Primary Gearing
(Back Gears)
for the Grizzly 9x20 Lathe

Although I consider myself a hobby machinist, I am not in the hobby for the purpose of turning large pieces of metal into larger piles of chips. The machine tools are just that, tools, with which I accomplish the desired goals in other hobbies. Model building is one hobby. Fabricating my version of farming equipment is another. Construction; my house is over an hundred years old, it takes a lot of work to keep it up. And a lot of equipment. When I pay someone to do something for me, most of that is compensating them for the equipment that they have invested in. I know how to do the work, I only need the means. So I build it.

The original version of this modification was fabricated for a Grizzly G1550 lathe. The 1550 was a version of the Asian 9x20 that has had considerable touch up work done by the distributor before marketing. For all intents and purposes of this description, it is identical to the plethora of imports that are sold under a variety of names. Jet, ENCO, and Harbor Freight are just a few of the monikers hung on this machine. Different distributors may furnish the machine in varying levels of finish, you get what you pay for and you pay for what you get. The current Grizzly model is the G4000. Spindle thread is the biggest difference.

I have a 14" lathe in advanced stages of excessive wear. To repair this machine, I must, for example, cut a left hand, tapered thread, among other things. By the time I got the 1550 modified to where it could make the parts I needed, I realized that, with all the modifications, it would do everything that I needed to do. There was no need to rebuild the junker. It is still out in the barn.

Threading at reduced speed was only one of several reasons for the development of this device. Parting off and knurling are other functions that benefit, as well. Initially, I had considered a second countershaft and another stage of belt reduction. Looking into the forces and required belt tension left me with gearing as the only practical solution. Machinery's Handbook, Nr 26 Pg 2372 covers theory of belting. What they have to say is not pretty. I have a stock of salvaged gears, metric modulus 1, that will mate with the existing gears on the Grizzly. But hanging a countershaft off the back of the headstock did not really appeal to me. It would require relocating the electrics and the headstock casting, to me, has questionable strength for arbitrarily drilling holes and banging around.

I had another project where I had been considering using planetary gearing because of the compact package. After due consideration, I decided to use the same approach for the lathe. Due consideration, of course, meaning a cup of coffee and a nap. The lathe provided a test bed for proof of concept in a simpler application.

The next step was locating a planetary gear package that was strong enough to be used in this situation. The gearcase from a battery powered drill wasn't going to work. After considerable head scratching, debate with myself, and sleeping on the problem, I settled on the use of the low gear package from an automotive transmission. Since the days of the Model T, planetary gear sets have been used in automotive applications and the gears are strong enough, by a wide margin.

Doing the arithmetic for torque and horsepower (HP=(Torque x RPM / 5250)), I decided that a 10:1 margin was a safe bet. The gearset was donated by a local transmission shop. Mostly to get me out of his hair, if the truth be known. Most salvage yards should have automatic transmissions that are beyond economical repair. But sometimes they are proud of the “Hard” parts; ask around.

My first rule of modifiction is to, when ever practical, keep the machine in a state where it can be restored to it’s original condition, should it become necessary. Some of the parts fabricated for this project are redundant. Keep it that way and “rathole” the original parts. You never know.

Detailed information on planetary gearing may be found in Machinery’s Handbook. (Number 26, Pg 2084). Use of planetary (or epicyclic) gearing provides a means of obtaining a compact design of power transmission, with driving and driven shafts in line, and a fairly high ratio of reduction. Certain combinations will cause reversed output of the driven shaft relative to the driving shaft.

The most desirable ratio for back gearing a lathe is properly calculated after analyzing the available speeds on direct belt drive. In this instance, the final result of 3:1 was determined by what ratio gears I could lay my hands on. I will concede this is a “shade tree” fix. It is, however, quite inexpensive and well within the abilities of the amateur. Further, this modification was fabricated using only the lathe itself and a small drill press. No milling, as such, is required.

The resultant speeds are as tabulated:

Belt	Direct	Geared
BC3	130	42.5
BC2	300	98
AC1	400	131
BC3	600	196
AC2	1000	327
AC3	2000	650

The gears that I scrounged for this project are S=34 and R=70. In this application, S is the input, F is the output, and R is fixed against rotation.

Where: S = Number of teeth in SUN gear

R = Number of teeth in RING gear

F = Planet gear FOLLOWER plate

The formula would be F= [1+(R/S)] or (1+(70/34))=3.059 ~ 3:1 .

The steel driver plates are 14 gauge, ~0.080", for all practical purposes 2mm. Two pieces will be required, rough size approximately a half inch larger than the ring gear. The actual gauge of the metal is optional, I would say the 2mm size would be the minimum usable.

The lathe spindle is 30mm OD on the drive end. This determines the size limitations for the gears. The sun gear must run on the spindle, at a higher speed. The part that I used had a finished ID of an inch and a half (38mm+). Four millimeters is thin for a bushing, but usable. The ring gear is somewhat less than five inches outside diameter. A larger size would probably indicate a higher ratio. The limit here is interference with the existing parts of the machine.

New pulleys will be fabricated so that the original drive pulley may be stashed. Quarter inch aluminum plate is the most easily acquired, in my case it was more “donated” junk that had been gathering dust for some time.

There are also some specialized fixtures required for mating up parts during machining. I happened to have some aluminum round stock. Any easily worked material will do, there is little pressure. They are shown in the pictures and referred to in the text when they are needed.

The Gears Since several parts will be sized to the gears used, we will start there. Acquire, by whatever means (beg, borrow, steal or, heaven forbid, buy) a planetary gear package (**PHOTO-1**) from an automatic transmission. Dismantling will depend on how the particular drive is assembled. I had to punch out a number of pins and it just sort of fell apart. I saved the pins and bearing rollers for future use as dowel pins. The end result will be as pictured in **PHOTO 2L.** This particular system is from an unknown model; knowing the person that donated it, I would have to say it probably is from a General Motors product. On this gear set, there were four planet gears. I am only using three in this project.

The gears will require annealing. I used an Oxy/Natural torch and brought each piece to a dark red colour, holding it there for some minutes. Pulling the flame back allowed me to bring the temperature down slowly over several more minutes. The slower they cool, the softer they will be. Cooling in a sand bed would have been preferable. Or better still, a treating furnace. If the piece can be scratched with a file, it should be soft enough to machine. Using carbide tools helps if the gears are not fully annealed.

Measure the thickness of the planet gears, excluding shoulders. If there is more than an inch, you should have enough stock to split them and get two sets. (**PHOTO 2R**) The sun gear and the ring gear should be more than long enough. I fabricated an expanding mandrel for the planet gears. A chunk of bronze was chucked and trued. The outboard end was drilled and tapped for 1/4" tapered pipe thread, then turned to size for the ID of the planets. Two freehand hacksaw cuts, in place, and a pipe plug to expand the mandrel. This is a crude solution, expected to be used a maximum of nine times. (**PHOTO 3**)

Mount one of the planets. Take a light cut midways then, running at 140 RPM, cut almost all the way through with a hacksaw. Such a blade is a quarter the width of a parting tool and the gear will require facing for width anyway. This is not really a good practice but makes a very narrow kerf and if done slowly will not cause busted knuckles. Make the final cut with the piece removed from the machine so as not to disturb the truth of the mandrel.

When facing the gear, I left a narrow shoulder, 0.02", to keep the entire face of the gear from running against the end plates. Reverse each piece and trim down the shoulder there as well. Cutting two of the planets will provide four pieces; we only use three; set the rest away for later use. Width of the gear should be 0.400", including the shoulders. Finished width is not critical,but all three pieces should be the same.

Using the same general technique, but with the chuck (**PHOTO 4**), I cut down the ring gear and the sun gear, making the sun gear 0.400" and the ring gear some 0.425". With the 4" chuck on the Grizzley, I found the inside jaws would clamp up well on the inside of the ring gear. The sun gear was stepped down to a spline. I chucked by the spline to bore the I.D. to finished size, then chucked by that I.D. to face for width. The ring gear may have a chamfered edge on the original side. Duplicate this in the machined side. This will be an exposed edge when running. A smooth chamfer here may well save a finger one day.

The five pieces may now be laid out in place on the bench per **PHOTO 6L.** Examine the bearing surfaces of each piece. We are not going to reharden these gears; it is not necessary in this low power application. There may be some scale from the annealing process, particularly on the planet gears. They originally ran on roller bearings. We are going to run them on brass (or bronze) pins. They will need honing internally. I used a brake cylinder hone in a hand drill. The ring gear, when in reduction setup, will run against the outer plates. The face should be reasonably smooth after machining to width. Do a few figure eights on 400 grit cloth on a plate.

Side Plates The next parts to build will be the drive plates. Rough two pieces of 14 Ga steel, generally circular, to a diameter somewhat larger than the ring gear. I used pans from an electrical enclosure. Divide into thirds from the center, then drill for three 6-32 screws to hold the plates together. Place these screws a quarter inch or so inside the finished diameter as determined by the ring gear. I realize it is common knowledge, but to reiterate; draw a line through the center then draw the circle. Leaving the dividers at the radius, swng left and right from the point that the circle and line intersect on both ends. The result is sixths of the circle.

Mount the plates to the face plate in the most appropriate manner for your methods. I used small (5/16-18) milling clamps from my shaper stuff around the outer edge. Use a piece of plywood or hardboard as a backer. At this stage, centering with the tailstock center is sufficiently accurate. Rough drill out to an inch. The light gauge metal is easily drilled with a step drill or hole saw. I used one with electrical conduit sizes. (**PHOTO 5**) Open the hole to 30mm (1.181") with a boring tool, making the last pass only a few thousandths. This size will be a finished surface on one piece and is a critical dimension. Although it is time consuming, I would suggest you dismantle the drive end of the spindle and verify that the plates are a snug fit on the spindle. It will be a long way to backtrack if the finished size is not correct. Separate the drive plates and label them as “DRIVER” and “FOLLOWER”. If one, perchance, has a rough bore or other defect, use it as the “DRIVER” as the bore will be enlarged later. Note the faces so that they may be reclamped later in the same relationship. You will notice that Photo 5 shows two different sets of plates. I botched the first set and started over, using a hole saw the second time.

Using a scrap piece of aluminum (or what have you), make a shouldered hub. The small end is to be 30mm, a snug fit in the DRIVER plate, and some 1/4" long. The middle will be a snug fit into the sun gear, a half inch or so long. The big end is to be 2.0". I used 2" round billet. These surfaces need not be polished but should be as smooth as practicable. Leave a slight dimple in the center of the small end for use later with a dividers. This piece is shown in the lower left corner of **PHOTO 6.**

Clamp the sun gear to the DRIVER plate. Use the hub to achieve registration. (**PHOTO 7**) Scribe inside the sun gear onto the plate. Scribe the root of several teeth also. Unclamp and turn the plate over, so that the scribe marks are visible, then reclamp, again using the hub to register the assembly. Strike a circle with a dividers midway between the bore mark and the gear tooth root marks, then divide for screw centers. Center punch and drill through the plate and the gear with Nr 36. Apparently I had not properly annealed the gear, I found it almost as tough as the tap. After breaking a couple, I drilled the rest of the holes to Nr 33. This still provides 65% thread and was a lot easier on the tap. Make an odd shallow hole between two screws for registration.

Separate the assembly, drill Nr 27 through the holes in the plate. The odd hole need not be drilled out. Tap the holes in the sun gear for 6-32, deep enough for the screws. The odd hole need not be tapped. Debur all surfaces. Assemble the sun gear to the plate, with the layout marks to the gear side, using the 6-32 screws. (**PHOTO 6R**) Use the hub to set alignment before snugging. The depth of the flathead part of the screw is deeper than the gauge of the plate. The countersink must cut slightly into the face of the sun gear. Remove the screws one at a time and countersink. There will be a bushing running against the outside of the DRIVER plate; sink the screw heads slightly below the surface. As the countersunk screws are installed, set them with thread lock cement and torque well.

Chuck the sun gear by the INSIDE. Indicate truth of the front face near the center then check the outer edge of the DRIVER plate for run out. Any problem is likely a speck or burr at the sun gear. Open the bore of the DRIVER plate to a few thousandths greater than the ID of the sun gear. Use care not to cut into the sun gear. The cut will take part of the screw heads. It is expected, hence the large number of screws.

Using another piece of scrap aluminum, turn to a snug fit inside the planet gears. Bore to a snug fit for your center punch. Lay out the DRIVER plate, gear up, on the bench. Assemble the ring gear and the planets. Align the planets to the three scribed lines made earlier. If the number of teeth in the ring gear is not divisible by three, there will be a slight misalignment. It does not matter provided the planets are at close to thirds. Holding the DRIVER plate in one hand, rotate the ring gear back and forth to be sure that there is no binding. Clamp the ring gear to the DRIVER plate and wriggle each planet to assure there has been no movement when clamping, no bind. Adjust the clamping as necessary to get a loose fit here.

I really have not found a better method for this. After several unsuccessful tries at measuring the gears and calculating the dimensions, I resorted to this primitive but workable method. If there is a better way, I would love to learn it. Using the punch transfer bushing, punch for the center of each planet. Disassemble the ring and planet gears.

Determine the finished diameter for the plates. If there is a chamfer on the ring gear, use the lesser diameter. Clamp the FOLLOWER plate behind the DRIVER plate. Use the alignment hub through the sun gear to verify center then reassemble using the three 6-32 screws to clamp the plates together. Drill 1/8" at each planet gear center. Open the holes in stages up to “F” (1/4"). Mark the outside of the FOLLOWER plate. The number of teeth on the gears was not divisable by three; the location of the planet gears is slightly asymmetric

Chuck again by the sun gear bore and turn the outside to size to match the diameter of the ring gear. With the lathe cutter, touch up the joint between the plates. Little is needed. With a file, round over and debur the outside edges. These edges, like the ring gear, will be exposed while running. Cut matching notches on the edge of the plates. The notches serve to keep the two plates in registration. This will become an issue later. Separate the plates and set aside the DRIVER plate.

Fabricate three drive pins, of brass or bushing bronze, diameter to a running fit in the planets; length 0.375". Drill Nr 7 wire size, tap through to 1/4-20.

Temporarily fasten the drive pins to the FOLLOWER plate with round head machine screws. Be sure the marked side of the plate is out. Assemble the planets onto the drive pins. Slip the ring gear over them. You will need to wriggle the ring gear a little to make it fit. Insert the sun gear into the center. It will need a little wriggling also. You will have a sandwich of the drive plates with the gears in the middle. Rotate the drive plates relative to each other a few times to let the gears “unbind”. Torque the screws, checking that the pins did not shift causing a bind.

We will mount the drive pins to the FOLLOWER plate with 1/4-20 x ½” socket flathead capscrews. Disassemble the gears, leaving the drive pins on the FOLLOWER plate. Clamp one of the pins to the plate with small clamps. Leave as much working room as possible around the machine screw head and then remove it. Countersink for the flathead screw. Note that, as in the sun gear, the countersink cuts into the stock below the plate. Torque it up well, using thread lock cement. Repeat for the other two screws.

Reassemble the gears as before, being sure to rotate the drive plates relative to each other a few times to let the gears “unbind”. Verify that there is no binding before the thread lock cement has time to set up. Rotate the plates so that the notches at the edge are aligned and the holes in the DRIVER plate line up with the drive pins on the FOLLOWER plate. Set the assembly aside.

The Bushing The drive bushing will be keyed to the spindle, along with the follower plate. I stumbled into a 30 mm shouldered bushing at a salvage house. To make one, bore slowly with light cuts to 30 mm. The inside diameter will be keyed to the spindle. The outside is a running fit in the sun gear, with a couple thousandths oil clearance. Make the shoulder 0.1" by 0.1". Make the running surface a little long, then fit to the sun gear and DRIVER plate assembly plus 0.025". The bushing will bottom out against the FOLLOWER plate, allowing the DRIVE plate and sun gear to run inside the shoulder. With the bushing drawn up tight to the follower plate, the keyway in the bushing will provide additional torque transmission to assist the follower. You may pin them if you like, I did not and there is no sign of wear after many hours of abuse; augh, running.

Unplug the lathe from the power plug.

Examine the lathe spindle between the drive sheaves and the head stock. There is a 40 tooth bull gear for driving the lead screw. **PHOTO 8** will be slightly different from the box stock machine. I have installed tumbler gears to reverse the lead screw. The lock nut on the outboard end of the spindle has a grub screw that must be loosened before removing. Remove the lock nut, pulley assembly and the bull gear. This will allow removal of the key in the spindle. Reinstall the 40 tooth gear. Slide the assembled planetary drive onto the spindle. It will not fit tightly but we are primarily interested in interference, especially around the 80 tooth idler gear next to the bull gear. If you have built, as I have, a screw reversing tumbler, it will also affect this area. Make a conservative note of the required length of spacer required between the planetaries and the bull gear. Err on the side of caution, I am prone to cut two or three times and it still be too short.

Reassemble the drive end of the lathe. Be sure to install the key. When tightening the locknut, note that it is the preload adjustment for the spindle taper bearings. Torque it up tight, then back off a notch or two. Snug the grub screw, not so tight as to damage the spindle threads. Pull the spindle over by hand to make sure nothing is jammed, relubricate the spindle bearings and reconnect the power cord.

The spacer length is as measured, I.D. of 30mm, O.D. of 38mm. Unless your machine has something other than a 40 tooth bull gear. If so, subtract 2 from the number of teeth to get the O.D. in millimeters. Fabricate the spacer, facing carefully for concentricity. We will trim this spacer later for finished size, this is for preliminary assembly.

The Pulleys This step will require another special setup piece. As it happens, mine is used regularly for other purposes and is longer than needed here. Cut a piece of 3/8-16 all thread some 14" long. Chuck it and smooth the threads on each end. Drill each end with a Nr 2 center drill. Also have on hand some “Fender Washers”. They are thinner than a standard 3/8" washer but have a larger outside diameter. I also prefer to use threaded rod coupling nuts. In 3/8" size, they are about 3/4" long. You should also have (or make) a shouldered piece that fits into the outboard end of the spindle and is drilled for 3/8".

The pulley blanks will be made from 1/4" aluminum plate. The grade is not important, I did avoid a piece of “diamond tread” that I had on hand. If you can get your hands on 5/16", all the better. Cut and shape as described, then face it to 0.300". The stock sheaves are three, four and five inches (plus a little on each size). I punched centers and laid out the circles a quarter inch oversize to allow for bobbles, then cut roughly circular on a band saw. Once the pieces are sawn, layout circles for the finished size.

On the smaller pulley blank, lay out another circle 2-9/16" diameter. This works out to be 5/16" inside the finished size. Divide into sixths by swinging the radius and marking at the intersections of the 2-9/16" circle. These will be the through bolts for the assembly. From here on, the blanks must be referenced to each other. Punch a witness mark at some convenient point inside the finished size on each blank. Drill the three pieces 3/8", centered, and stack them together with a 3/8" bolt, keeping the witness marks in line. Drill Nr 25 through the three blanks at the six locations marked. Tap the holes in the largest blank to 10-24. Drill the middle and smallest to Nr 9 for clearance.

I usually am not that concerned about precision unless it is needed. You may wish to drill for and install a couple dowel pins in this assembly. Feel free to do so, I did not. Using a piece of heavy paper between each piece and the 3/8" bolt for alignment, assemble the three blanks with 10-24 machine screws. Use soft (cheap) round head screws at this point. Grind, or file off flush, the excess that passes through the larger disk. When the six machine screws are all drawn up tight, remove the 3/8 bolt through the middle.

The pulleys are 1/4" thick with a 0.197" groove, leaving very little clearance for cutting them as a completed assembly. I suppose one could cut down a 1/4" threading tool to 0.200" and fabricate a zero clearance toolholder to accomplish this. I am not particularly lazy, but do believe in avoiding unnecessary work. With a little care, the pulleys can be cut individually and assembled to run reasonably true. That is the method I describe here.

Mount the stacked pulley blanks to the face plate, largest to the back, using a piece of plywood as a backer. Clamp through the center with the threaded rod. Adjust to center by bringing the tail center into the end of the threaded rod and pressing against the face plate. When the draw bolt is tight, pull the tail stock back out of the way. Turn the pulleys to finished diameter, as marked. The paper separator will serve to prevent the tool from marking the next larger layer behind.

Clamp the pulley stack around the perimeter. I used the store boughten clamping furniture that I have for a small shaper. When the pulleys are well secured, at least at three points, remove the threaded rod. Originally, I chose to use a hole saw for the bore because of the depth of the clamps. It worked out well, as I later needed the plugs from the saw for use as spacers. The target I.D. is the two inch outside diameter of the multi-stepped hub made earlier. I used a 1.75" saw for roughing. You must cut through each layer of plate separately, then back off the saw to clear the plug. These saws are for field use by installers, they cut slightly oversize. The 1.75" saw left a hole slightly under the 2.0" target. Using a boring tool, turn the inside diameter to a 2.00" smooth fit to the alignment hub.

Knock down this setup; reinstall the chuck. Grip each pulley, individually, by the inside with the chuck. True it up such that it runs concentric as well as flat. The stock 4" scroll chuck is usable for this. Use a 60 Deg threading tool to cut the pulley groove. The threading tool will cut a sharp “V” groove, while the belt actually has a flat bottom. Normal operation has a “V” belt is gripping by the sides. This “V” groove prevents the belt running against the back. The groove is to be 5mm (0.197") wide, use your spare belt (you do have a spare belt?) as a guide, cutting the groove deep enough that the belt is just below the rim. Alternately, make a guage from a scrap of flashing tin to fit the OEM pulley.

Use the smallest pulley; fit it to the stepped hub. Fit the sun gear / drive plate to the hub with the sun gear out. Position the pulley such that the “F” holes in the drive plate fall between the six Nr9 holes in the pulley. This need be eyeball accurate only. Clamp the pulley to the drive plate. Set the hub aside. Transfer the witness mark on the pulley to the drive plate then transfer the six Nr 9 holes. I used a Nr 9 in a hand drill to start the hole. Remove the pulley, then drill and debur the holes through the drive plate. Again, using the stepped hub, assemble the sun gear / drive plate with the three pulleys. The smaller pulley is to the inside, same as the OEM drive mechanism. Be sure to observe the witness marks and pulley sides. Install six 10-24 x 1" flat head screws. With the screws tight, remove the hub; then remove the screws, one by one, and counter sink the screw hole, replacing the screw as you go. The inside of the driver plate will be running against the planet gears, set the screw heads slightly below the surface.

Drive Dogs will be required for direct drive (normal operation). Here again, one could dress up the work by fitting closely to the planet gears. I didn’t bother. Sections of 3/8" aluminium were shaped to conform to the general curvature of the ring gear and cut to a length that fit easily between two of the planets. The inboard side was trimmed to clear the sun gear.

During the original layout work, the follower plate was divided into six parts. Three of the marks were used to install the planet gears. Since the sun and ring gears have an even number of teeth (not divisible by three) there is a slight amount of offset in the assembly. Layout, by eye, the three blocks between the planet gears as shown in Photo 9. Clamp them securely and drill through with Nr 25, two places toward the ends. Tap each hole for 10-24. Punch witness marks for each so they may be reassembled as drilled. Take note that the drive holes fell in a different position on each plate.

Refering back to the section where layout was made on the drive plates, note the reference to the three “F” holes in the drive plate. These holes align the drive pins to the follower plate.

With the gear package assembled, and the notches aligned, rotate the plates sixty (60) degrees relative to each other. Make permanant notches to show alignment. These notches will be used whenever the gears are changed from reduction to direct drive. Make them large enough to see in bad light; I rounded off the edges a little, too, so I wouldn't snag a finger when I feel them into place.

You must now drill through the pulleys to "F" size. Tap to 5/16-18. For the drive dogs, I used hardware store 5/16" capscrews. They are softer and had threads up to the bolt head. You will need to chamfer the holes about one thread pitch to permit the capscrews to "bottom" in the hole. Count the threads extending out the back of the drive plate. This, plus one pitch, is the length that must be undercut to 0.250". Refer to **Photo 11**. The end of the screws should be turned to a point temporarily, for use as a transfer punch. (One time use in aluminium)

With the gearcase assembled, and the alignment notches aligned, run the 5/16 screws in until they just start to push the assembly apart. Strike each screw head lightly with a hammer. Disassemble the gearcase and remove the dog blocks from the follower plate. You DID remember to punch registration marks, right? Drill each block at the punch with Nr F. Debur and reassemble. Test your fit by running the screws into the dog blocks. The plates should rotate relative to each other until the screw pins are installed. Make sure all three screws will run in together. A slight chamfer on the dog blocks may be necessary to guide the screws in. When you are satisfied with the fit, grind the screw tips to a rounded profile such that the extended shaft is slightly shorter than the thickness of the ring gear. It may be necessary to loosen the dog blocks, insert the pins, and then retighten.

There has been considerable discussion recently in the hobby arena about using a hand wheel on the outboard end of the spindle for threading by hand. This strikes me as an outstanding idea. If you intend to use such a device, it could easily be attached to the pulley face using the dog pin screws. Should you opt to do so, might I suggest that you make another set of screws that are somewhat longer than described here to accomodate the thickness of the handwheel hub. A further thought would be to use the steel hub of the handwheel as a nut for the screws that bind the pulleys to the drive plate. I have not had a problem with these screws coming loose, but it sure feels funny to have the entire assembly held with screws tapped into quarter inch aluminium.

So far, we have been dealing with direct drive (1:1). To use the reduction gearing, it will be necessary to secure the ring gear against rotation. My approach was brute force simple. Drill a hole in the perimeter of the ring gear and install a screw as a pin. A more elegant solution would be a band brake. Too complex for the application, but it sure would look spiffy and make for easier gear changes. Back to the pin. See **Photo** 12 for the drilling rig. I tapped the hole 1/4-20. Using a grade 5 screw approximately 2 ½" long, which has one inch of thread, cut off all but four or five threads before the shoulder. The finished length will vary depending on the ring gear. The target is to bottom the screw in the hole and have the end flush with the root of the internal gear. In Photo 14, the top hole is an oil hole, when in reduction.

Cut a piece of 1-½" by 1-½" by 3/16" angle about 3" long. Centered along one edge cut a notch a quarter inch or so wide, about half way through. In the other leg, drill two Nr ‘F’ holes. Drill Nr 7 and tap corresponding holes in the backing plate that carries the countershaft, belt tensioner and such. Alignment is such that the dog pin on the ring gear catches in the notch. If there is any slight misalignment in the planetaries, the ring gear will try to follow it. If the locking dog is tight, the gearing will bind up, causing irregular speed. Too, with angle cut gears, the ring gear will track left or right depending on direction of rotation. This arrangment allows the ring gear to ride loose. I found it convenient to drill and tap a hole in the bracket to store the pin when using direct drive. You will notice in Photos 13 & 14 that this bracket is fairly close to the ring gear. The excess length of the screw is to make for easier handling.

Spacers The final pieces to make are the spacers that position the gearcase on the spindle shaft. With the gearcase pulley side up on a surface, and the OEM pulley adjacent, use a straightedge to determine the length of the spacer. In **Photo 10**, I have used a piece of styrene below the scale to give better contrast in the photo. This is the space that must be filled between the gearcase and the change gear train. Trim the back spacer to this dimension.

There are other possible considerations here. The OEM pulley is 0.300" center to center of the pulley grooves. I used 1/4" stock for the pulleys and did not use a spacer. I adjusted the height of the gear case such that the center pulleys were aligned. The large and the small pulley run 0.050" or so out of true. My experience has been that it doesn’t matter. The purist may want to adapt to the situation.

With the spacer and the gear case installed, note the length of spacer necessary to have the spindle nut drawn up tight against the bushing in the drive plate. When tight, there should be one or two threads exposed outside the nut. In my case, I used the plugs from the hole saw when I cut the center from the pulley blanks. If you used a different method to cut the center out of the pulley you must make a spacer the correct length; ID 30 mm full, OD some small amount less than the pulley bore. See Photo 14.

On the original version of this device, I used a key that was undercut in places to accomodate the bushing and spacers. On this version, I managed to get the sun gear large enough that the bushing is thick enough to accept a keyway cut in the ID of the bushing. This keyway must also be cut in the spacers. I used a hacksaw and a 3 square file to shape it by hand. Yes, I have a shaper. Yes, I could have set it up to make the keyways. This project was bronze and aluminium and tolerances were not critical. Hell, for that matter, I have keyway broaches. Could have made a bushing. The hacksaw was faster. What can I say. I am profoundly ashamed. But I got done faster. Besides, the point to publishing this piece is that the gizmo can be fabricated with no machines other than the lathe itself and a drill press..

Lapping For finishing, I used “Old Dutch Cleanser” to make a lapping compound. That is the brand recommended by an old timer as having the most consistant grit size. If you have some lapping compound, by all means use it. Mix a thin paste of light machine oil (5w) and the cleanser. Using clean oil, lubricate the inside of the gears where they run on brass. Use a light coat of the paste on the gear teeth, and around the ring gear.

Remount the reduction gear assembly on the spindle. The sequence is: the key, the threading train gear, the inside spacer, the follower plate with ring gear, the driver plate, and the outer spacer. Run the spindle nut up snug. Clamp the chuck to a piece of 1x2 softwood, with the end down between the shears into the bed of the lathe. Turning the pulley by hand should cause the ring gear to run opposite the pulley. Make a full rotation to make sure there are no binds, then belt up to the outside (slowest) sheave. Let the machine run for a solid two minutes. Probably would be a good idea to get a couple minutes in reverse as well. Add some light oil to the joint around the ring gear whenever it starts to complain. We have left a lot of marks on the soft gears during machining, and this will help clean them up.

That was a rather traumatic experience for me, but the gears managed to survive it. I used kerosene for cleanup. Be absolutely certain that you have removed ALL the lapping compound.

Lubricate with clean oil or white lithium grease. I have started using “Marval Mystery Oil” on a lot of my stuff. The machines seem to like it and my air tools are ecstatic. But I do lubricate the machines EVERY time I use them. Keep in mind, too, that this mechanism is open to the environment. Chips and dirt can enter the gap around the ring gear. Regular cleaning is probably a good idea. Keep a watch, too. At higher speeds, oil from the gears will sling off, making a bit of a mess. I guess I’ll have to devise a spatter shield.

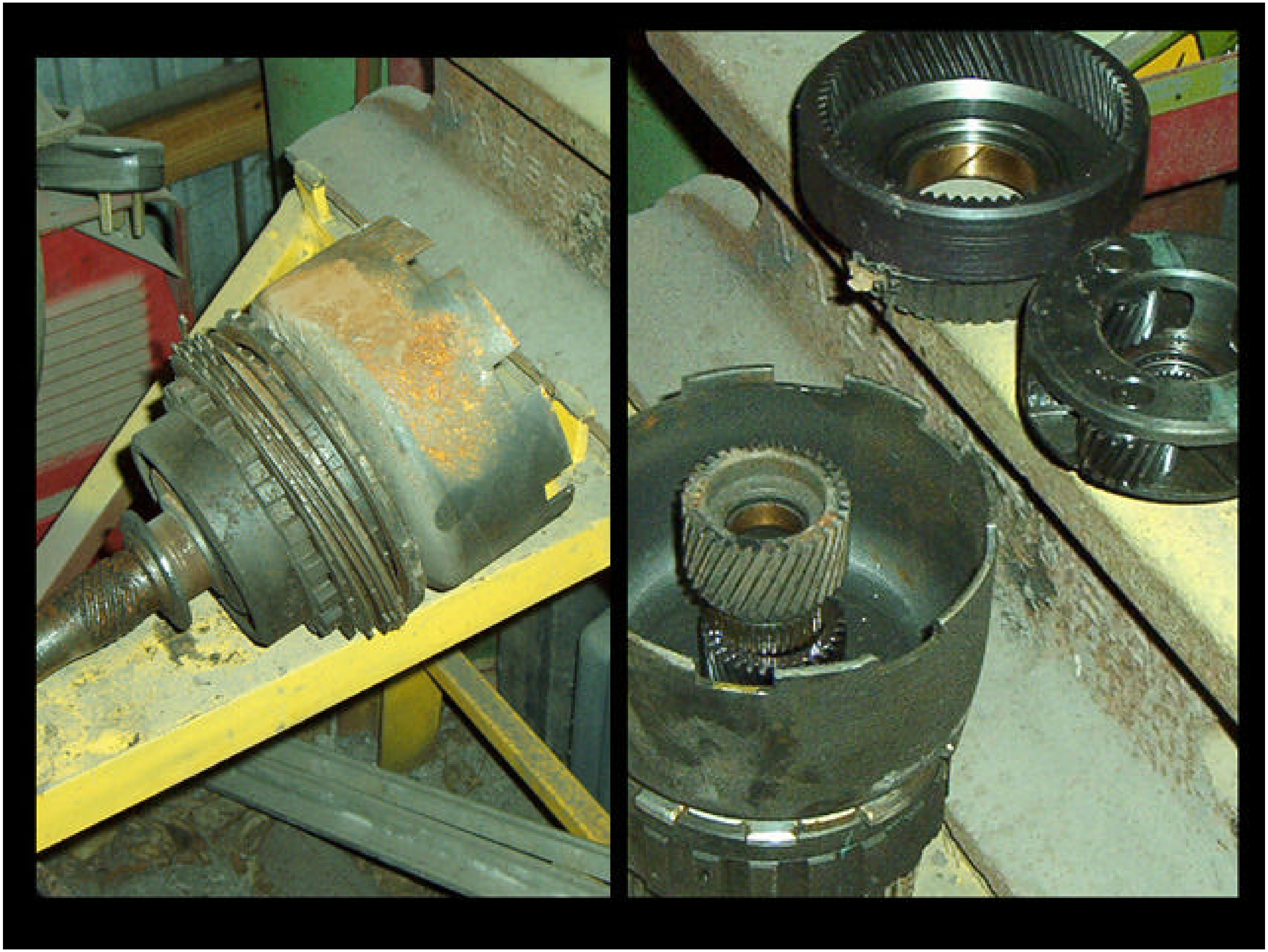
Proper lubrication is a problem with this device. On the earlier versions, I went to great lengths to provide oil holes and passages. After using the device on an irregular basis for a number of years, I have come to the following conclusion: ....It was a waste of effort.

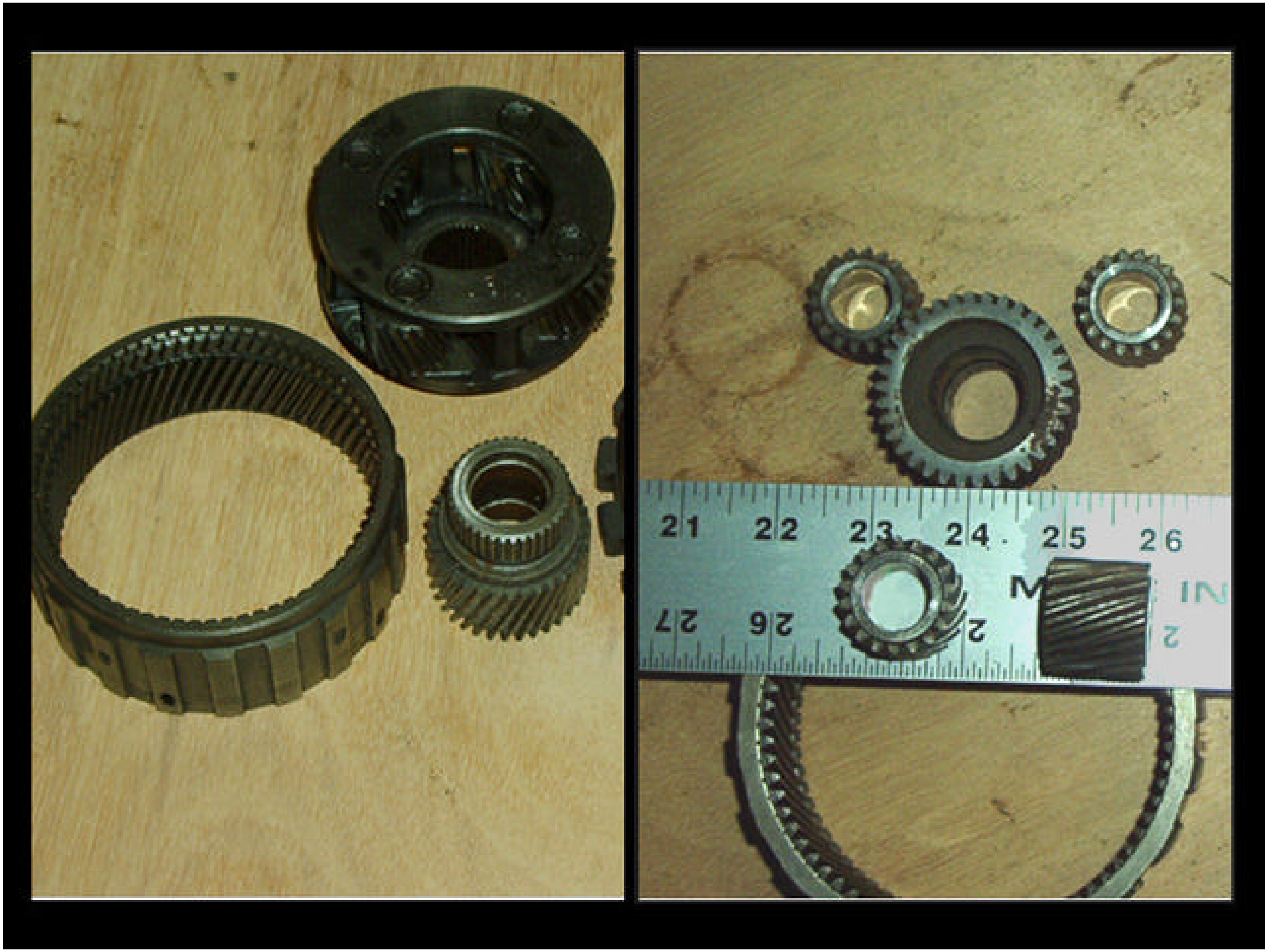
During normal, full speed operation the entire gearcase rotates as an assembly. It has no motion relative to itself. The gears do not turn internally. As I stated above, I lubricate the machine whenever it is operated. That may be for 20 hours this week, and then sit for two months. On the odd occasion that I use the reduction gearing, the project has paid for itself. I just have to be particular about making sure it is well oiled when I use it.

The pulleys run dead true, the ring gear does not. Well, obviously I flubbed it somewhere. So what? It works, well, and does it evermore have torgue when I need it. Should I wear out this machine, the gear case can be easily transferred to another.

I am aware of the move, in the hobby arena, toward variable speed drives. This is a trickle down from industrial machines. It is how I put beans on the table. You must be aware, however, that a variable speed drive loses torque at a distressing rate below about 65% base speed. That would be OK for coil winding and such, but when cutting 5/8-8 Left Hand ACME, some serious torque was necessary. To combine this device with a variable speed drive would provide, to me, the ultimate in control. Perhaps it will solve a problem for you as well.

Visible in some of the photos is the tumbler mechanism for reversing the lead screw. My implementation of this has a very thin profile to provide clearance for the gear case. The gears run on bronze shafts that are fastened from behind the tumbler arm with countersunk screws. The gear is chamfered on the outboard end and the bronze shaft has a tapered shoulder that matches. This serves to hold the gears in place with no protrusion to interfere with the gearcase. Specifics are not given, as there are several versions already in print. Just be aware of the clearances when installing the gearing.

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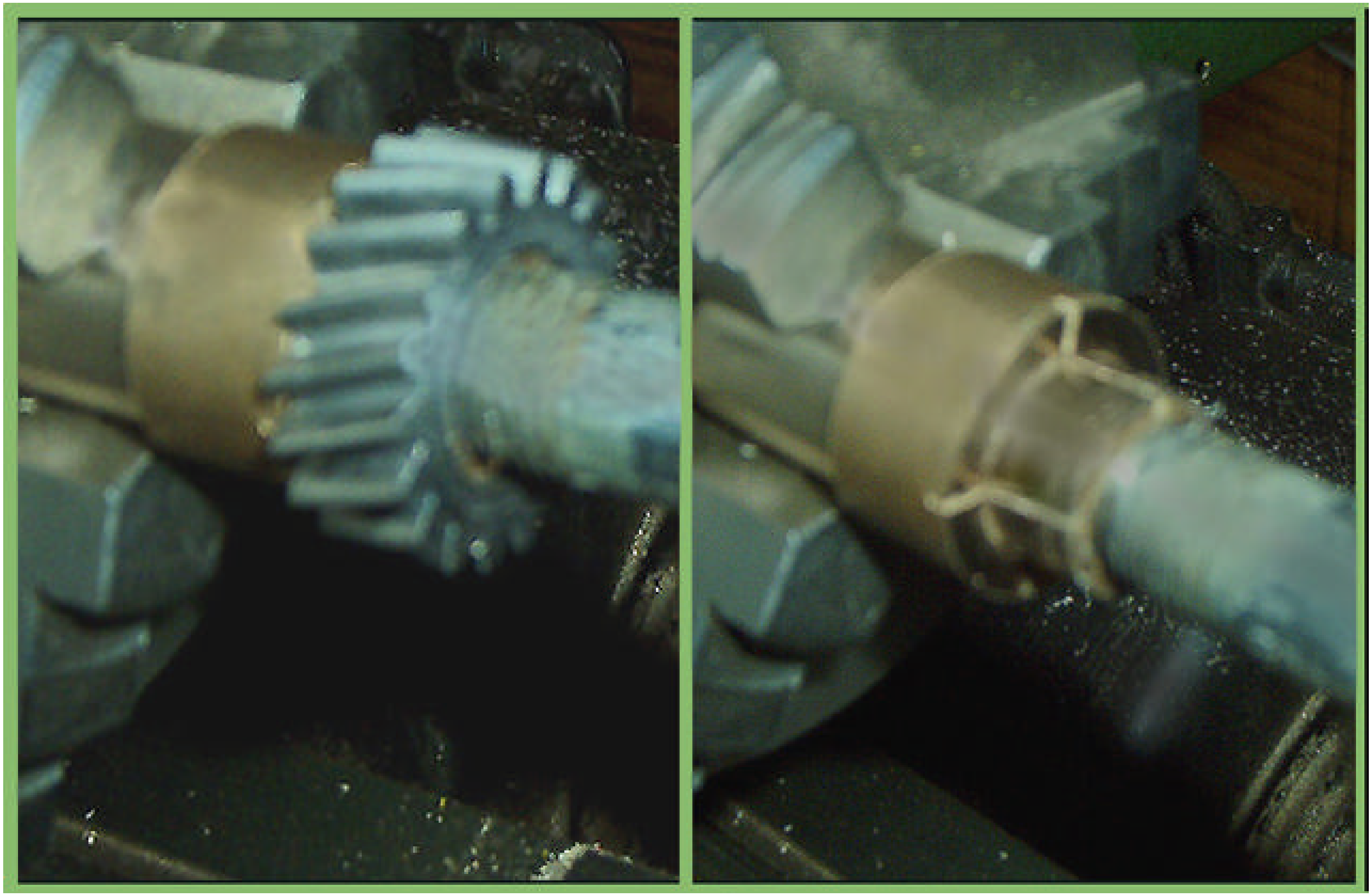

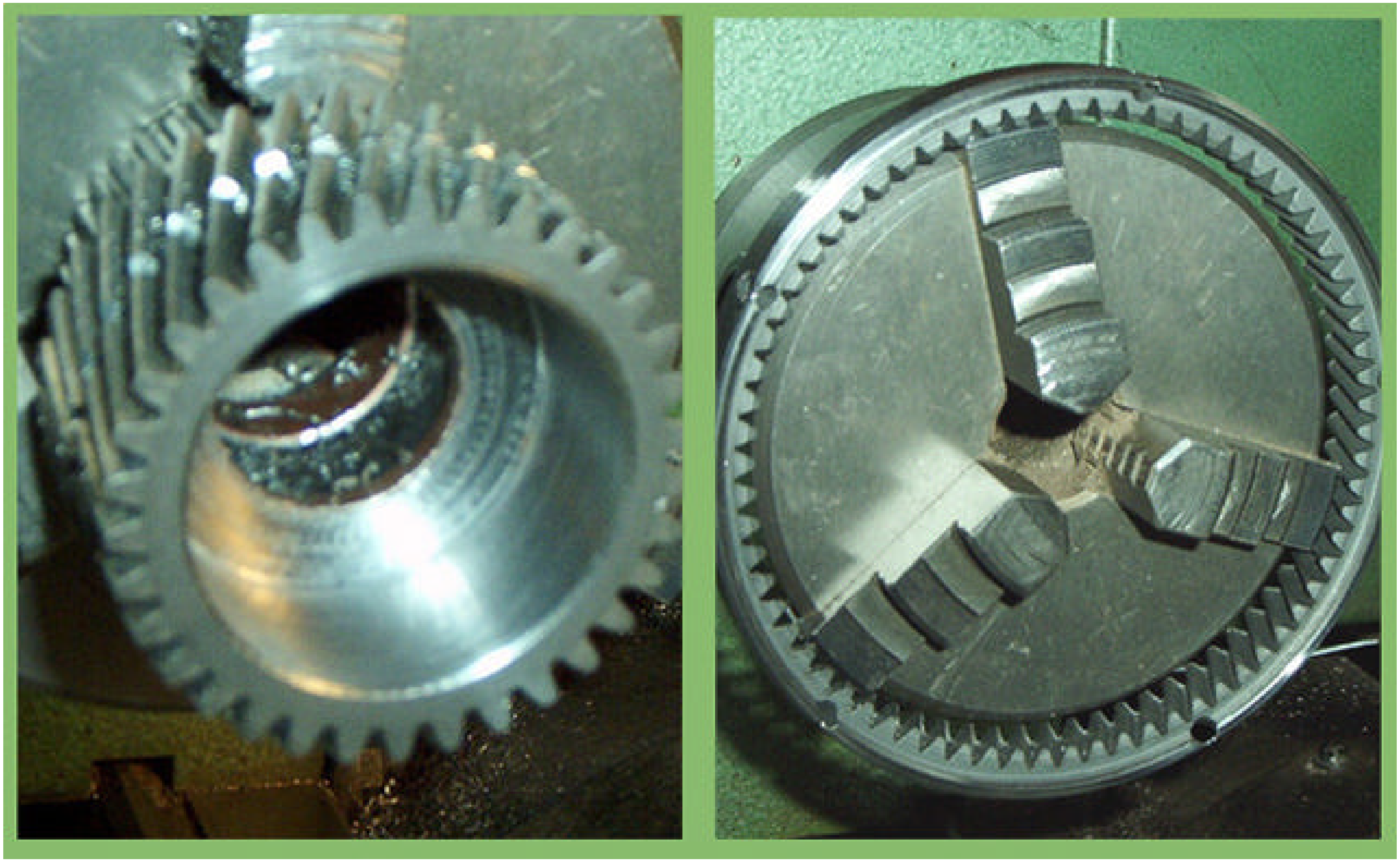

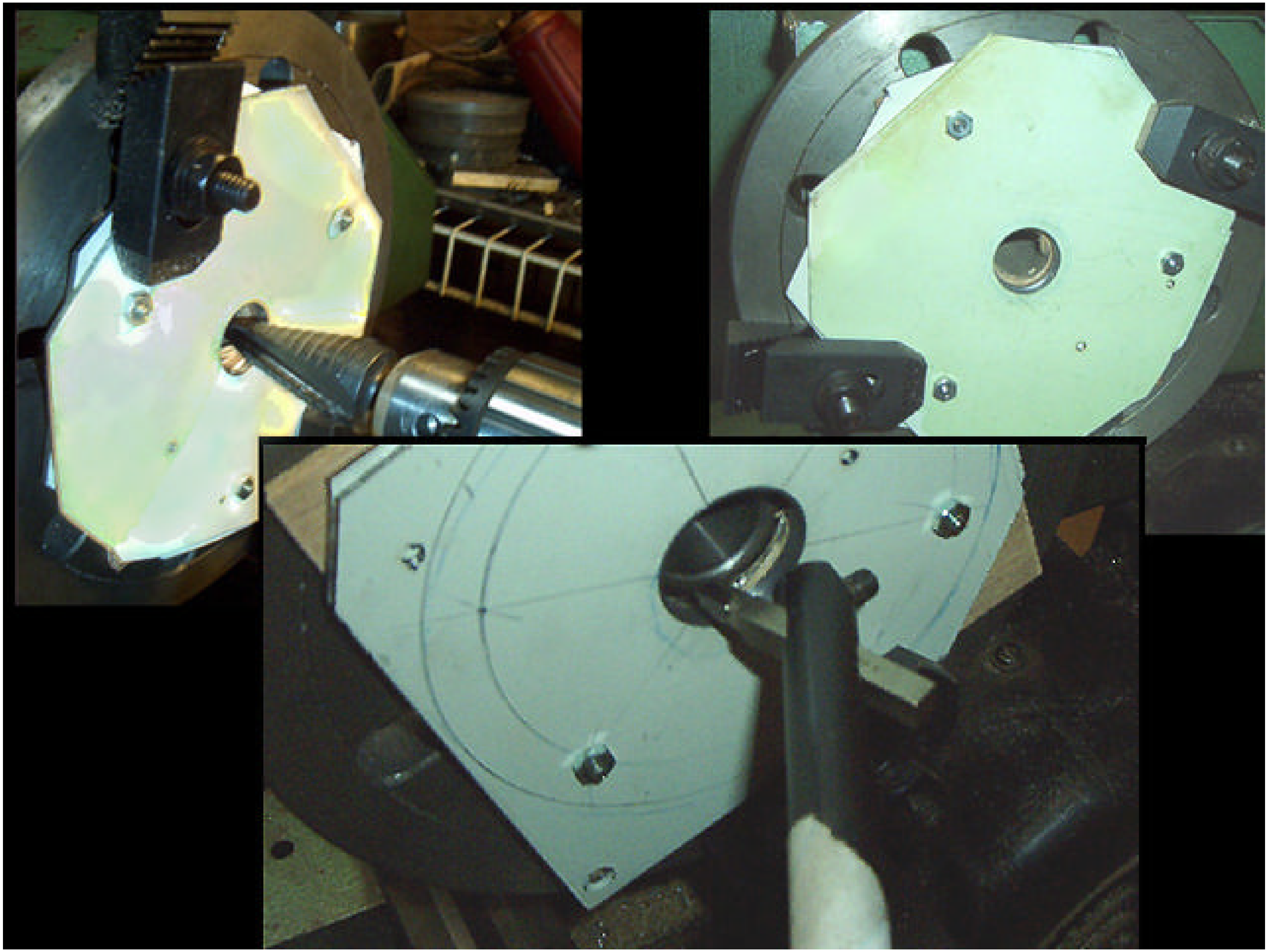


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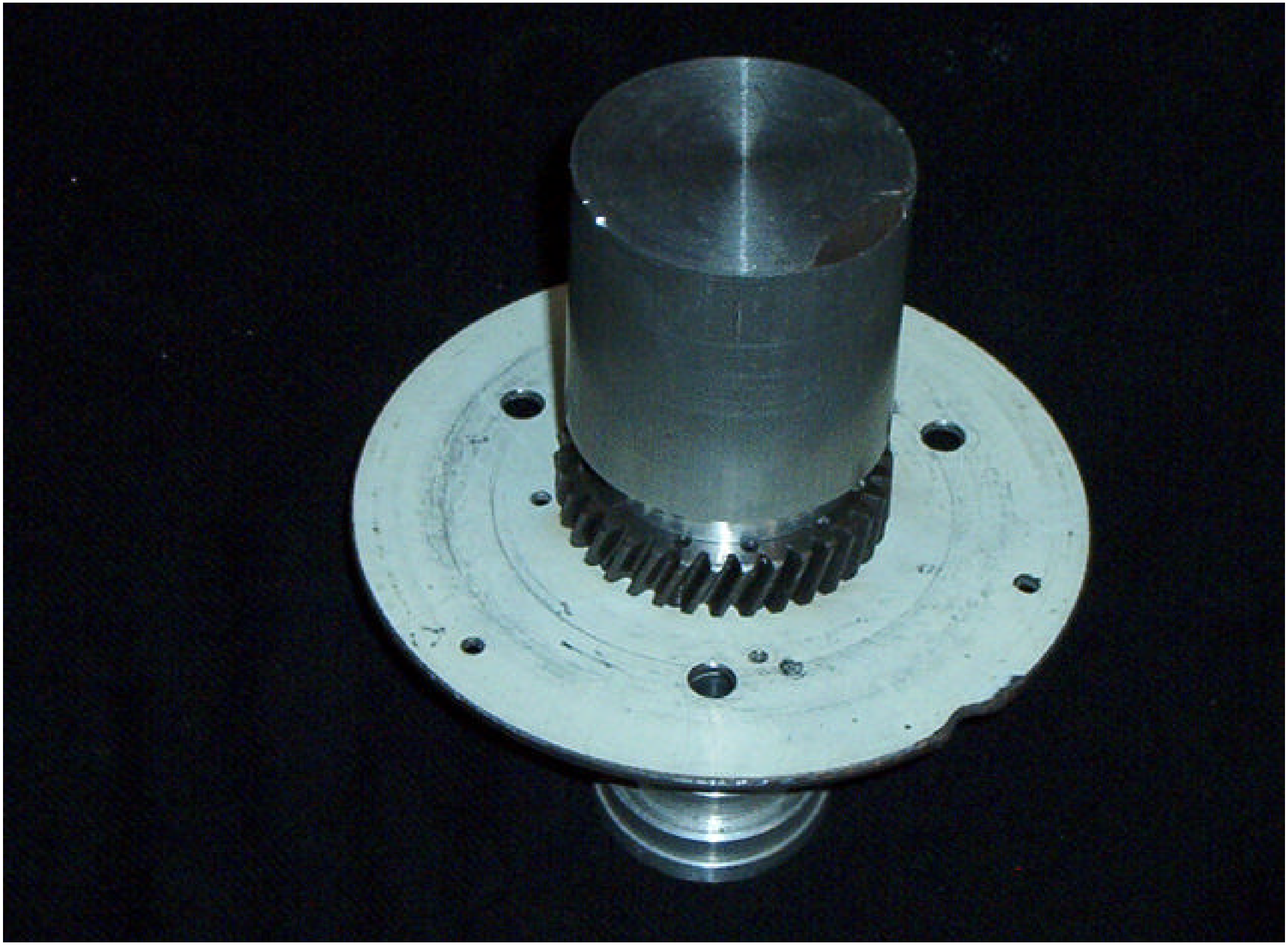

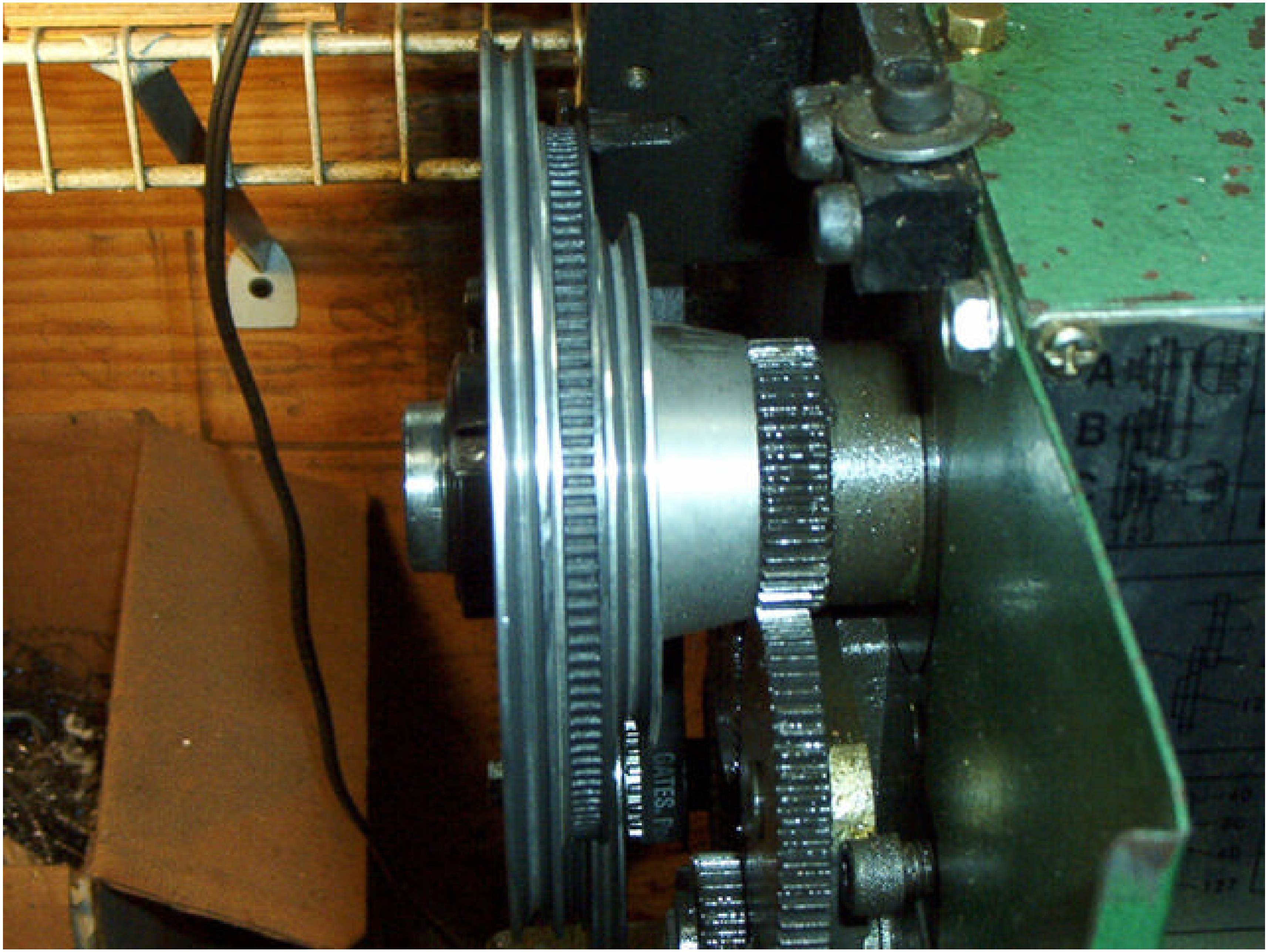
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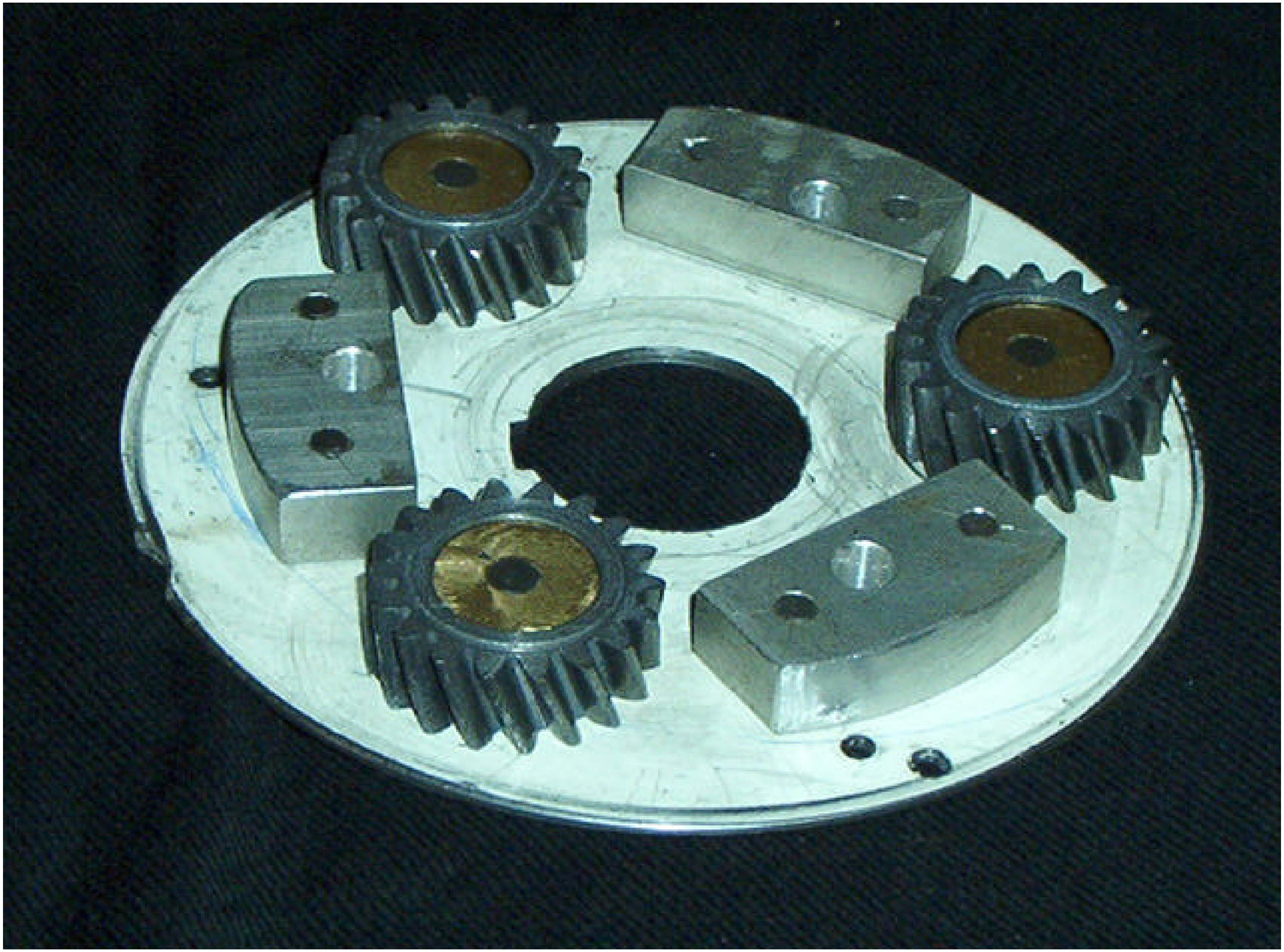

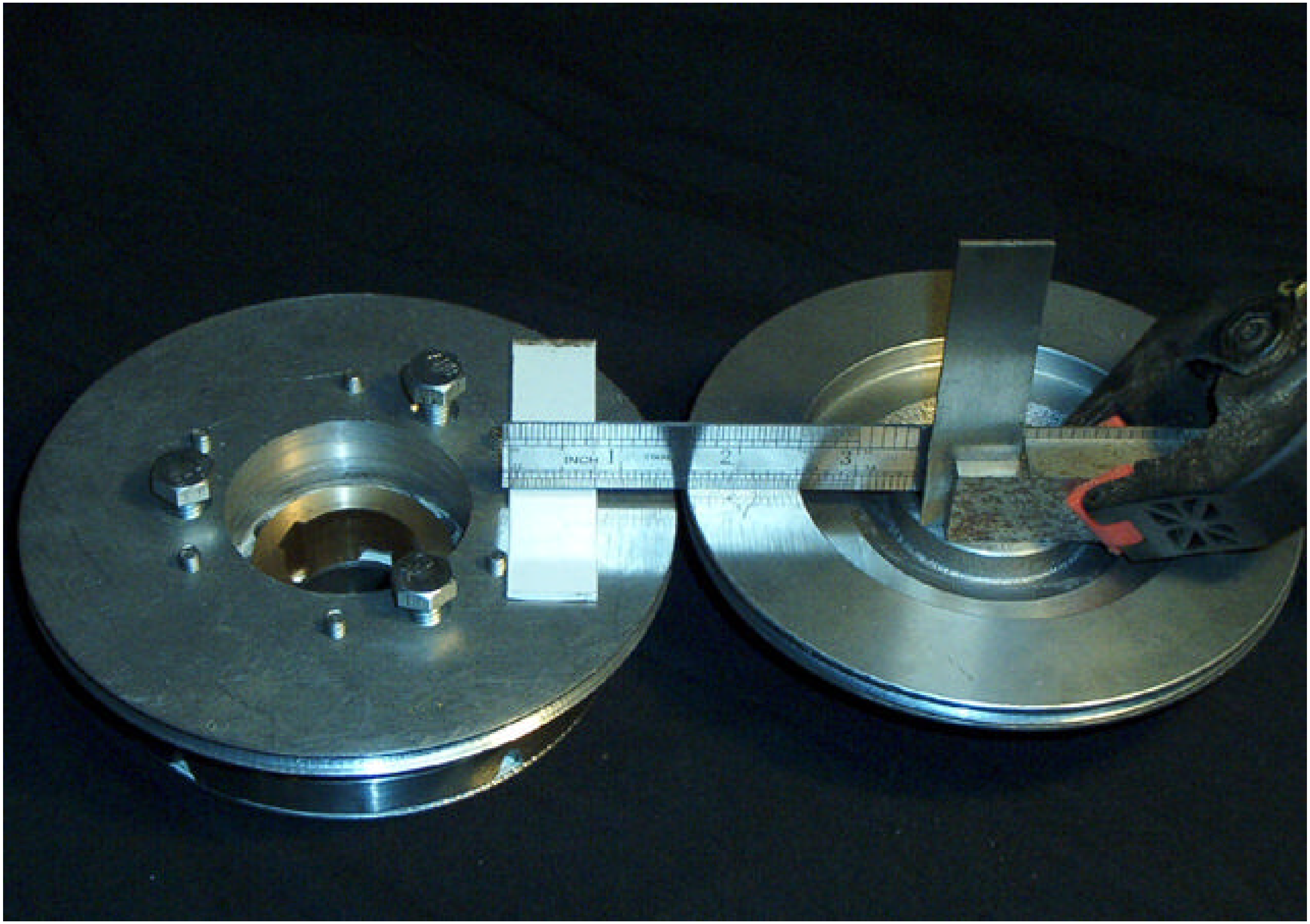
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