SET-UP and OPERATION
of
Brown & Sharpe
Automatic Screw Machines

No. 7

Of a Series of Booklets
for Training Operators

Center, Drill, Form,
Ream and Cut Off

Brown & Sharpe Mfg. Co.
North Kingstown, R. I., U. S. A.

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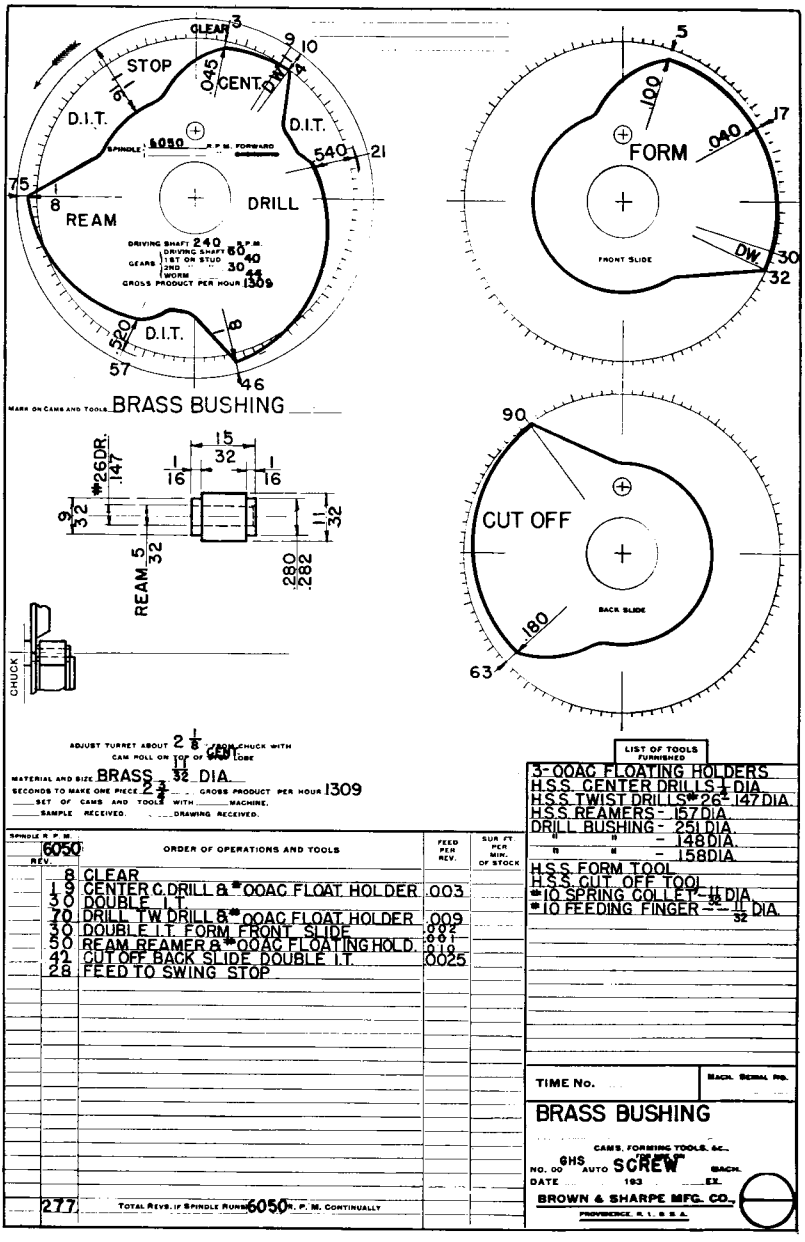


SPINDLE R.P.M. 6050 REV.	ORDER OF OPERATIONS AND TOOLS	FEED PER REV.	SUR. FT. PER MIN. OF STOCK
8	CLEAR		
19	CENTER & DRILL & #00AC FLOAT HOLDER	.003	
30	DOUBLE I.T.		
70	DRILL TW DRILL & #00AC FLOAT HOLDER	.009	
30	DOUBLE I.T. FORM FRONT SLIDE	.002	
50	REAM REAMER & #00AC FLOATING HOLD.	.010	
42	CUT OFF BACK SLIDE DOUBLE I.T.	.0025	
28	FEED TO SWING STOP		
277	TOTAL REVS. IF SPINDLE RUNS 6050 R.P.M. CONTINUALLY		

LIST OF TOOLS FURNISHED

3-00AC FLOATING HOLDERS
H.S.S. CENTER DRILLS 1/4 DIA
H.S.S. TWIST DRILLS #26 - .147 DIA
H.S.S. REAMERS - .157 DIA.
DRILL BUSHING - .251 DIA.
" " - .148 DIA.
" " - .158 DIA.
H.S.S. FORM TOOL
H.S.S. CUT OFF TOOL
#10 SPRING COLLET - 11/32 DIA.
#10 FEEDING FINGER - 11/32 DIA.

TIME No. MACH. SERIAL NO.

BRASS BUSHING

CAMS, FORMING TOOLS, &C.
NO. 00 AUTO GHS SCREW MACH.
DATE 193 EX.

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I. U. S. A.

Fig. 1. Work Sheet for Job No. 6

NO. 7 OF A SERIES OF BOOKLETS FOR TRAINING OPERATORS

JOB NO. 6

Center, Drill, Form, Ream and Cut Off

To save time on a screw machine job where only three turret stations are to be used, the machine may be set up for double indexing. This is an arrangement by which the turret automatically indexes through two stations each time the turret trip lever is lifted. Since there are but three turret operations called for on the work sheet of Fig. 1, we will use double indexing for the production of this bushing.

The bushing of Job No. 6 is the first of our work pieces which has had a hole and thus we must study for the first time the use of a center drill, drill and reamer. This also is the fastest job we have had for the five cutting operations are completed in 2¾ seconds.

Strip the Machine.

Back off cross slide stop screws.
Insert feed finger.
Insert collet.
Insert bar of stock.
Adjust length of feed.
Adjust collet pressure.
Disconnect coupling driving spindle reverse carrier.
Put on feed change gears.
Make spindle speed changes.
Put on cross slide and turret lead cams.

Adjust Turret Position. The work sheet, Fig. 1 requires that you "adjust turret about 2⅛" from chuck with cam roll on top of CENTER lobe." This figure is greater than the normal 1⅞" distance employed on preceding jobs and requires a change in turret setting. Turn the driving shaft handwheel until the turret lead cam lever is on top of the centering lobe between positions 9 and 10. Measure the distance from the cylindrical surface of the turret to the nose of the chuck. For the usual machine setting it will be 1⅞".

To obtain the 2⅛" value, remove the guard from the top surface of the turret slide. Six screws hold the guard in position. With the guard removed, you will see the rectangular back surface of a rack which is in engagement with a gear or

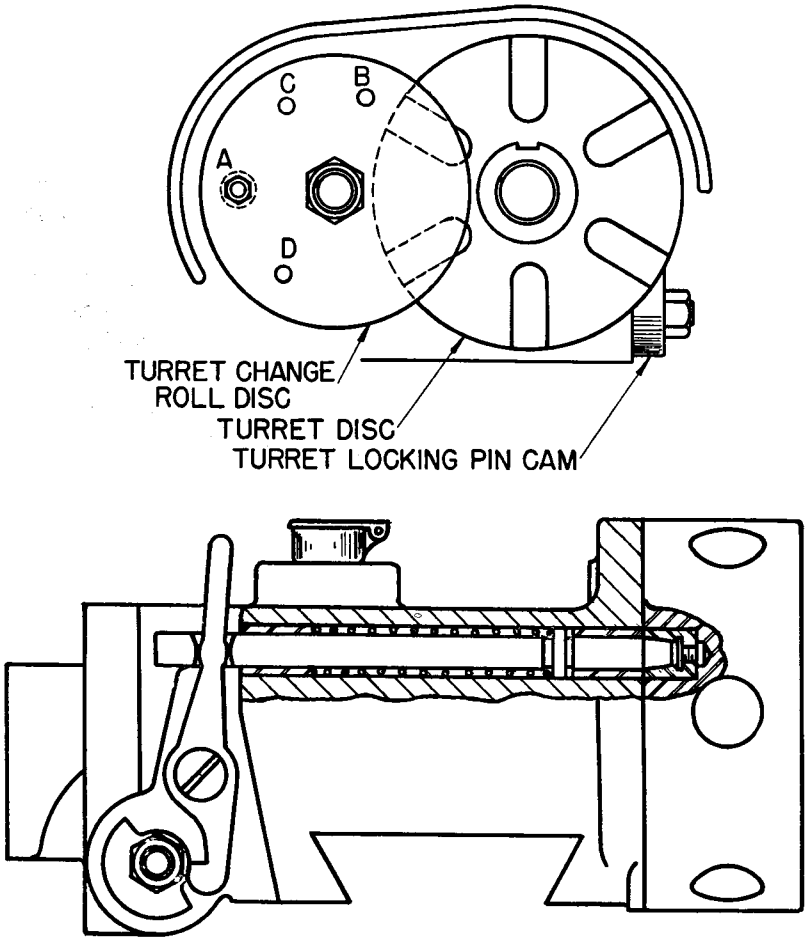


Fig. 2. Turret Indexing Mechanism

toothed segment below. Press forward on the turret slide and at the same time lift the rack up out of engagement with the segment. Move the slide back about ¼" and reengage the rack teeth. Check the turret to chuck distance (2⅛") to be certain you have engaged the proper teeth. Replace the guard and screws.

Set the Machine for Double Indexing. Remove the vertical plate or guard held by screws on the back side of the turret slide. This will expose the members shown in Fig. 2. Trip the turret index trip lever and watch the index while you make one turn of the driving shaft handwheel. Notice that the locking pin cam

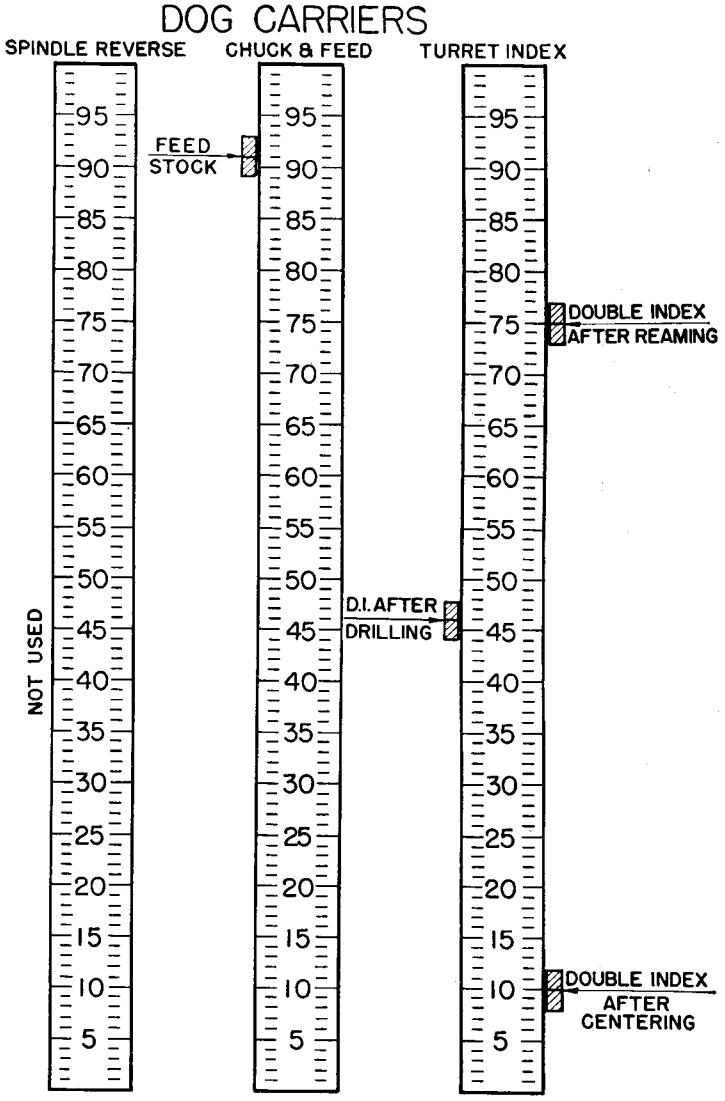


Fig. 3. Dog Settings for Job No. 6

withdraws the turret locking pin just before the roll begins to index the turret and releases the pin just as the index is being completed.

Remove the shaft nut which holds the turret change roll disc in place, and pull off the disc. There will be a single roll at position A. For double indexing, mount a second roll at position B. Reassemble the disc. Remove the turret locking pin cam and in its place mount a double or long dwell cam. For double indexing the locking pin must be held out longer than for single indexing and thus the double cam is required. Put the cam on so that rise will be coming toward you as you rotate the driving shaft handwheel. The rise can be identified by its rounded form. The drop has a straight or flat side. If the cam is mounted correctly, the rise will lift the turret locking pin lever and the drop will release it. Notice that the double cam has two keyways. Use the keyway which will delay as long as possible the withdrawal of the locking pin and which will permit the cam to hold the pin out to the latest possible point in the indexing cycle.

To see the double indexing action and to check the changes you have just made, turn the driving shaft handwheel for one revolution.

Having satisfied yourself on how double indexing works and having set up with rolls at A and B, replace the guard on the turret slide.

Set All Carrier Trip Dogs.

(a) Turn the driving shaft handwheel until the turret lead cam lever roll is at the peak of the centering lobe of the cam, position 10 on the work sheet. Snap down the trip lever dog and set the first carrier dog to operate at this point.

(b) Turn the handwheel until the lever roll is at position 46 on top of the drilling lobe. Set the second carrier trip dog for turret index.

(c) Continue turning the handwheel and bring the cam lever roll to the top of the reaming lobe, position 75. Set the third turret index carrier trip dog.

(d) Watch the back cross slide and when it has been withdrawn about $\frac{1}{8}$" or when close to position 91, snap down the chuck trip lever dog and set a chuck carrier trip dog.

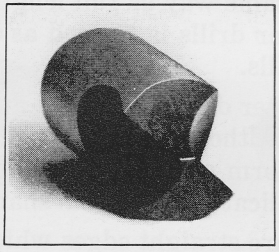
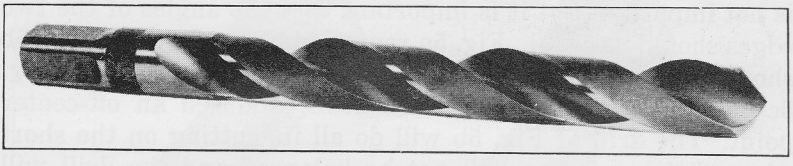


Fig. 4. Typical Center and Regular Drills



(e) The spindle does not change speed and no dogs are necessary on the spindle reverse carrier. Fig. 3 shows approximate dog settings for all carriers.

Sharpen, Mount and Adjust the Circular Cutting-Off Tool and set the back cross slide for depth. For the time being adjust the slide so that when at the peak of the cutting-off cam the cutting-off tool will have cut a groove about $\frac{1}{16}$" deep. Later, after setting the drill, we will make a final setting for the depth to which the cutting-off tool is fed.

Adjust the Swing Stop.

Sharpen the Drills. A center drill is simply a short, stubby drill supported so close to its point that it has great rigidity and cannot be easily deflected off-center when cutting. Since its

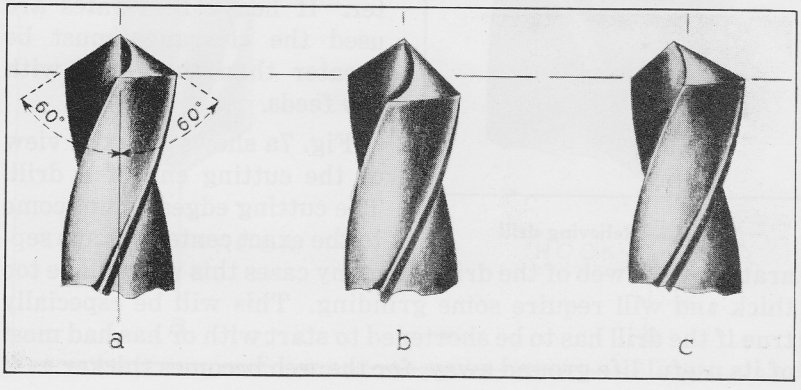


Fig. 5. Correct and incorrect methods of sharpening drill

cutting edges are ground in the same way as full length drills, the grinding of center and regular drills is treated as a single subject. Fig. 4 shows typical drills.

Get a new, unused, large diameter drill from stock and study its angles and ground surfaces. Although you may later wish to modify slightly the standard form you will at first be doing well if you can grind a drill to duplicate the original sharpening.

The two cutting lips of a drill are straight edges which make a 60 degree angle with the axis of the drill. The exact 60° angle is not important but it is important that the angles of the two edges should be equal. Fig. 5a represents a good grind. Fig. 5b shows unequal angles although the drill point is central. Fig. 5c shows unequal angles which have produced an off-center point. The drill of Fig. 5b will do all its cutting on the short edge. Cutting forces will not be balanced and the drill will chatter and crowd to one side, producing an unsatisfactory hole. The drill of Fig. 5c will cut an oversize hole for the drill will try to sweep out a hole whose radius is produced by the long cutting edge. The longer and smaller a drill, the more important it is to have equal lips and a balanced cut.

In a drill, as in all the tools we have considered thus far, the surface trailing behind the cutting edge must be ground for clearance. In Fig. 6, the conical surface has been relieved so the drill will not rub as the cutting edge is fed into the work. A clearance angle of 12 degrees at the outside edge is standard. This angle should increase as the edge approaches the center. If heavy feed rates are used the clearance must be greater than that used with low feeds.

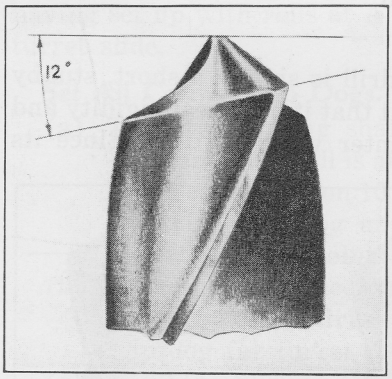


Fig. 6. Relieving drill

Fig. 7a shows an axial view of the cutting end of a drill. The cutting edges do not come to the exact center but are separated by the web of the drill. In many cases this web will be too thick and will require some grinding. This will be especially true if the drill has to be shortened to start with or has had most of its useful life ground away, for the web becomes thicker as it

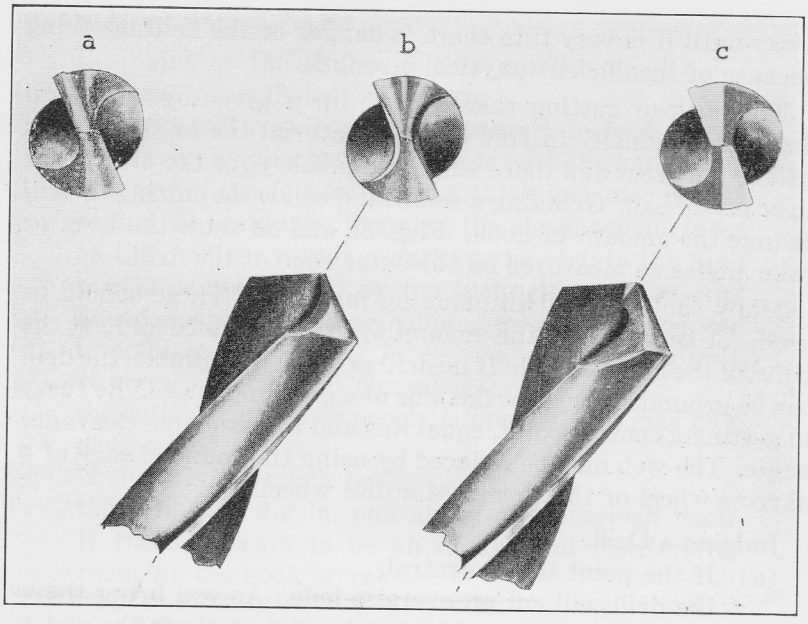


Fig. 7. Methods of thinning web of drill

approaches the shank of the drill. Fig. 7b and 7c show by lines and shaded areas the metal which is removed in two methods of thinning the web. If the web is too wide, great pressure will be required to feed the drill into the work. If the web is ground

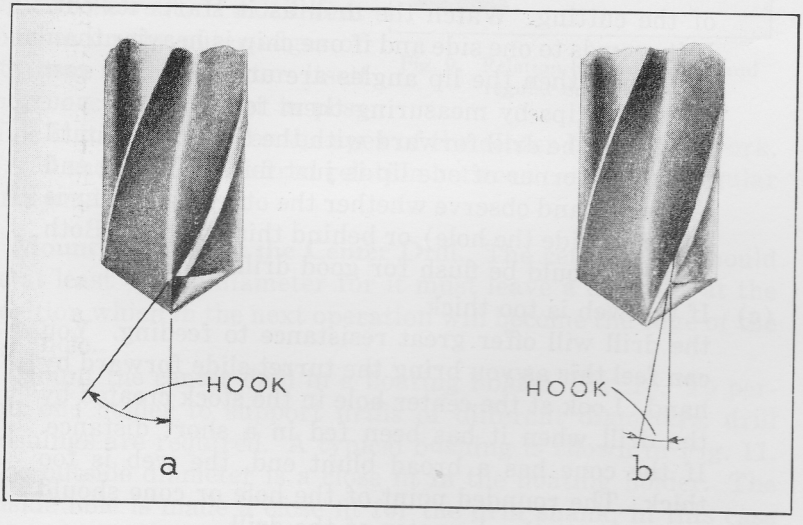


Fig. 8. Method of decreasing rake angle

away until it is very thin there is danger of the drill breaking because of insufficient physical strength.

The hook or cutting rake for the lip is given by the spiral flute. Occasionally in free cutting material the angle of hook will be too great and there will be a tendency for the drill to dig in or pull ahead. Grinding a small land below the cutting lip will change the amount of hook. Figs. 8a and 8b show the hook or rake angles as measured on the outer edge of the drill.

Many shops have drill grinding machines. These should be used, for they control the amount of drill clearance and get the point of the drill central. If no drill grinder is available, the drill can be ground against the flat side of a grinding wheel. Be fussy in getting a central point, equal lips and a reasonable clearance angle. The web may be reduced by using the rounded edge of a narrow wheel or the corner of a disc wheel.

Judging a Drill.

(a) If the point is not central,
the drill will cut an oversize hole. As you bring the turret slide forward by hand and first touch the end of the work bar with the drill point, the point will make a small circular groove instead of forming a center.

(b) If the cutting edge angles are unequal,
the drill will cut unevenly with one lip doing most of the cutting. Watch the drill as it starts its cut. If it crowds to one side and if one chip is heavier than the other, then the lip angles are unequal. You can check the lips by measuring them for length or you can bring the drill forward with the turret slide until the outer corner of one lip is just flush with the end of the bar and observe whether the other lip corner is ahead (inside the hole) or behind this position. Both corners should be flush for good drilling.

(c) If the web is too thick,
the drill will offer great resistance to feeding. You can feel this as you bring the turret slide forward by hand. Look at the center hole in the stock created by the drill when it has been fed in a short distance. If the cone has a broad blunt end, the web is too thick. The rounded point of the hole or cone should be $\frac{1}{10}$ to $\frac{1}{16}$ the diameter of the drill.

(d) If the web is too thin,
the point of the drill will chip and break off.

(e) If there is insufficient clearance,
the drill will require heavy pressures to feed it into the stock. Moving the turret slide with the hand lever will reveal the forces. Since a thick web also causes high drill pressures, examine the clearance surfaces on the drill for rubbing marks to be certain the high pressures are caused by too little clearance. Grind added clearance until no rubbing marks are produced in drilling.

(f) If there is too much clearance,
the cutting lip will be poorly supported and may chip or break off.

(g) If there is too much hook,
the drill may dig in, pull ahead and overload itself. If there appears to be an in and out chatter, try reducing the hook or rake.

Relation of Center and Regular Drill Angles. The angle which the cutting lip of a center drill makes with the axis should be less than the lip angle of the regular drill which follows it. If a drill first touches on the outer edges of its cone it will center itself more accurately than is possible if its point strikes the apex of the center hole in the work. Fig. 9 shows the preferred relation between center and regular drill angles.

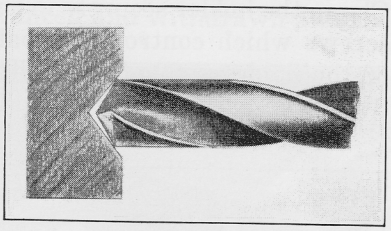


Fig. 9. Relation between center and regular drill angles

Mount and Adjust the Center Drill. The center drill should be at least $\frac{3}{16}$″ in diameter for it must leave a chamfer at the position which in the next operation will become the edge of the $\frac{5}{32}$″ hole.

Mount the center drill in a floating holder, Fig. 10. To permit one holder to support drills of different diameters, drill bushings are required. A typical bushing is shown in Fig. 11. The outside diameter is a close fit in the floating holder. The inside hole is made a close fit for the drill shank, in this case .251″ in diameter. It is particularly important that the hole

in the bushing be parallel with the elements of the outside surface or that its axis coincides with the axis of the bushing.

If the bushing hole is out of line, you cannot drill a true hole in the work. Notice that there is a slot cut through the middle of the bushing and that a semi-circular shoe is located here. On the top surface of the shoe is a flat provided as a seat for the holder clamp screw. When assembled in position, the clamp screw will press the shoe down firmly on the drill shank and hold the drill and bushing securely in position. Select a drill bushing of the proper size and insert it in the holder so that the flat on the shoe is under the clamp screw. Place the center drill in position and clamp it tightly.

This type of bushing will be used for the regular drill and for the reamer described later.

Mount the holder in a turret station and then turn the driving shaft handwheel until the turret lead cam lever roll is at the beginning of the feed on the center drilling lobe or at position 3 on the work sheet. Now move the holder forward in its station until the drill point just clears the end of the work piece. Clamp the holder securely in the turret. Loosen the two holder screws which control the float and move the floating section of the holder so that the drill will be central with the work. Start the machine spindle and bring the turret slide forward with the hand lever while you guide the drill with your left hand. The drill will center itself. Tighten the two clamp screws. Bring the slide forward by hand a second time to be certain you have not changed the "on center" position by tightening the clamp bolts.

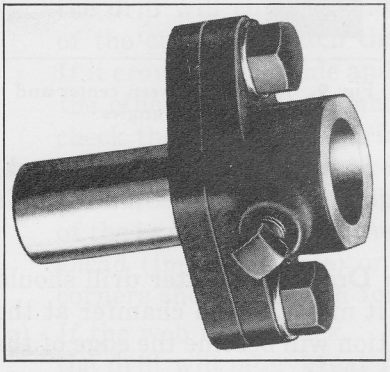


Fig. 10. Floating Holder

Now engage the driving shaft clutch and let the machine run until the drill has been advanced and withdrawn and the turret indexed. Measure the diameter of the center in the work. Move the center drill forward or back enough to get a $\frac{3}{16}$" diameter.

Mount and Adjust the Drill. This drill should be about .005" to .009" smaller than standard, or .147"-.151" in diameter. After

the hole is reamed it must be 5/32" in size. The drilled size is thus made small to allow stock for the finishing operation of reaming.

Mount the drill in a floating holder and the holder in the third turret station counting the center drill station as No. 1. Turn the driving shaft handwheel until the turret lead cam lever is just on the feeding section of the drilling lobe or at position 21 on the work sheet. Now adjust the drill in its holder or the holder in its turret station until the drill just clears the work surface cleaned out by the center drill.

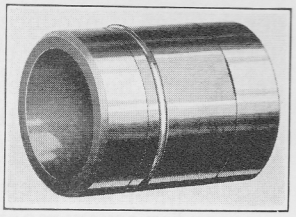


Fig. 11. Bushing

Loosen the floating clamp screws and start the machine spindle. Bring the turret slide forward by hand and guide the drill and floating holder with your fingers. If the drill has been properly sharpened it will center itself. Having centered the drill, clamp the two float control screws.

Engage the driving shaft clutch and let it remain in engagement until the drill has been advanced and withdrawn and the

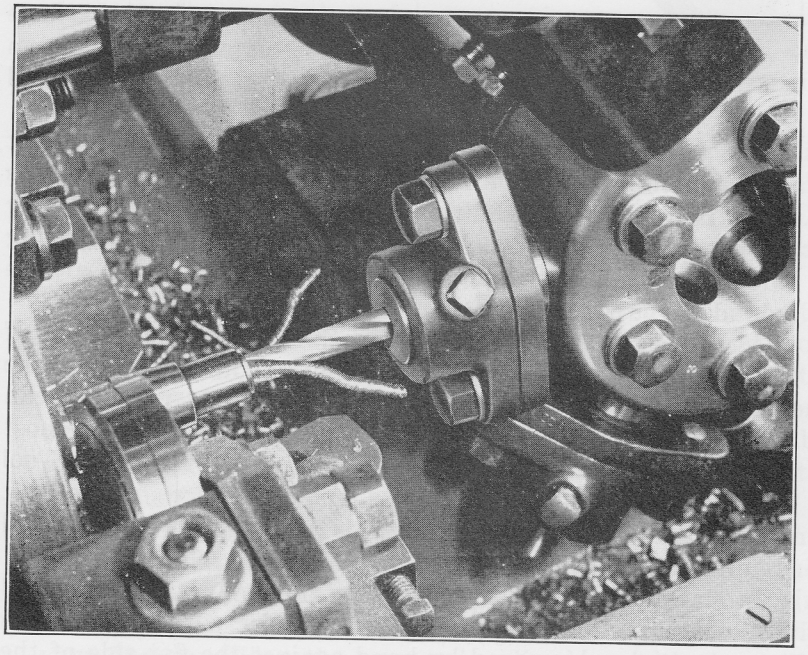


Fig. 12. Drill held in Floating Holder

turret indexed. Now bring forward the cutting-off tool by hand and cut off the work piece. Examine the spot left in the bar of stock by the drill. The drill will have been adjusted to proper depth when it produces a center hole in the stock which has a diameter at the outer end equal to the diameter of the drill. The drill should have gone by the cutting-off tool only enough to let the outer corners of the cutting lips touch the end of the next work piece. Adjust the drill to the proper depth.

Select and Sharpen Reamer. The most commonly specified reamer for screw machine work is the stub-length fluted reamer Fig. 13. The reamer teeth do all their cutting at the front end where they are chamferred to create a cutting edge. Since the limit on the $\frac{5}{32}$″ hole is standard to plus .001″, a standard $\frac{5}{32}$″ reamer should be selected. If too much stock is left in a drilled hole, giving the reamer a heavy chip to remove, the reamer may produce a large or oversize hole. If your reamer is cutting a hole much greater than its own diameter, check on the drilled hole size.

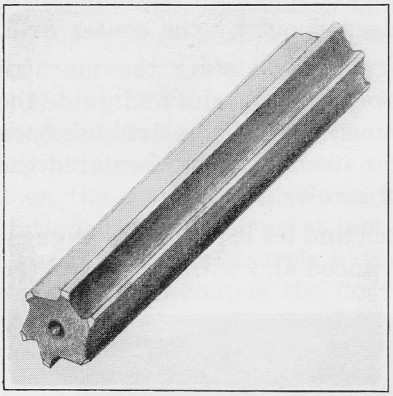


Fig. 13. Fluted reamer

The reamer outside diameter cannot be ground without changing the size of the hole produced by the reamer. Thus in sharpening a reamer, this surface is left alone and only the chamferred nose is renewed by grinding. The following side of the chamferred edge is ground low to give a clearance behind the cutting edge.

A reamer has several (4 to 8) teeth. If the same amount of metal is not removed from each chamferred surface, then the teeth will not cut evenly. Small variations in grinding can easily cause one or two teeth to do all the cutting. The most reliable sharpening of reamers is done in a Universal and Tool Grinding Machine where angles and clearances can be set exactly and stops can be located to make the grinding of all chamfers the same.

In many shops the bench grinder is the only grinding wheel available for tool grinding. The chamferred surfaces of a reamer can be sharpened by hand against the flat side of the

wheel. This operation does, however, require extreme care. If a reamer is feeding .012″ per revolution of the stock then each of the six teeth would remove a chip .002″ thick. Therefore, if the cutting edge on one flute is .002″ behind the cutting edge on the preceding flute, it will miss its chip altogether. Good operators, when hand grinding reamers, usually compare flute chamfers with a magnifying eye glass and watch the chips produced when the reamer makes its first cuts.

The angle the cutting edge makes with the reamer axis is approximately 60°, the same as the angle on a drill. This permits the reamer to conform with the conical end of a drilled hole.

Fig. 14. Grind away the reamer nose when resharpening

The reamer chamfer should extend to the root diameter of the flutes, but not further. As a reamer is reground, grind away the flat end or nose of the reamer, for this surface should only be a short distance ahead of the outside corner of the cutting edge. See Fig. 14.

Mount and Adjust the Reamer. Bring the back cross slide forward by hand and cut off the work piece. Mount the reamer in a floating holder and place the holder in turret station No. 5. Now turn the driving shaft handwheel until the turret lead cam lever roll is at the top of the reaming lobe or at position 75 on the work sheet. Adjust the holder in its turret station or the reamer in the holder until the flat end of the reamer is about $\frac{1}{32}$″ in front of the stock or just in line with the middle of the cutting-off blade. This setting will permit the reamer to completely finish the work piece and yet will provide a reasonable clearance between the end of the reamer and the end of the drilled hole.

Engage the driving shaft clutch and let the cycle continue until the drilling operation is completed and the reamer is ready to go forward. Now loosen the float clamping screws and bring the turret slide forward by hand while guiding the reamer with your fingers. When the reamer has lined up with the drilled hole clamp the two screws.

If the reamer cuts a bell-mouth hole, look for misalignment, for the reamer axis is probably at a slight angle with the work axis. Check the reamer or holder bushing for eccentricity and make sure the parts of the holder are seating squarely when clamped.

Sharpen, Mount and Adjust the Form Tool. A raising block must be used on the front slide with a forward direction of rotation. The tool post adjustment in the cross slide T-slot must be such that the $\frac{1}{16}$" shoulders are obtained. A stop screw setting should be made to give a close limit to the $\frac{9}{32}$" shoulder diameter.

Adjust the Back Cross Slide for Depth. Since the cutting-off blade breaks into the drilled hole, it is not necessary to feed beyond center to cut off the work piece. Turn the driving shaft handwheel until the back cross slide cam lever roll is at the peak of the cutting-off lobe (position 90). Then turn the cross slide adjusting nut until the cutting-off tool has cut off the completed bushing and the inner edge of the blade has just passed the edge of the drilled hole or center in the end of the bar. Lock the adjusting nut. It will not be necessary to use the stop screw for no diameter is controlled by the cutting-off operation.

Set Work Deflector and Adjust Coolant. Valves in the cutting oil circuit are usually opened wide when there is a drilling operation required on the work piece. To make sure oil gets into the hole, the work and drill are kept flooded with coolant.

Inspect the Work Pieces. Let the machine run through a few cycles and check the pieces produced. Be sure you are meeting all the specified limits on the worksheet, examine the finish obtained on reamed and formed surfaces. Let your foreman see one of these pieces.