MACHINERY'S REFERENCE SERIES

EACH NUMBER IS A UNIT IN A SERIES ON ELECTRICAL AND STEAM ENGINEERING DRAWING AND MACHINE DESIGN AND SHOP PRACTICE

NUMBER 106

AUTOMATIC SCREW MACHINE PRACTICE

PART VIII

MILLING, CROSS-DRILLING AND BURRING OPERATIONS

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CONTENTS

CHAPTER I

MILLING ATTACHMENTS

One of the most commonly used milling attachments for the Brown & Sharpe automatic screw machines is the screw-slotting attachment. This attachment, shown at *A* in Fig. 1 is fastened to a boss provided for this purpose on the machine. The apron *B*, which is also an additional part, carries the arbor *C* to which the transferring arm *F* is attached. The transferring and advancing cam levers *D* and *E* are also fastened to bosses on this apron. These levers are operated by the advancing and transferring cams *J* and *K*. The block *H* is fastened to the arm *F*, and a slotting bushing to carry off the screw is

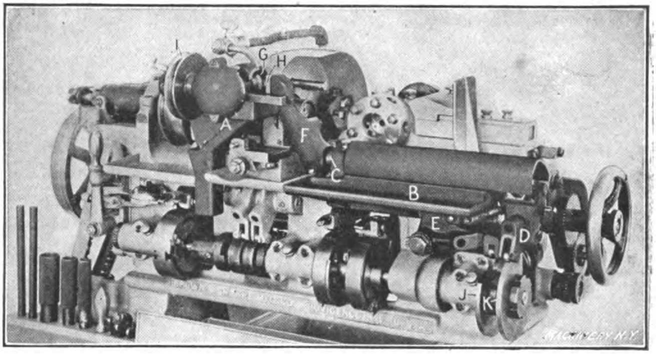


Fig. 1. No. 00 Brown & Sharpe Automatic Screw Machine equipped with a Screw-slotting Attachment

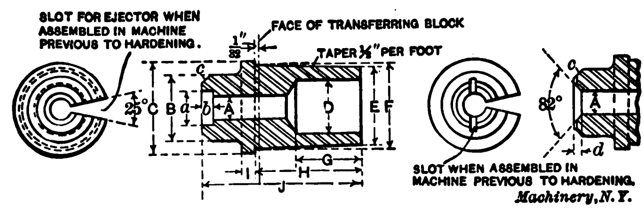
driven into it. This bushing grips the screw and holds it while the slotting saw *G*, held on an arbor and driven from pulley *I* through bevel gears, mills the slot in the head. The pulley *I* is driven by a round belt from the overhead works. The design and action of this device is described in detail in MACHINERY's Reference Book No. 100, "Automatic Screw Machine Practice—Designing and Cutting Cams for the Brown & Sharpe Automatic Screw Machine," where the laying out of cams for this device is also described.

Slotting-bushings

The method of holding the screw when presenting it to the saw in the screw slotting attachment is of special importance. In Table I is shown the standard form of slotting-bushings used for holding fillister- and flat-head screws. The type of slotting-bushing used for round- or button-head screws is similar to that shown for the fillister-head screw, except that in some cases the bushing is not counterbored for the head of the screw. The proportions for slotting-bushings for the various sizes of Brown & Sharpe automatic screw machines are also given in Table I. The diameter of the hole A governs the diameter B of the front end of the bushing, and also of the hole D. These sizes, of course, pertain only to bushings for standard screws, the slotting-bushing being made to suit the work as desired. The diameter A should be made from 0.001 to 0.0015 inch larger than the screw diameter, while the diameter a should be made from 0.002 to 0.003 inch larger than the diameter of the shoulder or head of the screw, as the case may be.

When a bushing is to hold a shouldered screw, and when the length of the shoulder is greater than or equal to the diameter of the shoulder,

TABLE I. PROPORTIONS FOR SLOTTING-BUSHINGS



Mch. No.	A	B	C	D	E	F	G	H	I	J
00	1/16 to 3/16 3/16 to 1/4	3/8 1/2	9/16 9/16	1/4 5/16	0.450 0.450	0.476 0.476	1/2 1/2	11/16 11/16	1/16 1/16	1 1
0	1/8 to 1/4 1/4 to 3/8	1/2 11/16	11/16 11/16	5/16 7/16	0.600 0.600	0.631 0.631	9/16 9/16	3/4 3/4	1/16 ..	1 1/8 1 1/8
2	3/16 to 5/16 5/16 to 1/2	5/8 7/8	7/8 7/8	3/8 9/16	0.750 0.750	0.792 0.792	5/8 5/8	1 1	1/8 ..	1 1/2 1 1/2

the diameter A is made to fit the body of the shoulder instead of the body of the threaded part of the screw. When the length of the shoulder is less than the diameter, the bushing is made to fit both the shoulder and the body of the screw. The screw head should also fit in the counterbored hole in the bushing. The distance between the shoulders on the screw should always be less than the distance between the shoulders in the bushing, so that the screw head alone will bear against the shoulder in the bushing. The distance d on the bushing for flat-head screws should be made equal to one-half the thickness of the head, when the body of the screw is greater than 1/4 inch. When the body of the screw is less than this, the head, as a rule, is usually sunk the full depth in the slotting-bushing. The corner c should only be beveled when the diameter of the counterbored hole A will permit, otherwise the corner should not be beveled, but rounded slightly.

Slotting-bushings are usually made from tool steel, and are not hardened until the cams have been tried out and the whole equipment is completed. The slot for the ejector is cut before the bushing is inserted in the transferring block, and the slot for the saw in the bushing for flat-head screws is cut when the bushing is held in position in the transferring block. When a bushing is to hold a fillister-head screw, the slotting saw does not, as a rule, touch the bushing at all, the depth of the counterbore *b* in the bushing being slightly less than the difference between the depth of the slot and the thickness of the head of the screw. The dimension *F* is not taken at the shoulder of the bushing, but is the largest diameter of the taper hole

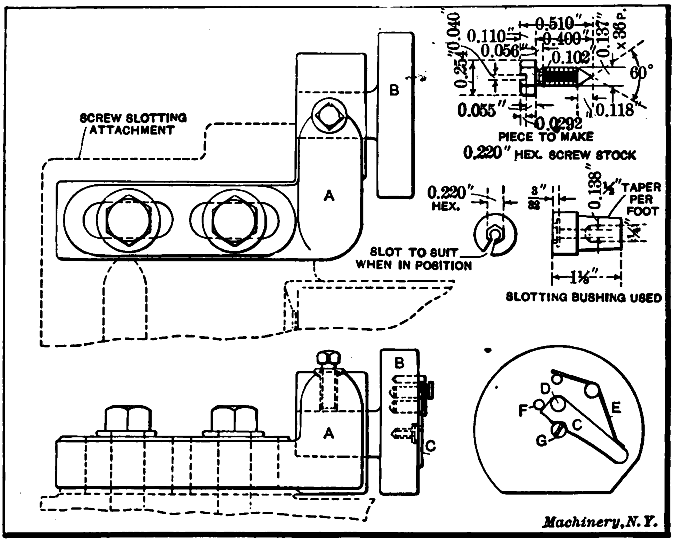


Fig. 2. Device for Locating Hexagon-head Screws in the Slotting-bushing

in the transferring block. This allows the bushing to be driven tightly into the block, 1/32 inch being allowed for driving. It is customary, however, to make the dimension *F* slightly larger than necessary and fit it into the block when trying out the job. The bevel in the bushing for holding flat-head screws is made to suit the included angle of the head, the angle shown being that adopted by the A. S. M. E.

Slotting Hexagon-head Screws

When the slot in the head of a hexagon screw has to bear some definite relation to the sides of the head, it is necessary that the screw be located in an exact position in the slotting-bushing. The bushing for holding the screw has usually an impression in it, which fits the hexagon head, but it is often difficult to get the screw to locate properly in the bushing. If the bushing is forced onto the work when it is attached to the bar, the screw will seldom be correctly located in the hexagon hole, but the corners of the head will be torn off, and the screw broken off before it is severed from the bar. To obviate this difficulty, some device must be employed for locating the screw in the bushing, after it has been severed from the bar.

A device which is used for locating a hexagon-head screw in the slotting-bushing is shown in Fig. 2, where the screw and slotting-bushing are also shown. This device consists of a cast-iron bracket *A*, which is held on the slotting attachment, being retained in position with the same screws that hold the slotting attachment. Held in the boss of bracket *A* is a holder *B* to which is attached the locater *C*. This consists of a piece of sheet steel about 1/16 inch thick, held on a pin *D* and free to swivel. Pressing against this locater is a spring *E* which forces the locater against the stop pin *F*. A screw *G* acts as a stop, being adjusted in or out as desired to locate the head of the

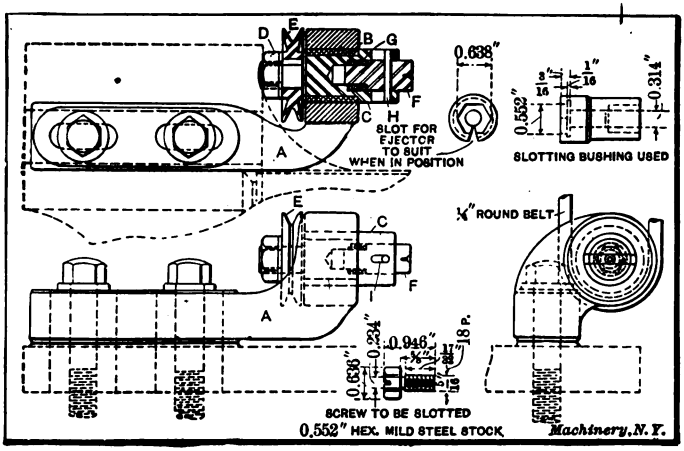


Fig. 3. Another Hexagon Screw Locating Device

screw against the shoulder in the bushing, and also acting as a stop for the locater *C*.

In operation, as the screw is removed from the chuck by the slotting bushing, the arm, in ascending, is brought to dwell in an intermediate position, and is then advanced towards the locater *C*. As this locater is beveled, the screw forces it up, and the action of the spring turns the screw around in the bushing, so that the hexagon head is located properly, the arm at the same time advancing and forcing the screw in to the desired depth. The method of designing the transferring cam to dwell in this intermediate position will be described in connection with the burring attachment, in another chapter.

In Fig. 3 is shown a device for locating hexagon-head screws in the slotting-bushing which differs somewhat in principle from that shown in Fig. 2. This device consists of a cast-iron bracket *A*, which is fastened to the slotting attachment as previously described. The bracket is provided with a phosphor-bronze sleeve *B*, in which a spindle *C* is free to rotate. Keyed to the spindle *C*, and held by a nut *D*, is a grooved pulley *E*, which is driven by a ¼-inch round belt from the overhead works. Held in the spindle *C* is a spring plunger *F*, which is pressed forward by an open-wound spring *G*. This spring plunger is prevented from rotating by a pin *H*, which fits in an elongated slot *I*, cut in the spindle *C*.

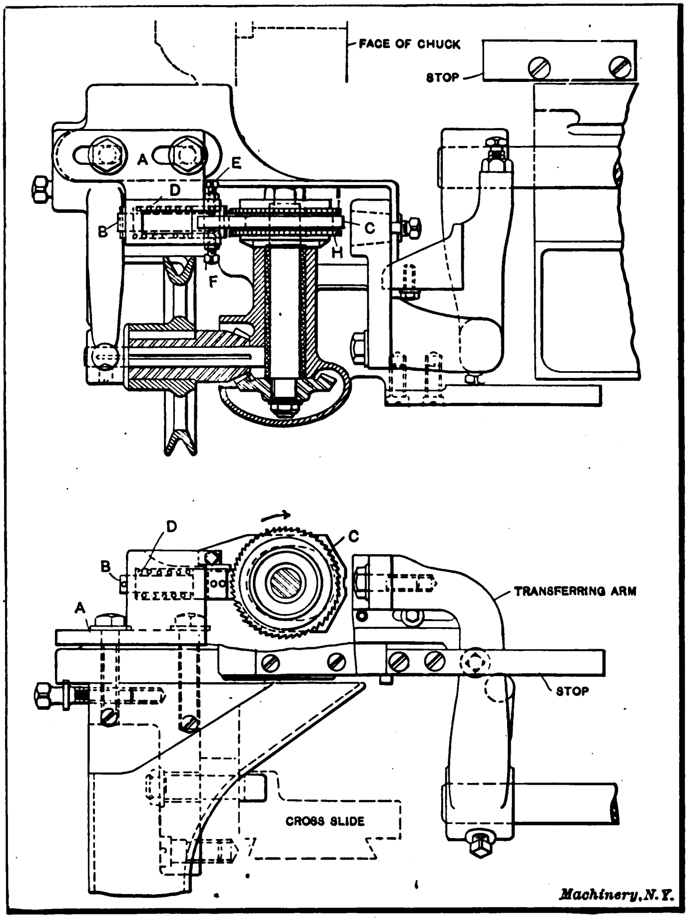


Fig. 4. Slabbing Attachment used on Screw-slotting Attachment

In operation, as the slotting-bushing lifts the screw from the chuck, the arm dwells in an intermediate position, travels forward and presses the screw against the rotating plunger *F*. As this plunger is driven slowly, and as the arm is advanced, the friction between the head of the screw and the plunger rotates the former. On the continued forward travel of the arm, the screw is located correctly in the bushing and forced in to the correct depth. The screw and the slotting bushing used for holding it are shown in the illustration, where the principal dimensions on the slotting-bushing are also given.

Slabbing Attachment

A slabbing attachment which is fastened to the ordinary screw-slotting attachment is shown in Fig. 4. The screws which hold the slotting attachment to the frame of the machine are removed and the slabbing attachment *A* is seated on the top face of the base of the slotting attachment. The screws are again inserted, and the slabbing attachment fastened in position. The main body of the attachment is an iron casting, and a boss on it is bored out to receive a plunger *B* to which is attached a guide or ejector *C*. The plunger *B* is riveted to this guide member *C*, and a coil spring *D* is located behind the shoulder of the plunger to keep it out.

Two set-screws *E* and *F* with lock-nuts are provided for guiding the member *C*. This guiding or ejecting member *C* has an elongated hole bored in it, fitting over the saw arbor, so that the ejector can be forced back by the piece when it is being advanced to the slabbing saws by the transferring arm. The front face of the ejector *C* is knurled, so that the piece is prevented from rotating in the slotting-bushing when the saws *H* and *I* commence to cut. This attachment is driven in the same manner as the ordinary screw-slotting attachment, and the bushing in which the work is held while being slabbed is also of a similar type. Of course, the exact shape of the bushing would depend entirely on the shape of the work. In the lower view, the driving mechanism has been removed to show the slabbing attachment more clearly.

Spindle Indexing Device

A device which converts the Brown & Sharpe automatic screw machine into a milling machine is shown in Fig. 5. This device was designed for making a special piece, which is shown at *A* in Fig. 6, where the cams for making the piece are also shown.

To apply this device to the automatic screw machine, the pulleys *A* and *B* shown in Fig. 7 are removed, as is also the clutch mechanism. The outer sleeve *A* of the attachment shown in Fig. 5 is then slipped over the regular spindle. This sleeve is cast integral with a bracket *B*, the lower end of which is located on the shaft *C* shown in Fig. 7. This shaft is part of the belt-shifting arrangement which is used for obtaining two different speeds for the spindle when threading steel. The attachment is driven from the rear driving-shaft by the ordinary gears *D* and *E* which drive the belt-shifting arrangement as shown in Figs. 5 and 7. A 35-tooth gear *D* is placed on the driving shaft, which meshes with a 70-tooth gear *E* located on the shaft *C*. On the same shaft is an 80-tooth gear driving an 80-tooth gear *F* on the stud *G*.

A trip and indexing mechanism somewhat similar to that used on the turret, is used here for indexing and locking the spindle. The 80-tooth gear *H* meshes with a 40-tooth gear *K* keyed to the sleeve *L* held on the spindle. This sleeve has two holes drilled in it, in which the plunger *M* fits. A spring *N* behind this plunger keeps it in contact

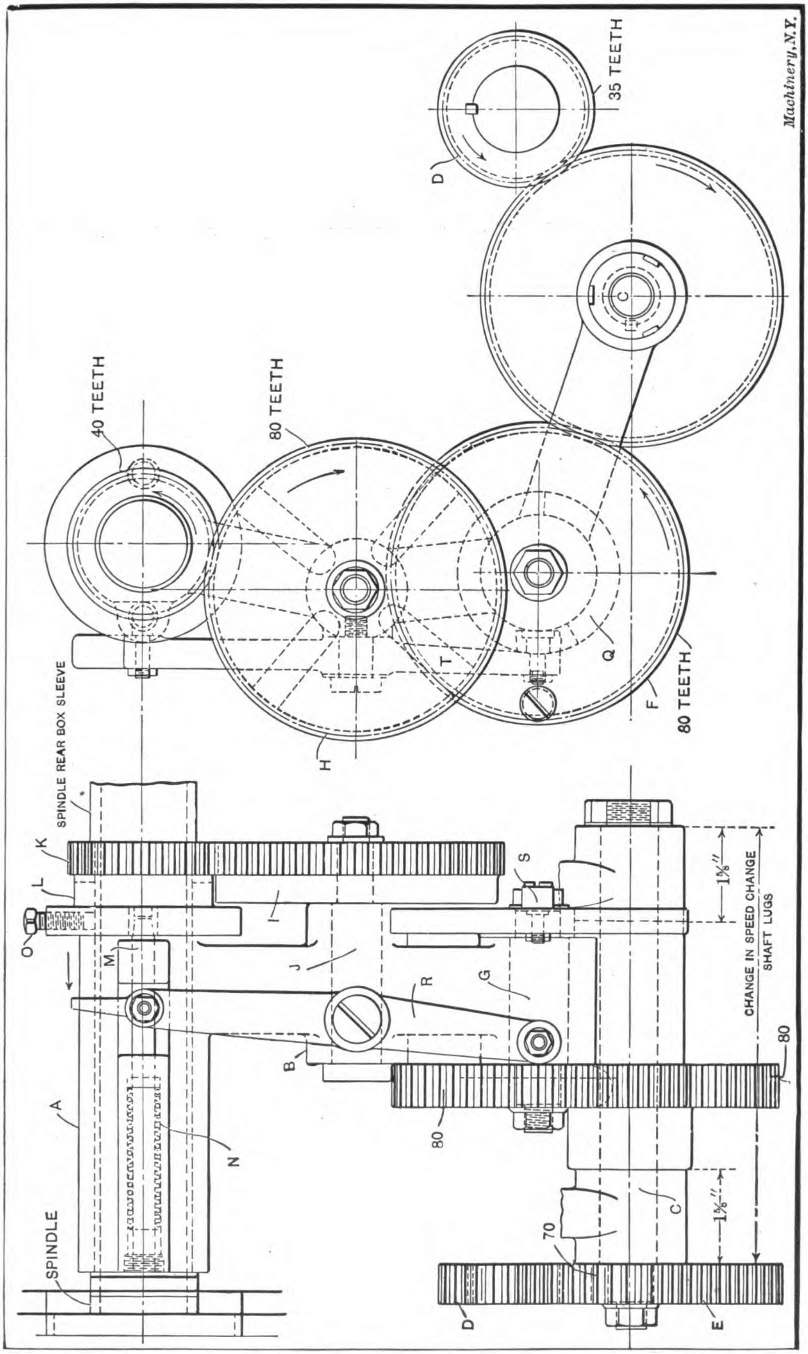


Fig. 5. Attachment for Indexing the Main Driving Spindle of a Brown & Sharpe Automatic Screw Machine

with the sleeve L. This sleeve L is fastened to the main driving-spindle of the machine by a set-screw O. This attachment is operated as follows:

The dog on the drum held on the front cam-shaft, is set to trip the lever, which, when tripped, operates the tooth-clutch P, Fig. 7, thus rotating the rear driving-shaft. As the rear driving-shaft rotates at 180 R. P. M., the gear D will revolve at the same speed, while the gear E will revolve at 90 R. P. M., and will transmit a speed of 90 R. P. M. to the gear F. This gear F carries a cam Q, and a roller attached to

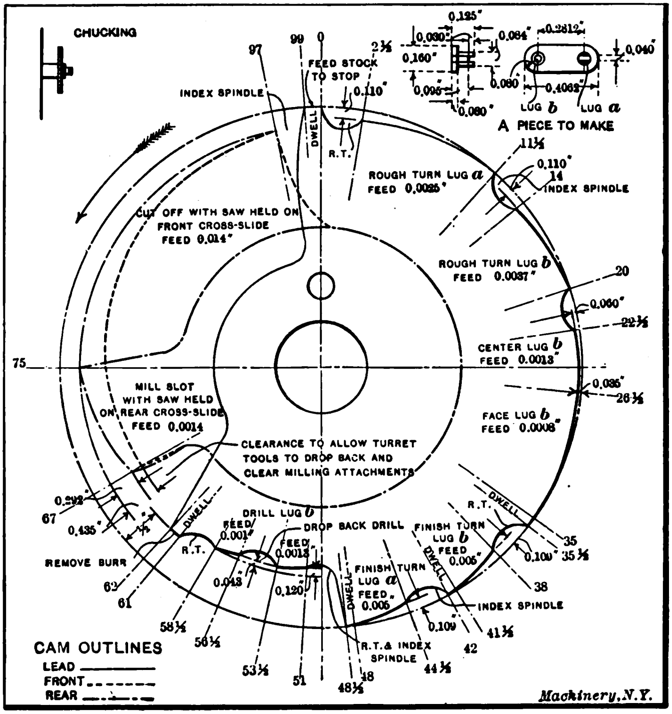


Fig. 6. Lay-out of a Set of Cams for Making a Piece requiring the Indexing of the Work-spindle

the lever R runs on this cam. Then when the dog trips the lever, the driving-shaft rotates, thus driving the gears, which in turn rotate the cam Q. As the cam Q is rotated, the arm R is moved in the direction indicated, which action withdraws the pin M from the bushing L. Now at the same time that the pin M is withdrawn, the roller S comes in contact with the slot T in disk I held on the stud J, thus rotating the disk on one quarter turn. This disk is provided with four slots T, and as this indexing device requires to be indexed 180 degrees to bring each part of the piece into position, the disk I is moved two spaces before another dog on the drum trips the lever that disengages the tooth-clutch P, Fig. 7.

Referring to Fig. 6, it will be seen that the piece to be made has two lugs on it designated *a* and *b*. The stock from which this piece is made is of special shape, so that its outside circumference does not require to be finished; the lugs *a* and *b* are to be formed, drilled and slotted. The work is not revolved, but is only indexed to bring the stock into position for forming the two lugs. To turn these lugs, the turret is packed out an amount equal to one-half the distance between the center of the two lugs, and drilling attachments are used in the turret for holding hollow mills and drills. The order of operations is as follows:

Order of Operations	Revolutions	Hundredths
Feed stock to stop	4½	1
Revolve turret	12	2½
Rough turn lug *a* with hollow mill held in drilling attachment, speed 684 R. P. M. at 0.0025 inch feed	43	9
Index spindle and revolve turret	12	2½
Rough turn lug *b* with hollow mill held in drilling attachment, speed 684 R. P. M. at 0.0037 inch feed	28	6
Revolve turret	12	2½
Center and face lug *b* with centering tool held in drilling attachment, speed 684 R. P. M. at 0.0013 inch feed to center and 0.0008 inch feed to face	62	13
Revolve turret	12	2½
Finish turn lug *b* with hollow mill held in drilling attachment, speed 684 R. P. M., at 0.005 inch feed	19	4
Index spindle	12	2½
Finish turn lug *a* with hollow mill held in drilling attachment, speed 684 R. P. M., at 0.005 inch feed	19	4
Revolve turret and index spindle	12	2½
Drill hole in lug *b* with drill held in drilling attachment, speed 3555 R. P. M. at 0.0013 inch feed	12	2½
Pull out drill to remove chips	14	3
Finish drill hole in lug *b* with drill held in drilling attachment, speed 3555 R. P. M., at 0.0011 inch feed	9	2
Revolve turret	12	2½
Remove burr and broach with tool held in floating holder	4½	1
Clear	24	5
Mill slot in lug *a* with special milling attachment held on rear cross-slide, speed 400 R. P. M., at 0.014 inch feed	(26)	(8)
Cut-off with special milling attachment held on front cross-slide, speed 480 R. P. M., at 0.014 inch feed	143	30
Index spindle	10	2
	476	100

Cross-slide Slotting Attachment

The special slotting attachment designed for cutting the slot in lug *a* shown in Fig 6 is shown in Fig. 8. This attachment consists of a block *A*, the base of which is held to the rear cross-slide by a bolt and

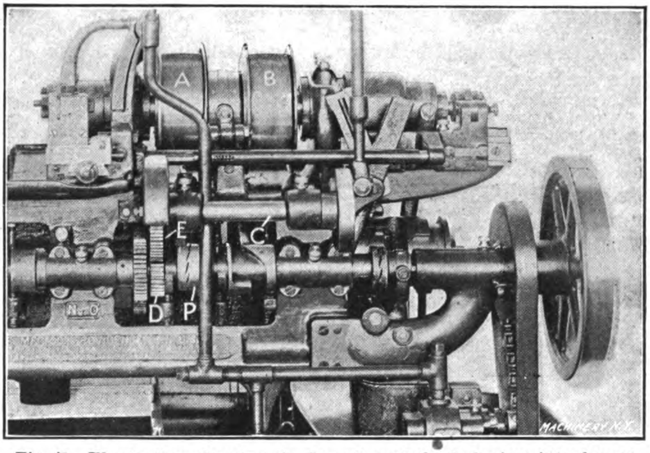


Fig. 7. Illustration showing the Location of the Indexing Attachment

nut *B* and *C* as shown, the former fitting in the T-slot in the cross-slide. The spindle *D* passing through the casting which is bushed with a bronze sleeve, has attached to it a bevel gear *E*, meshing with a

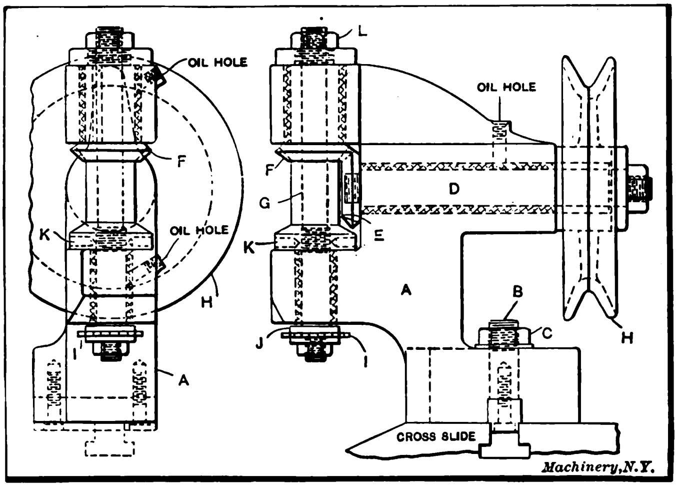


Fig. 8. Slotting Attachment held on the Rear Cross-slide

bevel gear *F* keyed to the vertical spindle *G*. This vertical spindle *G* also runs in bronze bushings. The pulley *H* is keyed to the rear end of shaft *D* and is held to it by a nut and washer as shown. A round belt which passes over a grooved pulley held on the countershaft, drives this pulley *H*, which, in turn, drives the slotting saw *I* held on the lower end of the vertical spindle. Adjustment is provided for the slotting saw *I* by varying the thickness of the washer *J* and also by means of the adjusting nuts *K* and *L*. Gear *F* has a shank which fits in the upper member, so that the spindle *G* can be adjusted without affecting the position of this gear.

Cross-slide Sawing Attachment

The attachment which is used for cutting off the piece shown at *A* in Fig. 6 is shown in Fig. 9. This attachment is held on the front

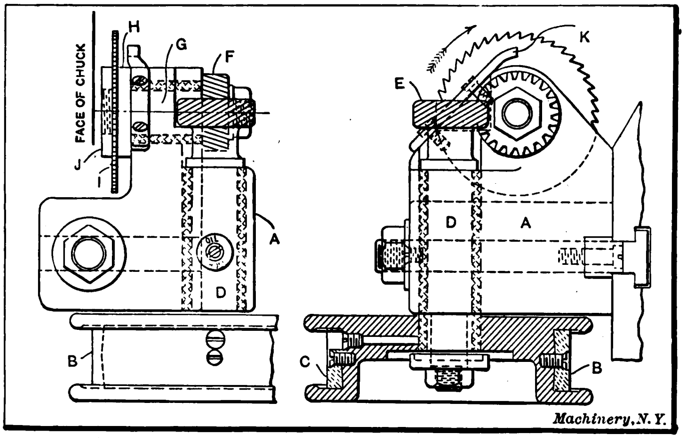


Fig. 9. Sawing Attachment held on the Front Cross-slide

cross-slide, and consists of a holder *A* somewhat similar to the ordinary holder used for the circular form tools, and is also held to the cross-slide in a similar manner. A three-quarter inch flat belt, which passes over a pulley fastened to the countershaft, drives this attachment through the pulley *B*. This pulley *B* has a leather strip *C* fastened to it which increases the friction and gives a more positive drive to the cutting-off saw. The pulley *B* is keyed to a shaft *D*, and also held to it by a nut and washer as shown. The shaft *D* which passes through a bronze bushing held in the holder *A* has a helical gear *E* cut on its forward end. This helical gear meshes with a mating gear *F* held on the cutter spindle *G*, which is located at right angles to the spindle *D*. The spindle *G* fits in a bronze sleeve held in the holder *A*, and is provided with a shoulder *H* against which the slotting saw *I* is held by the nut *J*. The guard *K* is used to prevent the work from springing away from the saw when almost cut off.

CHAPTER II

CROSS-DRILLING ATTACHMENTS

In order to avoid a separate operation in manufacturing parts requiring to be cross-drilled, the Brown & Sharpe Mfg. Co. has designed what is called an "index drilling attachment." This attachment, which is used for drilling cross-holes in studs and capstan-screws, is illustrated in Figs. 10, 11 and 12.

The Brown & Sharpe index drilling attachment, which is shown located on a No. 00 automatic screw machine in Figs. 10 and 11, consists mainly of a cast-iron bracket A, fastened by cap-screws to a boss

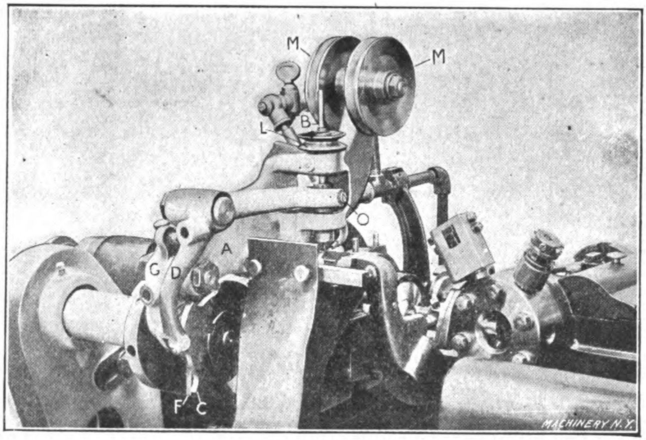


Fig. 10. Front View of the Index Drilling Attachment, placed on a No. 00 Brown & Sharpe Automatic Screw Machine

provided for that purpose on the machine. In this bracket are held the work- and drilling-spindles, the latter being held in a vertical position and in line with the work-spindle. The camshaft from which the attachment is operated, is driven by a chain and sprocket, which is shown encased in Fig. 10. A sprocket-wheel for driving the attachment is placed on the front camshaft of the machine, and an idler pulley, fastened to a bracket, gives the chain the desired tension on the sprocket. Figs. 10 and 11 give a general idea of the construction of this index drilling attachment, but for a more detailed description reference should be made to Fig 12. Similar parts in the three illustrations bear the same reference letters.

The drilling-spindle B is driven by a ⅜-inch round belt from the overhead works through pulleys L and M, the pulleys M acting as idlers, to change the direction of the belt from a vertical to a horizontal position. Spindle B is operated by a cam C acting through a lever D, while the indexing of the work-spindle *E* is accomplished by a cam *F* acting through a lever *G*. The forward end of the lever *G* has teeth cut in it (see Fig. 18) which mesh with the segment gear *H* on the work-spindle *E*, Fig. 12. A ratchet *I*, held to the segment gear by a shoulder screw and nut as shown, and acted upon by a spring, fits in a ratchet disk I_1 (see Fig. 18) which is keyed to the work-spindle *E*. The locking plate *J* has V-notches cut in it, the number of which (usually four) equals the indexings of the spindle required, this plate being used for locking purposes only. A spring plunger *K* fits in the notches in plate *J* and holds it in place until the spindle is again indexed.

In operation, when the indexing lever *G* is raised by the cam *F*, it depresses the spring plunger *N*, and at the same time rotates the seg-

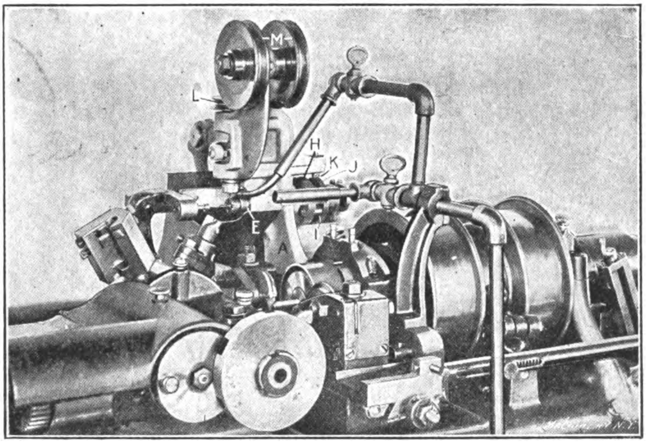


Fig. 11. Rear View of the Index Drilling Attachment in Place on a No. 00 Brown & Sharpe Automatic Screw Machine

ment gear *H* carrying the ratchet *I*. The spring plunger returns the lever to its normal position when the roll on the lever drops down to the smallest diameter of the cam, and in so doing returns the indexing disk *H* to its normal position ready for the next indexing. The work-spindle is indexed by the ratchet *I* meshing in one of the teeth in the ratchet disk I_1.

The drilling-spindle *B* is raised and lowered by means of the lever *D*, which is connected to it by two screws *O*, holding two shoes, the latter fitting in milled slots cut in the sleeve *P*. This sleeve is held on the spindle *B* by check-nuts *Q*. The drill-spindle runs in bronze bearings, and is provided at its lower end with three set-screws *R* for holding the drill. The upper end of the drill-spindle fits in a steel bushing *S*, to which it is keyed. The pulley *L* is also keyed to bushing *S*, and as the spindle *B* is provided with a groove, it is possible to rotate the spindle, and at the same time move it up and down by the lever *D*.

A general outline of the construction of the various details of the attachment is given in the following:

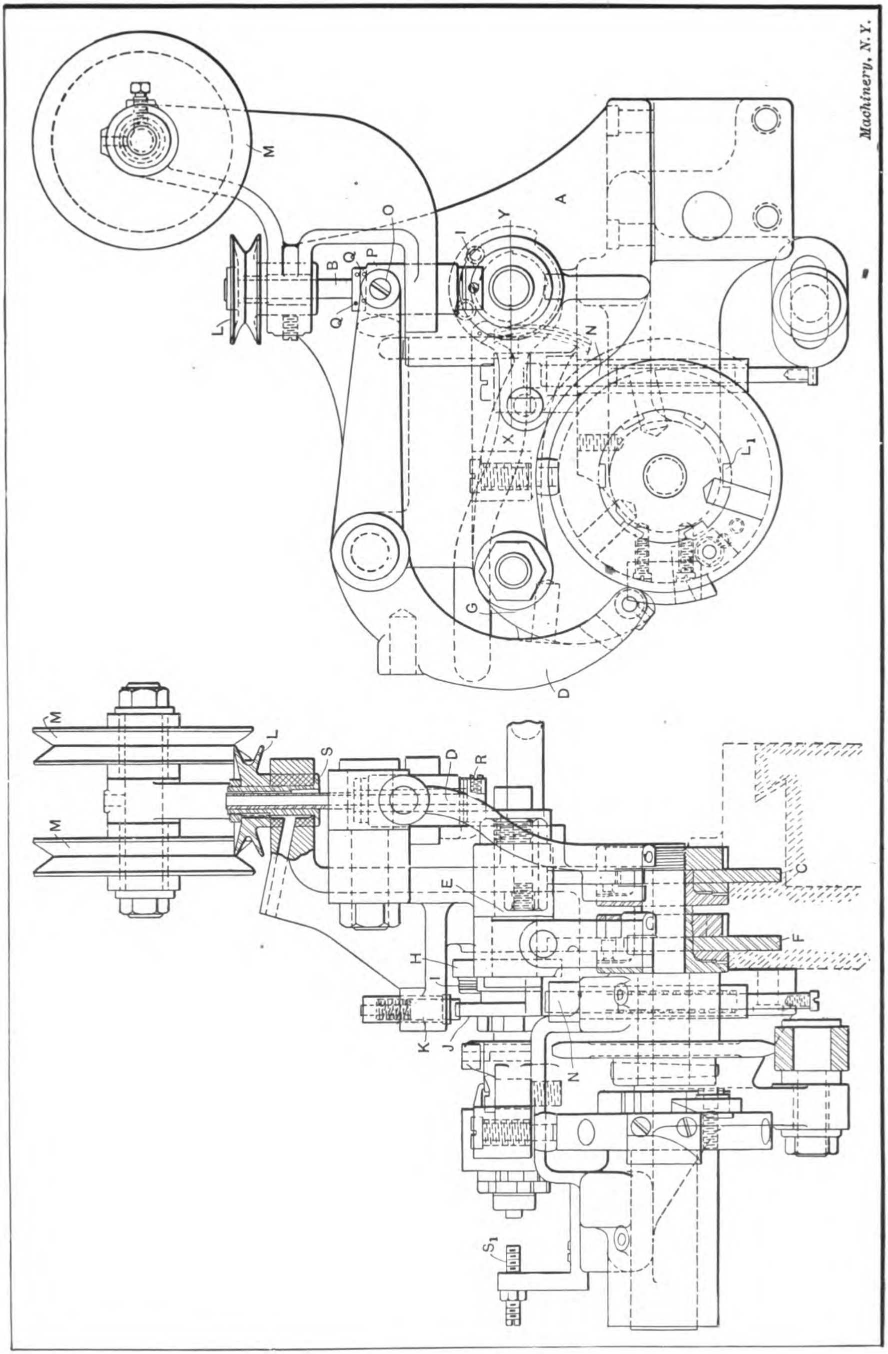


Fig. 12. Assembly View of the Index Drilling Attachment for the No. 00 Brown & Sharpe Automatic Screw Machine

Construction of the Index Work-spindle

Fig. 13 shows a sectional view of the index work-spindle, the section being taken on the line X–Y, Fig. 12. The spindle, as has been previously stated, is indexed, but otherwise remains stationary. The chuck A is closed by means of the cam B, which is fastened by screws to the drum D, while the cam C operates the lever M for opening the chuck. A roller L, attached to the lever M, and which is guided by the cam-blocks B and C, operates the lever M for closing and opening the chuck.

In operation, as the lever M is forced by the cam C in the direction indicated by the arrow C_1, it withdraws the clutch sleeve N from beneath the fingers O, allowing the latter to drop and release their pressure on the sleeve P. Now, as the mouth or front end of the sleeve P_1 is beveled to an angle which is greater than the angle of repose, and as the chuck A is split and spring-tempered, the withdrawal of the clutch sleeve N from beneath the fingers O allows the bevel on the chuck to force the sleeve P back, thus permitting the chuck to open and the work to be ejected by the plunger S. Inversely, as the lever M is forced by the cam-block B in the direction of the arrow B_1, the clutch sleeve N is forced under the fingers O, so that their circular bearings or ends rest on the straight cylindrical portion of the sleeve. This action on the fingers O causes the sleeve P to be pushed forward and butt against the sleeve P_1, forcing it over the tapered portion of the chuck A, and thus closing the latter on the work.

The work, when forced into the chuck A, butts against a brass ejector or stop S which is screwed onto the rod R. This rod passes entirely through the spindle R_1, and is held outward by a coil spring E. When the work forces the ejector S into the chuck, the head on the rod R comes against the stop-screw S_1, which is clamped by the lock-nut shown. The position of the stop-screw governs the distance to which the work can be inserted in the chuck, thus locating the position of the drilled holes. The desired grip of the chuck A on the work is obtained by adjusting the check-nuts G. The work-spindle can be taken out by removing the nuts H and I and the lever M.

Laying out Cross-slide Cams for Cross-drilling Operations

The method of laying out a set of cams for a cross-drilling operation is similar to that for any other job, except that there are a number of special points to be considered which relate chiefly to the clearance allowances for the transferring arm in its ascent and descent to and from the work-spindle. Possibly the best way to illustrate the method employed is to take a practical example and describe each step. Assume that it is required to make the piece shown at A in Fig. 14, which is a binding post, made from 9/32-inch brass rod. The turret and cross-slide cams, also shown in this illustration, are laid out in the usual manner, except that sufficient space is allowed, as shown from 86 to 91 (on the cam circumference) for bringing down the transferring arm to grip the work. One hole should be left vacant in the turret, so that the transferring arm can be brought down without coming in contact with any of the turret tools.

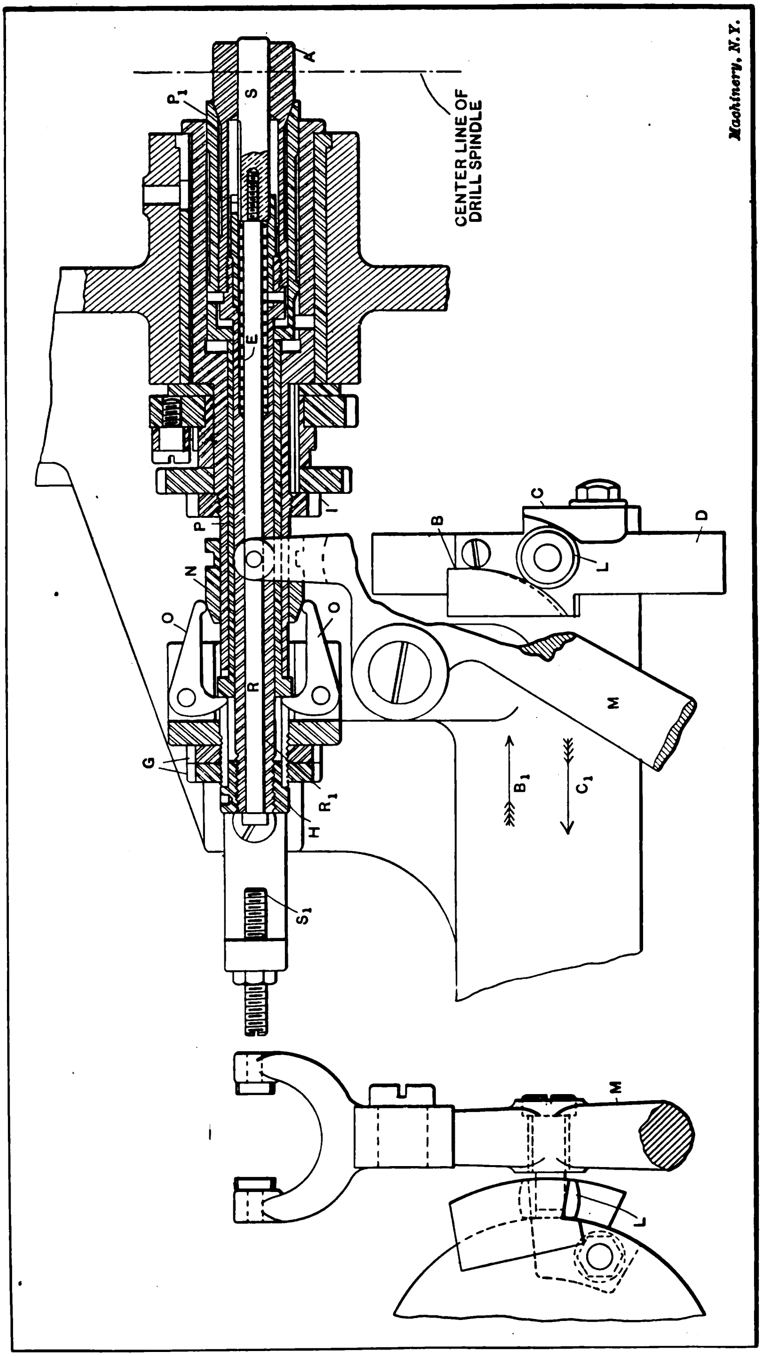


Fig. 18. Sectional View of the Index Drilling Work-spindle

Before laying out the lead and cross-slide cams, it is preferable to make a lay-out as shown in Fig. 15, drawing in the position of the circular form and cut-off tools and also the tools used in the turret. If this is done, the amount that the cams are to be cut down below the largest diameter of the cam circumference, and also the clearances necessary for the turret and circular form tools, can be found. After the necessary information has been obtained from this diagram, another diagram, such as in Fig. 11, Reference Book No. 100, "Designing and Cutting Cams for the Brown & Sharpe Automatic Screw Ma-

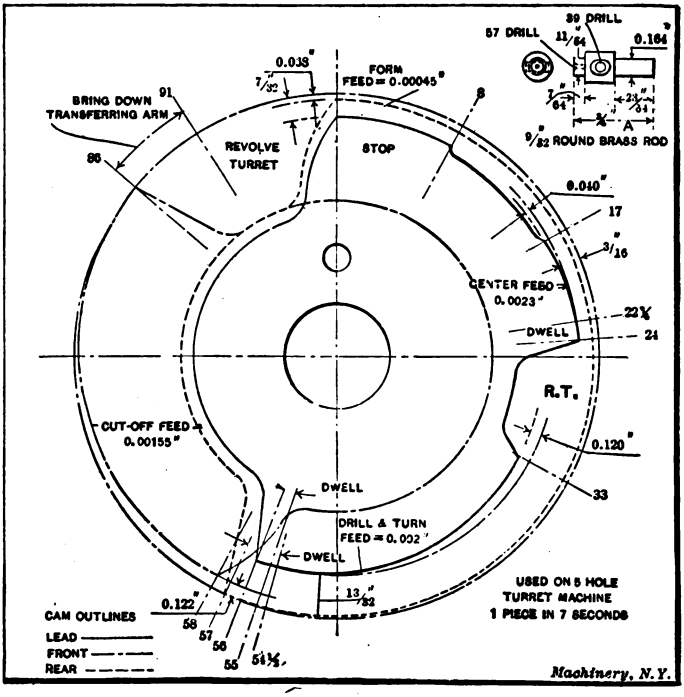


Fig. 14. Lay-out of a Set of Cams for a Cross-drilling Operation on the No. OO Brown & Sharpe Automatic Screw Machine

chines," should be made so that the rises and the cut-downs on the transferring and advancing cams can be obtained. Of course, the example given in that illustration applies more particularly to a screw-slotting job; the method of procedure, however, for laying out the cams used on the index drilling attachment is similar.

Laying out the Transferring and Advancing Cams

As the method of laying out the transferring and advancing cams is described in Part II of this treatise, MACHINERY'S Reference Book No. 100, it will not be necessary to describe it here. The drawing of the transferring and advancing cams used in connection with the piece shown at *A* in Fig. 14, is shown in Fig. 16. Here the lobes and their uses are clearly indicated. The lay-out of these cams does not differ materially from that for a screw-slotting job except, of course, that the lobes on the advancing cam are made with a dwell, no feeding movement being necessary. To determine the relative heights of the lobes *A* and *B* on the advancing cam, a diagram similar to that in Fig. 11, Reference Book No. 100, should be drawn, the slotting saw being replaced by the chuck *A* and stop *S*, shown in Fig. 13. The lobe *A*, Fig. 16, should be of sufficient height to force the work into the chuck to the proper distance, and thus locate the stop *S*, Fig. 13, up against the stop-screw S_1.

Laying out the Indexing and Drilling Cams for the Cross-drilling Attachment

In laying out a set of indexing and drilling cams, it is always preferable to start from some predetermined point. The practice usually

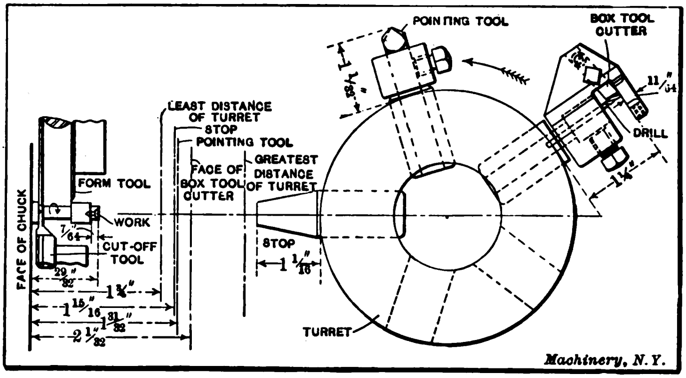


Fig. 15. Diagram for Obtaining the Cut-down on the Lead Cam, and Clearance for Tools

followed is to allow 1½ hundredth clearance between the finishing point on the inserting lobe *A* (see Fig. 16) and the starting point *A* on the drilling cam, Fig. 17, and then lay out the corresponding lobes on the drilling and indexing cams from this point. As soon as the advancing roller is on the top of the lobe *A*, Fig. 16, the index drilling chuck should be opened, and closed again before the roll drops off the lobe. About one hundredth of the cam surface should be allowed for clearance, so in this case the chuck should be opened at 4 on the cam circumference. The chuck is opened by the cam *C* on the drum *D*, Fig. 13, in the manner previously described.

The indexing and drilling cams used for drilling the binding post shown at *A* in Fig. 14 are shown in Fig. 17. Here it can be seen that the drill begins to operate at 5½ and finishes at 52, one one-hundredth being allowed for the drill to make a smooth finish. The order of operations for the lead, cross-slide, advancing, transferring, drilling and indexing cams is given in the tabulated arrangement on the following page.

Lead and Cross-slide Cams

Order of Operations	Revolutions	Hundredths
Feed stock to stop and chuck	22.40	8
Revolve turret	25.20	9
Center 0.040 inch rise at 0.0023 inch feed, dwell 0.125	19.60	7
Revolve turret	25.20	9
Drill and turn with box-tool 0.120 inch rise at 0.002 inch feed, dwell 0.15	64.40	23
Form with circular tool 0.058 inch rise at 0.00045 inch feed, dwell 0.25	(159.60)	(57)
Clearance	5.60	2
Cut-off 0.122 inch rise at 0.00155 inch feed, and revolve turret	78.40	28
Clearance for transferring arm	14.00	5
Revolve turret	25.20	9
Total	280.00	100

Transferring and Advancing Cams

Order of Operations	Revolutions	Hundredths
Place transferring bushing on work	11.2	4
Drop arm back from work	5.6	2
Lift up transferring arm	20.2	7¼
Clearance	2.8	1
Dwell with transferring arm while placing work in chuck and drilling	187.6	67
Place work in index drilling chuck	21.0	7½
Dwell with arm while closing chuck	11.2	4
Drop back arm	14.0	5
Dwell with arm while drilling	131.6	47
Drop down transferring arm to pick up piece	30.8	11
Clearance	2.8	1
Advance to put bushing on work	11.9	4¼

Drilling and Indexing Cams

Order of Operations	Revolutions	Hundredths
Drill and countersink 0.218 inch rise at 0.0017 inch feed, dwell 0.10	127.4	45½
Lift out drill	9.1	3¼
Push down lever to index	11.2	4
Dwell to allow spring to return lever	4.9	1¾
Index second time	22.4	8
Dwell to allow spring to return lever	4.9	1¾
Clearance	9.1	3¼
Countersink 0.062 inch rise at 0.0031 inch feed, dwell 0.10	22.4	8
Pull out drill, open chuck, and allow clearance, to drop and raise transferring arm and close chuck	65.8	23½

Referring to Fig. 17, it will be seen that the indexing cam is provided with two projecting lobes *B* and *C*, which are used to force the lever down and thus rotate the indexing disk. These two lobes are necessary because the piece to be drilled has only one cross-hole countersunk on both sides, which necessitates indexing the spindle four times for each piece. Since the indexing and drilling cams rotate at the same speed as the turret and cross-slide cams, the time required for indexing is approximately equal to the time required for feeding the stock, which can be verified by referring to the illustration, the space required being from 61 to 69. Three hundredths of the cam surface is the minimum space which should be allowed, on account of the rolls requiring that space to drop down. A milling cutter at least 1/16 inch larger in diameter than the roll should be used for cutting

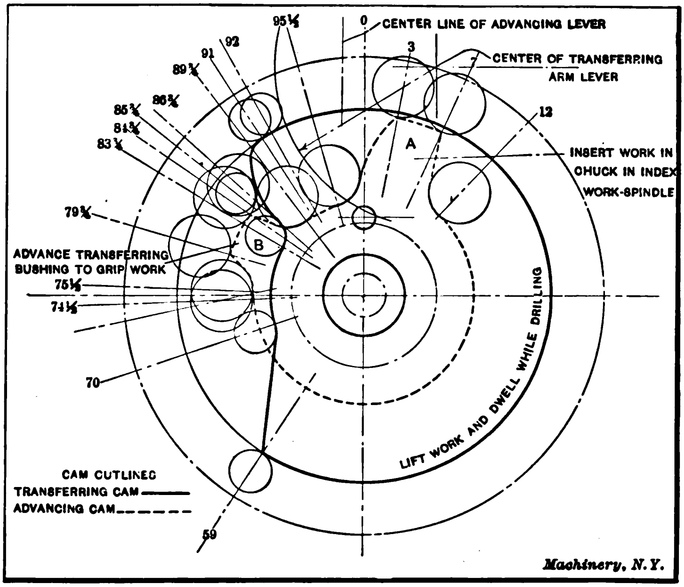


Fig. 16. Transferring and Advancing Cams for Lifting and Placing the Work in the Index Drilling Chuck

the cams. The motion transmitted by the cams to the indexing and drilling levers *G* and *D* is clearly shown by the full and dotted lines in Fig. 18. The maximum travel of the index drilling spindle is equal to the distance *A*, which on the attachments used is as follows:

No. of Machine	Distance A in Inches
00	9/16
0	3/4
2	13/16

The maximum diameters of the indexing and drilling cams for the attachments used on the various machines are as follows:

No. of Machine	Distance B in Inches
00	4
0	4 1/2
2	4 1/2

The cut-down required on the cam for indexing can be found by laying out a diagram similar to that shown in Fig. 18. When the indexing disk I_1 is provided with six teeth instead of four, the cut-down required will be, of course, proportionately less.

Speeds and Feeds for Cross-Drilling

The speeds and feeds used for cross-drilling do not vary from those used when drilling from the turret, and to obtain the required speed for the drill a grooved pulley of suitable size should be placed on the

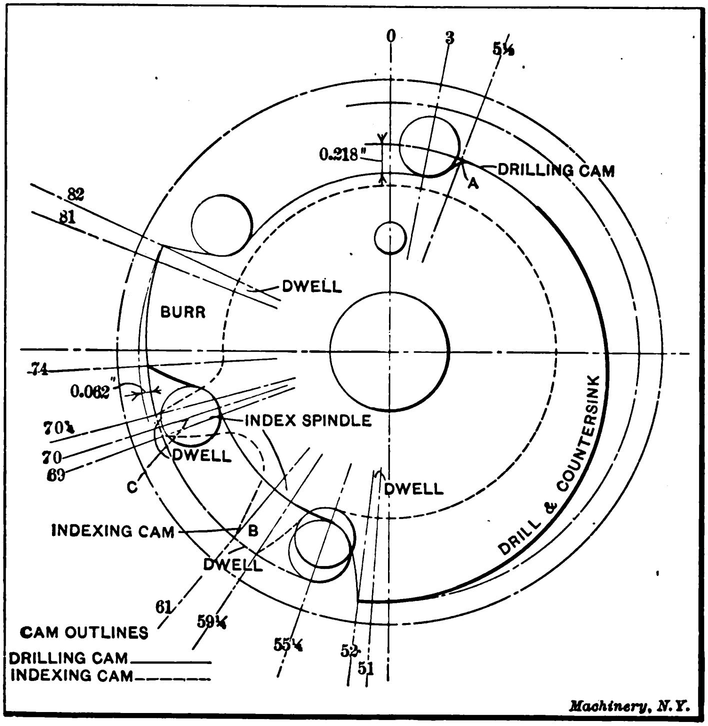


Fig. 17. Indexing and Drilling Cams for the Piece shown at A in Fig. 14

countershaft. The drilling speeds and feeds for ordinary carbon and high-speed twist drills for drilling different materials are given in MACHINERY'S Reference Book No. 103, "Internal Cutting Tools for the Brown & Sharpe Automatic Screw Machines."

Transferring Bushings

When transferring a piece of work from the work-spindle to the index drilling spindle, it is necessary to have a transferring bushing which will insert the work in the index drilling chuck. The ordinary screw-slotting bushing cannot be used for this purpose, except when the work is sufficiently long and the hole in a suitable place, so that the work can be inserted in the chuck without the aid of a spring plunger. When he work is not of the character specified, it is necessary to use a transferring bushing in which is placed a spring plunger for inserting the work in the index drilling chuck.

At *A* in Fig. 19 is shown a capstan-screw and the transferring bushing used for inserting it in the index drilling chuck. This screw, as shown, has two holes drilled clear through the head at right angles to each other. The transferring bushing consists of a shell *a* which is held in the transferring block. Inserted in this shell is a spring plunger *b*, pressed outward by a coil spring *c*, this coil spring being retained in the bushing by means of the nut *d*. The hole in the spring

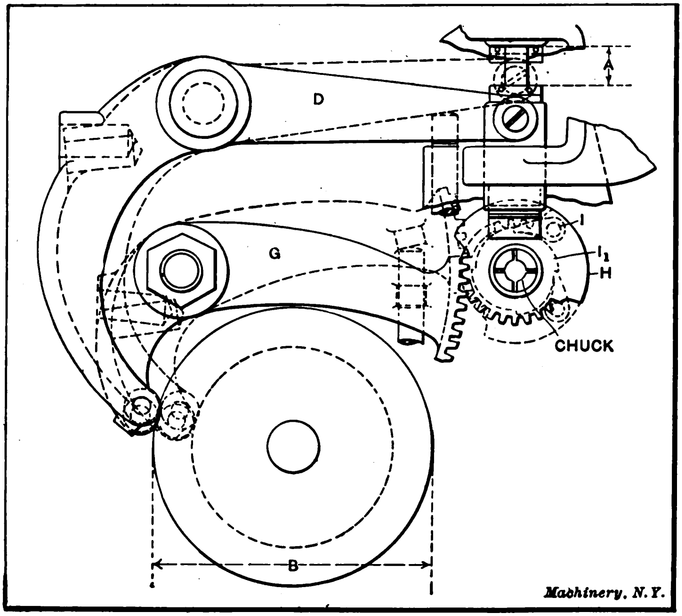


Fig. 18. Diagram illustrating the Movement of the Indexing and Drilling Levers

plunger should be larger in diameter than the body of the screw, so that the work can be inserted easily into the plunger. The type of transferring bushing shown at *A* is suitable for capstan-screws and similar work.

Another transferring bushing for holding a binding post is shown at *B*. This bushing differs from that shown at *A* in that it is provided with a spring chuck as well as with a plunger. The reason for this was that the piece had to be inserted in the chuck to such a distance that it was necessary for the chuck *e* to retreat so that the work could be inserted. This transferring bushing was not a success on account of this combination arrangement of spring chuck and plunger. Difficulty was encountered with the spring chuck *e*, because of the variations in the diameter of the stock. When the stock was much greater in diameter than the hole in the chuck, the chuck was forced back into the holder so that the work was not held, as the plunger *f* kept it out.

Owing to the short amount of grip on the work, it had to fit snugly in the bushing, or it would drop out while being transferred from the work chuck to the index drilling chuck. To overcome this difficulty several methods were adopted. First, the spring *g* was made stiffer, so that when work slightly larger than the hole in the chuck was encountered, it could be inserted without pushing back the plunger. This

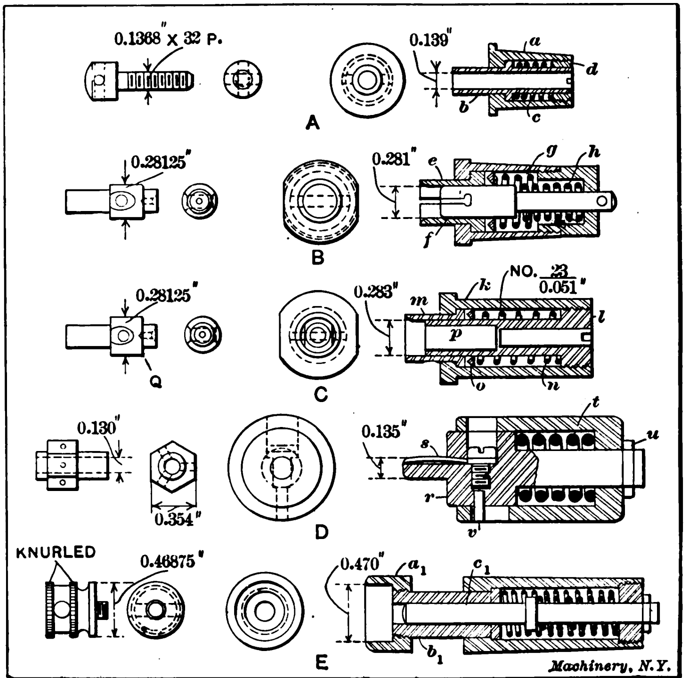


Fig. 19. Representative Types of Transferring Bushings and the Work they were designed to hold

overcame the difficulty of placing the work in the chuck *e*, but when the latter was transferred to the index drilling chuck, the work could not be ejected from the chuck. The spring *h* was made stiffer, but this brought about the same conditions as before, and prevented the work from being located properly in the chuck *e*.

This type of bushing was finally discarded and the one shown at *C* was adopted.. This bushing consists of an outer sleeve *k*, as before, in which is screwed a stationary holder *l*. A chuck *m* is made a sliding fit on holder *l*, and also in the sleeve *k*, and is pressed outward by a spring *n*. This spring acts against a washer *o*, which is beveled, as shown, to reduce the friction, thus preventing the spring from being twisted in the holder when work of larger diameter than the chuck is encountered, causing the chuck to rotate. The hole p in the holder is made slightly larger than the diameter Q on the work, while the hole in the bushing m is made slightly larger than the largest diameter of the work. The holder l is slabbed on both sides on the front end, as shown in the end view, and the index drilling chuck is cut out so that this holder can be inserted in it, thus carrying the work right into the chuck. This bushing proved very satisfactory, both as regards gripping the work and inserting it in the chuck, and was used on the piece shown at A in Fig. 14.

A transferring bushing of a different type is shown at D. This bushing, instead of passing over the work, has a plunger r which is inserted in a hole in the work. This plunger is slotted, as shown, and a flat spring s is held to it by a screw. Spring s is curved and rounded so that it fits snugly in the work. The plunger r is held out by a coil spring t, and is retained by a pin u. A small pin v, driven into the plunger and fitting in a slot cut in the bushing, prevents the plunger from rotating. As shown in the illustration, this bushing is not tapered on the shank, but is perfectly straight, so, obviously, a special transferring block had to be made to hold it.

Another type of transferring bushing is shown at E. This bushing has a marked resemblance to that shown at B, but gives satisfaction because of the character of the work. The hole in the chuck a_1 could be made larger than the diameter of the work, and still the latter would not drop out; thus the difficulty of inserting the work in the chuck is overcome. The hole in the plunger b_1 to which the chuck is attached is made larger than the teat or threaded part on the work. A spring plunger c_1 is used for inserting the work in the index drilling chuck. Obviously, there are a number of different types of transferring bushings used, but as those shown incorporate the principal features of bushings of this type, it would seem that any further descriptions are unnecessary.

CHAPTER III

BURRING ATTACHMENTS

Quite frequently it is found necessary to drill holes in both ends of a piece of work. This cannot be done while the piece is attached to the bar, but necessitates rehandling the work. The Brown & Sharpe Mfg. Co. has designed what is called a "burring" attachment, which is used in connection with its automatic screw machines for drilling and chamfering holes in both ends of the work.

A front view of the burring attachment fastened on a No. 00 Brown & Sharpe automatic screw machine is shown in Fig. 20. Fig. 21 shows a rear view, while Fig. 22 shows plan, end and sectional views,

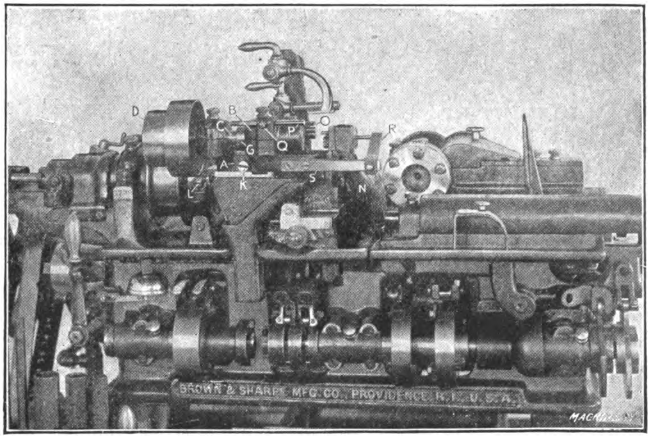


Fig. 20. Front View of No. 00 Brown & Sharpe Automatic Screw Machine equipped with a Burring Attachment

respectively. The attachment consists essentially of a cast-iron base *A*, provided with bearings *B*, in which a spindle *C* is free to rotate, being driven by the two-stepped cone pulley *D*. The bosses *B* are provided with phosphor-bronze sleeves *E* and a thrust washer *F*. The nut *G* is provided for taking care of the end play of the spindle. The burring tool is held in a bushing *H*, fitting in the nose of the spindle *C*, and is furnished with a clamping block *I* acted upon by a set-screw *J*.

This burring attachment can be adjusted to and from the machine by means of the collar-head screw *K*, and the top part of the attachment can be adjusted on its base in a plane with the axis of the spindle, by means of the collar-head screw *L*. The standard work-holder *M* is shown in section in Fig. 22, and more clearly in Fig. 26, to which reference should now be made. Here *A* is the chuck, slotted and spring tempered, *B* the chuck-closing sleeve and *C* the ejector. The chuck-closing sleeve is operated by means of a lever *D*, which is acted upon by pin *E*. To close the chuck, the arm *N*, Fig. 22, is made to dwell in an intermediate position between the work-spindle and the burring spindle, or, in other words, directly in front of the chuck-closing device *O*. The arm *N* is then advanced, when the device *O* forces the sleeve *B* onto the chuck *A*, thus closing the latter on the work.

The chuck *A*, Fig. 26, which is screwed into the transferring block, is opened by means of the pin *E* coming in contact with the end of the rod *P* held in the burring head by a set-screw *Q*, see Fig. 22. When pin *E* comes in contact with rod *P*, the former forces back lever *D*, which, in turn, releases the chuck-closing sleeve *B* and allows the chuck to expand, thus facilitating the removal of the work. The work

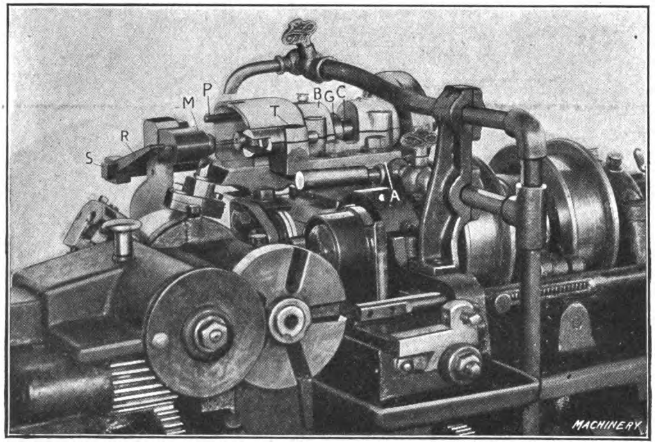


Fig. 21. Rear View of the Burring Attachment placed on a No. 00 Brown & Sharpe Automatic Screw Machine

is removed by means of the plunger *C*, which comes in contact with the finger *R*, Fig. 22, when the arm *N* drops back. This finger is held by a set-screw on a square rod *S*, which, in turn, is fastened to the base of the burring attachment.

Referring now to the view to the right in Fig. 22, the transferring arm *N* is made to dwell in an intermediate position by the combined action of the two cams—transferring and burring—and the two springs A_1 and B_1. The transferring lever C_1 is fulcrumed on the stud D_1 and works in a slot in the connecting link E_1. The link E_1, in turn, is connected to a slotted block F_1, which is fastened to the transferring arm shaft by a cone-pointed set-screw, not shown. The spiral spring A_1 bears against the face of the transferring lever C_1, the transferring lever being held to the link E_1 by means of the fillister head screw G_1 and two check nuts H_1. The spring B_1 is used to keep the roll in the lever C_1 in contact with the transferring cam, while the spring A_1 is used to steady the transferring arm. When the set-screw in the arm *N* comes in contact with the square rod *S*, the lever C_1 continues com-

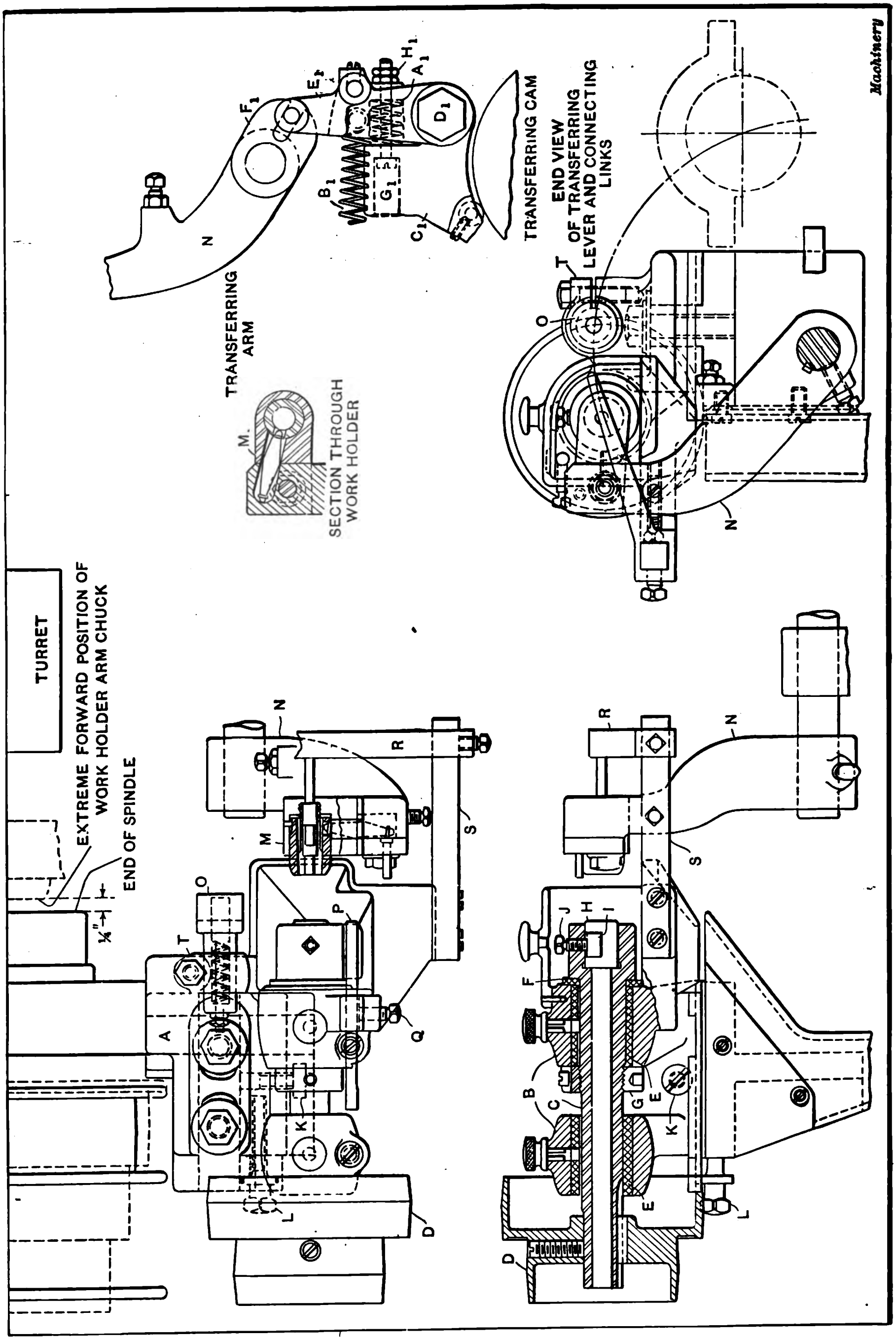


Fig. 22. Plan, Sectional and End Views of the Burring Attachment used on the No. 00 Brown & Sharpe Automatic Screw Machine

pressing the spring A_1, thereby keeping a tension on the arm N while the burring operation is being performed. The spring B_1 is fastened to the link E_1 and to the tray or bracket-holder for the transferring arm rod. The height of the lobe on the transferring cam governs the angular position of the arm N.

Laying out Cross-slide and Lead Cams for Burring Operation

The same remarks which were made in the previous chapter in regard to laying out cross-slide cams for cross-drilling operations apply

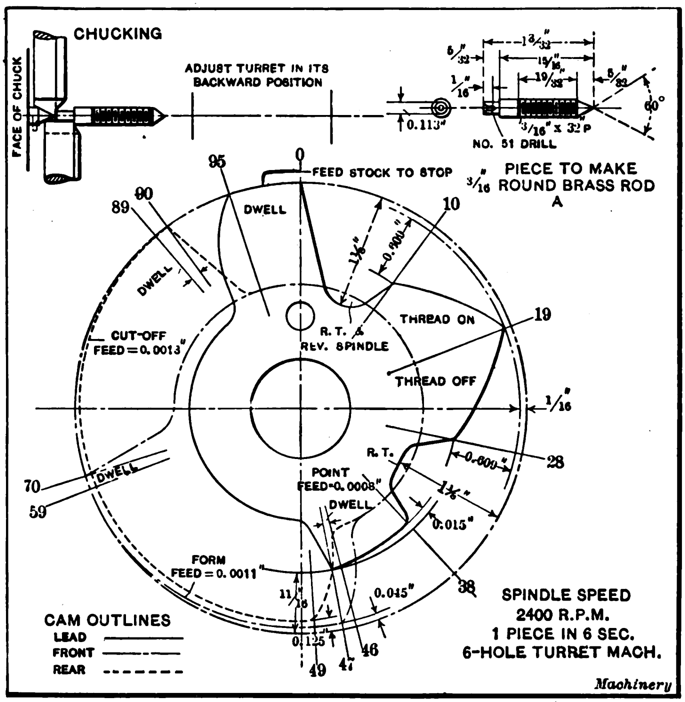


Fig. 23. Lead and Cross-slide Cams for Making a Cone-pointed Screw having a Hole drilled in the Rear End

to the laying out of cross-slide cams for burring operations, it being absolutely necessary to leave sufficient clearance for the arm to ascend and descend to and from the work-spindle. The character of the work and the shape and size of the work-holder also play an important part in regard to the amount of clearance necessary. This, of course, has to be worked out for each individual case. To illustrate clearly the method of designing a set of cams for an ordinary burring operation, we will lay out a complete set of cams for producing the cone-pointed screw shown at *A* in Fig. 23. As can be seen a No. 51 drill hole is to be produced in the rear end of this screw, which without the use of this attachment would necessitate rehandling the work and performing a second operation on it.

The cross-slide and lead cams for making this screw are also shown in Fig. 23, where the functions of the various lobes are clearly indicated. It might be mentioned, however, that it was necessary to ad-

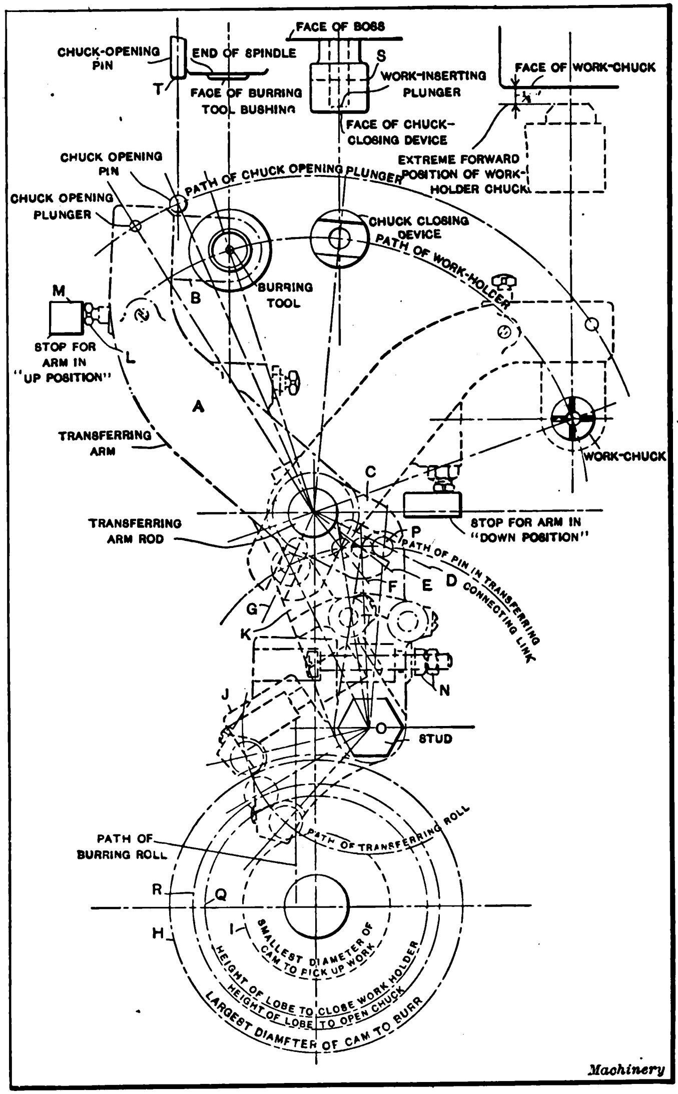


Fig. 24. Diagram used in Determining Rises on the Transferring and Burring Cams

just the turret slide back to the extreme limit to make this long screw in a No. 00 B. & S. automatic screw machine. The time allowed to feed stock is also less than that usually provided, being 5 hundredths instead of 10 hundredths of the cam circumference. The reason for this is that the turret is not revolved, but is just advanced to gage the stock to length.

Laying out the Transferring and Burring Cams

Before proceeding to lay out the transferring and burring cams, a diagram similar to that shown in Fig. 24 should be made. Here the work-chuck, chuck-closing device, burring tool and chuck-opening pin should be laid out in their respective positions, and the angular movement of the arm from one point to the other should be determined.

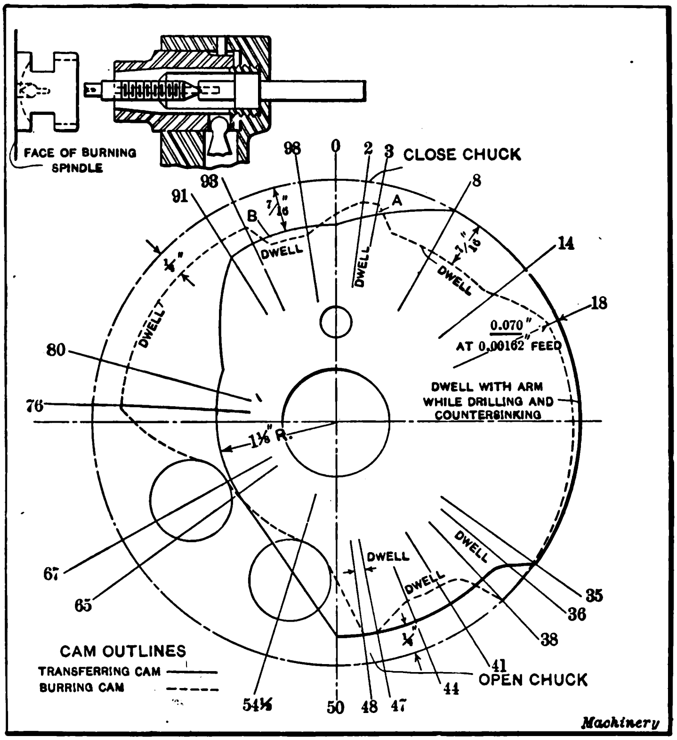


Fig. 25. Transferring and Burring Cams for the Piece shown at A in Fig. 23

A good method for obtaining the angular movement of the arm *A* is shown in Fig. 24. All those parts which are designated by full lines are drawn in; then make a templet of the arm *A*, work-holder *B* and slotted block *C*, on tracing cloth. Now by pivoting this templet on the center of the transferring arm rod, and swinging it around to he various positions, the lines *D*, *E*, *F* and *G* can be drawn which represent the center of the slot in the block *C*, when the arm is swung to the various positions. Next draw the circles *H* and *I*, representing the largest and smallest diameters of the transferring cam, after which a templet of the transferring lever *J* and connecting link *K* should be made on tracing cloth.

As was previously mentioned, the lever J should compress the spring A_1, see Fig. 22, when the set-screw L touches the square rod M, thus steadying the arm during the burring operation. To provide for this the nuts N are adjusted, so that the spring A_1 will bear the weight of the arm A. To proceed, pivot the templet of the transferring lever and connecting link on the center of the stud O, swing the templet so that the center of the pin P comes in line with the lines E and F, respectively, and draw circles Q and R representing the heights of the lobes for closing and opening the chuck. Care should be taken in laying out the lobes to lift the arm from the chuck-closing device to the chuck-opening pin, as the space between the two members is not adjustable. As the spring A_1, see Fig. 22, is compressed further when

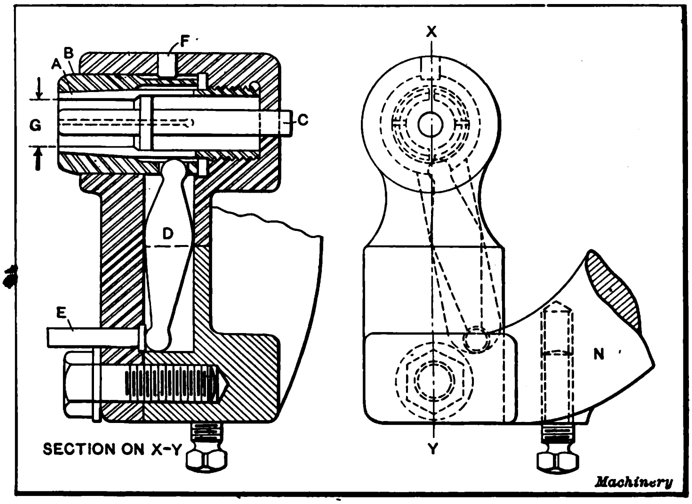


Fig. 26. Standard Work-holder used in Connection with the Burring Attachment

the arm A is in the "up position" than when it is in the "down position," it is necessary to start swinging the arm A from the work-chuck, and to proceed towards the burring tool. It will be found that the roll in the lever J will fall below the largest diameter of the cam, when the arm is in line with the burring tool; this allows the spring A_1 to be compressed and thus steady the arm.

To obtain the heights of the lobes on the burring cam, a diagram similar to that shown in the upper view of Fig. 24, should be made. The burring tool should be drawn in position, as well as the work in the work-chuck. The chuck-closing device S, and chuck-opening pin T are adjustable within a considerable range, but it is best to work from a setting which will be most convenient to the burring tool and work.

The method used in obtaining the heights of the lobes on the advancing cam was described in connection with Fig. 11, Reference Book No. 100 (Part II of this treatise), while the proper procedure to follow in laying out the lobes on the transferring cam in their correct relation to the lobes on the advancing cam was described in connection with Fig. 12 in the same book. The diagrammatical method used in laying out the transferring and advancing cams for the Nos. 0 and 2 B. & S. automatic screw machines was illustrated in Fig. 14 of Reference Book No. 100.

The transferring and burring cams used in connection with the piece shown at *A* in Fig. 23 are shown in Fig. 25, as is also a sectional view of the work-holder with the work in position. The order of operations for making the piece is as follows:

Lead and Cross-slide Cams

Operations	Revolutions	Hundredths
Feed stock to stop	12	5
Revolve turret and reverse spindle	24	10
Thread on	21.6	9
Thread off	21.6	9
Revolve turret	24	10
Point, 0.015 inch rise at 0.0008 inch feed, dwell 0.10	21.6	9
Form, 0.045 inch rise at 0.0011 inch feed, dwell 0.10	(55.2)	(23)
Cut off, 0.125 inch rise at 0.0013 inch feed, dwell 0.10, and revolve turret four times	98.4 + 4.8	41 + 2
Clearance to bring down arm	12	5
Total	240	100

Transferring and Burring Cams

Operations	Revolutions	Hundredths
Drill and countersink, 0.070 inch rise at 0.00162 inch feed, dwell 0.20	48	20
Drop back with piece	7.2	3
Rotate to open chuck	28.8	12
Dwell on burring cam to open chuck	2.4	1
Drop back to eject piece	10.7	4½
Drop down to grip work	36	15
Dwell with arm before advancing	4.8	2
Advance on work	21.6	9
Raise arm to close chuck	26.4	11
Advance arm to close chuck	9.6	4
Close chuck	2.4	1
Rotate to burring spindle	19.2	8

Referring to Fig. 25, the lobe *A* on the burring cam moves the arm forward to close the chuck, and during this period the transferring arm roll is on the "dwell" on the lobe *B* of the transferring cam. The springs previously referred to steady the arm when in this intermediate position, but on account of this undependable method of steadying the arm, it is not advisable to make a piece in less than three seconds on the No. 00 B. & S. automatic screw machine.

Work-holders and Chuck-closing Devices

The standard work-holder furnished in connection with the burring attachment is shown in detail, connected to the arm *N*, in Fig. 26, where its construction can be clearly seen. The operation of this work-holder has been described, but it may be advisable here to give a few more particulars regarding it. The diameter *G* of the chuck *A*, is made equal to the maximum diameter of the work. The chuck-closing sleeve *B* is made with a tapered hole to suit the chuck *A*, the taper being about ten degrees, and is provided with a slot in which a pin *F* fits, preventing the sleeve from turning around. The sleeve is also cut out to receive the ball end of the lever *D*, which is used for releasing it from the chuck, thus allowing the work to be pushed out by the plunger *C*. The lever *D*, as before mentioned, is operated by means of the headed pin *E*.

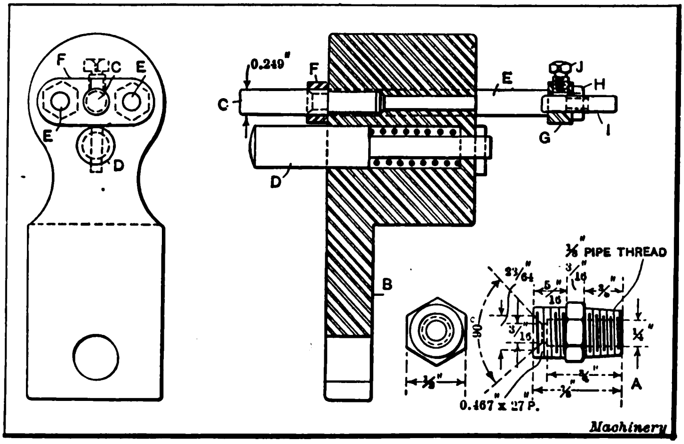


Fig. 27. A Work-holder of Special Design

Another type of work-holder, which was developed for a special piece, is shown in Fig. 27. This was for holding the threaded piece *A*, which, as can be seen, could not be gripped in a chuck of the type shown in Fig. 26 on account of the end which is placed in the chuck being tapered and threaded, thus preventing the chuck from gripping it securely. The work-holder consists essentially of a machine steel block *B* of the shape shown, which is fastened to the transferring arm by a cap-screw. This block is provided with a boss in which holes are drilled for the work-holder *C*, locating pin *D*, and ejecting pins *E*. The locating pin *D* comes in contact with the flats of the hexagon, and thus prevents the work from turning around on the work-holder *C*. The work-holder *C* is driven into the block *B*, and two studs or pins *E* pass through the block *B*, on the forward end of which is fastened an ejecting block *F*, forming a link connecting the two studs. The rear ends of these studs are also provided with a link *G* held to them by nuts *H*. An adjustable pin *I* located in the link *G* is retained by the set-screw *J*. This pin *I* comes in contact with the finger *R*, Fig. 22, and ejects the work after it has been burred.

The standard chuck-closing device provided with the burring attachment shown at *O*, Fig. 22, is shown more clearly at *A* in Fig. 28. It consists of a body *b* provided with a slot *c* in its front end through which the chuck passes on its transit from the work-spindle to the burring tool. The body *b* is counterbored to receive the spring plunger *d*, which is acted upon by the spiral spring *e*. The plunger is adjusted by means of the check-nuts *f*, and forces the work into the chuck against the ejecting pin *C*, see Fig. 26.

A special locating device used in connection with the work-holder shown in Fig. 27 is shown at *B*, Fig. 28. This device consists of a body *g*, which fits in the clamping bracket *T* on the burring attachment (see Fig. 22). The device is provided with a spring plunger *h* acted

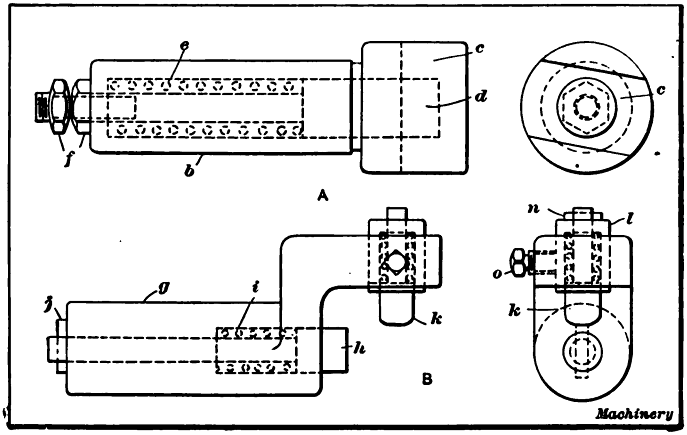


Fig. 28. Standard Chuck-closer, and Device for Locating Work on the Holder shown in Fig. 27

upon by the spring *i*, and is retained in the holder by means of pin *j*. This plunger *h* is used for forcing the work onto the pin *C*, Fig. 27. The plunger *k*, which rotates the work on the work-holder, and thus locates it correctly against pin *D*, is held in a bushing *l* counterbored to receive a spring, and is retained in the holder by means of the pin *n*. The bushing itself is held in the holder by means of the set-screw *o*.

Burring Tools and Holders

The type of burring tool and holder used in the burring attachment is governed entirely by the work it is to perform. In Fig. 29 are shown a few representative types of burring tools and their respective holders. *A* is the burring tool used for burring the piece shown at *A* in Fig. 27. This is made from round drill rod, as shown, and is provided with a leader fitting in the work, the cutting face being tapered to the required angle. The type of burring tool and holder used for drilling and countersinking the screw shown at *A* in Fig. 23, is shown at *B*. The holder *a* is made to fit in the burring spindle, and is slotted out to receive the clamping block *b*. A combination drill and countersink *c* of the required shape and diameter is held in this holder by means of a set-screw bearing on the clamping block. The front end of the holder is counterbored to receive the work-holder chuck, and is also provided with two slots *d* which allow the chips to escape.

Another type of burring tool, and the work on which it is used is shown at *C*. In this case the burring tool is a combination holder and tool, being made to fit the hole in the burring spindle. It is also provided with a leader *e* to fit the work, which is turned down on the rear end to suit the holder and held in it by a set-screw as shown.

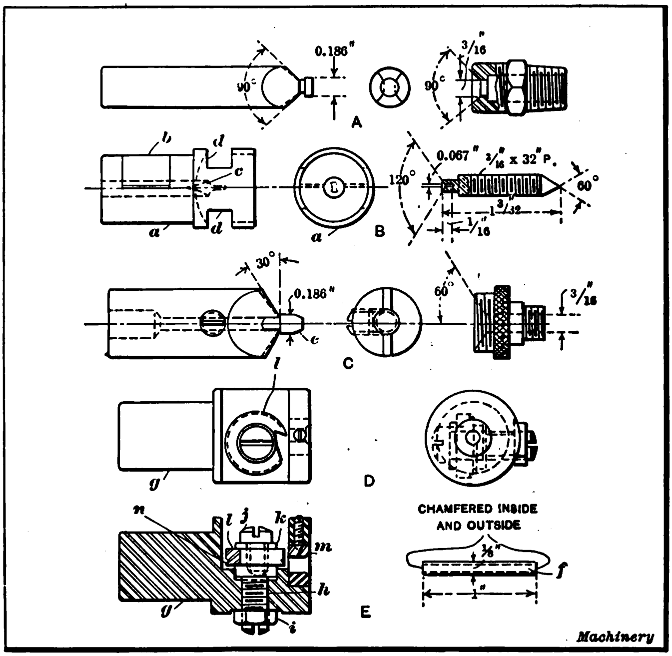


Fig. 29. Various Types of Burring Tools and Burring-tool Holders

Three views of still another type of burring tool and holder are shown at *D* and *E*. This holder and tool is used principally for chamfering the inside and outside of tubing as shown at *f*. The tool used is similar to a circular form tool except that it is of small size. It is held in the holder *g* on a stud *h*, which is threaded into the holder and is provided with a nut *i* for locking it in the desired position. The stud carrying the circular tool is slotted in the lower end, so that it can be adjusted, thus bringing the tool in the correct position to chamfer the inside and outside of the work.

The circular tool *l* is held on the stud by means of a screw *j* and washer *k*. The front end of the holder is provided with a bushing *m*, which fits the external diameter of the work and is held in place by a headless screw as shown. When designing this type of tool, it is preferable to lay out the work on a large scale, about 10 to 1, and from this obtain the diameter of the tool, and the distance it is to be cut down below the center, so that the tool will clear and not rub, which would tend to produce a poor finish on the work. The depth of the recess *n* should only be a few thousandths greater than the length of chamfer required on the work, because the greater the depth *n*, the smaller the diameter of the tool, and also the smaller the amount of tool circumference that can be utilized for cutting. From the diagram the location of the stud *h* can also be obtained.

Speeds and Feeds for Burring

The speeds used for burring when the tools are made from ordinary carbon steel should be similar to those used for drills, a table of which was given in MACHINERY'S Reference Book No. 103, "Internal Cutting Tools for the Brown & Sharpe Automatic Screw Machines." The feeds used when the burring tool is smaller in diameter than ¼ inch should never be greater than 0.003 inch for brass, 0.002 inch for machine steel, and 0.001 inch for tool steel. The feeds should also be decreased near the end of the cut, and a dwell equal to at least three revolutions of the burring tool should be allowed on the burring cam. When the burring tool is ¼ inch or greater, the same feeds as those used for centering tools, given in the article previously referred to, can be used with satisfactory results.

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