PART II

DRILLING MACHINE
SHAPER AND PLANER
MILLING AND GRINDING MACHINES

SPUR GEARS AND BEVEL GEARS

BY

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Extract of Shaper and Planer Sections

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PREFACE

The preface of Part 1 gives the reasons for preparing this text. Part 1 deals with lathe work, bench work, and work at the forge. An attempt has been made in this volume (Part II) to organize the *fundamental principles of construction and operation* of the Drilling Machine, Shaper, Planer, Milling Machine, and Grinding Machine. A chapter embodying what every machinist should know concerning spur gears and bevel gears is included.

Only fundamentally has this work anything to do with production. Special rapid production machines and tools represent various combinations of fundamental mechanisms, methods and processes. The purpose of this text is to discuss these fundamentals, and build a foundation for rapid production; the same sort of foundation that arithmetic builds for mathematical calculations.

Perhaps a statement regarding the way in which the following text is presented and the reasons therefore should be made here.

First: While there are a great many sizes, types, and kinds of each of the standard machine tools, and while the makers differ in details of design, the fact remains that the primary function, and the basic principles of construction and operation of the given class of machine, are the same regardless of the size or where it is made. Therefore, a well-known example of each of the machine tools under discussion has been selected and described, and typical mechanisms illustrated and explained in such a way as to bring out the general details.

Second: The operator's production, interest and progress are in proportion to his understanding of the basic principles of the construction of the machine he is running—the special mechanical features, feed changes, speed changes, and adjustments of the machine. Consequently, these things have been discussed early in the study of the particular machine.

Third: The broader the student's knowledge concerning the cutting tools used in the given machine, and the quicker he gets a fairly comprehensive idea of the shapes, sizes and characteristics of these tools, the easier and better he can "run the machine." Therefore the cutting tools used have been explained in considerable detail.

Fourth: It is well worth while to look up or reason out correct answers to questions concerning a subject in which one is interested; it not only adds that bit of information to the store of facts one has but makes for progress. Several hundred questions appear in the book as an incentive.

Fifth: Information concerning operations and methods, or suggestions concerning typical set-ups may be expected from a text, and brief instructions regarding the job at hand may be obtained from the foreman or the instructor. However, the student must understand that if he hopes to succeed, he must use his own reasoning powers and develop his resourcefulness. Hence, principles have been discussed and unnecessary details omitted.

Only occasionally has a concrete example of a specific operation been given, because jobs vary daily in every shop. Rather the aim has been to give the reason underlying the particular construction, the principles which determine the right set-up, the "why" of the proper cutting tool for the given purpose, and as far as possible in so brief a text, a survey of established usages and methods of operating the machine in question.

It is hoped that these pages will prove helpful to the young man beginning his work on the various machines; that the text is clear, comprehensive, and interesting enough for the reader to enjoy studying it. Also, that the descriptions and illustrations, the suggestions and the questions, will stimulate to the student to seek further information contained in numerous treatises on machine tools.

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SHAPER CONSTRUCTION

53. Introduction.—The function of the shaper is, primarily, the production of flat surfaces. The work is held on an adjustable work table or more often in a vise fastened to the work table, while the cutting tool, which is given a reciprocat-

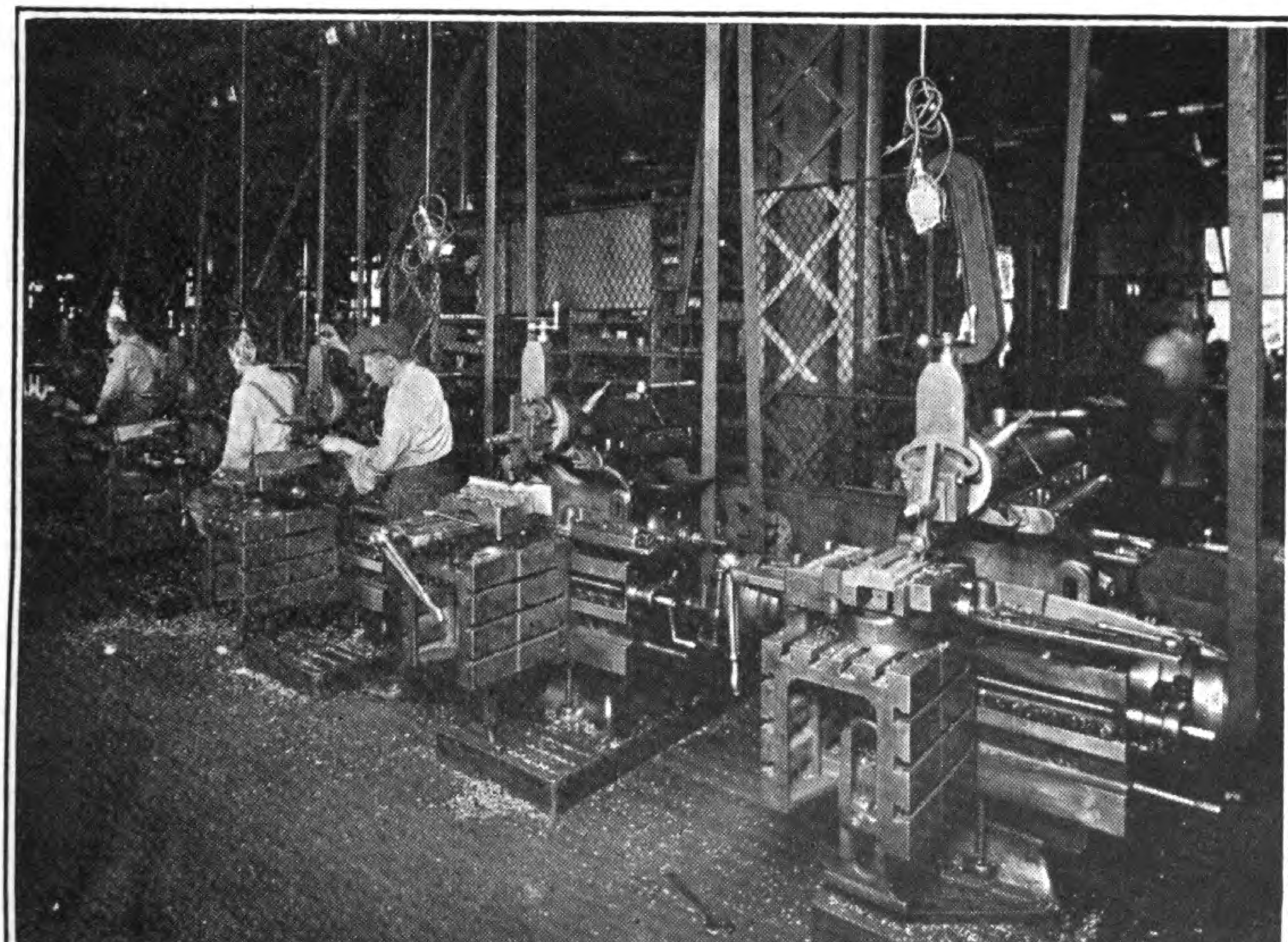


FIG. 62.—Gould and Eberhardt shapers in a tool department. (*Photo Brown Bros.*)

ing motion, that is, caused to move forward and back, peels off a chip on the cutting stroke. During the return stroke the feed operates to move the table (and work) the desired amount.

Shapers are classified as to size (14," 16," 20," etc.) by the maximum length of the cut that may be taken, and a standard shaper of a given size will hold and plane a cube of that size. Shapers are made in a variety of types, some of them being very special in their application. The different manufacturers of course differ to a considerable extent in detail of design and construction for a given type.

The crank shaper (Fig. 63) in which the tool carrier is driven forward and back by a vibrating arm operated by a crankpin in the main driving gear or "bull wheel," and in which the feed is transmitted to the work table, is generally recognized as the most efficient design and is so commonly used as to be termed standard.

54. The Value of the Shaper.—The relative values of different methods of doing a job, or of the kinds of machines to use, is one of the most profitable and interesting studies in machine shop work. For example, for a small number of pieces it may be better to plane one piece at a time in a shaper, for a larger number of pieces it may be more efficient to set up and plane several at a time in a planer. It may be cheaper and quicker to take one or more cuts on say twenty-five pieces in a shaper or planer rather than in a milling machine; on the other hand if there were enough pieces to make the extra initial expense worth while, it probably would be much better to provide a special fixture and a special cutter, and machine them in the milling machine.

The shaper is especially adapted to small work which may be held in a vise bolted to the work table. The tool head is so constructed as to permit of horizontal, vertical, or angular cuts being taken. For tool room work such as punch and die work, jig and fixture parts and on short work for other special tools or machines, the shaper is practically indispensable.

The shaper cutting tool is easily ground the desired shape for the cut to be taken and when dull may be quickly sharpened. The range of stroke and position of stroke; of vertical adjustment of work table; of feeds—lateral, vertical and angular, together with the adaptability of the single cutting tool, serve to make the shaper more efficient for many jobs than the milling machine. This is especially true in model work or tool work involving at most only a few pieces. On the average shorter cuts within its capacity the shaper is more efficient than the planer for the following reasons: It costs less to buy, it takes less power to run, occupies less space in the shop, is about one-third quicker, the work is more easily adjusted, and generally speaking less skill is required in operation.

A wide variety of very accurate work may be easily and quickly accomplished in the shaper if the machine is in good condition, clean and well oiled, and the operator understands its construction and the principles of its operation.

55. Parts of Shaper.—On the following pages is illustrated and described an excellent example, as regards both detail of design and efficiency, of a standard shaper. In connection with your job in the shaper, study the illustration (and machine) and text carefully and learn the names and functions of the parts.

A machinist who can intelligently run a lathe made by a manufacturer in Cincinnati will have no particular difficulty in operating a lathe made by another company in Hartford. These lathes may have different features in design but, in principle, they are alike in construction and operation. So with shaper work, a shaper is built for certain operations and the machinist who understands the construction of a given standard shaper will have no trouble in understanding quickly the constructional features—that is, the functions of the various levers, handles, etc. of any shaper.

PRINCIPLES OF THE CRANK SHAPER DRIVING MECHANISM

56. The Cutting Stroke and the Return Stroke.—The ram is actuated by a slotted vibrating arm *M*, (Fig. 64) which is pivoted at its lower end to the column while the upper end is connected by a link *A* to the adjustable clamp block *B* which is clamped to the ram. The vibrating arm is caused to

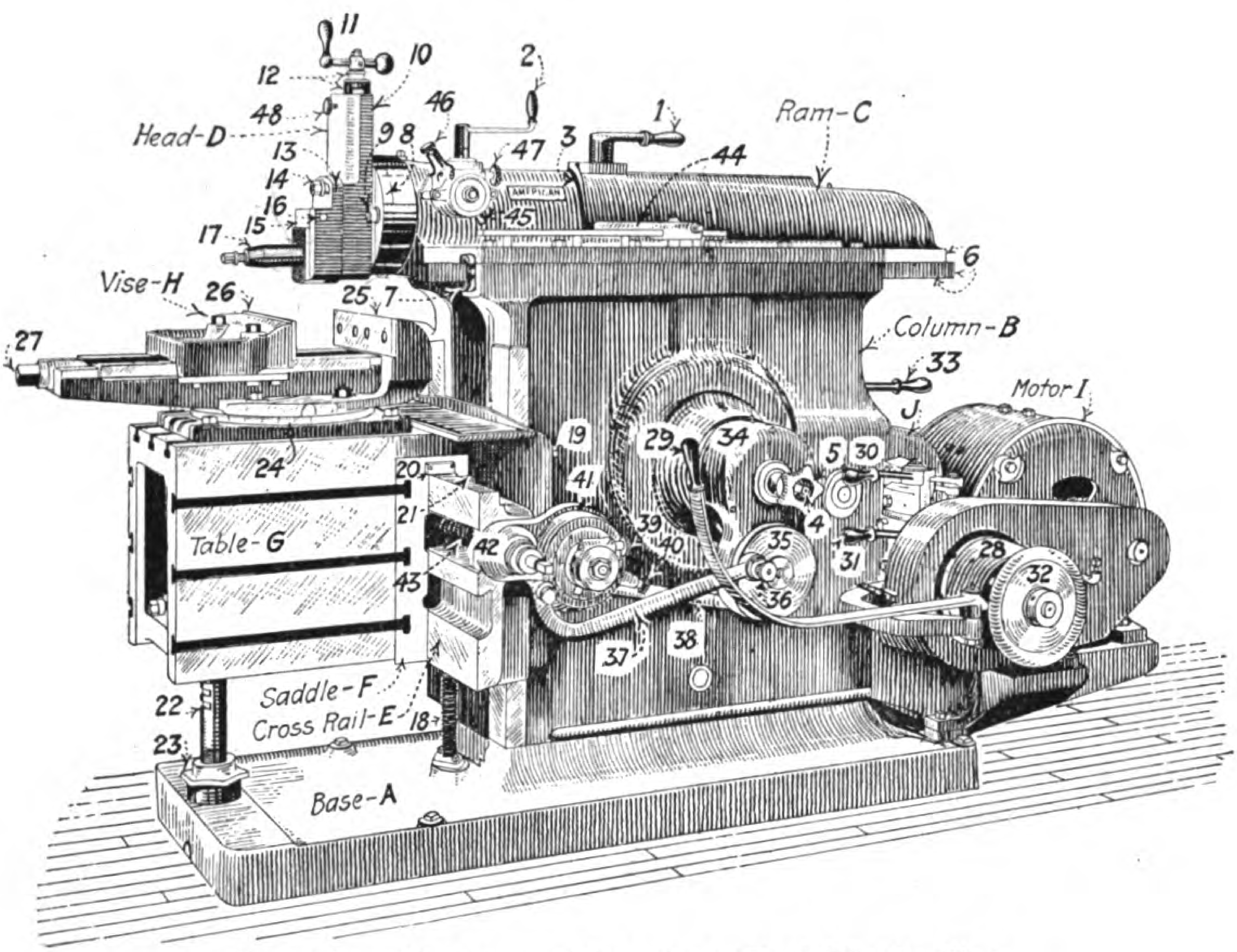


FIG. 63.—Shaper. (*American Tool Works Co.*)

PARTS OF THE SHAPER

Index to Unit Names

A. *Base*, pan shaped to keep oil off floor.

B. *Column*, main support for operating mechanism. The top is machined and scraped to form a flat bearing for the ram.

C. *Ram*, carries the tool head. Cast in cylindrical form to give strength and stability, has, in operation, a reciprocating motion on the column which is actuated by a crank driven mechanism within the column. The length of the stroke and the position of the ram with reference to the work are adjustable.

D. *Head*, holds the tool and contains the down feed; is swivel in construction to permit the tool to be fed at any desired angle with the top surface of the table.

E. *Cross rail*, held in any desired position on a vertical slide machined and scraped in front of the column. Carries the saddle and work table, also part of the table feeding mechanism.

F. *Saddle*, table connection to cross rail, and work support when table is removed.

G. *Work table*, bolted to saddle; is provided with T-slots. When constructed to swivel on the saddle, and also to be tilted, it is called a universal table (see Fig. 81). Most shaper work is done in a vise bolted to the table.

H. *Vise*, work holder on swivel base.

I. *Motor*, initial driver; constant speed; direct geared to speed box shaft.

J. *Speed box* and *speed-control mechanism* (see also Fig. 66).

K. *Table feed mechanism*, automatic transverse feed to table *G* (see following part numbers 34 to 43 inc.).

L. *Power down-feed mechanism*, automatic feed to tool head *D* (see following part numbers 44 to 48 inc.).

M. *Vibrating arm* (not shown, see Fig. 64).

N. *Bull wheel*, main driving wheel (not shown, see Fig. 64).

Index to Part Names

1. *Binder lever* for securing ram to vibrating arm *M*.
2. *Crank* for operating ram positioning screw (first loosen binder lever 1).
3. *Pointer* for indicating the length of tool travel.
4. *Stroke setting shaft* (regulates position of crankpin in bull wheel *N*).
5. *Knob* for locking stroke setting shaft.

6. *Ram bearing surfaces.*
7. *Oilers* and *wipers* for sliding surfaces (contain felt inserts to wipe off dirt and retain oil).
8. *Swivel plate* for head, has graduations, in degrees, for angular positions of tool travel.
9. *Clamping bolts* for locking head to ram.
10. *Tool head slide.*
11. *Hand feed crank* on screw, for vertical feed to tool.
12. *Graduated micrometer collar* on screw, for fine adjustment.
13. *Clapper-box* with angular adjustment.
14. *Clamping bolt* for clapper-box.
15. *Tool block* or *clapper*, holds tool post.
16. *Hinge pin* for tool block.
17. *Tool post*, secures tool in position.
18. *Screw for raising or lowering cross rail*, moved by miter gears. The rod and handle are on other side of the shaper.
19. *Clamping screws.* Used to secure rail to column after adjustment up or down. It is imperative that these screws be loosened slightly before raising or lowering the table and tightened when the table is in position.
20. *Oiler and wiper*, similar to No. 7.
21. *Full-length taper gib*, for taking up wear and regulating fit between cross rail and saddle. A gib similar to this is located between the ram and the column.
22. *Table support.* This bears on base and is secured to table. It is adjustable to suit table height. Used when heavy work is placed on the table.
23. *Lock nut* on foot of table support, used for fine adjustment.
24. *Swivel base for vise*, graduated at joint for angular positions of vise body.
25. *Stationary jaw* and *vise body* combined.
26. *Movable jaw of vise*, moved by screw No. 27.
27. *Screw for clamping work* in vise jaws.
28. *Friction*, connects motor gears (or single drive pulley) to speed box shaft. A brake is furnished at other end of driving shaft for stopping ram quickly after friction is released.
29. *Friction* and *brake engaging lever*, pushed to the right to operate friction clutch (28), to the left to operate brake.
30. *Speed-changing lever*, operates upper pair of slip gears.
31. *Speed-changing lever*, operates lower pair of slip gears.
32. *Hand wheel* on driving shaft, used to revolve gears so they may be engaged when motor is not running, also to move ram slightly when setting tool, etc.
33. *Back gear shifting lever*, operates either set of the double train of back gears between speed box and bull wheel. For detail see Fig. 66.
34. *Feed gear bonnet*, carries feed operating gears, upper gear revolves with bull wheel and engages with lower gear which is located back of reverse plate (35).
35. *Feed reverse plate*, carries reverse knob (36).
36. *Feed reversing knob* for changing position of feed crankpin so that table feed may be arranged to take place on the reverse stroke. Crankpin engages either one of two holes in opposite sides of center of the feed gear.
37. *Feed operating link*, connects feed gears in bonnet with feed device on cross rail.
38. *Distance link*, controls the distance between bull wheel center and feed device on cross rail to relieve feed operating link (37) from strains when rail is adjusted up or down on column, and maintain correct center distances at all times.
39. *Knob* for regulating the amount of feed per stroke. Operates a worm and wormwheel mechanism which exposes any number of notches in a feed disk which is engaged by pawl (40).
40. *Pawl knob*, stops and starts table feed in either direction. When pawl is in neutral position, it does not engage feed disk notches and there is no feed.
41. *Large feed gear*, revolves on stationary stud in cross rail.

NOTE.—Gears 41 and 42 are under gear guard.

42. *Feed pinion* on table feed screw (43).
43. *Table feed screw*, for moving saddle and table on cross rail. Feed screw nut is attached to rear wall of saddle *F*. For hand feed put crank handle on squared end of screw.
44. *Dog* (adjustable), operates down feed lever (45) at each return stroke of the ram.
45. *Down feed lever* actuates pawl (46).
46. *Pawl knob on down feed.* The pawl engages feed notch wheel inside of casing, which transmits motion to down feed screw through two shafts in ram and two sets of miter gears one gear forming a nut on the down feed screw.
47. *Feed regulating knob*, similar to (39) on cross rail.
48. *Thumb screw*, secures down feed screw against turning when power down feed is in operation.

move back and forth by a crankpin *C* which is carried by the driving gear or "bull wheel" *N*. The crankpin operates in a block *D*, provided with wide bearing surfaces, which slides in a slot in the vibrating arm. As the bull wheel revolves the crankpin travels in a circular path, and through a part of its travel moves the arm in one direction and during the remainder of its travel moves the arm in the opposite direction. The position of the crankpin with reference to the center of the bull wheel determines the distance the upper part of the arm moves back and forth, and this determines the movement of the ram, that is, the length of the stroke.

57. Adjustment for Length of Stroke (Fig. 64).—The crankpin C carrying the block D is *fastened* in a *second* block E into which the screw S is threaded. Thus the crankpin may be

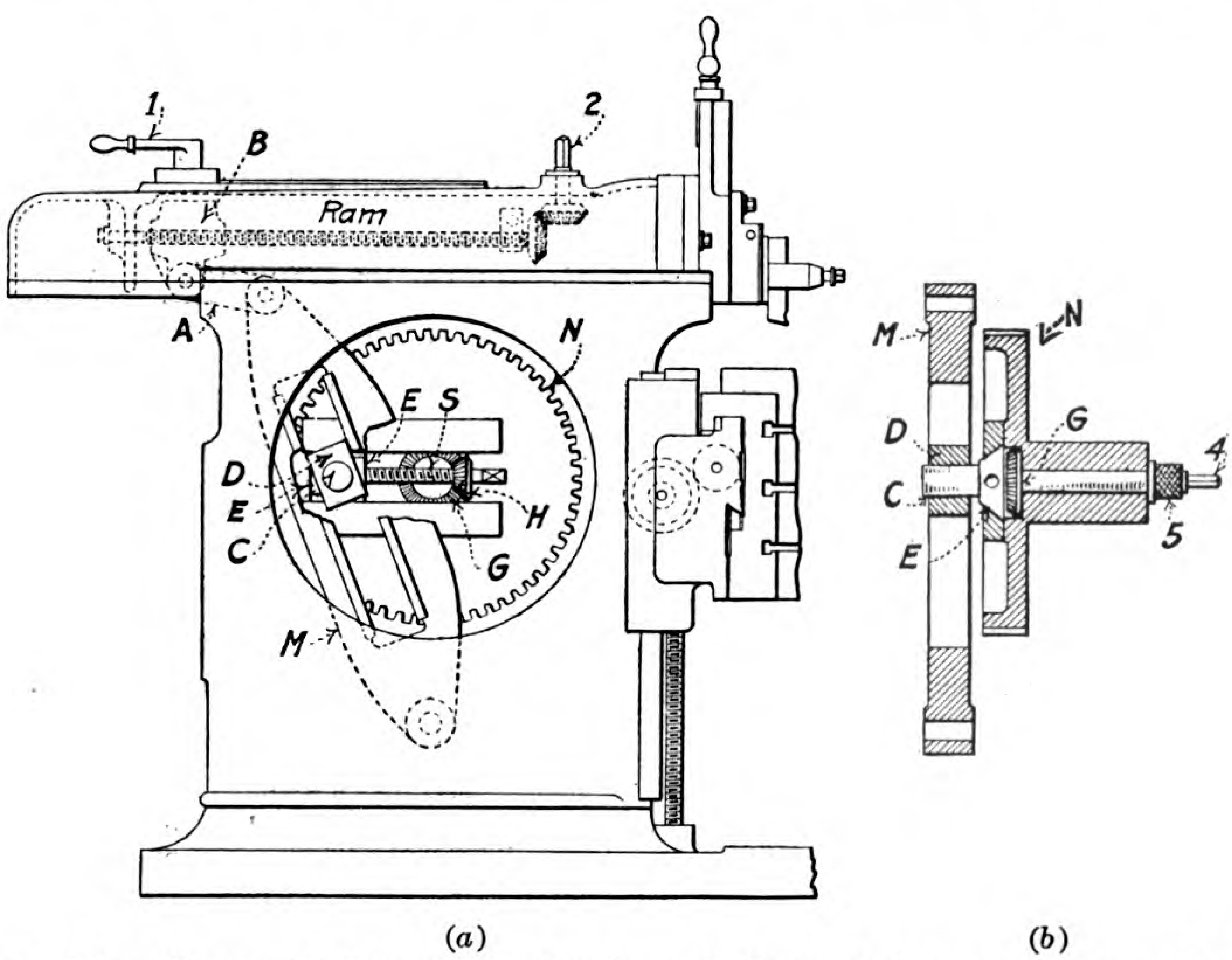


FIG. 64.—Shows driving mechanism from bull wheel N to ram. also mechanisms for adjusting *length* of stroke and *position* of stroke. In vertical section (*b*), gear H is not shown and in (*a*) a portion of the vibrating arm has been cut away.

moved along a radial slide in the bull wheel by turning the shaft (4) which operates the screw S by means of the bevel gears G and H. Consequently, as the shaft (4) is turned (by means of the handle supplied) the crankpin is moved towards or away from the center of the bull wheel, depending on which direction the shaft is turned. A convenient index plate and pointer (3) (Fig. 63) are provided for reading the length of stroke. The shaft (4) is locked by turning the knob (5) to the right after the correct length of stroke is obtained. (For (4) and (5) see also Fig. 63.)

58. Adjustment for Position of Stroke (Fig. 64).—After the correct length of stroke is obtained, the adjustment for the position of the ram, so that the extreme end of the cutting path of the tool may be correctly placed with reference to the work, is quickly accomplished. Loosen the clamp block *B* by turning handle (1) next bring the vibrating arm *M* to its extreme forward position by turning the driving pulley, or handwheel, by hand, then by turning handle (2) adjust the

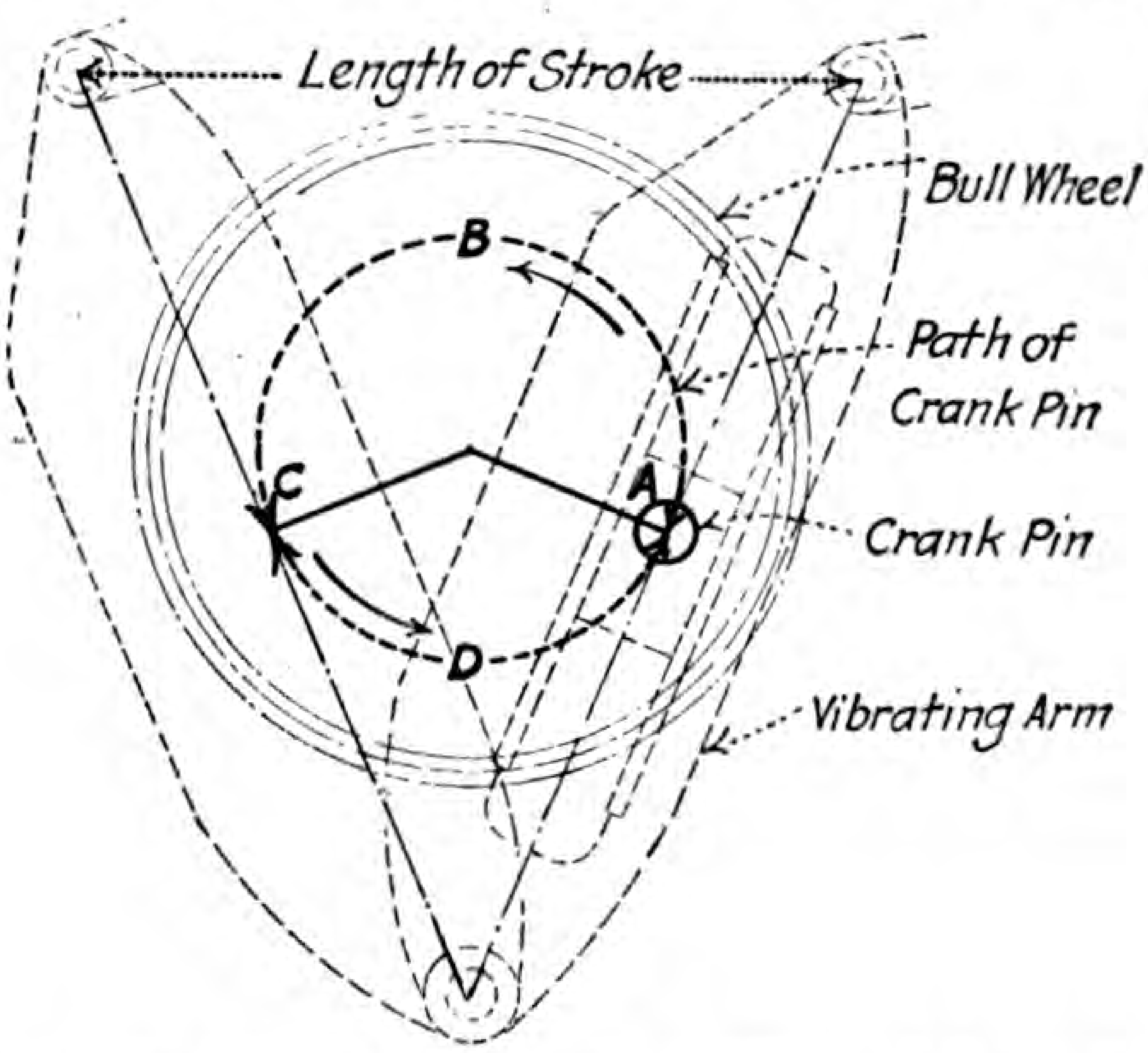


FIG. 65.—Shows principle of quick return (Viewed from right-hand side.)

cutting tool about one-fourth inch or one-half inch beyond the edge of the work. The adjustment for the length of the stroke should be made before the adjustment for position.

59. The Quick Return.—Due to angular position of the vibrating arm at the point of reversal, the ram travels faster on the return stroke than on the cutting stroke. The principle of this "quick return" is shown in Fig. 65. In the circular path of the crankpin the arc *CDA* represents the *time* of the return stroke and the arc *ABC* the *time* of the forward or cutting stroke, and the ratio (average) is about 2 : 3 in most shapers. That is, it takes about one and one-half times as long to make the cutting stroke as it does to make the return stroke (ratio $2:3 = 1:1\frac{1}{2}$).

60. Speeds of Shaper.—At a given speed of the driving gear a shaper will make a constant number of strokes per minute whether they are long or short. To obtain a given *cutting speed* per minute for the tool, the shaper must have twice as many strokes for a cut 2″ long as for a cut 4″ long. Therefore, to allow for the different lengths of stroke (and also for the different metals to be cut) the shaper is provided with different speeds.

In the shaper with cone pulley drive the speed changes may be obtained by changing the belt on the various steps of the pulley. In the shaper with single pulley drive or individual motor drive the different speeds are obtained through *speed change gears.* The gearing, etc., which constitute the speed change mechanism is in effect the same as the mechanism of a "geared head" of a lathe or milling machine but in the shaper is termed the "speed box."

The smaller shapers (14″ and under) are usually provided with four speeds; in the larger sizes the number of speeds is doubled by the use of back gears.

The speed-box illustrated in Fig. 66 is the unit removed from the shaper shown in Fig. 63, and Fig. 67 shows the development of this shaper drive. There are two series of four speeds each, one series through the back gear train *H–I* the other through the back gear train *J–K* as follows:

Speeds	Lower Lever (31) moves gears *A* and *B*	Upper Lever (30) moves gears *G* and *F*	Gear runs	Strokes per minute
First speed (slowest)	Left	Left	*B-E-D-G-H-I*	8
Second speed	Right	Left	*A-C-D-G-H-I*	11
Third speed	Left	Right	*B-E-C-F-H-I*	15
Fourth speed	Right	Right	*A-C-F-H-I*	23
Fifth speed	Left	Left	*B-E-D-G-J-K*	34
Sizth speed	Right	Left	*A-C-D-G-J-K*	49
Seventh speed	Left	Right	*B-E-C-F-J-K*	71
Eighth speed (fastest)	Right	Right	*A-C-F-J-K*	105

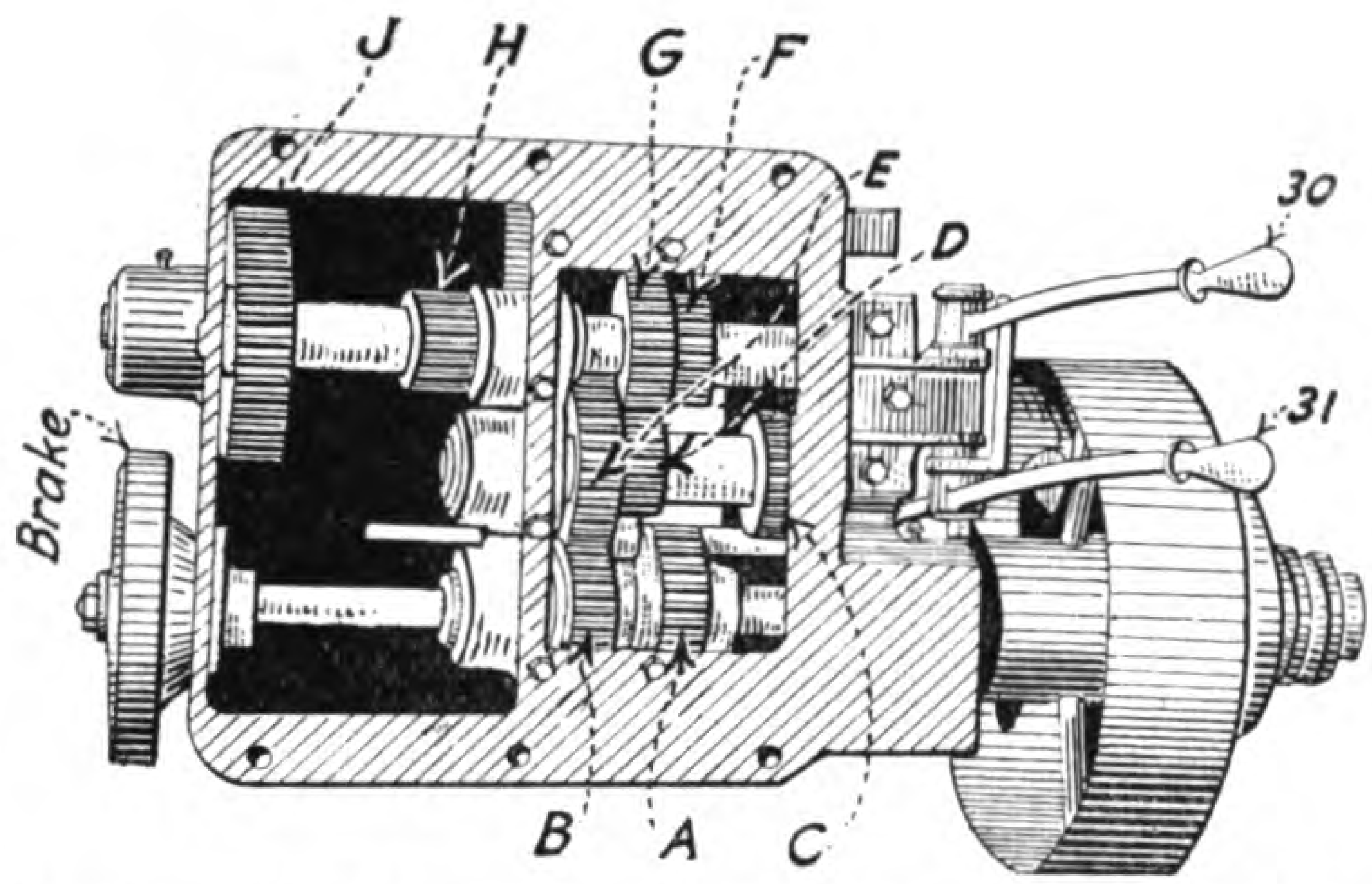


FIG. 66.—Speed box removed from shaper illustrated in Fig. 63.

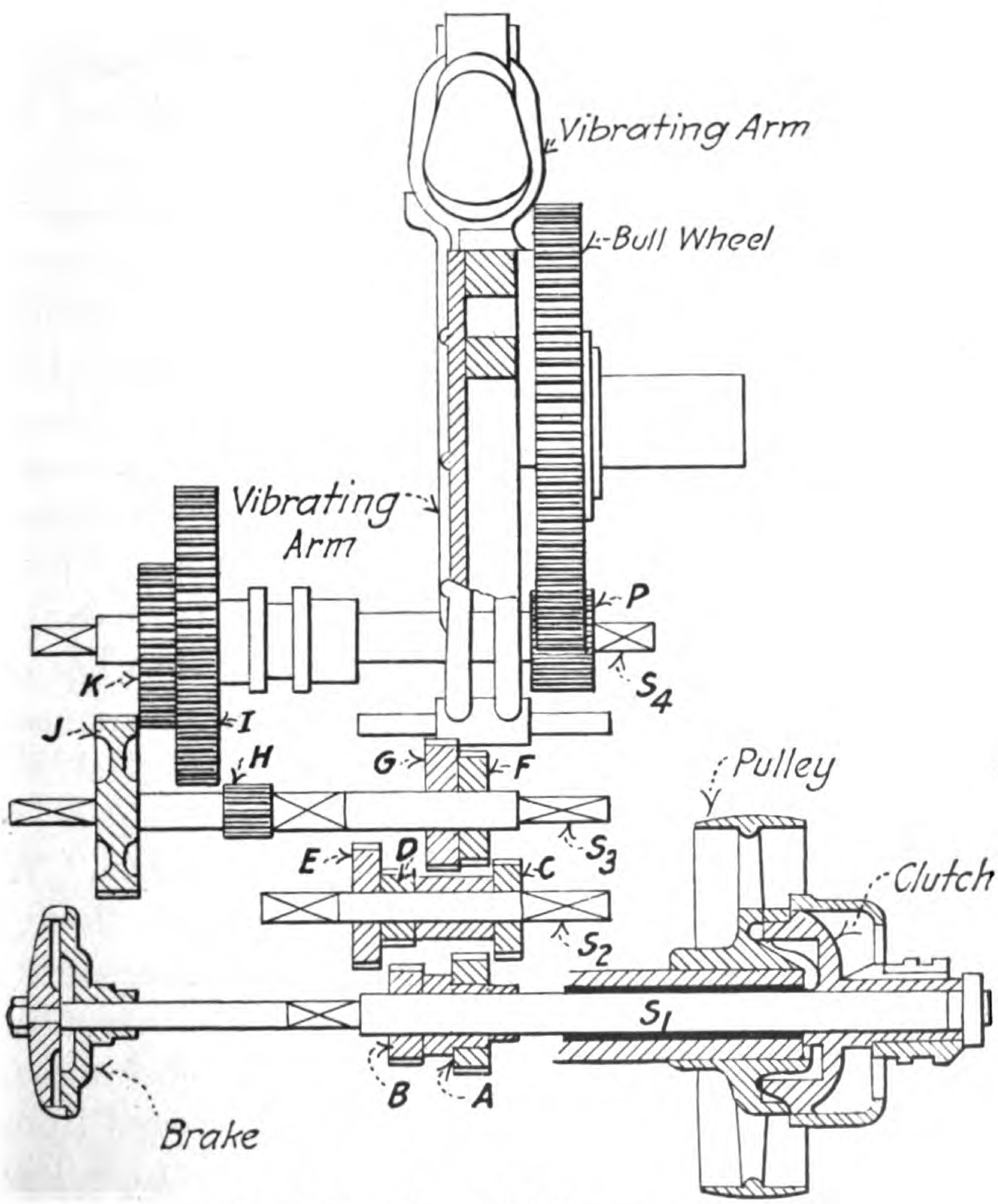


FIG. 67.—Shaper driving mechanism.

It will be observed that the speed at which the final driven gear (bull wheel) revolves is determined by the relative sizes of the driving and follower gears in the various pairs of gears which make up the compound gear trains which serve to transmit motion from the shaft S_1 to the bull wheel. Thus in the slowest speed B is smaller than E, D is smaller than G and H is smaller than I which makes for a reduction of speed in each pair of gears. To produce the next slowest speed the lower lever is moved out. This disengages B with E and engages A with C which serves to slightly increase the speed of S_2 and this increase is of course carried on to S_3 and the bull wheel.

61. The work table may be *fed* horizontally either by hand or by power; and may be *adjusted* vertically to provide for different jobs, which may vary considerably in height. The table is bolted to a saddle, and the saddle is gibbed to the cross rail which provides a suitable bearing surface for the horizontal (feeding) movement of the work table when the feed screw is turned. Either a rapid traverse of the table or the desired amount of "hand feed" may be obtained by means of a crank placed on the squared end of the feed screw. The automatic feed will presently be explained. The front face of the column of the shaper is finished to form a suitable bearing surface for the vertical adjustment of the cross rail. That is, the cross rail together with the saddle and table may be raised or lowered. This is accomplished by means of a vertical screw operated through bevelled gears by a horizontal shaft, the squared end of which is on the side of the machine. The same crank handle that is used for hand feed is used here. Clamping bolts are provided on both sides of the shaper to securely bind the cross rail to the column. Whenever the vertical adjustment of the table is made these bolts should first be loosened, the adjustment made, and then the bolts tightened to give rigidity to the work. As a further method of imparting rigidity to the table and work under the pressure of the cut an adjustable brace is arranged from the base of the machine to the table. If the table is to be lowered it will of course be necessary to loosen this brace.

The work table is provided with T-slots on the top and on both sides for the purpose of holding bolts for clamping the work or the work holding devices. In nearly all shapers the table is permanently bolted to the saddle but at an additional cost certain manufacturers will furnish a "universal table." This table may be swiveled on the saddle plate thus providing an angular adjustment of the work at right angles to the direction of the stroke. Also, the top being hinged on the back side, the front may be raised thus providing an angular adjustment in the direction of the stroke. These table swivel and tilting features are very useful where any considerable amount of angular (bevel) or taper planing must be done. See Fig. 81.

Questions on Shaper Construction

1. In a crank shaper how does the bull wheel drive the vibrating arm?

2. What is a crank shaper?

3. What is the use of the slot in the vibrating arm?

4. Where and how is the crankpin held?

5. How is the screw turned to move the crankpin? Why are bevel gears used? Where is the check nut? How does it serve to hold the crankpin in position?

6. How much movement has the vibrating arm when the crankpin is on center? Why? Away off center?

7. What is meant by the stroke of a shaper? Cutting Stroke? Return stroke? What is the maximum length of stroke of the shaper on which you are working? What size shaper is it?

8. Is there a link between the hinge pin and the vibrating arm, or between the arm and the ram? What is the use of the link?

9. What is the reason for the slot in the top of the ram?

10. How is the vibrating arm connected to the ram? How is the position of this connection changed? How does it effect the "position of the stroke?" Why are bevel gears used between the handle and the screw?

11. Explain the "quick return" of the shaper ram.

12. What clamping bolts must be loosened before adjusting the table vertically? How much should they be loosened? Why?

13. How is the elevating screw oiled? How are the thrust bearings oiled? How often?

14. What amount of vertical adjustment of the table is possible?

15. What is the value of the table brace support?

16. Why does turning a screw move the work table horizontally? How is this screw turned by hand? What is this movement called?

17. How are the various speeds obtained in the shaper? What is the need of having several speeds? Are back gears provided in a shaper? Give reason.

18. On what kinds of work is the shaper particularly useful.

19. Give several reasons why the shaper is better than a planer for small work.

62. Feeding Mechanism.—The automatic feed of a shaper is obtained by causing the feed screw to make part of a revolution. The feed screw is actuated by a pawl[1] which engages

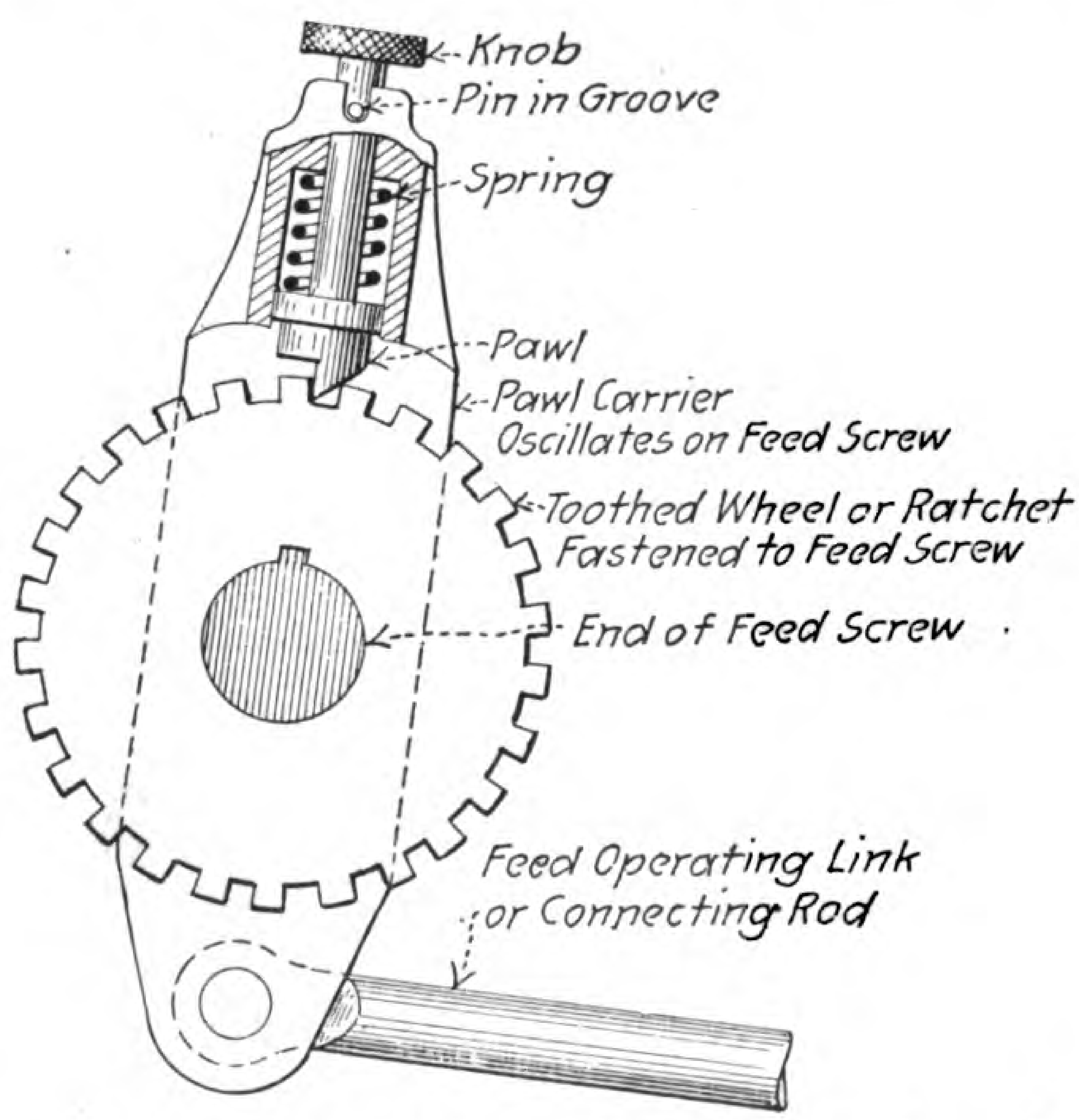


FIG. 68.—Illustrates one type of ratchet and pawl mechanism. Lift pin out of groove and turn knob half way round to reverse direction of feed, one-quarter turn for neutral.

a notched wheel, (Fig. 68), which is either fastened to the screw or transmits its motion to the screw through gears.

When the pawl is "in," it *operates* once, and *gets ready* to operate again, during each revolution of the bull wheel. This is because the oscillating motion of the pawl carrier

[1] *Pawl.*—A hinged or pivoted piece, or a piece arranged in a pivoted carrier (pawl carrier), having an edge made to engage with the teeth of a notched wheel for the purpose of giving motion to this wheel in a given direction.

moves the pawl *forward* and then *back* one or more teeth on the notched wheel. This oscillating motion of the pawl carrier is transmitted either (1) from a crankpin arranged to make one cycle when the bull wheel revolves once (see Fig. 69 also numbers 35, 36 and 37 Fig. 63) or (2) from an eccentric on the bull-wheel hub (Fig. 70), which of course completes one motion when the bull wheel revolves once.

If the feed motion is transmitted through a *feed rocker arm* as is the case when actuated by an eccentric on the bull wheel

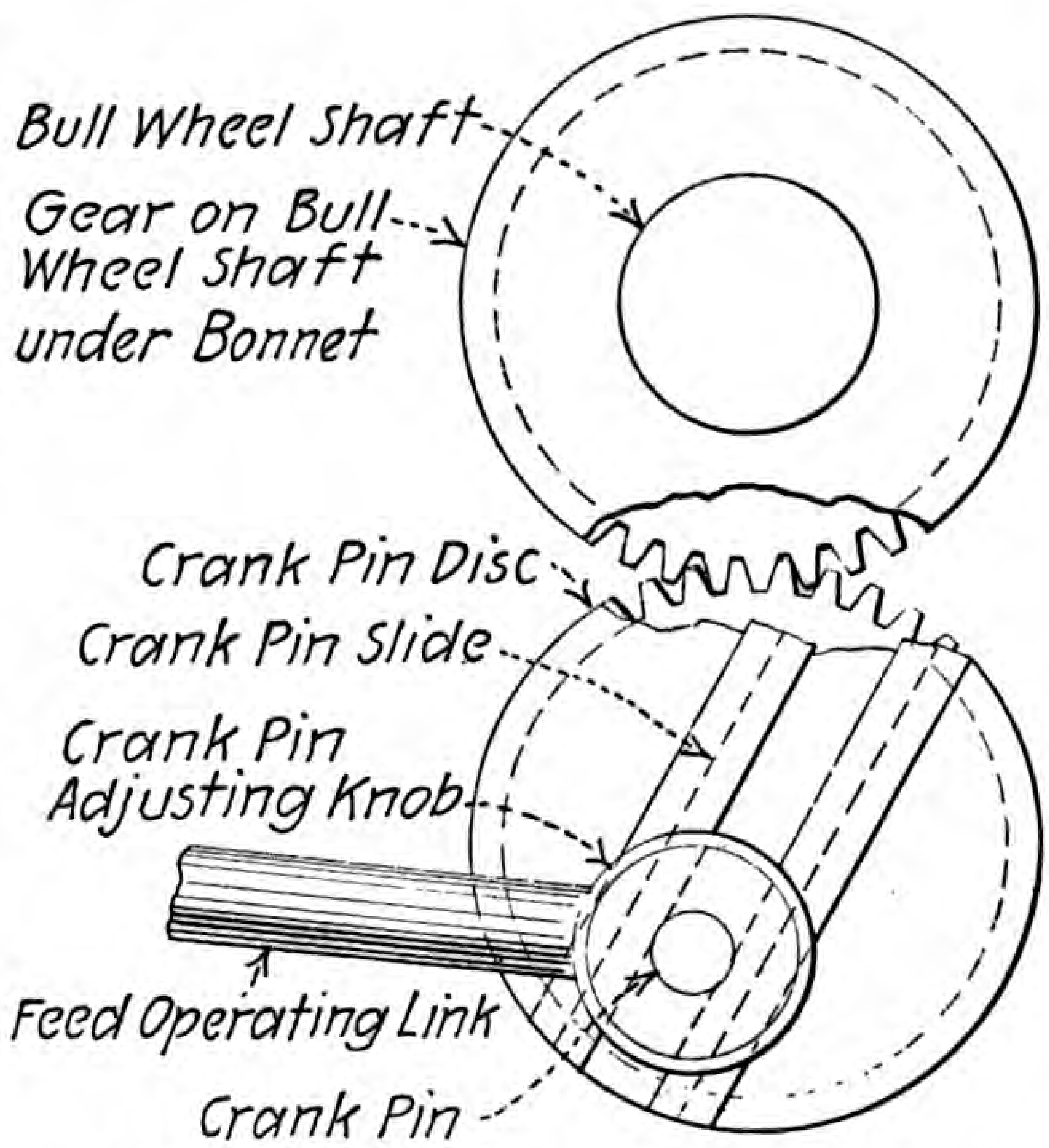


FIG. 69.—Shaper feed mechanism (operated by gears). The upper gear is fastened to the hub of the bull wheel and the lower gear is carried on a stud shaft in a bonnet. The crank pin disc is located in front of the lower gear. The gears are equal therefore each revolution of the bull wheel causes an oscillating movement of the feed operating link.

(Fig. 70), then the position of the feed adjusting knob, one side or the other of the rocker arm center, determines whether the feed shall be during the forward or return stroke.

This same principle applies in shapers that have the feed operating link or connecting rod actuated by a *crankpin* in a slotted disk, the disk being revolved by means of gearing at the outer end of the bull wheel hub (see Fig. 69 also description 36, Fig. 63).

The feed should take place *on the return stroke* because to feed during the cut puts undue strain on the feeding mechanism.

The amount of automatic feed is governed by the number of teeth the notched wheel moves at each return stroke of the shaper, and this is controlled by the position of the feed-link adjusting knob in the rocker-arm slide (Fig. 70), or in the crankpin slide (Fig. 69). On center there is no feed and the greater the distance from center the more the feed.

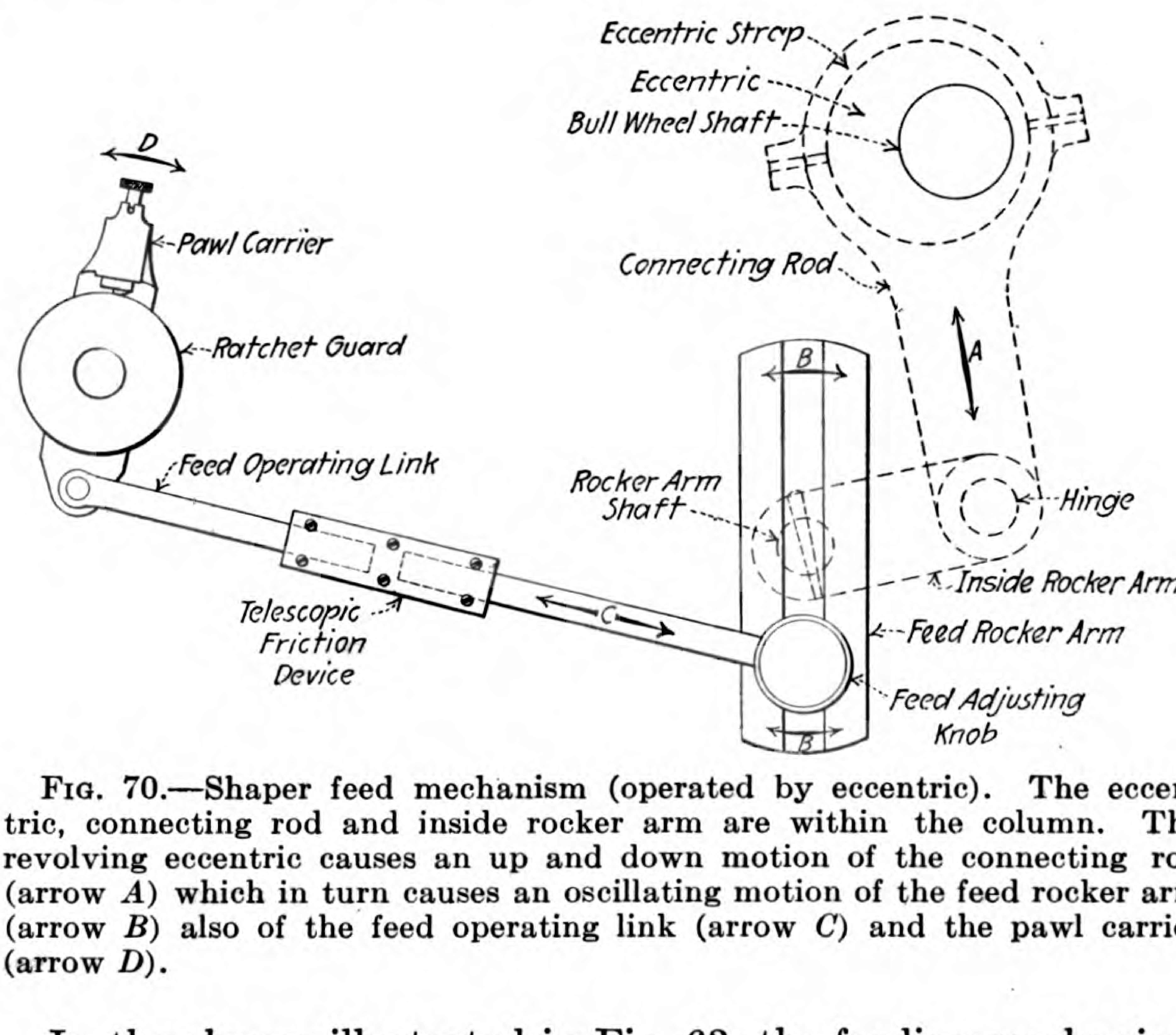


FIG. 70.—Shaper feed mechanism (operated by eccentric). The eccentric, connecting rod and inside rocker arm are within the column. The revolving eccentric causes an up and down motion of the connecting rod (arrow *A*) which in turn causes an oscillating motion of the feed rocker arm (arrow *B*) also of the feed operating link (arrow *C*) and the pawl carrier (arrow *D*).

In the shaper illustrated in Fig. 63, the feeding mechanism is operated by a crankpin (36). In this machine the oscillating movement of the pawl carrier is constant, the amount of feed being regulated by turning the knob (39) which exposes one or more teeth to the action of the pawl.

In the older shapers it was necessary to adjust the feed operating link (connecting rod) between the crankpin and the pawl carrier every time the work table was raised or lowered because of the variable distance between them. In modern shapers this is unnecessary and the ingenious devises which obviate this nuisance are interesting. See (38, Fig. 63), for one example, and the telescopic friction devise shown in Fig. 70 for another example.

TOOL HEAD. VERTICAL AND ANGULAR DOWN FEED

63. The tool head (Fig. 71) is designed to hold the tool and also for the purpose of adjusting the tool for the desired cut. A graduated collar on the down feed screw serves to indicate

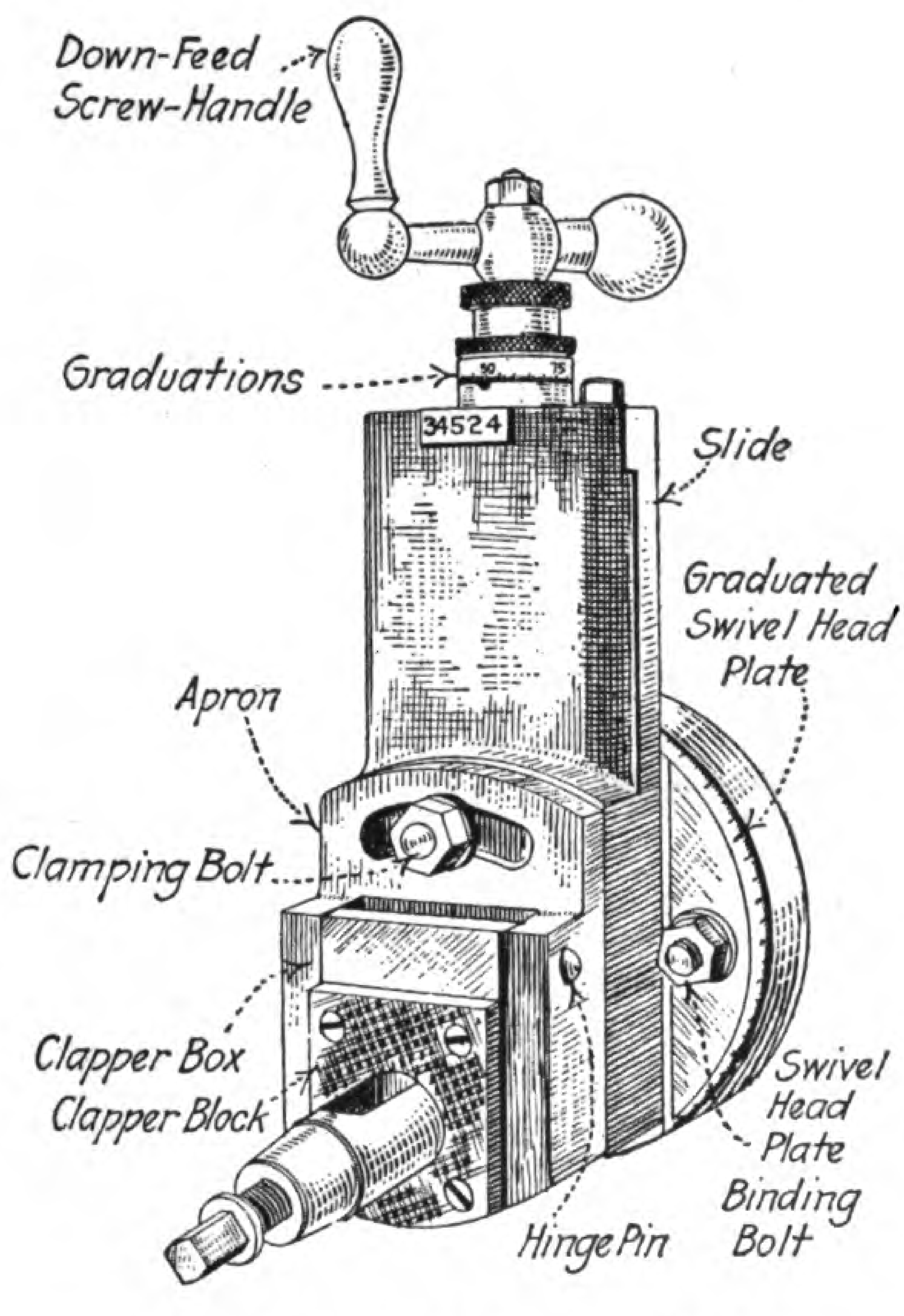


FIG. 71.—Shaper tool head.

the movement of the slide (and tool) in thousandths of an inch. Moreover, the slide and screw permit of a considerable down feed and, because of the swivel construction between the head and ram, this feed may be vertical or at any desired angle in the plane of the swivel. That is, a vertical cut of considerable depth or a fairly wide bevel cut may be taken in the shaper by means of the downfeed. The swivel head plate is graduated in degrees, and is easily adjusted after loosening the binding bolts.

The cutting tool is held in the tool post securely against the tool block, or "clapper block." The tool block fits snugly to the sides and back of the clapper box and is held by the hinge pin.

During the cutting stroke the tool block is rigidly supported in the clapper box but on the return stroke the block hinges outward slightly on the hinge pin allowing the tool practically to clear the work, and prevents the severe rubbing and consequent ruin of the cutting edge of the tool which would otherwise happen.

By loosening the apron[1] clamping bolt the whole apron may be swiveled through a small arc in either direction, for the purpose of allowing the tool to clear the work when taking a vertical or angular cut. This is more fully explained in paragraph 87, page 103.

The power downfeed is a comparatively recent development in shaper construction but most manufacturers will now furnish this feature at the option of the purchaser (see 44 to 48 inclusive Fig. 63). It is worth while for the reason that power feed is usually more efficient than hand feed.

Questions on Shaper Construction II

1. What is an eccentric?

2. Describe the feed rocker arm?

3. In what direction does the rocker arm move on the forward stroke of the shaper? On the return stroke?

4. How is motion transmitted from the rocker arm to the pawl?

5. Describe the operation of a ratchet and pawl.

6. If the feed screw is $\frac{1}{5}$ pitch (5 threads per inch) every time it makes one revolution it moves the table $\frac{1}{5}$ of an inch. If the notched wheel (ratchet) has 50 teeth, how much is one tooth feed? Two teeth? Four teeth?

7. How is the amount of feed changed?

8. How is the power feed of a shaper reversed?

9. Have the feeds arranged to cause the table to move from right to

[1] *Apron.*—The tool block, clapper box, and hinge pin comprise what is called the "apron."

left and note if the feed operates on the forward stroke or on the return stroke. Reverse the feed (to cut from left to right), does the feed operate on the same stroke as before?

10. What do you change to make the feed operate on the return stroke when the direction of the feed is reversed?

11. Why should the feed always operate on the return stroke?

12. How do you clean and oil the cross rail bearing surfaces?

13. How is the saddle plate bearing adjusted on the cross rail? Why is the provision for adjustment made?

14. Examine the head of the shaper. How is the head fastened to the ram? How may it be swiveled?

15. Set the head over 30°. What angle will the downfeed make with a horizontal surface.

16. Set the head over to make an angle of 30° between the downfeed and a horizontal surface. How much is the head swiveled?

17. What is meant by downfeed in a shaper?

18. How many thousandths does one revolution of the down feed screw handle move the slide?

19. How many graduations are there on the graduated collar? If you move the handle one graduation, how far have you moved the slide?

20. What is the value of the graduated collar on the downfeed screw? Why is it adjustable?

21. Do you read the graduations or the figures, or both? Why?

22. Clamp a tool in the tool post. Is the tool firmly seated during the forward stroke? Can it lift slightly during the return stroke? Why is it so arranged?

23. Where does the hinge pin fit tightly? How does it fit in the clapper block? Where is it oiled?

CHAPTER V

SHAPER WORK

64. Shaper Cutting Tools.—The variety of cuts that may be made in a shaper on any of the metals used in machine construction calls for various shapes of tools. The general shapes are illustrated in the chart (Fig. 74). The similarity of certain of these tools to lathe tools will be apparent; they differ, however, in respect to the clearance angles. The lathe turning tool, for example, is ground with 10° or 12° front clearance, but is set above center to have the effect of perhaps 2° or 3° working clearance.

65. Clearance Angles.—There is no rocker in the tool post of the shaper, hence the tool cannot be adjusted for clearance;

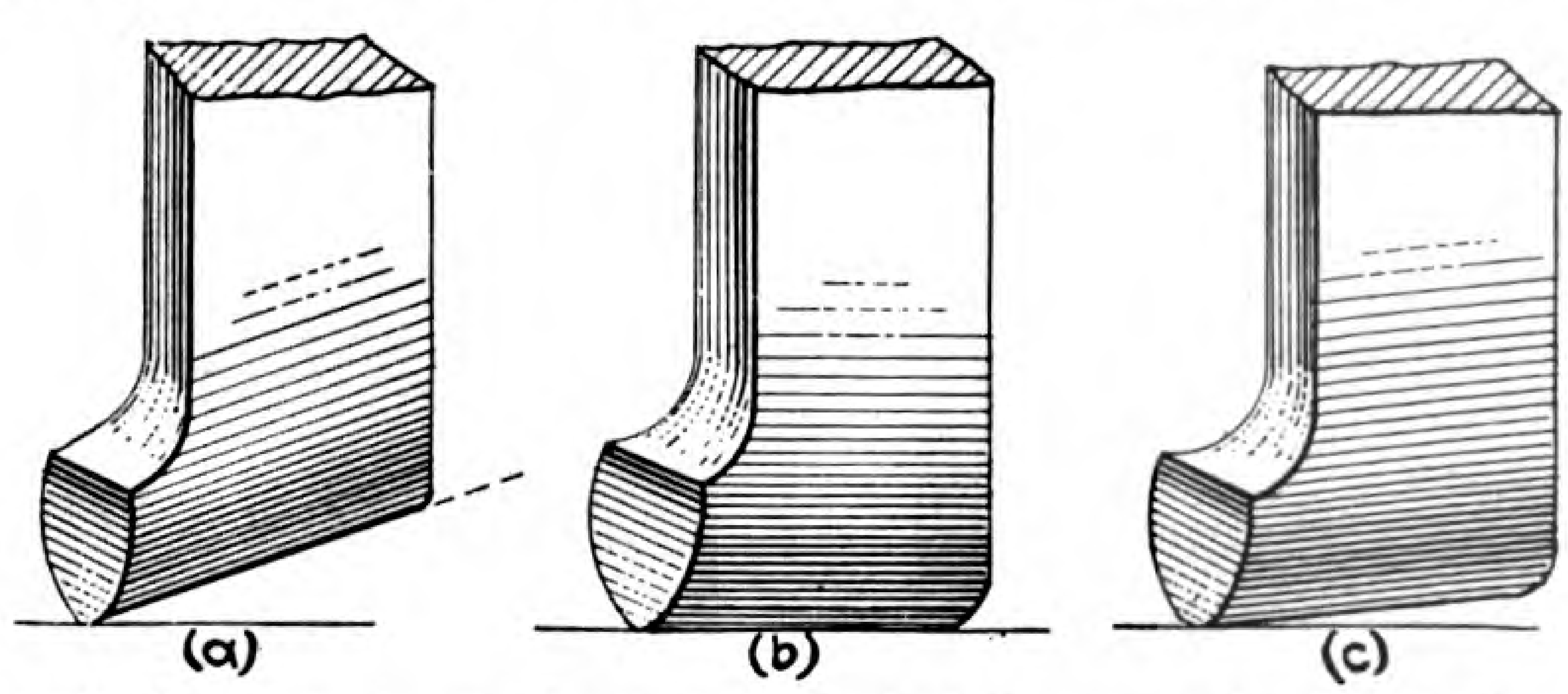


FIG. 72.—Front clearance on shaper tool, (*a*) too much; (*b*) not any, will rub; (*c*) correct, about 3 degrees.

the proper clearance angles must be ground on the tool. The front clearance angle is usually about 3° *c*, (Fig. 72). Since the shaper feed does not operate during the cut as does the lathe feed, a side clearance of 2° or 3° is plenty.

NOTE.—The elements of a shaper tool or planer tool, that is, the front, side, front clearance, side clearance, front rake, side rake, etc., are in the same relative positions as on a lathe tool, regardless of the fact that the shaper tool when in operation is held vertically and the lathe tool horizontally.

If a shaper tool is given too much front clearance *a*, (Fig. 72,) it will dull quickly because the cutting edge, not being backed up by metal, crumbles away; if given no front clearance the cutting edge cannot well get under the chip and will merely rub, spoiling the appearance of the work. The same is true with regard to side clearance. Briefly stated, the shaper cut is a straight-away cut and just sufficient front and side clearance is given the cutting edge of the tool that there is no tendency for any part of the tool to rub.

66. Rake Angle.—The shaper tool is usually given side rake of 10° or more depending on the kind of tool and on the hardness of the metal to be machined, but no front rake

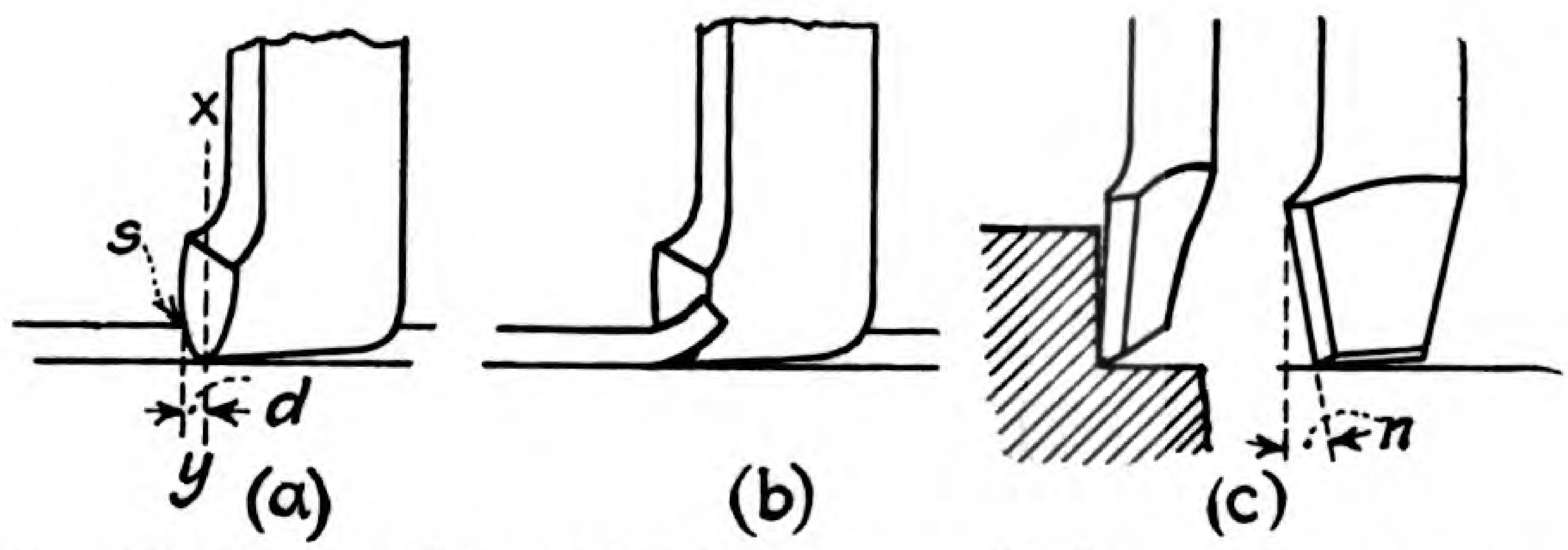


FIG. 73.—Cutting action of tool when machining a plane surface. Note in view (*a*) that line *xy* is parallel to the base of the tool and therefore the tool has no front rake. Note also that since the cutting edge is given side rake, the start of the cut is made at *s* and the distance *d* is traversed before the full depth of the cut is taken; thus the tool enters the work gradually and prevents the shock of the full cutting edge striking the metal at once. The way in which the chip curves is shown in (*b*). In (*c*) is shown a side tool with the cutting edge ground flat to take a finishing cut, say a quarter of an inch or more wide. Note the angle of shear *n* to give an easy start and finish of the cut. A side tool ground in this way is much used in shaper and planer work for finishing cast iron.

except in the finishing tools. The action of a tool when machining plane surfaces is illustrated in Fig. 73.

67. Right-hand and Left-hand Tools.—When setting up a job in any machine it is best if possible to arrange the work and also the tool in such a way that the operator can readily see the cut from his normal position at the machine, that is, from the position in which he controls the machine. For this reason it is customary when taking a horizontal cut on the shaper or planer to start the cut on the side towards the operator, and when shoulder or similar cuts are to be made, to arrange the work so these cuts will come on this side. Many shaper jobs, however, include tongues, grooves, and angles which involve cuts on both sides of the work. Since in work of this kind it often makes for greater accuracy and speed to *machine in one setting of the work all of the surfaces possible,* it is necessary to have right-hand and left-hand tools.

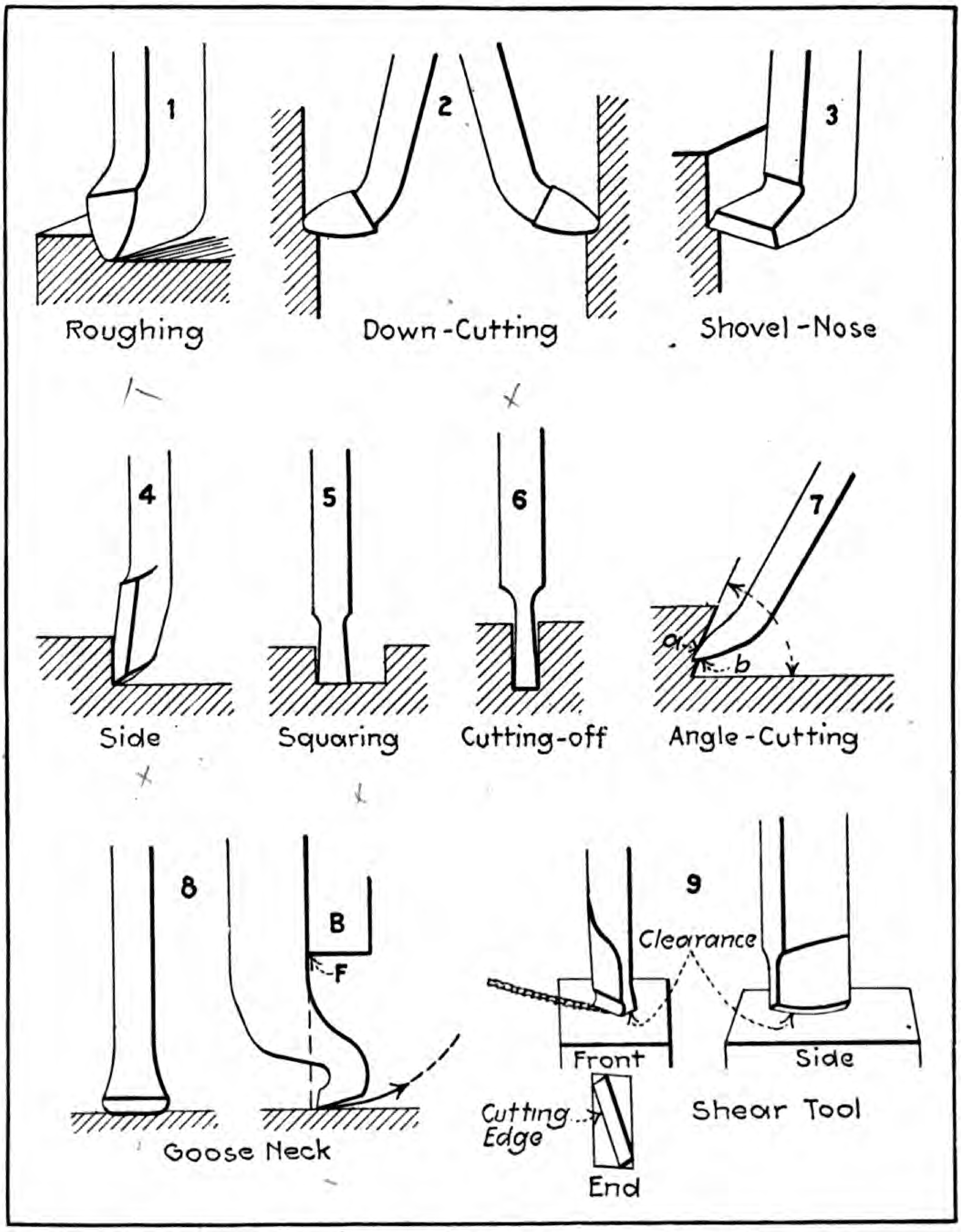


FIG. 74.—Chart of forged shaper tools.

The terms right-hand and left-hand as applied to shaper or planer tools are derived from lathe tools of similar shape. The right-hand tool is most used in the lathe and the left-hand tool is most used for shaper and planer work.

FORGED SHAPER TOOLS

1. *Roughing* or "Shaper Tool."—Similar in contour to lathe turning tool (Taylor). Has side rake but no top rake; amount of side rake, 10° to 20°, depends on the hardness of the metal being cut, the harder the metal the less the rake. For run of shop jobs a very efficient tool for roughing either cast iron or steel. To save the time of changing tools it may be used with a fairly fine feed for finishing smaller surfaces. Used mostly left hand (as shown) but may be ground with the proper clearance and rake and used right hand.

2. *Down Cutting.*—Made substantially in the shape of R. H. or L. H. roughing tool except that it is bent as shown in order to cut down on a vertical surface.

3. *Shovel Nose.*—A very popular and efficient tool for cutting down; cutting edge is widest part of tool; corners are slightly rounded for longer life; cuts down equally well on either right or left side. A tool of this same general shape may be used with a very light chip, coarse feed and a slow speed for finishing horizontal cast iron surfaces.

4. *Side Tool.*—Made either R. H. or L. H. Used for finishing vertical cuts and occasionally for finishing a narrow horizontal cut adjacent to the vertical cut.

5. *Squaring.*—Cutting edge is widest part of blade. Made in any desired width for roughing and finishing sides and bottoms of grooves, keyways, and shallow shoulder cuts.

6. *Cutting Off.*—Similar to lathe cutting off tool, except for front clearance.

7. *Angle Cutting.*—Made either R. H. or L. H. Cutting edges *a* and *b* are ground to the angle required, as for example, 60° as shown. The cutting edge *a* finishes the angular surface, and *b* finishes the horizontal surface. A light chip and fine feed is used for finishing. For roughing the point should be well rounded to give longer life to the tool.

8. *Spring Tool or "Goose Neck."*—For finishing cast iron. Owing to the fact that the cutting edge is back of the fulcrum point *F* of the tool shank in clapper block *B* any spring of the cutting tool is in the direction of the arrow or away from the surface of the work. With this tool there is less tendency to chatter and to "dig in" than with such a tool as the shovel nose.

9. *Shear Tool.*—Used to obtain a particularly high machine finish on steel. It is forged with the blade about $3/16''$ thick and twisted 15 or 20 degrees. The cutting edge is ground on a curve ($3''$ or $4''$ radius) and backed-off. With $.003''$ or $.004''$ chip and one-tooth feed an excellent finish is obtained, especially if lard oil is used as a lubricant.

68. Tool Holders.—The tool holder and high-speed steel bit have largely superseded the forged tool for shaper work. The tool bit may be ground to the shape required to accomplish the desired result for practically any operation. Figure 75 shows a patented tool holder (Armstrong) which in the smaller size is used for shaper work and in the larger size is very efficient for use in the planer. The construction of this tool holder permits of the tool bit being securely and rigidly held in any one of the five positions shown in *b* so that horizon-

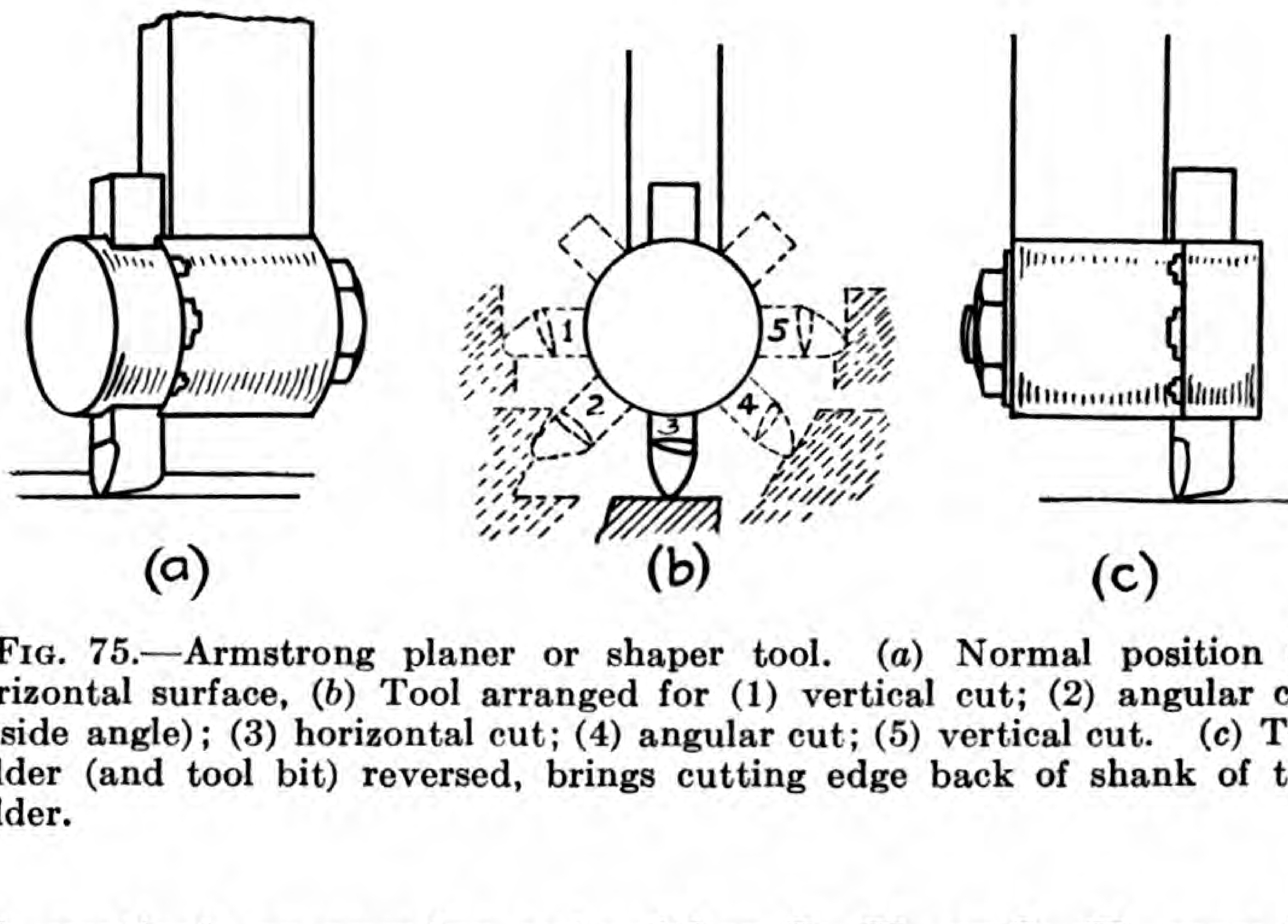


FIG. 75.—Armstrong planer or shaper tool. (*a*) Normal position for horizontal surface, (*b*) Tool arranged for (1) vertical cut; (2) angular cut, (inside angle); (3) horizontal cut; (4) angular cut; (5) vertical cut. (*c*) Tool holder (and tool bit) reversed, brings cutting edge back of shank of tool holder.

tal, vertical, or angular cuts either R. H. or L. H. may be made. Another advantage of this tool holder lies in the fact that for heavy cuts the tool holder may be reversed in the tool post (and of course, the tool bit is also reversed, see Fig. 75 *c*). Since the cutting edge is then back of the shank of the tool the tendency of the tool to chatter or to "dig in" is eliminated. In any case the tool bit should not be allowed to project too ar, as this will result in unnecessary spring.

The lathe turning tool holder and bit makes a very satisfactory shaper tool provided the tool bit is not given too much clearance, especially too much front clearance. Of course, the position of the bit set at an angle of 20° with the shank of the tool gives a front rake which, while not being desirable, is not prohibitive for light cuts.

The spring tool holder, an example of which is illustrated in Fig. 76 is especially useful in shaper work. Since the body is in the form of a substantial U-shaped spring, this tool holder provides the characteristic feature of the goose neck (8) (Fig. 74). A forming tool of the desired outline may be quickly made for use in this holder to produce a narrow irregular surface (see paragraph 90 page 108).

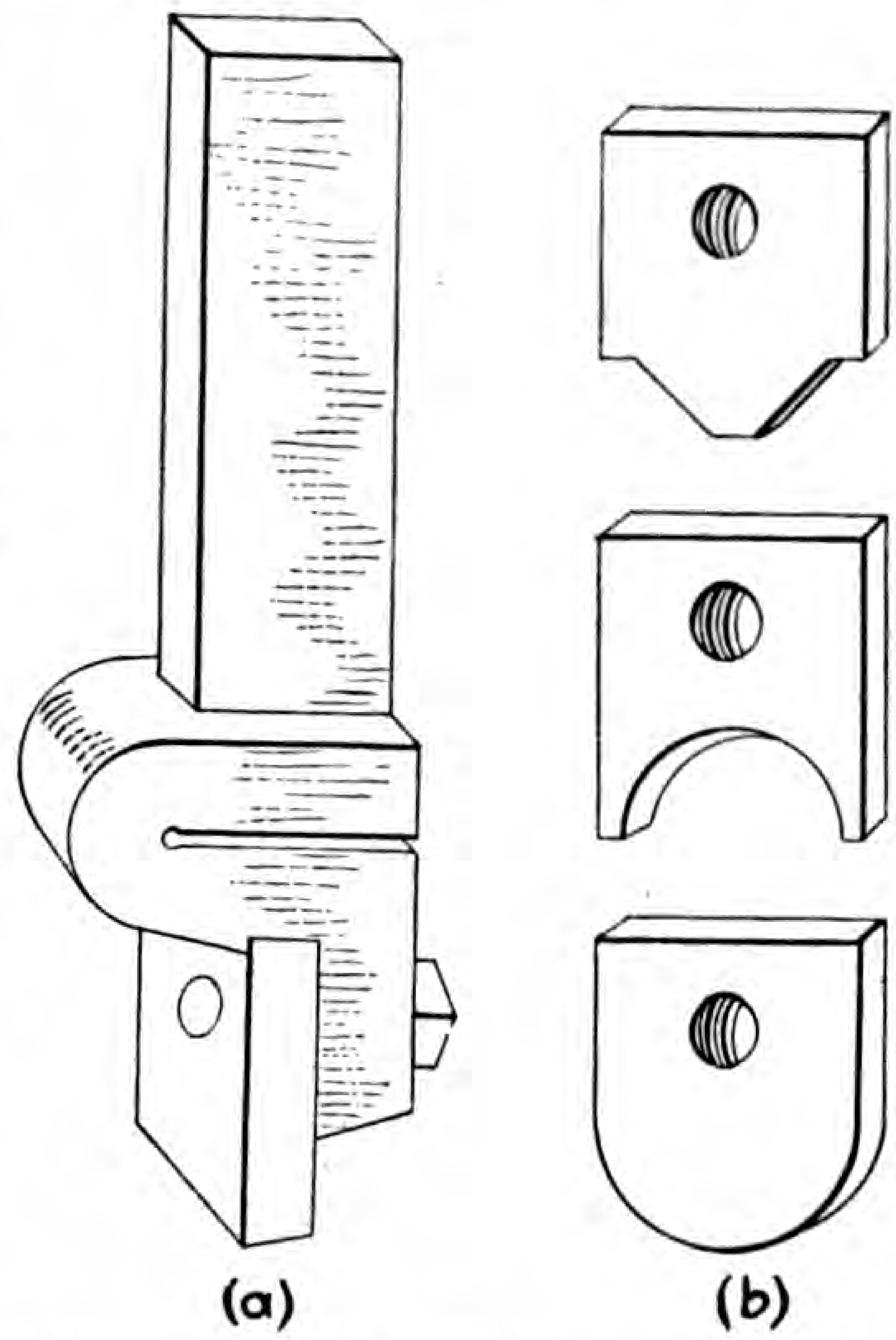


FIG. 76.—(*a*) Spring tool holder and square nose tool. (*b*) types of tools.

Questions on Shaper Tools

1. What is the general shape (contour) of the cutting edge of the most commonly used shaper tool?

2. How much front clearance has a shaper tool? How much side clearance? Why is a rocker not provided with the shaper tool post?

3. Why will a shaper tool dull quickly if given too much clearance?

4. Why is rake ground on a tool? Do the same principles that determine the amount of rake that is given a lathe tool apply to the shaper tool?

5. If a shaper tool has side rake will it cut equally well if fed in either direction? Give reason.

6. What is the particular value of the spring tool?

7. How much rake has a shear tool? Are you able to grind a shear tool on the end of a tool bit?

8. Why is a shovel nose tool particularly good for cutting down? Does it have value for radial facing in a lathe for the same reason?

9. Why is it wise to remove the tool bit from the holder before grinding?

69. Speeds and Feeds.—The reason for machining metal parts (in any machine tool) is usually twofold: (1) to remove surplus metal bringing the work to a given size and (2) to produce a smooth surface. To accomplish these results at least two cuts, one or more roughing cuts and a finishing cut are nearly always necessary. To operate the machine efficiently to produce these results means a reasonable understanding of the proper speed feed and chip for roughing and also for finishing.

To understand the cutting speed is comparatively easy; it depends almost entirely on three things: (1) the kind of material being cut is a factor, the softer the material the faster the speed at which it may be cut. (2) The amount of material being removed in a given time is a factor, a light cut may usually be taken at a greater speed than a heavy cut; for example, the speed for a finishing cut in steel may often be increased 25 per cent over the roughing speed. (3) The kind of steel from which the cutting tool is made is a very important consideration because a high-speed tool will cut at least double the speed of the carbon steel tool.

70. Depth of Cut and Feed.—The value of any machine tool depends upon its power; the strength and rigidity of its construction; the rapidity and smoothness of its action; its convenience in operation and its accuracy. Modern shapers may be classed as particularly rugged machines, carefully designed and accurately built. Whenever a considerable amount of metal must be removed the shaper should be made to *work* during the roughing cut, that is, the cutting speed should be suitable and the depth of cut and feed should be proportioned to remove as big a chip as the shaper will drive, provided the nature of the work, the way it is held and the strength of the tool will permit. It is impossible to give a rule for the depth of cut or the amount of feed, or for a proportion of feed and chip, but the following suggestions may help the beginner.

First, with a given tool and the given amount of metal to be removed per cut, a coarse feed and lighter chip is not as efficient as a deeper chip and a finer feed for two reasons: (1) the thick chip does not curl so easily and takes more power and (2) the tear in the metal is greater thus producing a rougher surface. A safe rule to follow is to give as much feed as possible without producing a rough or torn surface, and then all the chip the machine and tool will stand, provided that amount of metal must be removed.

Second, the angle the cutting edge of the tool makes with the surface being cut has a considerable influence on the thickness of the chip. This is illustrated in *a*, (Fig. 77) which represents three chips with the same depth *D* and the same feed *F* but different thicknesses *T* due to the different angles the cutting edge *E* has with the surface of the work. It has been found by experience that a tool with the cutting edge about 20° from the perpendicular *b*, (Fig. 77) with the end well rounded will give the most efficient results in roughing either cast iron or steel.

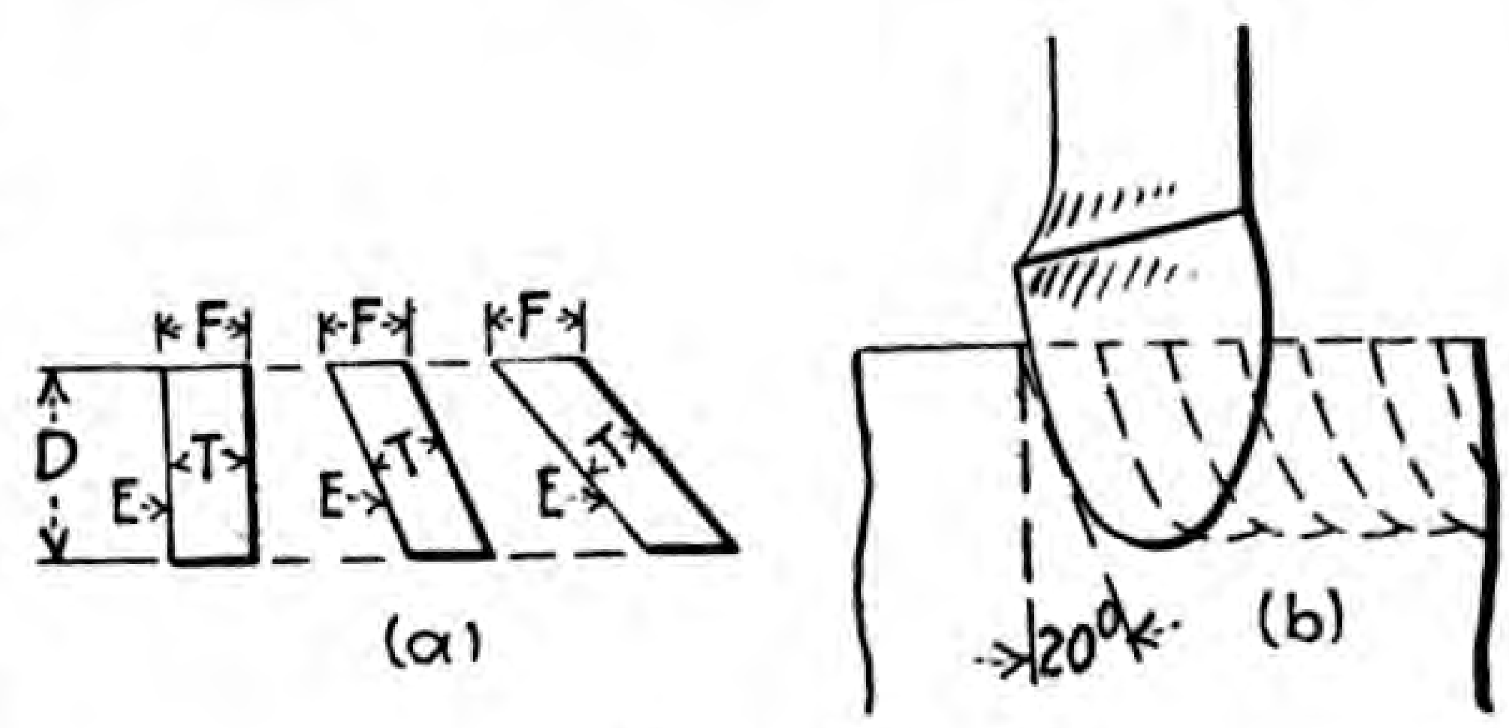


FIG. 77.

The following table of (average) cutting speeds and feeds of cutting tools made of carbon and high speed steels is given for the convenience of the beginner.

TABLE OF SPEEDS AND FEEDS

Cutting tool	Cast iron		Mach ne steel		Carbon steel		Brass	
	Speed	Feed	Speed	Feed	Speed	Feed	Speed	Feed
High-speed steel..	60	1/12	80	1/16	50	1/20	160	1/20
Carbon steel......	30	1/16	40	1/20	25	1/25	100	1/20

The usual practice is to run the shaper too slowly. It is well for the beginner to calculate the number of strokes necessary to give the proper cutting speed for the work at hand until he gets accustomed to seeing the shaper move fast enough.

71. Cutting Speed Calculation.—The calculations for cutting speed for shaper work are more involved than for lathe or drill press work for the reason that the shaper cuts only during the forward stroke and further, the return stroke is faster than the cutting stroke.

Given the ratio of return stroke *time* to cutting stroke *time* as explained in paragraph 59, as 2:3, the sum of the terms of the ratio equals 5 and $\frac{2}{5}$ of the time equals the *time* of the return stroke and $\frac{3}{5}$ of the time equals the *time* of the cutting stroke.

Given the length of stroke in inches and the number of strokes per minute, their product gives the number of inches cut during one minute of the machine's operation. Since cutting speed is expressed in feet this must be multiplied by $\frac{1}{12}$ to reduce to inches. As noted above the actual time of cutting this distance is $\frac{3}{5}$ minute. Therefore since distance divided by time equals rate, divide the distance (in feet) by $\frac{3}{5}$ (*i.e.* multiply by $\frac{5}{3}$) and the result will be the cutting speed. Instead of multiplying in every problem first by $\frac{1}{12}$ and then by $\frac{5}{3}$ it will be quicker to multiply by .14 which amounts to the same thing ($\frac{1}{12} \times \frac{5}{3} = .14$ approximately). Hence the following:

Rule I.—To obtain cutting speed, *number of cutting strokes* and *length of stroke* being given:

Multiply the number of strokes per minute (N) by the length of stroke in inches (L) and the product by .14. Formula: $.14NL = \text{C. S.}$

Example.—Length of stroke 8″. Number of strokes per minute 30. What is the cutting speed?

Solution.—$8 \times 30 \times .14 = 33.6$.

Rule II.—To obtain the number of strokes necessary, required cutting speed and length of stroke being given:

Multiply the cutting speed by 7 and divide by the length of the stroke in inches. Formula: $N = \dfrac{C.\ S. \times 7}{L.}$

(*Derivation.*—From Rule I, $.14\,NL = \text{C. S.}$, or $N = \dfrac{C.S.}{L \times .14} = \dfrac{C.S.}{L} \times \dfrac{1}{.14} = \dfrac{C.S. \times 7.2}{L}$ and for practical purposes $N = \dfrac{C.\ S. \times 7}{L}$ is near enough.)

Example.—Length of stroke 8″. Required cutting speed 33 feet per minute. How many strokes per minute will be necessary?

Solution.— $\frac{33 \times 7}{8} = 30$ (about).

Questions on Speed, Feed and Chip

1. The proper cutting speed for a given job depends on three things. What are they? Give an example of each.

2. What is a safe proposition to follow concerning the feed and chip?

3. How would you grind and set a tool for roughing cast iron? For roughing steel?

4. About what cutting speed will be practical to start with on cast iron? Is the tool you are to use carbon steel or high-speed steel?

5. May it possibly be wise before long to change to a faster speed? To a slower speed? Give reasons.

6. How many strokes per minute are necessary to give the required cutting speed?

7. Do you suppose a machinist would use a formula to calculate the number of strokes necessary? How would he go about it? Of what value is the formula to the beginner?

72. Holding the Work.—Most shaper work is held in a vise which is bolted to the top of the table. However, the vise may be removed and work which is too large or otherwise impracticable to hold in the vise may be bolted to the top or side of the table, or to an angle plate or any special plate or other holding device fastened on the table. The cuts Figs. 78, 79, 80 and 81, show typical shaper set-ups.

73. The shaper vise is illustrated in Fig. 63 (Nos. 24 to 27). The body may be swivelled on the base plate to any angle desired, graduations in degrees showing the angular setting. This swivel feature is often useful for beveling ends, planing adjacent faces at other than 90° etc., but most of the work is done with the vise jaws either parallel with or at right angles to the direction of the cut. The shaper vise is especially strong, the jaws are long and deep, and the adjustment is sufficient to take work of a considerable width. The jaws are left soft and great care must be taken when clamping work to prevent them from being scored and dented. An auxillary rocker jaw is furnished for securely holding tapered pieces.

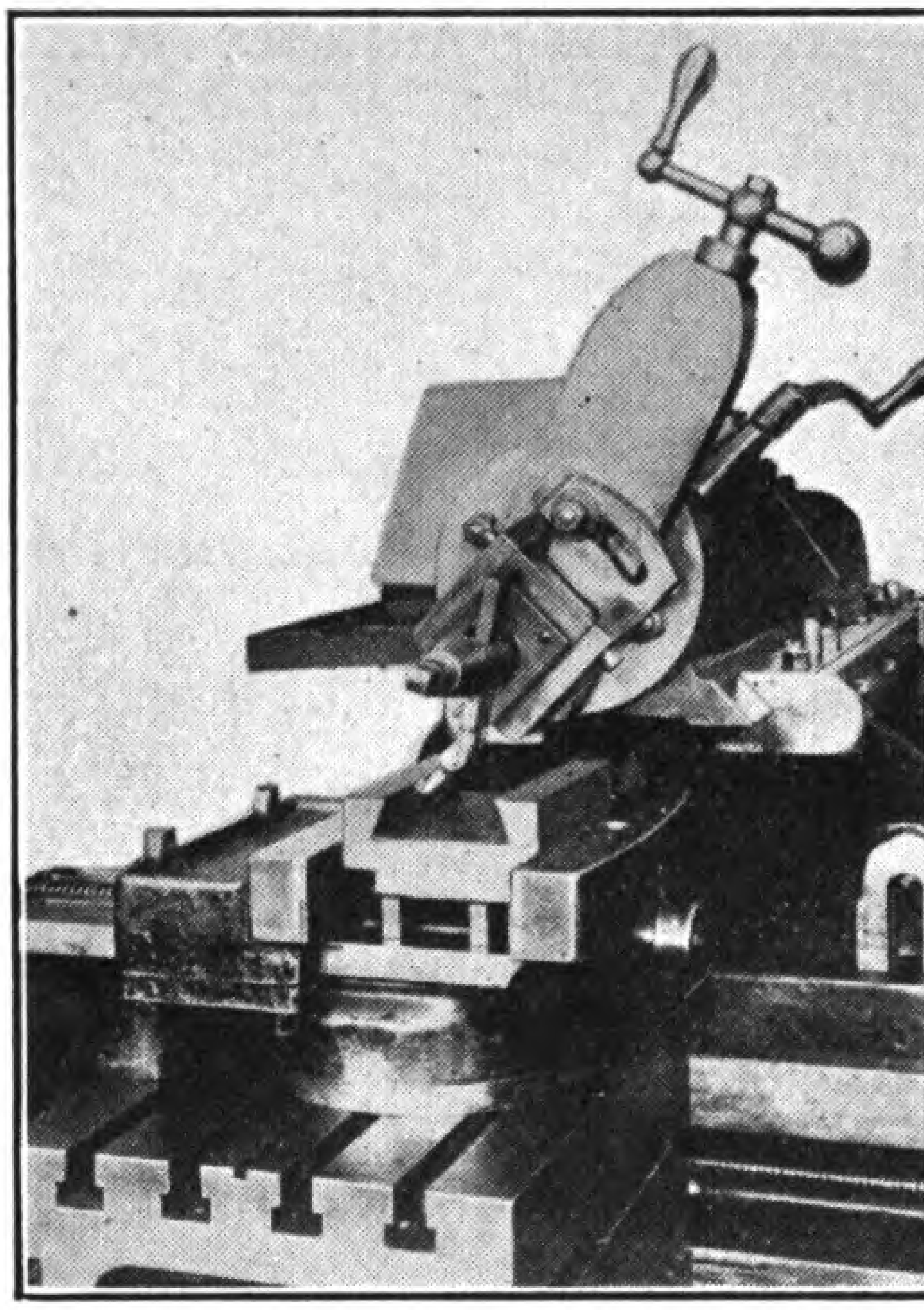


FIG. 78.—Planing a dove-tail slide bearing. Note the set over of the head and also of the apron.

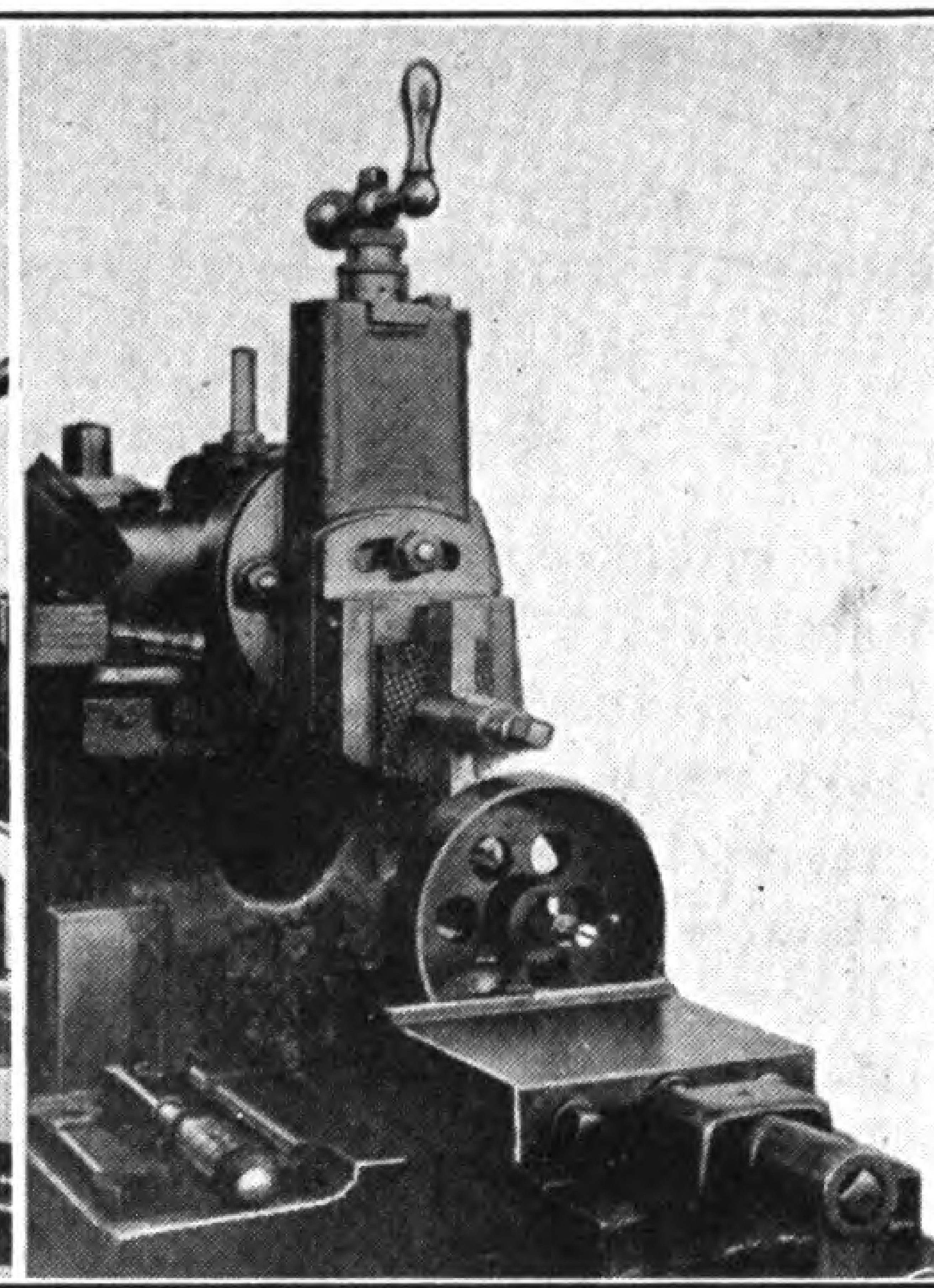


FIG. 79.—Planing a keyseat in a pulley. (The pulley is held in a milling vise gripped in the shaper vise.)

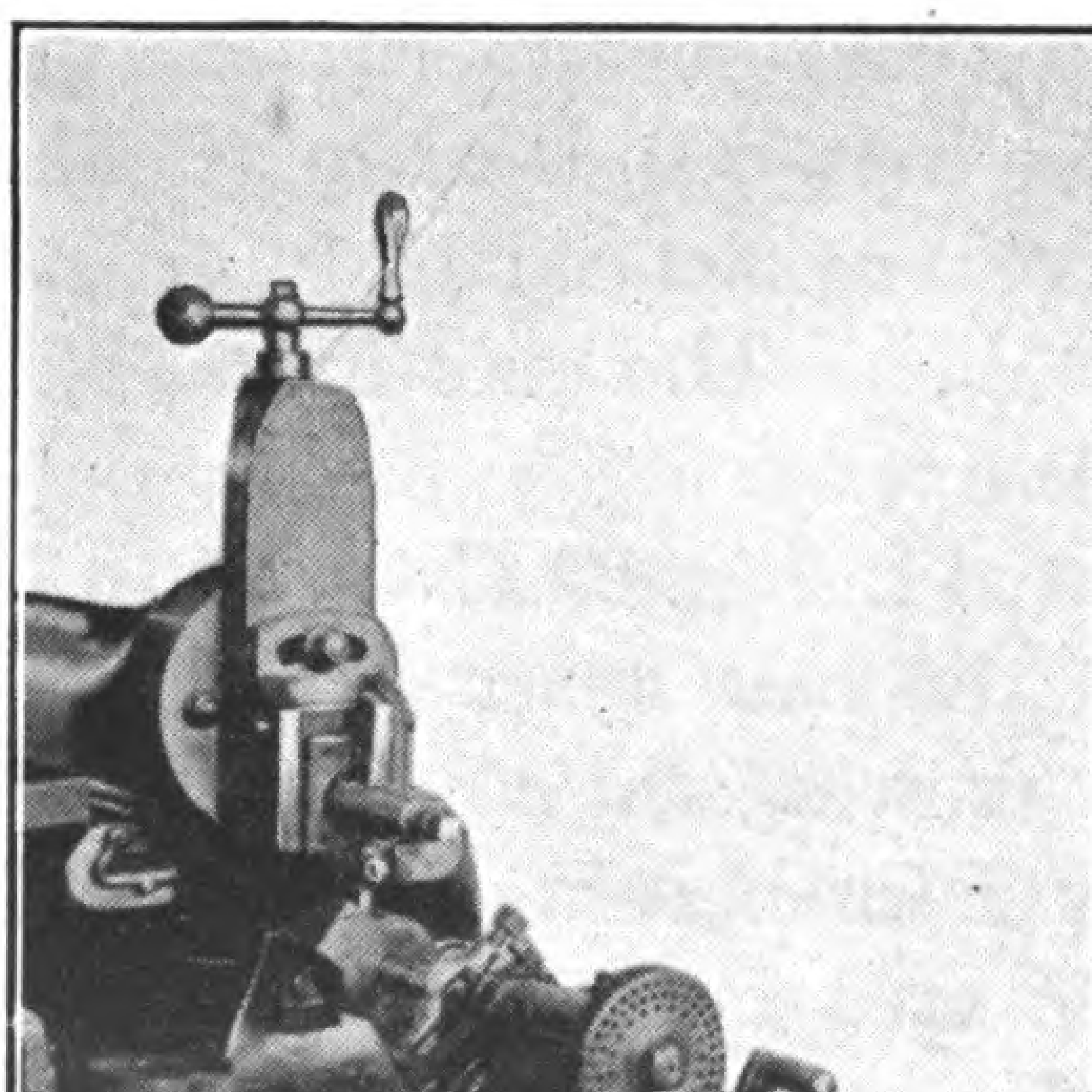


FIG. 80.—Using the shaper centers.

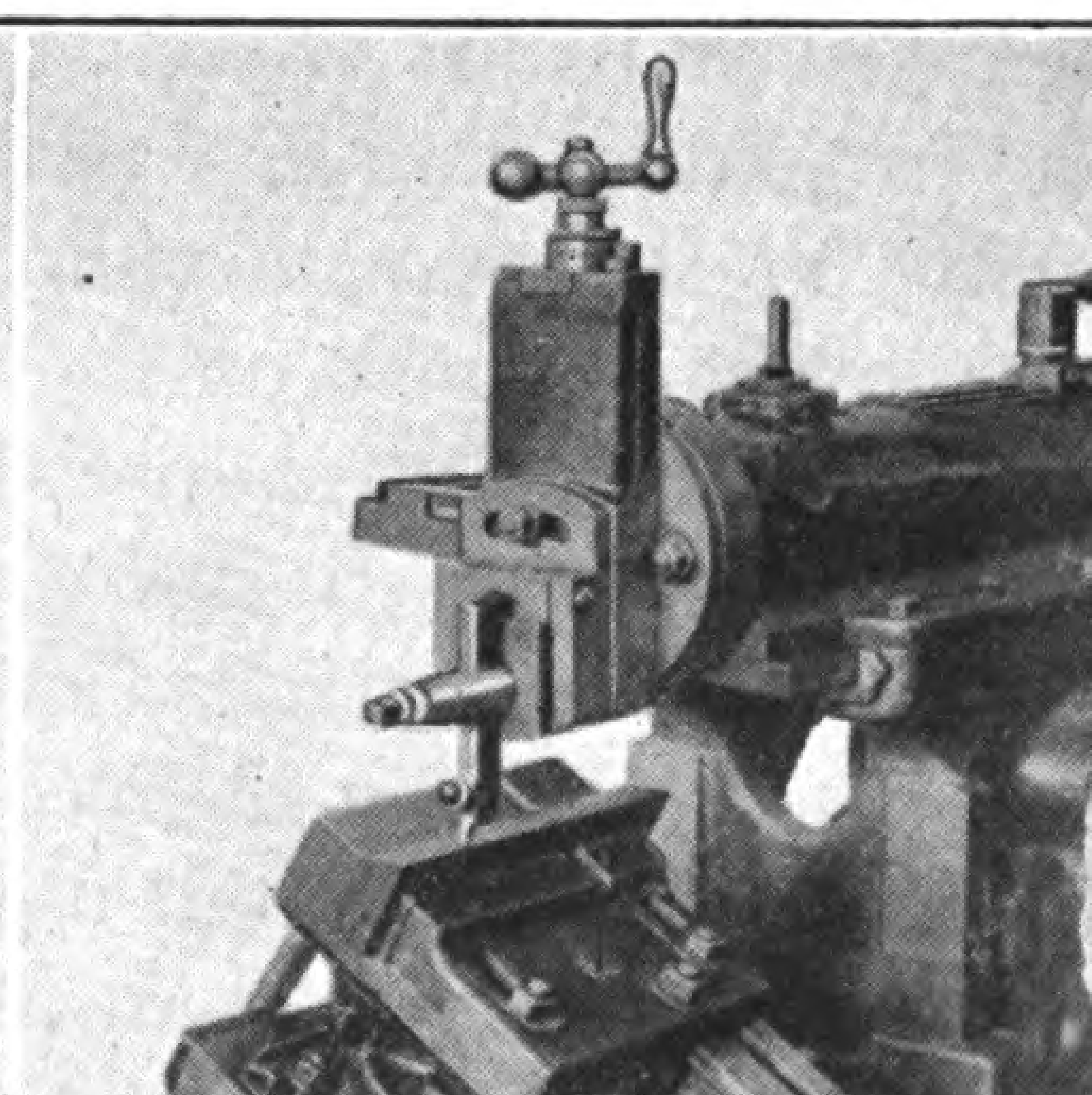


FIG. 81.—Shows universal table.

74. Angle plates, (Fig. 82), are of any size required, and are usually iron castings. An angle plate is composed of two members or wings, the outer surfaces of which are machined flat at an angle (usually 90°) to each other. When in use one

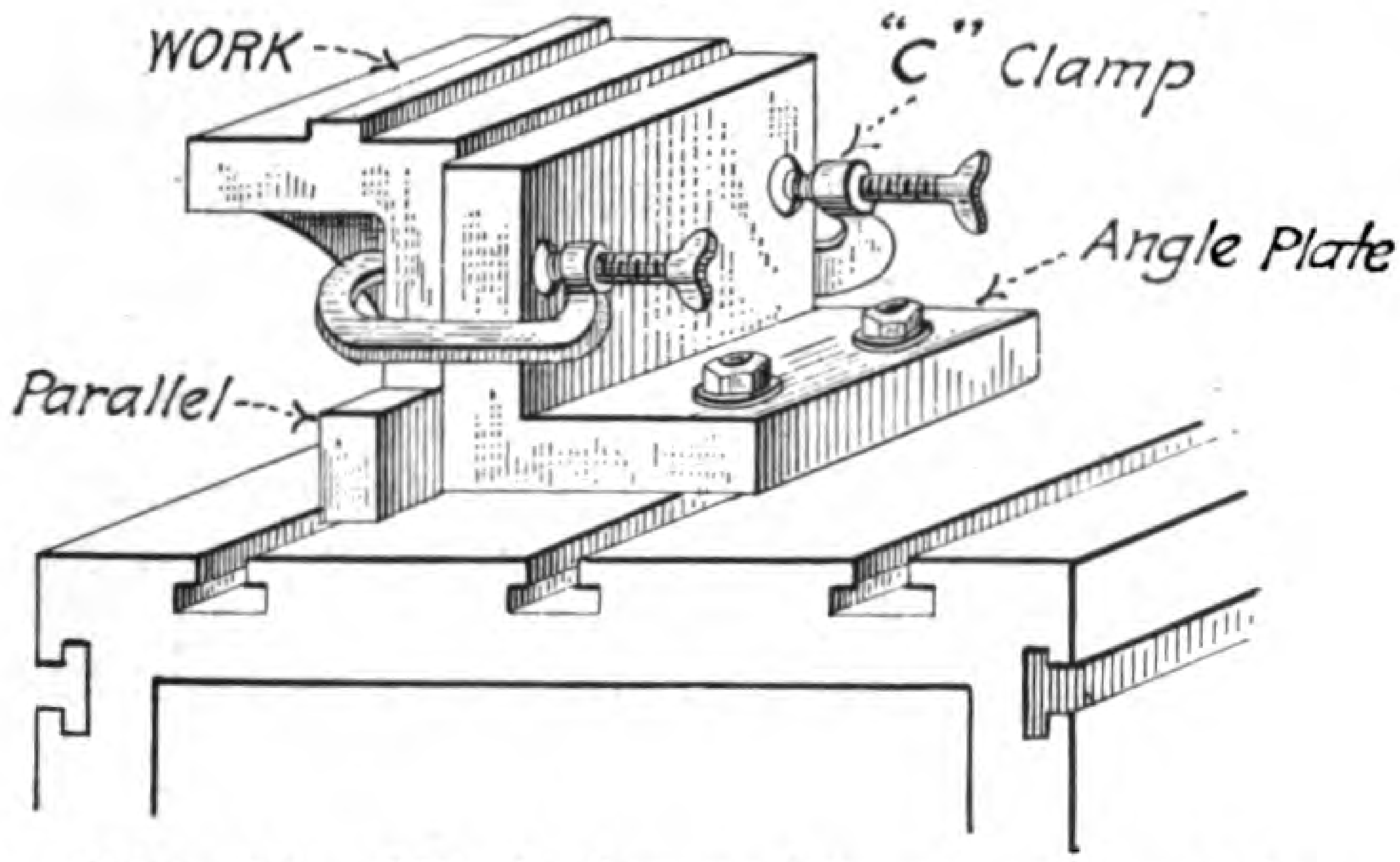


Fig. 82.—Work clamped to an angle plate.

surface is bolted to the table and the work is fastened to the other surface. Some angle plates have one of the inner surfaces finished which permits of work being bolted to this surface when desirable.

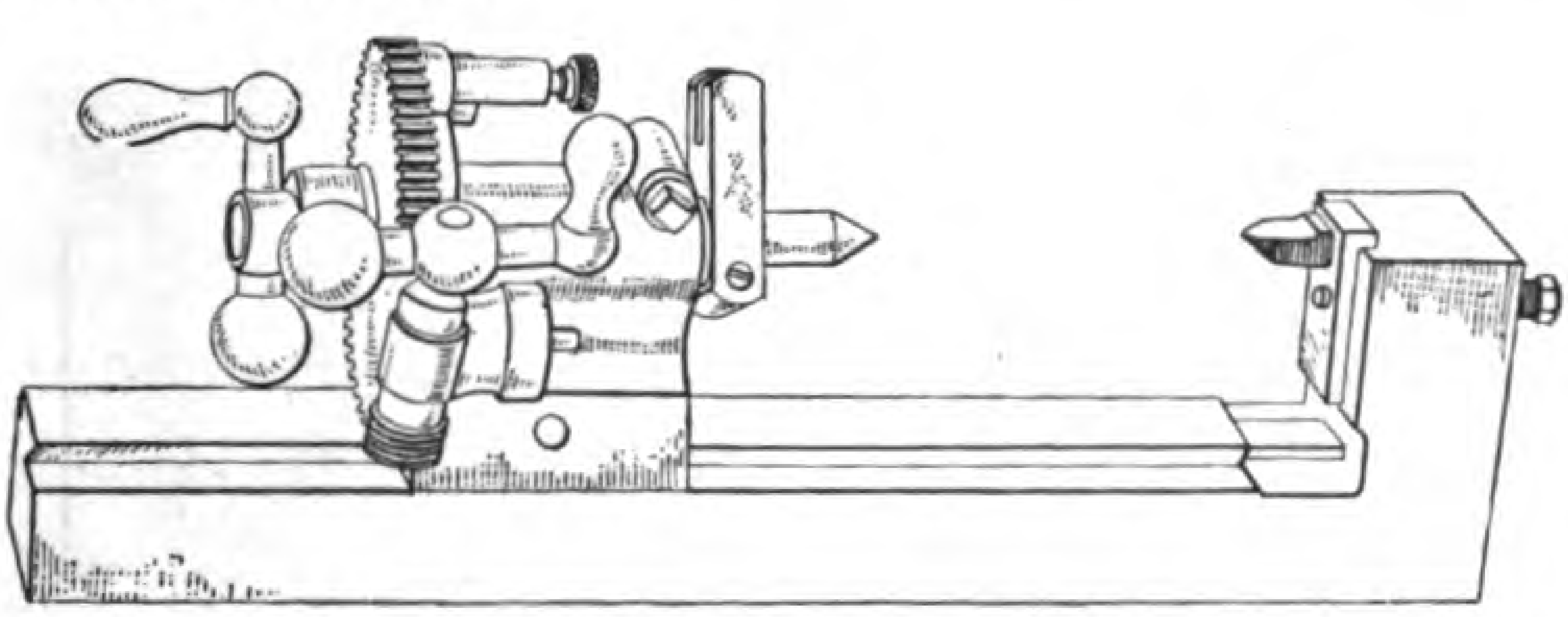


Fig. 83.—Shaper index centers. (*Potter and Johnson.*)

These index centers are designed to be gripped in the vise, and as the base of the vise is circular and graduated, the centers can be adjusted to any horizontal angle. The dead center has a vertical movement for taper work. The live spindle has screw adjustment longitudinally and it is revolved by worm and worm gear, or direct, with the worm thrown out of engagement. The worm gear has a series of holes drilled in its face, and the arrangement of the holes enables square, hexagonal and other common forms to be planed. The adjustable index head has a longitudinal movement for the entire distance between centers. Swing, 4 inches; maximum distance between centers, 8½ inches.

Holes are drilled where necessary for the clamping bolts, sometimes tapped holes are more convenient for the purpose of clamping the work, and often C-clamps are used.

In an *adjustable angle plate* the two members are hinged and a device is provided for clamping them rigidly when they are set at the required angle to each other.

75. Shaper centers, (Figs. 80 and 83), are very useful for certain curved surfaces that are partially cylindrical but have projecting portions and consequently cannot be turned in a lathe. They may often be used for finishing surfaces of pieces held on a mandrel more advantageously than the work could be done in a milling machine. The construction of the head permits of a variety of indexing[1] operations.

76. Parallels, (Fig. 84), are pieces of cast iron or steel of rectangular cross-section, of considerable length in proportion to their width and thickness, with opposite sides parallel and adjacent sides square. They are used to raise the work to the required height in the vise or to otherwise bolster and level it.

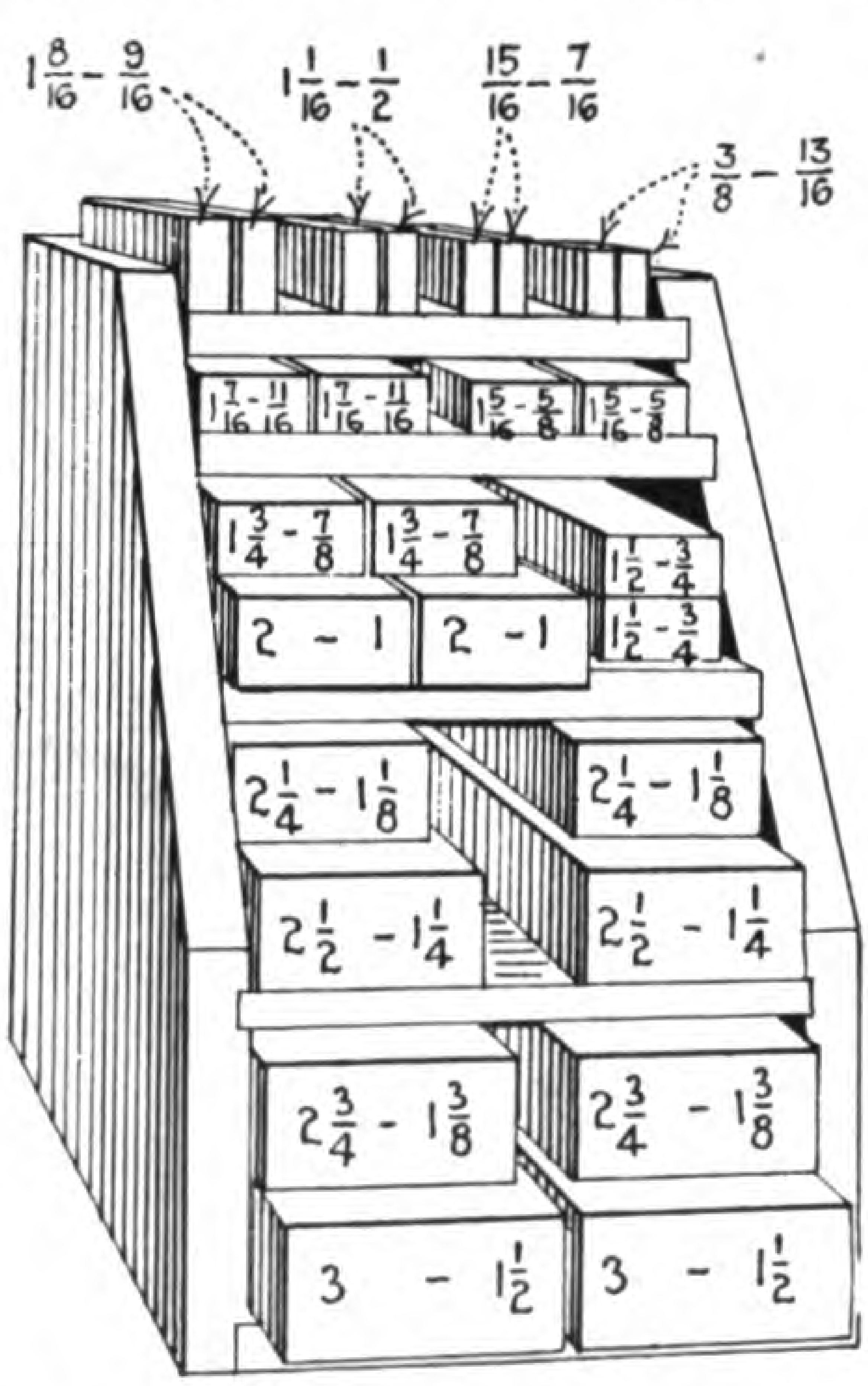


FIG. 84.—Parallels. (*O. S. Walker Co.*)

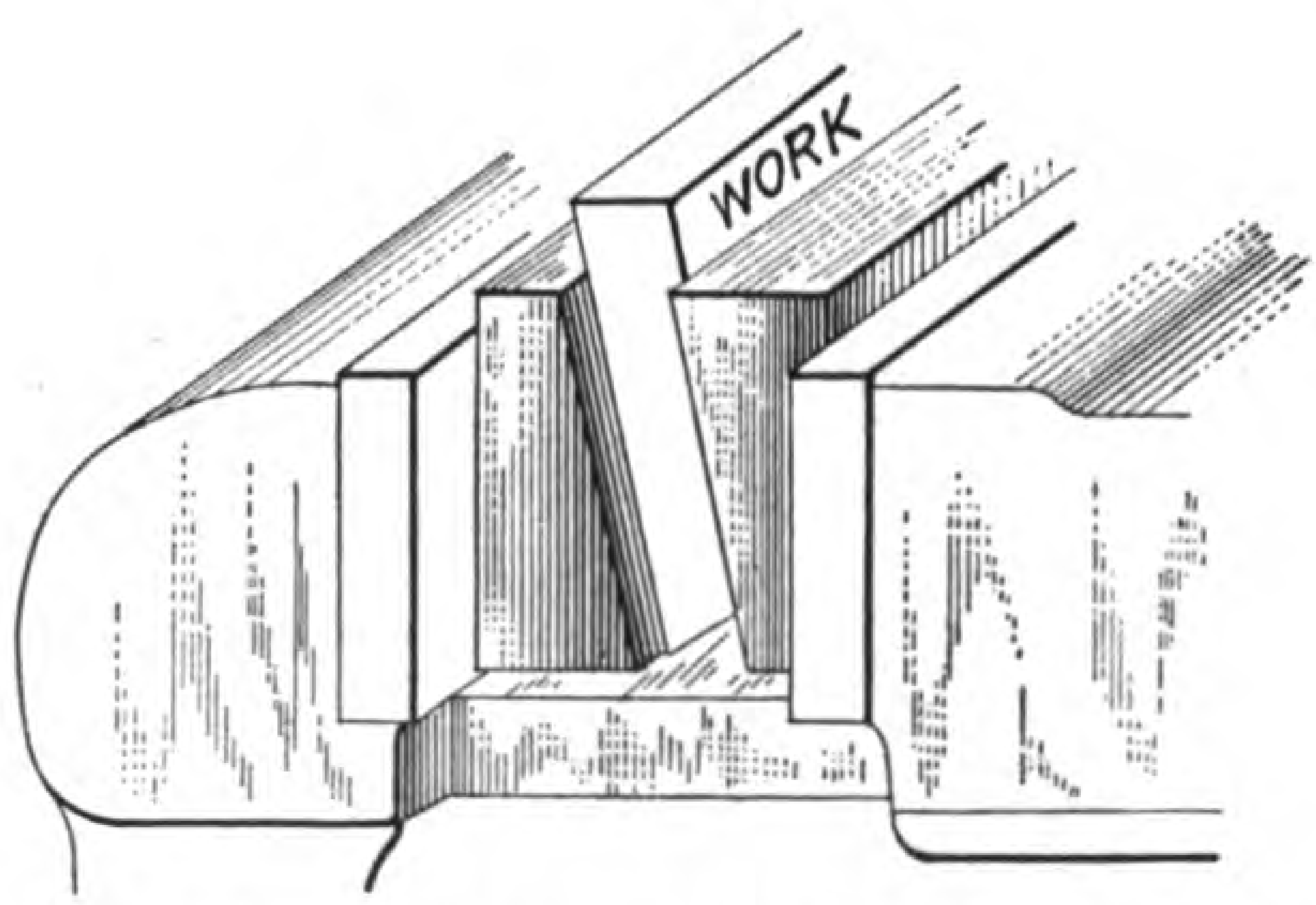


FIG. 85.—Shows application of degree parallels.

Parallels are made in pairs. Two or more pairs may often be used together.

77. Degree parallels (Fig. 85), so called, are similar to regular parallels except that one side of each parallel is planed "out of square" with the adjacent side a certain number of degrees.

78. Hold downs, or grippers (Fig. 86) are thin pieces of approximately triangular cross-section, of the length desired,

[1] *Indexing.*—Turning the work an exact indicated amount on its axis.

(6″ more or less) used most frequently to hold thin pieces in the vise. The narrow edge is rounded and the opposite edge is beveled about 2° toward the bottom. This insures the work being held down on the bottom of the vise or on a parallel as the case may be. Hold downs are especially valuable when parallels of the required height to raise the thinner pieces just above the vise jaws are not available. They are very useful also when it is desired to finish only the two opposite surfaces of a piece.

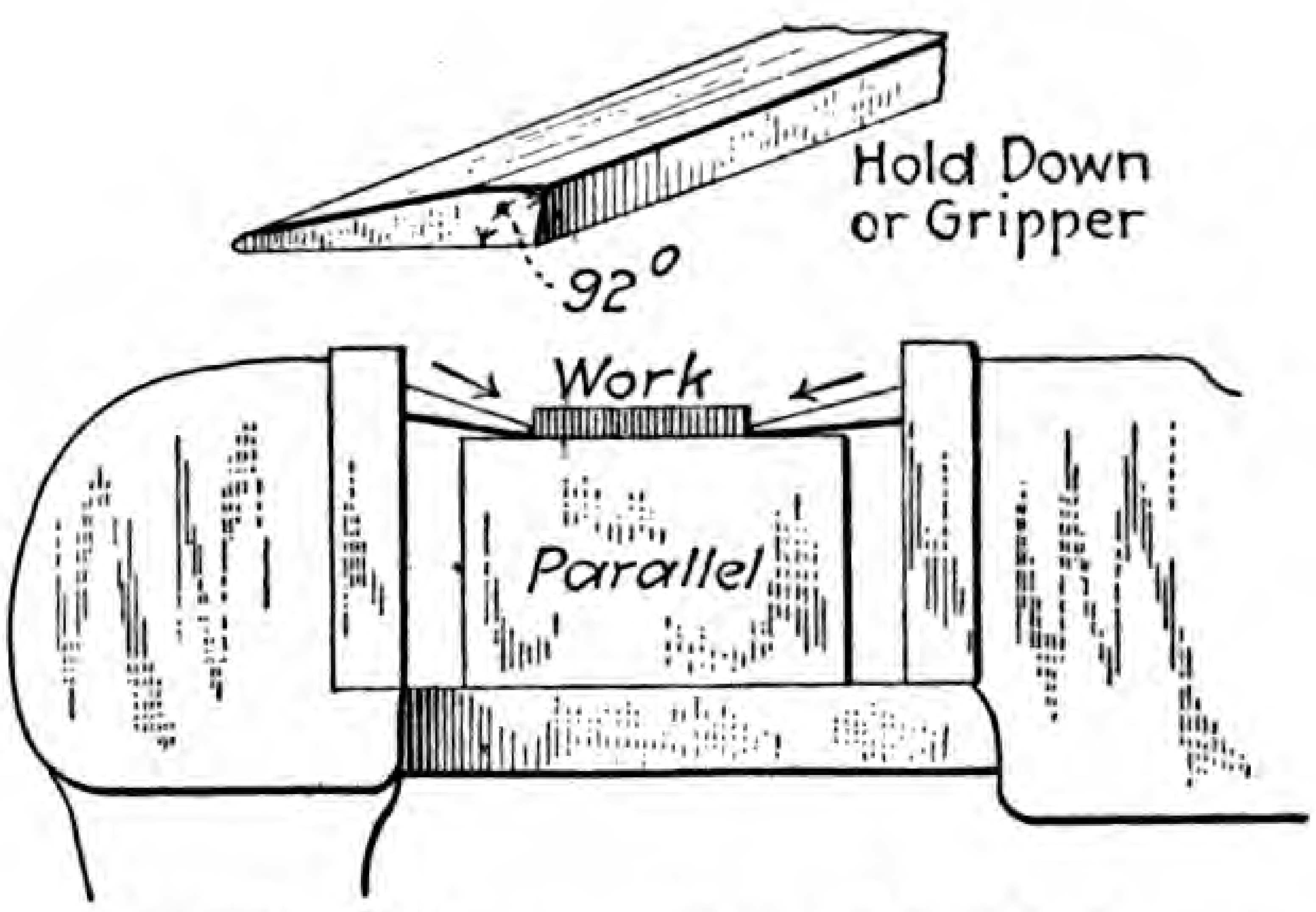


FIG. 86.—Shows action of hold downs.

CAUSES OF INACCURATE WORK

79. Inaccurate Vise or Vise Settings.—In most shops it may be assumed that the shaper vise, as it is arranged, is right enough for the average job, but it may so happen that it is necessary to plane in the shaper a piece which must be *accurate*—square, parallel, and to an exact size—in which case it will probably be advisable to test the bottom of the vise (on which the work rests) for parallelism, and also the solid jaw to make sure that it is square.

80. To Test the Work Seat.—Open the vise wide, be sure the bottom is clean and smooth and with an indicator of any convenient kind (dial test indicator is perhaps best) try the work seat to make sure that it is parallel. If a pair of fairly good sized accurate parallels are at hand they may be arranged as shown in Fig. 87 and four places *A*, *B*, *C* and *D* indicated for parallelism. If *B* and *D* are low it will indicate that the work table sags and probably the saddle gib will need tightening, or that there is dirt between the vise and the table. If either A and B or C and D are low it will indicate no doubt that the vise is not properly seated on the work table. These faults may be easily corrected to bring the work seat parallel. It may be advisable to shim with paper between the vise and the work table.

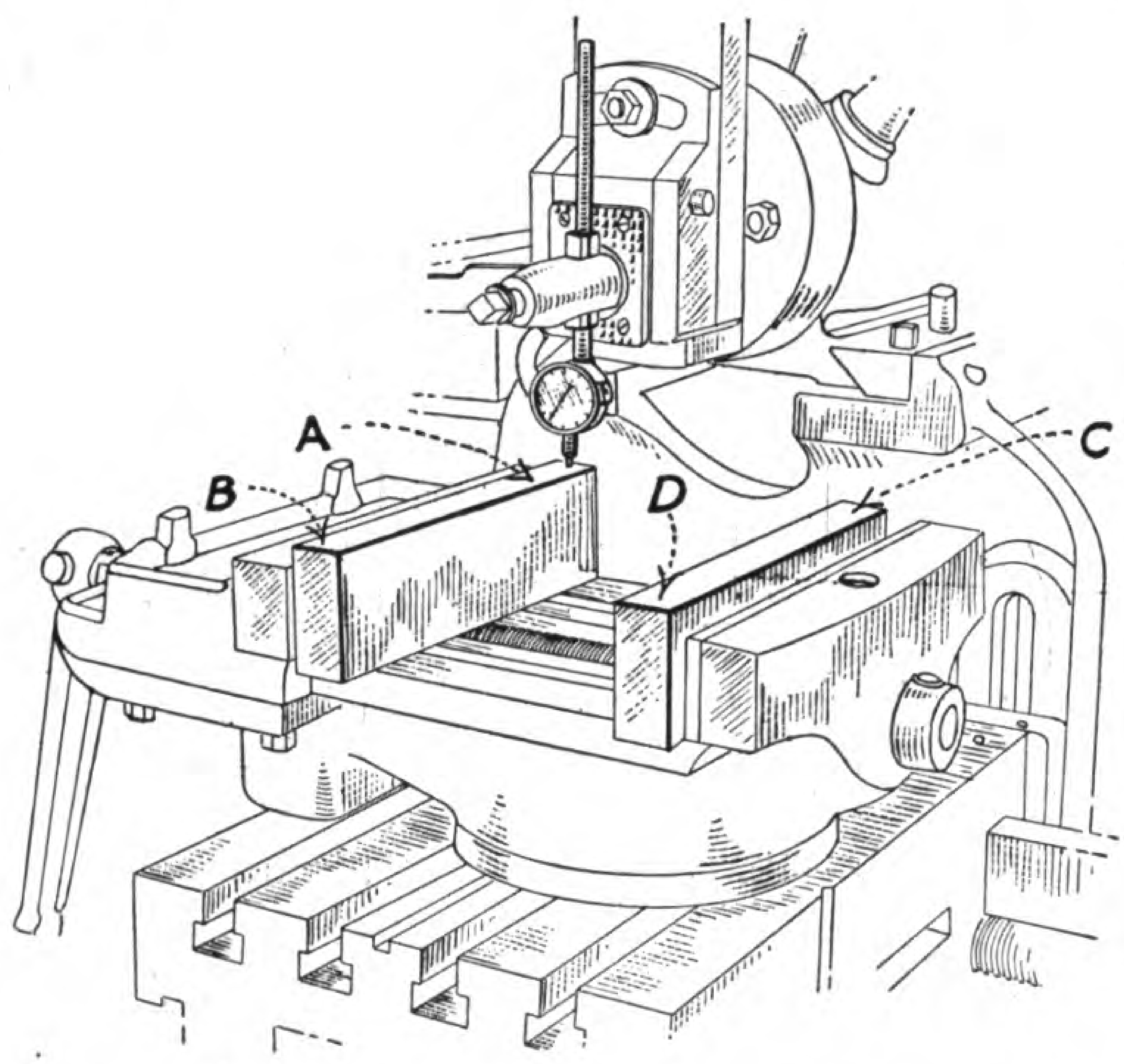


FIG. 87.—Testing the work seat for parallelism.

81. To Test the Solid Jaw.—If the face of either of the jaws of the vise is dented and scored it should be repaired. If the solid jaw is not square with the seat it is impossible to clamp the work against the jaw and plane it square. To test for square takes only a few minutes. Clamp the beam of a square against the solid jaw (with a piece of wood between the movable jaw and the square) as shown in Fig. 88. Arrange the indicator and move the work table the distance A to B. If the indicator registers the same at both ends of the blade the jaw is square. It will be best to try the jaw near each end and in the middle. If necessary, shim the jaw until it is square.

82. To Set the Vise Parallel with Direction of Stroke.—While the graduations on the swivel plate are accurate enough for nearly all purposes, occasionally a cut, for example, a shoulder, must be made exactly parallel with the edge located against the jaw or the work may be spoiled. To test for this position is very simple. Arrange the length of stroke to about the length of the jaw, hold the indicator in the tool post and slowly run the shaper by hand to note if the indicator registers the same at both ends of the jaw. If necessary to make adjustment clamp the vise lightly and tap with a babbit hammer until the setting is correct, then clamp tight and test once more.

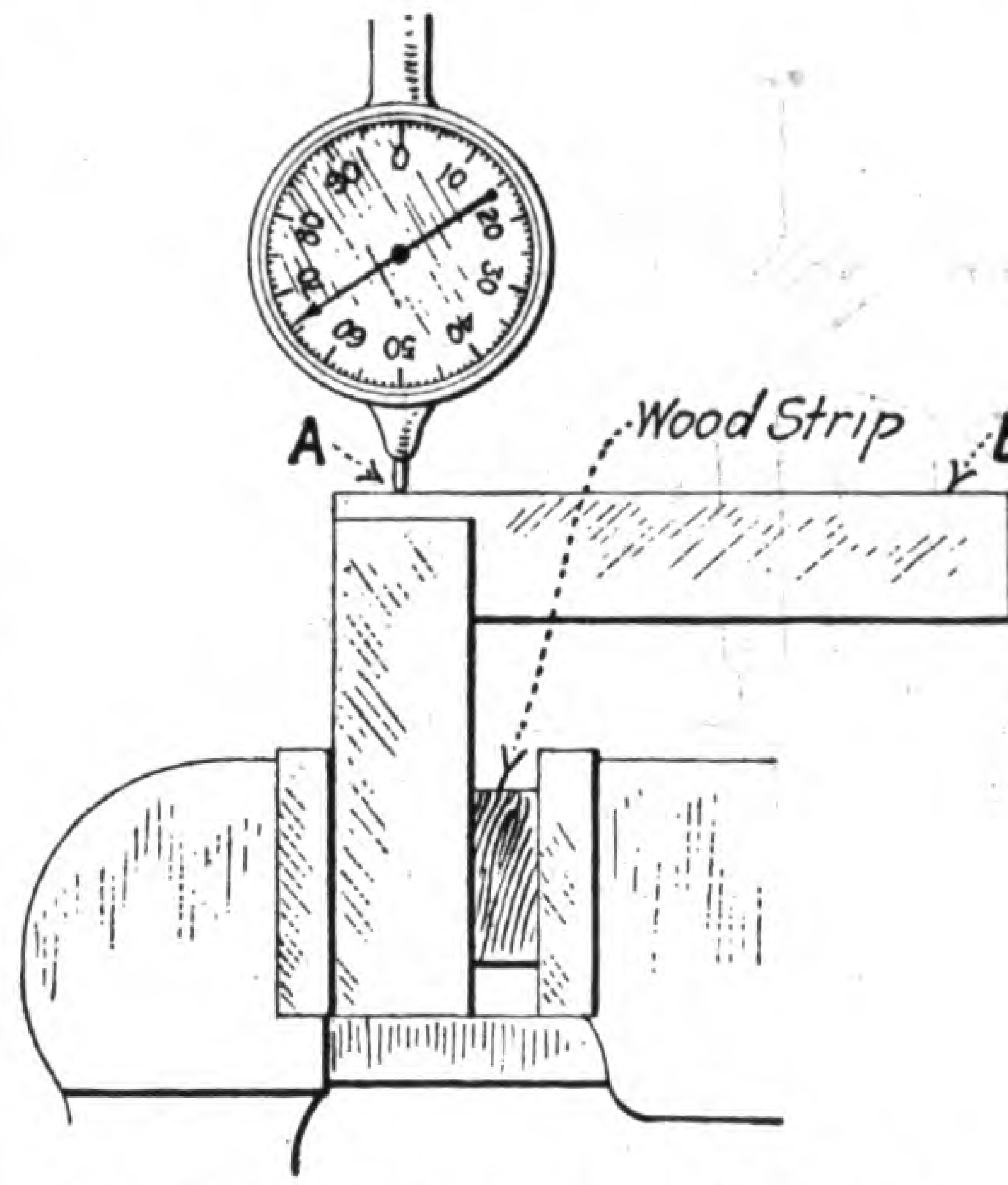


FIG. 88.—Testing the solid jaw for squareness.

82B. To Set the Vise Square with Direction of Stroke.—To test, and if necessary to correct the setting, the indicator is arranged as before but, the vise being turned around 90°, the *work table* instead of the *ram* is moved by hand to show the movement if any of the indicator needle.

NOTE.—An angle plate or similar holding devise when clamped to the work table may be tested for square or may be set square or parallel with the direction of the stroke in exactly the same way as the vise.

83. Chips and Burrs as a Cause of Inaccurate Work.—One of the most frequent causes of damaged or spoiled work is failure on the part of the operator before clamping the work to remove the burrs and clean the chips from the work and also from the holding device whatever it is—vise, fixture, chuck or clamp of any description.

Chips.—Steel chips are worse than cast iron chips, but if either are pinched between a finished surface of the work and the vise jaw, both the work and the jaw will be damaged, and possibly the work will be thrown out of true enough to ruin it.

If chips are allowed to get under the parallels, or between the parallels and the work, it is obvious that the work will not seat properly and the finished surface cannot be accurate.

Burrs.—Particularly on steel and wrought metal the last few strokes tend to roll the metal over the corner forming a burr. This burr is more or less difficult to remove, depending a great deal on the sharpness of the shaper tool. If the surface x, (Fig. 89) over which the burr is rolled is the next surface to be machined it will cause no trouble, but if surface x is to be used as a seat for finishing the opposite side, or if y is to be used as a seat the burr must be removed. Sometimes the heavier burrs are removed with a special burring chisel similar to a wood chisel; the lighter burrs are easily removed with a fairly fine file. In either case be very careful not to spoil the corner.

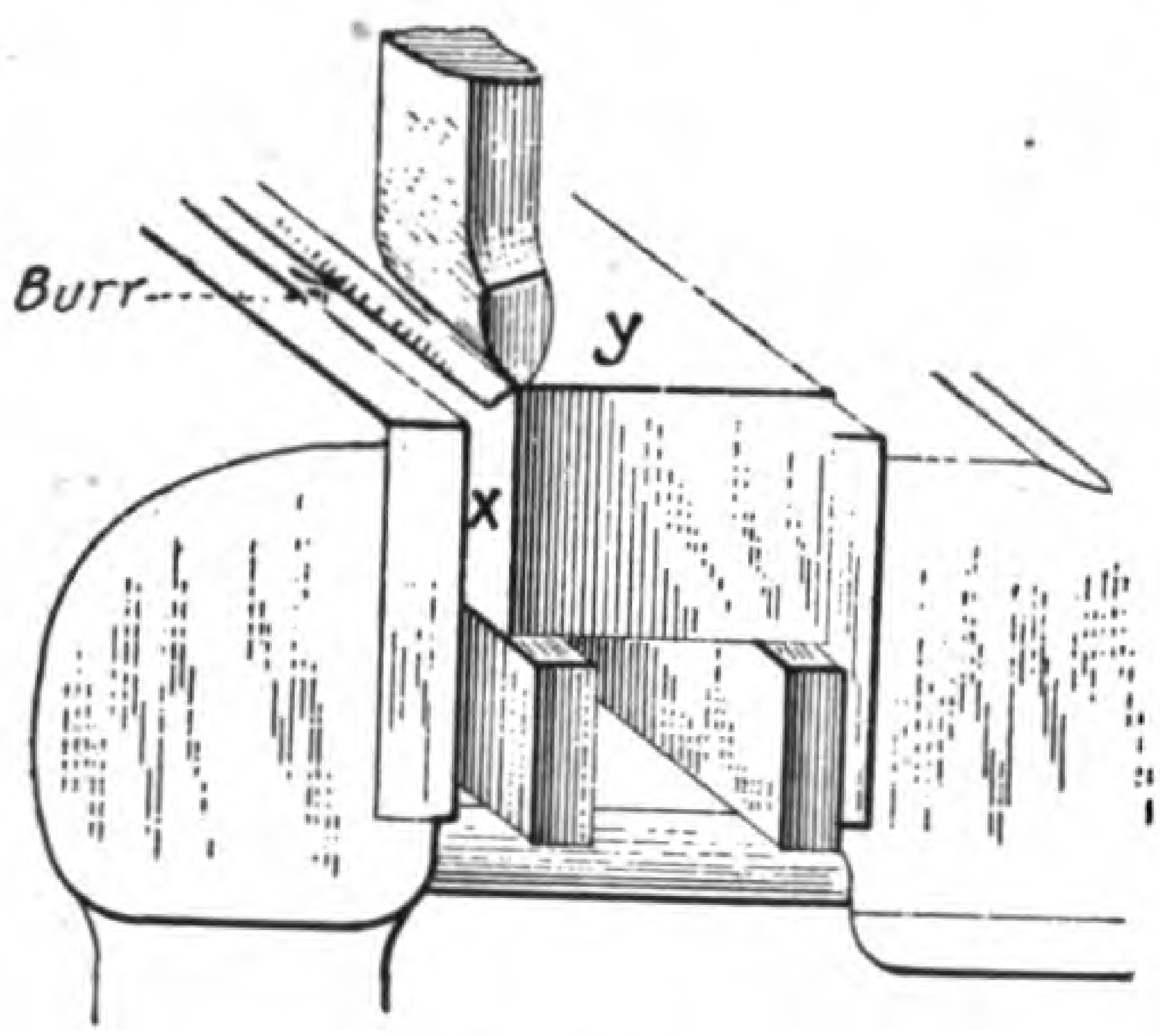


FIG. 89.

Then there is another kind of burr, the kind thrown up by making a nick or dent in a piece of metal. For example, pinching a rough forging or casting between the soft vise jaws without using protecting pieces, will dent the jaws and throw up burrs; likewise pinching a chip between the vise jaw and the finished surface. Dropping a parallel so it strikes the machine may nick it and throw up a burr, and hammering a rough piece down on the parallel will do the same.

It is certain that if the work itself, the holding device, and the parallels are not clean and otherwise in good condition, at least two evils will result, (1) the work will be inaccurate, damaged and possibly spoiled, (2) the parallels, vise, etc., will be damaged.

84. Preliminary Hints on Shaper Work.

1. Keep the machine clean and well oiled.

2. Use the proper wrench or handle, and when not in use keep them where they belong.

3. A vise jaw that is scored and dented and out of true is a disgrace in any shop. A real mechanic is careful. Use brass or copper or cardboard to protect the jaws when clamping the rough surfaces of bar stock, castings or forgings.

4. Parallels should be kept clean, free from burrs, straight, parallel and square. Examine them before using and be sure they are at least clean and free from burrs. Do not hammer a rough piece down on a parallel.

5. Be sure there are no chips on the seating surfaces, or the clamping surfaces of the vise, parallels and work.

6. Carefully remove the burr caused by any previous cut if it will interfere with the proper seating or clamping of the work.

7. Select the proper tool, grind it carefully and oil-stone it. A workman is often judged by the tools he uses.

8. To seat the work use a babbit hammer or babbit ball. Do *not* use a wrench.

9. Do not hammer the work with the babbit, tap it just hard enough to seat it.

10. Tissue paper "feelers" between the parallels and the work are often very useful to determine if the work is properly seated.

11. Do not pinch a thin piece of work too tight or it will buckle more or less and be out of true when the pressure is released.

12. Make sure the thrust bearing at the base of the screw is seated and then loosen the table clamping bolts before attempting to raise or lower the table; some shapers are so constructed that the elevating *screw* will turn without loosening these bolts and then when the bolts are loosened the table will drop.

13. Be sure the top of the table and the bottom of the vise plate are clean and also free from burrs before re-setting a vise that has been removed from the work table.

14. When setting the tool to a surface already finished (or to a size block) be sure the tool block is firmly seated, place a piece of tissue paper under the cutting edge, and then feed the tool down to lightly pinch the paper.

15. When setting up irregular work be sure the head, and also the bottom of the ram will clear the work, during the whole length of stroke and the whole width of the cut.

16. Be sure, at all times, that the tool block works freely and seats properly. Failure to do this has caused a lot of spoiled work.

17. Do not hammer the side of the apron to swivel it. If the edge of the seating surface of the apron is dented and burred it will cause the tool block to bind in the box.

85. The Horizontal Cut.—When the work is fed in a horizontal direction under the reciprocating cutting tool the surface produced is a horizontal flat (or plane) surface. Most of the work done in the shaper is of this description. The length of the stroke is set for approximately $\frac{3}{4}''$ longer than the work and the position of stroke such that $\frac{1}{2}''$ of this extra length comes at the beginning of the cut to allow the tool block to seat properly for the next cut. In this connection it may be well to state here that if a given piece may be planed either crosswise with a short stroke or lengthwise with a longer stroke, other things being equal it is better to take the longer stroke. To plane, for example, a piece 3″ by 6″ twice as much time will be wasted cutting air when cutting crosswise as when cutting lengthwise. This is illustrated in Fig. 90 where the shaded portion *B* shows air cut with cross-stroke and *A* the air cut with the lengthwise-stroke.

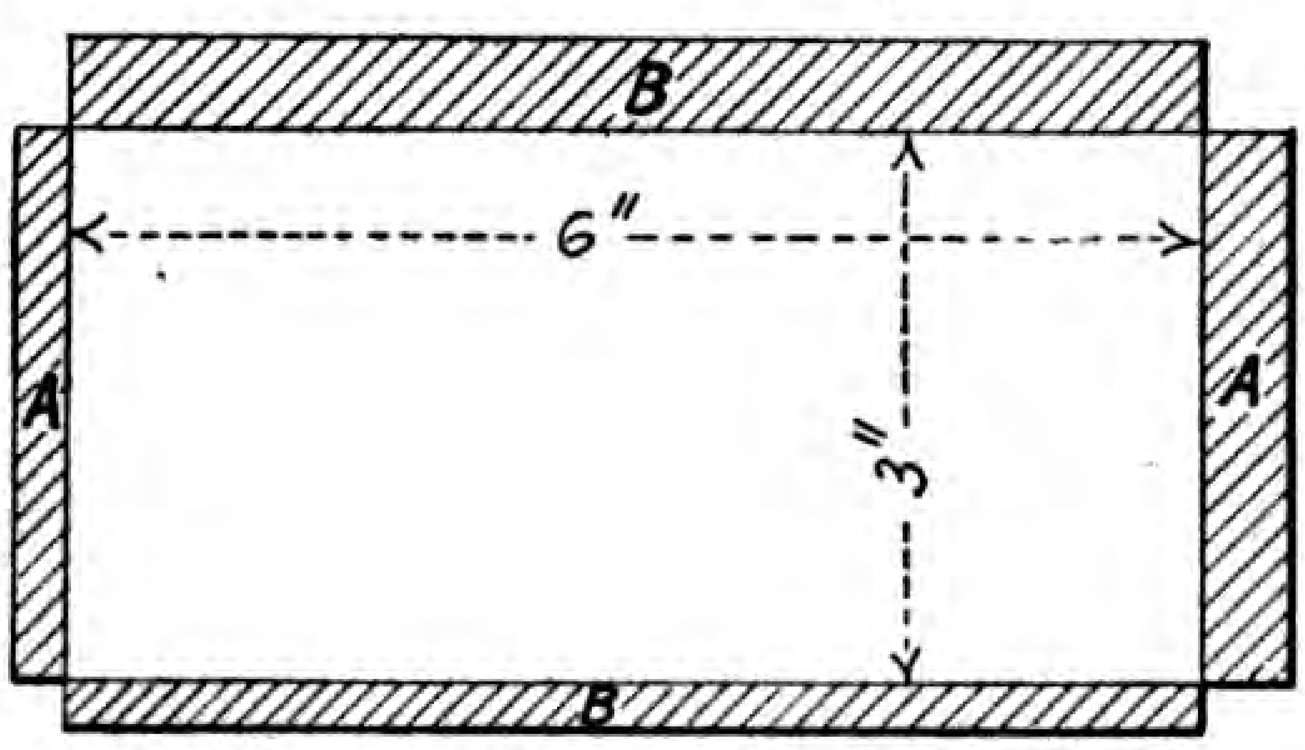


Fig. 90.

This is a little thing? Yes, but if you and I could have the value of the time wasted because of ignorance or carelessness of these little things we'd be *rich*.

The smaller pieces or any pieces that will tend to tip under the pressure of the cut are best held with the vise jaws at right angles to the thrust.

An important point in shaper construction and operation may be emphasized here. The shaper manufacturer takes the utmost care to have the clapper block fit the box. The bearing surfaces are scraped to provide the best of sliding fits with no shake, the axis of the hinge pin is exactly at right angles and consequently the block hinges freely in the box during the return stroke and is rigidly supported during the cutting stroke. The bearing surfaces should be wiped clean and a very little oil applied at least once a week. If the bearings are allowed to become dry or gummed with old oil or if for any other reason the block does not always seat properly trouble will surely result.

The position of the operator is at the right front of the machine with the speed and feed changes within easy reach. A low stool should be provided. In order that the depth of cut, the action of the tool etc. can be more readily observed, the cut is usually started on the right side—the side nearest the operator, the feed of the table is arranged to move the work toward the operator *on the return stroke* and the left-hand tool is used.

There is practically no difference in roughing steel or cast iron excepting the cutting speed. For roughing plane surfaces of either cast iron or steel the tool illustrated (1) (Fig. 74) or a tool bit ground to a similar shape held in a suitable holder may be used.

Clamp the tool in a vertical position or pointing *a very little* in a direction away from the work, so that if by any chance the tool moves due to the pressure of the cut it will move away from the surface instead of under cutting.

Do not allow the cutting edge to project too far from the tool post—"catch it short"—and clamp it tight. Be sure the tool head slide is not run down too far as this causes weakness and undue strain. It is much better to take time to raise the work table than to allow the tool slide to project below the head or to have the tool project too far.

The tool is adjusted to take the depth of cut desired by means of the downfeed handle, and the work is fed by hand (cross feed) until the cut is started, then, *and not until then*, the power feed is thrown in.

When planing cast metals the edge at the end of the cut should be beveled with a chisel or an old file about 45° practically to the depth of the cut (see Fig. 91) otherwise chunks of the corner will break out below the surface leaving the edge ragged.

Cast-iron scale is hard and gritty. Set the tool to take a chip deep enough *to get under the scale.* If during the cut a portion of the surface is low and the tool rubs on the scale the cutting edge will very soon be ruined. Provided it will not make the work undersize take a deep chip and if necessary reduce the amount of feed but *get the roughing cut under the scale* if possible.

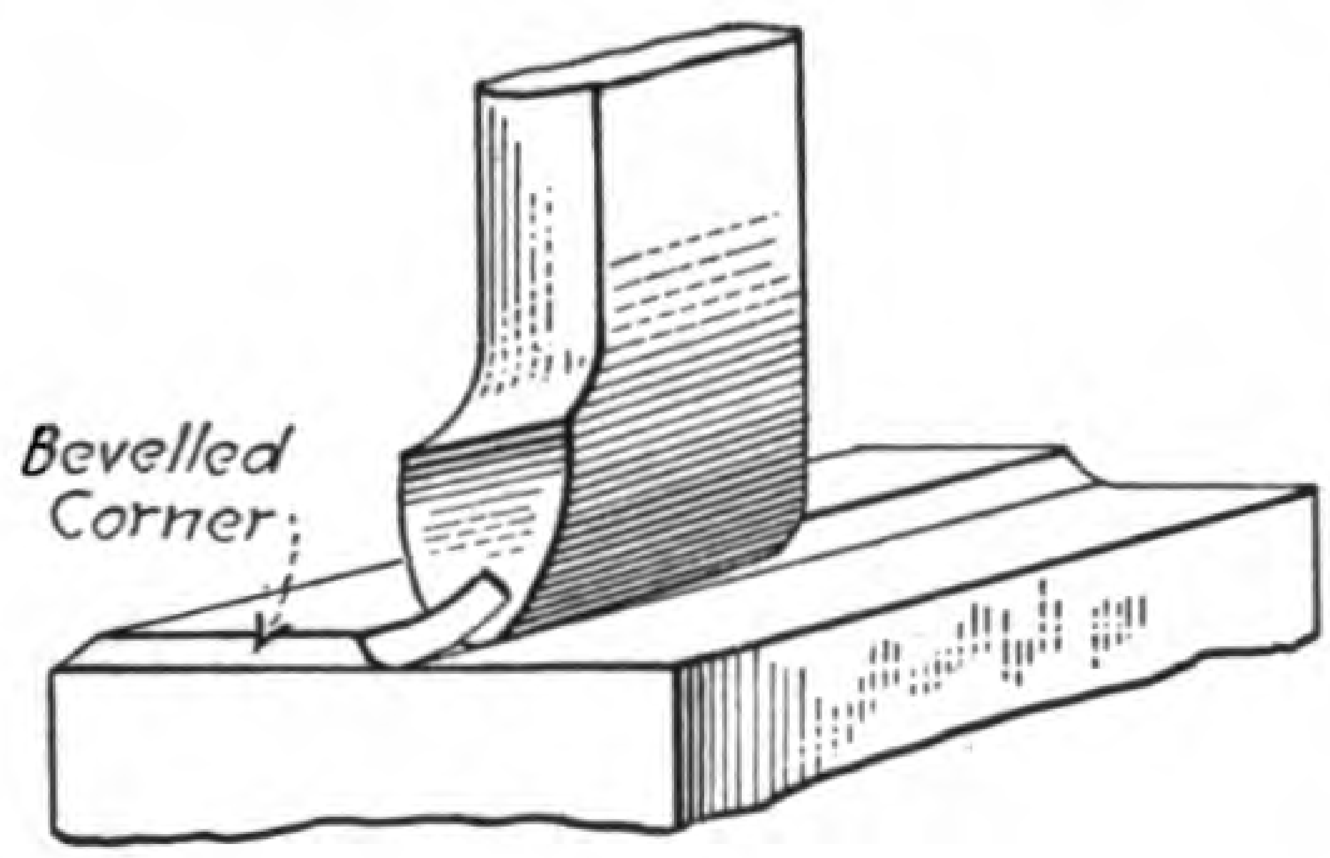


FIG. 91.

The finishing cuts should always be light. For finishing steel or wrought iron a small chip and a fine feed will give the best result. A tool of substantially the same shape as the roughing tool but with a narrower rounded end and a greater rake angle produces an excellent finish, or if desired the shear tool (9) (Fig. 74) may be used.

The accepted commercial machine finish on flat cast iron pieces of any considerable size is a surface that feels smooth and shows feed marks 3/8″ or more apart. This finish is obtained by the scraping action of a broad square-nosed tool. This tool may be a forging, or the tool bit fitted to any one of a number of kinds of tool holders may be ground to shape. The best tool holder and tool for this purpose is probably a spring tool of a type illustrated in Fig. 76, page 87. It is usually better to use a spring tool so that any tendency of the tool to "dig" will be overcome. With a sharp tool, .002″ to .004″ chip, and 3/8″ or more feed, a beautiful finish may be obtained. Use a slow speed and feed by hand. If the surface left by the roughing tool is badly torn it may be necessary to take two cuts.

When finishing cast iron the edge at the beginning of the cut should be filed slightly bevel so that the cutting edge of the tool will not strike the scale. Keep oil off cast-iron work, even oily finger marks may defeat a good finish.

86. To Sharpen a Square Nose Tool for Finishing Cast Iron (Fig. 92).—Grind the front of the tool flat with 4° or 5° clearance and round the corners slightly, oil-stone the top carefully and set in the tool post as nearly correct as can be judged (cutting edge flat on surface to be finished). Place a sheet of heavy paper on the work and on the paper a good oil-stone. The paper is to keep oil off the work. Raise the tool block, that is, hinge it forward, and bring the oil-stone and paper under the cutting edge of the tool. The tool block is now probably hinged forward 15° or more; raise the slide until it only hinges forward a very little (about 3°). Bearing lightly on the tool rub the oil-stone back and forth between the paper and the cutting edge. Lift the tool, that is hinge it way forward, occasionally and note when it is oil-stoned enough, then remove the oil-stone and paper, and allow the tool block to fall back into place. It is obvious that the tool is sharp and that the cutting edge is parallel with the work and has the proper clearance (about 3°). Feed down carefully to the work and take a very light chip, a coarse feed and a slow speed.

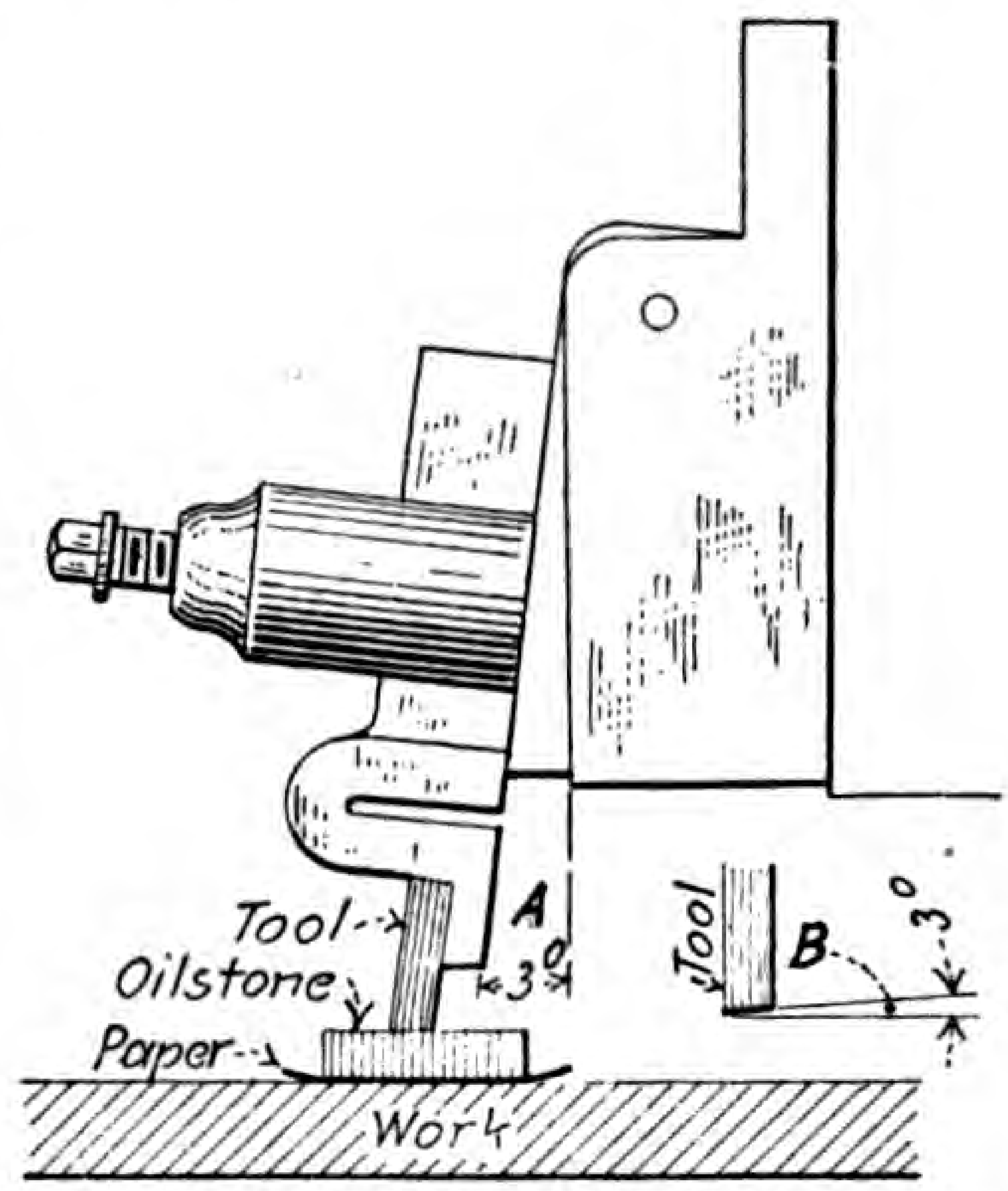


FIG. 92.—If the tool is oil-stoned when hinged forward say 3 degrees as at *A*, then when it is seated, as during a cut, it will have 3 degrees clearance as shown at *B*.

87. Vertical and Angular Cuts.—The downfeed is used for vertical cuts such as finishing the sides of tongues and grooves, squaring shoulders, squaring ends, cutting keyways and occasionally for cutting off. It is used also for angular cuts such as fairly wide beveled edges and ends, and for dovetails.

Except in the case of cutting off or a similar operation, or where the surface being planed is not much over $\frac{1}{4}''$ deep (or high) it is very necessary to swivel the apron when using the down feed. This is illustrated in Fig. 93. When the top of the apron is moved in a direction *away* from the surface of the cut, the tool block and tool will hinge in a direction up and *away from* the work during the return stroke. This is true in angular (bevel) cuts as well as vertical cuts (see Fig. 94).

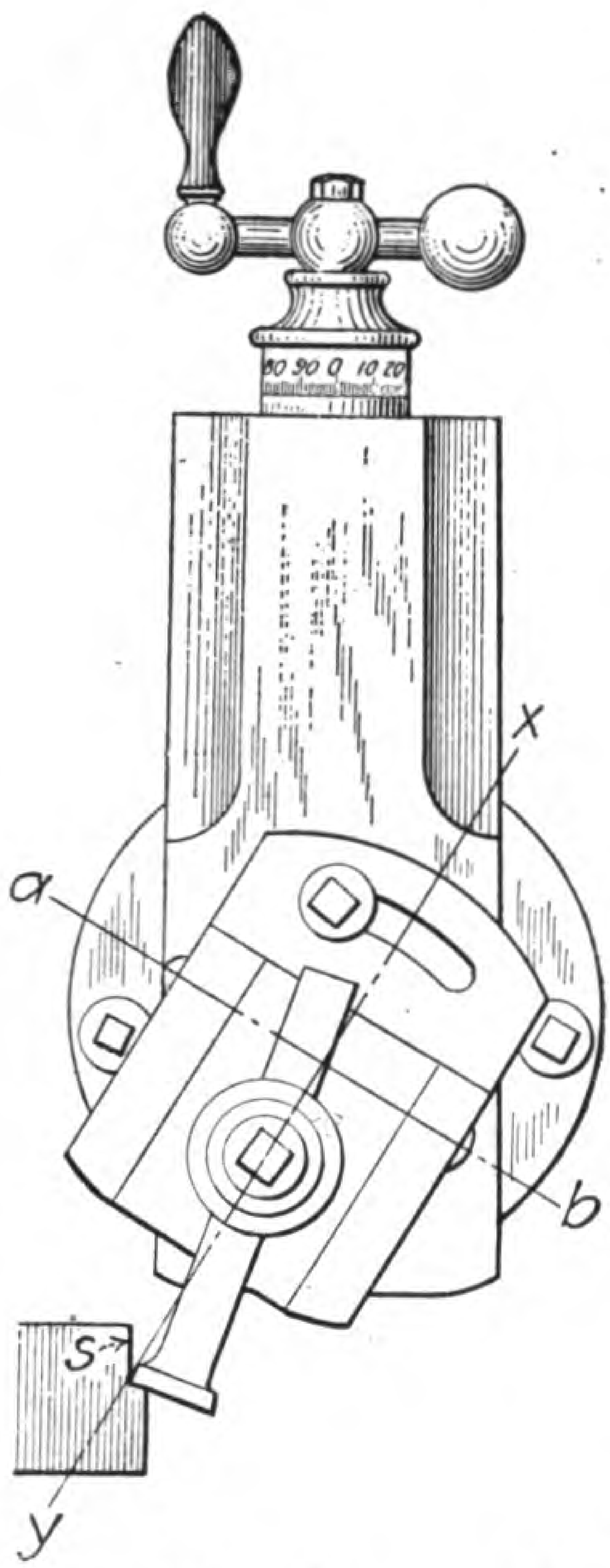


FIG. 93.—Apron swivelled for vertical cut. Axis of hinge pin is in line of *a b*. The direction in which the tool block may raise on the return stroke is in a plane *x y* at right angles to *a b*. If this plane is tipped away as illustrated, the tool will tend to raise in a direction away from the surface *s* and will not rub. If the plane is vertical the tool will rub along the surface *s* on the return stroke.

The set-up for an angular cut with the head swiveled and the apron also set over sometimes appears awkward and wrong. It may help the beginner to imagine the angular cut as a vertical cut and set the apron accordingly. For all vertical or angular cuts it is important to understand and remember the following:

RULE.—Always set the *top* of the apron in a direction *away from* the surface of the cut to be taken.

Although the construction permits of considerable down-feed of the head it is not good practice to use the head with the slide run down much below the swivel plate because in this position it is not as strong and rigid as when backed up by the ram. Sometimes it may be advisable or even necessary, but in no other case than for a finish cut.

Further, when the head is set over for an angular cut and the tool slide fed down too far, it is likely to bring up against the column as the ram slides back. Be careful when setting up to have the slide high enough at the start for either a vertical or an angular cut, that this weakness or this interference will not result during the cut.

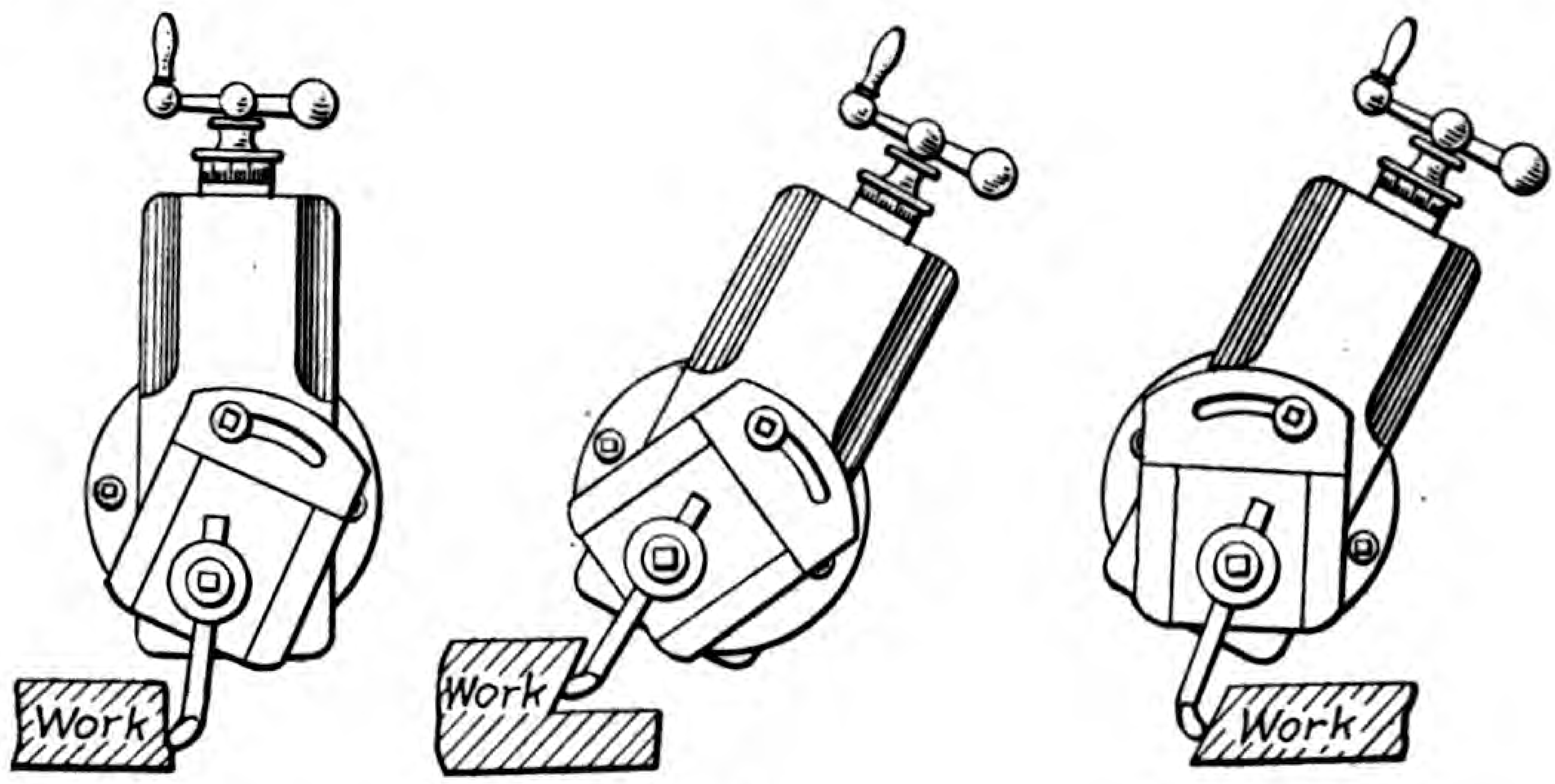


FIG. 94.—Note in each case the top of the apron is set over in a direction away from the surface being cut.

Questions on Shaper Work

1. What precautions should be taken regarding the vise jaws? Why?

2. What are parallels used for? How should they be cared for? Why?

3. Is it good practice to pound rough castings or forgings or bar stock down on parallels? How should they be protected?

4. What are "hold downs" or "grippers?" How are they used? When are they used?

5. State four ways in which the vise may be "out" enough to cause inaccurate work.

6. Explain how you may test the work seat.

7. Explain how you may test the solid jaw.

8. How do you set the vise jaw *exactly* at right angles with the direction of the cut? Exactly parallel.

9. Why is it necessary, in order to do good work, to keep the vise jaws clean?

10. What causes a burr on the work? There are times when it is unnecessary to remove this burr. Explain. If you have several pieces, when do you remove the burrs?

11. How much longer than the length of the cut do you set the length of the stroke? Why?

12. How is the tool arranged in the tool post for a horizontal cut? Why is it tipped? Why is it tipped "a very little"?

13. Frequently one sees the tool slide run down two or three inches below the head. What does this indicate? What is the remedy?

14. When taking a cut in cast iron why should you, whenever possible, plane under the scale the first cut?

15. What is the proper way to take a finishing chip on cast iron?

16. Explain how to sharpen the square nose tool for a shaper cut.

17. How does the clapper block fit the clapper box? Does it shake? Does it bind?

18. Are the bearing surfaces of the block and box smooth and clean? When and how should these surfaces be cleaned and oiled?

19. How may the apron be swivelled? How much?

20. Explain how hammering the side of the apron may prevent the proper seating of the tool block.

21. Clamp a short piece of board vertically in the vise allowing it to project a couple of inches above the jaws. Swivel the clapper box to the right and arrange to have the tool point touch the right hand side of the board. Lift the tool. Does it clear the work? How much?

22. Arrange to have the tool point touch on the other side of the board without changing the position of the apron. Can you lift the tool? What happens? How will you arrange to have the tool clear the work?

23. If the board is tipped 30° from the vertical and the shaper head is swiveled 30° will the same principles apply, both sides of the board, as applied in the preceding questions?

24. Why is the clapper box made so it can be swiveled on the head?

25. What is the rule for setting the apron when taking a vertical cut or an angular cut? Why is this rule important?

26. Why, when cutting in two a fairly thick piece in a shaper is it best to cut half way through from one side and then turn the piece over and make a cut to meet the one already made?

88. To Plane a Rectangular Block or Similar Piece Square and Parallel.—Plane one side, preferably one of the larger surfaces (1), (Fig. 95) then using this surface as a seat against the solid jaw, plane the adjacent side (or edge) 2. If the shaper vise jaw is square and smooth, and if the surface first finished is clean and free from burrs and properly seated against the vise jaw, the second surface planed will be square with the first surface. In order to make sure that the surface first planed is properly seated against the vise jaw, it is customary to use a rod or strip between the movable vise jaw and the work. This will obviate any tendency for the work to change its position, owing to any "give" in the movable jaw.

Next place the second finished surface down on the bottom of the vise or on parallels if necessary, and the first surface against the solid vise jaw as before, with the rod or strip between the movable jaw and the work, tighten the vise and with a babbit hammer tap the work down in the vise to make sure that it is properly seated on the bottom, and plane surface 3. If the vise jaw is square and the tool is sharp, and if care is taken to clean the surfaces of the finished work from burrs and chips, the two edges just planed should be parallel, and both square with the first side planed. Now place the first planed surface down on suitable parallels, clamp the work between the jaws without the rod or strip, and with a babbit

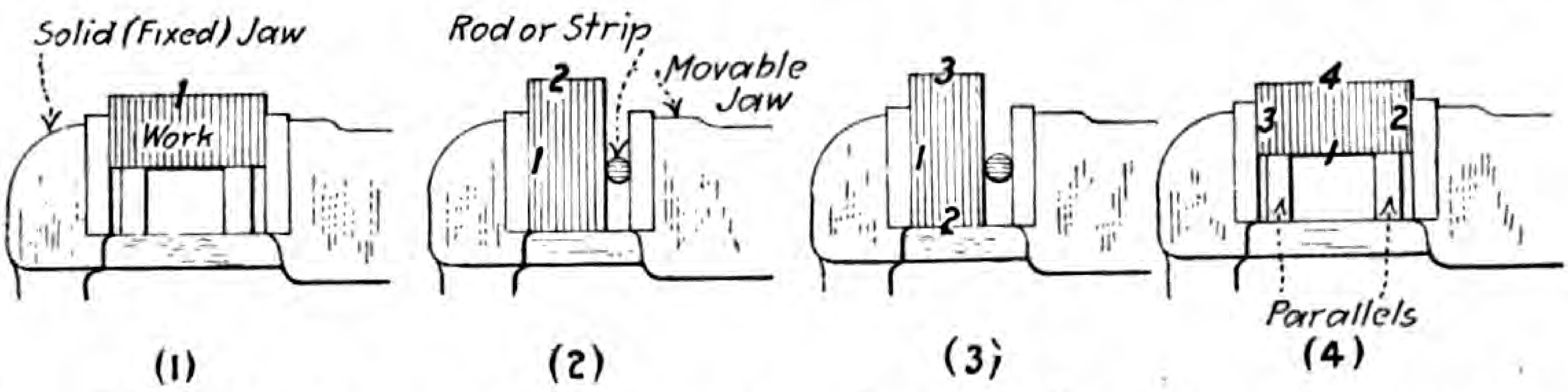


FIG. 95.—The four successive steps in planing the sides of a rectangular piece.

hammer tap (not pound) the work until it is properly seated. If the vise is true and the work is seated on both parallels so that neither parallel can be moved, then it is obvious that the fourth surface will be parallel with the first surface and square with the other two sides.

It is better to seat the work on two parallels rather than one for the reason that it is easier to judge if the work is properly seated. Further, it may be desirable to measure the piece with a micrometer or caliper; this may be more readily accomplished if there is a space between the two parallels or between one parallel and the vise jaw.

89. Squaring the Ends.—The ends may be planed square in two ways, the shorter pieces by taking the cut horizontally across, and the longer pieces by cutting vertically downward. The short piece is set in the vise, either on the bottom of the vise or on a suitable parallel, and a finished edge or side set perpendicular by means of a machinist's square as illustrated in Fig. 96. Hold the square down hard on the parallel and the piece of work hard against the blade of the square and tighten the vise lightly. Check the setting, tap the work one way or the other if necessary then tighten securely. If this is properly done, and the vise jaws clean and square, the end when planed should be square with the surfaces already planed. To finish the other end it is merely necessary to seat the work on the finished end, tap carefully with a babbit hammer to make sure that it is seated, and finish to the length required.

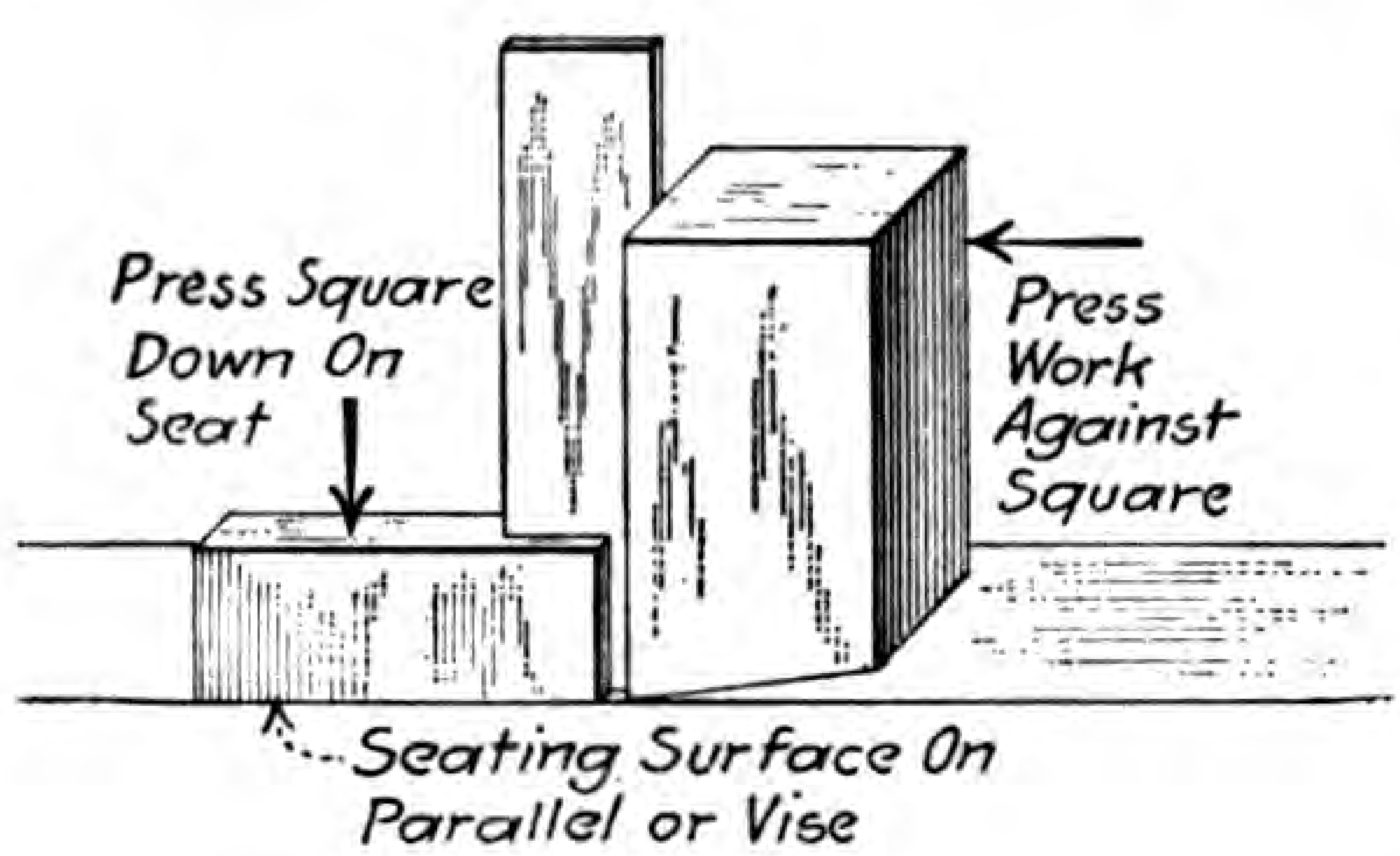


FIG. 96.

If the work is too long to finish the ends in this manner it may be set lengthwise in the vise, letting one end project in a position to be finished by a vertical cut. Use parallels to raise it substantially flush with the tops of the jaws and allow it to project from the end only a short distance. A tool like either (2) or (3), (Fig. 74), may be used in this operation. Tighten the vise securely. Run the tool slide well up toward the top, swivel the apron and adjust the tool. For the reason that the tool will probably have to project some little distance from the tool post in order to take the cut to the bottom of the piece without interference, a feed and chip somewhat lighter than for horizontal planing will be advisable. Care must be taken not to break out the corners at the end of the cut if cast metal is being planed. An excellent finish may be obtained on cast iron with a side tool; have about a quarter of an inch of the cutting edge ground straight and set vertically; take a very light chip, and a half turn of the downfeed screw for feed.

90. Planing an Irregular Cut.—A narrow irregular surface may be finished very efficiently with a forming tool. It will be better to hold the forming tool in some sort of a spring tool holder such, for example, as illustrated in Fig. 76. Even if only a few pieces are to be planed it will probably be worth while to make a suitable forming tool. When planing a wider irregular cut it usually is customary to lay out the irregular shape on the end of the work and plane to this line. When planing an irregular piece to such a line it is a good plan to rough to within a sixteenth or a thirty-second of the line and then with a file bevel the edge to the line at an angle of 45° or more as illustrated in Fig. 97. With a suitable tool, with a round nose if convenient to use, plane off the bevel. If just the bevel is removed, then the surface is finished to the lay-out line. It is easier to see the bevel and gage the cut than it is to split the line without the bevel. When planing a wide irregular cut of a curved outline the vertical *hand* feed may be employed in connection with the *power* table feed. It is easier and better to feed down than up, therefore, start at the highest

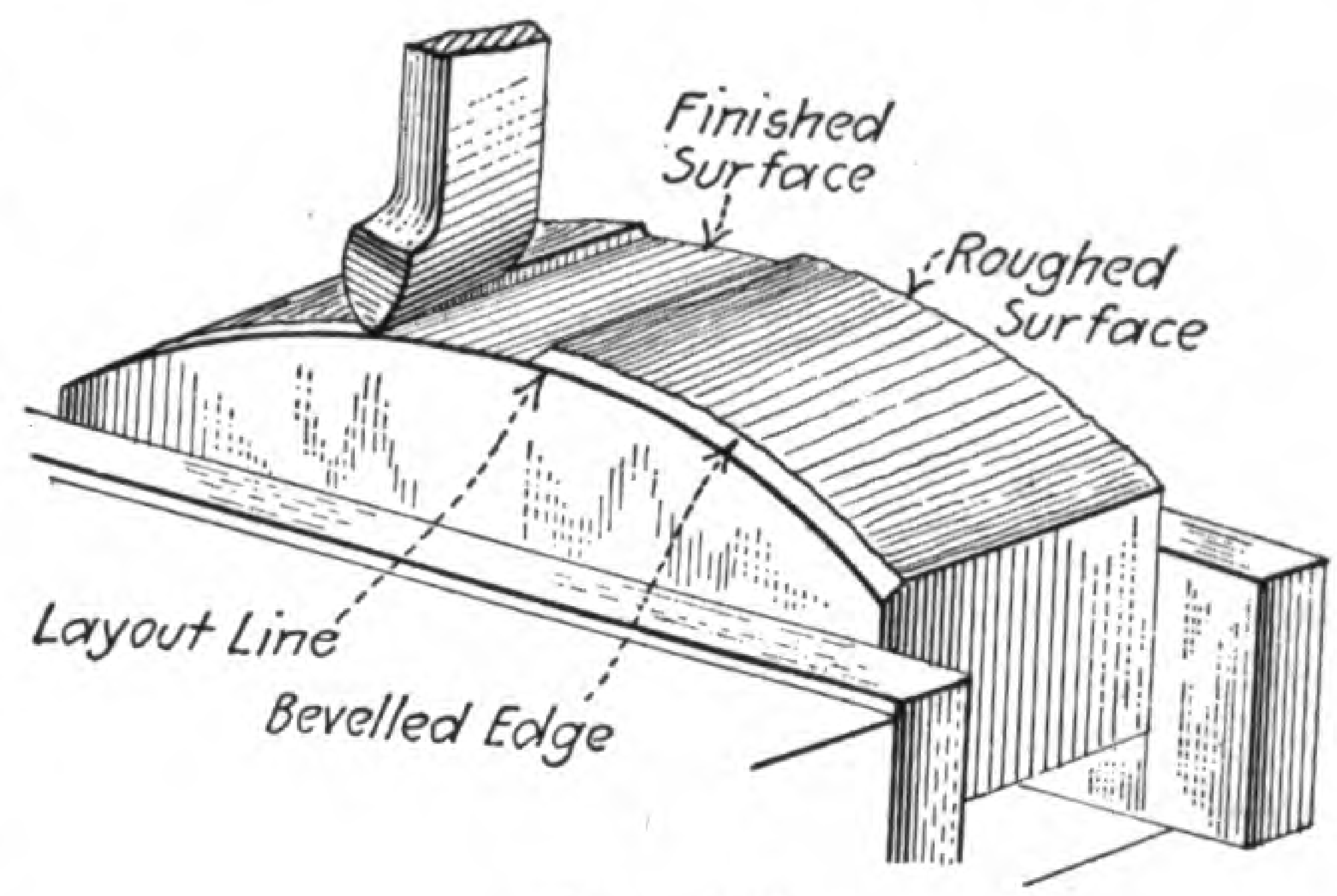


FIG. 97.

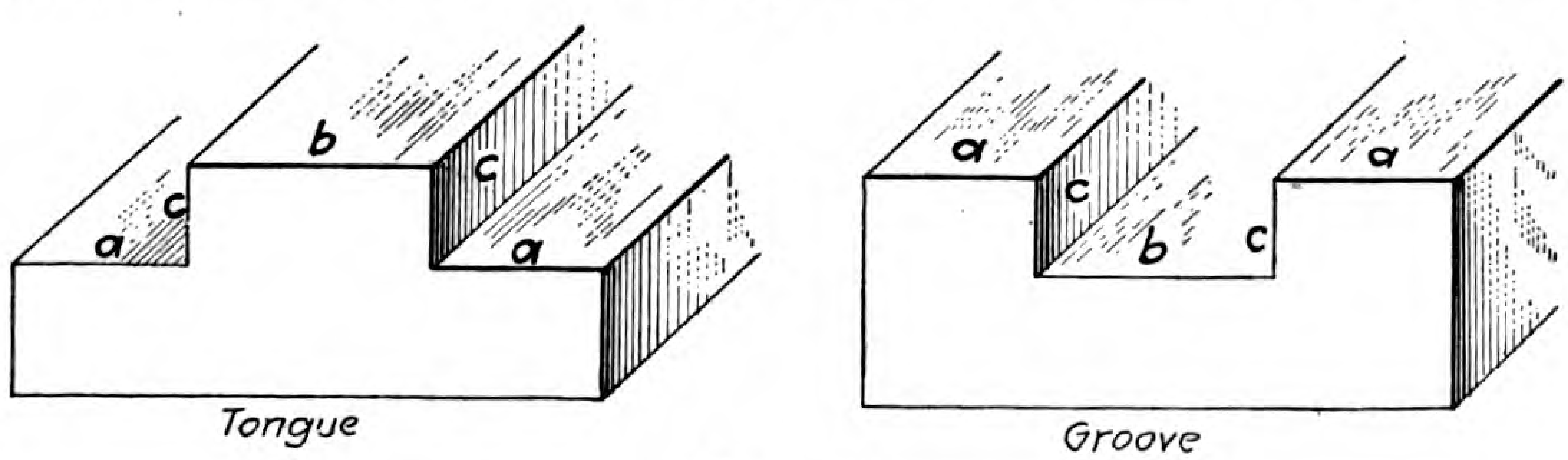


FIG. 98.

part, feed down by hand and feed the table in the desired direction, either by hand or power as desired, usually by power.

91. Planing Tongues and Grooves.—When planing tongues and grooves (Fig. 98) or other shoulder operations, the roughing cut should be made fairly close to the dimension required, using the regular round nose shaper tool wherever convenient.

When finishing, the surfaces *a* and *b* are planed as exact as necessary according to the degree of accuracy desired, but on each of these surfaces there is usually left a thousandth or two for the fitter to file or scrape off. For the distance from surface *a* to surface *b* the graduations on the downfeed screw may be near enough, or if desired a size block (Fig. 99) may be used. If the work is cast iron the tool illustrated in (5) (Fig. 74) may be used without rake for finishing all of the surfaces *a*, *b* and *c*. If the work is steel the finishing tools for the corners (and also for the bottom of the groove) may be shaped like (1) and (2) (Fig. 100). The cutting edges for side and bottom are represented by *x* and *y* respectively. These tools are given 15° or 20° side rake.

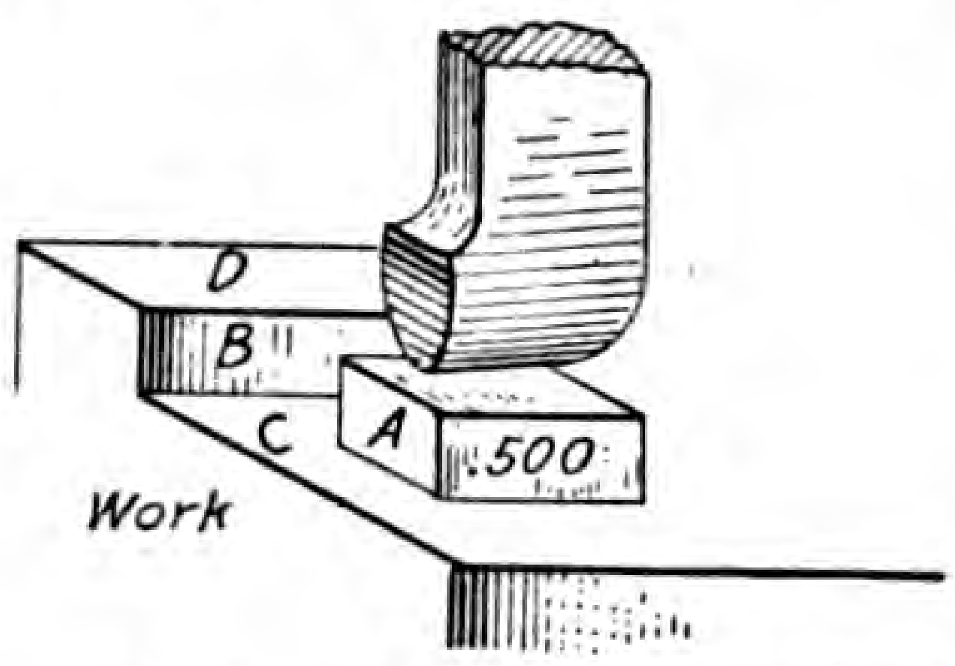


FIG. 99.—Use of size block. *A*, ½″ size block; *B*, shoulder; *C*, finished surface; *D*, surface to be finished ½″ from *C*. A set of gage blocks or "size blocks" is of great value to gage the setting of the tool for shoulders or similar projections. Gage blocks of any desired size, hardened, ground and lapped for extreme accuracy, may be purchased, but for ordinary shaper work a piece of cold rolled steel of the required thickness will answer.

92. Taper parallels or adjustable parallels, (Fig. 101), are useful in gaging the width of a slot or groove; slip one past the other until the slot is filled, then measure over the two with a micrometer. Possibly in a wider groove a straight parallel may be necessary to help fill the width of the groove.

93. Planing Slots Keyways, etc.—A keyway tool looks like a short cutting-off tool and has the same clearance angles.

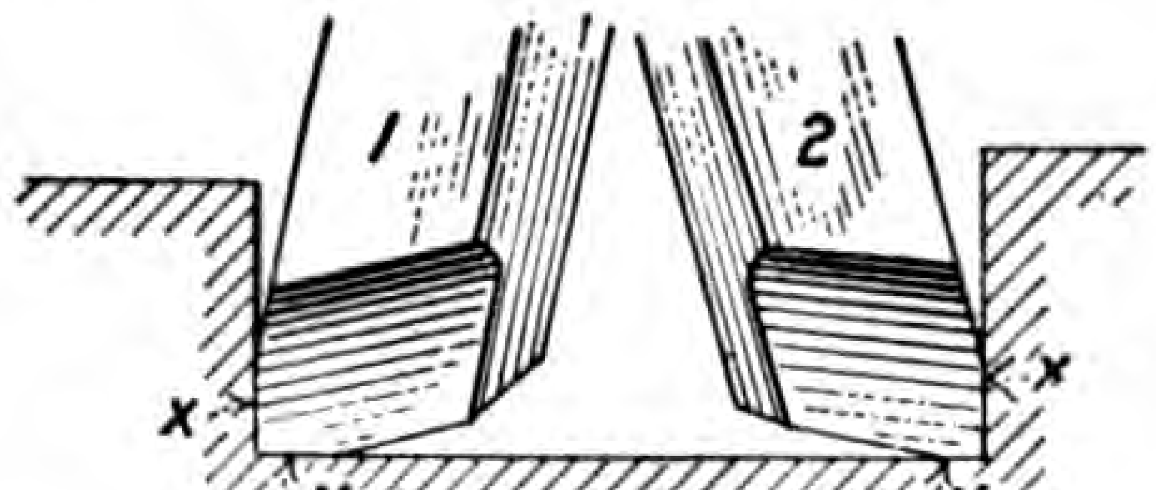


FIG. 100.—Tool bits ground for finishing corners, (1) left hand; (2) right hand.

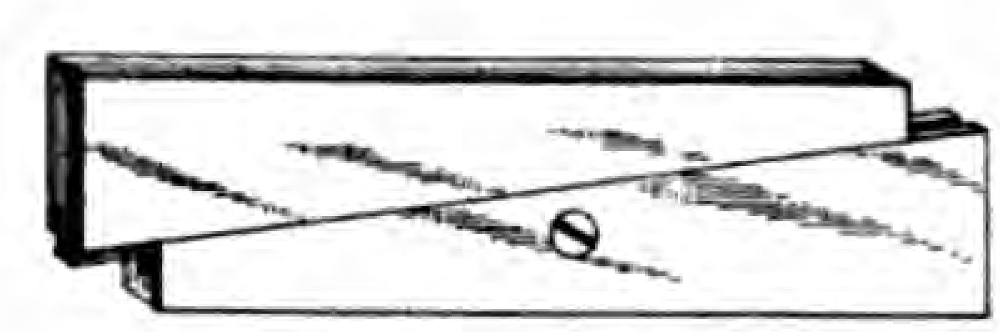


FIG. 101.—Adjustable parallel. (*L. S. Starrett Co.*)

When planing slots, keyways in shafts, or similar cuts, the average 14″ shaper will carry a tool ¼″ wide in steel or cast iron provided a fairly light chip—.005″ to .010″ is taken.

For a wider slot, two cuts or more may be necessary. If more than two cuts are necessary take the outside cuts to (or splitting) the lay out lines, then remove the metal left between.

94. Taking Cuts Which End in the Metal.—When making a cut which terminates in the metal, (Fig. 102), it is necessary to

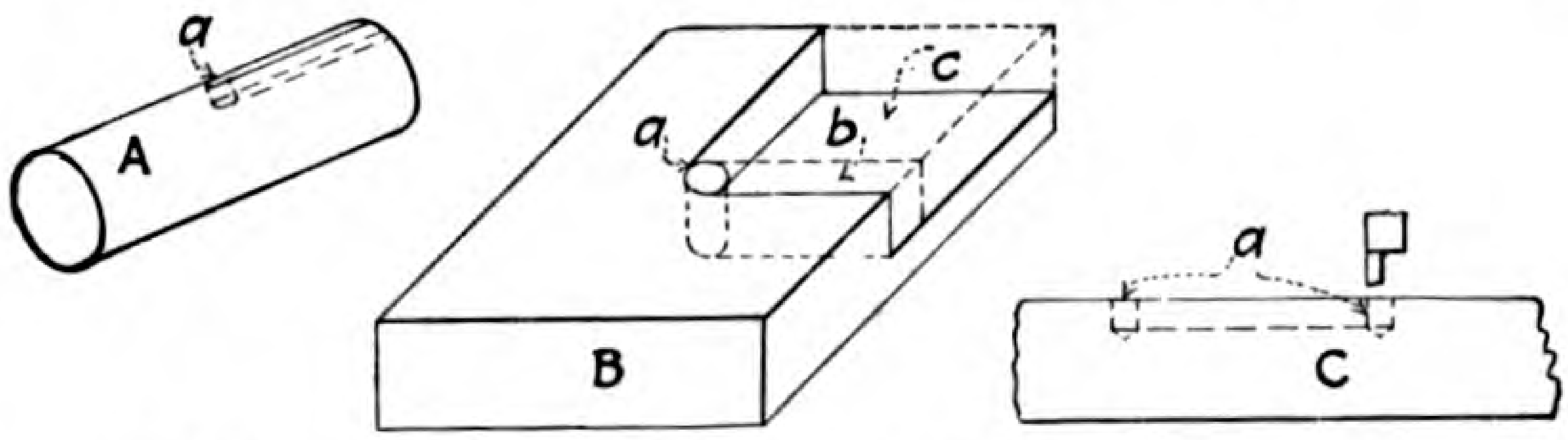


FIG. 102.—*A*, Diameter of drilled hole (*a*) equals width of keyway. In such a job as *B*, first drill hole at (*a*) say ¼″ diameter, next plane slot (*b*) then plane remainder (*c*) the cut ending in slot (*b*). Such a job as *C* requires a drilled hole at the beginning and also at the end of the keyway. Keyways such as shown in *A* and *C* are cut easier in the milling machine, but occasionally must be cut in the shaper or planer.

drill a hole, and in wide cuts to plane a groove, at the end of the cut for the reason that if the chips are not cut off they will remain to clog the cut and soon break the tool. Occasionally it is required to plane a groove, a keyway for example, somewhere between the ends of a rod or shaft *C* (Fig. 103). In such a case, holes should be drilled at the beginning and end of the slot.

NOTE.—Modern shapers are constructed to permit of the end of a shaft extending beneath the ram as far as desired.

95. Planing Keyseats.—It is often convenient to use a shaper to cut keyseats in the hubs of pulleys, gears, etc. A forged tool for this purpose is not economical and is not much used. Figure 103

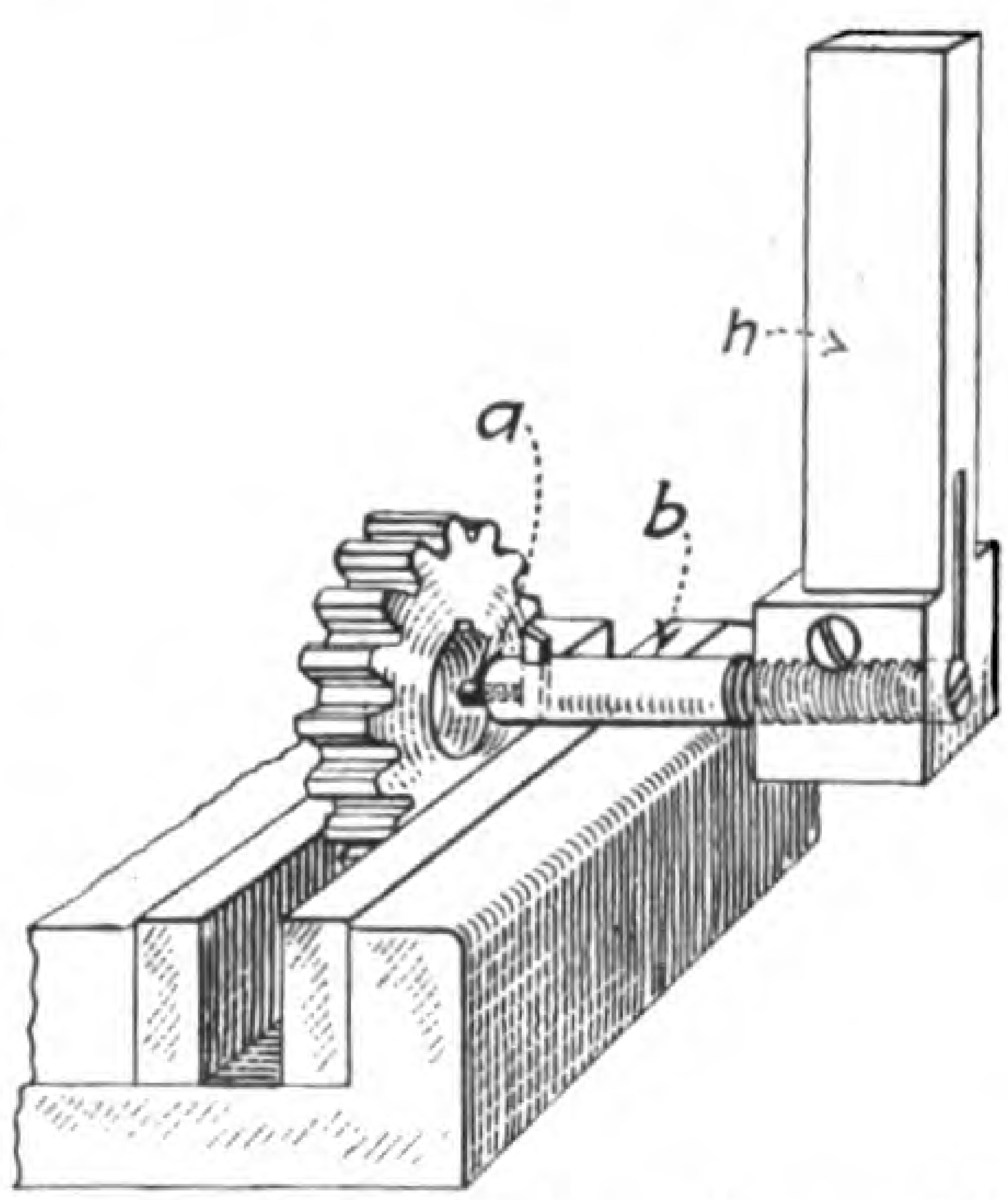
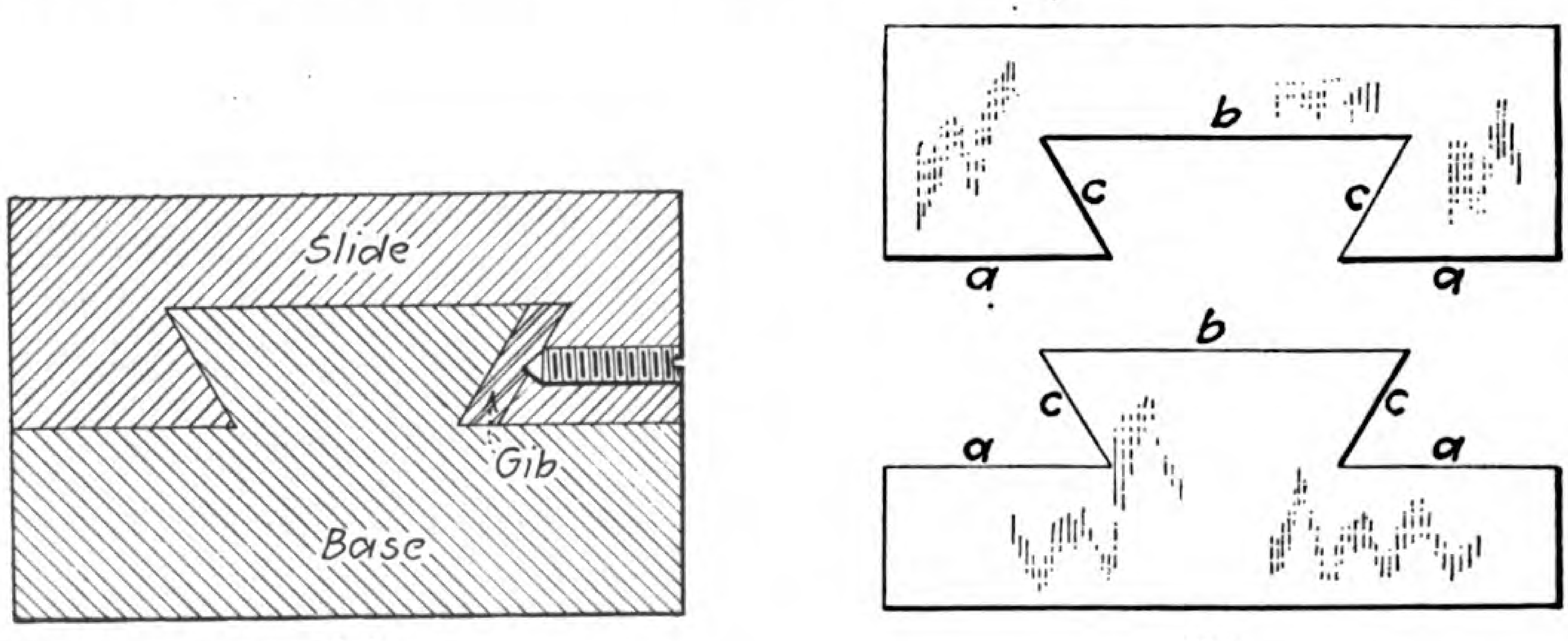


FIG. 103.—Planing a keyseat in a gear.

(see also Fig. 79) shows a keyway tool holder that works well. The tool point is held in the bar *b* by a setscrew *a* at the end. The thread on the bar screwing into the holder *h* helps materially in holding. Bars of various lengths may be used. It is much more efficient to set up the work with the layout on top and feed up as shown because of the tendency otherwise for the tool to chatter and jump.

Draw a radial line on the hub or blank, where it is desired to have the keyseat and set the work with this line perpendicular, using a square. After properly setting the tool adjust the work until the radial line is central with the tool. Take one stroke of the shaper by hand to be sure that there is no interference. When the tool touches the work set the graduations on the feed screw to zero and feed the required depth. On account of the springy nature of the tool use a fairly slow speed and do not feed over .010″ per stroke. If the keyseat is so wide as to make two cuts advisable it is best to lay out the sides of the slot to be cut.

96. Planing Dovetails.—A dovetail slide bearing is illustrated in Fig. 104. To finish such a bearing in the shaper



(*a*) (*b*)

FIG. 104.—Dovetail slide bearing

calls for operations which are very similar to cutting a tongue and groove, the chief difference being the planing of surfaces *c*. These surfaces, being angular, call for the set-over of the head and for at least one pair of undercutting tools. The shape of these tools is illustrated in (7) (Fig. 75) (see also Fig. 78). The work should not be disturbed after one side *c* is finished until the other side is finished. This means that a right-hand and left-hand tool will be needed. If considerable metal must be removed, it will probably need a roughing and finishing tool for each side. The surfaces *a* and *b* should be finished practically as for a tongue and groove, and without disturbing the setting of the work the surfaces *c* and the portion of the surfaces *b* under the overhang may then be roughed and finished. The tool that is used for surface *c* may properly be used for surfaces *a* and *b* provided the tool is not too slender and the surface is not too large. The beginner should pay particular attention to the swivel of the apron. Remember that when *not* properly set it may appear all right and therefore be *very sure* that the *top* of the apron is set in a direction *away* from the surface being planed.

97. Measuring Dovetails.—Probably the greatest difficulty in producing dovetails is in measuring them. When a gib[1] is used between two of the sliding surfaces as great a degree of accuracy is not required in planing as when the two pieces fit together. In either case, however, a smooth cut is necessary, a thousandth or two should be left for scraping, and care must be taken not to "leave too much," and certainly not to "take off too much." It is good practice to lay out the dovetail and if possible it should be scribed on a surface that has been finished. If several pieces are to be planed it will be advisable to make a template of sheet metal $\frac{1}{8}''$ to $\frac{1}{4}''$ thick to use for laying out and possibly as a gage.

The table on the next page should prove helpful in making accurate measurements of dovetails to find how much more it may be necessary to plane an angular surface and also to check the finished product. It consists of a series of fixed values for determining the measurements for various angles of dovetails when using various sizes of drill rod.

At first glance the table may appear rather difficult but its use involves only addition, subtraction and multiplication of decimals. In principle it is similar to the three wire method of measuring threads and its application is just as easy.

[1] Gib: In machine construction a piece of metal arranged to provide an adjustment for a bearing. In Fig. 104 *a* is shown a cross section of a straight gib between two bearing surfaces and adjusted by a series of screws. Frequently taper gibs are used and the dovetail in the base is made correspondingly wider at one end. Such a gib is adjusted lengthwise to take up the wear in the bearing surfaces.

MEASURING DOVETAILS WITH PIECES OF DRILL ROD

In the table R is the diameter of the drill rod and the values of D and F have been calculated as follows:

$$D = R\left(\frac{\cot \angle a}{2}\right) + R. \quad F = 2 \tan \angle a$$

Various diameters of drill rod	Various values of angle a			
	45°	50°	55°	60°
$R = \frac{1}{4}''$ $D =$	.853	.786	.730	.683
$R = \frac{3}{8}''$ $D =$	1.280	1.179	1.095	1.024
$R = \frac{1}{2}''$ $D =$	1.707	1.572	1.460	1.366
$R = \frac{3}{4}''$ $D =$	2.561	2.358	2.190	2.049
$F =$	2.000	1.678	1.400	1.155

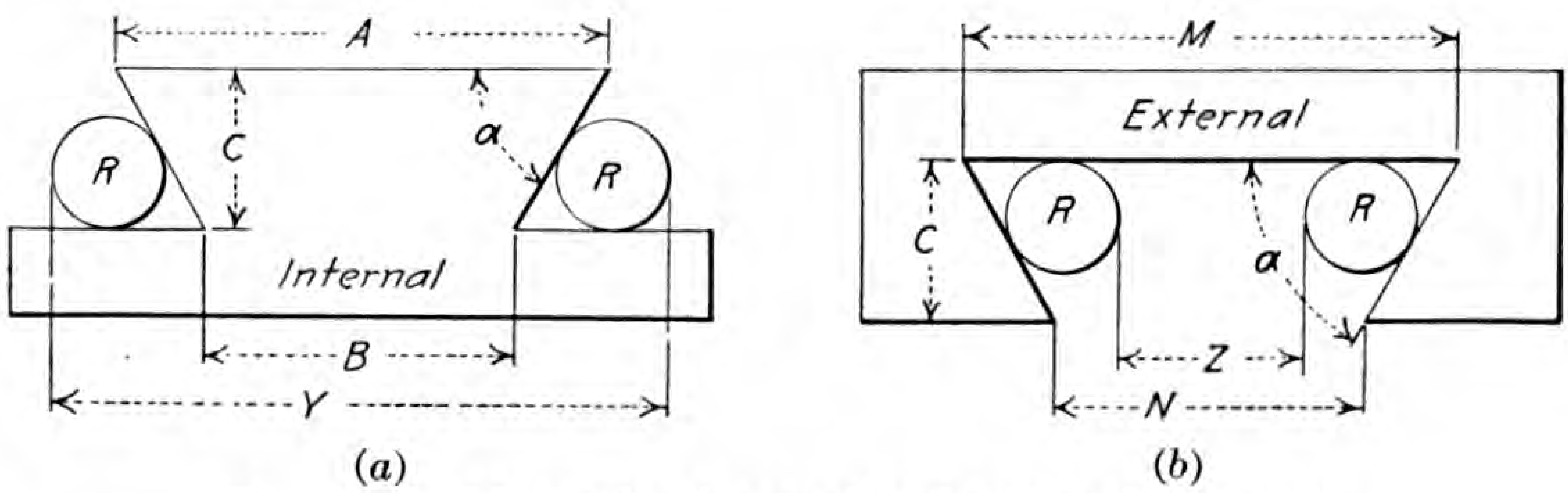


FIG. 105.—Measuring internal and external dovetails.

RULES

Internal

CASE I.—When the dimension B is given on the drawing.

$$Y = B + D$$

Example.—Angle $a = 60°$, $B = 2\frac{1}{2}''$. Using $\frac{1}{2}''$ drill rod, what should Y measure?

Solution.—$Y = 2.5'' + 1.366'' = 3.866''$.

CASE II.—When the dimension A is given on the drawing it is necessary to find dimension B before proceeding further.

$$B = A - CF$$

External

CASE I.—When the dimension M is given on the drawing

$$Z = M - D$$

Example.—Angle $a = 60°$, $M = 3''$. Using $\frac{1}{2}''$ drill rod what should Z measure?

Solution.—$Z = 3'', - 1.366'' = 1.634''$.

CASE II.—When N is the dimension given on the drawing it is necessary to find dimension M before proceeding further.

$$M = N + CF$$

Example.—Angle $a = 60°$, $A = 3''$, $c = \frac{3}{4}''$. Using $\frac{1}{2}''$ drill rod what should Y measure?

Solution.—First find dimension B thus: $3'' - .750'' \times 1.155 = 3'' - .866'' = 2.134''$.

Then $Y = 2.134 + 1.366 = 3.5''$.

Example.—Angle $a = 60°$, $N = 2''$, $c = \frac{3}{4}''$. Using $\frac{1}{2}''$ drill rod what should Z measure?

Solution.—First find dimension M thus: $2'' + .750'' \times 1.155 = 2'' + .866'' = 2.866''$.

Then $Z = 2.866'' - 1.366'' = 1.5$.

NOTE.—The measurement of Z may be made with adjustable taper parallels placed between the rods (see paragraph 92).

Questions on Shaper Work 2

1. Given an angular block say 2″ by 6″ and 1″ thick which side should you plane first? Which side will you plane next?

2. After planing the first surface, what objection is there to planing the opposite surface next?

3. Why is the surface that has been planed placed against the solid jaw of the vise?

4. Why is a strip placed between the movable jaw and the work?

5. When planing the third (and fourth) surfaces the use of two parallels, as far apart as convenient, is advisable. Why?

6. How does the arrangement suggested in the preceding question aid in making accurate measurement?

7. How are the ends planed when the piece is short? When the piece is over 6″ or 8″ long?

8. How is short work adjusted in the vise to make sure it is square when planing the ends?

9. Is a coarse feed or a fine feed used in finishing a cast-iron surface in a shaper? For finishing steel?

10. What kind of a tool is used for finishing cast iron? For steel?

11. In planing cast metals what precautions should be taken to prevent the metal breaking out at the end of the cut?

12. Why is it necessary to get under the scale when cutting cast iron?

13. What is a forming tool? Why is a spring tool holder excellent for holding a forming tool?

14. How is a comparatively narrow irregular surface planed?

15. After roughing out a wide irregular surface how is the edge bevelled? What is the object of the bevel?

16. What kind of a tool is used for finishing the sides of a tongue? The horizontal surfaces?

17. How may the groove be accurately and quickly measured?

18. Strange as it may seem, the cutter for keyseats works better up than down. How do you account for this?

19. When required to cut a keyway in a shaft a certain distance why do you first drill a hole at the end of the keyway?

20. What tool is used for finishing the angular surface of a dovetail?

THE PLANER

CHAPTER VI

PLANER CONSTRUCTION

98. Introduction to Planer.—The function of the planer is the production of flat surfaces on work that is too large or otherwise impracticable or impossible to machine in the milling

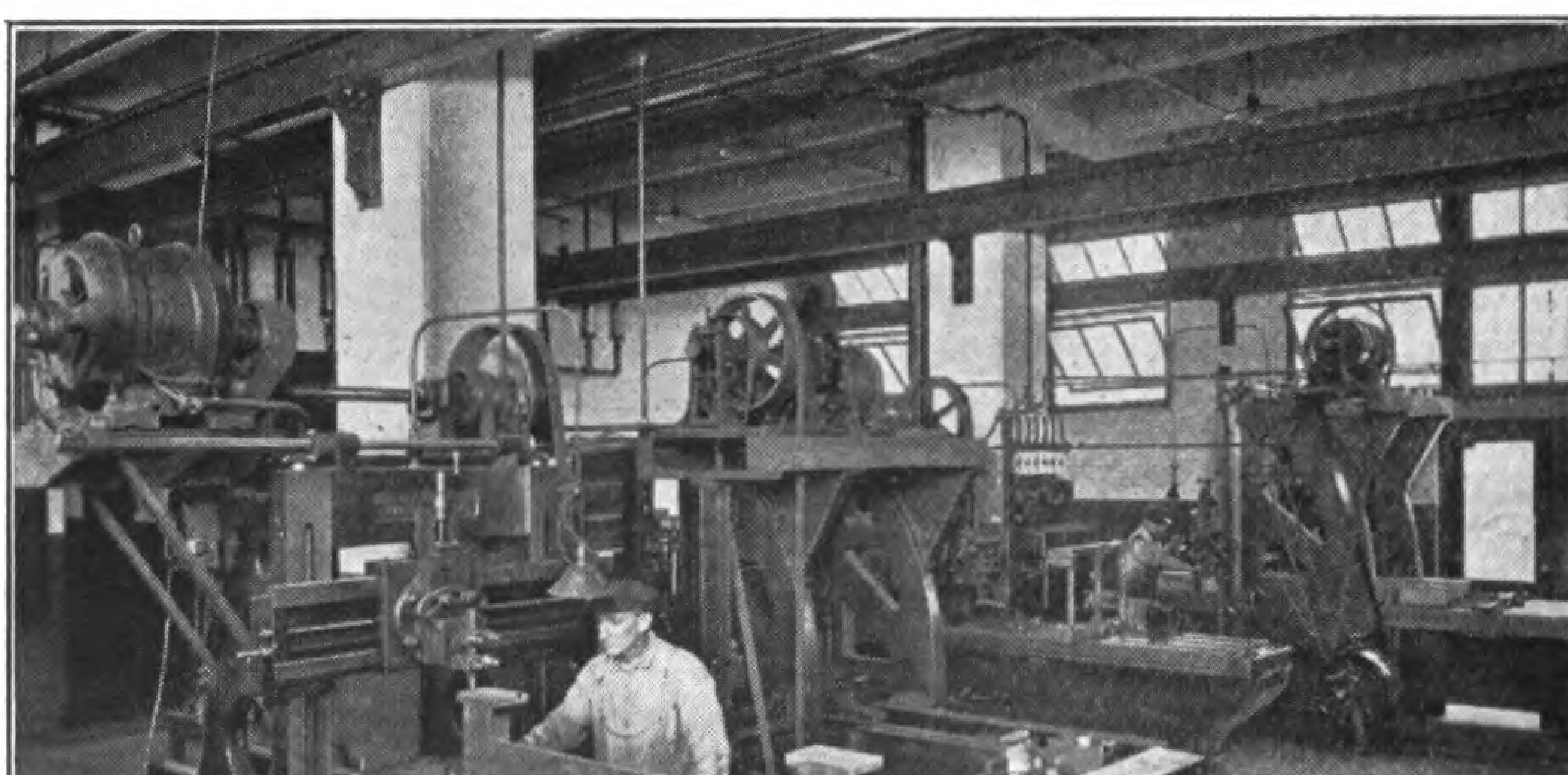


FIG. 106.—Typical shop view of small planers. (*Courtesy Taft-Pierce Mfg. Co.*

machine or shaper. The work is fastened on the work table or "platen" which has a reciprocating motion past the tool head. The tool cuts only on the forward or cutting stroke of the planer platen and is held stationary except for the feeding movement. The feed may be in a horizontal direction across the top of the work by reason of the movement of the tool head along the cross rail, or in a vertical or angular direction through the downward movement of tool head slide. The operation of the feeds will be explained later.

The single point cutting tool produces a more accurate surface and a surface much better adapted to the scraping operation than a milled surface. Each of the standard machines in the shop has its particular advantages and while the larger sizes of milling machines have taken the place of the planer in certain classes of work, they cannot compete with the planer in the production of flat surfaces that must be finished smooth and true. For example, such machine tool parts as lathe carriages, the bottoms of head stocks and tail stocks, the sliding surfaces of shaper columns and rams, also shaper tables, work tables of grinding machines, milling machines, etc. are planed. For the bases, frames, and heavier sliding parts of such machines as steam engines, locomotives, printing presses, and rolling mill, wood working, and textile machinery, etc. the planer is indispensible.

The general run of planing is very accurate work and calls for a high degree of skill. Planer work should prove very interesting. First-class planer hands are hard to find and consequently are among the best paid mechanics in the trade.

99. Parts of the Planer.—In order to understand certain necessary descriptions which follow it will be advisable for the beginner to become familiar with the names and functions of the planer parts. In a general way the names and descriptions given in the following pages apply to any standard planer of whatever make.

100. Size of Planer.—Planers are classified as to size by the distance between the housings, the distance between the platen and the cross rail at its highest position, and the maximum stroke, for example, the planer illustrated Fig. 107 is 24 × 24 in. × 6 ft.

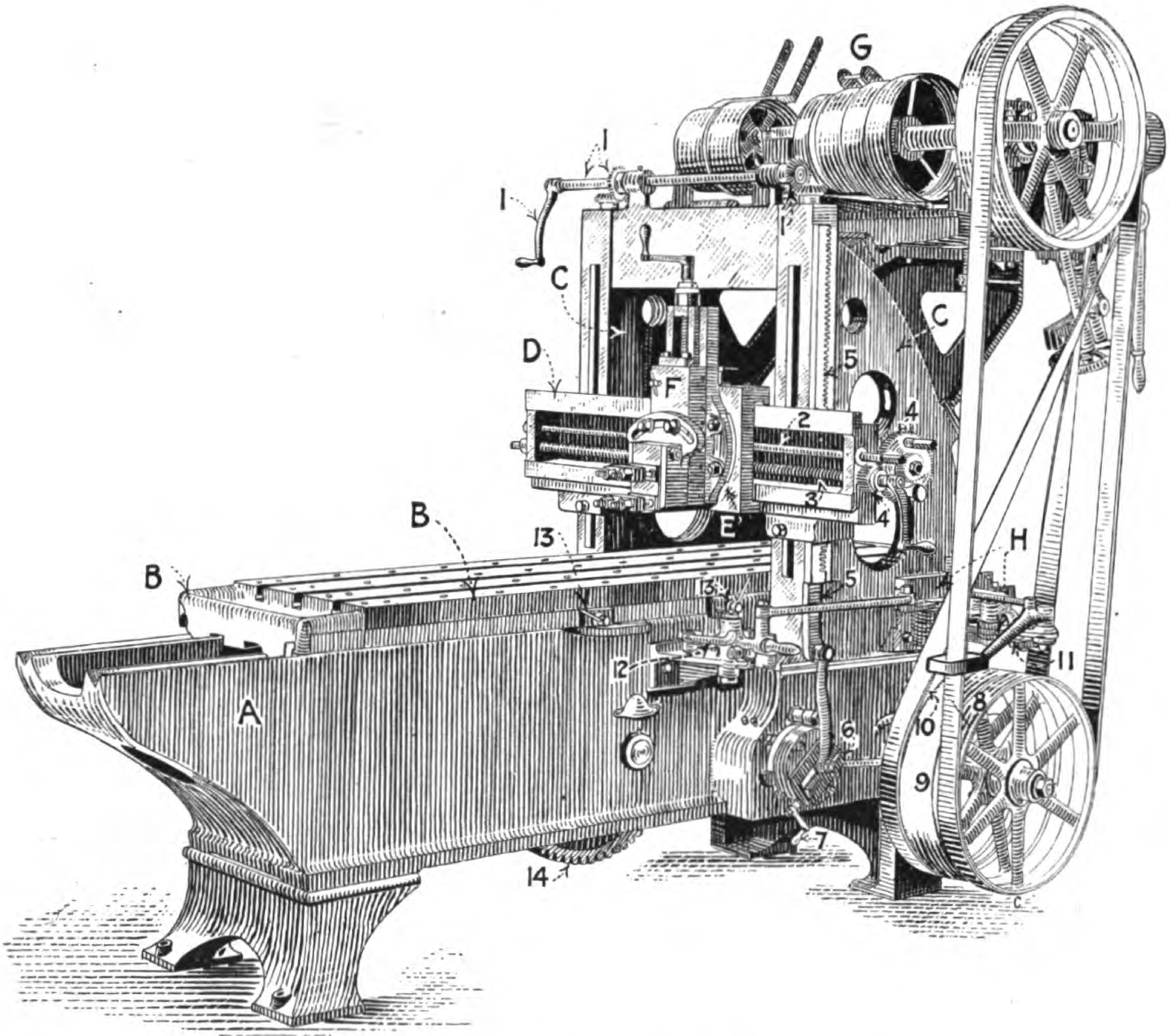


FIG. 107.—Planer. (*G. A. Gray Co.*)

PARTS OF THE PLANER

INDEX TO UNIT NAMES

A. *Bed*, of deep box section, with cross girths to give strength and stability. V-tracks accurately machined and scraped provide sliding ways for the table or "platen."

B. *Table or "platen,"* provided with T-slots and reamed holes for purposes of clamping or otherwise holding the work.

C. *Uprights or "housings" or "posts."* These very rigid supports for the cross rail are securely bolted and pinned or tongued to the bed. The front faces are machined and scraped to be parallel to each other, in perfect alignment, and square with the bed. They are tied together at the top by the "arch" to give greater strength and rigidity.

D. *Cross rail*, carries the saddle and tool head. May be raised or lowered and clamped in the desired position on the finished faces of the housings. (Release the clamps before adjusting.)

E. *Saddle*, supports the tool head, may be moved along the cross rail by hand or power

F. *Tool head,* is firmly fastened to saddle, which is accurately scraped to the cross rail with taper gib adjustment for wear. Has automatic cross feed on the rail, and the tool head slide and screw provide for vertical and angular feed. The feeds may be operated by hand from either side of the machine. Angular position of the head is indicated by graduations in degrees. Downfeed screw is provided with graduated dial reading in thousandths of an inch (for details see Fig. 108).

G. *Speed variator.* For part names see Fig. 114.

H. *Belt shifting mechanism.* For description of principle of mechanism see page 128.

I. Feeding mechanism. Numbers 3 to 7.

J. Driving and reversing mechanism. Numbers 8 to 14.

INDEX TO PART NAMES

1. *Handle, shaft,* and *bevel gears* for raising or lowering the cross rail Motion is transmitted to vertical screws, one back of the face of each upright. It is essential that the cross rail clamping bolts or levers are loosened before attempting to change the position of the cross rail, or the gears and threads will be strained and possibly ruined.

2. *Feed rod* for downfeed, operates through bevel gearing to downfeed screw in tool head.

3. *Feed screw* for cross feed, operates to feed the saddle (and tool head) along the cross rail. Provided with graduated collar reading in thousandths of an inch.

4. *Feed gears,* operate ratchet and pawl mechanism transmitting the feed motion to either the feed rod or the feed screw. (The small gear, "trigger gear," which in some planers encloses the ratchet and pawl may be changed from feed rod to feed screw as desired.)

5. *Feed rack,* operates feed gears (4).

6. *Rocker* on friction, connected by link to feed rack and moves feed rack up and down (friction described, p. 132).

7. *Handle* for adjusting the amount of feed. (Also the position of the nut on the adjusting screw one side or the other of center of rocker slot determines whether the feed shall operate at the end or at the beginning of the cutting stroke).

8. *Loose pulley* for carrying the reversing belt when it is off the tight pulley

9. *Tight pulley.*

10. *Loose pulley* for carrying the driving belt when it is off the tight pulley.

11. *Belt shifting devise* (cam action) operates at the end of the cutting stroke to shift the driving belt off the tight pulley and the reverse belt on. At the end of the return stroke this operation is reversed (explained more fully on p. 128).

12. *Shifter lever* operates the belt shifting devise (11) to reverse the motion of the platen when moved either automatically by means of the dogs (13) or by hand. Also operated by hand to bring the shifting devise to neutral position with both belts on the loose pulleys. In this manner the platen may be stopped without stopping the machine.

13. *Dogs,* adjustable along the side of the platen. The position of these dogs determine the length and "position" of the cutting stroke.

14. *Driving gear* or *bull wheel,* engages a rack fastened to the platen and extending the length of the platen (see "Planer Drive," p. 123).

Perhaps a larger range of sizes obtains in planer manufacture than in any other machine tool except the lathe, but fortunately, in the planer as in the lathe, the principles of construction and operation are practically the same for any size.

To be able to handle a planer, the operator should understand, first, the general construction of the machine, especially the driving mechanism, the feed mechanism, the tool head, and the adjustment of the cross rail which carries the tool head; second, the various methods of clamping the work, which operation, on the planer, probably calls for more skill than in any other machine shop tool; third, how to obtain the cutting action of the tools used which will give the best results.

101. The planer bed is particularly heavy and is designed for strength and rigidity under great weight and heavy duty. The ways for the platen sliding surfaces are planed and scraped. They are automatically oiled from oil wells suitably located. These wells should be filled every week and occasionally should be cleaned. The ways must be smooth and true if accurate work is to be expected. Careless and ignorant operators frequently lose sight of this fact and gritty dust and dirt are allowed to settle on the ways, in fact are often brushed into the ways. Be careful, remember that proper attention directed to the care of machinery marks the *real mechanic* whether he is the operator or the superintendent.

102. The planer platen supports the work. It is provided with accurately finished T-slots for the work holding strips or fixtures and the necessary bolts. It is also provided with reamed holes for stops, poppets, etc. The platen is made of the best cast iron. For the sake of permanency in its finished shape it is rough planed and then allowed to "season" a reasonable length of time before it is finish planed and the sliding surfaces scraped. To make for accuracy the top is planed on its own bed before it is shipped.

The platen is *not* an anvil, nor is it a suitable depository for half the bolts, clamps, and wrenches in the shop. The holes are accurately reamed to size and care should be taken to keep them round and smooth. Put a little oil on the stops or other planer "furniture" before you wring or tap them into the holes (never *hammer* them in). Two or three strips of old belting placed across the platen protects it when placing heavy castings. After the piece is in position it may be lifted, perhaps with a pry, and the belting removed.

103. The Cross Rail.—The cross rail carries the saddle and tool head. It is adjustable vertically on the finished front faces of the housings by means of two vertical screws; one in each housing. Both screws are moved an equal amount by turning a horizontal shaft arranged above the housings; motion of the shaft being transmitted through bevel gears to each screw at the same time. In the smaller planers the shaft is squared on the end to receive a crank, in the larger planers, 36″ by 36″ and over, a power elevating device is provided.

The cross rail should be clamped rigidly to the housings when in use, and it must be remembered to loosen the clamps when adjusting for height.

The cross rail is of box section construction enclosing the feed rod for power downfeed and the feed screw for the regular cross feed. Great care is taken to have the surfaces on the back scraped to an accurate flat bearing on the housings, and the surfaces for the saddle bearing perfectly fitted and parallel. The elevating screws are arranged to adjust the cross rail equally on each end, but for accurate work care must be taken, especially if the screws are worn or strained, that the rail when clamped is parallel to the platen.

To make sure the rail is parallel to the platen lower it on suitable parallels arranged each side of the platen and then clamp. Another way is to tighten an indicator in the tool post with the point touching the platen and note the reading as the head is run across the rail.

104. The Tool Head (Fig. 108).—In construction and operation the planer head is very similar to the shaper head.

As in the shaper head the vertical adjustment of the tool is made by turning the downfeed screw handle. The *planer head,* however, is always provided with power downfeed, motion being transmitted from the feed rod through a toothed clutch feathered on the rod, thence through two pairs of bevel gears G_1, G_2, G_3 and G_4 to the downfeed screw.

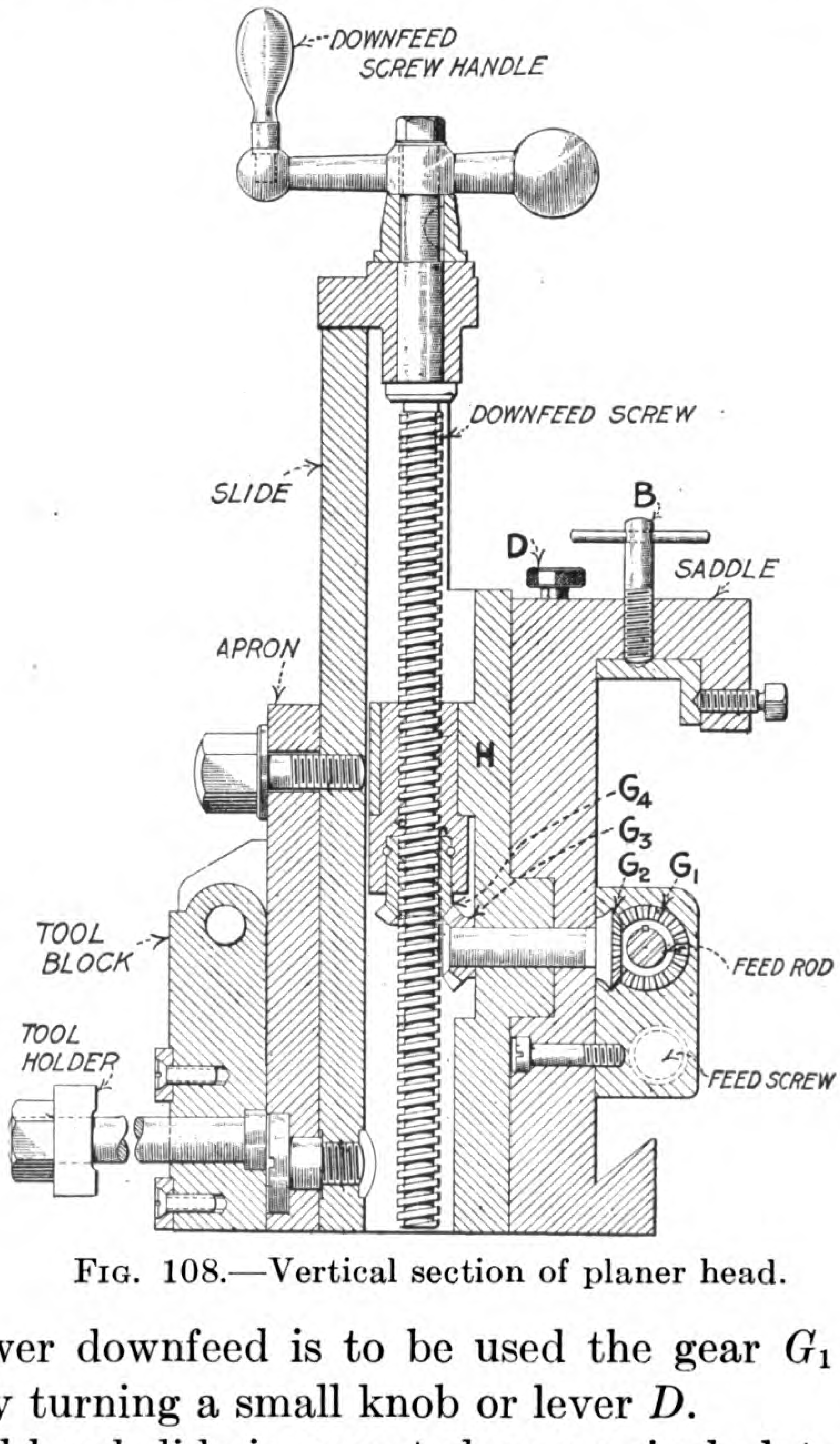


FIG. 108.—Vertical section of planer head.

When power downfeed is to be used the gear G_1 is engaged with G_2 by turning a small knob or lever D.

The tool-head slide is mounted on a swivel plate or "harp" H which is fastened to the saddle by two or more clamping bolts. When the bolts are loosened slightly the head may be swivelled through an angle of 90° either side of its vertical or normal position. Graduations in degrees indicate the angular setting. Similarly as in the shaper head the *apron* may be "set over" either side in order that the tool may clear the work when taking a vertical or angular cut (see p. 103).

A saddle binder screw B is provided for holding the saddle rigidly in position when taking a vertical or bevel cut and a tool slide binder screw is provided for holding the tool slide when taking a horizontal cut. Do not forget to loosen these screws when it is desired to move either part. *Remember always that every moving part of a machine should move freely.*

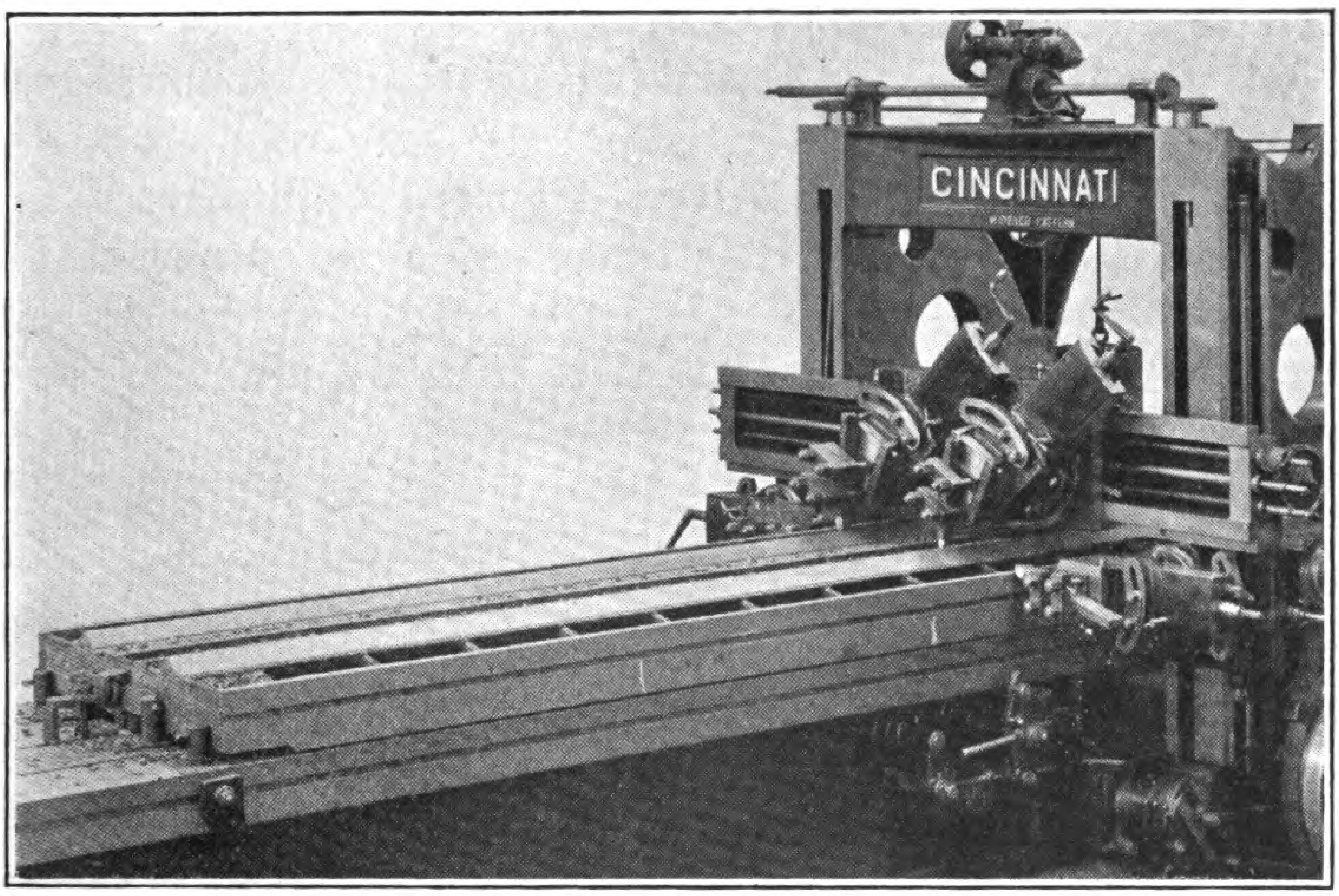


FIG. 109.—Planer with four heads working at the same time on the bottom and sides of a smaller planer platen. (*Courtesy Cincinnati Planer Co.*)

The smaller planers have only one tool head; the larger planers have two heads with independent feed screws. Planers 28″ wide and over may be provided with a side head mounted on the face of each housing. In such planers the finished faces of the housings are long enough to permit of the side heads being run down below the top of the table (see Fig. 109).

105. Planer Driving Mechanism.—The planer platen is driven by means of a gear meshing with a rack which is fastened on the under side of the platen. In most planers the driving gear is fairly large in proportion, and especially rugged in design, and is often termed the "bull wheel." There are two features of the planer driving mechanism that are especially interesting; (1) the gearing which serves to reduce the speed between the driving pulley and the bull wheel and (2) the mechanism which causes the reversal of the direction of rotation of the bull wheel to give the forward and return movement of the platen.

It may be stated that planer driving mechanisms are divided into three distinct classes: the extended gear train or "bull wheel" drive; the second-belt drive, and the spiral-gear drive.

106. The Bull-wheel Drive.—Figure 110 illustrates the extended gear train or bull-wheel drive as furnished for

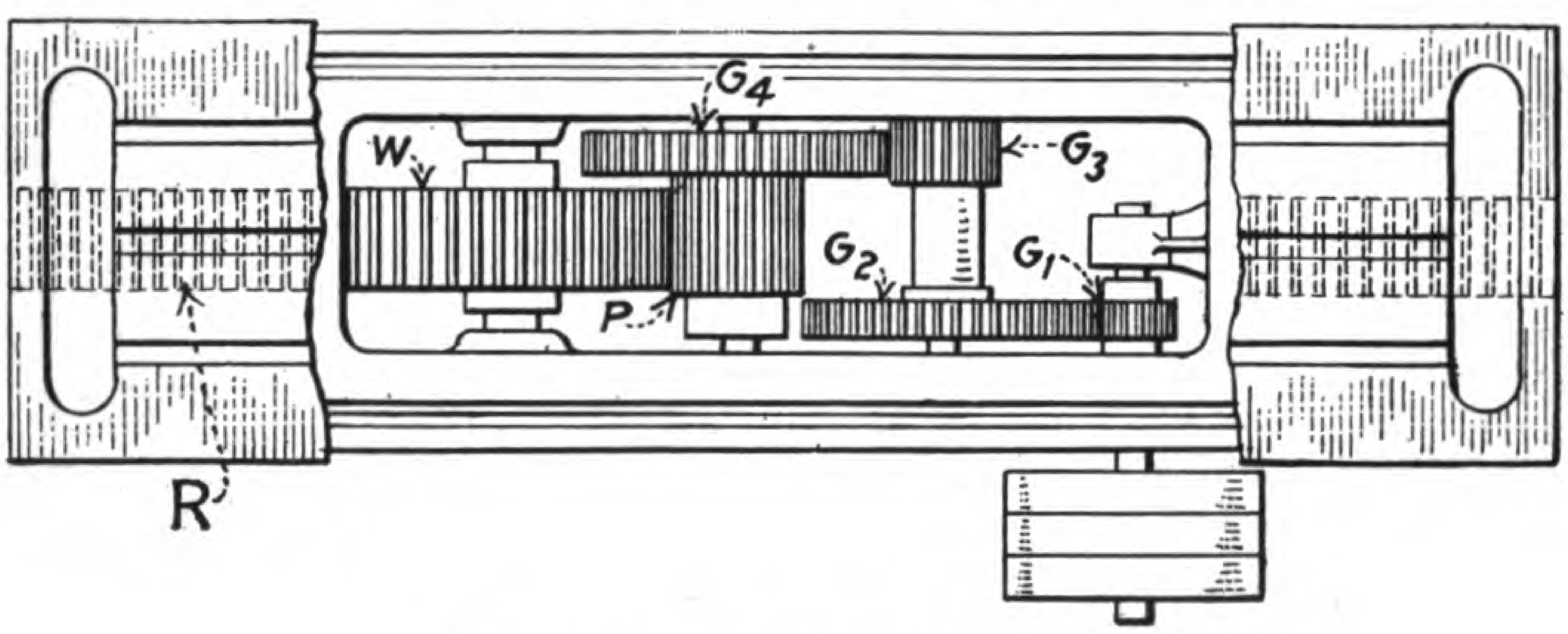


FIG. 110.—Bull wheel drive.

example, on the Gray Planer (Fig. 107). Motion is transmitted from the countershaft to the tight and loose pulleys by means of an open belt for the forward stroke and a crossed belt for the reverse. This motion is further transmitted and the speed reduced by the two pairs of reducing gears G_1 and G_2, G_3 and G_4. The bull-wheel driving pinion P is keyed to the same shaft as G_4 and being engaged with the bull wheel W and much the smaller of the two, serves to transmit motion to the bull wheel at still further reduced speed. The bull wheel engages the rack R which is fastened to the under side of the platen, consequently the platen moves forward or back according to the direction of rotation of the bull wheel.

107. The Second Belt Drive.—Figure 111 illustrates the principle of the second drive belt as applied to Whitcomb Planers. *A* indicates the two loose pulleys and one tight pulley driven from the countershaft. The "second" belt *D*

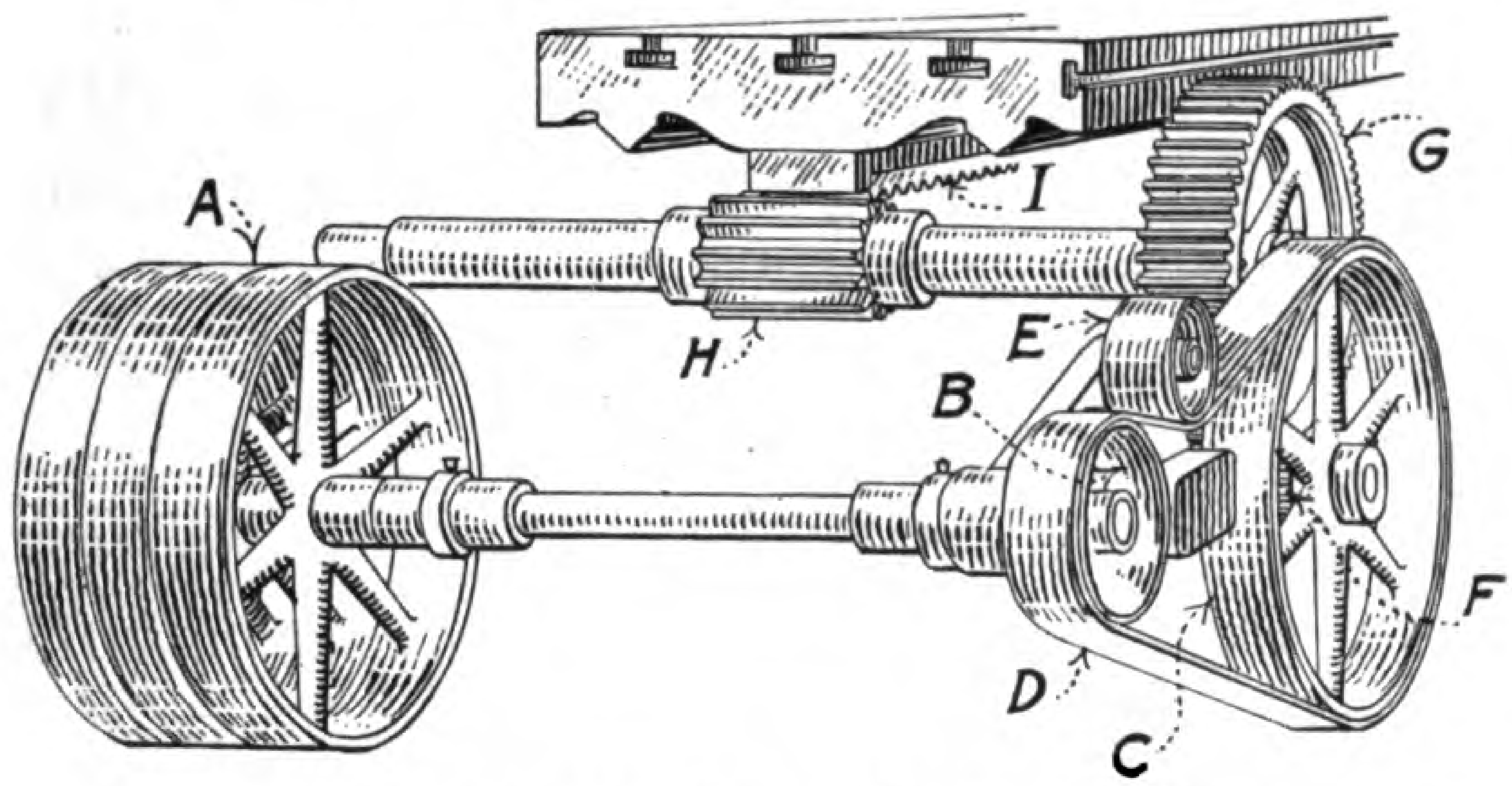


FIG. 111.—Second belt drive. (*Whitcomb.*)

transmits motion from the driving pulley *B*, to the driven pulley *C*. The pulley *E* is an idler which follows up the belt as it stretches and keeps it at the proper tension. The driving pinion *F* is carried by the pulley *C* and engages the large driven

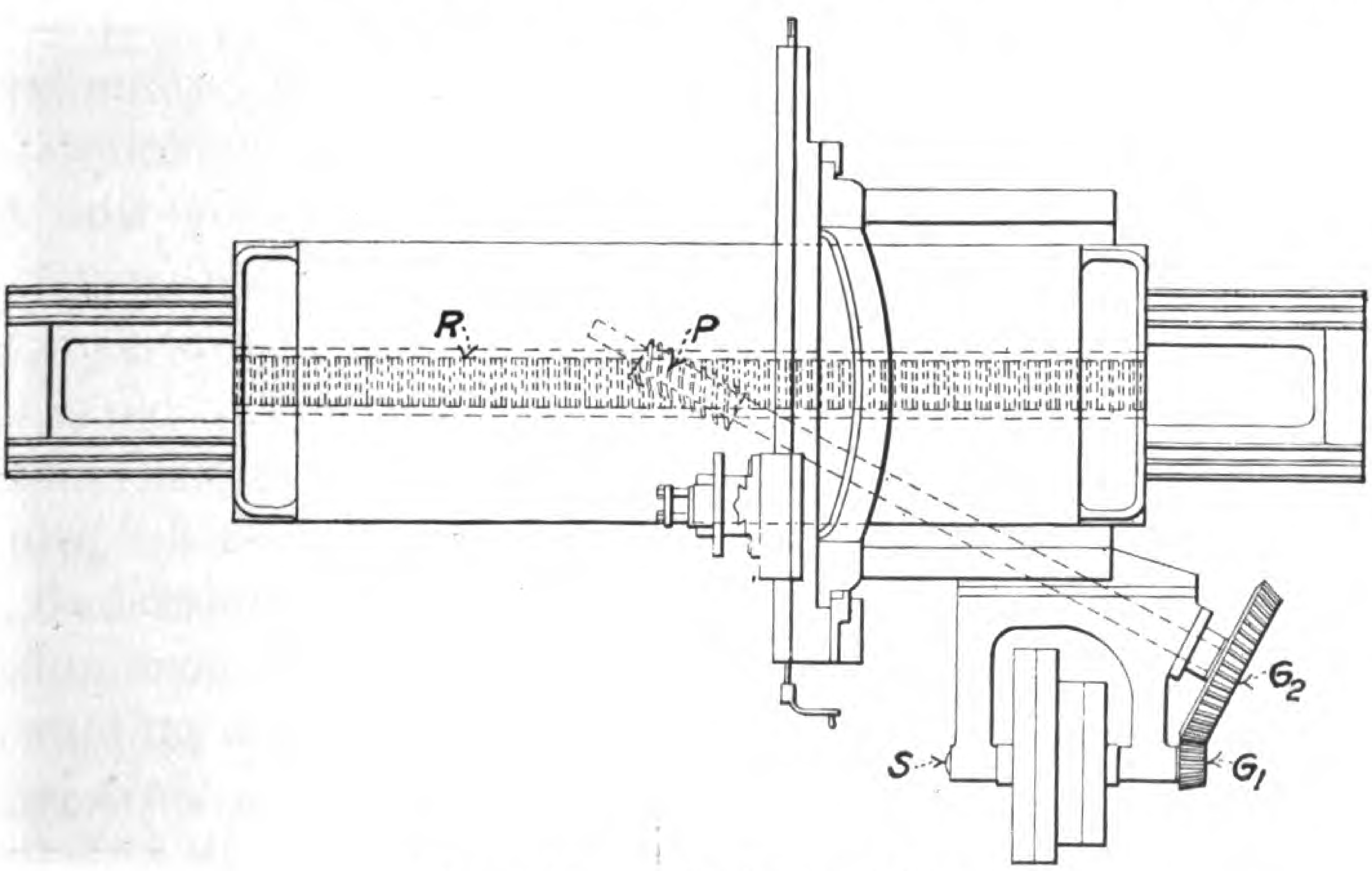


FIG. 112.—Spiral gear drive.

gear *G* which is mounted on the main driving shaft. The main driving shaft carries the gear *H*, which meshes with the rack *I* and drives the platen.

108. Spiral Gear Drive (Fig. 112).—In the planer with the spiral gear drive, motion is transmitted to the platen by means of a spiral pinion P which engages directly with the rack R, and has at all times several teeth in working contact. This spiral pinion is mounted on a shaft which crosses the bed diagonally and motion is transmitted to this shaft from the pulley shaft or driving shaft S through the bevel gears G_1 and G_2. The pulley shaft is parallel with the line of motion of the table, consequently the planer may be placed parallel with the line shaft which feature is often convenient. The continuous semi-rolling, semi-sliding action of the spiral gear drive gives to this type of planer a remarkable smoothness of motion and freedom from vibration.

109. Quiet Running Qualities of Planer.—Great care is taken in the design and construction of planers to insure smooth running and long life. The gears are of ample size cut from the solid with special cutters made for the particular number of teeth in each gear. The shafts and bearings are proportionally large, in fact, the whole machine is especially rugged. If proper care is taken to keep the ways and other flat bearing surfaces cleaned, all of the bearings, round and flat, properly oiled and the gears well greased, a planer will keep quiet and do its work indefinitely. The boy who has learned to use a piece of waste and an oil can *intelligently* on the machine he is running has gone a long way toward understanding the construction of the machine.

110. Reversing Mechanism.—In any belt driven planer there are two belts, one "open" and one "crossed," which serve in turn to transmit motion from the countershaft to the tight and loose pulleys of the planer driving mechanism. Some planers have one tight pulley and two loose pulleys all of the same diameter, others have two pairs of pulleys of different diameters one tight and one loose in each pair, the larger pulleys for the "cutting" belt and the smaller for the return belt. In either case belt shifters operate automatically when the machine is running, to shift the cutting belt off the tight pulley onto its loose pulley, and the return belt off its loose pulley onto the tight pulley at the end of the cutting stroke, and the reverse at the end of the return stroke.

The belt shifters are moved by means of a camplate operated through a series of two or more lever arms which are controlled by a slight movement of the initial shifter lever (12, Fig. 107) on the side of the planer. The end of this shifter lever opposite the handle projects far enough beyond the pivot pin to reach nearly to the platen, consequently the dog (13, Fig. 107), fastened to the moving platen, comes in contact with the lever, and causes a movement of the lever, a shifting of the belts, and a reverse movement of the platen. This movement will continue until the other dog pushes the lever in the opposite direction. The distance apart of the dogs determines the length of stroke and where they are located on the platen determines the "position" of the stroke.

The purpose of the camplate is to move the belt shifters in such a way that the one belt is completely off the tight pulley before the other is on, to avoid any tendency of the belts to pull against each other.

This feature of construction has the added advantage of making it possible for the operator with a slight movement of the shifter lever, by hand, to run both belts on the loose pulleys thus stopping the platen without stopping the machine. A safety locking pin is provided to prevent accidental starting of the platen. The operation of the belt shifting mechanism is illustrated in Fig. 113.

111. Planer Speeds.—The single speed planer, with a cutting speed of from 25 to 30 feet per minute and a return speed of from two to four times as fast, has been regarded as standard equipment. The single speed planer may still be regarded as suitable in shops having a large amount of uniform planer work provided the speed is arranged in the first place for the particular kind of work. However, the cutting speeds suitable for planer tools are governed by the same general conditions that obtain in other machine tools and therefore multi-speed planers must be recognized as most economical for general work. See List of Tables. p. 397

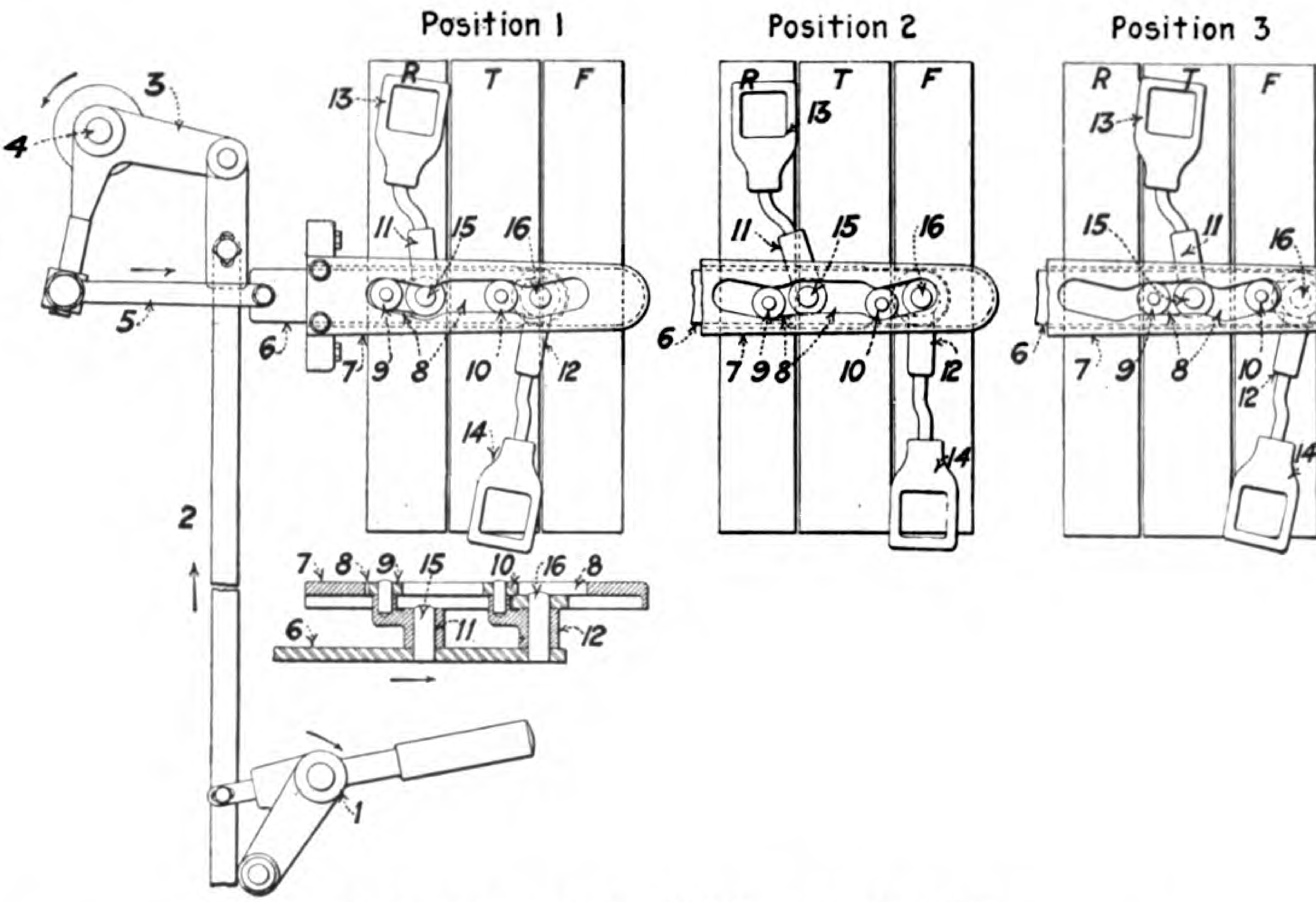


FIG. 113.—Belt shifting mechanism.

The dogs on the side of the planer platen serve to move the lever (1). The lever (1) moves the rod (2) and this operates the bell crank (3) pivoted at (4) and causes a movement of the rod (5) and also the sliding bar (6). Directly over the sliding bar is the cam plate (7) which is fastened to the side of the planer. The cam slot (8) is cut in the cam plate and (9) and (10) are rollers which fit the sides of the slot. The studs on which these rollers are carried are mounted respectively on the short arms of the bell cranks (11) and (12) the long arms of which carry the belt guides (13) and (14). The bell cranks being pivoted on the sliding bar (6) at (15) and (16) move with the sliding bar, and as the rollers (9) and (10) on the short arms of the bell cranks follow the outline of the cam slot the belt guides (13) and (14) are moved in accordance with the movement of these rollers in the cam but a greater distance due to the greater lengths of their lever arms. That is, the parts of the cam slot not parallel with the line of motion of the sliding bar (6) serve to move the short arms of the bell cranks and cause the belt guides to move a considerable distance over the pulleys.

The three positions of the sliding bar.

The cam slot is so made that when the sliding bar (6) is in the "position 1" the reverse belt guide (13) is over the loose pulley *R* and the cutting belt guide (14) is over the tight pulley *T* which is keyed to the driving shaft.

When the sliding bar (6) moves to "position 2" the belt guide (13) remains over the pulley *R* because the roller (8) following the slanting part of the cam slot serves to move the belt guide (13) back as the bar (6) is moved forward. That is, the belt guide (13) is moved back far enough to compensate for the movement of the sliding bar (6). The belt guide (14), however, moves over the loose pulley *F* because the roller (10) following the more abrupt curve in the cam slot throws the belt guide (14) over twice as far as the bar (6) moved. Therefore, in "position 2" the belts are running neutral, that is, both are on loose pulleys.

When the sliding bar (6) moves to "position 3" the guide (13) moves over the tight pulley *T* similarly as when the guide (14) was moved to "position 2," and the guide (14) remains over the loose pulley *F* similarly as the guide (13) did in moving to position 2.

When the direction of the guide plate is reversed the above movements are reversed, thus (14) remains on *F* until (13) is over *R*, at which time (14) moves over *T* as shown in position 1.

112. Speed Variator.—The various planer manufacturers have developed simple and effective means of quickly changing the cutting speed. The "speed variator" as it is called is usually mounted on a plate on top of the housings. One type of speed variator is illustrated in Fig. 114. Four speeds are obtained through a pair of opposed four-step cone pulleys connected by a belt. One of these pulleys is mounted on a

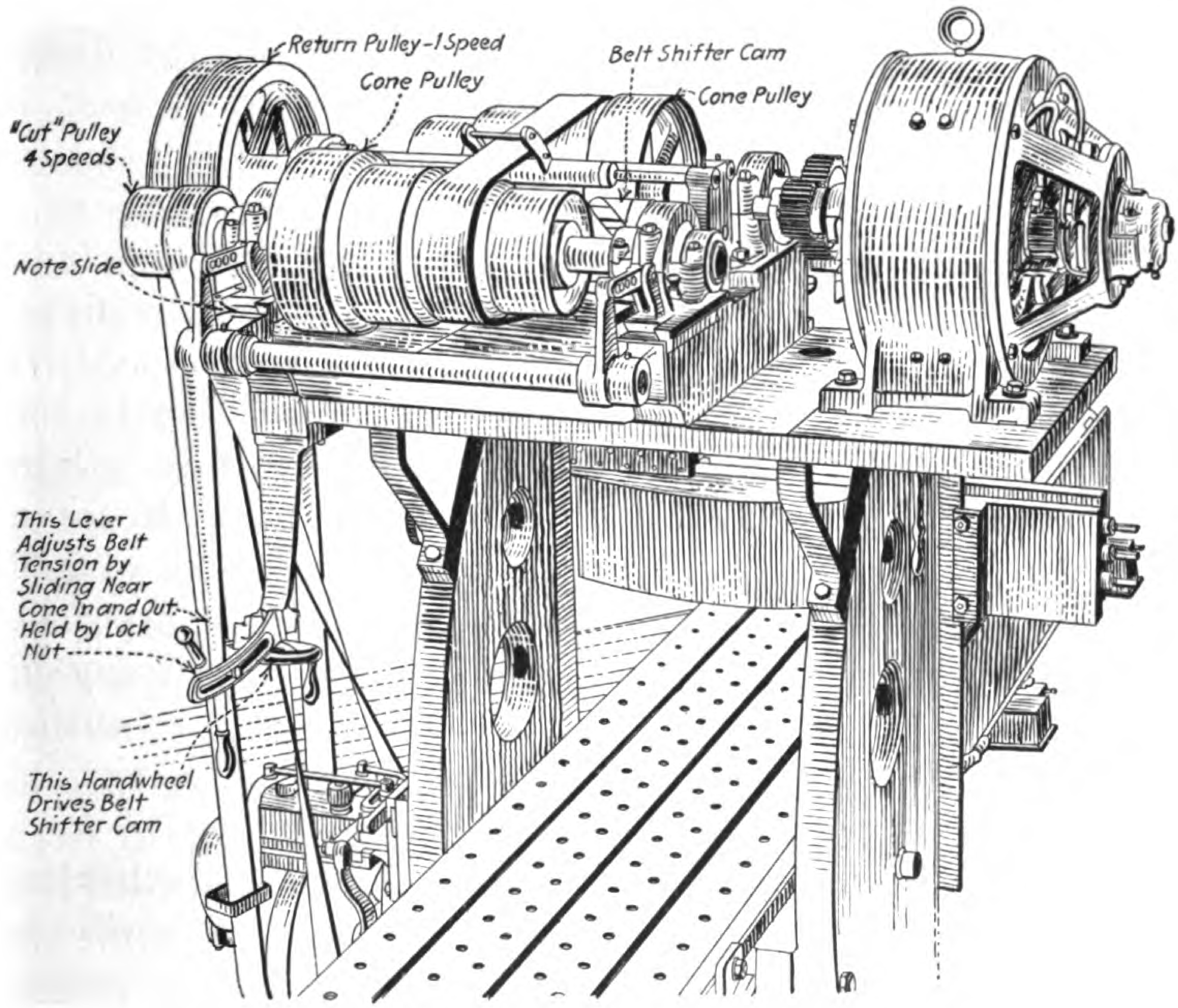


FIG. 114.—Planer speed variator. (*G. A. Gray Co.*)

constant speed shaft which may be driven by a belt directly from the line shaft or by a silent chain or by gears from a motor placed with the variator on the plate. On the end of this constant speed shaft is the return stroke driving pulley. Consequently the return of the planer platen is constant. The other cone pulley is mounted on the variable speed shaft on the end of which is the cutting stroke driving pulley. Consequently four speeds may be given this pulley.

The belt is moved from step to step on the cones by a conveniently arranged hand wheel or lever. On the smaller sizes of the planer the variator is usually arranged for the following speeds: 25 feet, 33 feet, 42 feet, 50 feet per minute cutting speeds and 100 feet per minute return speed, and on the larger sizes of planers, 22 feet, 30 feet, 37 feet, 45 feet cutting speed and 90 feet return.

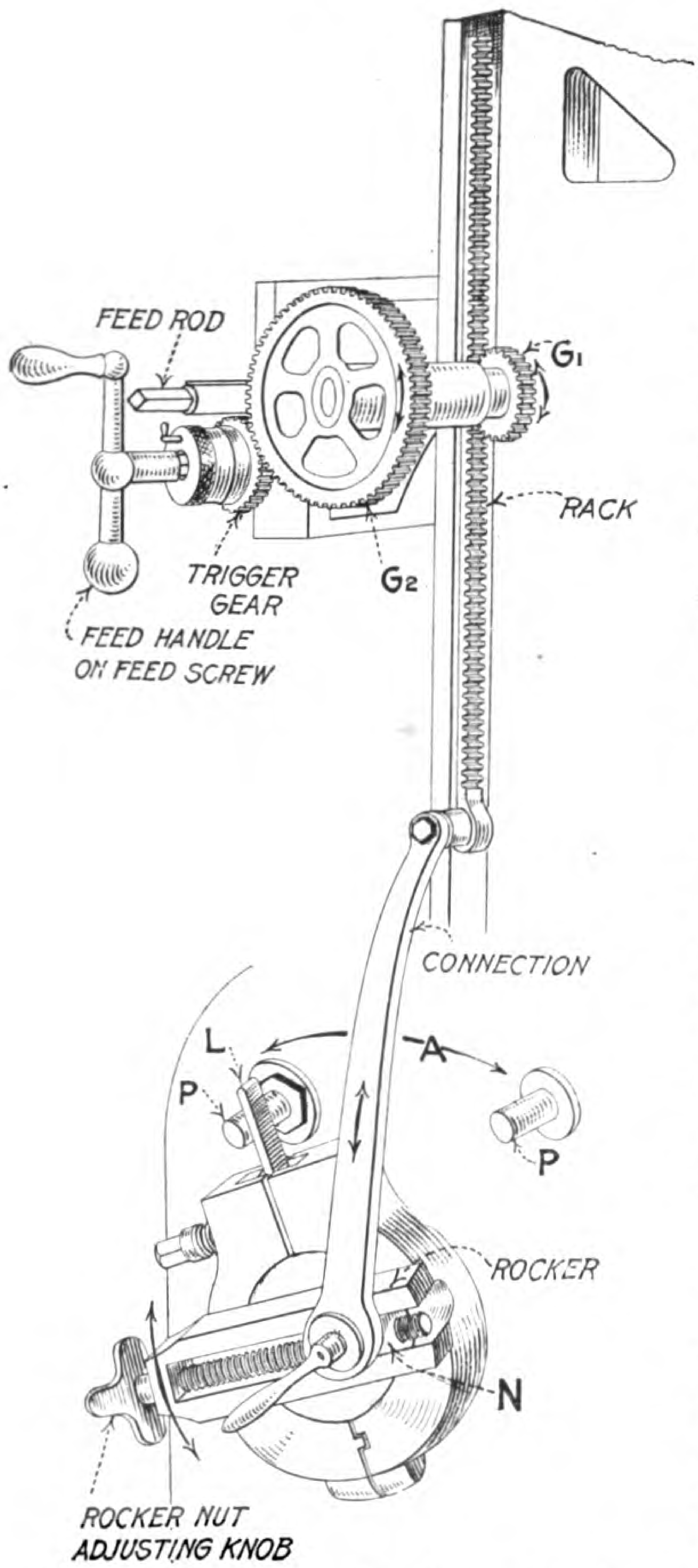


FIG. 115.—Planer feed mechanism.

The larger sizes of planers, however, are best equipped with a variable speed reversing motor directly connected to the initial driving shaft of the planer by means of a coupling. This variable speed drive is especially efficient and with it any one of a wide range of cutting speeds, and also return speeds, is available.

113. Feeding Mechanism. When planing a horizontal surface the feed is accomplished by causing the feed screw to move, thus causing the head to move along the cross-rail. When planing a vertical or an angular surface the feed is accomplished by causing the downfeed screw in the head to move.

The end of the feed screw is squared on the end to receive a handle which is used for adjusting the head to the required position on the cross rail, or for hand feed if desired. Likewise the end of the feed-rod is squared and the handle may be removed from the feed screw and put on the feed rod for adjusting the head vertically, if the bevel gears G_1 and G_2 (Fig. 108) are engaged. However most vertical adjustments of the tool are made directly by using the downfeed screw handle, the feed rod being primarily for the purpose of automatic down feed.

A ratchet and pawl mechanism is used in transmitting the automatic or power feeds and in most modern planers this mechanism is contained within a gear frequently called the "trigger gear" Fig. 115A.

In addition to being squared to receive the feed handle both the feed-screw and feed-rod are turned the same size, and keyed, to receive the trigger gear.

By referring to Fig. 115 which illustrates a common type of feeding device, it will be observed that motion is transmitted gear from the rocker, through a connecting link to the rack, thence through the gears (G_1) and (G_2) to the trigger. The trigger gear meshes with gear (G_2) when on either the feed screw or the feed rod.

As will be explained presently the rocker moves through a part of a revolution each forward stroke of the planer and back on the return stroke, consequently an oscillating motion is given to the trigger gear. The amount of this movement is governed by the distance the rocker arm nut N is off center, and whether the motion shall be at the beginning of the forward stroke or the return stroke is determined by the position of the nut one side or the other of the center. Regardless of the length of stroke, the operation of the feed takes place during four or five inches of the stroke. Except on the shorter cuts, it is customary to have the feed operate at the beginning of the forward stroke. Since the feed should take place *before the tool starts to cut,* the stroke is set four or five inches longer than the work.

114. The Feed Friction.—The principle of the friction which operates the rocker for this rapid feed motion during a portion only of the travel of the platen is an important feature of planer design.

The feed friction, one type of which is illustrated in Fig. 116, is usually at the end of one of the shafts of the driving gear train. The hub *H* is keyed to the shaft, consequently is turning in one direction or the other all the time the planer is running. A leather (friction) washer *W* is arranged on each side of the enlarged end of the hub, and the front plate of the

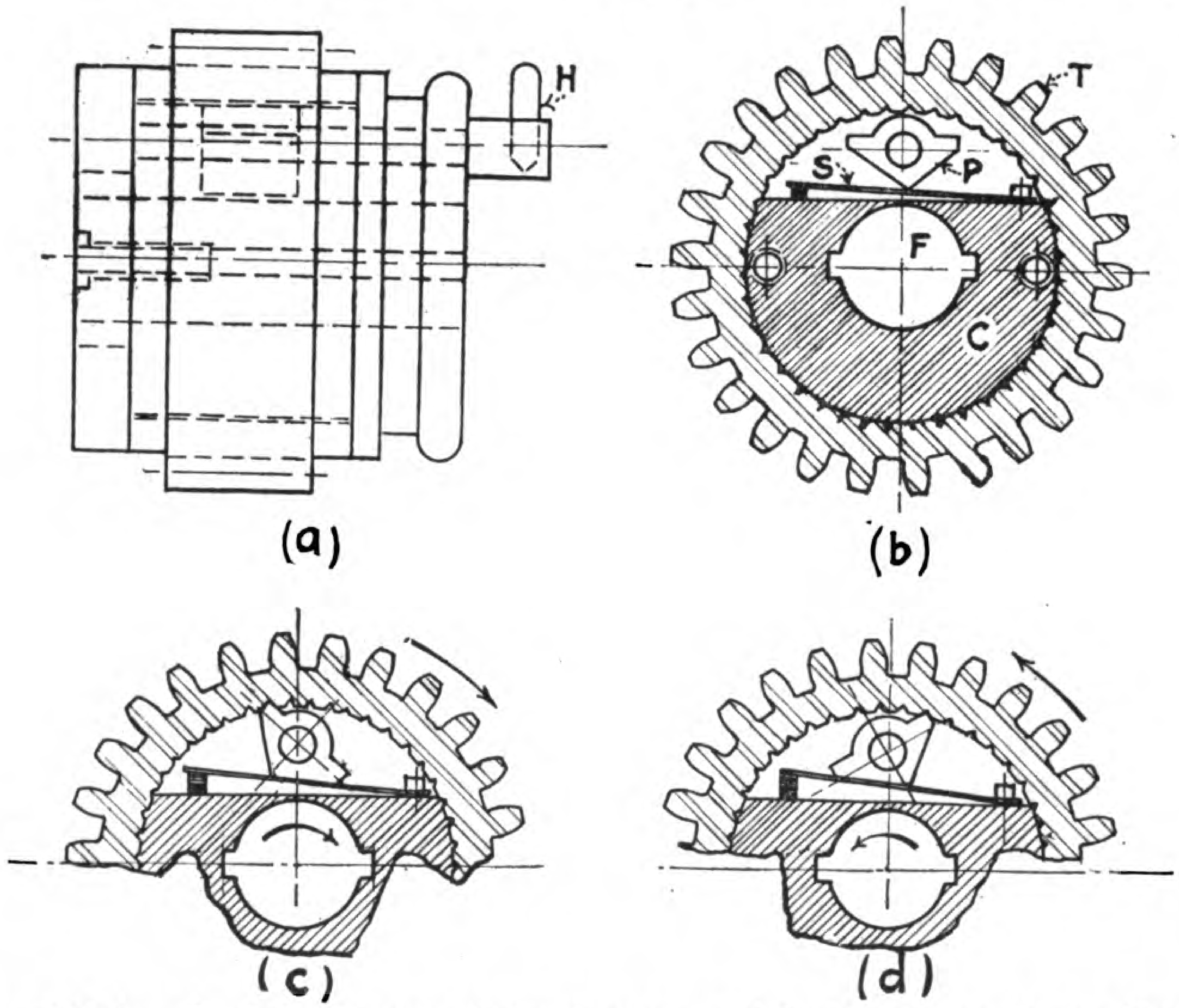


FIG. 115*A*.—Inclosed type of feed gear, ratchet and pawl, or "trigger gear." The pawl carrier *C* is a bushing fitting over the feed screw *F* or the feed rod as the case may be, and fitting freely within a fairly large hole in the gear *T*. A portion of the bushing is cut out to receive the trigger type of pawl *P* and the flat spring *S* that holds it in place. Notches are cut lengthwise through the hole in the gear to form the ratchet teeth. The handle *H* serves to change the trigger to any one of three positions as shown in (*b*) (*c*) and (*d*).

The oscillating movement of the gear *T* serves, in one direction, to move the pawl carrier and operate the feed, and in the other direction, to move the gear one or more teeth over the trigger ready for the next feeding motion. The position of the trigger determines the direction of the movement of the carrier and consequently the direction of the feed. This is shown in (*c*) and (*d*). In (*b*) the pawl is neutral and there is no feed.

friction (which carries the rocker) and the rear plate are pressed against these washers under spring tension by three or more screws. The friction band *B* practically surrounds the hub and the lever *L* is so arranged that when it strikes each stop P it opens the band a trifle and releases it from the hub.

At each reversal of the driving-shaft motion, the rocker travels through a part of a circle determined by the relative positions of the stop pins P. At this time both frictions on the hub operate and the combination of the two is sufficient to move the feed rack, feed gears, ratchet and pawl, etc., and give the cross feed or downfeed desired. During the rest of

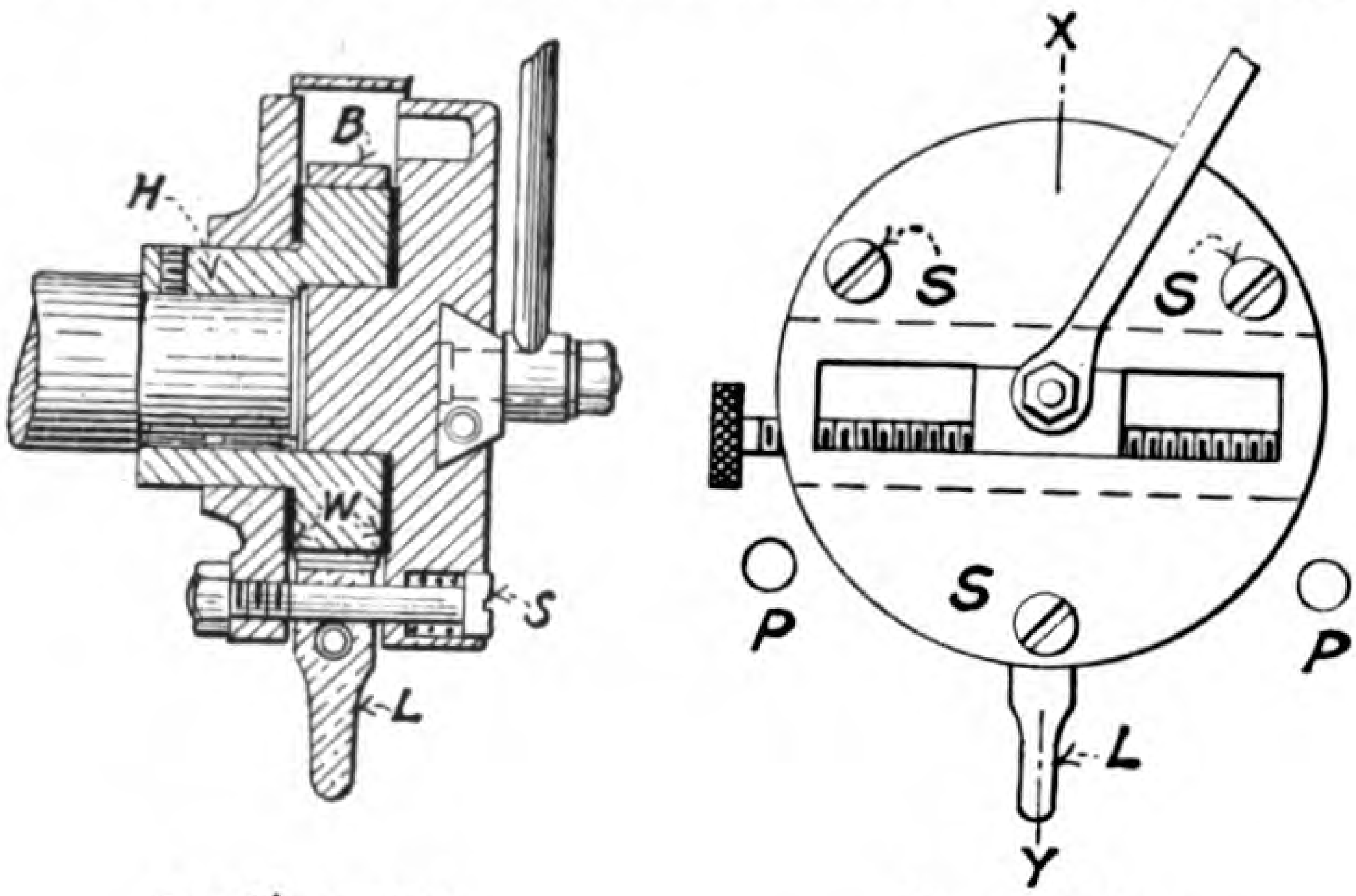


FIG. 116.—Planer feed friction.

the planer stroke the face friction alone operates since the band is released when the lever strikes either stop. The face friction serves to keep the lever against the stop and the band open. On the smaller size planers the combination friction is not necessary and often one friction only is furnished. Such a type is shown in Fig. 115. If even necessary to adjust the friction be *very* sure it is not too tight.

Questions on Planer Construction

1. What is the value of the planer in machine construction?

2. The bull wheel revolves much slower than the driving pulley. How do you explain this? Why is it necessary?

3. What is a rack? How is a rack used in moving the platen?

4. What is the purpose of having a quick return of the platen? How is it accomplished?

5. Why are the holes in the platen reamed?

6. How is the length of stroke changed?

7. The planer does not reverse at *exactly* the same point each stroke. How do you account for this?

8. What are the features of the housings that give them strength and rigidity?

9. How are the front surfaces of housings finished? Why?

10. How is the cross rail clamped to the housings? When is it clamped? When must it be loosened? Why?

11. What is the purpose of the saddle? What is the reason for having a gib between the saddle and the cross rail bearing surfaces? When is the saddle binding screw used?

12. What is the difference between the swivel graduations of the planer head and the graduations on the downfeed screw?

13. Why is it unnecessary to show by graduations the amount the apron is swivelled?

14. Downfeed may be accomplished by turning either one of two handles; where are these handles?

15. Explain briefly the general action of the belt-shifting mechanism.

16. In the planer, the feed operates during the time it takes to move the platen about 6″ and not during the whole stroke. How do you explain this? Explain how the feed would operate if there were no stops on the friction device.

17. Explain briefly the action of the feed rack, feed gears, ratchet and pawl.

18. How tight should the friction be adjusted? Give reason.

19. How is motion transmitted from the ratchet and pawl through the feed rod and four bevel gears to the downfeed screw?

20. How may the platen be stopped without stopping the driving belts? What is the purpose of the safety catch?

21. If the job is at all particular is it safe to assume the cross rail is parallel to the platen? That the head is set square?

22. How could you use parallels to set the cross rail parallel?

23. If suitable parallels were not available how could you use an indicator to test the setting of the cross rail? Why would it be advisable to clamp or block one end of the rail if an adjustment of the other end were necessary?

24. Arrange a tool up side down in the planer head and lightly clamp the frame of a micrometer to the tool, with the barrel projecting downward. Take a reading of the micrometer when the end of the barrel touches the platen (or a parallel on the platen) at each end of the cross rail. How much is the cross rail out of parallel?

25. If you should see a man tugging at a handle to move the planer head or the cross rail, what would you think? Give reason.

26. How much work does the feed friction have to do? How do you tighten the friction? How much?

CHAPTER VII

PLANER WORK

115. Methods of Holding Work.—A great variety of shapes and sizes of work may be machined in the planer, and of course this means that a variety of holding and clamping devices are necessary planer equipment.

Planer "furniture" in common with the work-holding appliances of any other machine tool, may be roughly divided into two classes—general utility tools and special tools. In planer work as in other machine work, the need and value of the special tools, jigs, fixtures, etc., is determined by the quantity of the work. That is, where a great many duplicate pieces are to be planed it is economy to make a fixture in which the work may be quickly set up, correctly aligned, suitably supported and properly clamped. The fixture may be designed to hold a single piece or a dozen or more depending on the size of the work.

On the other hand this work, one piece or a dozen, could, no doubt, be held very well by means of general utility furniture—clamps, stops, angle irons, strips, whichever seems best suited. Certainly one who can intelligently use the regular holding tools will have no trouble asing a fixture.

116. The Planer Vise.—The planer vise, sometimes called the planer chuck is very useful for holding many jobs that are too large or of such a shape as to be impracticable to machine in the shaper. Planer vises are made with plain or swivel bases. Figure 117 illustrates a swivel vise. By loosening the binding screw A, (in some vises one and in others two) the body of the vise may be set in any desired position, the angle of the setting being indicated by graduations in degrees. A taper pin, with a squared head for easy removal, is sometimes provided to exactly locate the vise when the jaws are either parallel or at right angles to the direction of the cut. One jaw of the vise is fixed, and T-slots are provided in the body for clamping the movable jaw *M* by means of the two bolts *B*. The upper face of the body has cross slots to receive the thrust strips *L* held in the backing block *K* which are provided to keep the backing block from slipping after it is located. To fasten the work in the vise, place it against the solid jaw, move sliding jaw up to the work, and tighten the nuts *B* lightly; bring up backing block with thinner section partly under the movable jaw and the thrust strips in the slots; tighten the three set screws *S* sufficiently tight

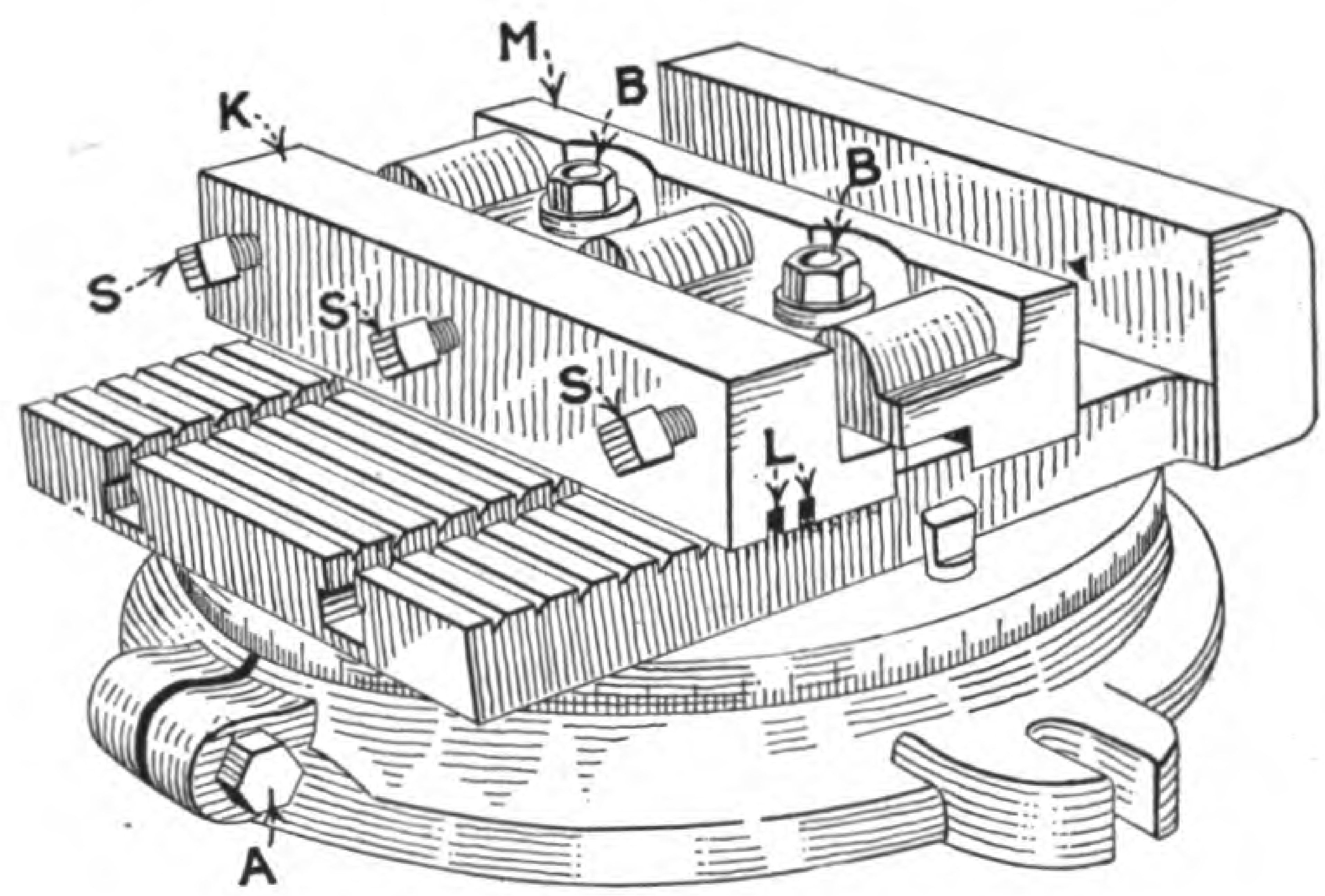


FIG. 117.—Planer vise or "chuck."

to hold the work and then set up the nuts *B hard*. Finally tap the work to make sure it is seated properly. Vise work operations in the planer and shaper are in principle exactly alike. The planer has the advantage of a longer cut. A piece much longer than the vise may be planed if a suitable support, a jack for example, is provided under each of the projecting ends. For information on vise work see page 95.

117. The planer centers (Fig. 118) are comparatively little used as a means of holding work. Most jobs that require indexing can be more advantageously done in a milling machine. There are, however, many occasions in the building of special tools and machines when the planer centers offer the most expedient way or perhaps the only way of finishing a given flat surface or a given curved surface, or one or more slots in an exact relation to a part already turned or in relation to a hole in which a mandrel may be inserted.

A suitable dog is fastened on the work or the mandrel and the tail is clamped in the slotted driver by a set screw after the work is adjusted between the centers. The work may be adjusted for position by turning the handle which operates the worm and wormwheel and is held in this position by the index plunger. For some pieces it may be advisable to further secure or steady the work by blocks or jacks.

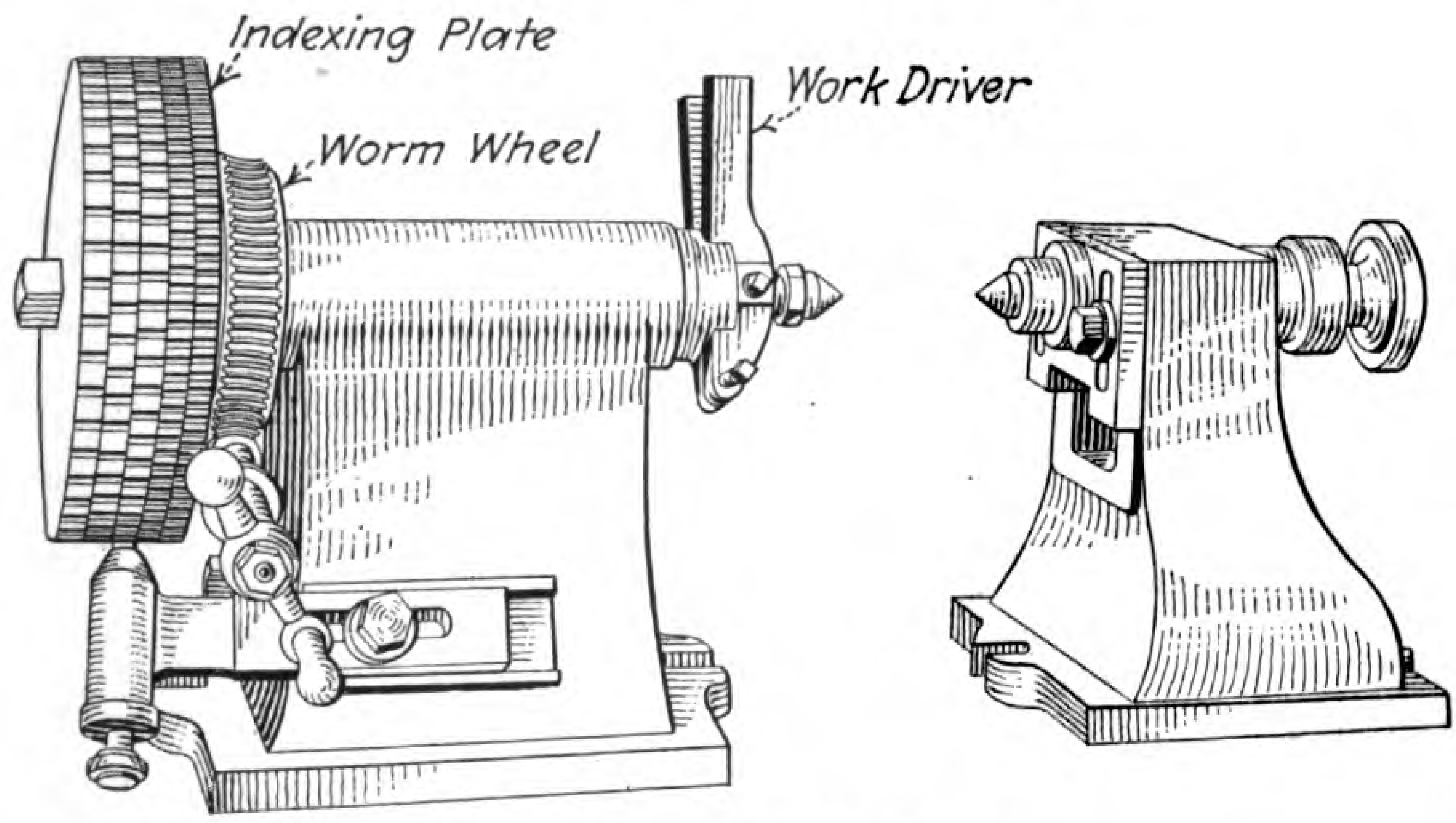


FIG. 118.—Planer centers.

If it is desired to plane a curved surface the tool is set "on center," a distance equal to the radius desired above center, and the work is "fed" for each cut by moving the worm handle a part of a turn.

The tailstock center is inserted in a block, adjustable vertically, for the purpose of planing tapered work.

118. Holding the Work on the Platen.—In ordinary planer practice but few pieces are held by any of the methods previously mentioned; by far the greater proportion of the work that is to be machined in the planer must be fastened more or less directly on the planer platen.

To be able to "set up" the average planer job intelligently the operator must know the tools used for holding and clamping and the principles of their application. For the best method of clamping he must often rely upon his ingenuity.

The success of any job that must be clamped to the table of any machine such as the shaper, drill press, boring mill or milling machine; the face plate of a lathe, or the platen of a planer, depends almost entirely on the manner in which it is clamped, that is, on the knowledge and resourcefulness of the operator. Efficient clamping looks simple enough but it certainly calls for brains.

CLAMPING ACCESSORIES

119. Bolts.—The familiar square head bolt (Fig. 119) is largely used, and for ordinary clamping purposes is satisfactory. To place in position it must be pushed along the T-slot from one end. The T-head bolt offers the advantage of being quickly placed in position as shown. Simply drop the head lengthwise in the slot and turn to the right. This is especially convenient when clamping on the inside of castings which would otherwise have to be lifted over the bolt. Many prefer the tapped T-head which is stronger and in the end probably more economical. If it is required to clamp inside of a casting the stud may be removed and the head pushed along the slot under the casting to the desired position. Studs of various lengths may be used as needed, requiring only a comparatively small number of tapped heads.

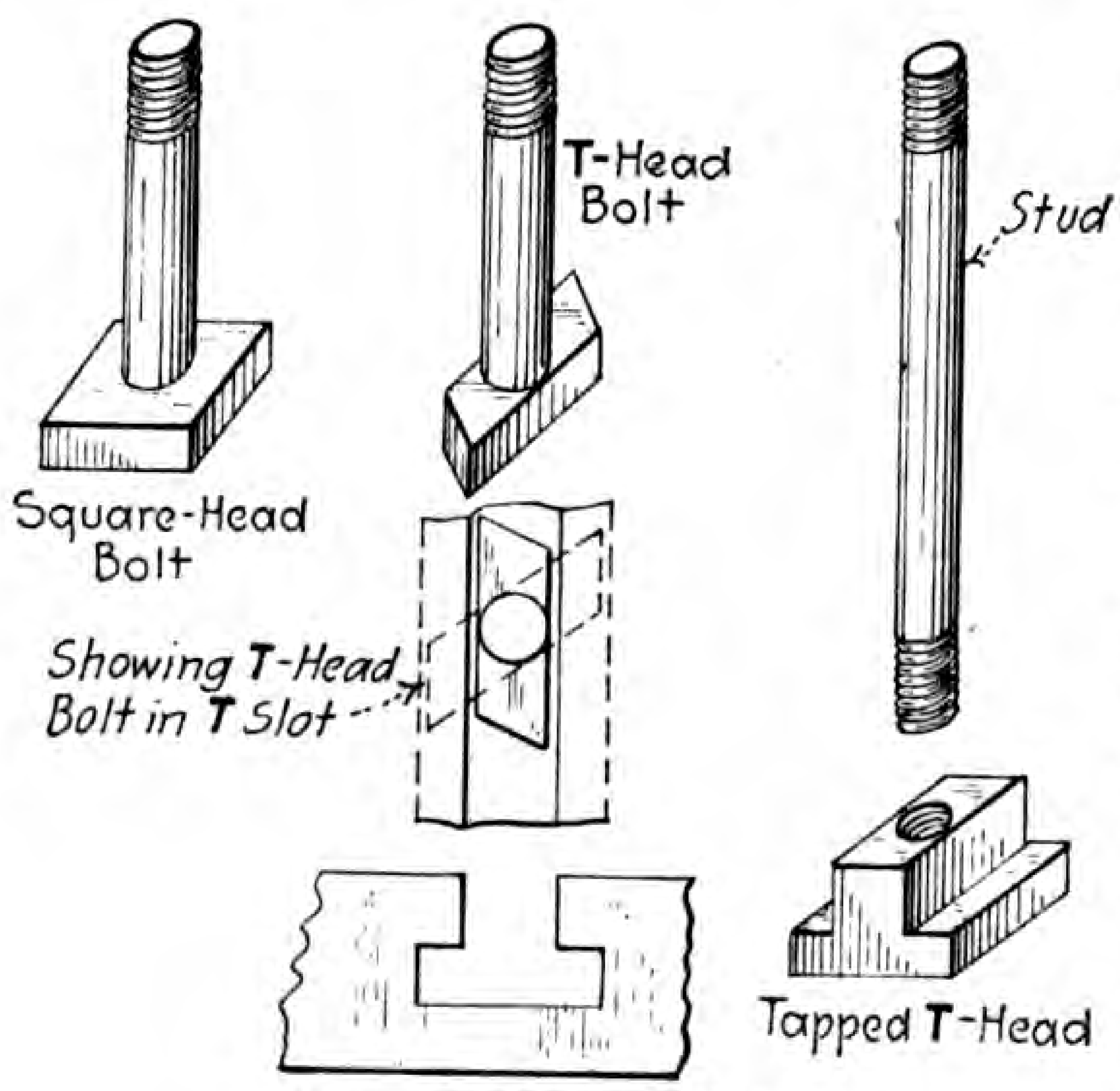


FIG. 119.—Bolts.

120. Clamps.—The *flat clamp* or "*strap*" (Fig. 120) is provided with a bolt hole (usually elongated) somewhat nearer the front end or work end. The front end is usually beveled as shown.

The *U-clamp* may be removed from the bolt without removing the nut. It is also very convenient for purposes of adjustment.

The *finger clamp* or *pin clamp*.—Sometimes a piece of work may be of such proportions that it is inconvenient or impossible to clamp in the regular way and permit the top of the work to remain clear. In such a case it may be admissable to drill one or more holes in each end for the purpose of receiving the turned portion of the clamp. If a finger clamp is not available a short piece of round steel may be used; allow about half an inch of the pin to project and apply a flat clamp.

The *bent clamp* is often useful when it is desired to bring the nut on the clamping bolt below the travel of the tool.

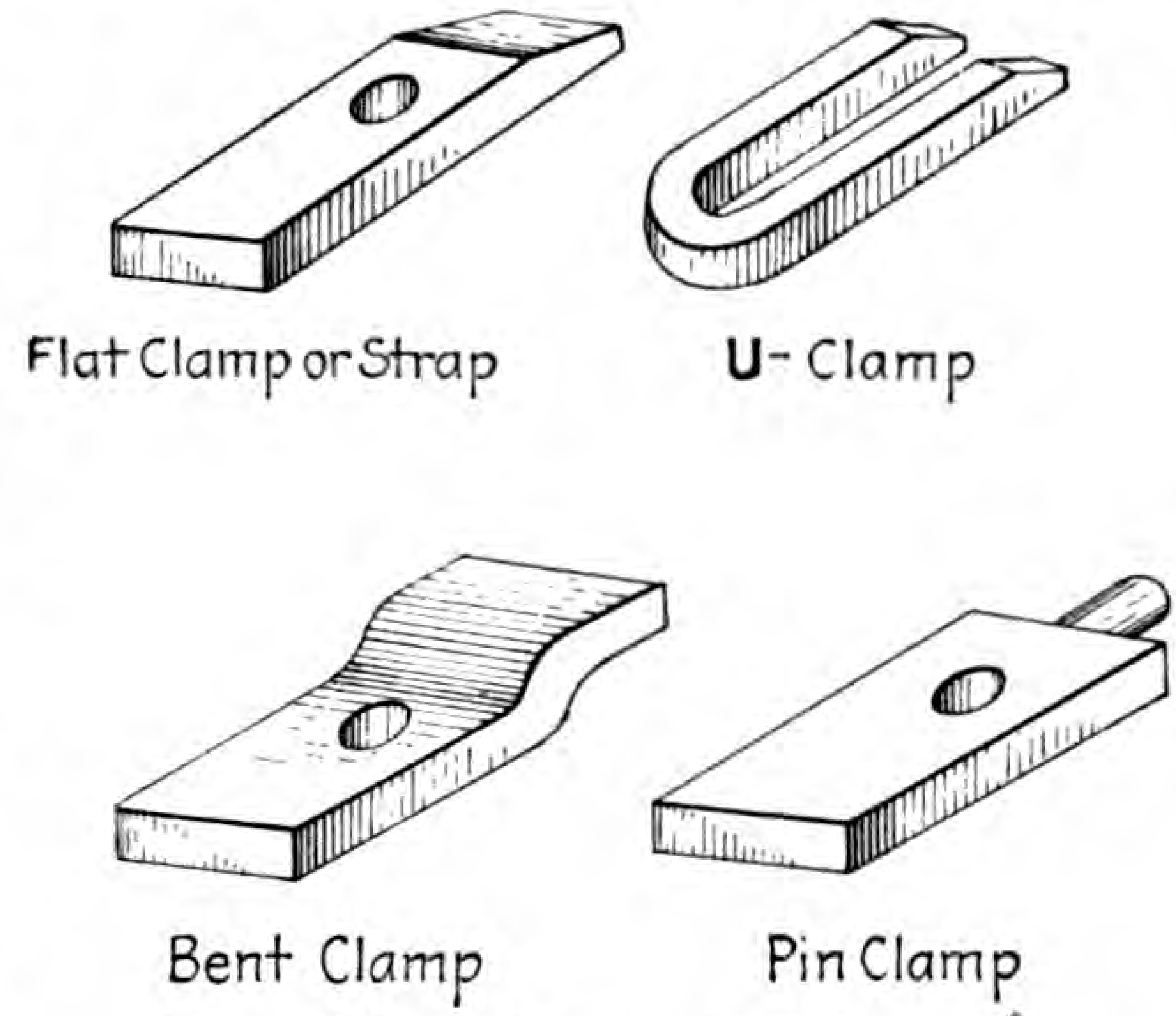


FIG. 120.—Clamps or "straps."

121. Packing Blocks.—Packing under the outer end of the clamp may consist of a piece of handy scrap metal of the required dimensions or if of considerable height suitable pieces of hard wood may be employed. Have the wood of sufficient cross-section to give the needed stiffness and arrange under the clamp so that the pressure will be exerted lengthwise of the grain. Figure 121 shows a step block which is very useful. Both bases are finished and either may be used.

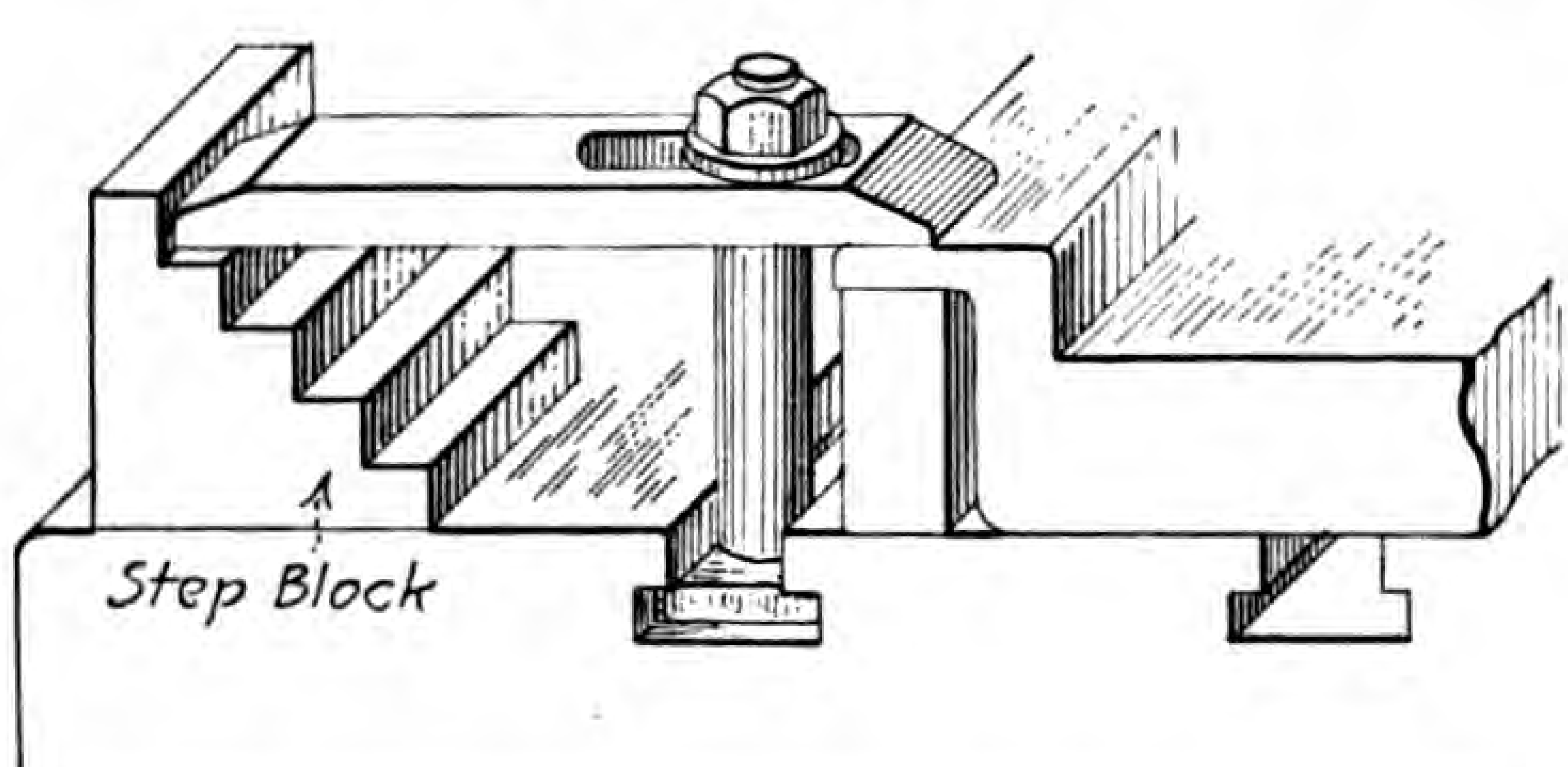


FIG. 121.—Shows use of step block.

122. Shims.—A shim is a piece placed between the table and the work or for that matter between any two pieces or parts for purposes of adjustment or to give support. A shim may be rectangular or tapered slightly, and may be of metal, wood, or paper. Usually, however, a shim is considered as a thin piece of metal, while the heavier pieces are called "packing blocks."

123. Planer Jacks.—For leveling up work or for supporting projections under cutting pressure a jack is an invaluable tool. Figure 122 illustrates a very convenient size. The jack *A* is 1¼ in. in diameter at the base and has a range from 2¼ in. to 3⅝ in. Two extension bases *B* and *C* are provided to extend

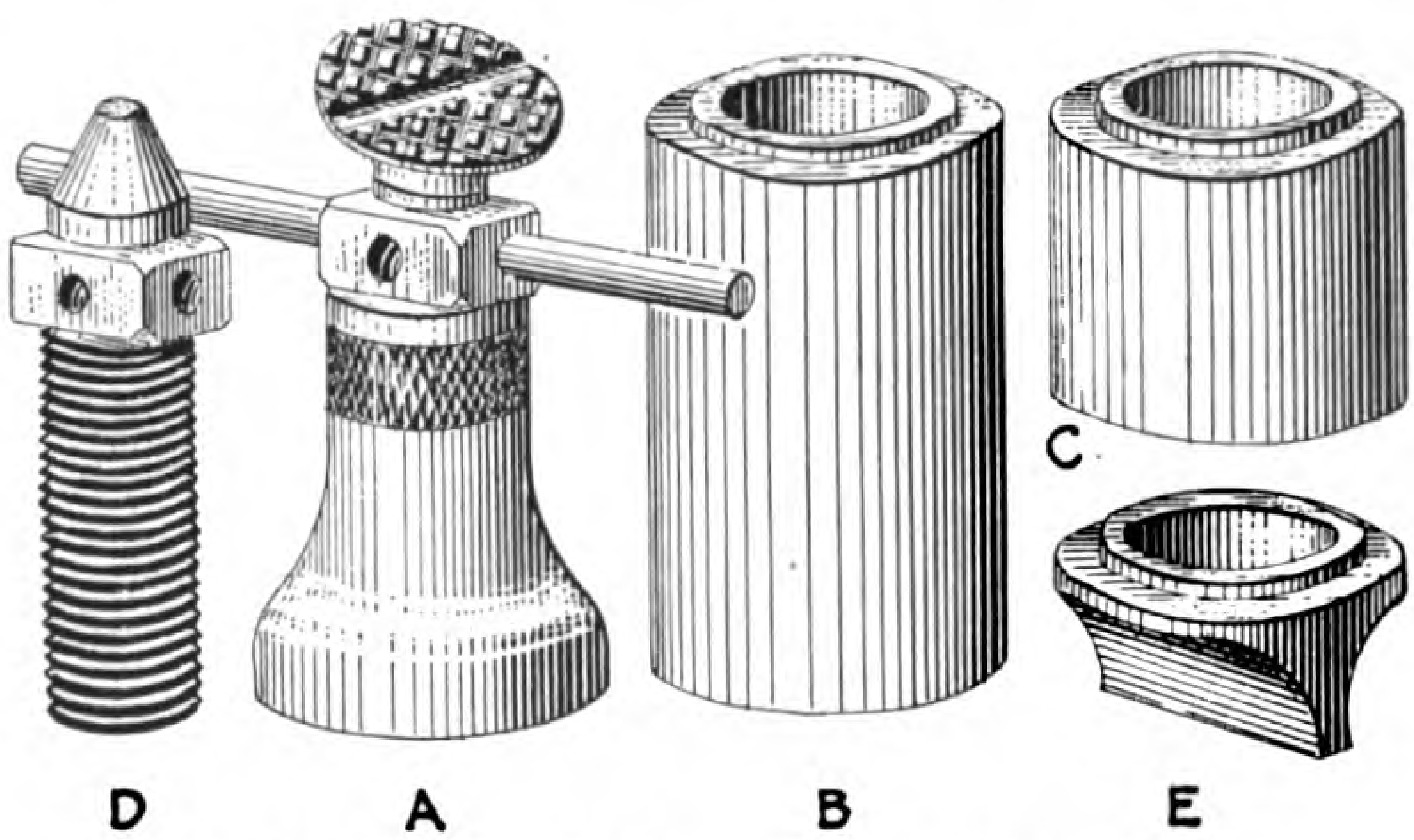


FIG. 122.—Planer jack. (*L. S. Starrett Co.*)

the range to 6½ in. The base *E* is supplied for use when such a shape is desirable. The pointed screw *D* is provided to be used in place of the screw with the swivel cap in certain places where it may be needed, as in a corner.

124. Braces.—Sometimes a job is of such proportions, fairly high and with a comparatively small seating surface, that braces are necessary to assist against the tendency to tip under the cutting pressure. Wooden braces arranged from the work to stops in the table are usually satisfactory.

If, however, a more substantial brace or perhaps an adjustable brace is desired, a piece of pipe of the length required may be provided between the jack *A* and the base *E* (Fig. 122), giving an excellent adjustable brace. A piece of pipe, with a washer, nut, and bolt or screw arranged in one end for the purpose of adjustment, makes a very satisfactory brace.

125. Planer Poppets, Stops, Toe Dogs.—Planer poppets may be made in either style *A* or *B* (Fig. 123). The hole is drilled and tapped about 10° out of parallel with the platen to give the screw a certain downward thrust when in use. Style *B* may be made of round or square stock as desired.

A poppet made as shown at *C* with the screw set low and parallel with the platen is very useful as a stop for the work.

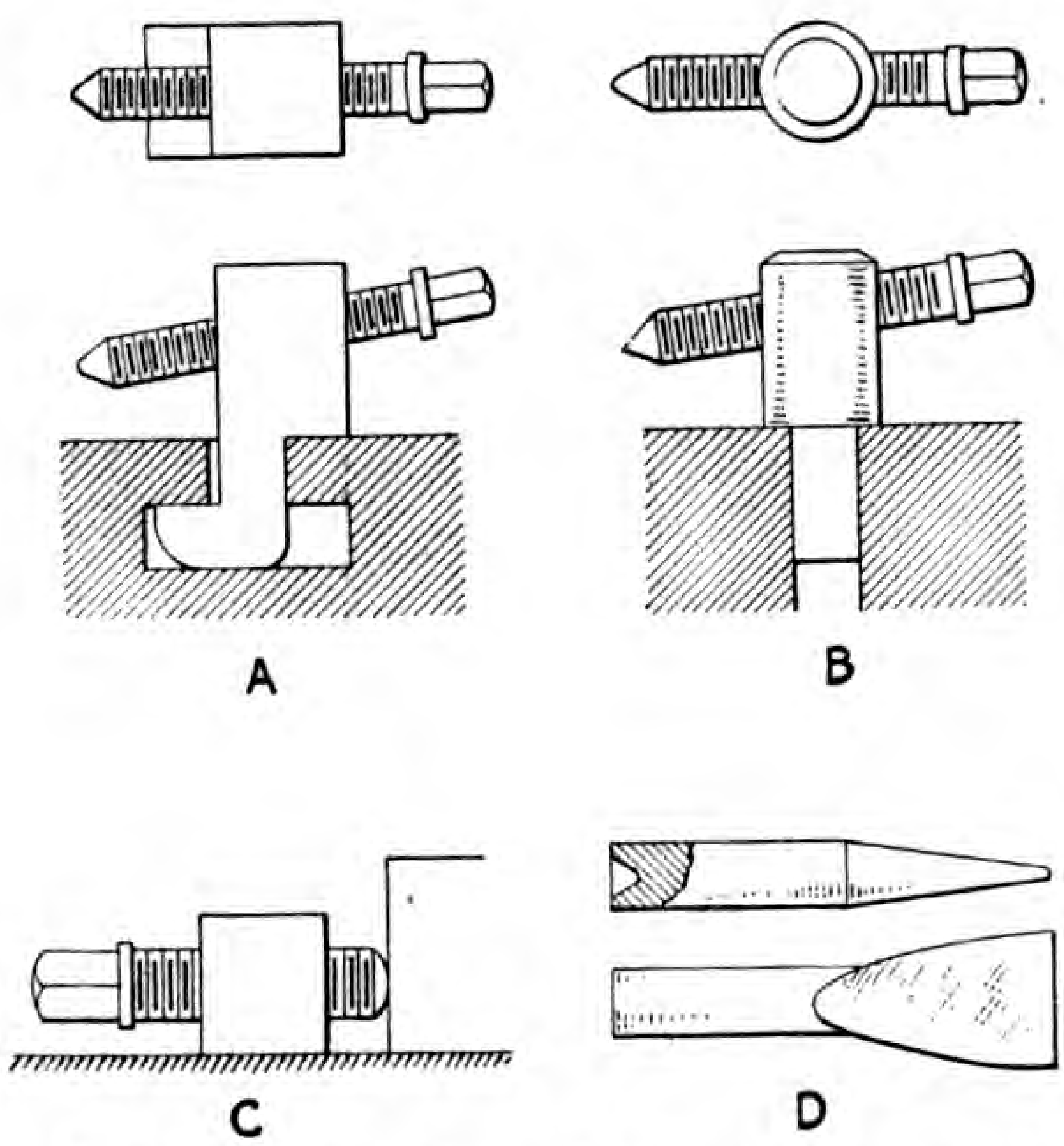


FIG. 123.—*A* and *B*, planer poppets; *C*, stop for work; *D*, toe-dog.

Toe dogs (*D*, Fig. 123) used in connection with the poppets offer an excellent holding device, especially for thin work. To protect the planer table a piece of thin stock, for example, a washer, should be placed under the toe. (See Fig 124 E also Fig 127). A positive stop should nearly always be used when the work is held by toe dogs and great care taken not to buckle the work by unduly tightening the poppet screws.

126. Planer Strips, V-blocks, Angles Plates (Fig. 124) are pieces of metal, usually cast iron, with a uniform cross-section of the desired shape and size and of any convenient length. The base of each is tongued or provided with keys that fit the slots in the platen and bolt holes or flanges are provided for the purpose of clamping. Two or more may be used for the

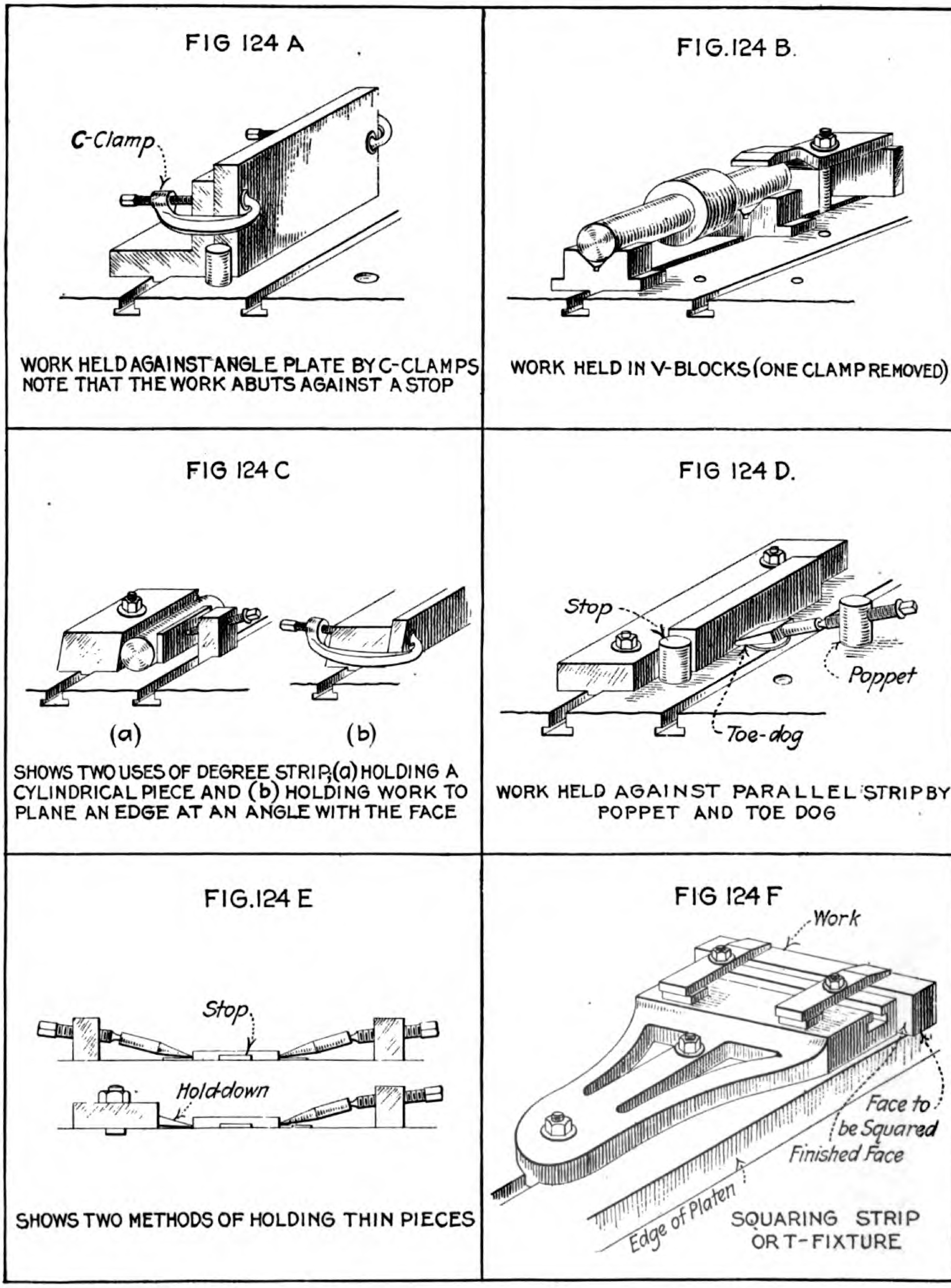


FIG. 124.—Typical planer set-ups.

longer work or when several short pieces are to be planed at one setting.

PRINCIPLES OF CLAMPING

127. Internal Strains.—A very large proportion of planer work consists of machining castings, mostly iron castings, direct from the foundry.

When a casting is poured, the molten metal coming in contact with the surface of the mold chills quickly and forms a skin or "scale" which is much harder and more brittle than the inside. This uneven cooling and the fact that the thin sections of the casting cool more quickly than the heavier parts, causes interior strains. These strains are held more or less in subjection by the scale, and when the scale is removed the casting gives or warps.

This is the reason why the roughing cuts should all be taken before any face is finished. This procedure is not always necessary but should be followed if practicable and must be followed if a certain degree of accuracy is desired. If extreme accuracy is required the casting should be allowed to "season" for a month or more between the roughing and finishing cuts.

128. External Strains.—Practically all metals used in machine shop practice, iron, steel, brass, aluminum, etc. spring under pressure. If a piece is clamped in such a manner that it is sprung or buckled while the cut is taken, when the pressure is released and the piece resumes its natural shape the machined surface will be inaccurate.

For this reason it is very essential if the work does not seat perfectly that it be shimmed or blocked, *particularly under the clamps,* to avoid springing. Usually the sound of a light hammer blow, *before the clamps are applied,* will indicate whether or not the piece is properly seated. A piece may be jacked, or braced, among other reasons to avoid the tendency to spring under the cutting action. Be careful, especially if screw action is used not to set up the brace or jack too tight.

129. Placing the Clamps and the Stops.—A clamp should be properly placed and the packing block under the clamp must be the correct height or the work may become loosened, with probable damage to both work and machine.

A very important point to be observed when clamping work is the position of the clamping bolt. It should be placed as near the work as conditions will permit. By the principle of levers the pressure on the work and on the packing block are inversely proportional to the distance that the work and the block are from the bolt. This is illustrated in Fig. 125.

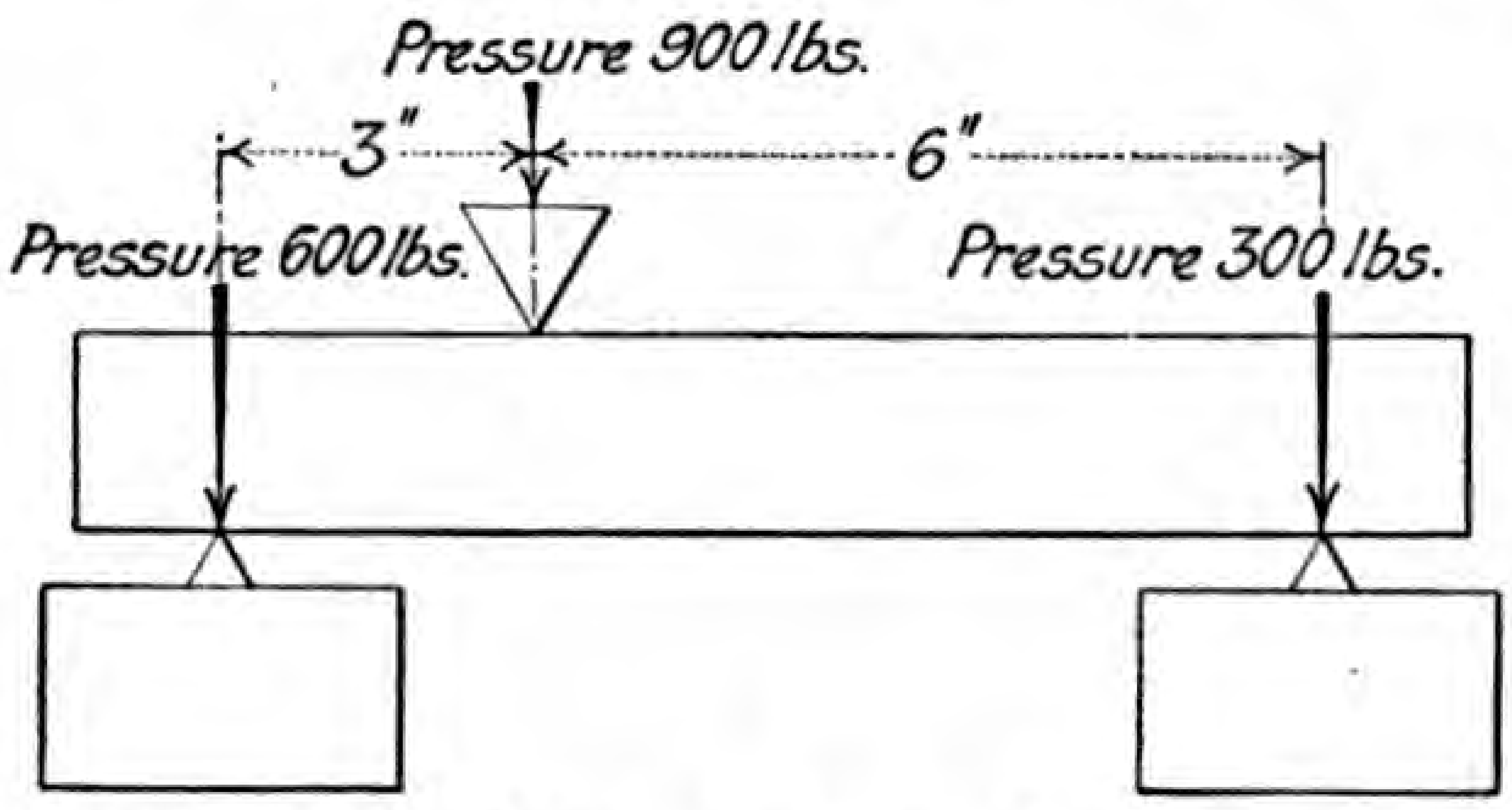


Fig. 125.—Shows a mechanical principle which should be applied when clamping work.

The clamp should have a firm seat on both the work and the clamping block. Packing under the outer end of the clamp

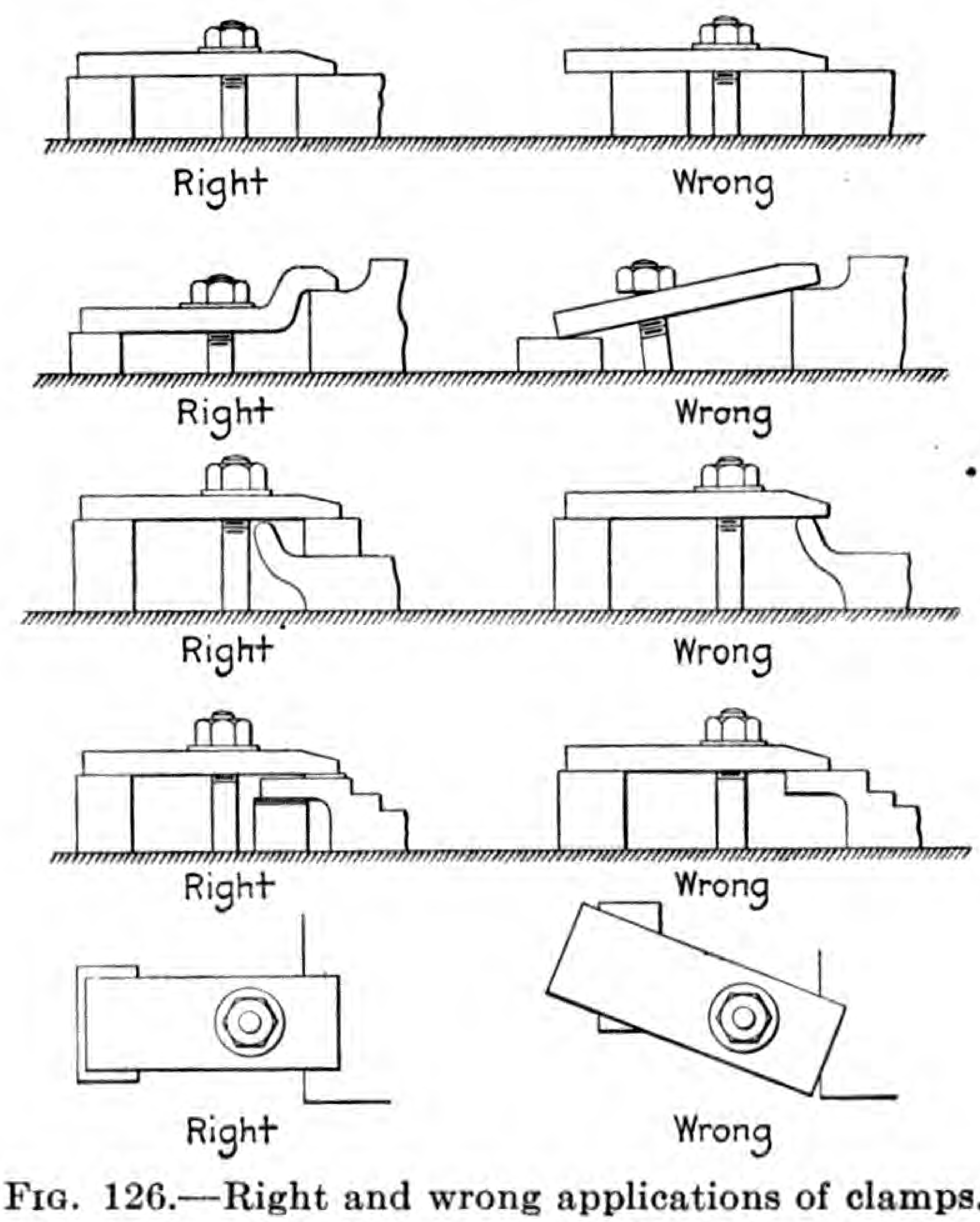


Fig. 126.—Right and wrong applications of clamps.

should be at least high enough to bring the clamp parallel with the surface on which the work rests. It must never be lower or the clamp will only have contact on the edge of the work. It may be a trifle higher to insure against an edge contact, but if either too high or too low the bolt-head contact in the T-slot, and the nut and washer contact on the clamp are faulty, and the clamping force correspondingly weak.

The clamp must not be placed over a part that will give or spring under pressure until suitable packing is placed under that part.

In Figs. 126 and 127 are illustrated right and wrong methods of using clamps, poppets and toe dogs.

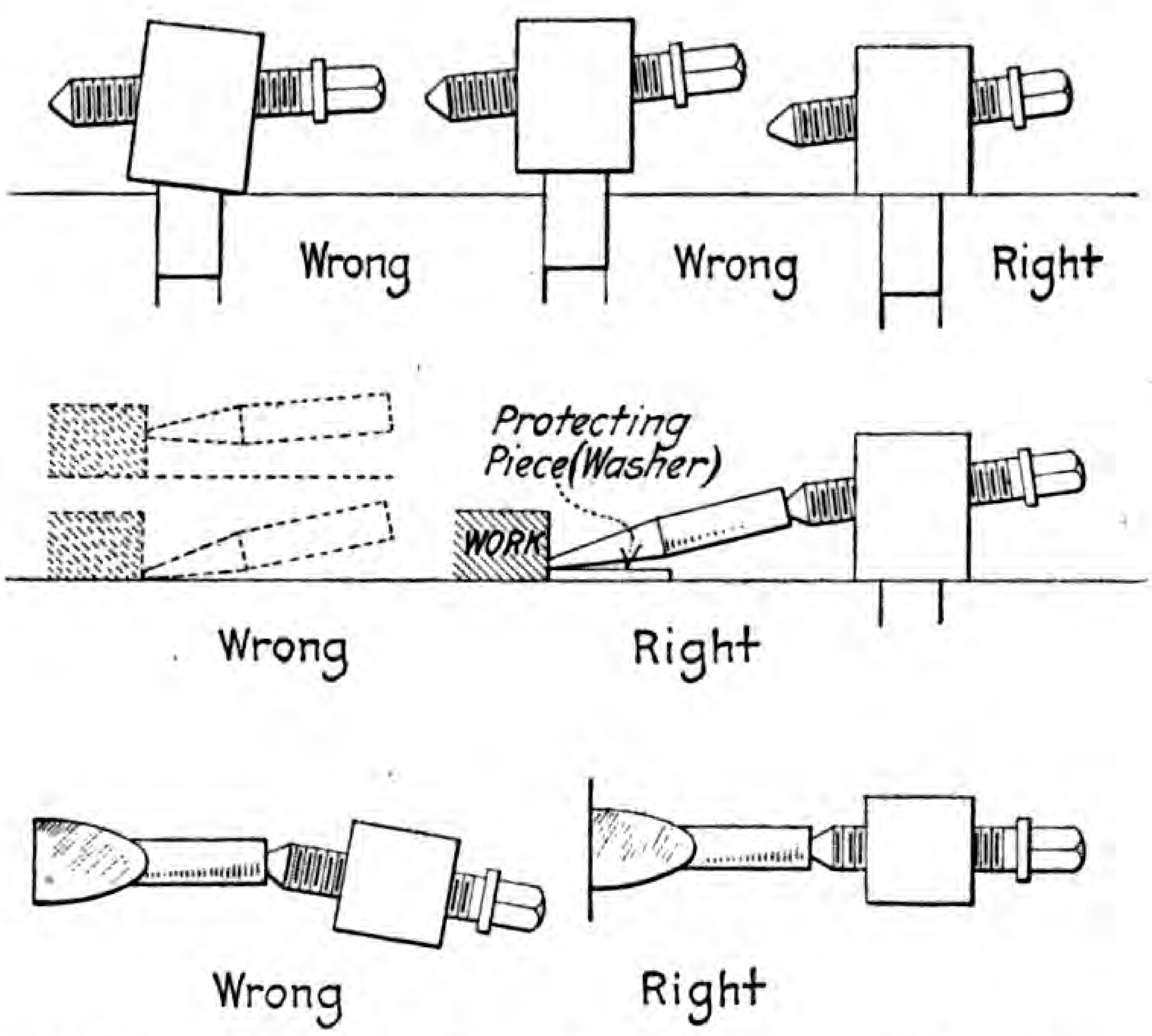


FIG. 127.—Right and wrong uses of poppets and toe-dogs.

The work should be held in the machine in such a way that it will not move under the cutting pressure. In planer work, the thrust of the tool is mostly in a forward direction and comparatively little in a sidewise direction. It is nearly always possible and advisable to use positive stops. Poppets may often be used, but if these are too high a clamp may be bolted to the table; if not high enough possibly an angle plate bolted to the table will do.

The first-class planer hand uses clamps and stops *when*, *where*, and *as* he should. As previously stated, this calls for brains. Size up the work to be done, use *reasoning* when determining how best to hold it, place the stops, clamps, strips, poppets, toe dogs, whatever is necessary to hold the work, with careful attention to having them placed and adjusted as right as any one could do it. If one does this, the chances are that it is a good set-up and a good set-up is often more than half the job.

130. Clamping Hints.—Do not depend on the accuracy of vise jaws, parallels, angle irons, etc., without testing them.

Do not put a clamp on a finished surface without protecting pieces.

It is very easy to score the table by sliding a rough casting across its surface. Put down protecting pieces of cardboard or similar material. Also do not fail to protect vise jaws, angle irons, parallels, etc., when clamping castings and forgings.

Many pieces are spoiled due to carelessness in cleaning the parts against which the work seats, or is clamped. When a piece is clamped in a vise, or against an angle iron or similar tool, great care must be taken to clean away all chips and dirt.

After a piece is clamped in a vise, tap lightly with a babbit hammer to seat it. Do not tighten the vise again after seating the work as this is likely to lift the work from its seat.

When work is held on a table against an angle iron or similar piece, place tissue paper under each end of the work to determine if it is properly seated. Tap it lightly if necessary.

Use a stop against the work wherever convenient, and avoid unnecessary clamping.

It is very easy to buckle a thin piece and great care must be taken when clamping such a piece in a vise, or when using hold downs or toe dogs.

Form the habit of sighting over the top of the work under the cross rail, and along the sides next to the housings *after* clamping, to make sure everything is clear.

Never use a nut without a washer.

Use the proper size solid wrench to avoid rounding the corners of the nuts.

The thread of the bolt or nut should be oiled occasionally to save time and trouble.

Avoid, if possible, using bolts that are excessively long, and do not in any circumstances use a bolt too short, with only three or four threads catching in the nut.

Particular care should be taken to return clamps, bolts, and all other clamping accessories to the place where they belong. This is only fair to all concerned.

131. Similarity of Shaper Work and Planer Work.—The similarity of the shaper and planer with regard to several of the details of construction, many of the methods of holding the work, and most of the operations and consequently the cutting tools used, serve to make a knowledge of the one a very great help in understanding the other.

It would seem as if the fundamental knowledge and initial experience in these operations should if possible be acquired in shaper work rather than in planer work for the following reasons:

1. The shaper is smaller and easier to handle.
2. Shaper work is lighter and the time taken to set up and make a cut on the average job is much less than in planer work.
3. In shaper work a more extended practice in grinding various tools and in performing a variety of operations common to both machines may be had in a given time and consequently a broader viewpoint of the possibilities and value of these operations and a better understanding of how they are performed may be obtained more quickly in shaper work than in planer work.

When a beginner is assigned to a machine, he should be given an opportunity to study the machine and acquire a reasonable understanding of its mechanisms and the principles and methods of holding, machining and measuring the given job. This, of course, involves more or less general information. About all that may be expected of a text is to supply briefly the fundamentals. If the beginner in planer work has studied this and the preceeding chapter he should have a fair understanding of planer construction and the methods of holding the work on a planer. Now he is ready to start the given planer job. The principles of the cutting operations in the shaper and planer are practically the same. An understanding of their application in one machine will serve as a general rule in the operation of the other.

Descriptions and explanations of many of the operations common to both planer and shaper have been given in Chapter V and will not be repeated here. Substantially the whole of Chapter V is as applicable to planer work as it is to shaper work. It is suggested, therefore, that the student who is not already familiar with shaper work as therein outlined refer to that chapter in connection with his work on the planer.

In addition to the above statement, references to certain particular pages in Chapter V are made in the following paragraphs on planer work for the convenience of the student and for the purpose of indexing.

132. Planer Tools.—The generally used planer tools are substantially like shaper tools for the kindred operations, the only difference being the size. Descriptions of these tools are given, beginning page 82.

PLANER OPERATIONS

133. Levelling.—As previously stated most work comes to the planer in the shape of rough castings. Frequently it is desirable to scribe layout lines on certain castings to represent the relative positions of the finished surfaces. In many cases if care is not taken in the layout, and in leveling or squaring by these lines in the set-up, the casting will not clean to dimensions required. Sometimes a casting, a plate for example, with apparently plenty of metal for machining, will be so badly warped that care must be taken when setting up for planing the first or working surface. It must be levelled in such a way as to average the corners for height, with due care for later planing the opposite side. It will probably be necessary to shim under two corners, maybe three and possibly all four corners. In addition shims will no doubt have to be placed under certain points where the clamps are to be applied, no matter what kind of clamping devise is used.

The surface gage is an invaluable tool in planer work, for scribing lines, for leveling either a surface or a line, and for gaging.

To plane several pieces (a "string") at one time no doubt saves a considerable amount of time in adjusting and measuring, and very frequently in the cutting operation. If many duplicate pieces are to be planed, a "string fixture" has many advantages in respect to saving time and labor.

134. The Roughing Cut.—When taking a roughing cut the combination of feed and chip should be as great as the nature of the work, the manner in which the work is held, the kind of cutting tool used, and the strength of the machine will permit. When roughing cast iron, care must be taken that the tool does not rub on the scale during any part of the cut. Also in roughing cast iron, in order not to break the corner below the surface at the finish of the cut and thus leave a ragged edge, this corner should be chipped or filed to a bevel of about 45° and to an amount about equal to the depth of the cut.

When roughing, the feeding movement should not take place at the end of the cut because the dragging of the tool on the scale will tend to injure the cutting edge. It should take place at the start of the forward stroke and *before the tool enters the metal* otherwise the feeding mechanism is unduly strained.

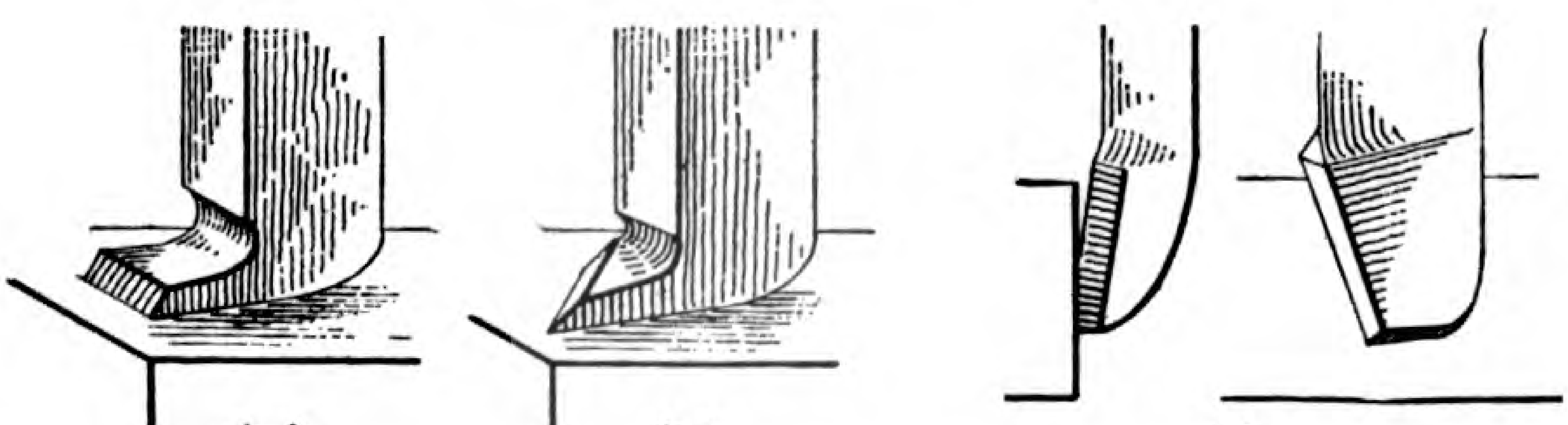


FIG. 128.—Tools for finishing cast iron. *a*, Shovel-nose; *b*, shovel-nose ground for shear cut; *c*, front and side views of side tool.

135. The Finishing Cut.—Usually a better finish is produced on steel with a fairly light chip and a fine feed. The commercial finish of cast iron is produced by using a wide square nose tool with a light chip (.002 in. to .005 in.) and a feed of ½ in. or more depending on the size of the work (see p. 102). That is, a better finish is obtained on cast-iron work by taking a fairly wide scraping cut than is obtained by taking a deeper cut with a finer feed. This is true on horizontal vertical or bevel surfaces. If the tool tends to chatter, the fault may often be remedied and the chatter marks removed by using a tool which will give a shear cut. In Fig. 128 is illustrated a shovel-nose tool for a horizontal surface and a side tool for a vertical surface each so made as to give a shear cut.

136. Measuring and Gaging.—The test of a plane surface is, first its flatness, second its relation to another surface—its squareness or its other angularity to this surface, or its distance from another surface. The best method of testing for flatness is by means of a surface plate or a suitable straight edge placed on the work, or by turning the work over and placing the surface to be tested on a surface known to be flat. In the latter case, the platen of the planer is frequently used. When the surface is flat there is no "rock" of the work on the platen or no "hollow sound" under a light blow given anywhere on the work.

If a straight edge is used it should be tried in several positions on the surface with tissue paper feelers[1] to determine the straightness and flatness of the surface. Feelers may often be used in a similar way between the corners of the work and the surface plate or planer platen.

Tissue paper feelers are frequently used with a square to test if a surface is at right angles with another surface and may be used with a bevel protracter to test the accuracy of an angular cut other than 90°.

For measuring or gaging the height of a surface, direct scale measurement may be good enough, or a surface gage set to a scale. For measuring the height of a shoulder accurately a height gage or a depth gage is useful. A combination square may be used to test the distance from one surface to another either horizontally or vertically. When a considerable num-

[1] If a straight edge is placed on a surface with narrow pieces of tissue paper between, say one at each end and one in the middle, and any one of them pulls easier than another it indicates that the surface is not flat.

ber of pieces are to be planed with angular cuts, shoulder cuts, etc., it is advisable to have tool-setting gages and work-testing gages as part of the equipment for that job.

137. Memoranda.—Planing Horizontal Surfaces, Vertical Surfaces, Rectangular Pieces, Angular or Bevel Surfaces. Slots, Tongues, Grooves, Keyways, Keyseats, Dovetails, have been described in the chapter on shaper work beginning page 100.

138. Planing T-slots—Use of Tool Lifter.—Figure 129 illustrates a tool for planing T-slots. Many T-slots in the smaller tables, fixtures, etc., are milled, but in the larger castings, they are planed. A slot somewhat narrower than the finished size is planed to the depth required with sides parallel. The lower part of this slot is then widened with the T-slot tools, first one side and then the other as illustrated in *b* and *c*, (Fig. 129), after which the original slot is carefully planed to exact width. When planing a T-slot it is necessary to lift the tool out of the slot before the return stroke, or *to block it so it cannot lift.* Otherwise the tool will tend to lift against the shoulder and will rub so hard as to spoil the work and break the tool. In order to obviate the necessity of lifting the tool by hand each time, a tool lifter, (Fig. 130), may be used. There are a number of kinds of tool lifters, but a hasp or hinge fastened back of the tool as shown works very well. Sometimes an undercut on the edge of a piece of work is advisable. Such a cut may be made in the same manner as the T-slot is cut. Further, the use of the tool lifter is frequently made when taking a

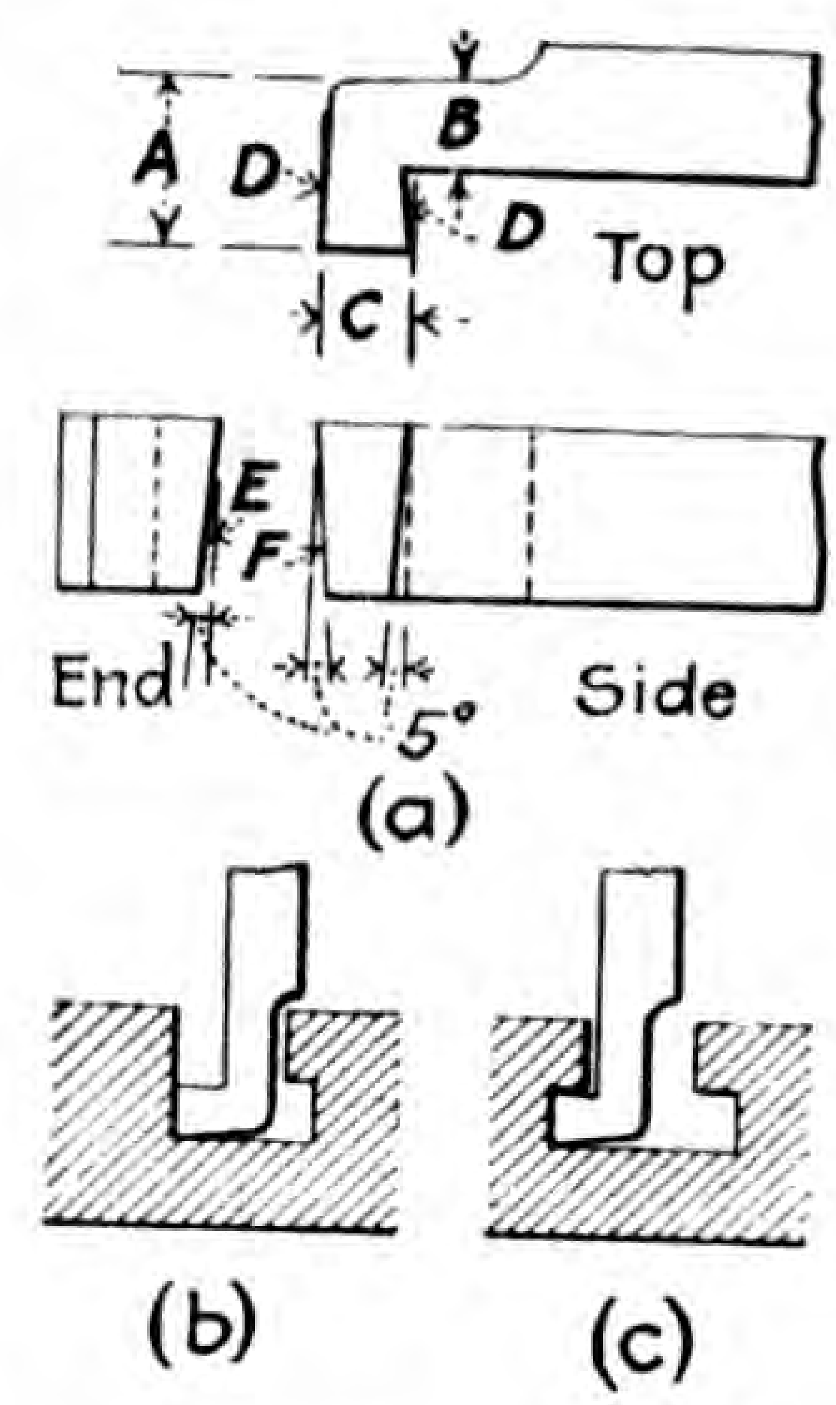


FIG. 129.—Tee slotting tools. Two tools (right hand and left hand) are needed. In the figure (*a*) shows three views of right hand tool, top face is flat (no rake), cutting edge *C* is given clearance of about 5° on front *E*, sides *F*, and also from the front as shown at *D*. As will be observed in *b* and *c*, which show respectively the start and finish of the cut, the width of the tool *A* cannot be greater than the original slot (see *B*) and the width of the neck *b* must be narrow enough to permit the tool to cut its share of the T-slot.

finishing cut over a large surface as it prevents the rubbing of the tool on the work and serves to prolong the life of the cutting edge.

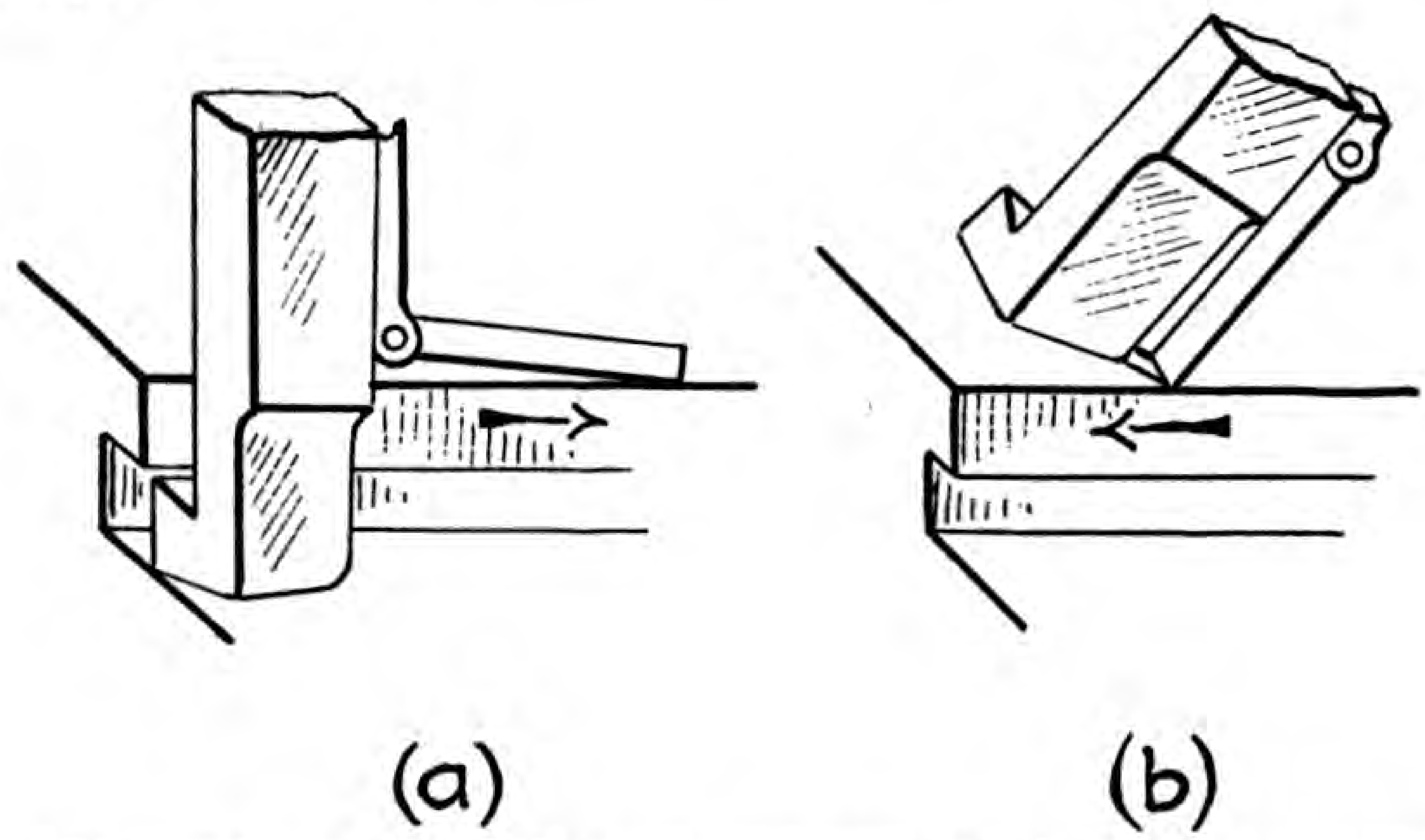


FIG. 130.—Shows tool lifter, *a*, cutting stroke, *b*, return stroke.

Questions on Planer Work, I

1. What do you understand by the term "fixture" in machine work? What is the value of a planer fixture?

2. Explain in detail the operation of gripping work in a planer vise? How is the movable jaw held down? When is it fastened down hard? How is it backed up?

3. What advantage has a T-head bolt over a square-head bolt?

4. What is the advantage of the tapped T-head?

5. What, in your judgment, is the use of a washer?

6. Describe briefly four kinds of clamps used in holding planer work.

7. What is the difference between "blocking" and "shimming?"

8. What is the advantage of a step block? How would you make a step block with four steps giving eight different heights?

9. Is the height of the block under the clamp an important feature of clamping? Give reason.

10. Is the position of the clamping bolt in relation to the work of any particular importance? Give reason.

11. When is a jack used in setting up a planer job? What precaution should be observed when using a jack?

12. When clamping work down on the platen, what precautions should be taken to avoid springing it?

13. How may a comparatively thin piece be held on the platen and the whole top surface planed at one setting?

14. What is the real purpose of a "stop" for the work?

15. In what respect is the "toe dog" like the hold down or gripper?

16. Manufacturers of high-grade machines take a roughing cut on tables, beds, frames, etc., and then pile them in the yard for two or three months, possibly longer. What is the reason for this?

17. Why is it usually advisable to take all of the roughing cuts before taking any finishing cut?

18. What do you understand by the term "levelling" in planer work?

19. State three different uses of the surface gage in planer work.

20. Frequently it is necessary to find the low spot on a surface to be planed and then set the tool to get under the scale the first cut. What gage would you use for finding the low spot? For setting the tool?

21. How do the statements in paragraph 63, page 79, apply to the planer?

22. Make a list of the statements in Chapter V that do not apply to planer work.

Questions on Planer Work, II

(For information see Chapter V beginning page 82)

1. What is the difference between a right-hand and a left-hand planer tool?

2. What is the effect of too much clearance on a tool?

3. How do you account for the tendency to grind too much clearance? What is the remedy?

4. What is negative rake? Explain the disadvantage of trying to cut with an edge having negative rake.

5. What do you understand by a shear cut?

6. Is Fig. 74, page 84, a chart of forged planer tools?

7. How do you reason the proper feed and a suitable depth of cut for a given planer job?

8. What are some of the reasons against running the tool head slide down too far?

9. Why is the apron set over when planing a vertical or an angular surface?

10. What is the rule for setting the apron when taking a vertical or an angular cut?

11. How do you prevent the breaking of the edge at the end of the cut?

12. How do you oilstone the cutting edge of a square nose tool?

TABLE 3.—PLANER CUTTING SPEEDS

Actual number of feet of metal cut per minute with given forward speeds and various return speeds.

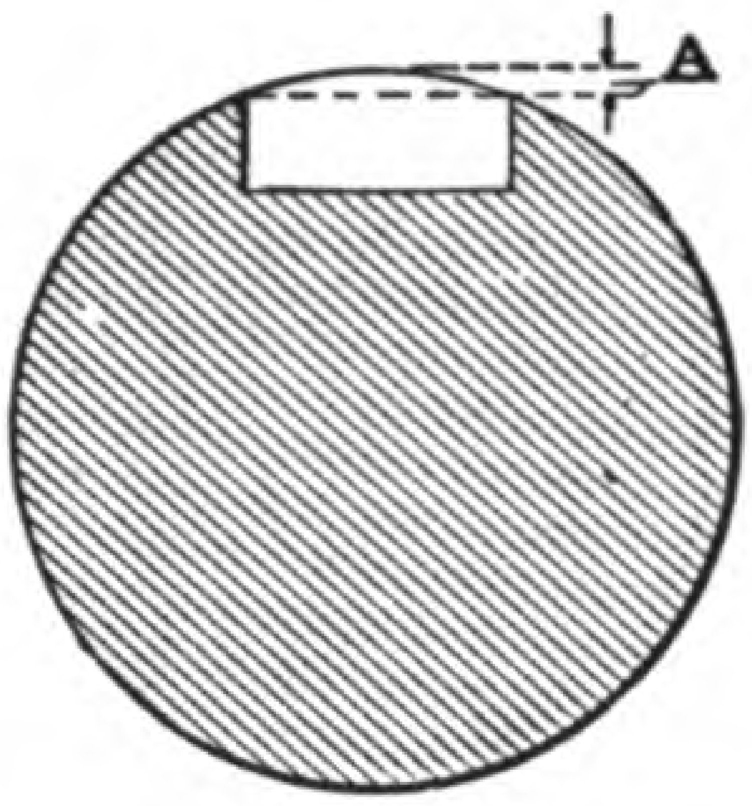
Forward Cutting Speed in Feet per Minute	Return Speed						
	2 to 1	3 to 1	4 to 1	5 to 1	6 to 1	7 to 1	8 to 1
20	13.3	15.	16	16.66	17.14	17.5	17.76
25	16.6	18.75	20	20.83	21.42	21.87	22.16
30	20.	22.5	24	25.	25.71	26.25	26.56
35	23.3	26.25	28	29.16	30.	30.62	31.04
40	26.6	30.	32	33.33	34.28	35.	35.52
45	30.	33.75	36	37.5	38.56	39.37	40.
50	33.3	37.5	40	41.66	42.84	43.75	44.48
55	36.6	41.25	44	45.83	47.12	48.12	48.95
60	40.	45.	48	50.	51.42	52.50	53.43
65	43.3	48.75	52	54.16	55.70	56.87	57.91
70	46.6	52.5	56	58.33	60.	61.25	62.3
75	50.	56.25	60	62.5	64.28	66.62	66.71

The table shows clearly that a slight increase in cutting speed is better than high return speed. A 25-foot forward speed at 4 to 1 return is much better than 8 to 1 return with 20-feet forward speed.

Economical planer speeds are given below (Cincinnati Planer Co.).

Cast Iron roughing......40 to 50 ft.; finishing......20 to 25 ft.
Steel casting and wrought iron roughing 30 to 35 ft.; finishing 20 ft.
Bronze and brass...50 to 60 ft.; Machinery steel...30 to 35 ft.

TABLE 9.—FINDING TOTAL KEYWAY DEPTH



In the column marked "Size of Shaft" find the number representing the size; then to the right find the column representing the keyway to be cut and the decimal there is the distance A, which added to the depth of the keyway will give the total depth from the point where the cutter first begins to cut.

Size of Shaft	1/4 Keyway	5/16 Keyway	3/8 Keyway	7/16 Keyway	1/2 Keyway
1/2	0.0325	....	....	....	....
9/16	0.0289	....	....	....	....
5/8	0.0254	0.0413	....	....	....
11/16	0.0236	0.0379	....	....	....
3/4	0.022	0.0346	0.0511	....	....
13/16	0.0198	0.0314	0.0465	....	....
7/8	0.0177	0.0283	0.042	0.0583	....
15/16	0.0164	0.0264	0.0392	0.0544	....
1	0.0152	0.0246	0.0365	0.0506	0.067
1 1/16	0.0143	0.0228	0.0342	0.0476	0.0625
1 1/8	0.0136	0.021	0.0319	0.0446	0.0581
1 3/16	0.0131	0.0204	0.0304	0.0421	0.0551
1 1/4	0.0127	0.0198	0.029	0.0397	0.0522
1 5/16	0.0123	0.0191	0.0279	0.038	0.0499
1 3/8	0.012	0.0185	0.0268	0.0364	0.0477
1 7/16	0.0114	0.0174	0.0254	0.0346	0.0453
1 1/2	0.011	0.0164	0.024	0.0328	0.0429
1 9/16	0.0107	0.0158	0.0231	0.0309	0.0412
1 5/8	0.0105	0.0153	0.0221	0.0291	0.0395
1 11/16	0.0102	0.0147	0.0214	0.0282	0.0383
1 3/4	0.0099	0.0142	0.0207	0.0274	0.0371
1 13/16	0.0095	0.0136	0.0198	0.0265	0.0355
1 7/8	0.0093	0.013	0.019	0.0257	0.0339
1 15/16	0.009	0.0127	0.0184	0.025	0.0328
2	0.0088	0.0124	0.0179	0.0243	0.0317
2 1/16	0.0083	0.0117	0.0173	0.0236	0.0308
2 1/8	0.0078	0.0111	0.0168	0.0229	0.0299
2 3/16	0.0073	0.0109	0.0163	0.0222	0.0291
2 1/4	0.007	0.0107	0.0159	0.0216	0.0282

For larger sizes see American Machinists' Hand Book