Benchtop versus Small Knee Mill

– one user's perspective: pros, cons, and trade-offs

This is a big topic, and I am certainly not an industry expert, but I have owned both types of milling machines and logged hundreds of hours on each. What follows reflects my direct experience with this equipment.

Benchtop Mill/Drills

Rong Fu in Taiwan popularized the benchtop mill/drill alternative to the conventional knee mill (typified by the Bridgeport line). These benchtop mills, in addition to performing like a benchtop drill press also have the necessary bearings and spindles to handle the side loads associated with milling operations. The XY table on the mill drill moves right/left (X-axis) and forward/back Y-axis) but does not move up/down. The head does move up/down on the column (Z-axis) to facilitate tooling of varying lengths.

These Mill/Drill machines come in two basic varieties: round column (similar to most drill presses) and square column. The round column versions are fine as a drill press, but lacking as a mill because the spindle loses its lateral registration when the head on the mill is moved up/down. The RF-30 and RF-40 typify this type.

The "Square Column" or "Dovetail Column" benchtop mill maintains spindle centerline registration when the head is moved up/down on the column and is thus more suited to milling operations, or where consistent spindle registration is required. The RF-45 typifies this type.

Round Column Mill/Drill

Square Column Mill/Drill

Why is spindle centerline registration important?

- Imagine you're drilling and tapping a hole. The drill chuck with drill bit will need something like 6-8" of spindle height above the table or vise holding the material being worked on. After you drill the hole, then the hole must be threaded with a tap. The tap, often held in a collet, is so short compared to the chuck and drill bit, that the head must be moved downward several inches to complete the tapping operation. With a round column mill, when the head is lowered, the head is likely to rotate slightly on the round column, so the tap is no longer aligned to the center of the hole you just drilled.

- You would be forced at that point to attempt to re-center the spindle over the hole, which could be impossible depending on the clearance for the necessary edge finders. Failure to re-center the spindle would be just begging for the tap to break inside the piece being threaded.
- This is just one example, and there are countless other situations where the head on a benchtop mill must be moved up or down between successive operations. For example, switching the tooling from a drill chuck operation to using an end mill is a frequent occurance. A square column mill will maintain spindle registration when the head is repositioned, a round column mill will not.
- The same operation on a knee mill (bringing the material closer to, or further away from the spindle nose) is accomplished by moving the XY table up/down since the head position remains constant. The "Knee" on that type of mill is the platform for the XY table, and it moves up/down on a dovetail column and maintains registration of the XY table to the spindle centerline.

For many years, Rong Fu was the sole manufacturer of benchtop mill/drills, all made in Taiwan to reasonably high standards of components, fit and finish. Several companies OEM'd the Rong Fu brand under their own labels (Enco, Powermatic, Jet, etc.) and it didn't take long, once mainland China opened up for them to clone the designs and start offering them through distributors like Grizzly. In general, the Taiwan-made machines are built to higher standards of fit/finish, higher quality of spindle and bearings, hardened tables and surfaces that slide against each other, etc. And they cost more as a result.

Today, there are several manufacturers in Taiwan making benchtop mill/drills, but they come into the USA via importers like Precision Matthews, Grizzly, Jet, and several others. They are all variants around the same design, with the biggest differences being size, weight, how the spindle is driven, and how speed changes are accomplished. The term "RF45" is now generic for "square column" benchtop mill and could mean lots of things when it comes to size, weight, cost, and capability.

The more basic benchtop mills, even with square column, are belt driven and speed changes are made via belt position changes, or they substitute a variable speed motor at a sacrifice in low speed torque. The more advanced versions of the benchtop mills have a geared head (think of it has a manual transmission) where levers select different gear combinations to vary the speed. Some even have powered down-feed - meaning the spindle can be driven downward under power automatically at specified rates (this can be very handy when drilling hard materials like steel or when using a boring head to enlarge a hole to a precision fit).

The Rong Fu 45 has a geared head, and the 45-N2F model also has power down-feed. Some models have single-phase motors, others have 3-phase motors, and one variant has a 3-phase 4-pole motor that is capable of 3000 RPM top spindle speed. It is easy enough with any 3-phase RF-45 (or clone) to add a $300 VFD on the side of the mill, power the VFD with single-phase 220VAC, and achieve true variable speed, and spindle speeds up to 2,500 RPM even with the standard 2-pole motor.

There are also variants in the size and capacity of the RF45 - "baby", "junior", and even larger capacity "super" RF45's from various manufacturers and importers (PM-932 being an example). Specs vary and tell the story, so look closely. For example, Precision Matthews and Grizzly sell miniature Chinese versions for under $2,000 that weigh 300 pounds, and they also offer super-sized versions that weigh 900 pounds (150-percent of what an RF-45 weighs) at just under $4,000 and made in Taiwan. There is at least one European manufacturer (Wabeco) making benchtop mills. These Wabeco mills are high quality, but expensive and small, light-duty machines.

In general, the rigidity of a mill is proportional to the weight of the mill and the stiffness of the square column. The rigidity of each machine is directly related to its ability to rapidly remove material and yield high quality surface finishes and tight tolerances. There are exceptions, but the more robust the machine, the more aggressive its milling capabilities. All of these benchtop mills will machine aluminum, but if aggressive milling of steel or other harder materials is required, a heavier and more robust machine is ideal.

Another variant is the spindle taper and the type of tooling the mill can accept. Most drill press machines have a Morse Taper spindle, probably an MT3, MT4, or MT5. Some of the smaller benchtop mills will have an MT3 spindle. The larger benchtop mills will typically have an R8 spindle, which is compatible with Bridgeport tooling. For example, the RF-31 (replacement for the round column RF30) is offered with either an MT3 or R8 spindle. In general, the more metal machining being pursued, the better an R8 spindle will be in the long run simply because of the wide assortment of tooling available for that type of spindle.

The primary advantage of the benchtop mill over the conventional knee mill is cost, smaller space requirement, and weight. Compared to a full-sized knee mill, the benchtop mill is a lighter duty machine, less capable of hogging off metal in milling operations. Most benchtop mills have a 1.5 or 2HP motor, whereas most full-sized knee mills have 3-5 HP motors and more substantial quills/bearings, etc. Also, a large benchtop mill weighs 600-1,000 pounds (depending on version), whereas a knee mill is typically 1,500-3,000 pounds. With the right stand, a benchtop mill can fit in a shop with constrained ceiling height, whereas the shortest knee mill I have seen (the one I own) requires a full 82-inches of ceiling height, but more typically a knee mill requires 90-inches of headroom.

Knee Mills

There are two basic knee mill design types/philosophies – the USA type and the European type. Briefly, the European type has a table on a knee that goes up and down. The table travels in the side-to-side direction (X-axis) only, and the head moves in and out (Y-axis) on a motorized ram. Deckel and Schaublin are typical of this variety, and they were made in various sizes and capacities, and are highly prized for their integrated power feed, robustness, and accuracy. They do come up on the used market in the USA but are expensive and require unique tooling for the spindle (neither R8 nor MT). Europe is a better source for used Deckel and Schaublin machines.

A quill head was optional equipment on Deckel mills, and many found in the used market do not have a head with a quill (that raises and lowers the spindle like a drill press). The spindle is thus fixed in position requiring the knee to be moved upward for drilling or other vertical (Z-axis) positioning, and this can be a distinct disadvantage in drilling, tapping and other similar operations. Most of these machines are equipped with a table that tilts and/or swivels for compound angle drilling/milling operations. FPS in Europe purchased the rights to Deckel designs and will make one to order and even help with shipment to the USA – but at a significant cost approaching $50,000. Oddly enough, Knuth (a German company) manufactures a Deckel-style mill in China which is available in the USA by special order.

German made Deckel FP2 Knee Mill

The USA types of knee mills were popularized by Bridgeport Crop, and widely copied by many different manufacturers. Most of the new knee mills available today are variants of the original Bridgeport design.

The design philosophy here is that the XY table moves in both directions (right/left and in/out) relative to the spindle, and the spindle is housed in a quill that will move up/down like a drill press. The table is mounted on a "knee" (hence the name) that also moves up/down on the column of the mill. This type of mill is by far the most widely used in the USA – Bridgeport having sold over 350,000 of them before going out of business. The Bridgeport name was purchased by another company, and new machines are offered under that name, with major parts and assemblies made in China. These new "Bridgeport" mills are about twice the price of an equivalent Asian-built knee mill of similar size under a different brand name.

Bridgeport-style Knee Mill with J-Head

To my knowledge, the only other company in the USA currently manufacturing a manual knee mill is Wells-Index. All the other new machines of this type are made in Taiwan or mainland China. Reconditioned Bridgeport-style machines are also available, but the quality of the restorations should be scrutinized. There are also a variety of Bridgeport-style mills available on the used market in just about every condition and under several brand names including Sharp, DoAll, Index, Logan, Acer, and many others. If you are not familiar with how to evaluate the condition of a used mill, you may be setting yourself up for a risky decision unless you pull in the help of someone experienced in evaluating the condition, and advising on necessary reconditioning steps to bring it into good service.

Today, knee mills also come in several sizes and capacities. Several companies in the USA import clones of various knee mill sizes including Grizzly, Acer, ACRA, Kent, Precision Matthews, Knuth, etc. For the purposes of this document, only the higher quality machines made in Taiwan are discussed.

Compared to the benchtop mills, a knee mill will typically have larger XY tables, and have slightly increased X and Y table movement specs. There are versions available with 40, 50 or 60-inch long tables. Some have 3HP or 5HP motors, and some are available with CAT or ISO 40 tooling spindle instead of R8. Lots of variations are available. Maximum distance from the top of the XY table to the bottom of the spindle nose (referred to as Z-height) varies but is typically equal to or considerably larger (if a riser-block is fitted to the column) than an RF45 clone. With the exception of the

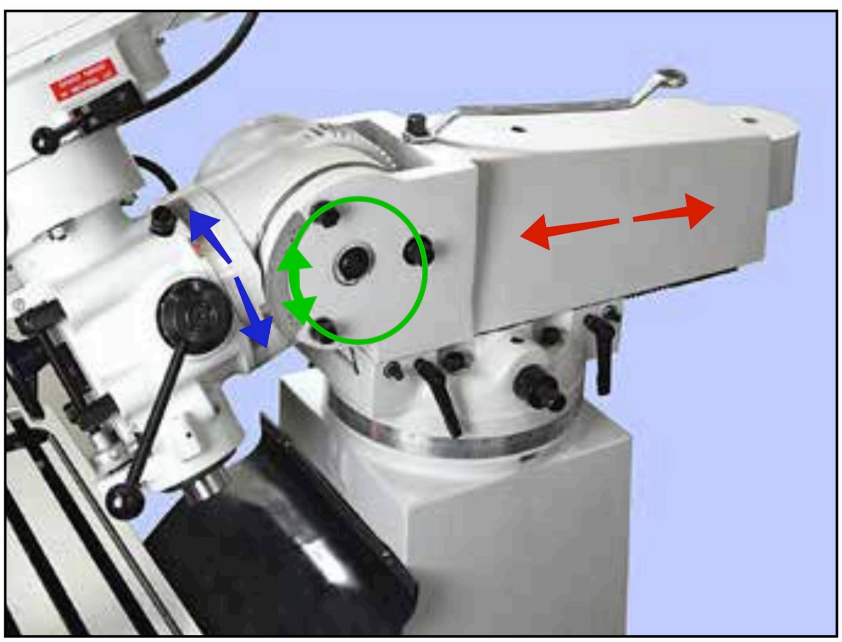
Wells-Index mills, almost all of knee mills have what is called a J-head - which is basically the same head design originated by Bridgeport in the 1930's. More on that below.

My Experience with Both Types of Mills

With my RF-45 N2F, I have been able to machine just about every type of material I've thrown at it. I have done lots of machining of tool steel, stainless steel, etc. and plenty of aluminum. My RF-45 had a 4-pole (meaning two-speed) 3-phase motor, and through the selector levers, was capable of speeds from 60 to 3,000. The RF-45 is an amazingly robust small milling machine. I sold it to make room for a junior-sized knee mill, and there are days when I regret that decision.

I have somewhat mixed feeling about the manual knee mill. Some aspects of these machines are superior to the largest/most robust benchtop mills, while other aspects are no better or even a step backwards in my opinion. I am particularly critical of the J-heads on these mills. The design hasn't changed or improved for almost 100 years, and in comparison to the geared head on the original RF-45 for instance, they are positively crude designs. Yes, people say Bridgeport mills with J-heads are the "world standard" and many people know how to use them and maintain them. But I have found three aspects of a Bridgeport-style knee mill that are clear trade-offs.

- First is the way the head attaches to the main column of the mill. The head is held out on a cantilevered arm called a "Ram". The Ram can be repositioned to move the head in or out (red arrows in the photo below) relative to the XY table and column. Once positioned, the Ram is locked in place prior to machining operations, and in practice the Ram is not often repositioned except for unique work holding setups. The J-head on all these knee mills is connected to the machine column with a Knuckle (think of it as a universal joint) attached to the end of the Ram (which is a long arm that attaches to the machine column). Look at the following photo – the knuckle (green arrows) in conjunction with the head tilt mechanism (blue arrows) provides the "universal joint" that can angle the spindle in two directions ("tilt" and "nod"):



This design provides for a static increase in the Y-axis envelope (distance from the mill column to the spindle) by moving the Ram in/out. The 350-pound head is held cantilevered from the machine column at the end of the Ram, and the Knuckle. The Knuckle facilitates articulation of the head in two axial directions - the head can nod up/down (green arrows) and tilt side to side (blue arrows). This facilitates tilting the head sideways and up/down giving the head pitch and yaw flexibility for drilling at compound angles. To be sure, the Ram and Knuckle give added capacity and adjustment flexibility, but at a potential sacrifice in rigidity (ability to maintain alignment and dampen vibrations under load.

Putting a large mass cantilevered at the end of that Ram & Knuckle sets the stage for lower rigidity. And by "rigidity" I mean that ability of the head to resist movement when it's machining material under load. All milling operations put vertical and horizontal loads on the head, and it's the stiffness and mass of the Ram, the Knuckle, and the fasteners that hold all that together that determines the rigidity of the machine. A machine with poor rigidity will produce poorer surface finishes and hold less tolerance than a machine with higher rigidity.

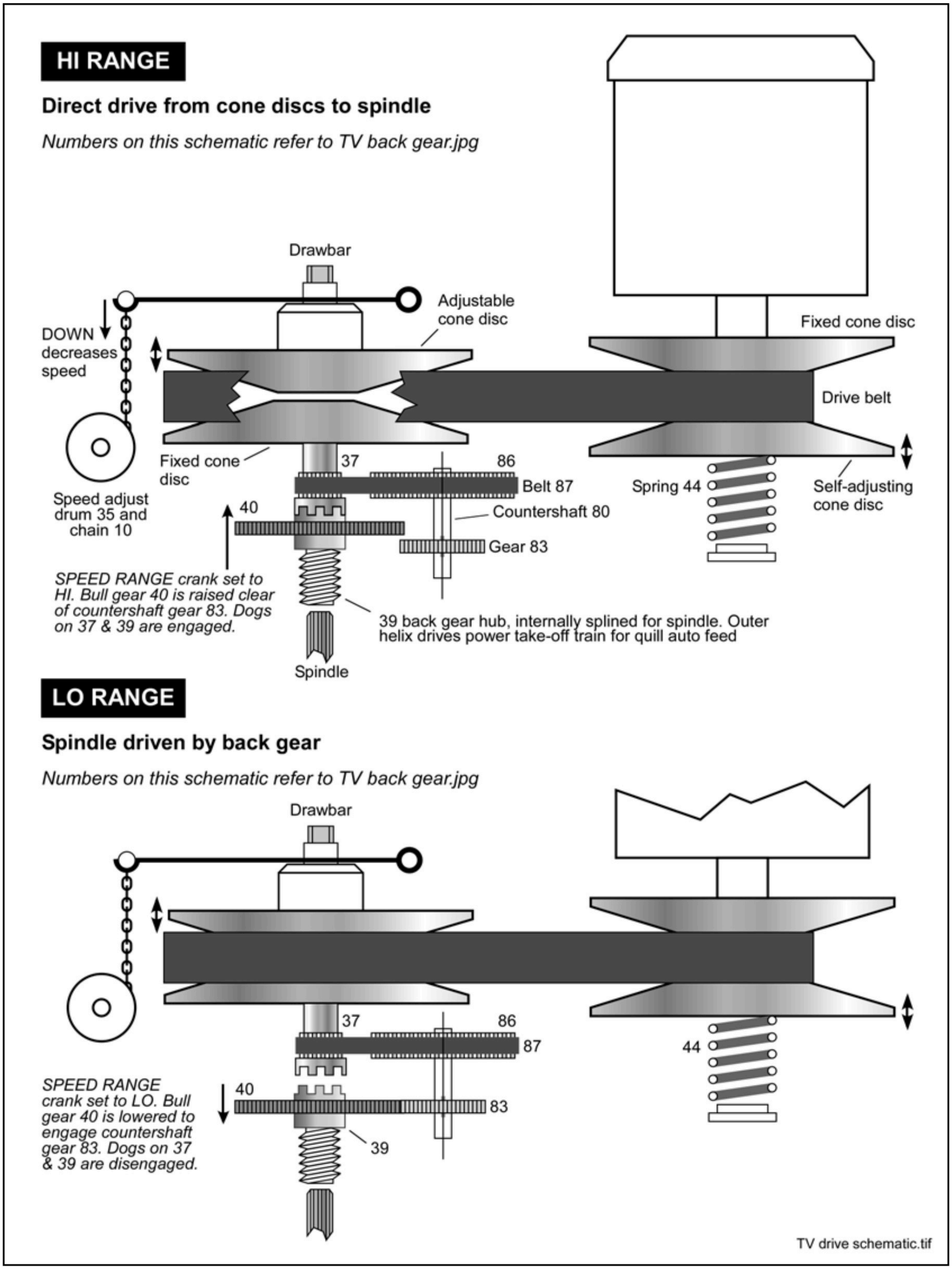
- Second, spindle speeds under about 400 RPM require the engagement of what's called the "back gear". This is a speed reduction system, which when engaged, lowers the spindle speed a factor of ten, and also reverses the rotation of the spindle - you have to remember to run the machine in the reverse after engaging the back-gear. Engaging the back gear requires several steps and can be error prone. Disengaging the back gear can be fussy as well.
- The third aspect of the J-head I find less that ideal is the complexity and use of the power down-feed system. This system is quite the Rube Goldberg contraption of teeter-totters and levers and push rods, a real pain to use in contrast to the power down-feed on a geared head benchtop mill. It works, but is not elegant, and in my case has been the source of some failure points.

The knee mill I purchased is the smallest and lightest weight Taiwanese-built manual knee mill I've come across - basically a 4/5ths version of the original Bridgeport except for the motor and head: the Precision Matthews PM-935TS. The "T" means it was made in Taiwan, the "S" means the speed changes are done via a belt-position change (or optional VFD and 3-phase motor configuration).

The PM-935 weighs 1,500 pounds and costs under $8,000 (December 2021 prices). In my experience, a large square column benchtop mill like the RF45, where the head is directly attached to the column with dovetails rather than cantilevered out on a Ram, can be more rigid than the Bridgeport head/Ram/Knuckle configurations found on junior-sized knee mills like the PM-935. Keep in mind that the rigidity of the benchtop square-column mills is directly related to the weight of the machine, and the quality of the column design. A 300 pound benchtop mill will certainly be less rigid than the PM-935.

I have made substantial upgrades and customizations to my PM-935, chief among them the addition of a new electronic control system with VFD driven motor for infinitely variable speed changes without belt position change requirements. With this setup, I have not encountered a situation where belt position changes were required. In back gear, the speed range is 54 to 470 RPM, and without the back gear, the speed range is 470-3,800 RPM. The new electronic controls also facilitate some advanced features such as auto-reversing back gear, and auto-reversing power down-feed (for tapping operations). Complete details on the upgrades (which included complete disassembly and re-painting) can be seen by clicking here.

That same PM-935 mill is available in a variable speed version as the PM-935TV with a mechanical Reeves belt-driven speed altering head unit. This simplified drawing, taken from the user's manual for the 935TV illustrates the variable diameter cone-shaped drive-pulley system on this machine. This kind of mechanical variable speed system has been in wide use for decades. It functions well, but in the long term is not as reliable as a VFD-driven 3-phase motor configuration. The following diagram also illustrates the back gear function for a 10:1 speed reduction which is common to all J-head mills and the primary means of attaining spindle speeds under 400 RPM.


HI RANGE
Direct drive from cone discs to spindle
Numbers on this schematic refer to TV back gear.jpg
Drawbar
Adjustable cone disc
Fixed cone disc
DOWN decreases speed
Drive belt
Fixed cone disc
37
86
Belt 87
Spring 44
Self-adjusting cone disc
Speed adjust drum 35 and chain 10
40
Countershaft 80
Gear 83
SPEED RANGE crank set to HI. Bull gear 40 is raised clear of countershaft gear 83. Dogs on 37 & 39 are engaged.
39 back gear hub, internally splined for spindle. Outer helix drives power take-off train for quill auto feed
Spindle
LO RANGE
Spindle driven by back gear
Numbers on this schematic refer to TV back gear.jpg
Drawbar
37
86
87
44
40
83
39
SPEED RANGE crank set to LO. Bull gear 40 is lowered to engage countershaft gear 83. Dogs on 37 & 39 are disengaged.
TV drive schematic.tif

Which Compact Milling Machine Makes Sense Today? (Late-2021)

The PM-935 is an excellent choice for a baby Bridgeport-style knee mill. For the price and the compact size, it's an interesting alternative to the benchtop category. However, in my use, it has proven to be less rigid and more temperamental than the RF-45 mill/drill it replaced. Plus, it comes with the J–head-style head and all that comes along with that (see previous section). You might find a few videos I did testing the rigidity of the PM-935 interesting. Click Here and watch the video and the four videos that follow.

I was able to get better surface finishes with the RF-45 in stainless and tool steel. I can push the PM-935 slightly harder than the RF-45 in terms of material removal rates (cubic inches of material removed per minute) by about 120 percent, but at a sacrifice in surface finish quality and tolerance to target dimensions. If the PM-935 is pushed too aggressively, the head is thrown out of alignment and must be realigned (called "tramming"). This behavior is something I never experienced with the RF-45.

Intuitively, I conclude this is attributable to the head attachment via the Knuckle and the attendant Ram. I have also proven through the use of indicators against the heads of both machines, that the head on the PM-935 can be flexed up or down a few thousandths of an inch by hand pressure, whereas the RF-45 head would not deflect under similar hand pressure.

Adding the Ram and Knuckle to the machine can provide extra reach and drilling angle flexibility, but at the cost of rigidity compared to a larger square column mill/drill like the RF-45 or others currently available. The idea that a benchtop mill is less rigid than a knee mill could be a fallacy in this case.

On the other hand, the ability to adjust the nod and tilt of the head has one distinct advantage – adjusting the vertical spindle alignment perpendicular to the surface of the XY table. This alignment process is called "tramming" and is an important step in the setup and alignment of the mill. If the spindle is not precisely 90° to the surface of the XY table, a milling cutter will produce a cutting path that is scalloped in shape, or a drilled hole will not be square to the surface of the part being machined. Tramming a Bridgeport-style mill is accomplished by simply altering the tilt and nod of the head. While this can be time consuming and fussy, having the flexibility of the Knuckle simplifies making this adjustment.

In contrast, tramming a square-column mill could be substantially more vexing. The benchtop mill head is easily tilted side to side by loosening mounting bolts and tapping on the head to bring the spindle into alignment, then securing the bolts. But the nod (leaning forward or backward relative to the XY table surface) is generally not facilitated by an adjustment mechanism. Instead, the nod axis of the spindle is adjusted by altering the column angle relative to the base platform of the mill. Such an adjustment is typically a one-time operation, but requires alteration of the attachment where the column is bolted to the machine base. Thin shims are added between the bottom of the column and the machine base to bring the column into tram with the XY table. This process is explored in more detail in a video you can view here.

Key Specifications of Popular Compact Milling Machines

The table below summarizes the key specifications of the RF-45 (the original Rong Fu), the PM-833 (both variations) and the PM-935 (both variations). To be sure, there are many other candidate benchtop mills that could be added to this chart – with mill/drills from a variety of suppliers at price points from $1,000 to $8,000 and corresponding differences in weight, capacity, and features. But for the purposes of this document, the table outlines some of the more popular alternatives within the Precision Matthews line. All machines listed are manufactured in Taiwan (not mainland China) and thus have higher quality components and longer warranties.

Key Specifications - Taken from Published Information						
		Bench top Mill			Junior Knee Mill	
Model		RF-45	PM-833T	PM-833TV	PM-935TS	PM-935TV
Motor Type		1- or 3- phase	1-phase	3-phase	1- or 3- phase	1- or 3- phase
Motor HP		1.5	2	2	3	3
Speed Range		60-1500 1-phase. 60-3000 3-phase	60-230, 450-1500 with belt change	50--3200 single position belt	80-600 in Back Gear 400-2720 Normal 50-5000 w VFD	60-500 in Back Gear 500-2700 Normal
Speed Change Selection		Geared Head 1-phase 6-steps, 3-phase 12-steps	Geared Head six steps	Proprietary VFD	4-Step Belt Change or VFD	Reeves Mechanical Variable
Head Type		Geared Head, Power downfeed options	Geared Head with Power Downfeed	Belt Drive with Power Downfeed	J-Head Belt Drive with Power Down/Up Feed	
Spindle Taper		MT3 or R8	R8	R8	R8	R8
Table Length	X	32.25	33	33	35	35
MaxTable Movement	X	20.5	21.75	21.75	24	24
Max Table Movement w Power Feed	X	18	19	19	22	22
Table Width	Y	9.5	8.25	8.25	9	9
Table Movement	Y	8.25	11	11	12	12
Quill Travel	Z	5	5	5	5	5
Head or Knee Travel	Z					
Maximum Z-Height (spindle nose to table)		18	20.5	20.5	17	17
Spindle to Column		10	11.25	11.25	4 to 15	4 to 15
Weight in Pounds		750	900	750	1430	1500

What the PM-935 does have that the RF-45 and 833 do not, is the availability power feed add-ons to the XY table in Y-axis. Having a power feeder on the Y-axis of the table is huge convenience when squaring stock and bring material to finished size. Adding power feed to the X-axis on a benchtop mill is a $300 proposition. Adding power feed to the PM-935 is a similar cost for each table axis and for the knee.

The biggest frustration I encountered with the RF-45 was the hand crank to move the head up/down, and there was no easy way to add power feed to the head elevation on that machine. The newer benchtop design typified by the PM-833T has a different head elevation system and optional power feed units are available for a reasonable cost (see discussion below).

The original Rong Fu 45 is still available, but none of the importers provide post-sales support, and the cost of the machine has gone up considerably, so it is no longer competitive. Very infrequently the RF-45 comes up on the used market – they are prized for their quality and general utility as both a drill press and lighter-duty milling machine. Only the 2-speed 3-phase motor version of the RF-45 is capable of speeds above 1,500 RPM unless a VFD is added. And only the N2F designated RF-45 has power down-feed.

Compared to the original RF-45, the PM-833T machine has slightly larger table size and 3-inches of additional travel in the Y-axis (which is an important distinction on a benchtop mill), and weighs a hefty 900 pounds without the stand – fully 50-percent heavier than the RF-45 from Rong Fu.

But there is one other significant difference: how the head is moved up/down. Like the RF-45, the PM-833 head can be raised and lowered via a hand crank on the side of the column. The RF-45 head elevation system is a rack & pinion setup which is quite stiff and awkwardly positioned on the left side of the column, whereas the PM-833 has a worm gear system that is easier to access and operate, and is compatible with an optional power feed unit to motorize the raising and lowering of the head. Like the RF-45, the PM-833 has an R8 compatible spindle, which opens the door to all the Bridgeport-style tooling.

There are two versions of the PM-833, each appropriate for slightly different needs. The PM-833T is a geared head machine, with speeds of 60-1500 in six steps simply by changing lever positions, and is powered by a single-phase 2HP motor. The following chart summarizes the spindle speeds available with the PM-833T

In contrast, the PM-833TV is a single-position belt-driven machine and is powered by a 2HP 3-phase motor that is controlled via a proprietary VFD. The advertised speed range is 50-3200 RPM, with corresponding diminishing power at both extreme ends of that range.

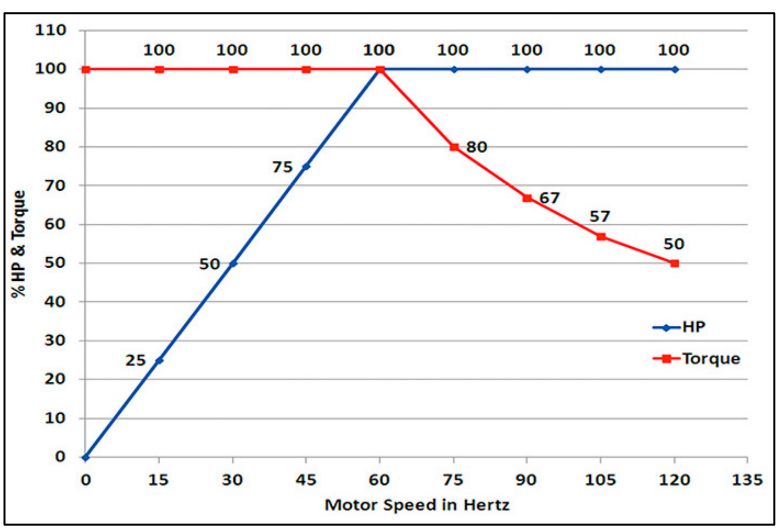
At present, neither of the PM-833 variants offer power down-feed on the quill/spindle, which for some operations (boring in particular) can be a disadvantage to the power a true power-down-feed quill arrangement. Moving the head downward on the square column mill is unlikely to provide sufficient alignment stability to produce high-tolerance boring results – particularly in contrast to a mill with a power-down-feed quill/spindle such as on a J-head knee mill or the RF-45 N2F. Quill movement typically keeps the spindle alignment to a variation of ±0.001", whereas the head moving on a dovetail with an adjustable gib is likely to have variations of ±0.003" or perhaps more.

What is the trade-off here?

The geared head 833T will have much better low-end power compared to the 833TV. From a practical perspective this distinction simply means that the geared head machine will be better at aggressive drilling and milling into hard metals like steel, or larger diameter powered tapping operations in to steel or other hard metals. If drilling ¾" holes in ½" thick steel, or aggressively running shell or face mills is not a requirement, the low-speed power reductions on the 833TV may not be an important distinction.

On the positive side for the 833TV, being belt driven, it will be quieter in operation than the geared head machine and more suitable for conversion to CNC. And the high-speed range of 3,000+ RPM is certainly an advantage when machining aluminum or other soft materials. It is worth mentioning that the belt-driven head on the 833TV is approximately 150 pounds lighter in weight (based on the published specs on the Precision Matthews web site), which might also indicate that in practice, the 833TV could be less rigid than the geared head 833T counterpart. This is pure speculation on my part, but worth bringing up in the comparison of the two alternative configurations; head weight contributes to rigidity.

Consider the following chart. To obtain the very slow speeds of 50-100 RPM, the VFD on the 833TV is driving the motor at 3-6Hz (three to six). The power available to the spindle is thus in the range of 10-20 percent of the rated motor horsepower.



This is the nature of VFD-driven motors that gives rise to my reservation about low-speed power for certain materials and operations using the PM-833TV.

The following chart illustrates a calculated VFD output frequency to achieve various spindle RPMs based on published data. The calculations are based on the assumption that the top speed claimed by PM is achieved by driving the 3-phase motor at 180 Hz.

		Spindle RPM					
PM-833TV	RPM	50	100	300	700	1575	3200
	Computed Motor Frequency in Hertz	3	6	17	39	89	180
			Ratio of RPM to Hz.			0.0563	

Since this document was originally published in mid-2020, actual user performance data is confirming some of the slow-speed analysis above. From the information that's already available, it's clear that the 833TV is lacking in power with the spindle operating below 150 RPM – typically power tapping anything harder than 6061 and face mill work on steel. This video (4:20 in the timeline) confirms the lack of low-speed power on the 833TV. Swapping out the factory motor for a vector-rated equivalent is certainly one way to get better low-speed performance out of the PM-833TV.

On the other hand, other anecdotal user experience suggests that the PM-833TV does perform satisfactorily with some limitations in mild steel, provided the RPM is kept at or above 160 RPM. Consider the following videos produced by one PM-833TV owner – keep in mind that A36 is fairly soft steel:

- This video illustrates driving a 1/2-13 tap through 3/4" of A36 mild steel. It stalled at 125 RPM but succeeded 190 RPM.
- This video illustrates a 5/8" drill bit into the same A36 steel at 160 RPM.
- This video illustrates a 2" diameter face mill at almost full width of cut into A36 mild steel at 0.030" depth of cut. The user reported that "It seemed rough leaving the material, but in no way did the motor feel like it was struggling."
- Other users have reported that the PM833T geared head version has substantially more power and torque at the low end of the speed range and is better suited for milling more difficult materials such as alloy steels. The following chart summarizes the speed selector possibilities on the geared-head version of the machine. This version offers three speed choices in low and in high gear, for a total of six speed alternatives. The chart restates the published specification as well as a calculated low gear performance based on the high gear ratios, so they are slightly different.

		Spindle RPM		
PM-833T	Claimed Low Gear	60	130	230
	Computed Low Gear	80	143	268
	Claimed High Gear	450	800	1500
	Ratio Low to High	5.6	5.6	5.6