A SMALL LATHE
BUILT IN A JAPANESE PRISON CAMP

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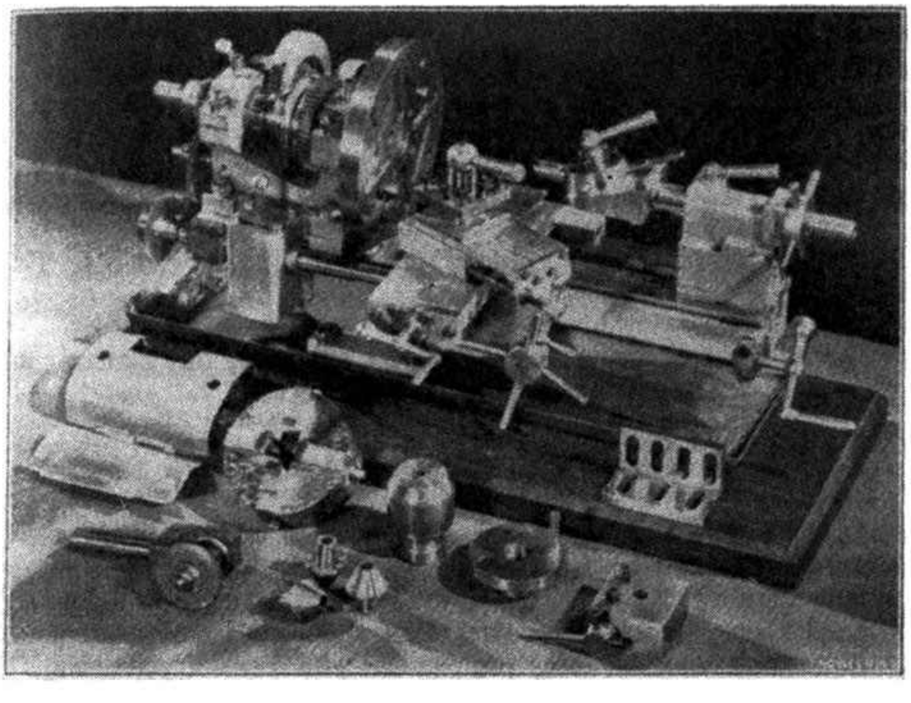
The author, as an officer in the Royal Artillery, was a prisoner of war in Japanese hands from February 15, 1942 to the capitulation in August, 1945. During that time, he was engaged with some fellow prisoners on much useful engineering work, including the design and construction of artificial limbs, and in order to equip a workshop for these tasks he secretly made a small lathe, which is illustrated, with some accessories, in Figs. 1 and 2. Visitors to the Machine Tool and Engineering Exhibition at Olympia in August and September, 1948, may remember seeing this lathe, which was exhibited on the stand of ENGINEERING in the gallery. The overall length is 17", and the distance between centers is 6-7/8". The swing is 4" over the bed, 5-1/4" in the gap, and 1-5/16" over the saddle. The cross slide traverses for 2-3/4" and the topslide for 1-5/8". The topslide can be fixed to the cross slide in any of 3 positions, and it can be rotated through 360 degrees. The lathe, together with the accessories illustrated in Fig. 1, weighs 30 lbs.



After nearly a year of captivity, which had included service in two working parties in the town of Singapore, the author found himself back in the Changi Headquarters Camp on the northeast side of Singapore Island, where, with fellow prisoners, he had first been imprisoned. Much had happened in that year, but one short story must suffice to show how the prisoners had learned to seize opportunities and outwit their guards.

A few officers had systematically stolen tools from the Japanese, while out with working parties, and had smuggled them back into camp, but it was so inconvenient to have to hide them whenever a guard appeared in the hut that it was decided to establish a workshop. A Japanese N.C.O., who acted as an interpreter, was engaged in conversation after a roll-call parade, and persuaded to draw the Japanese characters representing "man", "dog", "tree", "house", etc; the word "workshop" was easily included and the character was carefully noted. It was copied onto a piece of wood, and the next changing of the guard awaited. After the last round of the guards, the sign "Workshop" was hung up in the officers' hut, and the tools neatly arranged so that the new guard found a small joiner's shop functioning and took it for granted.

After the return to Changi, the author was engaged in camp routine duties and managed to occupy his time lecturing small groups on engineering subjects, navigation and astronomy. Several large parties had been sent out into Thailand, and more were expected to have to go to work upon the Burma-Thailand railway scheme, but when the details arrived for the dispatch of more labour the author had the good fortune to be ordered to remain in the camp to instruct a Japanese General in astronomy. The General spoke English very well, and it was possible to turn the conversation to put in complaints or requests as instructed previously by the British Staff. This useful contact with a senior Japanese officer lasted for several months.

Meanwhile, a small repair workshop which had been equipped with a few tools found in the area when it became a prisoner of war camp, was moved into the camp hospital area, and the author was put in charge of it to make artificial limbs and surgical instruments. During an astronomy lesson the General was informed of these activities, and of the difficulties occasioned by the shortage of tools and materials, with the result that he visited the shop himself, and a week or two later sent in a few hacksaw blades, files, twist drills, a quantity of aluminum rivets, and some light-alloy sheeting removed from crashed aircraft. The workshop was equipped with a 3-1/2" backgeared screwcutting lathe with a 7" 4-jaw chuck, a small hand bench-drill; a portable forge; and a few vises and hand tools. Unfortunately, there were no change-wheels for the lathes. The workshop was staffed by 12 R.O.A.C. tradesmen.

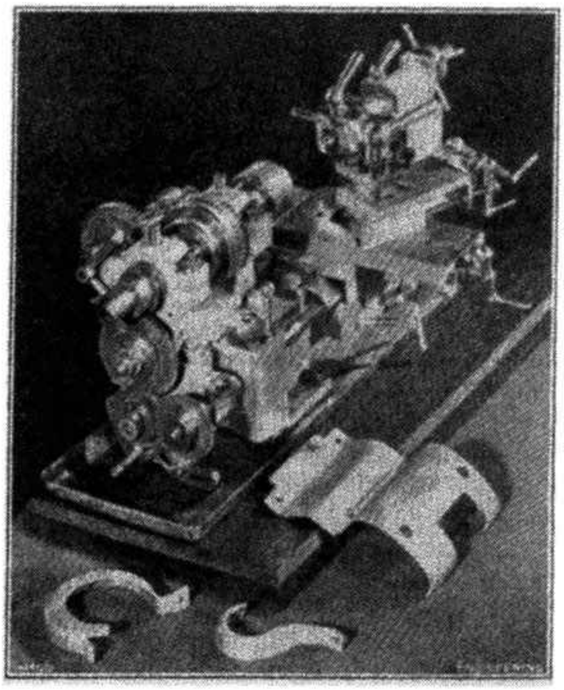
An endless stream of jobs poured into the workshop. They varied from repairs to cooking utensils to making sewing machine needles, from repairs to microscopes to making special splints, and at the same time experiments were being carried out with an artificial leg designed by the author. The patient was able to walk with the new limb, which had a link-motion instead of a hinge in the knee, and jigs and templates were prepared in order to facilitate production. Everyone learnt to improvise, and to salvage anything that could be of any conceivable use. Much useful scrap was handed in to the workshop. One officer brought along some gear wheels which were part of a set of change-wheels and were found to fit the 3-1/2" lathe, while another dug up and gave the author some artillery instruments (known as "transceivers") which had been part of the coast-defence guns; from them some precision gears and stainless-steel shafts were obtained.

Only six artificial limbs had been made, however, when orders were received to move the hospital, and several weeks elapsed before the workshop was established again, but it was recognised as part of the camp establishment and called the "Artificial Limb Factory". Both lathes were installed, and also a simple grinding spindle, and through the Japanese General a drill press was obtained from another workshop under his control. The workshop was extremely busy and the number of surgical instruments which had to be made increased week by week, in addition to heavier jobs such as turning 4"Ø rolls for rice-crushing machines, manufacturing parts for an ingenious machine which made nails out of barbed wire, and making components for many other labour-saving devices.

The author had given much thought to making the best use of the small precision gears, and he decided that a small and reasonably accurate screwcutting lathe, with a large range of accessories, would fill a growing need and would in any case allow much essential work to be continued if at any time the Japanese were to take away the larger machines. It was important, therefore, that the proposed machine should not be seen by the Japanese, that it should be small enough to hide and transport in a canvas pack, that it should be capable of fairly heavy work on large diameters, and that the essential parts should be made quickly while some machines were available.

A sturdy bed was the first requirement. Enquiries revealed that there was some 3" x 3" steel in stock in the Japanese workshops, and permission was obtained for a small piece to be brought into camp for the use of the Artificial Limb Factory. The author had a word with the officer in charge of the British personnel in the Japanese workshop, and he had the piece cut to the required length. The Japanese would have been suspicious if an exact length had been specified, and if a large piece had been requested, some weary prisoner would have had the task of carrying it.

The work was marked out from a dimensioned sketch, and the author drilled and chipped away with a cold chisel, all the surplus metal. The bed was then bolted to the saddle of the 6" lathe, and cleaned up with a fly cutter - an operation carried out on a Sunday when the workshop was allowed to be closed. Thus, in two weeks spare time the piece of steel was reduced in weight from about 33 lb. to 8 lb. The only available tool suitable for use as a surface plate was the ground face of a piece of heavy 6-ft. straightedge, and with its aid the top of the bed was scraped flat to receive the slides. These were made from a piece of good quality steel strip removed from an old R.A.M.C. stretcher, cut to length and then filed and scraped true before being put aside for a week or two while more drill and cold-chisel work was carried out on a piece of plate which was to form the lathe saddle.



The threads were turned off a phosphor-bronze screw to leave a piece of stock out of which the main bearings had to be made, and its size governed the diameter of the mandrel. The mandrel was machined from a piece of a truck axle, and although it had been annealed it was a difficult job for the only high-speed steel lathe tool the workshop possessed. The leadscrew and a brass nut were made on a Sunday, and, with a rack and pinion from a damaged typewriter, were hidden until required.

The slides were now checked again and found to have warped slightly, but after correction they were marked out and drilled for fixing screws and used as templates for drilling the holes in the bed, which were tapped No. 0 B.A. (This would be about 1/4 x 25 tpi. GBL.) The fitted screws were made with slotted heads to facilitate their insertion and possible future withdrawal, in case at any time it should become necessary to jettison the comparatively heavy bed and to preserve the accurate slides and the components made to fit them. When the fitted screws and some dowels were driven in and filed and scraped flush, the top surface was very nearly flat and required little correction. The rear edge was selected as the "master" edge and checked for straightness. Split brass bearings for the leadscrew were made by hand, and when the headstock fixing studs were fitted the lathe bed was considered finished and work was resumed on the saddle. It was built up so that the dovetail for the cross slide could be adjusted dead square, without scraping, when the machine was running. The cross slide, chipped out of a piece of 1/2" plate, was therefore set as nearly true as possible, and gibs, adjusting screws and a 1/4" Whitworth feedscrew were fitted.

So far, there was no suitable piece of metal out of which to carve the headstock, and while arrangements were being made for a piece to be obtained from the Japanese workshops the topslide was added to the assembly and ball handles were made and fitted. The leadscrew and complete apron had been fitted by the time a piece of steel 4" x 3" arrived, but after so many hours of drilling, chipping, filing and scraping, the author decided to try casting a headstock instead.

The workshop had developed considerably by this time, and several aluminum brackets, pulleys and bearing housings had been cast in sand bonded with chopped grass. In order to produce a dense casting, a deep mold was bent up out of 16-s.w.g. steel (part of a barrack-room locker) into the form of the headstock as seen from the front. This U-section mold was stood on end on the ground, sealed with clay and surrounded with sand, and pouring commenced. It was a complete failure. The furnace consisted of wood burning in an enclosure of red-hot bricks, and owing to difficulty in pouring, more molten aluminum went onto the floor than into the mold. However, a second attempt with the mold supported in a large mass of clay was successful, and there were no blow-holes apparent in the lower portion of the casting which was sawn off. The external surfaces were faced in the lathe and the remainder trimmed up with saw and file, making a very satisfactory headstock in a short time. The job was then set up on the cross slide of the 3-1/2" lathe, and with the bearing caps in position, bored for the phosphor-bronze bearings. They were bored 'in situ', the mandrel was fitted, and provided with a temporary aluminum pulley, and the headstock bolted in place on the bed.

This stage of the work was very interesting, and the author spent every available minute making the many small parts still required to complete the machine. A No. 0 Morse taper plug was made on the 3-1/2" lathe and the same taper was turned on some short lengths of 1/2" bar which were to serve as test pieces when adjusting the lathe. With the machine incomplete there was no time to scrape in the bearings to a perfect fit, and after a short period of running-in on the drilling machine table, with the mandrel driven by a leather bootlace, it was decided to bore the mandrel 'in situ' to fit the taper gauge. It was then possible to turn a test piece, and the headstock was adjusted until the machine turned parallel within 0.00025" on a 2" length. There was a piece of 1" steel plate in the scrap box, and, by drilling a circle of holes in it, the blank for a faceplate was obtained. This was chucked in the 6" lathe, machined all over, and tapped 5/8" Whitworth to suit the mandrel nose, but it did not run truly when fitted and had to be corrected by very light cuts at a low speed. A light cut across the face produced a slight concavity, and as this was desirable the remainder of the screws holding the cross slide dovetail to the saddle were fitted.

The next problem was the construction of the tailstock, which had to be made of two pieces of steel dovetailed together, but the joint was made to serve as the set-over slide for taper turning. Into the lower piece the cam-locking device for clamping the tailstock was fitted, and a tenon piece was added to fit between the main shears of the bed. The upper portion was carved out by hand, the rectangular bosses, one of which can be seen in Fig. 1, being left to take a screw adjustment for the tailstock set-over - a refinement that was never provided. The tailstock was assembled on the bed, between the headstock and the saddle, so that the latter could provide the feed in the operation of drilling and boring the tailstock barrel. Due to the overhang of the tool, which had a single cutter fixed by a setscrew, the finish of the bore was poor, but rather than make a new and longer bar and a steady bearing for it, it was decided to enlarge the bore and bush it. A bronze bush was bored and turned to fit, and after being pressed into the barrel in a vice it was reamed to 15/32" with one of the four reamers the workshop possessed, and so the job was made satisfactory without undue delay. The following Sunday, the only day on which the 3-1/2" lathe was available for any length of time, the tailstock spindle was machined, and threaded with a left-hand square thread; a keyway was "shaped" along the length of it, and a hole bored right through. Then a bronze nut was made to suit and, while still in the chuck, the spindle was screwed into it and bored No. 0 Morse taper to match the plug gauge mentioned above.

This work had been spread over a period of six months, and although still lacking a backgear the new machine could now be used. Before driving gear could be made, however, the Japanese ordered an early evacuation of the area, which was wanted in connection with the development of their new aerodrome. The hospital was divided into two, and the section which was to have the workshop was ordered to a site in the vicinity of the Changi jail. The 6" lathe and most of the heavier tools went to a new camp maintenance workshop, but after a few weeks the artificial limb factory was re-established in a newly-erected hut thatched with atap leaves. The workshop staff helped in the building of the hut, and arrangements were made for installing the new lathe in a screened-off corner which was to be the "toolroom" and office.

The 3-1/2" lathe was first set up, and the countershaft was mounted on a timber framework built on heavy timbers driven into the earth floor, and the motor was fixed on a platform below the shaft. Behind the motor was fixed a 12-volt car dynamo and cut-out (which appeared to the layman as part of the lathe driving gear); the leads were "lost" among the general wiring of the building and so conveyed to the office two 6-volt accumulators (spares from the operating-theatre emergency lighting set) which were kept charged up. This source of power, which was always available, drove another car generator as a motor. A switch was made to control the motor field, giving four speeds, an "off" position, and an induction brake, and the motor spindle was fitted with an aluminum 3-step V-pulley made to match that on the lathe.

The lathe was mounted on a wooden base and fastened down on the bench in contact with backstops by a single woodscrew through the front of the base at the headstock end. The motor was pivoted on its fixing lugs, so that its weight kept the belt tight, and yet the arrangements permitted the lathe to be removed quickly in the event of a Japanese guard coming into the workshop. When not in use the machine was housed in a wooden box with a drop-front, kept on a shelf in the tool cupboard, and experience showed that it could be whipped off the bench and moved about 4 feet into its box in a matter of seconds. In their searches of the camp for wireless sets - searches which became more frequent as the war turned in the Allies' favour - the Japanese were furious if they uncovered anything, no matter how innocuous, which they suspected had been hidden from them, so if everyone were ordered out on parade at an unusual time the author left cupboard doors open with the toolboxes on view.

The Japanese Command had been changed by now and the camp was completely reorganized. Rations were worse than ever, and many petty restrictions, which seemed calculated to annoy, were imposed on the prisoners, and it became necessary to proceed very cautiously to avoid beatings. The Japanese used to punish prisoners for breaking rules by locking them up, handcuffed, in a cell with practically no food. An officer of the British Staff managed to get possession of the handcuff key for about half an hour and sent it to the author who measured it, made a lead pattern of the peculiar thread within the sleeve, and returned the key unmarked. Two days later, British Headquarters had five handcuff keys and they were henceforth able to release the "criminals" for several hours a day.

With the workshop in production again, it was obvious that the small lathe would have to be completed quickly, and so one evening after roll-call the backgear pinions were cut with a fly cutter. The 18-teeth pinions were made integral with the bronze sleeves, and were designed to mesh with a pair of 48-teeth wheels which had been taken from a cinema projector when the lathe was first planned. The blanks were mounted together on a mandrel, clamped in hardwood V-blocks on the saddle of the 3-1/2" lathe, and indexed by a suitable gear wheel pinned to the mandrel. After a few more hours fitting, the small lathe with its four-speed electrical drive had 24 spindle speeds between about 50 and 2,000 rpm.

There were no longer any aluminum rivets available, and as rivets were required in the assembling of the artificial limbs, and increasing numbers were needed for the maintenance and alterations to the many appliances which were in use by this time, rivets had to be made out of copper salvaged from overhead transmission lines. Here was an obvious production job for the new lathe, and so the mandrel was bored right through 9/32"Ø (with a long D-bit made for the job) to clear the copper rod. A simple collet chuck and some collet blanks were made on the machine itself. Thereafter, the supply of rivets kept pace with the demand, but it was not long before the new machine was overloaded with jobs that had had to be refused previously. The solution was to provide the 4-tool turret with an indexing plunger and to make a 4-station tailstock turret. The button which releases the turret for manual indexing is just below the underside of the tailstock turret. There was a substantial increase in the quantity and quality of workshop productions, as components which had only been filed where necessary could now be machined in the 3-1/2" lathe, and there was no waiting for small parts to be made. The number of special tools and accessories for the new lathe increased week by week, and several spares, such as nuts for the leadscrew and feedscrews, were machined; the bearings were scraped true, felt wipers were fitted to the saddle, and much thought was given to the problem of providing the new machine with an efficient chuck.

Permission was given for a piece of metal to be supplied by the Japanese workshop, and as the result of a quiet talk with a colleague the metal arrived rough machined, tapped 5/8" Whitworth, and with 2 diametral slots 3/8" wide cut at right angles. One evening after roll-call parade, a cast steel T-slot cutter was "shaped" on the 3-1/2" lathe; next morning the cutter was hardened and tempered and that evening the T-slots were cut in the chuck body. The chuck jaws were milled with a fly cutter in the small lathe, then clamped base to base on the faceplate and the left hand square threads cut in them. Screws and horn blocks were made to suit. The jaws were made of annealed high-speed steel, and although, in any case, they could not be hardened in the workshop, they were considered hard enough as they were and the chuck was assembled.

Any temporary handles and levers on the machine were now replaced by new ones made on it from stainless steel which had been obtained from the shafting of a gun mechanism, and a big improvement was effected by removing the tumbler reverse and replacing it with a constant-mesh reversing gear, with sliding dogs, on the leadscrew. The basis of this gear is a small differential, and the shift lever visible in the illustrations operates in a gate with "left-hand", "neutral" and "right-hand" positions. The half-nut locking device was modified, and the machine pronounced complete, some refinements intended from the beginning of the project having seemed to be unnecessary. Once again, however, the author was wrong, and more accessories had to be made.

Allied bombers were now in evidence, and the Japanese reacted to the threat of invasion by imposing more restrictions on the camp. Rations were still further reduced, and nearly every man who was not actually in hospital or crippled was taken to work as a navvy on military defensive points. There were many rumours of what was in store for the prisoners, and one of the least gruesome was that, at the first sign of Allied activity, they would be herded within the walls of Changi jail. Any bombarding of Singapore would probably have resulted in the power supply to the camp being cut off, and with it the carefully organised radio news service, which at such a time might have been the means of receiving important instructions from the Allied forces.

A battery set was therefore designed by the experts, and arrangements were made for the materials for the primary cells to be taken into the jail with some medical equipment. The author was consulted on the mechanical details of the set, which had to be housed within the leg of a small table, and when machining the components in the small lathe, its battery power supply enabled him to work silently when the workshop appeared deserted, without even his closest friends suspecting that he had any connection with the secret wireless "ring". One of the hidden AC-powered radio sets was operated by a screwdriver pushed through a knothole in a hollow beam, but in the new set the author was able to reduce the hole diameter so that it could be mistaken for a worm hole. A toolpost grinder had to be made, but it was a simple job as a 1-1/2" dia. abrasive wheel was available, and also some small ball races salvaged from an instrument. When completed, the spindle was driven at 8,000 rpm from a large wooden pulley on a fan motor fixed to a beam 6 ft. above the lathe, and the belt was a length of gut carefully removed from an old tennis racquet. A fine taper reamer of about 3 deg. taper was made - the flutes being "shaped" out - and after hardening, was ground true. Some pieces of steel wire about 1/16" dia. had one end hardened and ground to the same taper. The spindles of the main condenser and trimmers (which complete occupied a space of only 4" x 2" x 2") were bored axially and reamered with the special taper reamer, so that, to tune the set, the wireless operator had merely to bend one of the wires to a right angle, poke the pointed end through the "wormhole", engage the taper and turn the wire.

While this work was going on in secret, the new lathe was used to great advantage in the workshop and many "toolroom" jobs were done. The workshop taps and dies were in very bad condition, and on the little lathe quite serviceable replacements were made of 1/4-20 and 3/16-24 sizes. At the same time, one of the workshop staff made excellent small files by hand, and also many short twist drills, the spiral flutes of which he filed out with specially made files.

When the Japanese eventually capitulated, the lathe was equipped with a large range of tools, hollow mills, drills, boring tools, and stainless-steel box-keys and spanners (wrenches). A special turret for the boring tools was included, also a simple indexing device (not illustrated), which fitted on the threaded extension of the mandrel. A member of the workshop staff made the drip tray in stainless steel, and another made the very necessary aluminum pulley and belt guards and the swarf cover for the leadscrew. About 600 hours were spent by the author in building the machine and its accessories, but it was time well spent in view of the many hundreds of hours of work carried out on it in the two years it was in use.

FOOTNOTE: If you've ever thought of building a small lathe, perhaps the foregoing will have provided some inspiration. If you should be inclined to pursue the matter, you might like to know about a set of drawings (catalog # WE/28) available from Power Model Supply Co. for a small lathe of about 2-5/8″ centerheight. One would need the use of a larger lathe in order to make it, but it appears to be a practical design. It was fully described in Model Engineer Magazine starting at page 537 in Vol. 150 (Jan/June, 1983).

ADDED TO THE 18th PRINTING, SEPTEMBER 2006

I've recently come up with a new idea relating to the **"Ultimate Box Latch"** (see page 125 herein). The idea is to make the latch disk octagonal, rather than round. An octagon will give a very grippable shape, with no need for knurling, although round ones I've made without knurling have never been hard to operate.

Now you might ask, "Why not hexagonal?" Well, my thinking is that if you make it hexagonal, anyone who sees it is going to think, "Oh, it's a nut. You have to turn it to open it." With an octagonal box latch, there is – as with a round one – no particular or immediate visual clue as to how to operate it. I think this is desirable, for the sake of mystifying the uninitiated.

Also, a square workpiece will be slightly easier to hold in the 4-jaw chuck for machining the eccentric groove. On the other hand, if you made it hexagonal – in which case you would logically start with a slice off a piece of hex bar of the right size – you could chuck the disk very quickly in the 3-jaw chuck for machining the pivot hole, which is dead center.

If you like the octagon idea, start with a 3/8"+ slice off a 2" square piece of CRS, brass or aluminum, or with a piece of 3/8" thick plate sawn oversize, and machined down to an accurate square. (If I were doing this in my vertical mill, I'd machine the workpiece down almost to final dimensions, and then take a final pass over two adjacent faces with the quill/cutter height and knee locked. This should readily produce a dead square workpiece.)

Locate the center of the square on both front and back faces, and centerpunch same on the front face. On the back (inner) face, make a centerpunch mark offset 1/16" from dead center on a diameter line at 90° to one of the 4 faces of the square. This will be the center of the eccentric groove on the back face.

When you are ready to machine the eccentric groove, use a wobbler (see page 22 herein) to set the offset centerpunch mark to run true. Once the eccentric groove is done, reverse the job in the 4-jaw chuck, and use the centerpunch mark on the front face to set the job running true for boring the 2-diameter hole for the disk to pivot on. After that, reverse again, and indicate from the hole – or a plug in same – to get the disk running true for boring the washer recess on the back side.

To reduce the 2" square to a 2" A/F octagon, set it up in the milling machine vise in a V-block, so one of the square corners is "up". Use a piece of say 1"ø aluminum or CRS about as long as the V-block in the V-block to act as a pusher, to push the job hard up against the fixed jaw of the vise. Then mill off the corner. Assuming your box latch is in fact a 2.000" square, to turn it into an octagon, mill down 0.414" from first contact of a sharp cutter with each sharp 90° corner of the workpiece. Then a few strokes with a #2 cut hand file and a rub with 320 wet/dry paper to get rid of the tool marks, and you're done. Also, of course, file a slight bevel at the edge of the disk on each of the 8 flats so everything feels nice. See also something more re this at page 196/197.