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OPERATION OF MACHINE TOOLS

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PLANER—SHAPER—SLOTTER

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CHAPTER I

CONSTRUCTION AND OPERATION OF A PLANER

The planer is used principally for producing flat surfaces. The construction or design of planers of different makes varies somewhat, and special types are built for doing certain kinds of work. There is, however, what might be called a standard type which is found in all machine shops and is adapted to general work. A typical planer of small size is illustrated in Fig. 1. The principal parts are the bed *B*, the housings *H* which are bolted to the bed, the table or platen *P* to which the work is attached, the cross-rail *C*, and the toolhead *T*

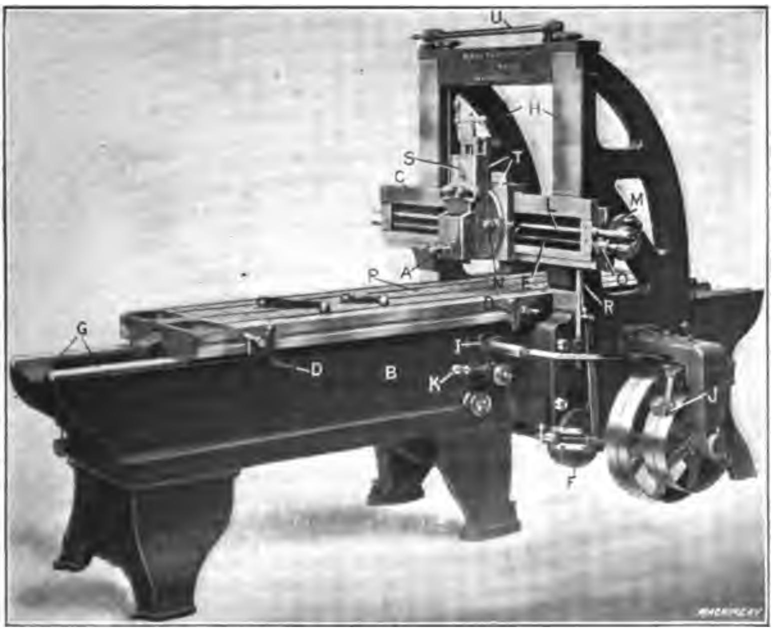

Fig. 1. Flather Single-head Planer

which is mounted on the cross-rail. When the planer is in operation, the platen slides back and forth on the bed in V-shaped grooves *G* which cause it to move in a straight line. While this reciprocating movement takes place, the work, which is clamped to the platen, is planed by a tool held in position by clamps *A*. This tool remains stationary except at the end of each stroke of the platen, when the toolhead and tool feed slightly for a new cut. The amount of feed for each stroke can be varied to suit the conditions, as will be explained later. The movement of the table or of the length of its stroke is governed by the position of the dogs *D* and D_1. These dogs may be adjusted along the groove shown and they serve to reverse the table movement by engaging tappet *I*. Before explaining just how the movement of tappet *I* controls the point of reversal, the arrangement of the driving mechanism, a plan view of which is shown in Fig. 2, will be explained.

The Driving and Reversing Mechanism

The shaft on which the belt pulleys *f*, f_1, and *r*, r_1 are mounted carries a pinion *a* that meshes with a gear on shaft *b*. This shaft drives, through the gears *c* and *d*, a second shaft which carries a pinion *e*, and

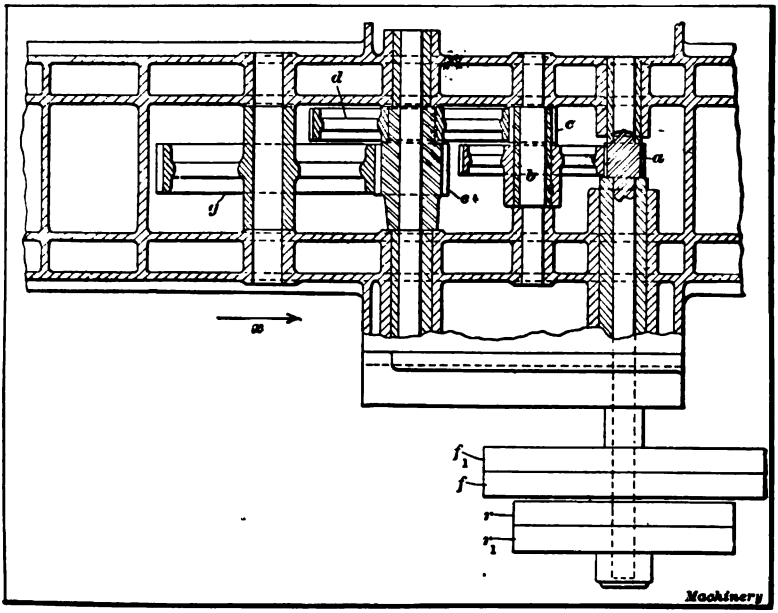

Fig. 2. Driving Mechanism of a Spur-geared Planer

which meshes with a large gear *g*. This large gear, which is called the "bull-wheel," in turn engages a rack attached to the under side of the table, and, as the gear revolves, the table moves along the ways of the bed. There are two pairs of driving pulleys and also two driving belts connecting with an overhead countershaft. One pulley of each set is keyed to the shaft and the other is loose and revolves freely. The belt operating on the large pulleys *f* and f_1 is "open" whereas the belt for the smaller pulleys *r* and r_1 is crossed, which gives a reverse motion. The position of both belts is controlled by guides *J* (one of which is seen in Fig. 1) which are operated by tappet *I*. Now when the open belt is running on the tight pulley *f*, the reverse belt is on the loose pulley r_1, and the table moves as shown by the arrow *x*, which is in the direction for the cutting stroke. When the table is advanced far enough to bring dog *D* (Fig. 1) into engagement with tappet *I*, the latter is pushed over, which shifts the open belt on loose pulley f_1 and the cross belt on the tight pulley *r*. The pulley shaft and the entire train of driving gears is then rotated in the opposite direction by the crossed belt and the table movement is reversed. This is the return stroke, during which the planing tool glides back over the work to the starting point for a new cut. To change the length of the stroke, it is simply necessary to shift dogs *D* and D_1 as their position determines the point of reversal. When the workman desires to reverse the table by hand or stop it temporarily, this can be done by operating hand lever *K*. It will be noted that there is considerable difference in the diameter of the two sets of belt pulleys, those for the forward or cutting stroke being much

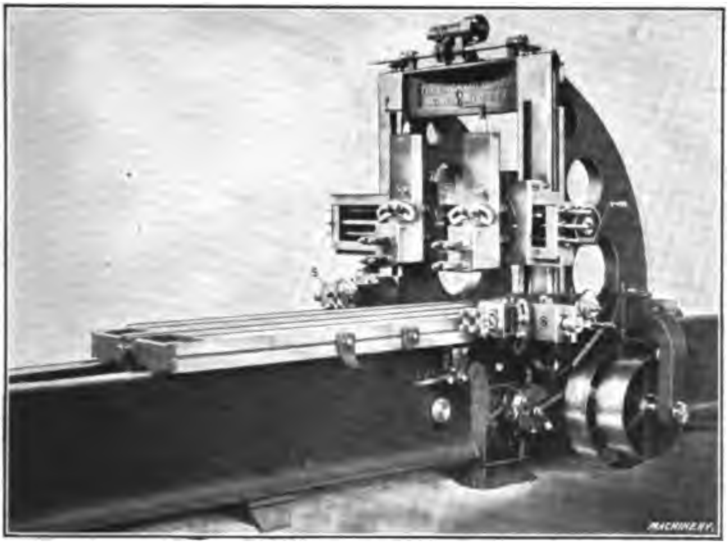

Fig. 3. Cincinnati Four-head Planer

larger than those for the return movement. As the size of the countershaft pulleys is in the reverse order, the speed of the table is much less when the large pulley is driving than when the cross belt is shifted to the small pulley. The result is that the table is returned quickly after the cutting stroke in order to reduce the idle time that elapses between the end of one cut and the beginning of the next.

The Feeding Mechanism

The feeding movement of the tool takes place just before the cutting stroke begins. If a horizontal surface is being planed, the tool has a crosswise movement parallel to the platen, but if the surface is vertical, the tool is fed downward at right angles to the platen. In the first case, the entire toolhead *T* moves along the cross-rail *C*, but for vertical planing, slide *S* moves downward. Surfaces which are at an angle with the table can also be planed by loosening nuts *N* and swiveling slide *S* to the required angle as shown by graduations on the circular base. The horizontal and vertical movements of the tool can be effected by hand or automatically. The hand feed is used principally for adjusting the tool to the proper position for starting a cut. The tool can be set to the right height by a crank at the top of the tool-head, and the crosswise position of the tool and head can be varied by turning horizontal feed-screw *E*. This screw is turned for a hand adjustment by placing a crank on the squared outer end. The automatic feeding movement is derived from a feed disk *F*, which turns part of a revolution at each end of the stroke and is connected to a rack *R*. This rack slides up and down with each movement of the crank and imparts its motion to gear *M* by means of an inner pinion which it engages. Gear *M*, in turn, meshes with a gear *O* placed on the feed-screw. The feeding movement is engaged, disengaged or reversed by a pawl attached to gear *M* (on this particular planer) and the amount of feed per stroke is varied by adjusting the crankpin of the disk *F*, to or from the center. The vertical feed is operated by a splined shaft *L* which transmits its motion to the toolhead feed-screw through gearing. This shaft is also driven by gear *O* which is removable and is placed on it when an automatic vertical feed is desired.

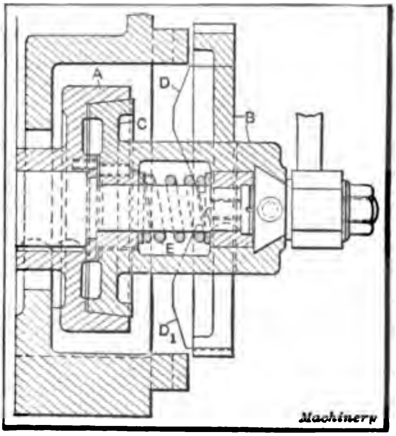

Fig. 4. Friction Feed Disk

The friction disk *F* is turned by pinion shaft *c* (Fig. 2), of the driving mechanism. The number of revolutions made by this pinion shaft for each stroke depends, of course, on the length of the stroke, but the feed disk is so arranged that it only rotates part of a revolution at each end of the stroke, so that the feeding movement is not governed by the length of the stroke. In other words the feed disk is disengaged from the driving shaft after being turned part of a revolution. One type of feed disk is shown in the sectional view Fig. 4. The cup-shaped part *A* having an inner tapering surface is attached to the main pinion shaft. Crank-disk *B* has a tapering hub *C* which fits into part *A* as shown. If the hub is engaged with cup *A* when the planer is started, the crank-disk is turned until a tapered projection *D* strikes a stationary taper boss on the bed which disengages hub *C* from the driving member by moving it outward against the tension of spring *E*. The disk then stops turning and remains stationary until the driving member *A* reverses at the end of the stroke. The hub then springs back into engagement and the disk turns in the opposite direction until another taper projection D_1, on the opposite side, strikes a second boss on the bed which again arrests the feeding movement. It will be seen that this simple mechanism causes the disk to oscillate through the same arc whether the stroke is long or short.

Double Head Planers—Use of Side-heads—Two-speed Planer

Modern planers, with the exception of comparatively small sizes, are ordinarily equipped with two tool-heads on the cross-rail, as shown in Fig. 3, so that two tools can be used at the same time. Some planers also have side-heads *S* mounted on the housings below the cross-rail for planing vertical surfaces or for doing other work on the sides of a casting. These side-heads have an automatic vertical feed and can often be used while the other tools are planing the top surface, the method being to start first the regular tools (which usually have the largest surfaces to plane) and then the side-heads. If the planing on the side requires hand manipulation, as when forming narrow grooves,

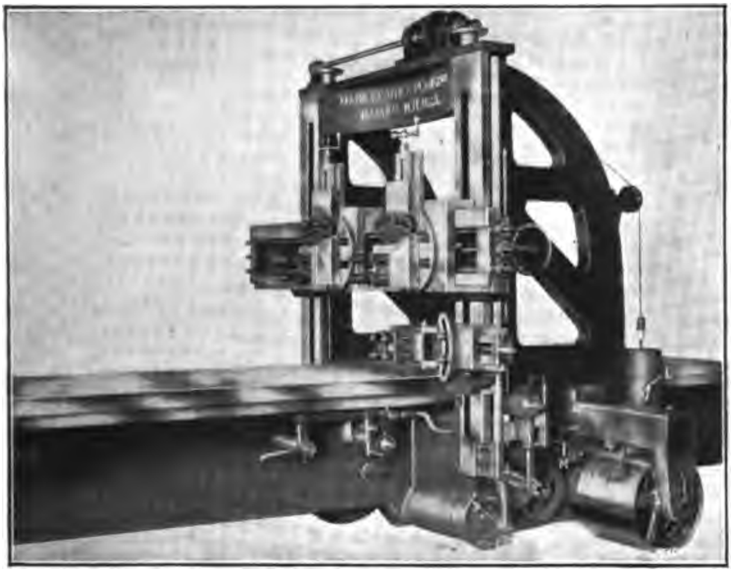

Fig. 5. Flather Two-speed Planer

etc., the planing would be done on first one side and then the other, assuming that both sides required machining, but when the surfaces are broad the automatic feed enables both side-heads to be used at the same time, on some classes of work. These side-heads often greatly reduce the time required for planing and they also make it possible to finish some parts at one setting, whereas the work would have to be set up in one or two different positions if a planer without side-heads were used.

The planer illustrated in Fig. 5 has two speeds for the "cutting stroke" of the table, instead of a single speed. This feature is very desirable as it enables the cutting speed to be varied in accordance with the kind of material to be planed or the character of the work. The speed is changed from fast to slow or *vice versa* by operating lever *L* which, through a segment pinion and rack *M*, shifts sliding gears which are located inside the bed and form a part of the driving train.

CHAPTER II

EXAMPLES OF PLANER WORK AND ADJUSTMENT OF MACHINE

A simple example of planing is illustrated in Fig. 6. The work *W* is a base casting, the top surface of which is to be planed true. The casting is first fastened to the table by bolts and clamps *C* and C_1, and it is further held from shifting by stop-pins *S*. The platens of all planers are provided with a number of slots and holes for the

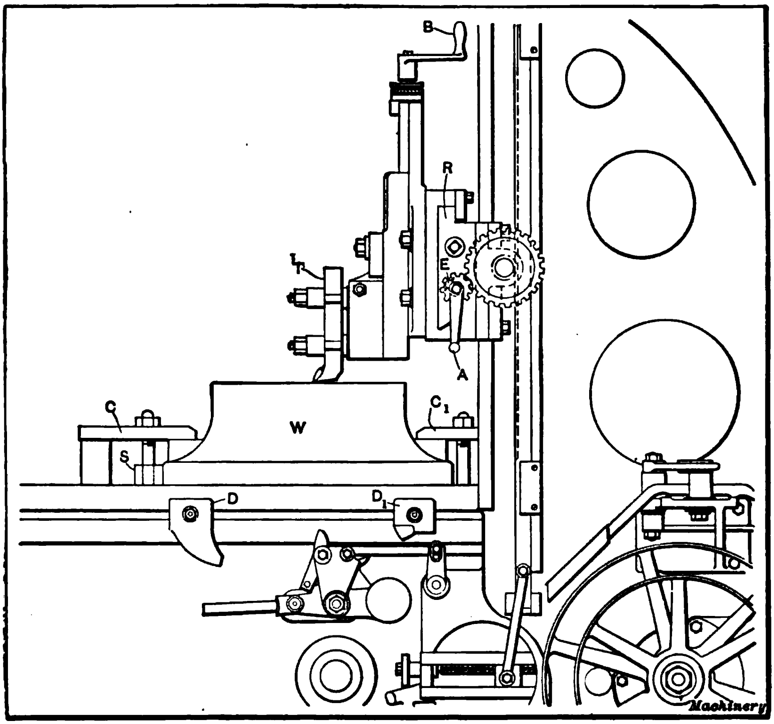

Fig. 6. Side View of Planer with Work in Position

reception of clamping bolts and stop-pins. When the casting is securely attached to the platen, a planing tool *T* is clamped in the toolpost, and cross-rail *R* is set a little above the top surface of the work. The dogs *D* and D_1 are then placed opposite the work and are set far enough apart to give the platen and work a stroke slightly greater than the length of the surface to be planed. The movement of the work during a stroke is illustrated in Fig. 7, the full lines showing its position with relation to the tool at the beginning of the cutting stroke, and the dotted lines the end of the stroke or the point of reversal. The dogs should be adjusted so that the distance *x* is not more than $1\frac{1}{2}$ to 2 inches and the tool should just clear the work at the other end. If the stroke is much longer than the length of the surface being planed, obviously more time is required for planing than when the stroke is properly adjusted.

Taking the Cut

The tool is moved over to the work by handle *A* and is fed down to the right depth for a cut by handle *B*. The planer is started by shifting an overhand belt (assuming that it is belt- and not motor-driven) and the power feed is engaged by throwing the feed pawl into mesh. On this particular planer, the feed pawl is inside the gear and it is engaged or disengaged by handle *E*. The tool planes the surface of the casting by feeding horizontally across it and removing a chip

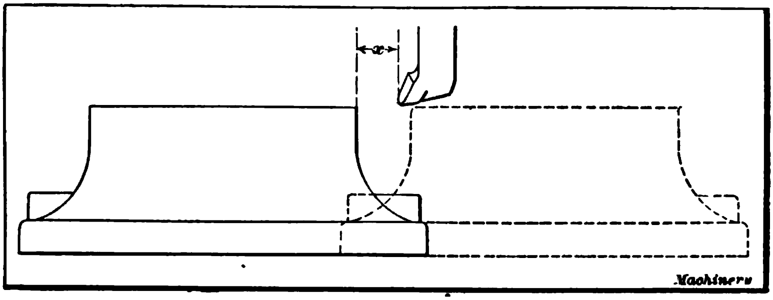

Fig. 7. Movement of Work with Relation to Planing Tool

during each forward stroke of the work. If there is not much metal to be planed off, one roughing and one finishing cut would probably be all that is necessary. For the finishing cut, a broad tool having a flat edge is often used, especially for cast iron, as it enables wide feeds to be taken, which reduces the time required for the finishing cut. The different types of tools ordinarily used on a planer, are illustrated in Chapter IV, which also explains how they are ground and gives typical examples of their use.

Planing Work held in a Chuck

Another planing operation is illustrated in Fig. 8. In this case, the sides of a cast-iron block *B* are to be planed parallel and square to each other. One method of holding the work would be to grip it in the planer chuck *A*. A cut can then be taken over the entire surface of one side, whereas if ordinary clamps *C*, Fig. 6, were used, they would interfere with the movement of the tool. This chuck, an end view of which is shown at *A* in Fig. 9, has one fixed jaw *J* and one movable jaw J_1 and the work is clamped between the jaws by the screws shown. The work is "bedded" by hammering it lightly, until the sound indicates that it rests solidly on the bottom of the chuck.

After a cut has been taken over the upper side *a* (Fig. 8), the casting is turned to bring its finished face against the stationary jaw *J* as shown at *A*, Fig. 9. A finished or planed surface should always be located against the fixed or stationary jaw of the vise, because the movable jaw is more liable to be out of alignment. If the fixed jaw is square with the planer table, and face *a* is held flat against it, evidently face *b*, when planed, will be at right angles to face *a*. Unless care is taken, however, the work may be tilted slightly as the movable jaw is set up, especially if the latter bears against a rough side of the casting. The way this occurs is indicated at *B*. Suppose, for example, that the rough side *c* is tapering (as shown somewhat exaggerated) and the jaw J_1 only touched the upper corner as shown. The

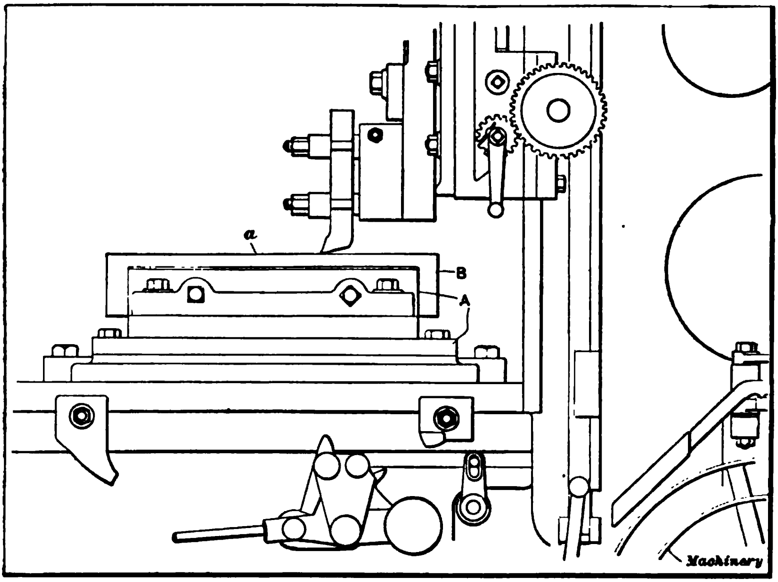

Fig. 8. Planing Work held in Chuck

finished face will then tend to move away at *x* (sketch *C*) as jaw J_1 is tightened, so that face *b*. when planed, would not be square with the side *a*. One method of overcoming this difficulty is to insert narrow strips of tin (or strips of paper when the irregularity is small) in the space *s* (sketch *B*) to give the clamping jaw a more even bearing. This tilting can also be prevented by placing a wire or cylindrical rod *w* along the center of the work as shown at *D*; the pressure of clamping is then concentrated at the center and the opposite side is held firmly against the fixed jaw. Sometimes a special packing strip *p*, having a rounded face, is inserted between the jaw and the work to prevent tilting, as at *E*. This strip acts on the same principle as the wire, and it is more convenient to use.

When the sides *a* and *b* are finished and the casting is being set for planing side *c*, it is necessary not only to have a good bearing against the fixed jaw, but as the sides are to be parallel, the lower side *a* must, at this setting, bear evenly on the bottom of the chuck. A simple method of determining when work is firmly bedded, is as follows: Place strips of thin paper beneath each end of the work, and after tightening the chuck and hammering the casting lightly to give it a good bearing, try to withdraw the paper strips. If both are held tightly, evidently the casting rests on the chuck and the upper side will be planed parallel, provided the chuck itself is true.

The foregoing method of planing a block square and parallel, by holding it in a chuck, is not given as one conducive to accuracy, but rather to illustrate some of the points which should be observed when

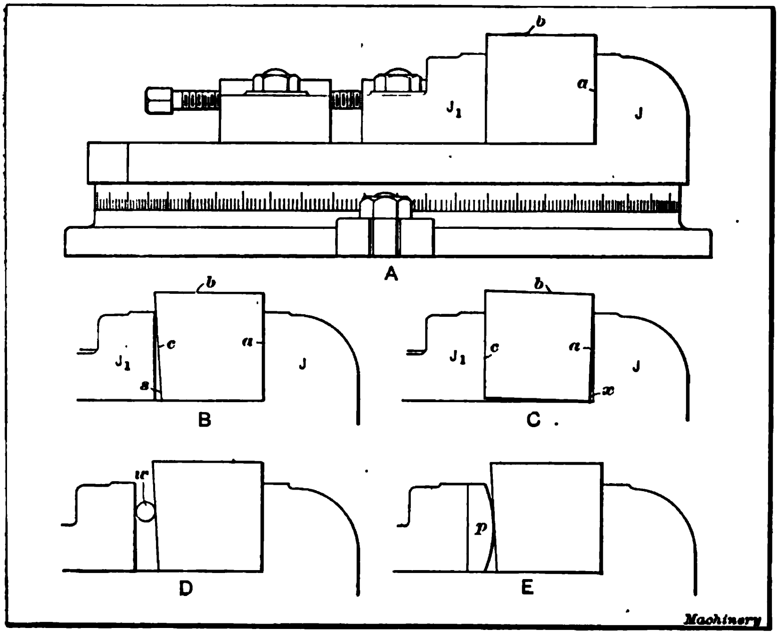

Fig. 9. Planer Chuck—Diagrams showing how Work is Tilted and Methods of Holding it Square

clamping work in a planer chuck. If considerable accuracy were required, the work could be held to better advantage by fastening it directly to the table with special clamps, as indicated in Fig. 10. The particular clamps illustrated have round ends which are inserted in holes drilled in the work. Of course, such clamps can only be used when the holes are not objectionable. As will be seen, these clamps are not in the way of the planing tool, and the block is held directly against the true surface of the platen.

This block could be planed accurately as follows: A roughing cut is first taken over all the sides to remove the hard outer surface, and then one side is finished. This finished surface is next clamped to the platen, thus permitting the opposite side to be planed. These two surfaces will then be parallel, provided the planer itself is in good condition. The finished sides are next set at right angles to the platen by using an accurate square, and the third side is planed. The fourth and last side is then finished with the third side clamped against the platen. By this method of holding the work, it would be easier to secure accurate results than by using a chuck; a chuck, however, is often very convenient for holding small parts.

Planing Vertical and Angular Surfaces

When vertical surfaces or those which are at right angles to the platen are to be planed, a tool having a bent end as shown at *A* in Fig. 11 is ordinarily used, unless the planer has side-heads, in which case a straight tool is used. The tool-block is also set at an angle, as shown, by loosening bolts *E*, which permit it to be swiveled to the right or left from its vertical position. The tool-block is set over in this way to prevent the tool from dragging over the planed surface on the return stroke. It should be explained that the tool-block of a planer is

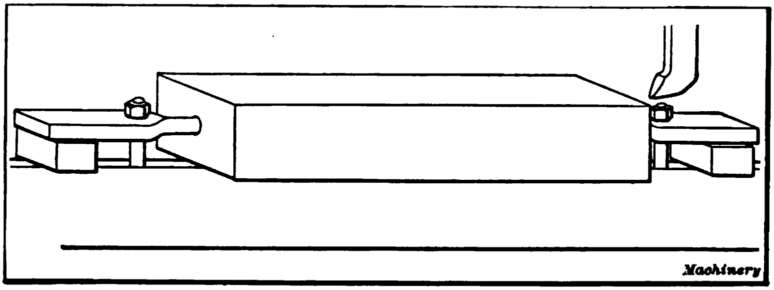

Fig. 10. Holding Block directly against Planer by Finger-clamps

free to swing forward so that the tool can lift slightly when returning for another cut. When a heavy cut is being taken, the tool is sprung sidewise to some extent, as well as backward, and if it were held rigidly on the return stroke, the cutting edge would drag heavily over the work and this would soon dull the edge. When a horizontal surface is being planed, the tool on its return tends to lift upward at right angles to the surface, because the tool-block is then set square with the platen. If, however, the tool-block were left in this position for vertical planing, the tool-point would swing upward in a plane *y–y*, and drag over the finished surface, but by setting the block in an angular position, as shown, the tool-point swings in a plane *x–x*, or at right angles to the axis *a–a* of the pin on which the block swivels. As plane *x–x* is at an angle with the surface of the work, the tool-point moves away from the finished surface as soon as it swings upward. The angular position of the tool-block does not, of course, affect the direction of the tool's movement, as this is governed by the position of slide *S* which is changed by swiveling the graduated base *D*.

A vertical surface is planed by adjusting the saddle *G*, horizontally along the cross-rail until the tool is in position for taking a cut. The tool is then fed down by hand, until the cut is started, after which the vertical feed is engaged, thus causing slide *S* and the tool to feed downward a certain amount for each stroke, while the saddle remains stationary on the cross-rail. The surface *y–y* will be planed square with the platen, provided the swiveling base *D* is set in the proper position. Before planing surfaces that are intended to be square with the platen, the position of the tool-slide *S* should be noted by referring to the graduation marks on the base *D*. When the zero marks on the stationary and swiveling parts of the base exactly coincide, the slide should be at right angles to the platen. Its position, however, can be determined more accurately by holding the blade of a square which

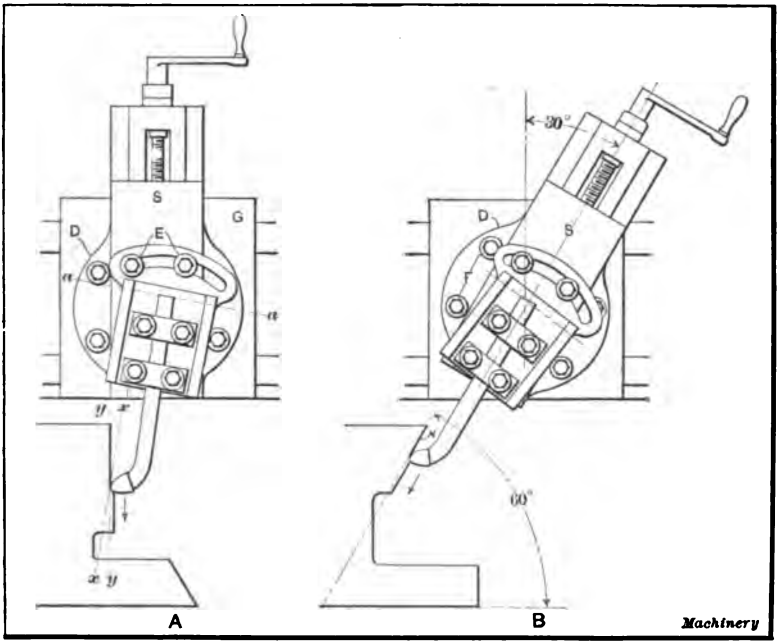

Fig. 11. Positions of Tool and Head for Planing Vertical and Angular Surfaces

rests on the platen, against one side of the tool-slide, as it is difficult to set graduation lines to exactly coincide, and even though they were in line, errors might result from other causes.

The planing of an angular surface is illustrated at *B*. The tool-head is first set to the proper angle by loosening bolts *F* and turning the base *D* until the graduations show that it is moved the required number of degrees. For example, if surface *s* were to be planed to an angle of 60 degrees with the base, as shown, the head should be set over 30 degrees from the vertical or the difference between 90 and 60 degrees. The tool would then be fed downward, as indicated by the arrow. The tool-block is also set at an angle with slide *S*, when planing angular surfaces, so that the tool will swing clear on the return stroke. The top of the block should always be turned *away from the surface to* *be planed*, which applies to the planing of either vertical or angular surfaces when using the cross-rail head.

An example of angular work is illustrated in Fig. 12, which shows a planer arranged for planing the V-shaped ways or guides on the bottom of a planer platen. Both tool slides are set to the required angle for planing one side of each vee. As there are two tool-heads, both vees can, of course, be planed simultaneously. The sides of the

Fig. 12. Double-head Planer set for Planing Angular Surfaces

platen are also planed at the same setting by tools held in the side-heads.

Position of the Tool and Cross-rail—Alignment of Cross-rail

The tool should be set about square with the work, as shown at *A*, Fig. 13, when planing horizontal surfaces. If it is clamped in the tool-block at an angle, as shown at *B*, and the lateral thrust or pressure of the cut is sufficient to move the tool sidewise, the cutting edge will sink deeper into the metal, as indicated by the dotted line, whereas a tool that is set square will swing upward. Of course, any shifting of the tool downward may result in planing below the level of the finished surface which would spoil the work. The tool should also be clamped with the cutting end quite close to the tool-block, so that it will be rigidly supported.

As previously mentioned, the cross-rail should be lowered until it is quite close to the top surface of the work. If it is set much higher than the work, the tool-slide has to be lowered considerably to bring the tool in position for planing; consequently, both the slide and the tool extend below the rail and they are not backed up and supported against the thrust of the cut as solidly as when the rail is more directly in the rear. The vertical adjustment of the cross-rail on the face of the housings is effected by two screws which are connected through bevel gearing with the horizontal shaft *U* (Fig. 1) at the top. On small planers this shaft is turned by hand, but on larger ones it is driven by a belt. Before making the adjustment, bolts at the rear which clamp the cross-rail to the housings must be loosened, and care should be taken to again tighten these bolts before using the planer. The ways on which the cross-rail slides, should be wiped clean before

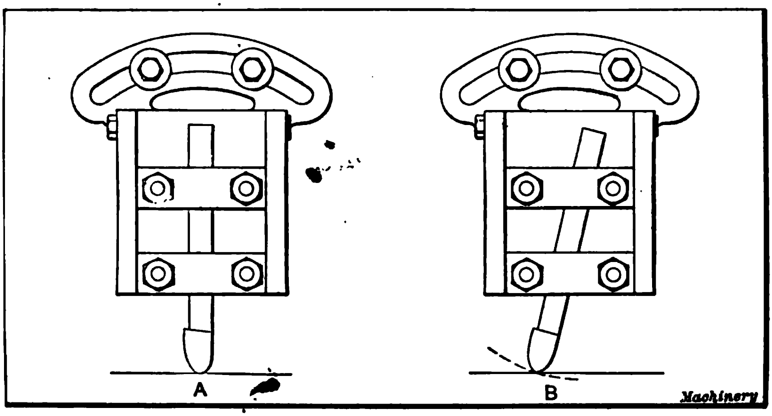

Fig. 18. Correct and Incorrect Positions for Planing Tool

making an adjustment, to prevent dirt from getting back of the rail as this would affect its alignment.

The cross-rail of a planer which is in good condition, is parallel with the upper surface of the platen, so that the planing tool, as it feeds horizontally, moves in a line parallel with the platen. Unfortunately this alignment is not always permanent and if accurate work is to be done, especially on a planer that has been in use a long time, it is well to test the cross-rail's position.

One method of making this test is as follows: An ordinary micrometer is fastened to the tool-head in a vertical position either by clamping it to the butt end of a tool, or in any convenient way, and the head is lowered until the end of the micrometer thimble is slightly above the platen. The thimble is then screwed down until the end just touches the surface to be tested, and its position is noted by referring to the regular graduations. The thimble is then screwed up slightly for clearance and, after the tool-head is moved to the opposite side, it is again brought into contact with the platen. The second reading will then show in thousandths of an inch any variations in the cross-rail's position.

Multiple or Gang Planing—Use of Planer with Double- and Side-heads

When a number of duplicate parts have to be planed, much time can often be saved by arranging the castings in a straight row along the platen so that they can all be planed at the same time. This method enables a number of parts to be finished more quickly than would be possible by machining them separately, and it also insures duplicate work. An example of multiple or gang planing is shown in

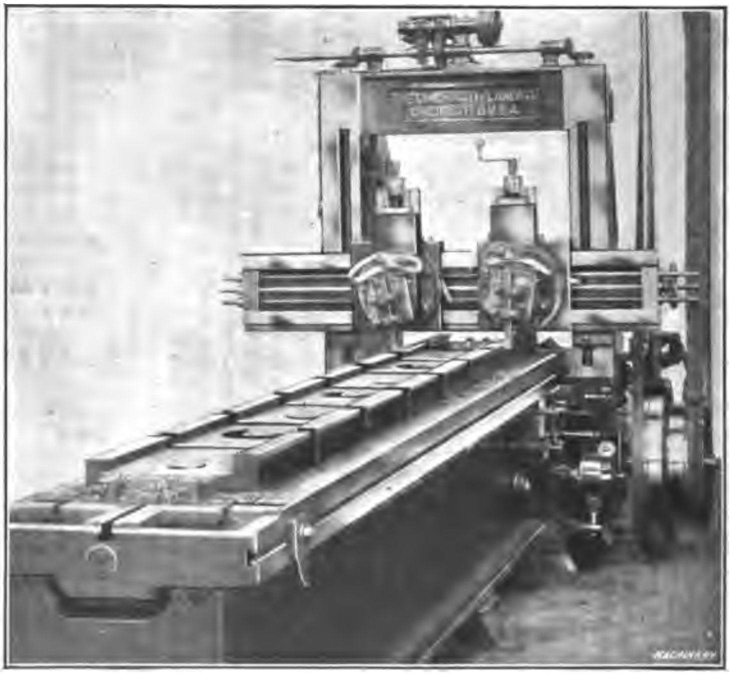

Fig. 14. Planing a Row of Duplicate Parts

Fig. 14. The particular castings illustrated are the "saddles" of planer tool-heads and eight castings are being planed at the same time. Both tool-heads are in use, and the tops and sides of the castings are finished at this setting.

This method of planing cannot always be employed to advantage as the shape of the work or location of the surfaces to be machined sometimes makes gang planing impracticable and even impossible. If the castings are so shaped that there will be considerable space between the surfaces to be planed, when they are placed in a row, so much time might be wasted while the tool was passing between the different surfaces that it would be better to plane each part separately. Some castings also have lugs or other projections which make it impossible for the tool to pass from one to the other without being raised to clear the obstruction. On the other hand, when castings are quite symmetrical in form and the surfaces are so located that the planing tool can pass from one to the other with a continuous stroke, as indicated in Fig. 14, the gang method of planing insures a uniform product and greatly reduces the time required for machining.

Two or more tools can often be used at the same time in connection with many planing operations. Fig. 15 shows a cross-section of an engine bed and illustrates how a double-head planer would be used on this particular job. The tool to the left is started first because it is the *leading* tool, as determined by the direction of the feed. This is

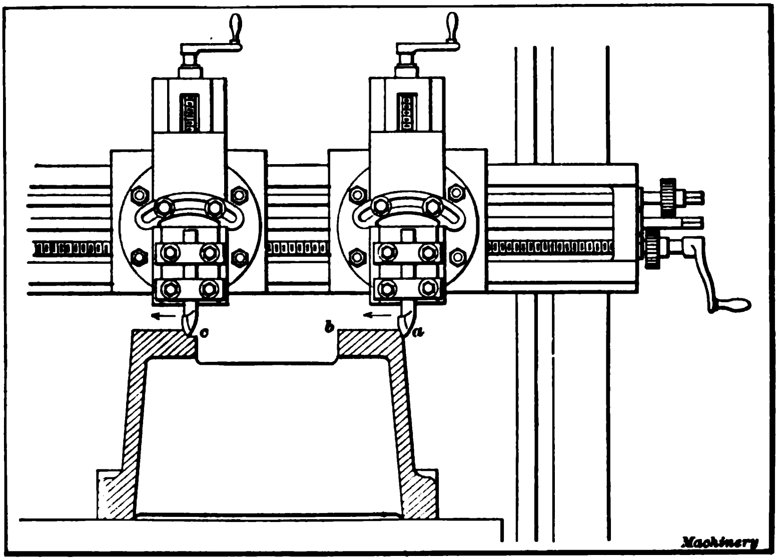

Fig. 15. Planing Two Surfaces Simultaneously with Two-head Planer

a good rule to follow especially when the tool-heads are quite close, as it prevents one head from feeding against the other, which might occur if the *following* tool were started first. The tools illustrated, cut principally on the side and are intended for deep roughing cuts in cast iron. The surfaces should be finished with a broad tool with a wide feed. If the planer were heavy and rigid, a feed of ½ or ¾ inch for each stroke, or even more, could be used for the finishing cut, but if the planer were rather light or in poor condition, it might be necessary to reduce the feed to ¼ inch or less, to avoid chatter. It is impossible to give any fixed rule for the amount of feed as this is governed not only by the planer itself, but also by the rigidity of the work when set up for planing, the hardness of the metal, etc. The final cut should be taken by a single tool to insure finishing both sides to the same height. This tool should be fed by power from *a* to *b*, and then rapidly by hand from *b* to *c* for finishing the opposite side.

The use of two tools for rough planing, greatly reduces the time required for machining work of this kind.

A typical example of the class of planer work on which a side-head can be used to advantage, is shown in Fig. 16. The operation is that of planing the edge and face of a large casting. The tool in the side-head is rough planing the vertical surface, while the other tool planes the edge. As the side-tool has the broadest surface to plane, it is started first. On some work two side-tools can be used simultaneously. The use of both cross-rail tool-heads at the same time is very common in

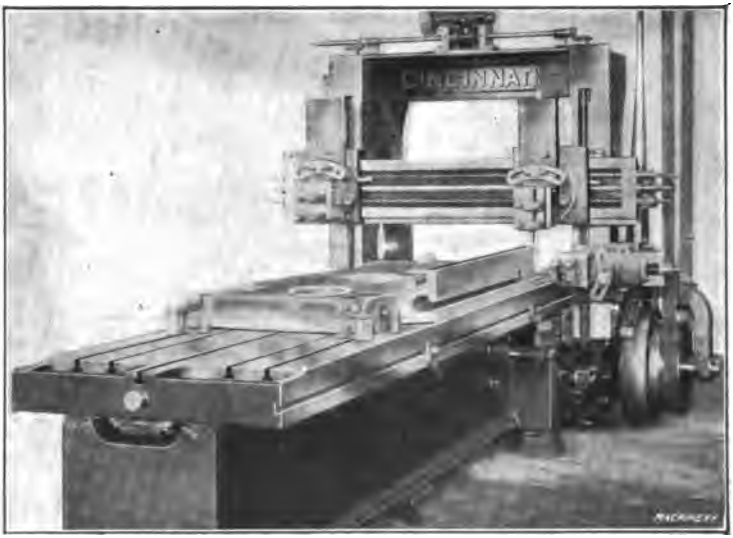

Fig. 16. Planing Top Edge and Side of Casting—Illustrating use of Side-head

connection with modern planer practice. Whether it is feasible to use one tool or four, simultaneously, depends altogether on the shape of the work and the location of the surfaces to be machined. Very often only one tool can be used and, occasionally, four tools can be operated at the same time, provided, of course, the planer is equipped with four heads. There are few fixed rules which can be applied generally to planer work, because the best way to set up and plane a certain part depends on its shape, the relative location of the surfaces to be finished, the degree of accuracy necessary, and other things which vary for different kinds of work. Before beginning to plane any part, it is well to consider carefully just what the requirements are and then keep them in mind as the work progresses.

CHAPTER III

HOLDING AND SETTING WORK ON THE PLANER

A great deal of the work done on a planer is very simple as far as the actual planing is concerned, but often considerable skill and ingenuity are required in setting the work on the planer and clamping it in the best manner. There are three things of importance that should be considered when doing work of this kind. First, the casting or forging must be held securely to prevent its being shifted by the thrust of the cut; second, the work should not be sprung out of shape by the clamps; and third, the work must be held in such a position

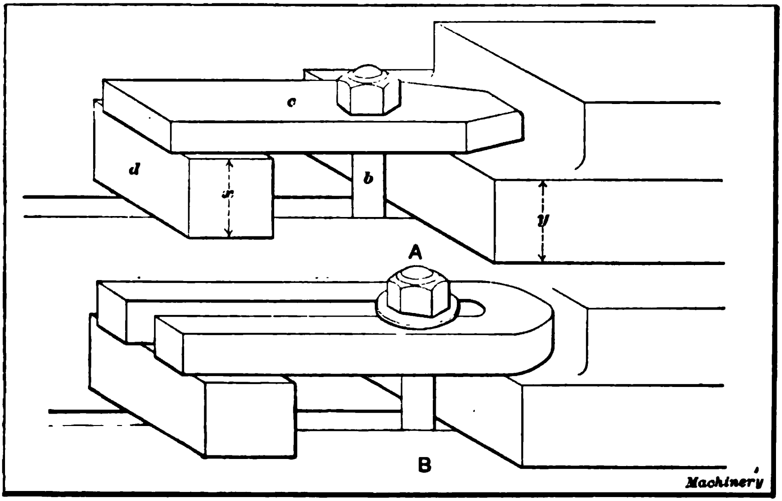

Fig. 17. Clamps for Attaching Work to Planer Platen

that it will be possible to finish all the surfaces that require planing, in the right relation with one another. Frequently a little planning before the "setting up" operation, will avoid considerable worry afterwards, to say nothing of spoiled work.

Different Forms of Planer Clamps and Bolts

Most of the work done on a planer is clamped directly to the platen. A form of clamp that is often used is shown at *A* in Fig. 17, *c* being the clamp proper, *b* the bolt, and *d* the packing block on which the outer end of the clamp rests. Obviously when the bolt is tightened, the clamp presses the work downward against the platen, and as this pressure is greatest when the bolt is close to the work, it should, if possible, be placed in that position. If the bolt were located near the packing block, the latter would be held tightly instead of the work. Another point to be observed is the height of the packing block. This height x should equal the height y of the part being clamped, provided a straight clamp is used. The end of the clamp will then have an even bearing on the work which will be held more securely than it would be if the clamp were inclined so that all the bearing was on the end or at the edge of the work. Packing blocks are made of either hard wood or cast iron.

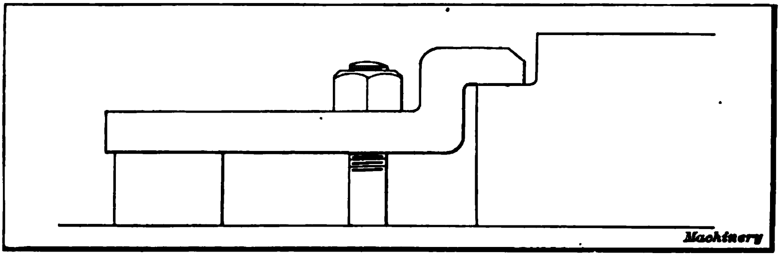

Fig. 18. Off-set Clamp

An excellent form of clamp, known as the U-clamp, is shown at *B*. This type is made by simply bending a square or rectangular bar of steel around, as shown, so as to form a slot in which the bolts can be placed. This continuous slot enables a bolt to be located in the best position, which is not always the case with clamps having holes.

Bent or off-set clamps are preferable to the straight type for holding certain kinds of work. Fig. 18 shows an off-set clamp applied to a casting which, we will assume, is to be planed on the top. If in this

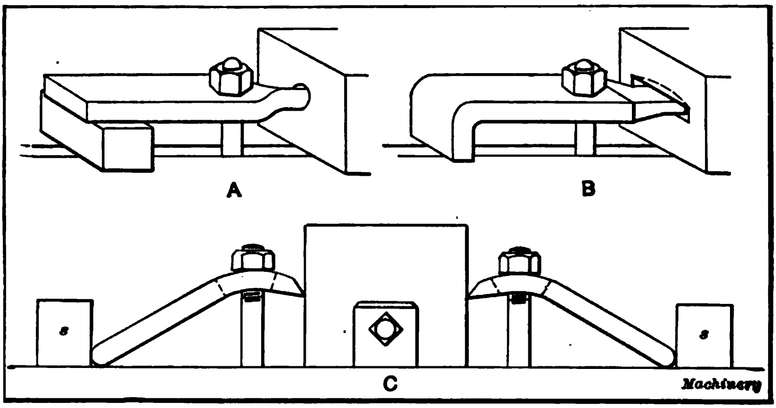

Fig. 19. Methods of Clamping Work which cannot be held by Ordinary Means

case a straight clamp were used, the clamping nut might be high enough to interfere with the planer tool, but the off-set clamp enables a shorter bolt to be used.

Frequently the "finger" clamps illustrated at *A* and *B* in Fig. 19 are convenient if not absolutely necessary. This type is used for holding work which cannot be held by ordinary means without interfering with the planer tool. The style to the left has a round end which enters a hole drilled in the work, whereas the clamp to the right has a flat end which engages a milled slot. An illustration of the use of finger clamps is given in connection with Fig. 10, Chapter II. As previously stated, they are only adapted to work in which holes or slots are not objectionable. Sometimes these clamps can be inserted in cored pockets or holes that are needed for other purposes. Sketch *C* illustrates a method that is sometimes resorted to when there are no projections for clamps and when holes or slots are not desirable. The clamps are placed in an angular position between the work and stop-pins *s* or strips clamped to the platen, and when the bolts are tightened, the work is forced downward. The bolt holes are elongated to permit the angular position of the clamps to be varied somewhat, and the nuts bear on the curved ends.

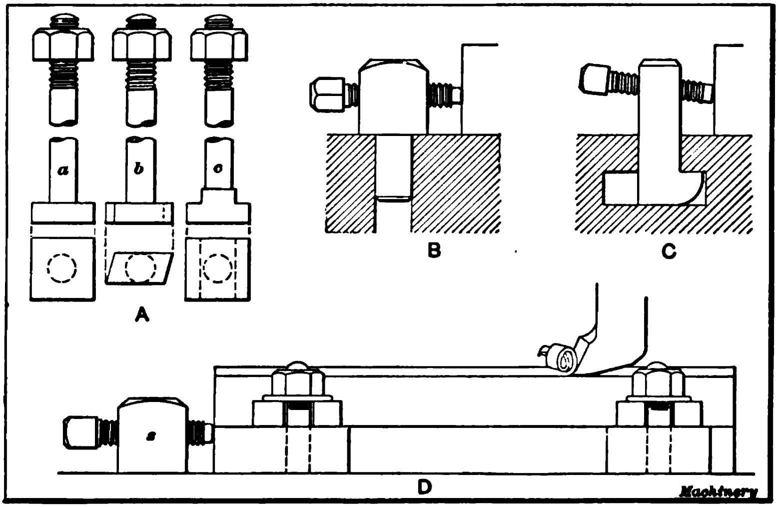

Fig. 20. Planer Clamping Bolts—Stop-pins—Use of Stop-pins

Three styles of bolts that are generally used for planer work are shown at *A*, Fig. 20. Bolt *a* has a square head so that it must be inserted at the end of a platen slot and then be moved to the required position. Occasionally it is desirable to place a bolt through some opening in a casting, in which case the bolt *b* can be used. The head is narrow enough to be inserted in the T-slot from above, and when the bolt is given a quarter turn, it is held the same as the square-headed type. Another style is shown at *c* which can be inserted from above. The lower end or head of this bolt is in the form of a nut planed to fit the T-slot. When the bolt is to be inserted from above, this nut is moved along the T-slot to the proper position and then the bolt is screwed into it after which the upper clamping nut is tightened.

Stop-pins and Braces

It would be very difficult to hold work securely by using only clamps and bolts, because the pressure of the clamp is in a vertical direction, whereas the thrust of the cut is in a horizontal direction, which tends to shift the work along the platen. To prevent such a movement, practically all work that is clamped to the platen is further secured by one or more stop-pins *s*, which are placed at one end of the part being planed as indicated at *D*, Fig. 20. These pins are generally made in two styles, one of which has a shank that fits the holes in the planer platen as shown at *B*, and the other an end which enters the T-slot as at *C*. By having one type for holes and another for T-slots, the stop-pins can be located in practically any position. After the pins are inserted in the platen, the screws shown are adjusted against the work. Stop-pins are ordinarily placed at one end of the work to take the thrust of the cut, and sometimes they are needed along the sides to prevent lateral movement. The screws of some stop-pins are inclined, as shown at *C*, in order to force the work down against the platen. These pins are also made without adjusting screws.

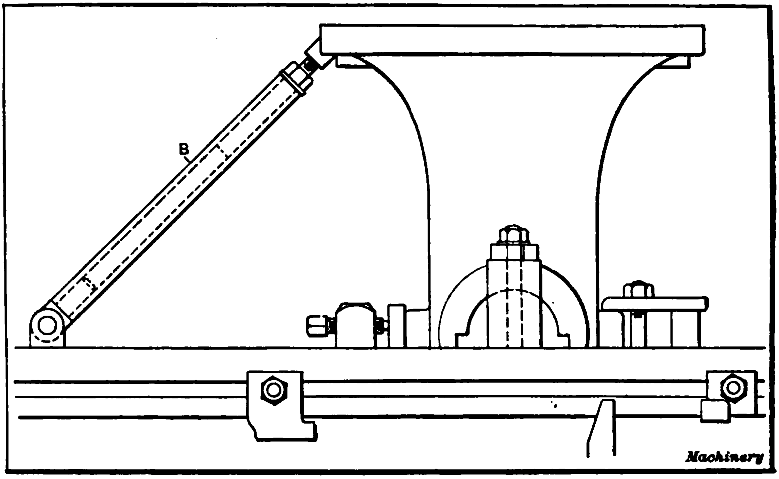

Fig. 21. High Work supported by Brace which takes Thrust of Cut

Some castings have surfaces to be planed that are a considerable distance above the platen, as shown in Fig. 21, which illustrates a large pillow-block set up for planing the base. As will be seen, the end resting on the platen is comparatively small, and if the casting were simply clamped at the lower end, it would tend to topple over when being planed, because the thrust of the tool is so far above the point of support. To prevent any such movement, braces *B* are used. These braces serve practically the same purpose as stop-pins. The style of brace shown has a hinged piece in its lower end, which enters a hole in the platen, and the body of the brace is a piece of heavy pipe. At the upper end there is an adjustable fork-shaped piece which engages the work, and the hinged joint at the lower end enables the brace to be placed at any angle. In some shops, wooden blocks are used as braces. The arrangement of these braces and the number employed for any given case, depends of course on the shape and size of the casting, and this also applies to the use of stop-pins and clamps. The location of all braces and clamping appliances should be determined by considering the strains to which the part will be subjected during the planing operation.

Use of Stop-pins and Planer Strip—Parallel Strips

An arrangement which can often be used to advantage in place of a chuck is shown in Fig. 22. The part to be planed is held between ordi-

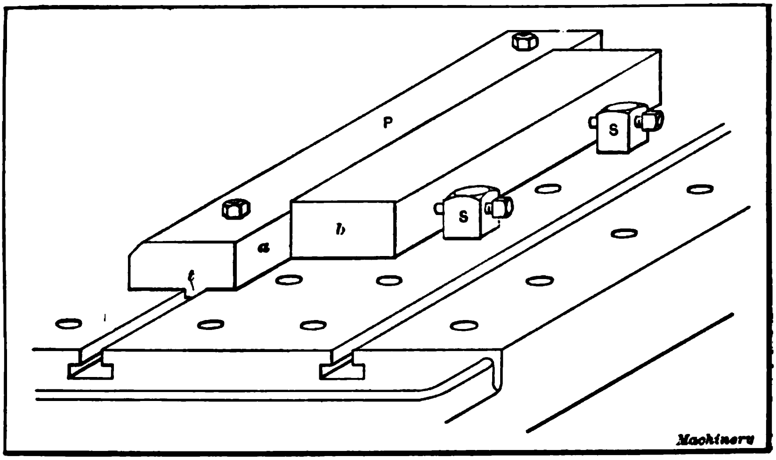

Fig. 22. Work held between Stop-pins and Strip Bolted to Platen

nary stop-pins *S* and a "planer strip" *P* that is bolted to the platen. This strip has a tongue piece *t*, which fits into the T-slot and locates the side *a* parallel to the travel of the platen. A stop-pin should be placed against the end *b* of the work to prevent longitudinal movement.

Parallel strips are placed beneath parts to be planed usually for the purpose of raising them to a suitable height, or to align a finished

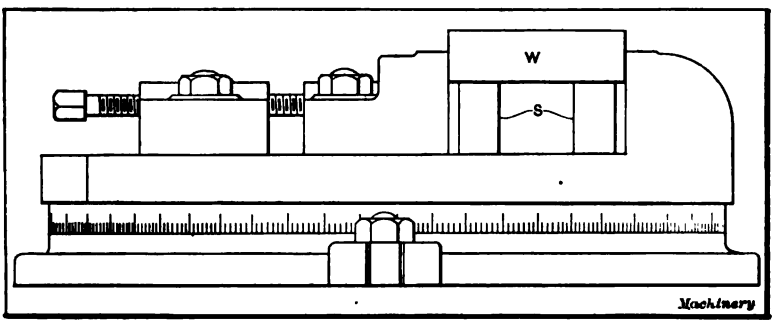

Fig. 23. Illustration showing use of Parallel Strips

surface on the under side with the platen, when such a surface cannot be placed in direct contact with the platen. These strips are made in pairs of different sizes and their sides are square and parallel to one another. An example showing the use of parallels in connection with chuck work, is illustrated in Fig. 23. If the part *W* were placed down on the bottom of the chuck, the top surface would be lower than the chuck jaws and the latter would interfere with the planing tool. By mounting the work on two parallel strips *S*, it is raised, and at the same time the under side is kept in line with the chuck, provided the parallels are accurate and the work is properly "bedded" on them.

Holding Castings of Irregular Shape—Holding Thin Work

The method of holding an odd-shaped casting on an angle-plate is illustrated in Fig. 24. The angle-plate *A* has two faces *a* and *b*

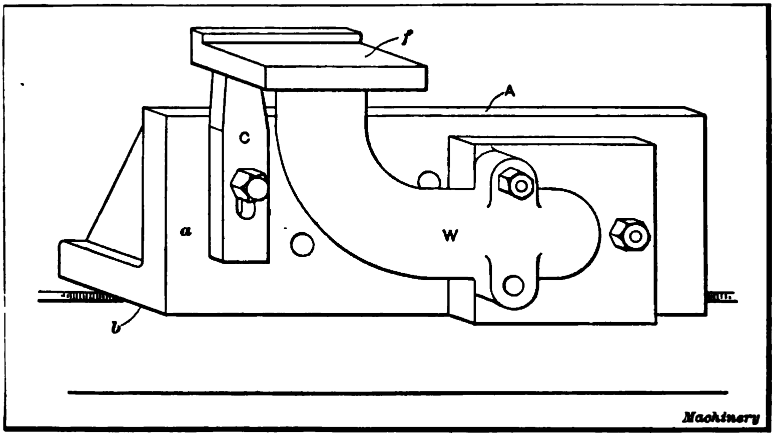

Fig. 24. Odd-shaped Casting attached to Angle-plate

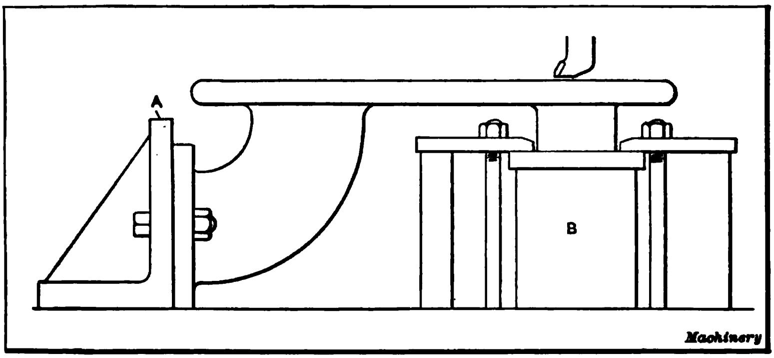

Fig. 25. Use of Angle-plate in Conjunction with Clamps for Holding Work

which are square with each other, and the work *W* is bolted or clamped to the vertical face, as shown. The arrangement of the clamps or bolts depends, of course, on the shape of the work. The particular part illustrated, which is to be planed at *f*, is held by bolts inserted through previously drilled holes, and the left end is supported by a clamp *C*, set against the under side to act as a brace and take the downward thrust of the cut. Angle-plates are generally used for holding pieces, which, because of their odd shape, cannot very well be clamped directly to the platen. Occasionally an angle-plate can be used in conjunction with clamps for holding castings, as illustrated in Fig. 25. In this example the angle-plate *A* is placed across the platen and serves as a stop for taking the thrust of the cut. The flange on the opposite end is supported by a block *B* against which the casting is clamped.

Some castings are so shaped that a great deal of time would be required for clamping them with ordinary means and for such work, special fixtures are often used. These fixtures are designed to support the casting in the right position for planing, and they often have clamps for holding it in place. Some work which could be clamped to the platen in the usual way, is held in a fixture because less time is required for setting it up. This is the practice where a large number of pieces have to be planed.

When it is necessary to plane thin plates or similar work which cannot be clamped in the usual way, either wedge-shaped or pointed pieces similar to those shown at *A* and *B*, Fig. 26, are used. These are known as "spuds" or "toe-dogs," and one way in which they are applied

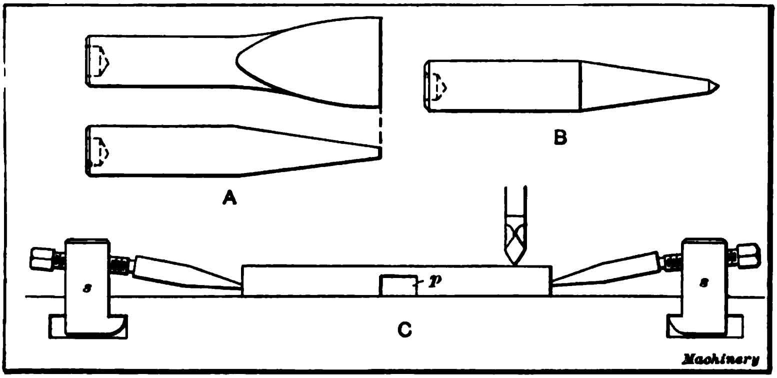

Fig. 26. Method of Holding Thin Flat Plates while Planing

is indicated at *C*. Stop-pins *s* are inserted in the platen on each side of the work, and the dogs are forced against the work by tightening the screws. Owing to the angular position of the dogs, the work is pressed down against the platen. The inclination should not be too great, as the outer end of the dog will move upward when the screws are tightened, without transmitting any pressure to the work. One or more stop-pins *p* should be placed in front of the part being planed to take the thrust, and at least two dogs will be required on each side unless the work is comparatively short.

Planing Round Work

The planer is sometimes used for cutting keyways or splines in shafts, and occasionally, other round work requires a planing operation. In order to hold and at the same time align round work with the platen, V-blocks (Fig. 27), are used. These blocks have a tongue piece *t* at the bottom which fits the T-slots in the platen, and the upper part of the block is V-shaped as shown in the end view. This angular groove is central with the tongue piece so that it holds a round shaft in alignment with the T-slot, which is parallel with the travel of the platen. The diameter of a shaft held in one of these blocks can vary considerably, as indicated by the two circles, without affecting the alignment. In other words, the centers c and c_1 of the large and small circles, respectively, coincide with the vertical center line.

Fig. 28 shows how a shaft is held while a keyseat is being planed in the end. Only one V-block is shown in the illustration, but ordinarily the opposite end of the shaft would be supported in a block

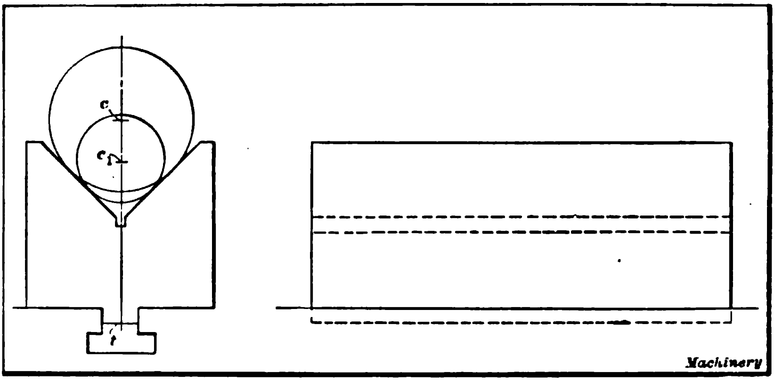

Fig. 27. V-block for Holding Cylindrical Parts

of corresponding size. Before the planing operation, a hole h is drilled to form a clearance space for the planing tool. The keyseat is then planed by using a square-nose tool, and if the V-blocks are accurately made, it will be in line with the axis of the shaft.

Fig. 29 illustrates how V-blocks are used in locomotive shops for holding a piston-rod while the cross-head, which is mounted on the

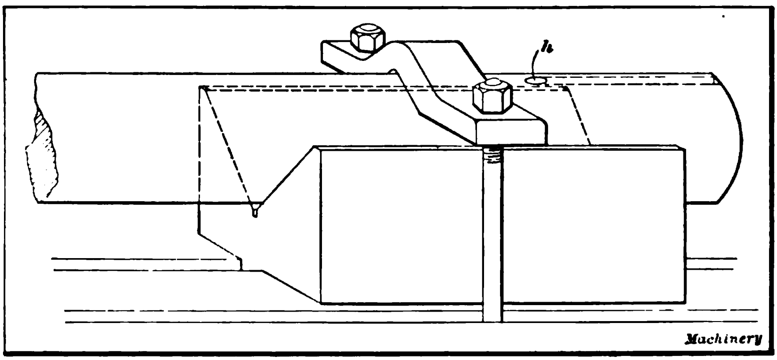

Fig. 28. End of Shaft Clamped in V-block

end, is being planed. The bearing surfaces of the cross-head must be in line with the rod which fits a tapering hole in one end. By assembling the cross-head and rod and then mounting the latter in V-blocks, the bearing surfaces are planed in alignment with the rod.

A good method of making a pair of accurate V-blocks is as follows: First plane the bottom of each block and form the tongue piece t, Fig. 27, to fit closely the platen T-slots. Then bolt both blocks in line on the platen and plane them at the same time so that they will be exact duplicates. A square slot or groove is first planed at the bottom of the vee, as shown, to form a clearance space for the tool. The head is then set to the required angle and one side of the vee is planed. The blocks are then reversed or turned "end for end" and the opposite side is finished without disturbing the angular setting of the head. This method of reversing the work, instead of setting the head to the opposite angle, insures equal angles for both sides and a vee that is exactly central with the tongue piece.

A special planer strip which is used in conjunction with screw-stops for holding round parts, is illustrated in Fig. 30. The strip has an angular face *f* so that pressure from the screws *s* tends to force the

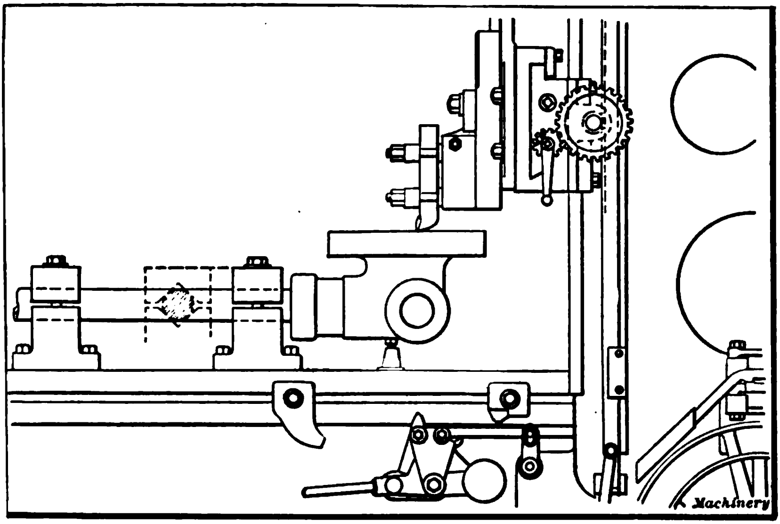

Fig. 29. Piston-rod and Attached Cross-head Mounted in V-blocks for Planing

shaft down against the platen as well as against the strip itself. This angular face is aligned with the platen by the tongue piece *t*.

Distortion of Work

When castings or forgings are set up on the planer for taking the first cut, usually the side that is clamped against the platen is rough and uneven, so that the work bears on a few high spots. This condition is shown illustrated on an exaggerated scale in Fig. 31, which shows a casting that bears at *a* and *b*, but does not touch the platen at the ends where the clamping is to be done. If the clamps were tightened without supporting the work at the end, the entire casting would probably be sprung out of shape more or less, depending on its rigidity, with the result that the planed surface would not be true after the clamps were released, because the casting would then resume its natural shape. To prevent inaccurate work from this cause, there should always be a good bearing just beneath the clamps, which can be obtained by inserting pieces of sheet metal, or even paper when the unevenness is slight. Thin copper or iron wedges are also used for "packing" under the clamps. It is good practice when accuracy is required and the work is not very rigid, to release the clamps slightly before taking the finishing cut. This allows the part to spring back to its normal shape and the finished surface remains true after the clamps are released.

Very long castings or those which are rather frail but quite large and

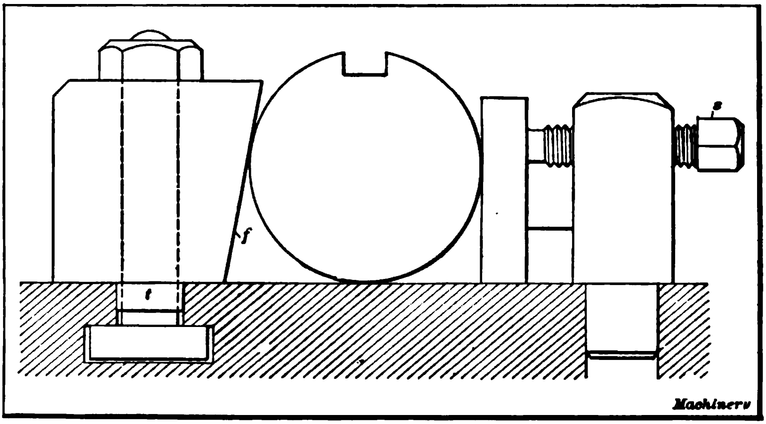

Fig. 30. Method of Holding Shaft for Splining or Keyseating

heavy, sometimes bend by their own weight or are sprung out of shape by the pressure of the planing tool, unless supported at the weak points. In such a case jacks, such as the one illustrated in Fig. 32, form a very convenient means of support. This particular jack has a ball joint at the top which allows the end to bear evenly on the work, and the screw can be locked after adjustment to prevent it from jarring loose. These jacks, which are made in different heights can also be used in various ways for supporting work being planed. Fig. 29 shows

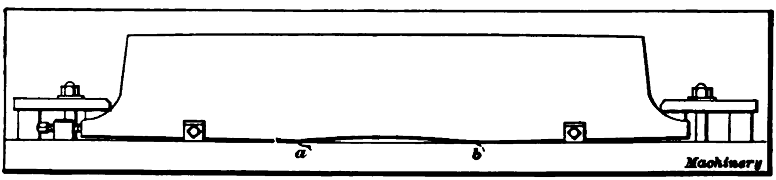

Fig. 31. Class of Work which is sometimes Distorted by Clamping

a practical application of planer jacks, two being inserted beneath the cross-head to prevent any downward spring. Hard-wood blocks cut to the right length are also used as supports.

Castings, even though properly clamped, are sometimes sprung out of shape by the internal stresses existing in the casting itself. These stresses are caused by the unequal cooling of the casting in the foundry. When a casting is made, the molten metal which comes in contact with the walls of the mold, naturally cools first and, in cooling, contracts and becomes solid while the interior is still more or less molten. The result is that when the interior cools and contracts, the tendency is to distort the part which solidified first, and internal stresses are left in the casting. These stresses often act in opposite directions and when a roughing cut is taken from one side of such a casting, thus relieving the stress on that side, a slight distortion takes place. This is illustrated on an exaggerated scale in Fig. 33. Suppose a casting is clamped as at *A*, so as to avoid all spring, and then a roughing cut is taken over side *a*, thus removing the hard outer surface. The chances are that the shape would change as shown (exaggerated) by the dotted lines, because the stresses which formerly counteracted those of the opposite side are now removed. Let us assume that the casting is next turned over and clamped as at *B* without springing it by the pressure of the clamps. If a roughing cut is then taken from the opposite side *b*, another change would probably occur because this would relieve the tension or stress of that side. The work would then assume what might be called its natural shape, and if both sides were then finished, they would tend to remain true, though slight changes might occur even then. Because of this tendency to distortion as the result of internal stresses, all work, especially if not rigid, should be rough-planed before any finishing cuts are taken. Of

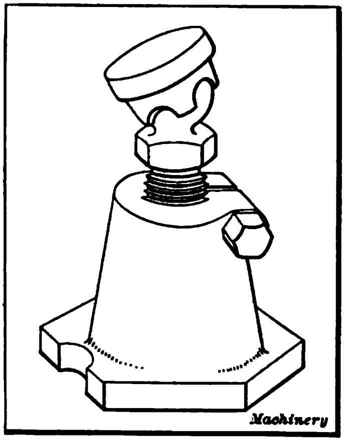

Fig. 32. Planer Jack

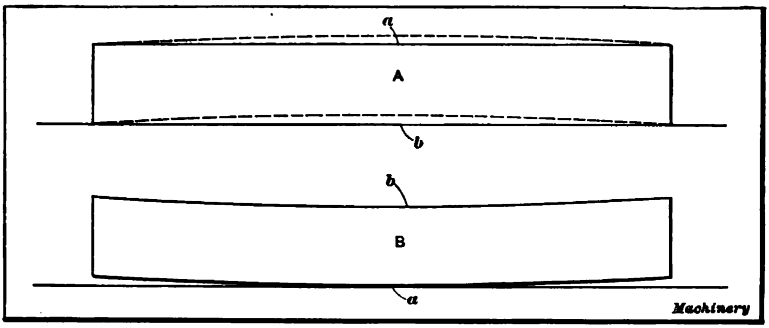

Fig. 33. Diagrams Illustrating, on Exaggerated Scale, Distortion from Internal Stresses

course, such a change of shape does not always occur, because the stresses may be comparatively slight and the planed surface so small in proportion to the size of the casting, that distortion is impossible.

Another important point in setting work is to locate it so that all surfaces to be planed can be finished to the required dimensions. On some work it is also desirable to have a planed part fairly true with a surface which remains rough, either to secure a neater finish or for more important reasons. Therefore, when either a casting or forging is being set up on the planer, it should be located according to the requirements for that particular part. As an illustration, suppose a flange *a*, the boss *b* and the surface *c* of a cast-iron cover plate, Fig. 34, is to be planed so that the distance between these surfaces corresponds to the dimensions given on the drawing. The first operation would be to plane the side *c*, the work being set up in the position indicated at *A*. The casting is first set about parallel with the platen, but it should be remembered that the surface which is set level or parallel is not necessarily the one to be planed. In this case the side *d* is to remain rough, and it is desirable to have a uniform thickness *x* when the cover is finished; therefore the casting is set by side *d* rather than by the upper surface *c*, or in other words, is located so that the *finished* surface will be true with the rough side of the casting.

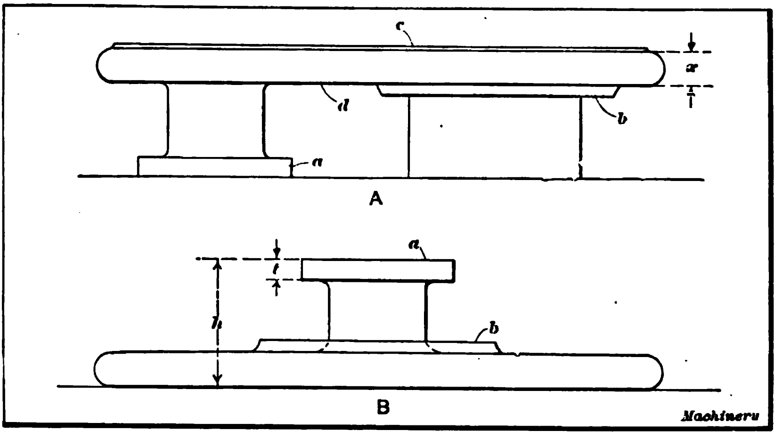

Fig. 34. Diagram illustrating Points relating to Position of Work

The amount of metal to remove when planing side *c* must be determined by considering the relation of this side to the other parts that are to be finished when the casting is turned over. For example, it should be possible to plane flange *a* to a height *h* (as given on the drawing) without removing too much or too little metal from the flange. Suppose a light cut were taken from side *c*, just deep enough to true it and then the casting were turned over, as indicated at *B*, for finishing the opposite side. When planing the flange it might be necessary to make the thickness *t* considerably less than it should be, in order to secure the proper height *h*. This, however, would not occur if when planing side *c*, the thickness of the flange as well as the height *h*, were considered. Therefore, the relation between the different surfaces should be kept in mind. Sometimes it is necessary to set a casting very carefully and to plane off just the right amount, in order to finish the other surfaces to the required dimensions.

The Surface Gage and its Use

The surface gage is used very extensively in connection with planer work for scribing lines that represent finished surfaces and also for setting parts parallel with the platen. This tool, which is shown in Fig. 35, has a rather heavy base on which is mounted a rod carrying a pointer or scriber *S*. The latter can be adjusted in or out and it also can be moved to any position along the rod. After the scriber or pointer has been set to about the right height, it can be set accurately to the position desired by turning screw *A* which gives a fine adjustment. There are two pins *B* in the base which can be pushed down when it is necessary to keep the gage in line with the edge of a plate or the side of a T-slot. The method of using a surface gage for setting a surface parallel to the platen is indicated in Fig. 36. The scriber *s* is first set to just touch the work at some point; the gage is then moved around to the opposite side, as shown by the dotted lines, and in this way the height at various points are compared.

Fig. 35. Surface Gage

The surface gage is also used extensively for laying out work. As a simple illustration, suppose the sides *b* and *c* (Fig. 36) were to be planed and it were necessary to have the thicknesses *x* and *y* of the flanges and the height *z* all conform to given dimensions. If lines *l* and l_1 representing the finished surfaces were first scribed on the flanges, these would serve as a guide when planing, and such lines could easily be drawn by using a surface gage, even though the sides did not lie in the same vertical plane. The surface gage is also used for setting lines which have been scribed on the work and represent the location of finished surfaces, parallel with the planer platen.

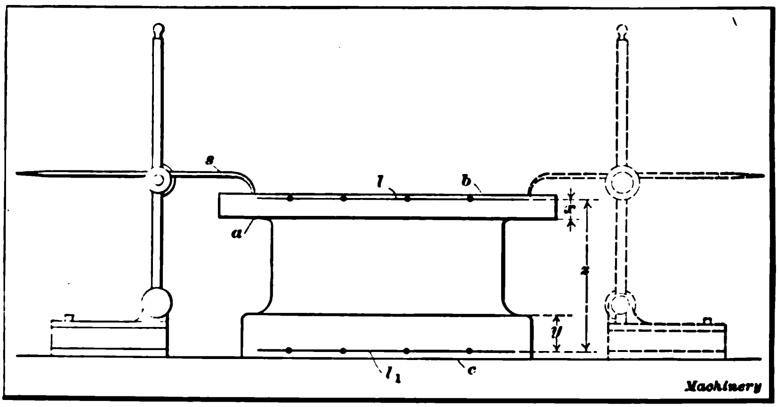

Fig. 36. Testing Alignment by using Surface Gage

CHAPTER IV

PLANER TOOLS—VARIOUS FORMS USED AND POINTS ON GRINDING

The number and variety of the tools used on a planer depend on the character of the work which is done on that particular machine. If the work varies considerably, especially in its form, quite a number of tools of different shapes will be needed, whereas, planers that are used principally for making certain parts, do not need a large tool equipment. In Figs. 37 and 38, two sets of tools intended for general work are shown. Occasionally, tools of special form are required, but the various types in the sets illustrated, will take care of practically all ordinary planing operations. Fig. 37 also shows some typical examples of the kind of planing for which the different tools are adapted.

The tool shown at *A* is a roughing tool. This form is particularly adapted for taking deep "roughing" cuts in cast iron, when it is necessary to remove considerable superfluous metal. This style of tool is also made to the opposite hand as at *B*, as it is sometimes desirable to feed the tool toward the operating side of the planer; ordinarily, however, horizontal surfaces are planed by feeding the tool *away* from the operator, the tool moving from right to left, as viewed from the front of the machine. This enables the workman to see just what depth of cut is being taken at the beginning of the cut. The tool *C* with a broad cutting edge is used for taking finishing cuts in cast iron. The cutting edge is set parallel with the planer platen, and the feed for each cutting stroke is a little less than the width of the edge. Notwithstanding the coarse feed, a smooth surface is left on the work, provided the tool is properly ground and set, and does not chatter when in use. Tools of this type are made in various widths, and when planing very large and rigid castings, wide cutting edges and coarse feeds are used. A plain round-nose tool is shown at *D*. This style is often used for rough planing steel or iron. It can also be made into a finishing tool for the same metals by grinding the nose or tip end flat. The width of the flat cutting edge is much less, however, than for cast-iron finishing tools, because if very broad edges and feeds were used when planing steel, there would be danger of the tool gouging into the work. Steel offers a greater resistance to cutting than cast iron and that is why broad tools tend to gouge in, especially if the tool is not held rigidly to prevent its springing downward. Tool *E*, which is known as a diamond point, is also used for rough-planing steel or iron. The bent tools *F* and *G* are used for planing either vertical surfaces or those which are at a considerable angle with the platen. These are right- and left-side roughing tools, and they are adapted to either cast iron or steel. They can also be used for finishing steel. Finishing tools for vertical or angular cast-iron surfaces are shown at *H* and *I*.

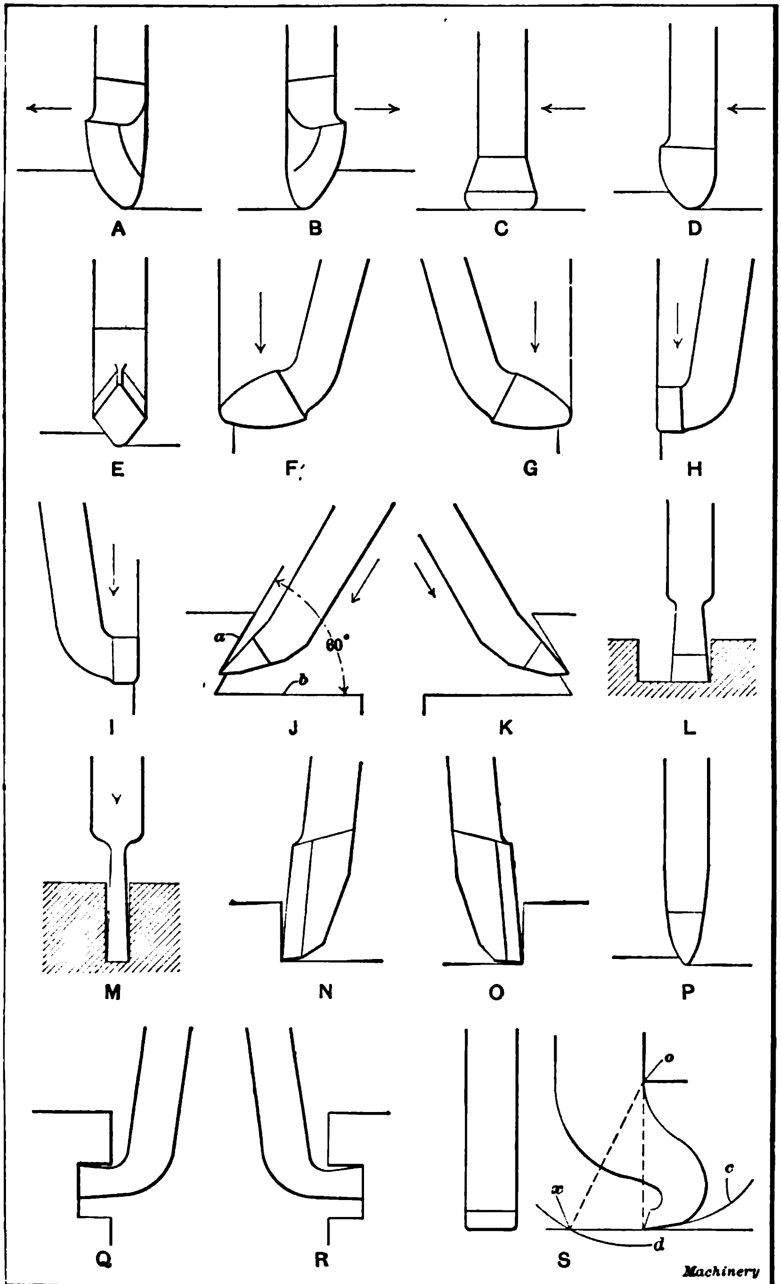

Fig. 37. Planer Tools of Different Form and Work to which they are Adapted

These have wide cutting edges to permit coarse finishing feeds. Vertical surfaces can often be planed to better advantage by using a straight tool in the side-head, when the planer is so equipped. Right and left angle tools are shown at *J* and *K*. This style of tool is for planing angular surfaces which, by reason of their relation to horizontal or other surfaces, can only be finished by a tool having a form similar to that illustrated. A typical example of the kind of angular planing requiring the use of an angle tool is indicated in the illustration. After finishing side *a*, the horizontal surface *b*, (from which a roughing cut should have been taken previously) could be planed by feeding the same tool horizontally. A square-nose tool is shown at *L*. This is used for cutting slots and squaring corners, and

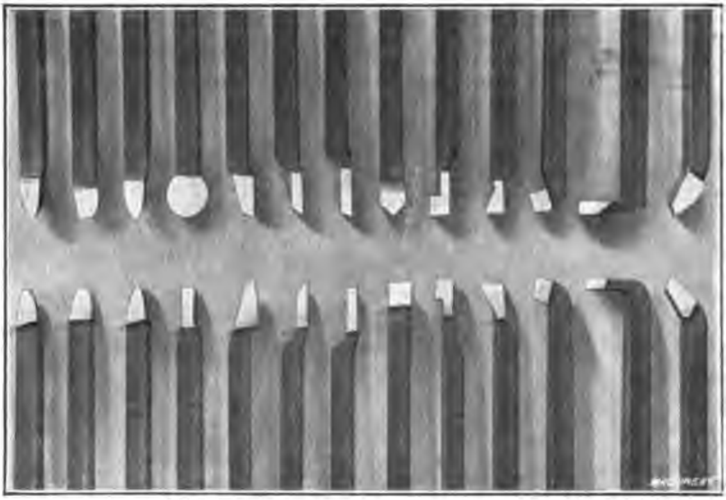

Fig. 88. Set of Planer Tools ground on Sellers Tool-grinding Machine

the same style of tool is made in different widths. A narrow square nose or "parting" tool is shown at *M*. It is adapted to cutting narrow grooves, and can also be used for cutting a part in two, provided the depth does not exceed the length of the narrow cutting end. Right and left side tools are shown at *N* and *O*. These can frequently be used to advantage on vertical or angular surfaces. A tool for planing brass is shown at *P*. It has a narrow rounded cutting edge and is very much like a brass turning tool. For finishing cuts in brass, tools having narrow flat ends are often used. Right and left bent square-nose tools are shown at *Q* and *R*. Such tools are used for cutting grooves or slots in vertical surfaces and for similar operations. The peculiarly-shaped tool shown by front and side views at *S*, is especially adapted to finishing cast-iron surfaces. This type is known as the "goose-neck" because of its shape, and it is intended to eliminate chattering and the tendency which a regular finishing tool has of gouging into the work. By referring to the side view it will be seen that the cutting edge is on a line with the back of the tool shank, so that any backward spring of the tool while taking a cut, would cause the cutting edge to move along an arc *c* or away from the work. When the cutting edge is in advance at some point *x*, as with a regular tool, it will move along an arc *d*, if the strain of the cut causes any springing action, and the cutting edge will "dig in" below the finished surface. Ordinarily the tool and the parts of the planer which support it, are rigid enough to prevent such a movement, so that the goose-neck tool is not always necessary.

All of the tools shown in Fig. 37 are forged from a solid bar of steel, the cutting end being forged to about the right shape, after

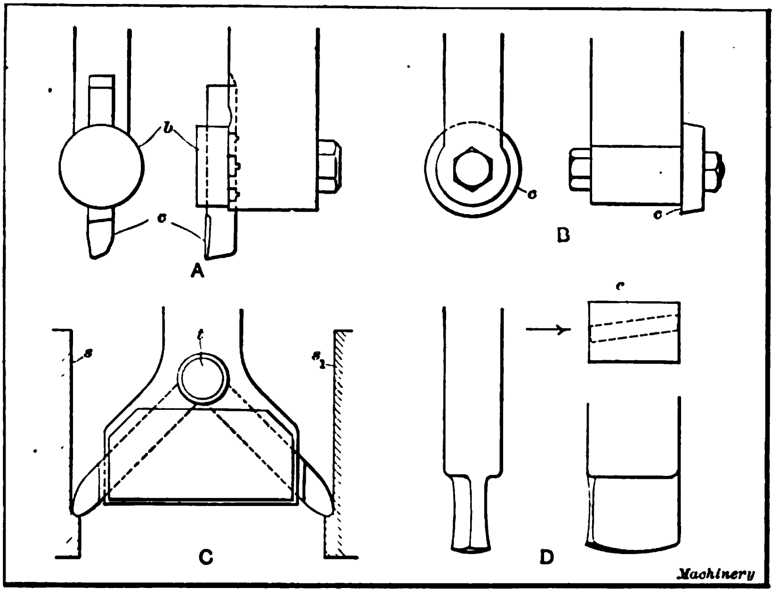

Fig. 39. (A) Planing Tool with Inserted Cutter. (B) Radius Tool (C) Tool having Two Cutters. (D) Finishing Tool

which the end is correctly formed by grinding. After the tool has been worn away considerably by repeated grindings, the end has to be re-forged or "dressed" to bring it back to the original form. To eliminate this work, and also to reduce the amount of steel required, tools are often used on the planer and other machines, having shanks into which small cutters can be inserted. These tools are made in many different designs, one of which is shown at *A* in Fig. 39. This particular style is so arranged that the cutter *c*, which is held against the shank by bolt *b*, can be set either vertically, horizontally, or at an angle of 45 degrees and the cutting edge can be placed on the right or left side of the shank, as required. This adjustment adapts the tool to the planing of horizontal, vertical or angular surfaces. It should be noted that the cutter is firmly seated in slots cut in the face of the shank. This tool can be used with the cutter in advance of the shank or to the rear; when in the latter position it has the advantages of the "goose-neck" tool.

What is known as a form tool is shown at *B*. The cutter *c* is circular and it is held to the shank by a bolt as shown. This particular tool is used for finishing round surfaces, the cutter being made to the required diameter. Form tools are also used for finishing surfaces of irregular form, the cutter being made to correspond in shape to the form required. A tool having two cutters is shown at *C*. This style is sometimes used for planing duplicate work, having two surfaces *s* and s_1, a given distance apart. By having two cutters, both sides are finished at the same time. As the cutters are ground away, they are moved out to the required width by drawing in the taper bolt *t* against which the inner ends of the cutters rest. This is an example of the special tools sometimes used in planer work. The

Fig. 40. Roughing and Finishing Tools

tool shown at *D* is a solid forged type, that is excellent for finishing steel. The way this tool operates is shown by the plan view. The cutting edge *e* is at an angle with the shank, and as the work moves in the direction shown by the arrow, the corner or edge *e* removes a light shaving and leaves a smooth surface. The edge is curved slightly, as shown by the side view, so that the cutting is done at the center. By using soda water, or even plain water, while planing, a bright surface is obtained. Only very light cuts are taken with this tool.

The action of a planer is quite different from that of a lathe, as it is used principally for producing flat surfaces, whereas the lathe produces cylindrical surfaces. In the forming or grinding of planing and turning tools, however, there are many underlying principles which are common to both classes of tools.

Front and side views of a planer roughing tool are shown at *A*, Fig. 40. As the cutting is done by the curved edge *e*, the front surface *b* is ground to slope backward from this edge, to give the tool keenness. The end or flank of the tool is also ground to slope inwards to provide clearance. The angle *c* of clearance is about 4 or 5 degrees for planer tools, which is much less than for lathe tools. This small clearance is allowable because a planer tool is held about square with the platen, whereas a lathe tool, the height of which may be varied, is not always clamped in the same position. A lathe tool also requires more clearance because it has a continuous feeding movement along a spiral path, whereas a planer tool is stationary during the cut, the feed taking place just before the cut begins. This point should be considered when grinding planer tools, because the clearance of any tool should not be greater than is necessary to permit the tool to cut freely, as excessive clearance weakens a tool. The slope of the top surface *b* depends on the hardness of the metal to be planed, the slope angle being less for hard material, to make the cutting edge more blunt and consequently stronger. When tools are ground by hand, the angles of slope and clearance are not ordinarily measured, the workman being guided by experience. As the cutting is done principally by side *e*, the slope of the top (or front when the tool is in position for planing) is back from this point, or away from the *working part* of the cutting edge. By grinding a flat spot on the nose or lower end, this same tool can be used for taking finishing cuts in steel. Finishing cuts are also taken with a round nose, by using a fine feed. The edge *c* of the cast-iron finishing tool (*B*) should be ground straight by testing it with a small straightedge or scale. The corners should also be rounded slightly, as shown, as a square corner on the leading side will dull quickly. The illustration shows clearly the tool's shape. The square-nose tool (Fig. 41) cuts along its lower edge *e*, and is given clearance on the end and sides as shown in the two views. The lower edge is the widest part of the cutting end, the sides sloping inward in both a vertical and horizontal direction, which prevents the tool from binding as it moves through a narrow slot. The side-tool in the lower part of Fig. 41 cuts along edge *e*, which, as the side view shows, slopes backward. Planer side-tools are not always made in this way, but it is a good form, as the sloping edge starts a cut gradually, whereas a vertical edge takes the full width of the cut suddenly, thus producing a shock.

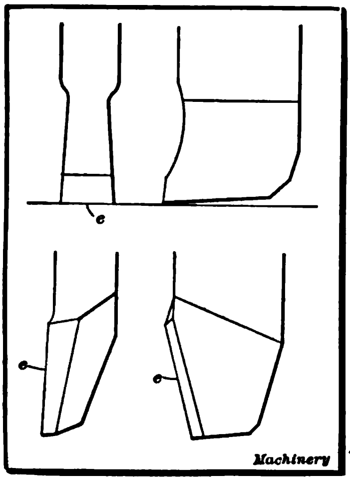

Fig 41. Square-nose Tool—Side-tool with Sloping Edge

Reference has been made to the grinding of these few types of tools, merely to point out some of the principles connected with the grinding of planing tools. When the principle of tool grinding is understood, the various tools required, whether regular or special in form, can be ground without difficulty. One thing that should be remembered when grinding a tool, is that it does not pay to force the tool too hard against the emery wheel or grindstone, as is often done in attempting to grind quickly. The tool should be ground with a moderate pressure, and it should be withdrawn frequently when forming a flat surface, to prevent excessive heating and burning of the tool. The grinding wheel should always be supplied with cooling water.

CHAPTER V

THE SHAPER

The shaper, like the planer, is used principally for producing flat surfaces, but it is intended for smaller work than is ordinarily done on a planer. The shaper is preferable to the planer for work within its capacity because it is less cumbersome to handle and quicker in its movement. The action of a standard shaper, when in use, is quite different from the planer; in fact, its operation is just the reverse, as

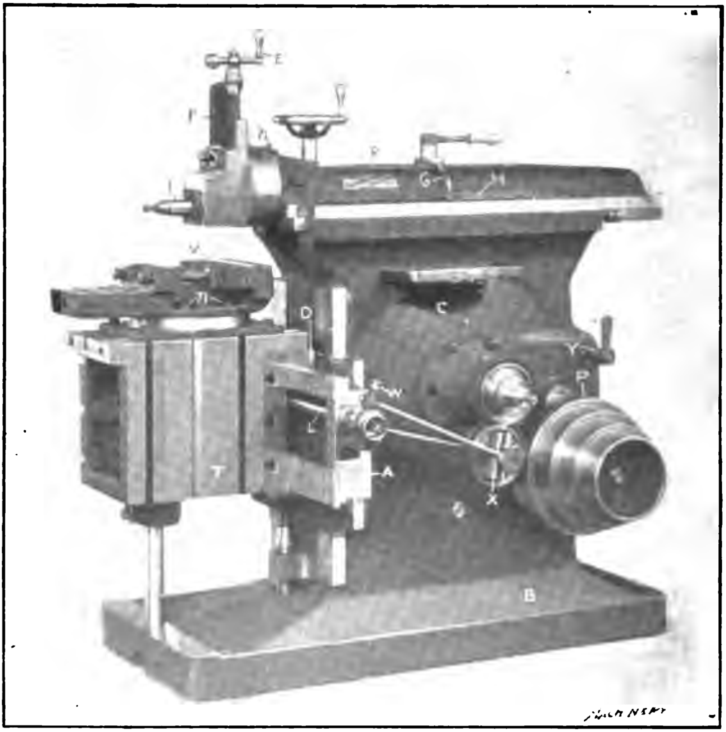

Fig. 42. Cincinnati Back-geared Crank Shaper

the tool moves back and forth across the work, which remains stationary, except for a slight feeding movement for each stroke. A shaper of typical design is shown in Fig. 42. The principal parts are the base and column *B* and *C*, the table *T* which has a vise *V* for holding work, and the ram *R* which carries a planing tool in tool-post *I*, and is given a reciprocating motion by a crank mechanism inside the column. The work-table is mounted on a saddle or cross-slide *D*, and it can be moved along the cross-rail *A* by turning the lead-screw *L*

with a crank or by an automatic feeding mechanism. The cross-rail can be adjusted vertically on the face of the column to accommodate work of various heights, and the tool-slide *F* with the tool, can be fed downward by handle *E*.

The driving mechanism for the ram is shown in the sectional views Fig. 43. Shaft *S* on which the driving pulley is mounted, is connected through gearing with crank gear *C*. This gear carries a crank-pin or block *B* which engages a slot in the arm *N*, and this arm in turn, connects with the ram *R* and is pivoted at its lower end. As the crank gear rotates, a vibrating motion is given to arm *N* which imparts a reciprocating movement to the ram. The amount that the arm moves and, consequently, the stroke of the ram, is governed by the position of the crank-block *B* which can be adjusted toward or from the center of the gear by shaft *O*. This shaft connects through spur and bevel gears with a screw that engages the crank-block as shown in the cross-section to the left. The stroke can be changed while the shaper is in motion, and the pointer *G*, as it travels along the stationary scale *H*, shows the length of the stroke in inches (see also Fig. 42). The *position* of the stroke can also be varied (while the machine is in motion) by turning handwheel *J* which causes screw *K* to rotate and shifts the position of block *L* with relation to the ram. Before making this adjustment, block *L*, which is ordinarily clamped to the ram, is loosened by turning lever *M*. By means of this adjustment for the *position* of the stroke, the tool is made to move back and forth over that part of the work that requires planing, whereas the stroke adjustment serves to change the travel of the tool according to the length of the work.

The cross-rail *A* with the attached slide and table, is adjusted vertically on the face of the column by a telescopic screw *Q*, which is rotated through bevel gears, by a horizontal shaft operated by a crank on the left side of the machine. Before making this vertical adjustment, binder bolts at the rear of the slide, which clamp the cross-rail rigidly to the column, must be loosened, and the column ways should also be cleaned to prevent chips or dirt from getting back of the slide. The outer end of the table is prevented from springing downward when taking heavy cuts, by a shaft *U* which rests on the base and can be adjusted for any vertical position of the table.

The feeding movement of the work-table for each stroke of the ram, is derived from a slotted crank *X*, Fig. 42, which is rotated by gearing. This crank is connected by the rod shown, with a pawl *W*. As the crank rotates, this pawl engages a ratchet gear and turns lead-screw *L*, thus moving the work-table along the cross-rail. The amount of this feeding movement for each stroke of the ram, is varied by adjusting the sliding block of crank *X* toward or from the center. When the power feed is not required, it is disengaged on this shaper by turning a sleeve around beneath the pawl, thus preventing the latter from engaging the ratchet gear. To reverse the feed, the pawl is simply given a half turn, which causes it to rotate the ratchet when moving in the opposite direction.

On this particular shaper there are eight speed changes for the

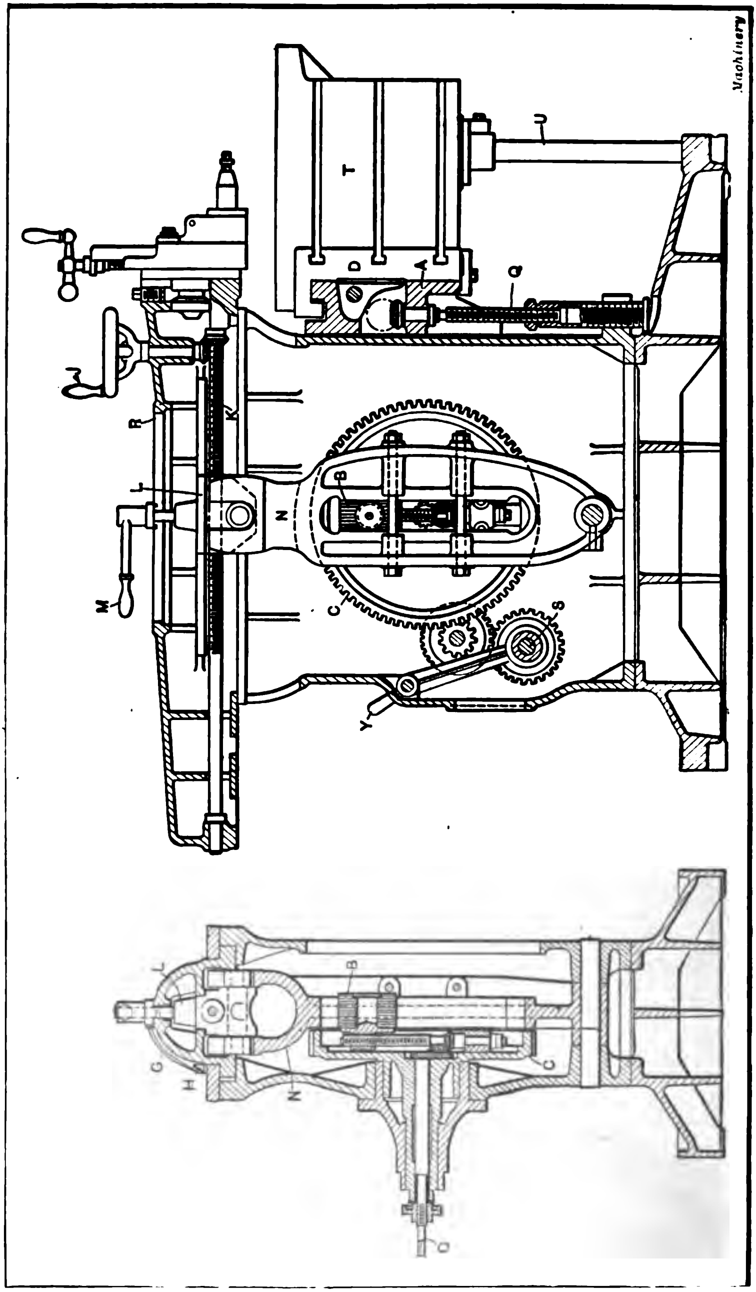

Fig. 43. Cross and Longitudinal Sections of Back-geared Crank Shaper

ram. Four of these are obtained by shifting the driving belt on different steps of the cone-pulley *P* (Fig. 42), and this number is doubled by back-gears inside the column which are engaged or disengaged by lever *Y*. Shapers are also made without back-gears, in which case the number of speed changes equals the number of steps on the driving cone pulley. The higher speeds are used when the tool travel or stroke is comparatively short and the slow speeds for long strokes. If there were no way of changing the speed and the shaper made the same number of strokes per minute regardless of the length, there would, of course, be a wide variation in the cutting speed of the tool. This change of speed, however, which accompanies a change of stroke, only occurs with a crank shaper, the cutting speed of a geared or rack shaper being constant for any length of stroke. The difference between these two types will be referred to later.

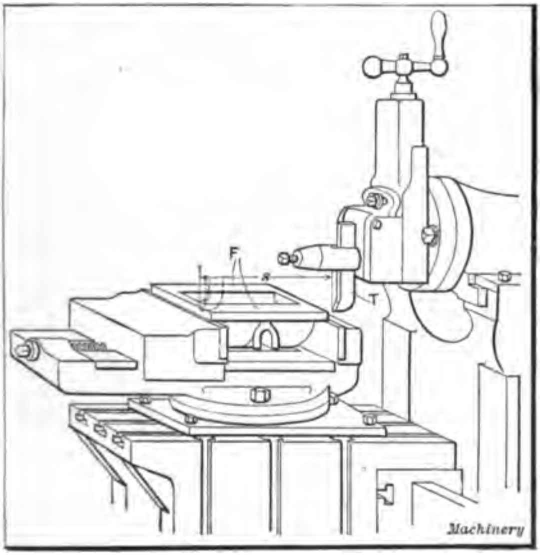

Fig. 44. An Example of Shaper Work

Examples of Shaper Work

Most of the work done in the shaper is either held in the vise *V* (Fig. 42) or is clamped to the table *T*, which is provided with slots for receiving the clamping bolts. The vise resembles a planer vise, and it can be removed readily when work is to be attached directly to the table. It can also be swiveled to any angular position by loosening nuts *n*, the position being shown by degree graduations. The table of this particular shaper is also removable, to permit clamping parts directly to the face of the saddle or cross-slide *D*, which also has bolt-slots in the front face.

Fig. 44 shows an example of the kind of work which is held in the vise. The part illustrated is a small engine slide valve, which is set up for planing the face *F*. After the casting is properly located in the vise and the tool *T* is clamped in place, the shaper is started and the stroke adjusted both for length and position, to give the tool a movement about as indicated by the arrow *s*. The tool is then fed downward to the work and the latter is moved crosswise, by hand, until a cut of the right depth is started; the automatic feed is then engaged by dropping the feed-pawl into mesh with the ratchet gear on lead-screw as previously explained.

The tools used in a shaper are similar in form to planer tools, though smaller. When taking finishing cuts in the shaper, broad tools and wide feeds cannot be used to the same extent as in planer work, because the shaper is less rigid and, consequently, there is a greater tendency for the tool to chatter.

Fig. 45 shows an odd-shaped casting bolted to the side of the table for planing the top surface. The table, in this case, serves the same

Fig. 45. Casting of Irregular Shape bolted to Side of Table

Fig. 46. Table removed and Casting Clamped to Cross-slide

purpose as an angle-plate on the planer, and the method of holding the casting to it is clearly shown in the illustration. Clamp *C* simply forms a stop for supporting the outer end of the casting, which would otherwise tend to sag down under the thrust of the cut. Work that is bolted directly to the table is held by practically the same kind of clamps that are used in connection with planer work.

In Fig. 46 the table is shown removed and a casting is clamped directly to the face of the cross-slide for planing the top bearing surface. This is an illustration of the class of work that can be held to advantage in this way. When setting work in the shaper, a surface gage can often be used effectively the same as in planer work. The tool itself can also be employed as a gage for setting the work level, by comparing the distance between the surface being tested and the tool point. When using the tool in this way, it is placed close to the work and the latter is shifted so that its height at various points can be determined.

When vertical or angular surfaces are planed in the shaper, the tool block is swiveled so that the top of the block inclines away from the surface being planed, to avoid any interference with the tool on the return stroke, as explained in connection with planer work. The entire tool head can also be set to any angle for planing angular surfaces, by loosening locking bolt *h* (Fig. 42), and its position is shown by degree graduations. Some shapers have an automatic verti-

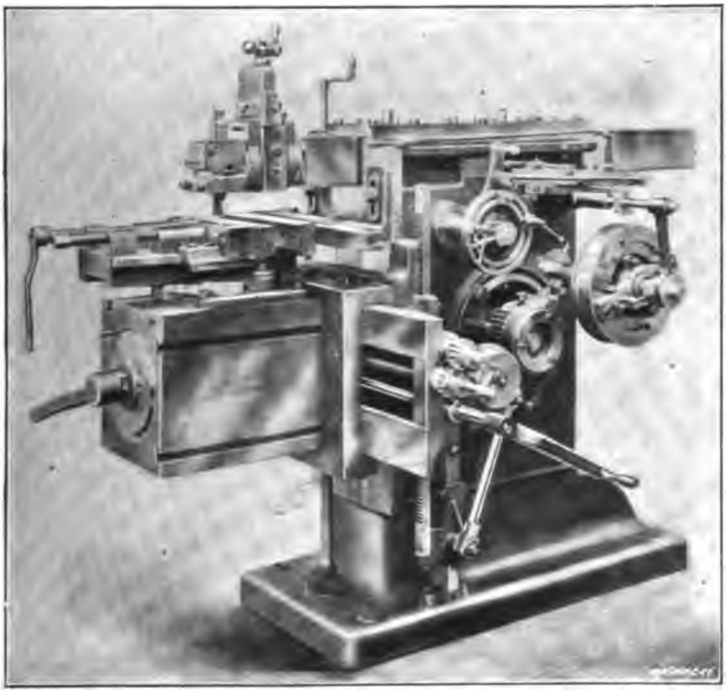

Fig. 47. Morton Draw-cut Shaper

cal feed for the tool as well as an automatic horizontal feed for the work, but most of the shapers now used are not so equipped, the tool being fed vertically by hand. Both the horizontal and vertical feed screws of the machine shown in Fig. 42, have graduated collars which are used when it is desired to feed the tool down or crosswise a definite amount. These collars have graduations representing a movement of 0.001 inch, and they can often be used to advantage for adjusting the tools.

Rack Shaper—Draw-cut Shaper—Special Types

A shaper of the type illustrated in Fig. 42, or one which is operated by a crank and slotted lever, is known as a crank shaper to distinguish it from the rack shaper which has an all-geared drive. The driving mechanism of a rack shaper is similar to that of a spur-gear type of planer. The ram has a rack on its under side and it is driven by a gear which meshes with this rack. The movement of the ram is reversed either by open- and cross-belts which are alternately shifted on tight and loose pulleys, or by friction clutches, which alternately engage the forward and return pulleys. The length of the stroke is controlled by adjustable tappets.

The shaper illustrated in Fig. 47 differs from the ordinary type in that the tool cuts when it is moving towards the column of the machine. In other words, the tool is pulled or drawn through the metal on the cutting stroke instead of being pushed. For this reason the name "draw-cut" is applied to a shaper of this type. The planing tool is, of course, set with the cutting edge reversed. The ram of this

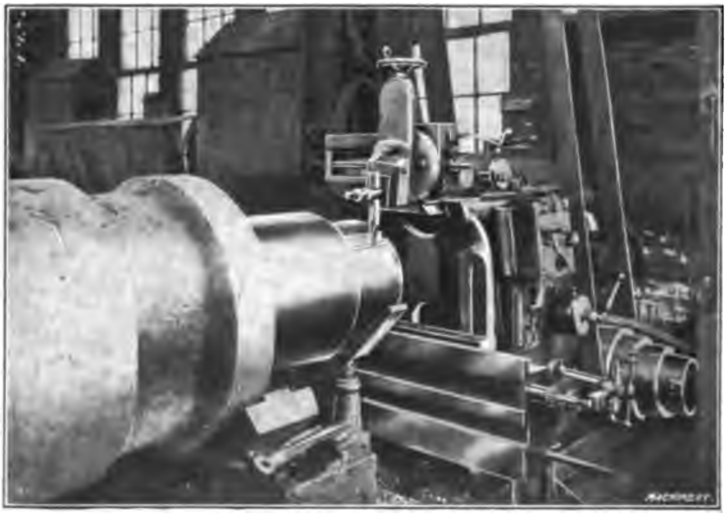

Fig. 48. Planing End of 20-ton Steel Roll, with Shaper having Side-traversing Tool-head

machine is driven by a rack and gearing, and the reciprocating motion is obtained by open- and cross-belts. The forward motion pulley is on one side of the column and the reverse pulley on the other. These pulleys are alternately engaged by friction clutches, and the length of the stroke is regulated by adjustable tappets mounted on the circular disk seen near the top of the column. There is also a hand lever for reversing the ram at any part of the stroke.

The object in designing a shaper to take a draw cut is to secure greater rigidity and, consequently, a higher degree of accuracy. The thrust of the cut is toward the column and this tends to relieve the cross-rail from excessive strains, especially when taking deep cuts.

Shapers of special types are also built in a number of different designs which are varied to suit certain classes of work. These differ from the standard types either in the motion of the ram relative to the work-table or in having a greater range of adjustment which adapts them to work which could not be handled in an ordinary shaper.

A shaper is shown in Fig. 48, which is provided with a cross traverse for the tool-head. The advantage of this feature, for certain classes of work, is indicated by the illustration. The regular table has been removed, and the end of a 20-ton steel roll is being planed. The traversing head enables horizontal cuts to be taken over the work which remains stationary. This shaper is a special design built by Gould & Eberhardt, and it can be used to advantage on large, unwieldy parts such as the one illustrated.

CHAPTER VI

THE SLOTTING MACHINE

The slotting machine or "slotter," as it is commonly called, is a vertical machine and is adapted to cutting keyways in the hubs of flywheels or pulleys and for finishing slots or other enclosed parts which could not be finished by the tool of a horizontal machine like the planer or shaper. The slotter is also used for various other classes of work, requiring flat or curved surfaces, which can be machined to better advantage by a tool which moves vertically. The ram *R* of the slotter, to which the planing or slotting tool is attached (see Fig. 49), has a vertical reciprocating movement at right angles to the work table. This vertical movement is obtained from a crank disk *D* which is connected to the slotter ram by a link and is driven by a cone pulley *P* and the large gearing seen at the rear. The tool is fastened to the end of the ram by the clamps shown, and the work is secured to the platen *T*. There are two sets of clamps on the ram so that the tool can be held in a vertical or horizontal position. The tools used for keyseating or finishing slots, are held in a vertical position, whereas larger surfaces which can readily be reached, are planed by a tool held horizontally against the end of the ram. The platen *T* can be moved crosswise along the saddle *S* and the latter can be traversed at right angles along the bed. In addition, the platen can be rotated about its center for slotting circular surfaces. These three movements can be effected by hand or power. The lengthwise adjustment on the bed is effected by turning squared shaft *A* with a crank; similarly, squared shaft *B* is used for moving the platen crosswise. The platen is rotated by turning shaft *C*. The automatic power feed for these three movements is derived from the cam *E* on the inner side of the large driving gear. This cam is engaged by a roller on the end of lever *F* and whenever the ram or tool is at the top of its stroke, an irregular place in the cam track causes lever *F* to oscillate. This movement is transmitted by connecting link and shaft *G* at the side of the bed, to the slotted crank *H*. This crank turns the large gear *I* slightly for each stroke of the ram, by means of a ratchet disk carrying a double-ended pawl *K* which engages the gear. Gear *I*, in turn, transmits the movement through the intermediate gears shown, to either of the three feed shafts. If a power feed along the bed is wanted, gear *J* is placed on the feed-shaft *A*, as shown in the illustration. On the other hand, if a cross feed is desired, gear *J* is inserted on shaft *B* and, similarly, the rotary feed is obtained by placing this same gear on shaft *C*. The amount of feed is varied by changing the position of the crankpin at *H*, and the direction of the feed is reversed by shifting the double-ended pawl *K*. The stroke of the ram is varied by adjusting the crankpin of disk *D*, to or from the center. The vertical position of the ram is changed so that the tool

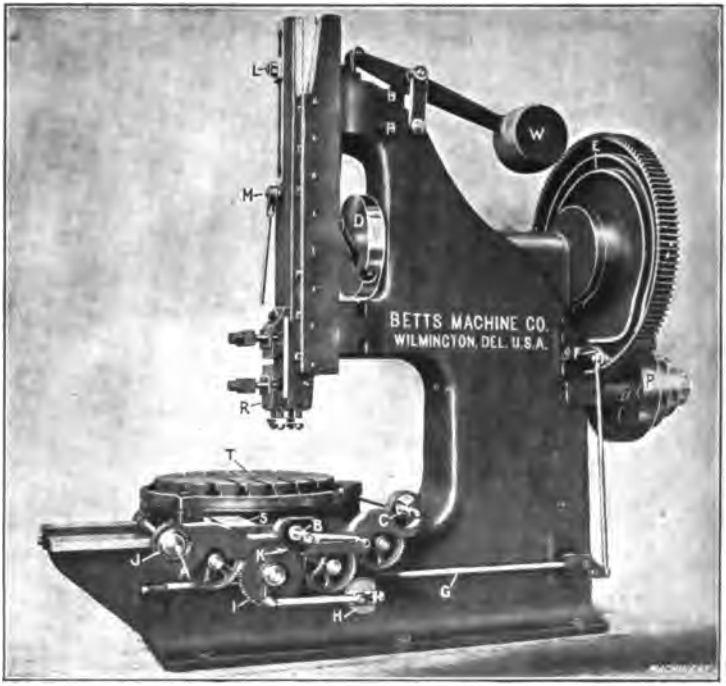

Fig. 49. Betts Slotting Machine

will operate in the right relation to the work, by loosening nut *L* and moving the ram up or down by turning shaft *M* with a hand ratchet. The ram is counterbalanced by a weight *W* and it has a quick return movement for the upward or idle stroke.

A typical example of the kind of work done on the slotter is shown in Fig. 50 which illustrates, diagrammatically, the slotting of a locomotive driving-wheel box. The side and top views at *A*, indicate how the inner sides of the box are finished. The work is set on parallel strips *s* to provide clearance for the tool at the lower end of the stroke, and it is secured to the platen by four clamps. The stroke of the ram *R* should be about one inch greater than the width of the surface to be slotted and most of the clearance between the tool and the work should be at the top of the stroke where the feeding movement takes place. When the stroke is adjusted, the ram is placed in its lowest position and it is lowered until the end is a little above the top of the work. The tool is extended below the end of the ram far enough to allow the cutter *c* to reach through the box when at the bottom of the stroke. The line previously scribed on the work to show the location of the finished surface, is next set parallel to the cross travel of the platen. This can be done by comparing the movement of the line with relation to the stationary tool-point while the work is fed

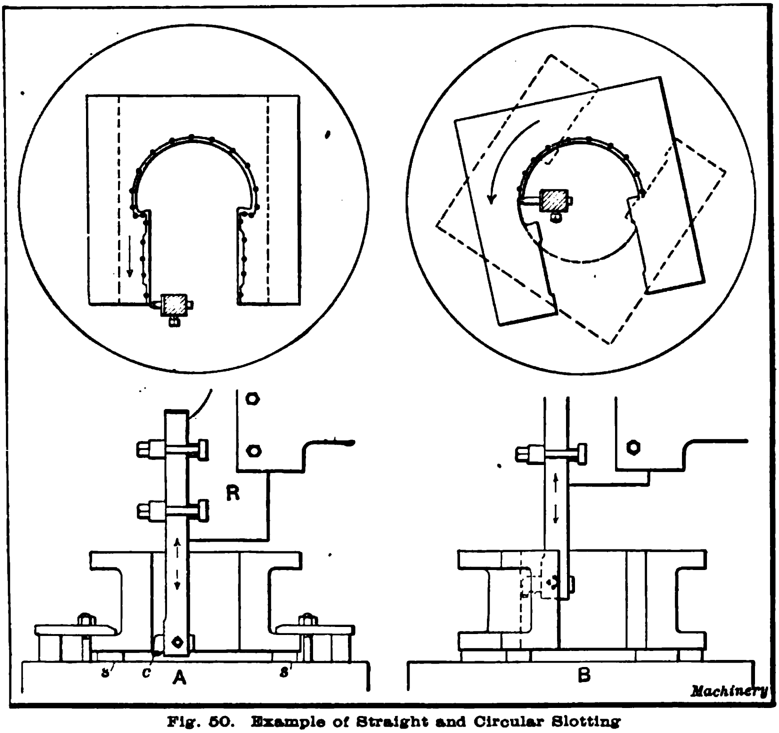

Fig. 50. Example of Straight and Circular Slotting

laterally by hand. If adjustments are necessary, these can be made by swiveling the platen one way or the other as required. When the work is set, the platen is locked to the saddle by clamps provided for that purpose. The cut is started at one end as shown in the plan view and the side is planed by the vertical movement of the tool combined with the lateral feeding movement of the platen and work. The opposite side is slotted without disturbing the position of the work by simply turning the tool half way around. The sketch at *B* indicates how the curved seat for the brass journal is finished. The radius of the seat is shown by a scribed line which must be set concentric with the center or axis about which the platen rotates. The platen must also be adjusted laterally and longitudinally, if necessary, until the tool will follow the finish line as the work feeds around. The position of the work soon after the cut is started is shown in the plan view by the full lines, and the dotted lines indicate how the box feeds around while a cut is being taken across the circular seat. After the slotter is set in motion, the cut is started by hand and then the power feed is engaged. The finish lines on work of this kind usually serve merely as a guide and the final measurements are determined by calipers or special gages.

A number of duplicate parts can sometimes be slotted simultaneously by clamping one piece above the other in a stack or pile. The tool then planes the entire lot to the same shape. This method only applies to work which can readily be stacked up.

Some of the tools used in the slotter are illustrated in Fig. 51. Those shown at *A*, *B* and *C* are forged from the solid bar and have

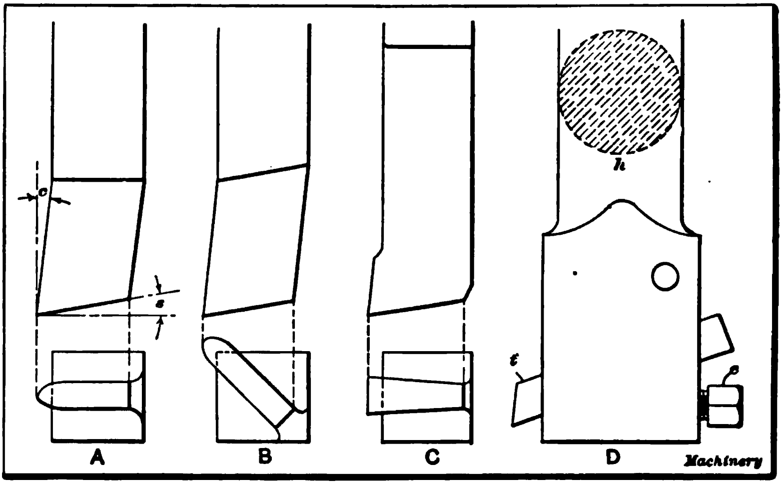

Fig. 51. Some of the Tools used for Slotting

cutting edges formed on the ends, whereas tool *D* consists of a heavy bar in which a small cutter *t* is inserted. Tools *A* and *B* are used principally for slotting interior surfaces, where there is little room for the tool to operate. For exterior slotting, or whenever there is plenty of room, tool *D* is preferable because it is more rigid. The cutting end of tool *B* is inclined to the right or left (as indicated by the end view) for working in corners, etc. The position of tool *D*, which has a round shank *h*, can be varied by turning it in clamps at the upper end which hold it to the slotter ram. The cutter *t* is held by setscrew *c* in a pivoted, spring-relief block which allows the tool point to swing away from the work on the upward stroke. The tool tends to spring away from the work on the downward or cutting stroke, and if there is no relief movement, it drags heavily over the planed surface on the upward stroke. Tool *C* is used for cutting keyways or narrow slots. These tools have a slope *s* at the end and the front side is ground to a clearance angle *c*. The direction of the slope at the end (which is the surface against which the chips bear while being severed) is away from the cutting edge, and this is a rule which applies generally to tools for turning or planing iron or steel.

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