

# Contractor Table Saw Alignment

or

## *Overcoming the Perverse Nature of an Inanimate Object*

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### Introduction

My woodworking journey began over a quarter century ago when I bought a well used Tool Kraft radial arm saw. The main mission was to finish our basement. Several years later I got the bug to build some furniture and quickly decided that the old radial arm saw was not going to cut it (pun intended.) I headed to Sears and bought a Craftsman 10 inch direct drive table saw with an aluminum table. I soon hated it, because in addition to being inaccurate, the aluminum ribs scratched and put black marks on the wood. As I was complaining about the Craftsman to the owner of a local industrial supply business, he said "I have a deal for you!" He had a Taiwanese made Contractor Saw that he had been unable to sell. It had cast iron extension tables, was fully assembled and ready to go. I really liked it for a few years until I bought some high quality blades and realized that the saw was out of alignment. The blade was heeled to the left resulting in burned wood especially when cross-cutting.

I bought several books (this was pre-internet) and following their instructions, attempted to align the blade to the miter slot. I didn't have any measuring tools more precise than a combination square, but by using the square, and pinch sticks, I was able to improve the alignment. However, no combination of pounding, pushing, pulling or other methods of persuasion could get the blade exactly parallel. Its adjustment range was just not great enough to be able to move the back of the blade from a "minus" to a "plus" location. I chalked it up as a learning experience, and proof that "Buying cheap usually costs you in the end." Someday I would buy a quality cabinet saw, and until then I would work around the problem.

Woodworking was put on hold when I became a small business owner, and moved 500 miles. For many years all my equipment sat unused, as after working 12 hour days I didn't have the time or energy to make sawdust.

### A Return to Woodworking

I have now retired and a major priority is to crank up the woodworking shop. The table saw's alignment was worse than ever after having been moved several times, and I decided that this time I was going to kill it or cure it. I bought a dial indicator with a magnetic base and a digital caliper, figuring that I should be able to jig at least one of them to take the guess work out of the measurements. A new problem was now apparent. While I could get it "almost" aligned, within

### Why is Alignment Important?

Visualize a perfectly aligned table saw making a crosscut. As the stock is pushed into the blade the teeth start making a kerf. Note that as the cut progresses the teeth only cut on their downward rotation (The upward moving teeth are moving through the kerf that has already been cut). Also note that the blade's steel plate does not touch the sides of the kerf. In this ideal setup the blade's downward rotating teeth will be pushing the stock down, and the upward rotating teeth will not be cutting, so therefore will not be lifting the stock, or creating sawdust

Now, visualize a saw that is misaligned. For the sake of illustration, assume that the blade is heeled to the left. As the stock is pushed into the blade the teeth cut a kerf as before, but shortly afterwards the stock collides with the blade's steel plate. If the stock continues to be pushed into the blade several things or a combination of things will happen depending on how severe the misalignment: (1) The blade will push the stock sideways across the miter gauge away from the blade. (2) If the stock is tightly clamped against the miter gauge, or if a stop on the gauge prevents the stock from sliding away from the blade, the blade's steel plate will attempt to burn its way through the wood. (3) The motor will stall. (4) The stock will kickback. After the stock passes the centerline of the blade the blade's rotation will try to lift the stock, and when the stock reaches the rear teeth, they will now start cutting the stock and add to the lifting force. Since the blade's rear teeth are cutting on their upward rotation the chance of stock tear out greatly increases as the rear teeth exit the stock

So what are the symptoms of a misaligned blade?

- Burning of the cut edge
- Stock tear out
- Sawdust kicked up by the rear teeth
- Cut wider than intended
- Stock drifts when ripping
- Stock slips on miter gauge
- Kickback

a few days it would drift back to major misalignment. I did some serious web surfing to see what other folks were doing. I hit pay dirt when I happened on Brian Grella's Garage Woodworking website and he pointed me to the Edward J. Bennett Company, the manufacturer of TS Aligner Jr. Bennett has a blog titled **The Ultimate Guide To Table Saw Alignment**. It is so much better than all the books and magazine articles on the subject that it isn't even in the same league. This was the beginning of a series of email conversations with Ed regarding my trials and tribulations. I can't thank him enough for all the help he has provided. By using the ideas gleaned from Brian's and the TS Aligner blogs I quickly made an alignment jig which yielded accurate and repeatable measurements.



### Identifying the Root Problem

A vexing problem was trying to move the trunnions. All the literature says to just slightly loosen the bolts, and tap the rear trunnion into place and tighten the bolts. Yeah, right. No amount of tapping through a block of wood (gentle or otherwise) would move the rear trunnion. I could move it by standing behind the saw and lifting and pulling/pushing on the motor mount, but as soon as I released it, it would return to about where I started. Back to Ed's site. I followed his suggestion to add more flat washers as well as some grease to the mounting bolts. It helped. Got a bright idea to use a Quick Grip clamp to pull the trunnion over and hold it while the bolts were tightened. It seemed to work, and I was starting to be happy. But, I had aligned it with the belt off to make turning the blade easier and when I reattached the belt, the alignment that I had achieved (0.003) went to 0.006

After several iterations of different approaches to achieve alignment with the belt on, I was getting nowhere and it seemed that if I just looked at the saw, the alignment would change before my eyes. The root cause of the problem (other than the poor design of contractor saws in general) was that the trunnion mounting holes were not large enough to achieve alignment. As much as I was avoiding it, the saw would have to be completely disassembled to access the trunnion holes.

### The Tear Down

- Removed fence, blade, and belt but left the fence guide rails and table extensions attached, as well as the motor.
- Invited my neighbor over for a Coke and drafted him to help me lift the saw straight up while I kicked the mobile base aside, and then we set the saw onto the floor. (It was almost too heavy for two people especially considering that one of the two (me) is only 68 inches tall.) We then tilted the saw to its left and lowered the table extension to the floor, repositioned our handholds, and turned it upside down on the floor taking care to prevent the motor from flopping around. (My neighbor went home moaning about his back.)
- Removed leg assembly from the base. Drafted more help (4 people this time, including me) and lifted the saw (still upside down) onto the leg assembly. The reason to move it from the floor was to eliminate having to bend over or sit on the floor to remove the trunnions. Remember, I am older than dirt, and getting up from the floor is a major effort.
- Removed motor from its mount and laid it on the extension as shown in the photo.
- Removed hand wheels, punched out roll pins, loosened set screws on tilt shaft collars and removed tilt and elevation shafts.



- Unbolted trunnions and moved the assembly onto the workbench for cleaning and inspection. I was encouraged to see that there was virtually no rust or wear evident on any of the parts.
- The trunnion holes were “as cast” and had not been machined to size. The rear trunnion holes were slotted, but the increased adjustment range provided by the slot was largely defeated by a round counter bore. The front trunnion holes were also “as cast” but were essentially round and had round counter bores.



**FRONT AND REAR TRUNNIONS BEFORE MODIFICATION**

**Fixing the Problem**

I was considering going to a machine shop and having the trunnion mounting bolt surfaces machined flat as well as lengthening the rear trunnion slots. After another email exchange with Ed Bennett I decided to limit the modification to just lengthening the holes with a file to avoid weakening the trunnions. Each rear trunnion slot was lengthened by approximately 0.100 inch (in the direction that would allow the rear of the blade to be moved further to the right when viewed from the front of the saw). While it probably wasn't necessary, I also slotted the front trunnion holes in the same manner to make sure that I would have all kinds of adjustment capability. (I never want to take this saw apart again!)



**MODIFIED REAR TRUNNION**

**FABRICATED WASHER**

Another factor that limited the adjustment range was that the washers on the trunnion mounting bolts would hit the edge of the counter bore and not allow the trunnion to be adjusted up to the bolt edge. This was solved in a two-fold manner. The first step was to modify flat washers by elongating its hole to allow the mounting bolt to be able to travel all the way to the end of the slot. These washers were then used as fillers to move the clamping surface to slightly above the un-machined surface of the trunnion. The second step was to replace the rear trunnion mounting bolts with a PAL'S kit. - see references. The trunnion clamping force is provided through the PAL's aluminum bracket, and the fabricated washer fills the counter bore depth. As can be seen in the photos the real beauty is that the adjustment is made with socket head cap screws instead of a hammer and a block of wood or whatever.



**PAL KIT**

**READY FOR PAL BRACKET**

The next step was to install the PAL's studs into the table top using a thread locking compound. (I used Loctite medium and let it cure overnight.)



**REAR TRUNNION SPACER**

**FRONT TRUNNION SPACER**

**Reassembly**

Finally, I put it all back together (except for the motor) and made some preliminary alignment measurements. This was probably the most painful part of the project as I had to lie on the floor, slide under the saw, take a measurement, slide out, stand up, adjust, repeat ad infinitum. At this point I wasn't interested in actually getting it zeroed in, but to establish whether I could go plus and minus from zero. Eureka! I could go plus and minus at least 0.015 inches (with the blade at 90 degrees.) Now it was time to check the alignment with the blade at 45 degrees. Not surprisingly it was off big



**PAL KIT AFTER INSTALLATION**

time. Using the procedures described in Ed Bennett's blog, the front trunnion needed to be shimmed up by 0.046 inch, I fabricated spacers from scrap metal that I had laying around. Nothing fancy here, used a hacksaw and files. I decided to over shim the front trunnion so that I would have plenty of latitude to make all final adjustments on the rear trunnion, since it is so difficult to access the front trunnion when the saw is on its feet. I put 0.080 inch spacers under the front trunnion, and 0.042 inch spacers under the rear.

I lubricated the tilt and blade height shaft bushings with white lithium grease, but I wasn't comfortable with using it for the gears because it is quite sticky and saw dust would stick to it. After considering and discarding several recommendations including using beeswax and paraffin (Mainly because the mess I envisioned on the kitchen stove), I decided to use a spray on Moly lube. I covered the arbor and the table top opening with an old towel and sprayed all of the moving parts making sure that the trunnion slots got a good shot. It dries almost instantly and it doesn't appear that saw dust will stick to it. (So far the Moly lube is working out well and the hand wheels turn easier then ever.)

Next came remounting the motor which was easier said than done when working alone. A helper to insert the pin into the mounting hole while I held the motor in position would have been nice. Also aligned the drive pulley with the arbor pulley and installed the belt guard.

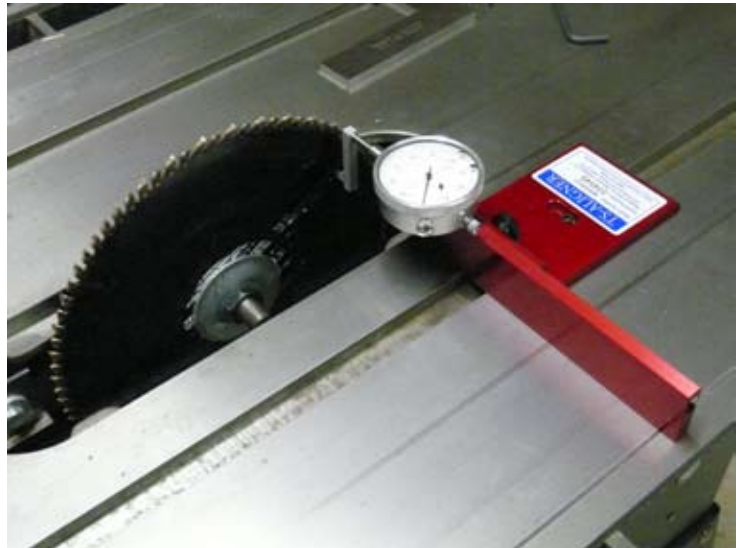
I reenlisted the assistance of my helpers and we lifted the saw off the leg assembly, and set it onto the floor. We then put the leg assembly into the movable base, picked the saw of the floor, rested it on the left table extension, and then lifted it onto the leg assembly. After installing the mounting bolts and drive belt, I was ready to make the final adjustments.

### **One Test is Worth a Thousand Opinions**

By this time I had purchased a TS-Aligner Jr. which was a major improvement over my home made jig in that I could position it for a measurement and then let go without the indicated measurement changing. My home made fixture requires constant hand pressure to keep it pressed against the edge of the miter gauge slot. With the PAL's adjustment kit and the TS-Aligner Jr. the final alignment was a piece of cake. I was able to adjust the alignment to dead on with the blade at

90 degrees. The 45 degree alignment was 0.010 inch which indicated the rear trunnion needed to be shimmed 0.023 inch. Not having any metal with that thickness, and electing not to cut up a soda can, I went down to a auto parts store and bought some 0.010 inch brass shim stock, as well as some 0.005 inch just in case. I cut four shims from the 0.010 material, loosened the rear PAL's nuts, which allowed to trunnion to sag down a bit, and inserted two shims under each side of the trunnion.. Final alignment resulted in no deviation at 90 degrees and 0.002 inches at 45 degrees! This is a major Whoop de Do - Mission accomplished!!

Finally I adjusted the 90 and 45 degree stops (using the TS-Aligner in conjunction with a 90 degree indicating square) so that a small amount of over travel happens when the height or tilt is at their stops. The logic is that if I set the stops



**TS-ALIGNER WITH BLADE AT  
90°**



**TS-ALIGNER WITH BLADE AT  
45°**

exactly today, by tomorrow or next week (due to temperature changes, the moon phase, vibration or whatever), they will probably be off. By intentionally setting them slightly past 90 and 45 degrees, I will be able to set the angle with the TS-Aligner and not have to get all bloodied up reaching into the saw's innards to adjust the stops again. Maybe an expensive cabinet saw will maintain its accuracy, but I am convinced that no contractor's saw, past or present, or future ever will.

### Miscellaneous Observations and Disclaimers

- This story is condensed and doesn't include all of the detours and turnarounds that didn't work out.
- Loosening and tightening front trunnion bolts drove me up the wall until I bought an 18 inch long 3/8 drive extension so I could operate a ratchet wrench from beneath the saw.
- Many web sites suggest using a combination square to make alignment measurements. Folks - it will never happen. There is no way to get the precise measurements needed with a combination square.
- Some say a misalignment of 0.010 inches is good enough and then show an example of taking the measurement several inches above the table which reduces the effective span of the measurement to about 3 inches. If the misalignment is 0.010 over 3 inches, the real misalignment is greater than 0.03 inches over a 10 inch blade, which is bad news.
- Most sites show measurements being made with squares of unknown accuracy. I've even seen pictures of plastic drafting triangles being used to set miter gauges. After buying the TS-Aligner Jr. I checked all my squares and my trusty combination square was the second only to my framing square as far as being inaccurate. Some of the cheapest were accurate, but - who's to know without checking?
- I tried using a dial indicator with a magnetic base with all sorts of bars and clamps as pictured in one web site. There are too many practical problems with such a set up to list, but a good reality check on a measurement setup is that you should be able to make a measurement at location "A", move the setup to location "B" and then return to location "A" and get the same reading. If you can't, don't waste your time trying to align anything.

### Inventory Increase

Ts-Aligner Jr.  
 Precision Indicating Square (6 inch)  
 PAL's kit  
 Dial Indicator  
 Digital caliper  
 Shim Stock  
 3/8 inch drive extension (18 inches)  
 Moly spray lube

### References

The Ultimate Guide to Table Saw Alignment	<a href="http://www.tablesawalignment.com/nologin.htm">http://www.tablesawalignment.com/nologin.htm</a>
TS-Aligner	<a href="http://www.ts-aligner.com">http://www.ts-aligner.com</a>
Contractor Saw PALS	<a href="http://www.in-lineindustries.com/saw_pals.html">http://www.in-lineindustries.com/saw_pals.html</a>
Garage Woodworks	<a href="http://www.garagewoodworks.com">http://www.garagewoodworks.com</a>
C. Peter James	<a href="http://home.metrocast.net/~cpjvkj/tstuneup.htm">http://home.metrocast.net/~cpjvkj/tstuneup.htm</a>
Me	<a href="http://lumberjocks.com/jocks/ajosephg">http://lumberjocks.com/jocks/ajosephg</a>