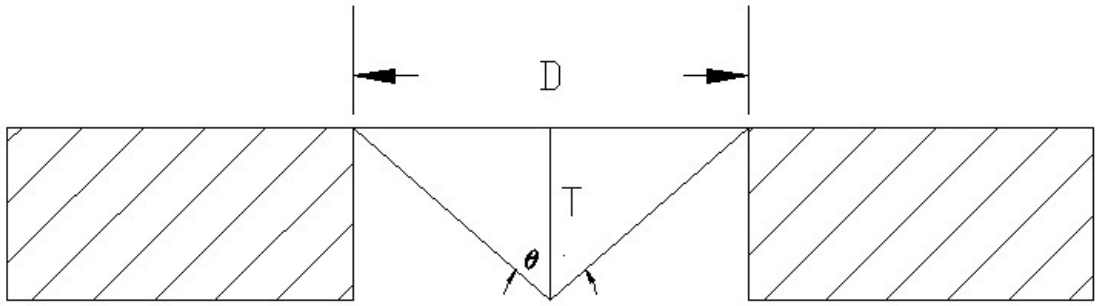
$$x = \frac{cot\frac{82}{2}}{2}$$

$$x = \frac{cot41}{2}$$

$$x = \frac{1.15036}{2}$$

$$x = .57518$$

Gauge Properties



Where:

- D = Gauge hole diameter
- θ = Countersink included angle
- T = Gauge thickness

Find the value of x where $x = \frac{D}{T}$

$$x = \frac{2\frac{D}{2}}{T}$$

$$x = 2tan\frac{\theta}{2}$$

Application:

The hole size in a 1/8″ thick gauge for an 82° countersink,

$$\frac{D}{T} = 2tan\frac{\theta}{2}$$

$$D = 2tan\frac{\theta}{2}T$$

$$D = 2(tan41)T$$

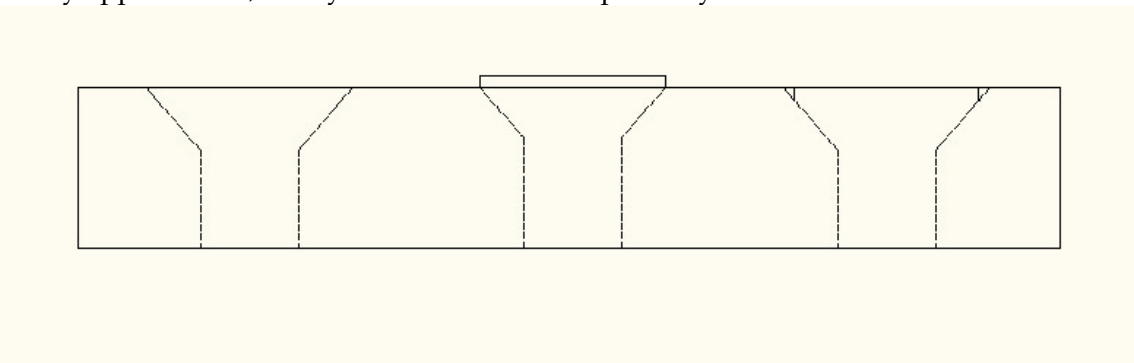
$$D = 2(.8693)(.125)$$

$$D = .217$$

3 On Second Thought...

3.1 In Hindsight

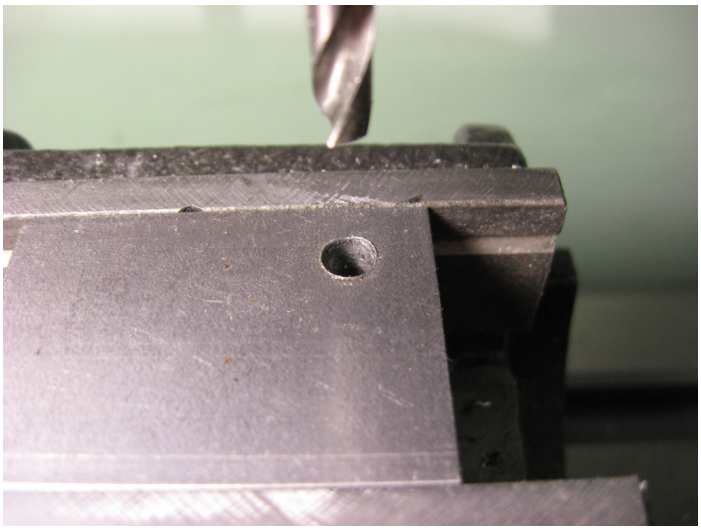
In use, the preceding approach gives pretty good results but not without a residual element of trial and error. The biggest problem seems to be variability in the shape of the screw head. The method assumes that the measured diameter is that of a perfect 82 degree cone. But it rarely, if ever, is. The periphery of the screw head is almost always slightly flattened, removing the knife-edge that is needed for accurate measurement. A recess based on its diameter is too shallow, the screw head stands slightly proud of the surface and some additional deepening by eye-ball is required. So if all you can hope for is a first try that never goes too deep but is otherwise only approximate, surely there must be a simpler way.



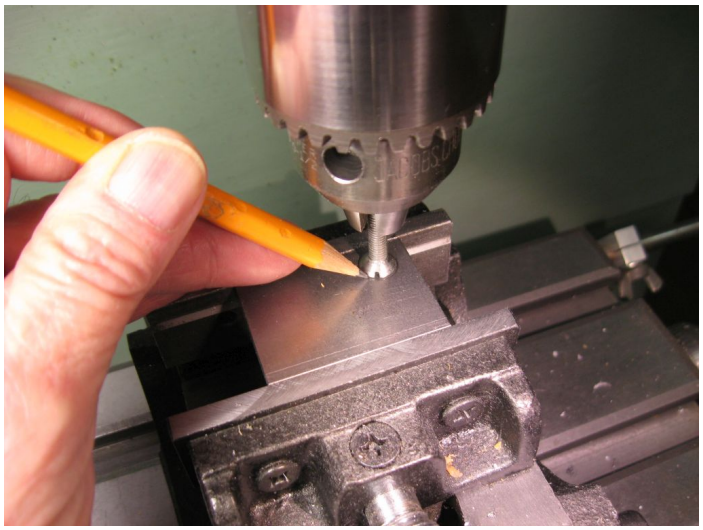
Perfection, Imperfection and Correction

3.2 Doing it more Simply

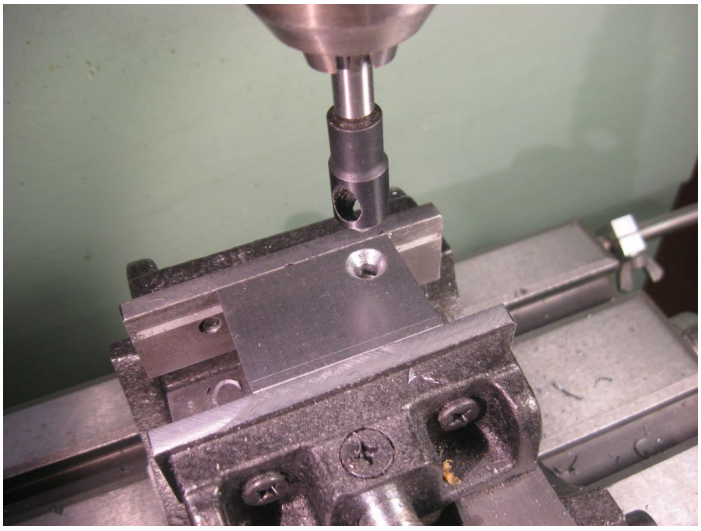
Here is a technique without measurement, tables or calipers, that works on any drill press and gets just as close on the first pass as the original. It still uses a gauge but it's just the screw itself lightly held upside down in the drill chuck. If the periphery of the screw head is quite sharp, a scriber can be used for marking. Otherwise, I find that the thickness of the pencil lead helps to compensate for the head edge flattening.



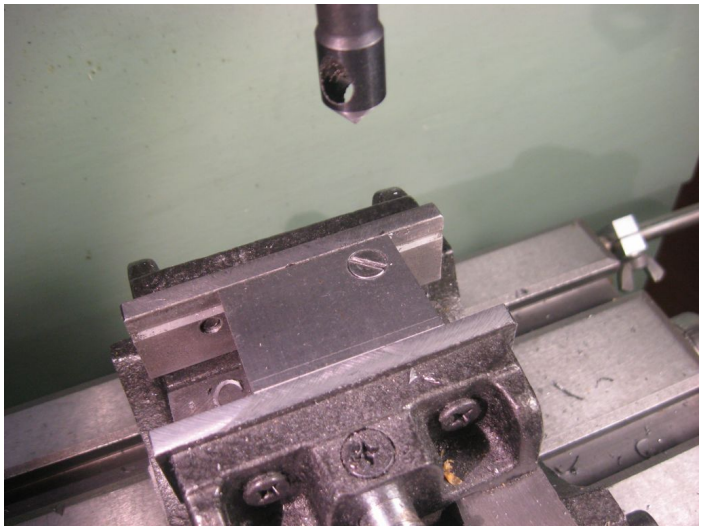
Drill a pilot hole



Mark the Perimeter



Countersink to the Mark



Check the Fit

It usually takes me more than one stroke to get a perfect countersink because of the inherent limitations in the gauging process. This is the best I've been able to do. If anybody out there has a better technique, I'd sure love to hear about it.

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